idiap
RESEARCH INSTITUTE

RESEARCH PROGRAM 2021-2024

JUNE 2019

« Le progrès scientifique en général, et en particulier celui réalisé dans l'informatique, ne doit pas asservir l'homme mais au contraire être à son service. »

« Der wissenschaftliche Fortschritt im Allgemeinen und insbesondere die Fortschritte in der Informatik dürfen den Menschen nicht versklaven, sondern müssen ihm im Gegenteil von Nutzen sein. »

« Scientific progress in general and progress in computer science in particular should not enslave man but on the contrary be at his service. »

Angelo Dalle Molle, philanthrope

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Département fédéral de l'économie, de la formation et de la recherche DEFR
Secrétariat d'Etat à la recherche et à l'innovation SEFRI
Division Recherche et Innovation Nationales

Contribution à des établissements de recherche d'importance nationale
Idiap Research Programme 2021-2024

S'applique aux établissements de recherche encouragés en vertu de l'art. 15, al. 3, let. a à c, LERI
(Autres bases légales: art. 20 à 23 O-LERI; art. 12 à 14 O-LERI-DEFR)

Etablissement (nom)	Institut de Recherche Idiap		
Adresse	Rue Marconi 19, Centre du Parc, 1920 Martigny		
Tél	+41 27 721 77 11	e-mail	info@idiap.ch
Coordonnées pour le paiement	UBS SA, Av. de la Gare 2, 1920 Martigny IBAN: CH71 0026 4264 6259 7401 M		
Organe de Révision	BDO SA, Rte des Arsenaux 9, 1700 Fribourg		
Directeur	Prof. Hervé Bourlard		
Tél	+41 27 721 77 20	e-mail	herve.bourlard@idiap.ch
Activités (parts)	Recherche	64.6%	
	Enseignement	5%	
	Prestations de services (Groupe Développeurs)	10.8%	
	Autres (Admin, Finance, Gestion de Projets, Groupe IT)	19.6%	

The present Research Programme was discussed and validated with the Idiap Foundation Council on November 29, 2018 and on May 2, 2019.

Main contact points

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Director
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Deputy Director
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Idiap Research Institute
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Overview of facilities and human resources

The table below gives a quick overview of the staff resources and facilities (office spaces and computer resources) as of 2018.

Staff statistics (2018)	Headquarter & facilities (2018)
4 professors (2 EPFL, 1 UniBe, 1 UCSB)	Centre du Parc, Rue Marconi 19
2 senior lecturers (EPFL)	1920 Martigny
8 permanent researchers	
7 research associates	**2500** m2
15 post-doctoral researchers	**3** meeting rooms
39 PhD students	**1** conference room
12 development engineers	**1** showroom
6 system engineers	**1** server room
13 internships (average/year)	**1** library
10 administration staff	**500** TB of storage (500 TB in 2017)
27 nationalities	**400** CPU for computing (400 CPU in 2017)
1279 man-months	**120** GPU for computing (40 GPU in 2017)
167 persons (arrival/departure)	**5'000** GB RAM for computing (4000 GB in 2017)
106.6 full time equivalent (98 in 2017)	**1** Gb/s Internet connection

December 31, 2018

Contents

Artificial Intelligence for Society

Institut de Recherche Idiap / Idiap Research Institute
VADE-MECUM 2019

Missions

L'Idiap est un institut de recherche, indépendant, à but non lucratif, reconnu par la Confédération Suisse et le Canton du Valais, associé au domaine stratégique des Ecoles Polytechniques Fédérales et spécialisé dans la gestion de l'information multimédia, les interactions homme-machine multimodales et l'intelligence artificielle.

The Idiap Research Institute is an independent, nonprofit research foundation associated with the strategic domain of the Swiss Federal Institutes of Technology, specialized in multimedia information management, in multimodal man-machine interaction and artificial intelligence.

Mission

L'Idiap a pour but de conduire des recherches fondamentales et appliquées dans les domaines de l'informatique avancée, ainsi que de contribuer à la formation supérieure et au transfert de technologie dans ces domaines.

The objectives of Idiap are to conduct basic and applied research in the fields of advanced computing, and to contribute to higher education and technology transfer in these areas.

Comptes / *Accounting* 2019

Charges / *Expenses* en millier de francs / in thousands francs

Charges de personnel / *Personnel expenses*	9'658	81%
Charges des projets / *Projects expenses*	169	1%
Charges administratives / *Admin. expenses*	161	1%
Charges informatiques / *Computer expenses*	336	3%
Charges d'immeuble / *Building expenses*	662	6%
Amortissement / *amortization*	328	3%
Autres / Other	627	5%
TOTAL	**11'941**	

Recettes / *Income* en millier de francs / in thousands francs

Canton du Valais / *Canton of Valais*	2'000	16%
Commune de Martigny / *City of Martigny*	700	6%
Confédération suisse / *Swiss Confederation*	2'334	20%
Total subventions / *Total subventions*	**5'034**	**42%**
Total dons / *Total donations*	**207**	**2%**
Projets suisses / *Swiss projects*	2'964	25%
Projets européens / *European projects*	2'037	17%
Projets USA / *USA projects*	972	8%
Projets industriels / *Industrial projects*	504	4%
Total projets / *Total projects*	**6'477**	**54%**
Autres / *Other*	**262**	**2%**
TOTAL	**11'980**	

Personnel et infrastructure / *Staff and facilities*

Statistiques du personnel / *Staff statistics* 31.12.2018

4	professeurs / *professors*
2	maîtres d'enseignement et de recherche (MER) / *senior lecturers*
8	chercheurs permanents / *permanent researchers*
7	chercheurs associés / *research associates*
32	postdoctorants / *postdocs*
41	doctorants / *PhD students*
16	ingénieurs de développement /*development engineers*
7	ingénieurs système / *system engineers*
38	stagiaires, moyenne/année / *internships, average/year*
13	personnes à l'administration / *administration staff*
27	nationalités / *nationalities*
161	personnes (arrivées, départs) / *persons (arrivals, departures)*
106.6	équivalents plein-temps / *full time equivalent*

Siège et infrastructure / *Headquarter and facilities*

Centre du Parc, Rue Marconi 19
1920 Martigny

2500	m2 de bureaux / *m2 of office space*
3	salles de réunion / *meeting rooms*
1	salle de conférence / *conference room*
1	salle de serveur / *server room*
1	bibliothèque / *library*
500	TB de stockage / *TB of storage*
400	CPU pour les calculs / *CPU for computing*
120	GPU pour les calculs / *GPU for computing*
5000	GB RAM pour les calculs / *RAM for computing*
1	Gb/s de connexion internet / *internet connection*

Organisation / *Organization*

Conseil de Fondation / *Foundation Council*

M. Olivier **Dumas**	Président, Administrateur indépendant, conseiller d'entreprises
M. Marc-André **Berclaz**	Directeur opérationnel de l'Antenne EPFL Valais Wallis
Dr. Michael **Baeriswyl**	Vice-Président Data, Analytics &AI, Swisscom
Mme Anne-Laure **Couchepin Vouilloz**	Vice-Présidente, Présidente de la ville de Martigny
M. Patrick **Furrer**	Collaborateur scientifique chez SwissUniversities
Dr. Anne-Claude **Luisier**	Représentante de l'Etat du Valais
Prof. Stéphane **Marchand-Maillet**	Professeur associé, chef du groupe Viper, Université de Genève
M. Jordi **Montserrat**	Directeur régional de Venturelab
M. Dominique **Perruchoud**	Président du Conseil d'administration de Cimark SA
Prof. Pierre **Vandergheynst**	Vice-Président, Vice-président pour l'éducation, EPFL

Conseil stratégique international 2018 / *International Advisory Board 2018*

Dr. Alex **Acero**	Senior Director at Apple, Cupertino, CA, USA
Dr. Alessandro **Curioni**	IBM Fellow, Vice President Europe and Director IBM Research, Zurich, CH
Prof. Anil K. **Jain**	Distinguished Professor, Dept. of Computer Science & Engineering, Michigan State University, USA
Prof. Johanna **Moore**	Head of the School of Informatics, Director of Human Communication Research Center, University of Edinburgh, UK
Prof. Klaus-Robert **Müller**	Professor of Computer Science, TU Berlin, Director, Bernstein Focus on Neurotechnology, Berlin, DE
Prof. Prem **Natarajan**	Vice President, Alexa AI- Head of NLU at Amazon, Greater Los Angeles region, USA
Prof. Neil **Lawrence**	Director of the Machine Learning of Amazon hub in Cambridge, Cambridge, UK
Prof. Bernt **Schiele**	Max-Planck Institute Director, MPI Informatics, Professor at Saarland University, Saarbrücken, DE

Direction / *Management*

Prof. Hervé Bourlard, Directeur / *Director*

Dr. François Foglia, Directeur adjoint / *Deputy Director*

Edward-Lee Gregg, Directeur financier / *Financial Director*

Doctorants / *PhD Students*, (Etat au 31.12.2018 / *As of 31.12.2018*)

41 étudiants dont / *students of which*

- 19 en 1e année / *in 1st year*
- 6 en 2e année / *in 2nd year*
- 11 en 3e année / *in 3rd year*
- 5 en 4e année / *in 4th year*

5 terminé en 2018 / *completed in 2018*

Comité de Recherche / *Research Committee*

Dr. André **Anjos**, Head, Biosignal Processing
Prof. Hervé **Bourlard**, Head, Speech & Audio Processing
Dr. Sylvain **Calinon**, Head, Robot Learning & Interaction
Dr. François **Fleuret**, Head, Machine Learning
Dr. Philip **Garner**, Speech & Audio Processing
Prof. Daniel **Gatica-Perez**, Head, Social Computing
Dr. David **Ginsbourger**, Head, Uncertainty Quantification & Optimal Design
Dr. James **Henderson**, Head, Natural Language Understanding
Dr. Jérôme **Kämpf**, Head, Energy Informatics
Dr. Michael **Liebling**, Head, Computational Bioimaging
Dr. Mathew **Magimai Doss**, Speech & Audio Processing
Dr. Sébastien **Marcel**, Head, Biometrics Security and Privacy
Dr. Petr **Motlicek**, Speech & Audio Processing
Dr. Jean-M. **Odobez**, Head, Perception & Activity Understanding

IdeArk, liste des entreprises / *IdeArk, list of companies* (www.ideark.ch)

Audiosearch
Biowatch – www.biowatch.com*
Eyeware – www.eyeware.tech*
Digit Arena - www.digitarena.tv
Katia – www.katia.ch
KeyLemon - www.keylemon.com*
Klewel - www.klewel.com*
Navitas Consilium – www.ncsa.ch
Orphanalytics - www.orphanalytics.com
Recapp - www.recapp.ch*
Vimalink – www.vima.swiss * spin-off de l'Idiap / *Idiap spin-off*

Publications et brevets / *Publications and patents 2018*

115 peer reviewed: Journals papers, Conference Papers, Books, Book Chapters, Theses, http://publications.idiap.ch
3 granted patents
2 filed patents

Principaux projets / *Selected projects* 2018:

AI4EU - www.ai4eu.eu/
BATL – US IARPA project
MEMMO - http://memmo-project.eu
MuMMER – www.mummer-project.eu/
TAPAS - www.tapas-etn-eu.org/
WeNet - www.internetofus.eu/

1 Executive Summary

Over the last 28 years, and thanks to the continued support of our public institutions, the Idiap Research Institute has built a significant scientific reputation and is now recognized worldwide as a reference model, in both academic and industrial environments. Our Institute is a major centre of excellence and a key player in several areas related to **Artificial Intelligence (AI) for Society**, including signal processing, machine learning, neural networks, applied statistics and mathematics, and uncertainty quantification and optimal design, applied to multilingual speech processing, natural language understanding, social computing, human perception and activity modeling, robot learning and interaction, biometrics security and privacy, computational bioimaging, biosignal processing (new group), and energy informatics (new group).

Leveraging on the Idiap-EPFL Joint Development Plan (signed and renewed in 2008, 2012, and 2017) this recognition is further boosting the continuous growth of our scientific, training and educational activities, as well as of our technology transfer activities, involving multiple national SMEs, as well as numerous small and large international companies. In addition to our educational activities with EPFL, we also initiated our own industry-driven AI Master program, in collaboration with Unidistance, and with the full support of the State of Valais. In the context of the submitted NCCR proposal around "Human Trust in AI", we are also discussing formal collaboration models with University of Geneva.

At the international level, Idiap is also continuously involved (as coordinator or partner) in numerous international projects (EU, US, India, etc), thus and confirming its exceptional scientific quality and unique potential. These aspects are discussed in detail in our annual *Scientific Report* and *Self-Assessment Report* (including extensive formal evaluation statistics), both submitted to SERI and available on request.

Why this success? Besides the recognized quality of its work, Idiap's success is also due to the fact that it is probably one of the very few medium-scale multi-disciplinary institutes of its kind where several different, but highly complementary research disciplines are tightly working together, sharing the same focused visions and same basic technologies, all revolving around signal processing, machine learning, neural networks, advanced statistics, and applied mathematics.

Impact on education: In collaboration with EPFL, and building upon the Idiap-EPFL Joint Development Plan, Idiap is also very much involved in training and education activities. As of this writing, Idiap is funding and directly supervising an annual average of 35-40 PhD students, all of them being registered at EPFL, most of them being enrolled into the EPFL Doctoral Program EDEE (Electrical Engineering Doctoral Program), recently created by EPFL in collaboration with Idiap. Furthermore, new EPFL academic positions are now open for Idiap's most prominent scientists (external MER, external Adjunct Professors, Tenure Track Assistant Professor, or full Professor). In addition to the 4 EPFL academic positions at Idiap, we also have one Adjunct Professor at Bern University (teaching at Bern University and EPFL), and one Adjunct Professor at the University California Santa Barbara (UCSB), all funded by Idiap, and working in our institute.

Impact on technology transfer: Finally, technology transfer activities being developed at Idiap (often in collaboration with different HES universities) are also quite impressive and successful. Indeed, Idiap is also very active in multiple national and international technology transfer initiatives, and is involved in numerous projects with industries, ranging from large institutions (e.g., Swisscom, Huawei, Airbus) to multiple SMEs (including Idiap's spinoffs). Besides these development projects, Idiap is also involved in Valais' "The Ark" initiative through their spinoff IdeArk, as well as through the "Alliance" project with EPFL.

With all the above in mind, we are hereby submitting our forthcoming R&D Program plan for the period 2021–2024 to the State Secretariat for Education, Research and Innovation (SERI). This proposal falls within the scope of a sound organisational structure, and a clear plan towards the diversification and consolidation of the Institute's expertise. Furthermore, we are happy to be able to count on the support not only of the Confederation, but also of the authorities of the Canton of Valais and the city of Martigny and on all of our partners towards these new challenges.

2 Missions and Organization

2.1 Missions

Over the last 25+ years, and thanks to the continued support of public institutions (SERI, the State of Valais, the City of Martigny, Swiss NSF, Innosuisse, Hasler Foundation, and Loterie Romande), as well as the support of EPFL, our key academic partner, Idiap has gained a significant scientific reputation. Indeed, our Institute is now recognized worldwide, in both academic and industrial environments, as a major player in the field of *"Artificial Intelligence (AI) for Society"*, as presented on our web site, and a key player in the economic development of Valais and Switzerland.

In the present present proposal, Idiap is now aiming at being fully recognized as a **Competence R&D Center on Applied AI in Switzerland**.

The proposed 2021-2024 R&D programme presented in this document is based on (1) the current SWOT analysis of the strengths and research potential at Idiap (summarized in Section 2.1.4, page 10), (2) Idiap's current organisational chart (Figure 3, page 14), research groups (presented in Section 3.3, page 31) and projects, and (3) the reassessment of future research directions for Idiap in well defined (AI related) research areas, taking into account current trends in AI, academic collaborations, expertise of our permanent researchers, as well as anticipated future trends, new opportunities, and industrial needs, yielding to a new organisational chart, presented in Figure 5, page 29.

Idiap's activities cover three main objectives:

1. **Research:** Conducting fundamental research projects at the highest level in its multi-disciplinary AI, signal processing, and machine learning expertise areas, thus taking its place among the best institutions on a national, European and global scale. Idiap benefits from a wide national and international network of partners and works actively with large universities, public and private research centers. This collaboration is always implemented through formal research projects, incl. SNSF, EU and US research programmes.

   This is briefly summarized below in Section 2.1.1, and presented in full detail in Section 3.3.

2. **Academic and Training Activities:** Through our academic anchoring with EPFL (and the EDEE and EDIC Doctoral Programs), our teaching activities at EPFL (10 courses), as well as our connections with numerous other academic institutions, we fund and supervise a large number of PhD students (35-40 per year on average), while also hosting international master and intern students. Numerous Idiap-internal activities towards improving personal research and communication skills are also provided. Furthermore, in 2019, we initiated, in collaboration with Unidistance, the first industry-driven AI Master, also seeking to counter the lack of skilled manpower in the IT area in general, and AI in particular.

   This is briefly summarized below in Section 2.1.2, and presented in full detail in Section 3.4.

3. **Technology Transfer:** Idiap is currently amongst the most important research centers in Valais that put special emphasis on research software maintenance, to facilitate technology take-up, technology transfer, creation of spin-offs, and attract startups. As discussed later, an entire team (currently 12+ people) is fully devoted to these important aspects, working in close collaboration with Innosuisse, as well as our IdeArk (www.ideark.ch) incubator, currently hosting 20+ startups, and regularly announcing good news regarding VC investment or large scale acquisitions.

   This is briefly summarized below in Section 2.1.3, and presented in full detail in Section 3.5.

As further discussed below and illustrated in Figure 1 next page, all of our research and development activities rely upon advanced signal processing and machine learning techniques, revolving around 5 key research themes, with 11 research groups (each headed by at least one senior researcher/PI), and 10 key applications domains, identified as of key importance to the development of Switzerland and the State of Valais in particular. Our main contributions to the Swiss research and innovation activities are discussed in Section 5, page 75.

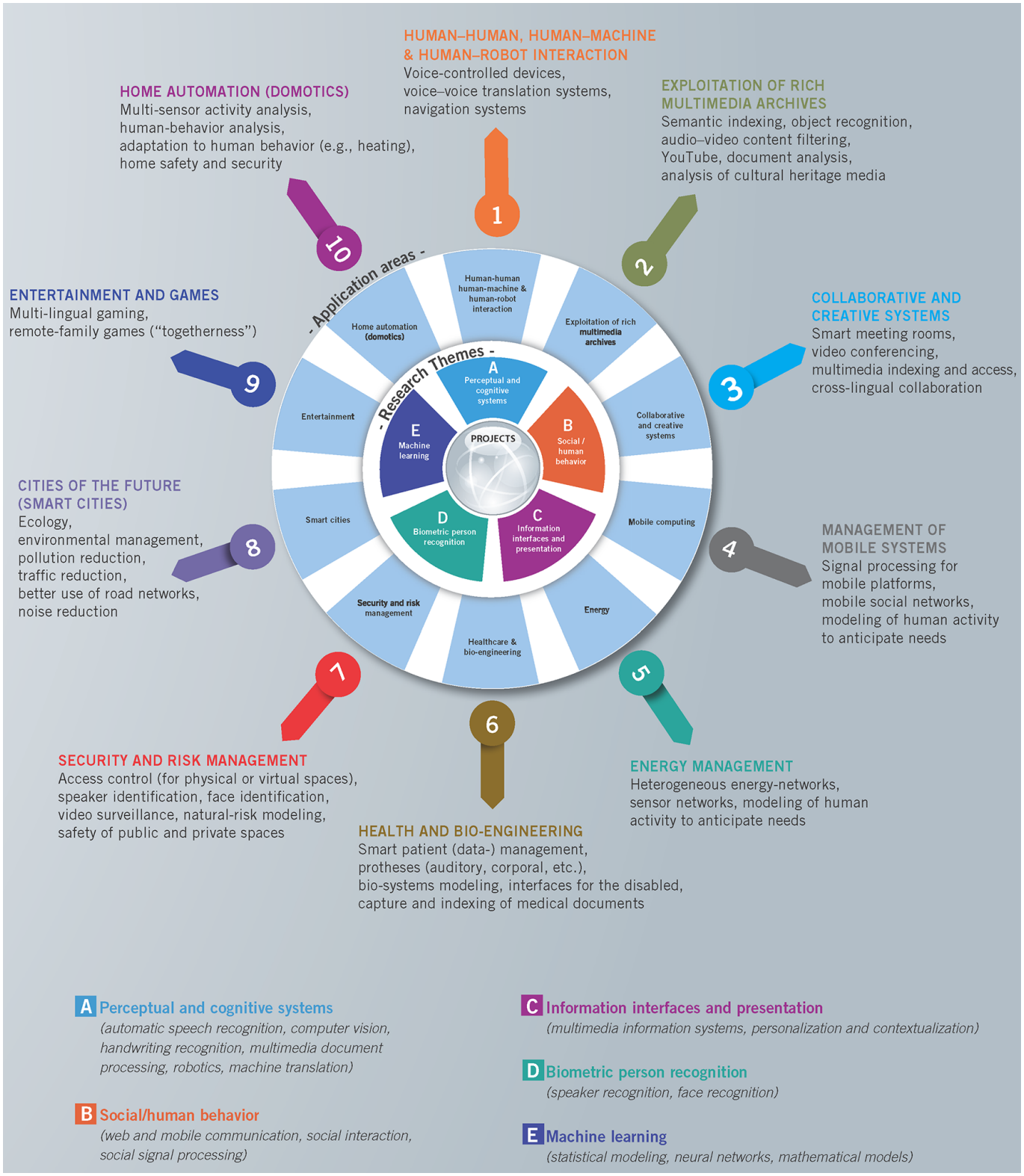

Figure 1: Illustration of Idiap's main research themes and application domains.

2.1.1 Research

Artificial Intelligence for Society: All of Idiap's R&D activities revolve around closely-related multi-disciplinarity expertises. This typically involves combining advanced signal processing, machine learning, applied statistics and mathematics with applications in complementary, but also strongly related areas. These areas include learning from large amounts of data, artificial neural networks, multilingual speech processing, natural language understanding, social computing, human perception and activity modeling, robot learning and interaction, biometrics security and privacy, computational bioimaging, biosignal processing (new group), and energy informatics (new group). The success of the Biometrics Security and Privacy group also resulted in the creation of the "Swiss Center for Biometrics Research and Testing", now FIDO accredited.

To follow the current trend around AI, to further encourage collaboration, and to share a common branding of the Institute, while still accommodating our continuous extensions of activities, Idiap provided itself with a new institutional overarching vision, referred to as "Artificial Intelligence for Society" (www.idiap.ch).

A quite unique, independent research institute, sharing a common vision: Besides the recognized quality of its work, Idiap's success is also due to the fact that it is one of the very few institutes of its kind where several different, but highly complementary research disciplines (in terms of technologies, as well as research and application potential) are tightly working together, sharing the same focused visions (regularly updated based on feedback and internal innovation meetings, as well as through their involvement in multiple international projects. As a consequence, we believe that this success is also due to the unique multi-disciplinary research, taking place in a same, dynamic, institute targeting common goals, as briefly discussed in the present document.

Main research themes: Currently, and in spite of its "diversity", all of our research themes are exploiting common, leading-edge expertise in *signal processing*, *statistical pattern recognition*, and *advanced machine learning* (including neural network modeling). As illustrated in Figure 1, the description of our current research activities can, however, be "clustered" around five big themes: (1) **Machine learning**, including statistical and (deep) neural network based machine learning, computational efficiency, targeting real-time applications, very large datasets, and online learning; (2) **Perceptual and cognitive systems**, including multilingual speech processing, natural language understanding and translation, document and text processing, vision and scene analysis, multimodal processing, cognitive systems, and robotics; (3) **Social/human behavior**: including human behavior modeling, Web social media, mobile social media, social interaction sensing, social signal processing, verbal and nonverbal communication analysis; (4) **Information interfaces and presentation**, including multimedia information systems, user interfaces, and system evaluation; (5) **Biometric user authentication**, including speaker identification/verification, face detection/identification/verification; and multimodal biometric user authentication. New activities in biometric security should also be deployed over the next years through our recently created "Swiss Center for Biometrics Research and Testing".

Through our last hirings, these R&D themes have also been successfully expanded towards Computational Bioimaging (Dr. Michael Liebling), Robot Learning & Interaction (Dr. Sylvain Calinon), Uncertainty Quantification and Optimal Design (Dr. David Ginsbourger, with applications, e.g., in environmental and energy management), Biosignal Processing (Dr. André Anjos), and Energy Informatics (Dr. Jérôme Kaempf).

Strong research groups:

1. **Machine Learning:** The goal of this group is the development of new machine learning techniques, with a particular interest in their computational properties. Our application domain is mainly computer vision and includes object detection, scene analysis, tracking of persons and biological structures, and image recognition in general.

2. **Speech and Audio Processing:** Speech processing has been one of the mainstays of Idiap's research portfolio for many years. Today it is still the largest group in the institute, and Idiap continues to be recognized as a leader in the field. The expertise of the group encompasses statistical automatic speech recognition (based on hidden Markov models or hybrid systems exploiting connectionist approaches),

text-to-speech, and generic audio processing (covering sound source localization, microphone arrays, speaker diarization, audio indexing, very-low-bit-rate speech coding, and perceptual background noise analysis for telecommunication systems).

3. **Natural Language Understanding:** This groups works on how semantic and discourse processing of text and dialog can improve statistical machine translation and information indexing, with a recent focus on neural machine translation and attention-based deep learning models, neural network structured prediction and representation learning for modeling the syntax and semantics of text and speech, including modeling abstraction (textual entailment) and summarization.

4. **Biometrics Security and Privacy:** This group focuses on the automatic recognition of individuals based on their behavioral and biological characteristics. It investigates and develops novel image-processing and pattern-recognition algorithms for face recognition (2-D, 3-D, and near-infrared), speaker recognition, anti-spoofing (attack detection), and emerging biometric modes (EEG and veins). The group is geared toward reproducible research and technology transfer, using its own signal-processing and machine-learning toolbox.

   The success of the Biometrics Security and Privacy group also yielded to the creation of the "Swiss Center for Biometrics Research and Testing"[1], which was recently accredited by FIDO[2] as its third, worldwide, FIDO certification body.

5. **Social Computing:** Social computing is an interdisciplinary domain that integrates theories and models from mobile and ubiquitous computing, multimedia, machine learning, and social sciences in order to sense, analyze, and interpret human and social behavior in daily life, and to create devices and systems that support interaction and communication. Current lines of research include ubiquitous sensing of face-to-face interaction, behavioral analysis of social video, crowdsourcing, and urban data mining using smartphones and mobile social networks.

6. **Perception and Activity Understanding**: This group conducts research into human-human activity analysis using multimodal data. This entails the investigation of fundamental tasks such as the representation, detection, segmentation, and tracking of objects and people, the characterization of their state, and the modeling of sequential data and the interpretation of that data in the form of gestures, activities, behavior, or social relationships. These investigations take place through the design of principled algorithms that extend models from computer vision, statistical learning, or multimodal signal processing. Surveillance, traffic analysis, analysis of behavior, human-robot interfaces, and multimedia content analysis are the main application domains.

7. **Robot Learning and Interaction:** The Robot Learning & Interaction group focuses on human-centric robot applications. The scientific objective is to develop probabilistic approaches for encoding movements and behaviors in robots evolving in unconstrained environments. In these applications, the models serve several purposes (recognition, prediction, online synthesis) and are shared by different learning strategies (imitation, emulation, incremental refinement, or exploration). The aim is to facilitate the transfer of skills from end users to robots, or between robots, by exploiting multimodal sensory information and by developing intuitive teaching interfaces.

8. **Computational Bioimaging:** This group focuses on research into computational imaging and the analysis of biomedical images. This includes developing algorithms for image deconvolution and super-resolution in optical microscopy, three-dimensional tomography reconstruction from projections, and more generally combining unusual sensing devices and approaches with computational methods to produce images ideally suited to the observation and quantification of complex and live biological systems.

[1] https://www.biometrics-center.ch/
[2] https://fidoalliance.org/certification/

9. **Uncertainty Quantification and Optimal Design:** The Uncertainty Quantification and Optimal Design group focuses on quantifying and reducing uncertainties in the context of natural and artificial complex systems. Application domains notably include energy and geosciences, with a number of collaborations ranging from safety engineering to hydrology and climate sciences. In all these fields the study of complex systems often relies on expensive data acquisition and model runs, calling for adapted experimental design strategies.

10. **Biosignal Processing:** Biosignals are signals from biomedical sensors and their analysis to support medical or related research. This group focuses on biomedical-related areas such as the analysis of e-Health records, human-signal sensing for healthcare and other related applications. Current trends in the field show refreshed interest on the use of machine learning techniques, complementing basic signal and sequence processing, all of which are key domains of research at Idiap. It leverages on Idiap's expertise on human subject handling, data acquisition, open science and data processing.

11. **Energy Informatics:** The Swiss Energy Strategy 2050 resides in three pillars: increasing the energy efficiency (including the building sector), increasing the use of renewable energy (by their promotion) and withdrawal from nuclear energy. These objectives are perfectly in-line with the Energy Informatics concepts: to exploit state-of-the-art Information and Communication Technologies to tackle global warming and climate change challenges, to increase integration of renewable and distributed energy sources by making energy systems smarter, and to increase energy efficiency beyond what improvements at component level can achieve. In that vein, the Energy Informatics Group at Idiap researches into ways of simulating energy transition pathways with intelligent control and adjustment mechanisms of evolving buildings with retrofitting and use, renewable energy production and energy storage in a changing climate.

Databases, platforms, and reproducibility of research: To foster science and favor reproducibility in research, Idiap will continue its policy of offering access to its databases, platforms, software, and will continue developing new tools to support large-scale research activities. For instance, BEAT (https://www.beat-eu.org/platform/) is one of our well recognized software platforms, which will also be one of the key elements of the future European AI4EU platform (https://www.ai4eu.eu/). Developed and hosted by Idiap, BEAT is indeed a European computing e-infrastructure for Open Science proposing a solution for open access, scientific information sharing and re-use including data and source code while protecting privacy and confidentiality. It allows easy online access to experimentation and testing in computational science. You define what data and modules you would like to use, we make sure the system runs and provides you with a result. Data from different experiments can be easily compared and searched. The platform also provides an attestation mechanism for your reports (scientific papers, technical documents or certifications).

Finally, regarding databases and software tools, Idiap is recognized worldwide as one of the key providers of open source software and public databases, all distributed through our web site, where we can currently find:

- **70 open source software libraries**: https://www.idiap.ch/en/scientific-research/resources/libraries
- **52 public datasets**: https://www.idiap.ch/en/scientific-research/resources/datasets; we also note here that all public datasets requiring clearance based on the new EU General Data Protection Regulation (GRDP) are submitted to the Federal official responsible for data information and transparency ("Préposé aux données").

Annual Self-Assessment and Scientific Reports: An annual Self-Assessment Report, as well as an Annual Scientific report, are delivered every year, and made available to SERI. As part of the appendices of the present document, and for the sake of completeness, the 2018 Self-Assessment Report is available at:
Annexes/1246_Self_Assessment_Report_2018.pdf
and the 2018 Scientific Report can be find here:
Annexes/1247_Idiap-Scientific-Report-2018.pdf

2.1.2 Training

In collaboration with EPFL, and building upon the Idiap-EPFL Joint Development Plan (initially signed in 2008 and renewed in 2012 and 2017), Idiap is also strongly involved in training and education activities. Training involves the supervision of multiple PhD students (average of 35-40 PhD students/year), master/intern students, and students coming from diverse international visitor programmes, including, e.g., these EU Marie-Curie exchange programmes or Swiss Government Excellence Scholarship. Education involves teaching activities at EPFL (currently 3 Bachelor/Master level courses, and 6 doctoral level courses, all listed and documented at https://idiap.epfl.ch/courses/), but also at different HES, University of Lausanne (Sébastien Marcel) and University of Bern (David Ginsbourger). Idiap also regularly teaches courses as invited speakers in different universities. We have also developed several internal skill development courses, e.g., to improve research methods, writing/presentation skills, as well as to foster the entrepreneurial spirit (Idiap's International Create Challenge, http://www.createchallenge.org/, 8th edition in 2019).

In collaboration with the State of Valais and Unidistance, we finally initiated an innovative Industry-Driven Master in Artificial Intelligence, inspired by the dual-track Swiss apprenticeship model, but pushed at the university level.

Some of these academic activities are recognized by academic titles from EPFL (1 full professor, 1 adjunct professor, and 2 MERs), one (1 adjunct professor) from University of Bern, and one (adjunct professor) from University of California Santa Barbara (UCSB). Given the large number of PhD students and courses delivered, it would however be advisable to increase the number of those academic titles, and possibly diversify the academic affiliation of our PhD students. In the future, it is indeed possible that Idiap will extend its academic affiliation to the University of Geneva (the second academic founding member of Idiap).

PhD students: Over the last 10 years, Idiap has been funding and directly supervising and average of 35-45 PhD students/year, all of them registered at EPFL and most of them enrolled in the EPFL EDEE (Electrical Engineering) Doctoral Program.

Teaching activities: Idiap's personnel teaches 9 EPFL courses (3 at the Bachelor/MS level and 6 at the doctoral level). See Self-Assessment Report and https://idiap.epfl.ch/courses/ for more detail.

Academic titles: To further strengthen our training activities, and according to the Idiap-EPFL Joint Development Plan, new EPFL academic positions should be open for Idiap's most prominent scientists (external MER, external Adjunct Professors, Tenure Track Assistant Professor, or full Professor). In addition to the Director (EPFL Full Professor), Idiap is currently hosting 1 Adjunct Professor (Prof. Daniel Gatica-Perez, "Professeur Titulaire") and two "Maîtres d'Enseignement et de Recherche" (MER), Dr. François Fleuret et Dr. Jean-Marc Odobez.

Besides our strong affiliation with EPFL, we also collaborate with many other universities and HES. For instance, Prof. David Ginsbourger, Head of the *Uncertainty Quantification and Optimal Design* group is Adjunct Professor at University of Bern (UniBe), and teaching at both UniBe and EPFL. David Ginsburger's PhD students are also registered at UniBe, while all other Idiap PhD students are affiliated to EPFL.

Industry-Driven Master in Artificial Intelligence: Early February 2019, Idiap has officially launched a Master in Artificial Intelligence. Inspired by the dual-track Swiss education system, the Master focuses to a large extent on the acquisition of professional expertise. It combines state-of-the-art theoretical courses and professional work in a company. The student specialises in AI and develops artificial intelligence projects within the company. Projects are supervised by AI researchers and specialists of the Institute.

This unique university education is the fruit of a strategic partnership between Distance Learning University (https://distanceuniversity.ch), the State of Valais, the State Secretariat for Economic Affairs (SECO) and Idiap. Distance University offers a cutting edge technical and organisational infrastructure thanks to its expertise in e-learning and its status within the Swiss higher education system. On its side, Idiap offers scientific expertise as a national centre of expertise in artificial intelligence.

The programme runs over 3 semesters (18 months). It consists of 14 modules, including 10 basic and 4 advanced. Alongside this, the student pursues a professional activity within the company.

The 90 ECTS credits of this MSc are distributed as follows:

- Professional activity 40 ECTS
- Basic modules (10 modules) 36 ECTS
- Advanced modules (4 modules) 14 ECTS
- *Total 90 ECTS*

Professional activity

- P01 AI Company strategy and definition
- P02 AI Project development

Basic modules

- M01 Practical course in Linear algebra and Probabilities
- M02 Data structure and algorithms for AI
- M03 Signal processing
- M04 Foundations in statistics for AI
- M05 Open Science and Ethics
- M06 Fundamentals in Machine Learning 1
- M07 Introduction to Image Processing and Computer Vision
- M08 Fundamentals in Machine Learning 2
- M09 Introduction to Speech Processing
- M10 Deep Learning

Advanced modules

- A01 Biometrics
- A02 Multimodal computational sensing of people
- A03 Natural language processing
- A04 Robotics

2.1.3 Technology transfer

Idiap is very active in multiple national and international Technology Transfer (TT) initiatives, and is involved in numerous projects with industries, ranging from large institutions (e.g., Samsung, Facebook, Thales) to multiple SMEs (including Idiap's spinoffs). Besides these development projects, Idiap is also involved in Valais' "The Ark" initiative through their spinoff (incubator) IdeArk SA. It is also collaborating with Polytech Ventures and the technology incubator, Fintech Fusion (located in Geneva).
To build and maintain optimal and sustainable relationships with industry and other partners (Innosuisse projects), Idiap maintains a dedicated multi-disciplinary team of developers and programmers who transfer software, algorithms, knowledge, and expertise. Initiation of all these activities involves the newly created *Technology Transfer Office (TTO)*, which directly works with the *Development Group*, a dozen of highly-talented software developers.

The organization of this Technology Transfer activity will be discussed in detail in Section 3.5, but is revolving around two entities, the Technology Transfer Office (TTO) and the Development Engineers Group.

TTO–Technology Transfer Office (Dr. Joël Dumoulin): Technology transfer is one of the Idiap Research Institute's three core missions. One of the fundamental challenges is to facilitate the interface between the knowledge and the skills of the researcher and the needs of the industrial partner. Idiap resolves this by providing a dedicated multi-disciplinary team of developers and programmers which transfers pieces of software, algorithms, knowledge and expertise. The TTO is responsible for bridging the gap between researchers and industry, identifying opportunities, building joint proposals (including Innosuisse project proposals), maintaining an up-to-date technology portfolio, and managing our IPRs.

Research and Development Engineers Group (Mr. Olivier Bornet): Once a project has been initiated through the TTO, it is then the responsibility of the Development Group to take care of its proper implementation, in collaboration with the researchers whose technologies are being transferred. Although the TT activities of the Development Group remain limited in terms of time-commitment (with support to research projects being the group's main activity), it is worth noticing that the group is nearly self-funded through its industry collaborations, as can be seen in Table 2 (internal funding distribution), page 73.

As discussed in Section 3.5, TT activities also involve many other components, including the maintenance of a technology portfolio, a corporate sponsorship program, and collaborations with multiple other TT institutions.

2.1.4 Idiap's strengths, key contributions and opportunities

Over the last 25+ years, and encouraged by several initiatives, including the SNSF National Centre of Competence in Research (NCCR) on "Interactive Multimodal Information Management (IM2)", 2001-2013, Idiap has built an exceptional reputation in the area of Artificial Intelligence, covering many of the research directions relevant to AI. Today, Idiap is recognized worldwide as a Centre of Excellence in multiple applied AI aspects, including machine learning, audio and speech processing (probably the only one in Switzerland with such a recognized expertise), computer vision, social computing, and robotics. See below for a short selection of key contributions over the last 25+ years.

The current Idiap's organizational structure is illustrated in Figure 3, page 14. The future organizational structure, targeted for 2021-2024, which will be discussed later in the roadmap section (Section 3.2, page 27), is illustrated in Figure 5, page 29.

More information about our activities, as well as factual evaluation indicators, along our three missions (research, training, and technology transfer) is available from our annual **Self-Assessment Report** (see Appendix).

In the following, we briefly list what we perceive as our biggest strengths and the key to our growing success.

Institute's structure:

- Independence and flexibility
- Coverage: horizontal (scientific themes) & vertical (from basic to applications)
- Excellent research teams and staff
- Excellent admin and project support
- Excellent computing infrastructure
- Federal and State governments can strengthen Idiap's position through strategic alliances and increased basic funding
- Alliances with industry sectors to create a competence center on applied AI (our NCCR proposal around *Human Trust in AI* largely demonstrated our potential to attract interest and commitments from large and small corporations)
- Idiap's perception is excellent locally (City, Canton), in line with development plans

Research:

- Long-term multi-disciplinary R&D in hot areas (AI, machine learning, applications)
- Complementary coverage of the institute's main expertise (applied AI)
- Recognized impact (open-source software, public datasets, paper awards)
- Excellent funding track record (SNSF, CTI, EU, US)
- International reputation and strong anchoring in Swiss academic landscape
- Capacity to attract new projects and high-level partners
- Capacity to attract top students and postdocs
- Wide academic and industrial network

Education:

- Excellent doctoral students (with an average of 40/year)
- Courses on cutting edge topics (9 courses offered at EPFL, https://idiap.epfl.ch/courses/)
- Growing alumni network worldwide
- Continuing education in AI for Swiss industry & the general public, also extending our initial initiative around the Industry-Driven AI-Master, https://master-ai.ch/en).

Technology transfer:

- Wide industrial network
- Excellent Technology Transfer support
- Dedicated development team
- Maintenance of open source libraries and databases
- Proactive initiatives, both pull (InnoSuisse, sponsoring) and push (International Create Challenge, www.createchallenge.org)

Examples of Key Contributions:

- Integrative research visions: Smart Meeting Room and Human-Human Communication; Reproducible Research (BEAT platform, https://www.idiap.ch/software/beat/)
- Pioneering Methods: Deep Neural Networks (DNN); Biometric Anti-Spoofing; Multimodal interaction and social signal processing
- Open-source software (70 libraries at https://www.idiap.ch/en/scientific-research/resources/libraries): Torch (ML library) used by industry (Facebook) and research institutions; Bob (biometrics); BEAT used by industry (Safran, BBC, Samsung) and institutions (EU JRC, Europol)
- Public datasets (52 public datasets at https://www.idiap.ch/en/scientific-research/resources/datasets, used by 100s of research groups worldwide): Augmented Multiparty Interaction (AMI) database (ACM 10 Years Impact Award); Mobile Data Challenge (MDC) database; Mobile Biometry (MOBIO) and Replay databases.

Opportunities to be exploited through roadmap 2021-2024:

There is currently high demand for AI basic & applied research, which is not expected to decrease in the future, and Idiap happens to have a unique reputation in that field. Idiap should continue building upon current success in innovation (spinoffs), and remain attractive for Swiss and international top-notch AI researchers.

In line with the mission of the art.15, and by exploiting the know-how and structures put in place by Idiap, it now seems reasonable and feasible to significantly develop the Institute's R&D activities, further fostering the collaboration between groups to better align our potential with industrial needs, hence have an even greater impact on the cantonal and national economy.

Finally, Idiap should be a key player in providing key contributions to reach the goals set by the Swiss Federal Council in the "Digital Switzerland Strategy" (Stratégie et plan d'action suisse numérique), Swiss Federal Council[3].

The 2021-2024 roadmap presented in Section 3.2, page 27, aims at further developing and exploiting the above strengths and unique positioning to consolidate Idiap as the leading **Competence R&D Center on Applied AI in Switzerland**. Idiap, as a leading research center in AI, has often been shown to be a key enabler of AI technologies in multiple application areas, and is well positioned to extend that role along several axes, including, for instance:

- Cyber-security, possibly extending Idiap's Biometrics Center, now also recognised as a FIDO accreditation institute (only three such institutions worldwide, one in France, one in US, and Idiap in Switzerland).
- Energy Informatics, exploiting the newly created group at Idiap, and our strong collaboration with CREM (Centre de Recherche en Energie Municipale) in Martigny and Energypolis in Sion.

[3] https://www.bakom.admin.ch/bakom/fr/page-daccueil/suisse-numerique-et-internet/strategie-suisse-numerique.html

2.1.5 Large EU network and project flow

As illustrated in Figure 2, Idiap is part of large EU networks and is (and has always been) involved in multiple EU projects, either as partners or as coordinator.

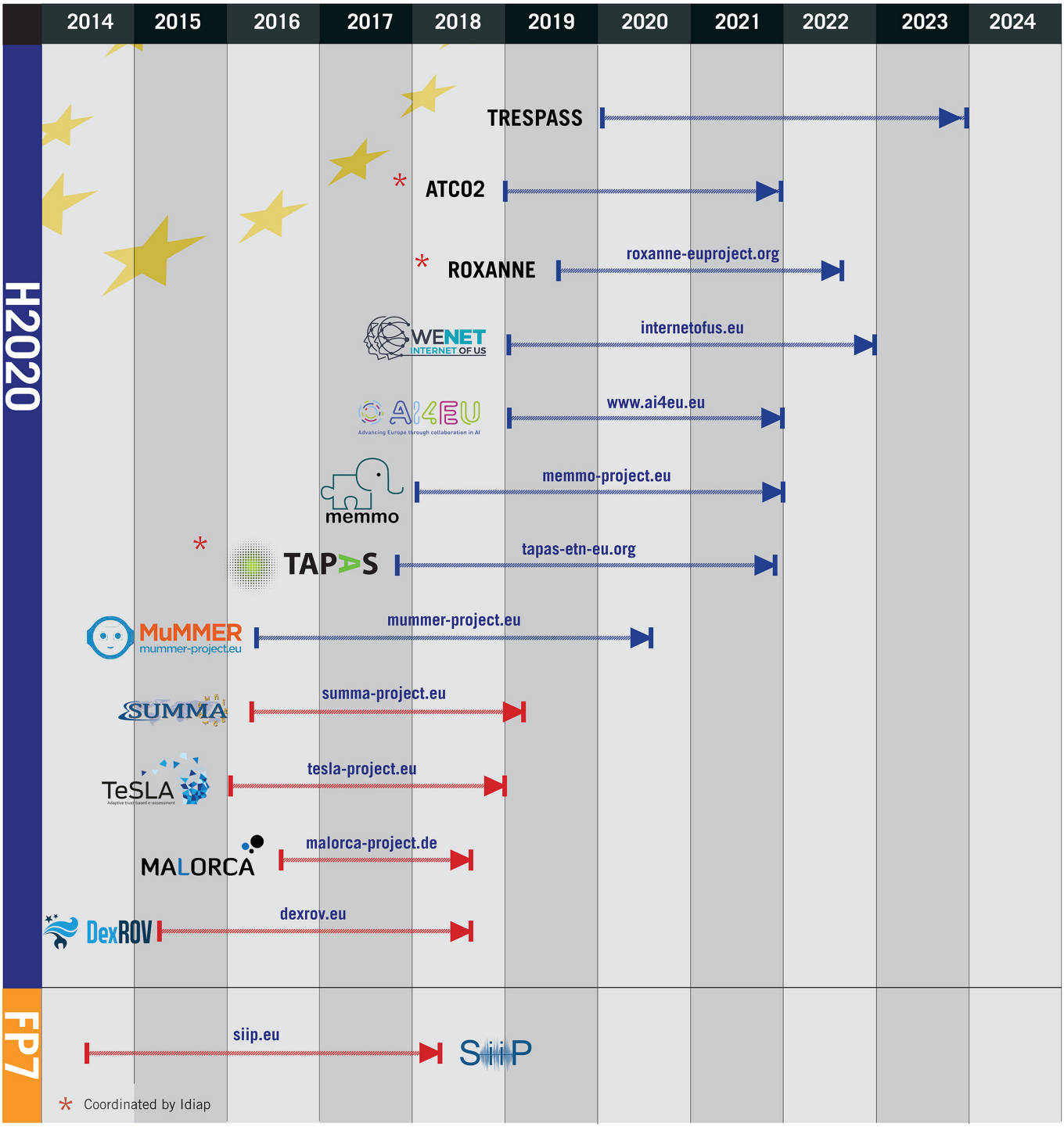

Figure 2: *Illustration of the flow of EU projects at Idiap, either as partner or as coordinator.*

2.2 Organizational Management

2.2.1 Statutes

Idiap is a fully autonomous, independent research institute, self-managed in terms of administration and financial structure, as well as in terms of research, development, and technology transfer activities. For its academic activities, Idiap is bound to EPFL through a Joint Development Plan, initiated in 2008 and renewed every 4 years.

According to our official statutes, Idiap is registered (version of 11 November 2008, slightly modified on 23.02.2010) as "Fondation de l'Institut de Recherche Idiap". The statutes indicate:

> *L'Idiap a pour but de conduire des recherches fondamentales et appliquées dans les domaines de l'informatique avancée, ainsi que de contribuer à la formation supérieure et au transfert de technologies dans ces domaines.*
>
> *Il s'agit en particulier des secteurs suivants:*
>
> - *Traitement des signaux au sens large*
> - *Apprentissage automatique statistique*
> - *Traitement et reconnaissance de la parole*
> - *Traitement de l'image et de la vidéo*
> - *Gestion de l'information multimedia*
> - *Interfaces homme-machine multimodales*
> - *Interactions sociales, signaux sociaux*
> - *Systèmes d'authentication biométriques ainsi que tous domaines convergeant ou découlant de ceux-ci.*

The officially registered statutes of the institute are given in:
Annexes/1210_Statutes.pdf.

2.2.2 Operational and management structure

Figure 3 illustrates the current operational structure of Idiap.

- The **Foundation Council**[4] is the highest management body of the institute. It is composed of representatives of the founding members, in addition to other members representing the economic, academic, or political worlds.

  The President of the Foundation Council (currently Mr. Olivier Dumas) plays an important role as the link between the Council and the Idiap Direction. He meets with Prof. Hervé Bourlard, Dr. François Foglia, and/or Mr. Ed Gregg at least once a month, and more often if required.

  The Foundation Council typically meets three times a year, with the mission to assist the institute management to reach its general goals, approving the budget, final accounting figures, and annual administrative and scientific reports. It is also responsible for the optimal implementation of all regulations, including the Idiap-EPFL Joint Development Plan, as well as the recently deployed Internal Control System (SCI, see below).

  The Foundation Council is also responsible for hiring the Director and approving the main strategic trends of the Institute, including the hiring of senior staff members.

[4] http://www.idiap.ch/the-institute/organization/foundation-council

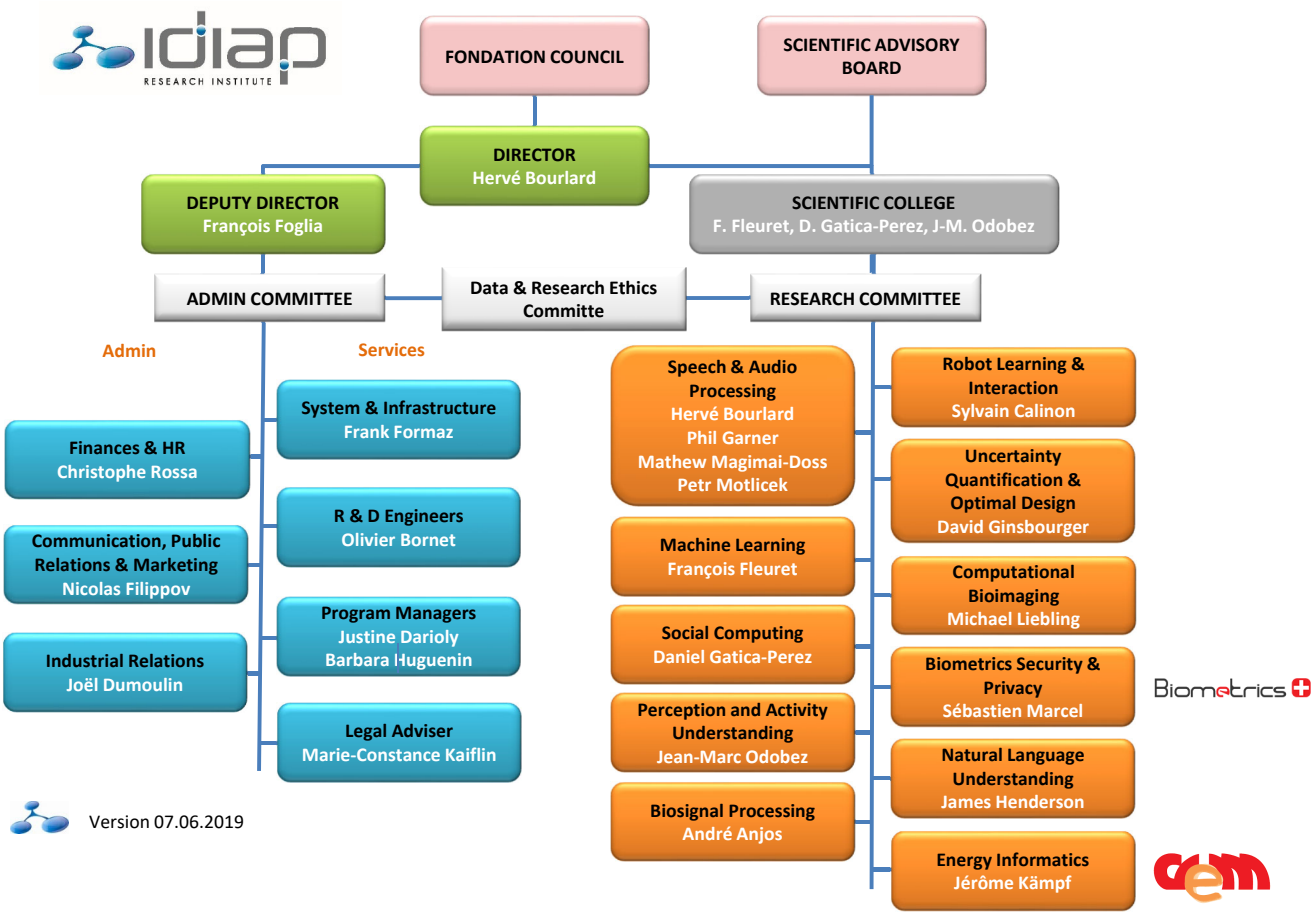

Figure 3: Idiap management and operational structure, including the main research and administrative responsibilities. For the research (right) block, managed by the Scientific College (in collaboration with the Research Committee), all names in white are key (autonomous) researchers, with clear supervision duties, who are all project PIs. On the left side, we find all the admin, IT management, and technology transfer activities, supervised by the Deputy Director, Dr. François Foglia, in collaboration with the Admin College. All those bodies are described over the next few pages (pointing to detailed job descriptions in Appendix). In addition to this management structure, we also have three "Internal bodies and processes" (Institutional Review Board, Infrastructure Committee, and Patent Committee), whose duties are described in Section 2.2.5. Finally, we have a set of management tools and processes, all discussed in Section 2.2.6.

The list of current members of the Foundation Council, together with the description of its tasks and duties (also part of the Idiap Statutes), can be found in:
Annexes/1221_Fondation_Council.pdf.

- **Idiap Direction**: The Idiap Direction is currently composed of the Director (Prof. Hervé Bourlard), the Deputy Director (Dr. François Foglia), and the Financial Director (Mr. Ed Gregg, also supervising the Human Resources). The Direction is responsible for the day-to-day management of all Idiap activities and meets at least once a month (usually first Monday of each month) to discuss/identify open issues and/or divergence to our global planning, perform intermediate budget tracking, and evaluate the Institute performance in terms of projects, training, and technology transfer.

  Composition, tasks and duties of the Idiap Direction are given in:
  Annexes/1222_Cahiers_des_Charges.pdf#page=5, Part 1, page 5.

- **Director**: The Idiap Director, Prof. Hervé Bourlard, also Full Professor at EPFL, is hired by (and reports to) the Foundation Council through annual reports and about 3 annual face-to-face Foundation Committee meetings.

  The job description of the Idiap Director is given in:
  Annexes/1222_Cahiers_des_Charges.pdf#page=6, Part 1, page 6.

- **Deputy Director**: Dr. François Foglia is hired by the Idiap Director, possibly in collaboration with the Scientific College, and upon approval by the Foundation Council. The Deputy Director, directly reporting to the Director, is responsible for all administrative and technology transfer activities at Idiap.

  The job description of the Idiap Deputy Director given in:
  Annexes/1222_Cahiers_des_Charges.pdf#page=7, Part 1, page 7.

- **Scientific College**: Taking collegial decisions about the general trends and key decisions about Idiap, the Scientific College is chaired by the Director and is composed of all permanent researchers with an academic title, at the Professor, Assistant Professor Tenure Track or MER level. The Scientific College has large powers in the areas of research priorities, staff hiring, projects submission, etc. The Scientific College meets at least once a month, usually the first Friday of every month.

  The composition and duties of Scientific College is given in:
  Annexes/1222_Cahiers_des_Charges.pdf#page=10, Part 1, page 10.

- **Research Committee**: Composed of all permanent researchers (group leaders, senior researchers and PIs), the Research Committee is mainly there to ensure optimal communication between the Idiap Management, Scientific College, and all key researchers, primarily aiming at maximizing the collaboration potential, discussing (ongoing or future) joint projects, etc. It is also a forum for discussing and pre-approving all important issues (which are formally discussed and approved by the Scientific College), including research directions, hirings, and all internal activities promoting communication and collaboration.

  The Research Committee (RC) meets at least once a month, usually the first Friday of every month.

  The composition and duties of the Research Committee is given in:
  Annexes/1222_Cahiers_des_Charges.pdf#page=11, Part 1, page 11.

2.2.3 Administration and technology transfer

The left part of Figure 3, page 14, concerns all the support activities to the core research activities, including finances, administration, and communication. Moreover, it also concerns all the system and infrastructure activities, as well as all technology transfer activities, hence resulting in 6 groups.

1. **Admin College**: The Admin College's duties are to supervise all the administration, financial, IT and infrastructure, development engineers, technology transfer, and program management efforts. The Admin College is currently composed of the Deputy Director and the head of each admin group below, and meets once a month to discuss open issues and status of previous action points.

   The composition and duties of Admin College are given in:
   Annexes/1222_Cahiers_des_Charges.pdf#page=12, Part 1, page 12.

2. **Finance and Human Resources (Mr. Ed Gregg)**: The Human Resources Department (HR) is integrated within the financial and accounting activities of Idiap and has taken on a greater importance in the past year. With employees from over 30 different countries, the finances and HR department is continually growing to meet the needs of each employee.

   Tasks and duties of the Finance and Human Resource management are available at:
   Annexes/1222_Cahiers_des_Charges.pdf#page=23, Part 3, page 23.

3. **Communication, Public Relations & Marketing (Mr. Nicolas Filippov)**: The mission of the communication, public relations and marketing department is to use all forms of media and communication to build, maintain, manage the reputation of the Institute, and to promote the Idiap services available for external institutions, such as EU project management, submission proposal tools, etc.

   Tasks and duties of the Communication and Public Relation group are available at:
   Annexes/1222_Cahiers_des_Charges.pdf#page=29, Part 3, page 29.

4. **System and Infrastructure (Mr. Frank Formaz)**: The main mission of the system and infrastructure group is to provide an optimal and efficient work environment for the Idiap collaborators. The tasks can be split into three main activities covering: (1) centralized IT services for the whole Institute (network, storage, servers, workstations, high performance computing, identity management, data distribution), (2) support for collaborators (helpdesk, project specific tasks, web presence), and (3) Infrastructure (building, offices, equipments, central purchasing office).

   Tasks and duties of the System and Infrastructure group are available at:
   Annexes/1222_Cahiers_des_Charges.pdf#page=24, Part 3, page 24-25.

5. **Development Engineers (Mr. Olivier Bornet)**: The mission of the development team is to provide support to Idiap researchers in the software development tasks. This is done in three areas. The first is to help on Idiap research by building prototypes, implement algorithms, design and run experiments, and manage legacy code. The second area is for all the technology transfer tasks. In the third activity, development engineers give daily support to Idiap researchers (software disclosures, showroom and internal demonstrators, development tools).

   Tasks and duties of the Development Group are available at:
   Annexes/1222_Cahiers_des_Charges.pdf#page=26, Part 3, page 26.

6. **Technology Transfer Office (Dr. Joël Dumoulin)**: Technology transfer is one of the Idiap Research Institute's three core missions. One of the fundamental challenges is to facilitate the interface between the knowledge and the skills of the researcher and the needs of the industrial partner. Besides maintaining Idiap's technology portfolio, and responding to industrial contact requests, the Technology Transfer Officer also pro-actively seeks out new opportunities. In this context, he assists Idiap researchers and companies to develop joint projects, including Innosuisse projects. He is also responsible to maintain a clear IPR strategy and track IP status across licenses, etc.

   Tasks and duties of the Technology Transfer Office are available at:
   Annexes/1222_Cahiers_des_Charges.pdf#page=27, Part 3, page 27.

7. **Program Managers (Ms. Justine Darioly & Mrs. Barbara Huguenin)**: The work of the program management team is divided into two types of activities. The first is the provision of services to researchers within the framework of European and Swiss projects. The second category includes activities ranging from event organization to database management, which are not directly linked to the management of research projects but facilitate the work of Idiap researchers.

   Tasks and duties of the Program Managers group are available at:
   Annexes/1222_Cahiers_des_Charges.pdf#page=28, Part 3, page 28.

8. **Legal Adviser (Mrs. Marie-Constance Kaiflin-Landelle)**: The main missions of the legal adviser are to write, analyse, negotiate project contracts (research, consortium, consultant agreements, NDA, Memorandum of Understanding, etc) or technology transfer contracts (patents, knowhow, licenses) with industries, universities or research institutions. The legal adviser deals also with all the legal aspects related to human resources (work contracts, staff regulations rules) and data protection (ethics, databases collection and distribution).

   Tasks and duties of the Legal Adviser group are available at:
   Annexes/1222_Cahiers_des_Charges.pdf#page=27, Part 3, page 27.

2.2.4 Controlling bodies and instruments

- **Scientific Advisory Board**: The Scientific Advisory Board[5] is a consultative committee, which primary mission is to offer feedback and recommendations to Idiap's Management within the framework of biannual 1-2 days meetings. The Committee's recommendations address Idiap's activities, including general scientific issues, research orientations, academic activities (including affiliation and Joint Development plan with EPFL), as well as our technology transfer activities.

  The composition and duties of the Scientific Advisory Board, as well as its last evaluation report, can be found in:
  Annexes/1240_IAB_Flyer_2019.pdf **and**
  Annexes/1246_Scientific_Advisory_Board_report_2018**.**

- **Internal financial controlling**: The annual budget is submitted to the Foundation Council before the end of the current year (usually in November). Annual accounting results are also submitted to the Foundation Council, usually twice a year: provisional accounting results usually at the beginning of the year, and final (audited) accounting usually in May.

  Final (audited) accounting results for 2018 and budget for 2019 are given in:
  Annexes/1241_Accounting_2018_Revised.pdf **and**
  Annexes/1241_Budget_2019.pdf**.**

[5] http://www.idiap.ch/the-institute/organization/international-advisory-board

- **Financial auditing**: The auditing firm is chosen by the Foundation Council, and is changed regularly (at least every 3-5 years). The current auditing company is BDO in Sion (with headquarters in Fribourg). We note here that since 2011, and given the amount of our annual budget, as well as new EC requirements for institutions managing high-budget projects, we had to move from limited ("restreint") to full ("ordinaire") auditing.

  The audit report for 2018 is given in:
  Annexes/1242_BDO.pdf.

- **Internal Control System ("Système de Contrôle Interne" – SCI)**: The full auditing procedure mentioned above requires the set up and regular update of an Internal Control System (SCI), defining all the internal financial and management processes. The SCI is now an integral part of the annual financial auditing, and is always subject to improvements.

  The current version of the SCI is given in:
  Annexes/1243_SCI.pdf.

- **Risk analysis**: Over the last 10 years, Idiap management has been maintaining a detailed risk management and contingency plan document. This document currently contains about **73** items, ranked (in a 1-to-4 scale) in terms of likelihood L and "criticity" C, where all entries with a risk $R = L \times C$ higher than a certain value have to be analyzed, with suggested contingency planning. This risk analysis document is also submitted to the Foundation Council for comments and advice.

  The current version of the Risk Analysis document is given in:
  Annexes/1244_Risks_Analysis.pdf.

- **International Audit**: The performance and progress of the Institute, as well as the quality of its researchers, has regularly been screened and measured against formal indicators in a Self Assessment Report (see below). In 2013, the Idiap management took the initiative to hold a more in depth auditing of the institute, in addition to our bi-annual International Advisory Board meeting, The audit took place at Idiap in September 3-5, 2014.

  The final 2014 International Audit Report report is available at:
  Annexes/1245_Audit_Report_2014.pdf.

- **Scientific Report**: Once a year, we deliver (end of March) an extensive scientific report, also made available to SERI. This report covers the main achievements of the institute and each of its research groups, also including (for each group) a list of the 5 most significant publications. For a short list of the most impactful publications over the last 5 years, with a brief explanation, see Section 6.5.

  As part of the appendices of the present document, and for the sake of completeness, the **last version of the Scientific Report (March 2019) can be find here:**
  Annexes/1247_Idiap-Scientific-Report-2018.pdf.

- **Self-Assessment Report**: In addition to our Annual Scientific Report, Idiap has now been carrying out (for the second year) a self-assessment exercise, with the aim of presenting a concise, clear, and factual picture of where we stand in terms of our organization, group structure, human resources, quality of projects and research staff, academic and professional activities, publications, and technology transfer activities. The first release was part of the material provided to the Audit Committee. However, this Self-Assessment report is now updated every year, with the second release submitted in March 2019. Based on feedback from different bodies, including the Foundation Council, we aim at continuously improving it and enriching it, with the goal to make Idiap always stronger.

  The last version of the Self-Assessment Report (March 2019) is available at:
  Annexes/1246_Self_Assessment_Report_2018.pdf.

2.2.5 Other internal bodies

- **Data and Research Ethics Committee (DREC)** Idiap has put in place a *Data and Research Ethics Committee (DREC)* that is in charge of reviewing and approving experiments that involve humans and are conducted by Idiap research staff. This responds to the need to systematize the increased participation of Idiap in non-invasive research that requires awareness and compliance with respect to ethics, privacy, legislation, data management, and other issues. The DREC is also well aligned with the best practices and standards adopted in Switzerland (e.g. EPFL Human Research Ethics Committee[6]). Finally, DREC is also responsible to make sure Idiap is properly following all best practices and regulations related to private data, including the EU General Data Protection Regulation (GDPR).
- **Infrastructure committee:** As suggested by the Audit Committee (in 2014), and recalled in Section 7, we just set up an "Infrastructure Committee" (referred to as "an advisory group" in the Audit Report) tasked with planning future infrastructure investments. The committee is chaired by Frank Formaz, the IT manager, and composed of key researchers (although all permanent scientists are invited) to discuss the future IT investments. Minutes of the meeting are also distributed to all permanent staff for feedback.
- **Patent Committee:** With the goal to encourage patenting (with currently an average of 3 patents granted per year), Idiap has a fully operational patenting procedure, endowed with a budget of CHF 30'000.-/year (covering a maximum of 3 new patents/year). After submitting a preliminary "Invention Disclosure" (see below), Idiap's researchers are welcome and encouraged to suggest patent applications, and can call for a Patent Committee meeting which will take a go/no-go decision based on several criteria, including: (1) novelty of the idea, (2) "patentability" of the idea, and potential for industrial exploitation (ideally at least one interested industrial partner should already been identified). The patent committee is chaired by the Idiap Director and composed of (at least) one representative of the Technology Transfer Office, Dr. Phil Garner (senior research at Idiap with strong experience with industrial and patenting processes) , and the "inventor".

2.2.6 Tools and processes

- **Invention Disclosure:** As a necessary first step to any patent filing, an "invention disclosure" aims to identify a technology with a certain level of maturity and some promising economic potential. This invention disclosure is also used as a key bridge between Idiap and IdeArk, and a mandatory step (part of the evaluation criteria) for IdeArk's startups to initiate research collaboration with Idiap, hence releasing some technology transfer funding from IdeArk (see Section 3.5). On average, about ten inventions are disclosed per year at Idiap.

- **Project Management System (PMS)**: To keep track of all scientific projects submitted by the researchers, Idiap has developed a database in which all important data related to a project is recorded (such as status, starting/end dates, budget, partners). With this database, Idiap can follow closely the evolution and lifespan of submitted project (funds, acceptance rate, etc.). Since the creation of the database in 2010, more than **537 projects** have been recorded. In 2018, we implemented an additional tool to have online access to all projects and project proposals, while also generating realtime statistics about project status (submission, in review, accepted but still to start, ongoing).

- **Customer relationship management (CRM):** To manage industrial and research partners interactions, Idiap has developed its own Customer Relationship Management (CRM) system, providing us with an up-to-date list of institutions and industries we have already worked with in the past. This list is regularly updated and currently contains 1382 entries of contacts and 948 company entries (Feb. 2019).

[6] http://research-office.epfl.ch/page-117376-en.html

- **Project Time Accounting (PTA):** Idiap has implemented a formal time management system, based on our own online time management tool (to record the number of hours worked by employees during a pay period), resulting in monthly time-sheets to properly track the cost of projects, supervision and teaching activities, as well as overheads. While this is particularly important for projects related to technology transfer, this was also important to comply with EU Framework Programme for Research and Innovation regulations.

- **Online Recruitment System (ORS)**: Given the large amount of job applications received every day, Idiap has developed its own "Online Recruitment System" (ORS) where (1) all the job openings are advertised at the same place (http://www.idiap.ch/education-and-jobs), (2) through which candidates have to formally apply to, filling a mandatory form, upload CV and motivation letter, and give names and email addresses of references. All application files are available to all permanent research staff, who can mark their interest if necessary, which will then initiate a detailed selection process, while otherwise rejection letters are automatically sent after 2 weeks. The 40 posts advertised in 2018 attracted more than 1607 applications. Statistics (till 2007) about the number of ORS job openings and applications received are given in the 2018 Self-Assessment Report (in 2018, 1607 applications for 40 openings).

- **Electronic Data Management (EDM) (Gestion Electronique de Documents – GED)**: Idiap is currently in the process of implementing (and moving to) a full EDM system, where all admin, financial, and project data will be digitized (when necessary, e.g., for postal mails), centralized, and managed, and made available to all the persons involved with the right permissions. Of course, this also has to be consistent with our Internal Control System mentioned above. The first phase consisted in selecting, installing and testing the most appropriate tool, which resulted in the choice of licensing "M-Files" (Enterprise Information Management Solutions, https://www.m-files.com/). We are now in the process of deploying the system across the different groups, agreeing on some form of internal standard data structure, and starting with the Project Management group (i.e., with all documents related to projects, from submission, review outcomes, reports, etc.).

- **Staff Reporting System (SRS):** SRS is an online tool running on the Idiap Intranet for the management and tracking of individual periodic progress reports. It provides an easy-to-use electronic reporting tool, allowing all the Idiap staff to complete their progress reporting by simply filling a standard template (which can also be turned into a printable .pdf document). The report is available to the supervisor who can either accept it, comment it, or reject it (for given reasons). All reports are properly archived, and each individual, as well as the supervisors, can have access to past and current reports. For PhD students, this reporting is done twice a year (and the template fits the one expected from EPFL PhD students once a year, to avoid extra work). For postdocs and permanent staff, the report is due by the end of the year and used as a basis for the annual evaluation.

- **Internal Management System (OPTIMISO):** To professionally deal with quality management, internal organization, risks and internal procedures and controls, Idiap is currently moving to the OPTIMISO software, https://www.optimiso.com/.

- **Accounting System (Abacus):** Given the obsolescence of the accounting software (BilanGT) used so far, the institute had to move in 2017 to Abacus, a more modern system, https://www.abacus.ch/.

2.3 Staff

2.3.1 Staff overview

Statistics

All the details regarding Idiap's personnel resources, including Idiap staff statistics (as of May 2019), are summarized in the Idiap *Vade-Mecum* (May 2019), presented at the very beginning (before the Table of Content) of the present document. This Vade-Mecum is largely distributed and exploited as a short (2 pages) fact-sheet to present a quick but complete overview of Idiap, including all key information, such as missions, budget, staff and facilities, organization, advisory board, PhD students, and pointers to the IdeArk companies.

Performance measures

All staff members have regular evaluation meetings, including a bigger one at the end of the year (also linked to salary reviews). They are also all encouraged to regularly perform a self-evaluation exercise, including h-index (they are all part of GoogleScholar, including postdocs and PhD students), number of high-quality publication, competitive projects, impact of their activities on the generation of "invention disclosures", technology transfer activities, academic activities, as well as professional services (awards, board memberships, etc).

Detailed Human Resources statistics (h-index, people flow and alumni, PhD student and PhD theses, etc) are provided in the **Self-Assessment report:**
Annexes/1246_Self_Assessment_Report_2018.pdf#page=19, Section 6.

The CVs of all key staff members are given as an Appendix at:
Annexes/1311_CVs.pdf.

2.3.2 Turnover of non-permanent staff

Besides PhD students (staying between 4 and 4.5 years, depending on whether they had an opportunity to spend time abroad as intern, which is always highly encouraged at Idiap), the staff turnover is quite satisfactory, with Postdocs also staying between 2 and 4 years (4 years being the maximum time possible with a "Postdoc" status), and very limited/natural senior turnover, as discussed in more detail below.

About 2 years ago, we identified a gap between Postdocs and Permanent Researchers, with very good Postdocs forced to leave Idiap (due to the 4 years rule) despite their high degree of expertise and contributions to Idiap, and the lack of funding for creating permanent positions. We thus created a new status, called "Scientific Collaborator" for exceptional Postdocs who are willing to stay at Idiap while being able to bring their own funding, or helping (permanent) Senior Researchers to bring that required funding. Although they do not have a permanent position, they are considered as key members of the Institute to maintain key activities. This is well aligned with some of the new initiatives planned by Swiss NSF in their *Multi-Year Programme 2017-2020*[7], including the "Postdoc Bubble".

The job description of the newly created function of "Scientific Collaborators" is available at:
Annexes/1222_Cahiers_des_Charges.pdf#page=20, Part 2, page 20.

[7] http://www.snf.ch/SiteCollectionDocuments/mehrjahresprogramm_2017_2020_e.pdf

2.3.3 Turnover of permanent staff

Departures of permanent researchers

- During 2013-2016: During the previous 4-year period (2013-2016), where we had the departure of Dr. Barbara Caputo (Artificial Cognitive Systems), whom left in 2013 for La Sapienza Univeristy, Roma, where she is now Associate Professor, and Dr. Ronan Collobert (Applied Machine Learning), whom left in 2014 for Facebook Research, US.
- During 2017-2020: In September 2017, we had the departure of Dr. Andrei Popescu-Belis, whom accepted a position of Professor of Computer Science at HEIG-VD (Yverdon), which provided us with more collaboration opportunities (as ongoing) with HES. From 2007 to 2017, Andrei had been a senior researcher at the Idiap Research Institute, head of Idiap's NLP group, and a lecturer at EPFL. The Natural Language Understanding (NLU) group was created/continued in September 2017 by the hiring of Dr. James Henderson (coming from UniGe and Xerox Research), as discussed below.

Newly hired permanent researchers % Technology Transfer Officer

During 2013-2016: 4 new senior researchers were hired at Idiap, Dr. James Henderson (Head of Natural Language Understanding group), Dr. Sylvain Calinon (Head of the Robot Learning & Interaction Group), Dr. Michael Liebling (Head of the Computational Bioimaging Group), and Dr. David Ginsbourger (Head of the Uncertainty Quantification and Optimal Design Group), and

During 2017-2020 (so far), three more seniors were hired at Idiap. For each of them, a brief biography and short activity description is given below.

Dr. James Henderson: BSc in Computer Science, Massachusetts Inst. Technology, USA, 1987; MSE & PhD Computer Science, Univ. Pennsylvania, USA, 1991,1994; Lecturer, Univ. Exeter, 1994-2001; MER & Chargé de Cours, Univ. Geneva, 2008–2012,2012–2018.

- Start date at Idiap: September 2017, replacing Dr. Andrei Pospescu-Belis.
- Expertise and name of the new group: Natural Language Understanding
- *Short CV*: Dr. James Henderson studied Computer Science at MIT and University of Pennsylvania, receiving his PhD in 1994. He has been a Lecturer at the University of Exeter, and MER and Chargé de Cours at the University of Geneva, as well as appointments at University of Edinburgh and Xerox Research Centre Europe. He joined Idiap as head of the Natural Language Understanding group in September 2017. He is Action Editor for Transactions of the Association for Computational Linguistics and was on the editorial board of Computational Linguistics, the two main journals in the field. He has been Program Co-Chair for EMNLP-CoNLL 2012 and Area Chair for six other top-rank NLP conferences. He has been PI on 14 grants, totalling over 5.5 million CHF.
- *Short activity description*: Dr. Henderson's research ranges from deep learning architectures to applications in natural language processing, with an emphasis on structured prediction and representation learning for the meaning of text. Understanding language is one of the principle problems in artificial intelligence, which he approaches at the lower level by developing neural network architectures with the computational, representational and generalisation abilities required to capture the complex structured nature of language, and at the application level by training these models on tasks which embody and require the meaning of text, such as machine translation, natural language inference. and opinion summarisation.
- *Key scientific output*: Contributions in the area of deep learning for natural language processing. Dr. Henderson was the first to successfully apply neural networks to linguistic structure prediction, and contributed to pioneering work on reinforcement learning for spoken dialogue systems. More recently,

he introduced a novel framework for modelling entailment (rather than similarity) in a vector space, and associated distributional semantic models of words. In collaboration with NLU group members, he has also proposed hierarchical attention for contextualised neural machine translation, and output class embedding models for predicting previously unseen text classes.

Dr. Jérôme Kaempf: BSc. in Physics, UKC, 1999; MSc. in Physics and Computer Science, UNIL, 2001 and 2003; MSc. in Teacher Education, HEP-VD, 2005; Ph.D., EPFL 2009); Postdoc, EPFL, 2009–2011; Research and Teaching Associate, EPFL, 2011–2016; Professor of Building Energy Efficiency, HEIA-FR/HES-SO Fribourg, 2016–2019.

- Start date at Idiap: September 2018
- Expertise and name of the new group: Energy Informatics
- *Short CV*: Dr Jérôme Kämpf trained in physics at the University of Lausanne, University of Kent at Canterbury and Imperial College London. He completed his training with a computer science and a post-graduate degree in teacher education, before doing his PhD at EPFL on the modelling and optimisation of urban energy fluxes. Jerome led for six years a research group at EPFL first in Sustainable Urban Development and then in Urban Systems Simulation, further developing the Urban Energy Simulator CitySim that he initiated during his PhD. From 2016 to 2019, he served as professor of Building Energy Efficiency at the HES-SO in Fribourg. Since the end of 2018, Jérôme heads the Energy Informatics group at Idiap.
- *Short activity description*: Research focuses on the exploitation of state-of-the-art Information and Communication Technology (ICT) to tackle global warming and climate change challenges. Applications include studies: (i) to increase integration of renewable and distributed energy sources by making energy systems smarter, (ii) to increase energy efficiency beyond what improvements at component level can achieve, and (iii) to develop appropriate management plans that optimize energy resources while protecting the environment. The developed methodologies intend to bring ways to simulate energy transition pathways with intelligent control and adjustment mechanisms of evolving buildings with retrofitting and use, renewable energy production and energy storage in a changing climate.
- *Key scientific output*: Smart control algorithms for an optimal comfort and energy efficiency of buildings (lightings, blinds and electrochromic windows, Heating Ventilation and Air-Conditioning systems). Developments of and around the dynamic urban energy simulator CitySim Solver (energy consumption and renewable production of buildings, evapotranspiration of plants, urban heat island phenomenon and pedestrian comfort). Simplified simulation methods for district heating and cooling networks as a vector to transport energy in cities.

Dr André Anjos: BSc, MSc & PhD Signal Processing, Federal University of Rio de Janeiro, Brazil, 1999, 2001, 2006, Research Associate at CERN/University of Wisconsin, (2006–2010), Research Associate at Idiap (2010–2018).

- Start date at Idiap: May 2018
- Expertise and name of the new group: Biosignal Processing
- *Short CV*: André Anjos received his Ph.D. degree in signal processing in 2006 studying the application of neural nets and statistical methods for particle recognition in the context of High-Energy Physics experiments at Large Hadron Collider at CERN, Switzerland. He joined the Idiap Research Institute in 2010 where he initially worked with biometrics. He currently heads the Biosignal Processing Group at Idiap. André teaches graduate-level machine learning courses at the EPFL and serves as reviewer for various scientific journals and conferences in pattern recognition, image processing and biometrics. He published more than 80 articles (more than 6'000 citations overall).
- *Short activity description*: Research on the intersection of medical data and artificial intelligence, with particular interest on robust and interpretable models. Medical applications very often require high to very high specificity, and must work across a distinct set of patients (age, gender, ethnicity, etc), be adaptable to disease changes, and highly interpretable. In these applications, models are used to predict

diseases, health deterioration, triage patients, relate symptoms to pathologies, and more. The aim is to build artificial intelligence solutions to support medical practice and interaction, that improve diagnosis and anomaly detection across a wide spectrum of patients.
- *Key scientific output*: Anomaly detection for anti-spoofing in biometric recogntion: Most systems work discriminatively, trying to separate attacks from *bona fide* users. This technique does not generalize well to never-seen-before attacks. We explored anomaly detectors and joint-modelling client identity as a way to calibrate output scores, showing increased robustness to unseen events. Reproducibility in Data Sciences: we argue reproducible work should possess the following characteristics: repeatability, shareability, extensibility and stability. Together with other groups at Idiap, we built an open platform for research in computational sciences related to pattern recognition and machine learning, to help on the development, reproducibility and certification of results obtained in the field.

Dr Joël Dumoulin: Bachelor in Computer Science (2009), Master of Science in Engineering (2011), PhD in Computer Engineering (2015).

- Start date at Idiap: July 2018
- Position: Technology Transfer Officer
- *Short CV*: Dr Joël Dumoulin is the Technology Transfer Officer of the Idiap Research Institute. He received his Bachelor in Computer Science from the School of Engineering and Architecture of Fribourg (2009), his Master of Science in Engineering from the University of Applied Sciences Western Switzerland (2011) and his PhD in Computer Engineering from the University of Florence (2015). His main research interests were Human-Computer Interaction, machine learning and multimedia processing. From 2012 to 2018, he was a lecturer at Master and Bachelor levels, involved in courses like Information systems, Machine learning and Algorithmic and data structures. He received a Diploma of Advanced Studies in Didactics from the University of Fribourg (2015). Since July 2018, he is the Technology Transfer Officer of Idiap.
- *Short activity description*: As Technology Transfer Officer, he is the contact person for companies interested in collaborating with Idiap. He identifies collaboration opportunities with potentially new partners. He presents Idiap and its activities to industrial partners. He collaborates with researchers to prepare industrial projects like for instance The Ark and Innosuisse projects. He brings his help if needed during the life cycle of these projects. He keeps up to date the Idiap technology portfolio and helps researchers in the process of patenting.

It is important to report here that all the research groups at Idiap, including the above two new ones, are fully autonomous, with their intrinsic growth, and developing their own funding model through different research and technology transfer projects.

3 Current and Future Activities

3.1 Introduction

The Idiap Research Institute has several key advantages, including: being independent and flexible yet affiliated to strong partners for key areas, being a long-standing player in an area that is undergoing exponential growth, having excellent staff, students, reputation, tech transfer, having a diverse portfolio of sustained funding sources, both from standard research instruments (SNSF, Hasler, EU, US/DARPA), from international research programs, and from industry (Innosuisse, direct contracts with industry, including startups), and covering, in a focused way, multiple fundamental and applied AI areas. Idiap is often considered by the industry as a "one-stop shop for AI".

We thus believe that consolidating Idiap's unique position, as a

Competence R&D Center on Applied AI in Switzerland

in addition to our well recognized affiliation to EPFL, would provide a unique opportunity to the State of Valais, and Switzerland.

We are currently facing high demand and multiple opportunities for diversification in synergistic areas, as well as in technology transfer activities at the national level. Size is currently a limiting factor; Idiap will pursue controlled growth and diversification, with focus on collaborative synergies and leveraging current strengths. Nevertheless, new funding would allow us to further diversify our activities, with an additional emphasis on industrial needs and technology transfer.

Relation to EPFL is multi-faceted (from independence to affiliation, depending on scope). In that context, Idiap has a unique status in the Swiss research landscape, and we must continue communication work and collaboration. EPFL is open to this and actually recognizes the strategic importance of Idiap, as an independent research institute, affiliated with EPFL, and possibly others).

Interaction with partners is key to ensure that Idiap fulfills expectations of funders and partners. Conversely, we must be able to rely on continued support from partners. New funding opportunities would also help in that direction.

Main objectives: As already introduced in Section 2.1, the main objectives of Idiap can be summarized as follows:

1. **Research activities**: Conducting fundamental research projects at the highest level in our identified multi-disciplinary and complementary areas and well targeted application domains. As confirmed by the funding distribution presented in Table 2, page 73, this research is carried on by a dozen of permanent researchers (funded *on average* on the basis of 75% of public/structural funding and 25% of soft/competitive funding), in collaboration with postdoctoral researchers, scientific collaborators, and PhD students, entirely funded on the basis of competitive projects.

   In the following, we start with Section 3.3, describing in 2-3 pages the mission of each of the research groups, their recent achievements, and the foreseen research activities for the next 2021-2024 programme.

2. **Academic and training activities**: Maintaining excellence in training and academic activities in the context of our relationships with EPFL, as well as by exploiting our large academic network. Training activities mainly include the supervision of an average of 35 PhD students, in addition to visitors and master students. All those students are entirely funded by competitive projects, and supervised (or co-supervised) by one of the permanent researchers. Our academic activities are mainly developed through the Idiap-EPFL Joint Development Plan, although some of them are also part of academic networking activities (such as EU Marcie-Curie International Training Networks).

In Section 3.4, page 55, we discuss the main academic and training activities, followed by a short discussion of how this very successful programme could be further improved.

3. **Technology transfer activities**: Besides fundamental research, training and education activities, Idiap is also contributing considerably to the economic development of Valais (and beyond), and is strongly involved in Technology Transfer (TT) activities, transferring research results (technology, software, algorithms, and more generally knowledge, know-how, and expertise) to interested industrial partners, startups or direct Idiap spin-offs. This is done on the basis of multiple instruments and processes, discussed in Section 3.5, and is specifically supported by a fully dedicated Technology Transfer and Research & Development group. The second group is composed of a dozen of highly talented development engineers, all interested in research, some even with a PhD, but who decided to mainly focus on prototyping and making fully operational the research outcomes.

   In Section 3.5, page 60, we describe our main technology transfer activities as we foresee them over the 2021-2024 phase.

Independence and complementarity of the different research and development units: since this may not be immediately clear from what follows in the next sections of this document, it is important to emphasize the following characteristics of Idiap's approach to the organization of research:

- All group leaders are quite autonomous, and are fully responsible for the development of their group, bringing in research projects, PhD funding, visitors, research contracts with industries, etc. The group leaders are thus entirely responsible for the sustainability of their research group, although Idiap keeps encouraging inter-group collaborations and projects involving multiple groups (which has always been one of the key strengths of Idiap). However, within these responsibilities, they are also free to adapt their research domains, as long as these remain within the scope of Idiap's core mission and, ideally, after they have been discussed within the Research Committee. Actually, as can be seen from Table 2, page 73, it is even expected that at least 25% of the PI's funding will come from projects, although Idiap's core funding will always remain available as backup to go through difficult times.

- As can also be seen from Table 2, page 73, most of our Technology Transfer activities are self-funded. And, given the high demand, it is expected that this group could significantly grow, however at a risk of jeopardizing its stability and not being able to keep/fund a larger group of people at any moment without some part of the public funding to cover the additional risks.

- As is obvious from the upcoming sections of the present document, all groups are usually working at full capacity, making it difficult, or nearly impossible, to answer new demands or, of course, to start entirely new strategic activities in areas related to energy, cyber-security, or smart cities, as often suggested by EPFL (in collaboration with EPFL Valais-Wallis). Idiap is actually facing new demands every day, and has to reject most of them for the above reason. This is yet another reason why the 2021-2024 budget (discussed in Section 4) is seeking additional funding to provide more opportunities for incremental diversification, staying perfectly aligned with our core business, while also allowing us to be more "opportunistic" and responsive in our research and Technology Transfer activities.

3.2 Roadmap for 2021-2024

Today, at the federal level, the Idiap Research Institute is registered under the federal law on the encouragement of research and innovation (LERI) art. 15. (contributions to research institutions of national importance), al. 3, let. b (non-profit research institutions established outside the universities or associated with universities).

The Federal government's decision, at the end of 2016, to support art. 15., institutions, but only along al. 3, let. a. (Infrastructures) and c. (National Technology Competence Centres) demonstrated that Bern wishes to have a concrete and rapid impact on the Swiss economy, especially around the theme of "Digital Switzerland". As a consequence, and in spite of the fact that:

- Idiap has always been very active in research, but also in technology transfer (through multiple projects with small and large industries, startups and spin-off, Innosuisse projects, licensing agreements with industries, etc.). At the State level, actually, Idiap is currently supported by SHE (Service des Hautes Ecoles), as well as by SETI (Service de l'Economie, du Tourisme et de l'Innovation). Idiap significantly contributes to the economic growth of Valais, not only through its own activities, but also by assisting the State of Valais in economic promotion abroad (incl. Silicon Valley).
- The excellent CSSI evaluation report[8] *"Appréciation des requêtes 2017-2020 au titre de l'art. 15 LERI, Rapport du Conseil suisse de la science et de l'innovation à l'attention du Secrétariat d'Etat à la formation, à la recherche et à l'innovation,"* from "Conseil suisse de la science et de l'innovation (CSSI)" on June 27, 2016, and where CSSI was unconditionally recommending to accept the budget increase requested by Idiap.

Idiap's federal support budget for the 2017-2020 period was kept more or less constant, which still didn't prevent Idiap from growing and intensifying its technology transfer activities. Today, Idiap is not only a research institute, but also a platform for sharing & transmitting knowledge, and is a key partner in the national economy development (as widely evidenced here and in our annual Self-Assessment Report). In addition to the facts reported annually in our activity reports, some very recent examples are also briefly discussed below.

First, the establishment of a dual Master degree in Applied Artificial Intelligence. Without a doubt, artificial intelligence is a source of innovation for a large number of companies (from startups to large companies). Therefore, this dual training in employment will further link Idiap with current market needs and promote the implementation of industrial projects. Funded by industry and the State of Valais, this new type of training is similar to the apprenticeship model, but at a university level.

Secondly, Idiap is involved in the only project funded by H2020 to develop an "EU AI Platform" (with a total budget of 20M €). This project, resulting from a very competitive evaluation process, and the selection of a single European consortium (in this specific case coordinated by Thales), was announced in August 2018 and still needs to be set up. It is clear that it will open up new opportunities for technology transfer and training.

Finally, Idiap, Leading House, in collaboration with the University of Geneva, was invited to submit a full proposal for a new NCCR on the subject of "*Human Trust in AI (HTAI)*". Final evaluation of this new NCCR proposal is still ongoing, but we believe the chances of success are quite reasonable. That NCCR proposal involves most of the national key AI industrial players, as well as contributions (in cash) from GAFAs (Google, Facebook, etc). We also take this opportunity to remind here that Idiap has already been Leading House of one of the (first wave) NCCRs on "Interactive Multimodal Information Management (IM2)", which had a very large and sustainable impact on several Swiss institutions, including Idiap itself, since that NCCR really boosted the institution, which managed to maintain its growth well after and well beyond IM2.

[8] https://www.swir.ch/images/stories/pdf/fr/2016_11_15_Rapport_CSSI_Art_15_LERI_publ_def_CORR.pdf

Figure 4 illustrates the application domains which Idiap will keep contributing to, often involving more that one research group, and requiring strong multi-disciplinary focus, strong platforms (extending what we already have at Idiap, as well as interface standardization, etc. For example, for the "Exploitation of rich multimedia archives", the content of the necessary "Cross Research Group (CRG)" (as presented in the organigram of Figure 5) is discussed in Section 3.3.12, page 53.

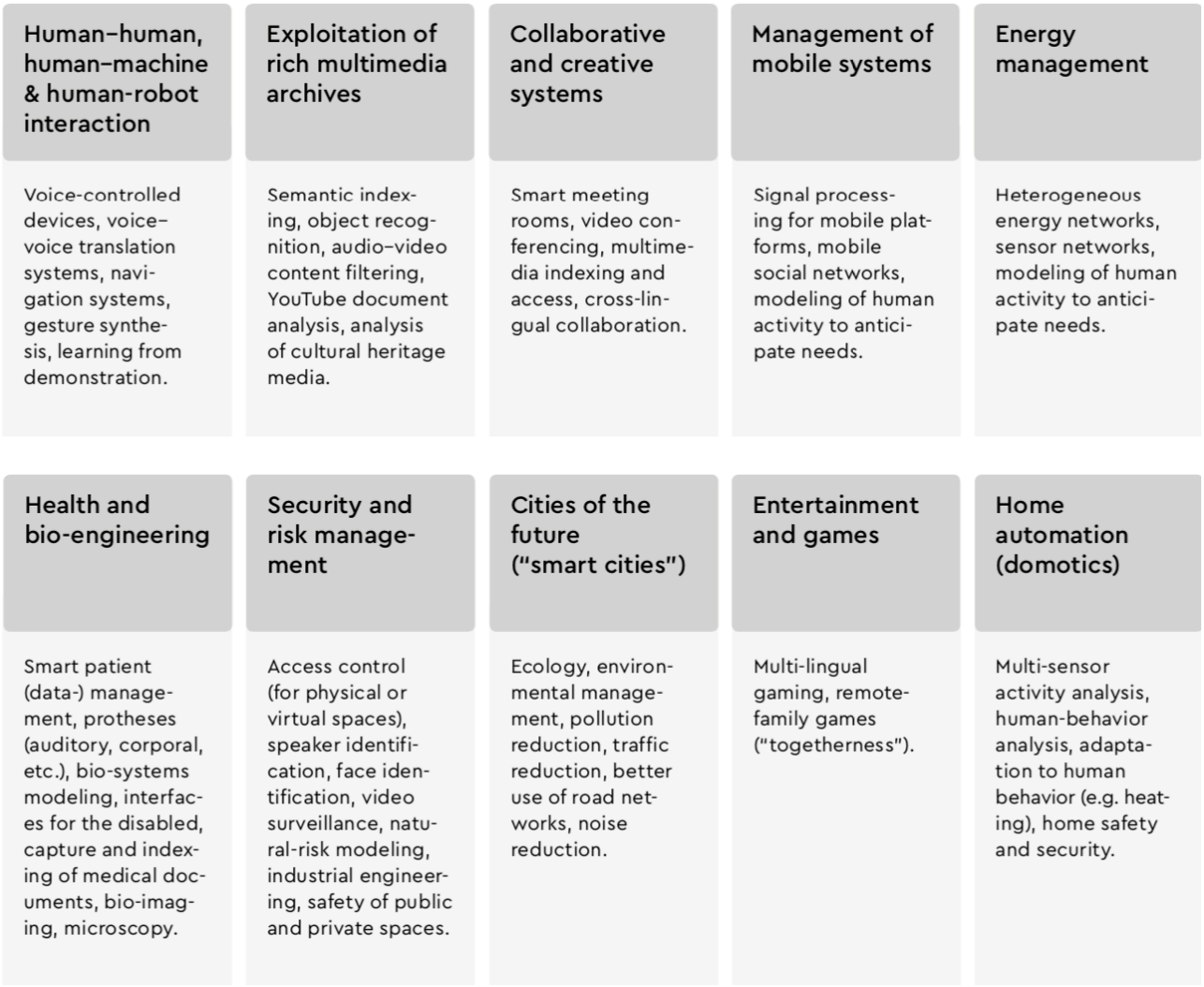

Figure 4: *Application domains which Idiap will keep contributing to, often involving more that one research group, and requiring strong multi-disciplinary focus, strong platforms (extending what we already have at Idiap), as well as interface standardization, etc. For the "Exploitation of rich multimedia archives", for instance, an example of the necessary "Cross Research Group (CRG)" project (as presented in the organigram of Figure 5) is discussed in Section 3.3.12, page 53.*

In line with the mission of the LERI art 15., al. 3, let c., and by exploiting the know-how and fully operational organizational structures put in place by Idiap, it now seems reasonable and feasible to significantly develop the Institute's activities in order to have an even greater impact on the cantonal and national economy. This figure illustrates the application domains which Idiap will keep contributing to, often involving more that one research group, and requiring strong multi-disciplinary focus, strong platforms (extending what we already have at Idiap, as well as interface standardization, etc. For the "Exploitation of rich multimedia archives", for instance, an example of the necessary "Cross Research Group (CRG)" project (as presented in the organigram of Figure 5) is discussed in Section 3.3.12, page 53.

Finally, Idiap, further reinforced by the unprecedented support of the Valais State and the City of Martigny (see support letters in appendix[9]), is now in a unique position to fulfill this economic development mission. Indeed, Artificial Intelligence is, more than ever, one of the keys to economic development and, since 1991, Idiap has developed its reputation and know-how around this theme. The resulting Idiap organizational chart for 2021-2024 is then presented in Figure 5, and discussed below.

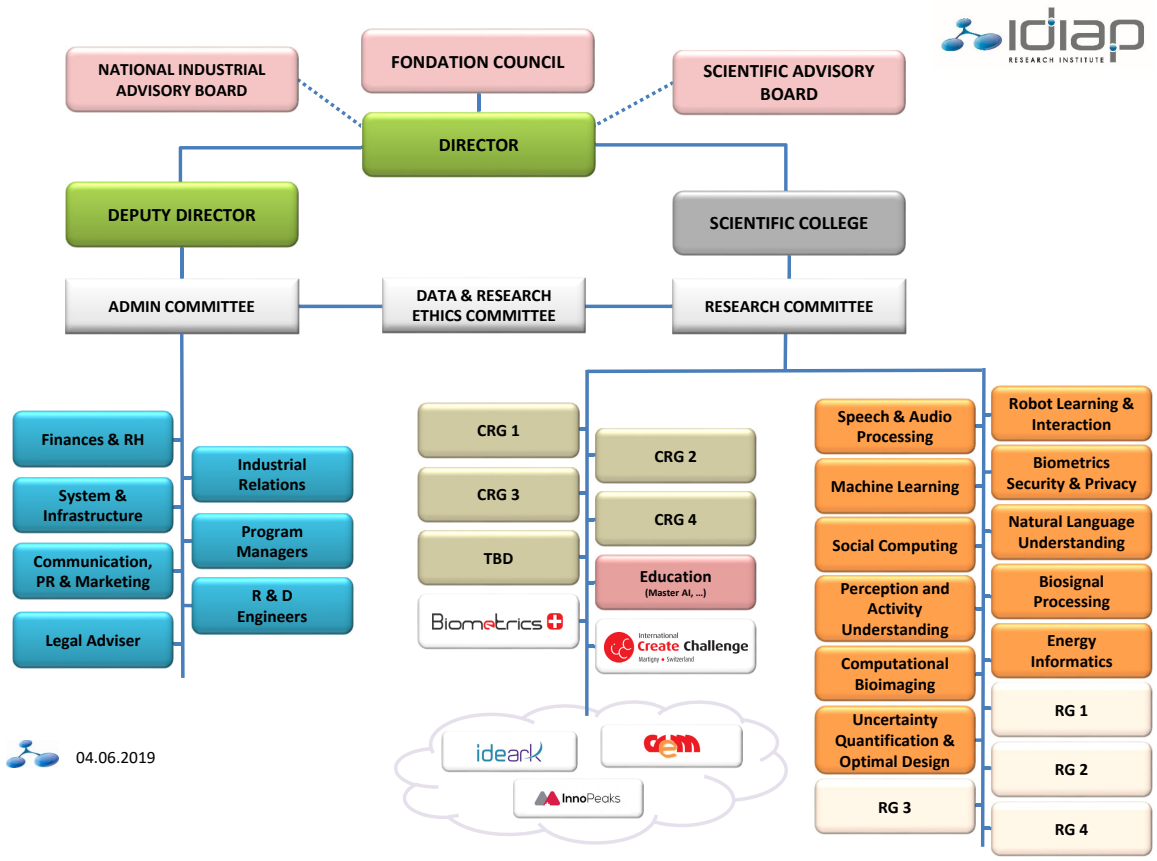

Figure 5: *Idiap management and operational structure foreseen to be developed during the next 2021-2024 period, including the main research and administrative responsibilities. For the main Research Groups (RGx, right block), managed by the Scientific College (in collaboration with the Research Committee), all group leaders are key (autonomous) researchers, with clear supervision duties, and are all project PIs. The new, middle, "pillar" covers the new multi-disciplinary groups, referred to as "Cross-Research-Groups" (CRGx), and covering the application domains discussed above. As part of that pillar, we also have all technology transfer ecosystem, including our startup incubator (IdeArk), affiliated (Biometrics and CREM) centers, or our industry oriented training activities (Industry-driven AI Master). On the left hand side, we find all the admin, IT management, and technology transfer (development) activities, supervised by the Deputy Director, in collaboration with the Admin College.*

Targeted application domains: Figure 4, page 28, shows the activities of Idiap according to key applications areas, in which the institute is already active through various industrial projects (direct contracts with industry, Innosuisse) or within the framework of European projects. Although not exhaustive, it is clear that these applications cover many strategic areas for the economic development of Switzerland. It is through our new Cross Research Groups (CRGx) that we will directly address those application domains, based on industrial needs.

[9] Annexes/2210_Lettre_Martigny_20180927 & Annexes/2210_Courrier_DEF_SEFRI_12.06.2019

New organizational structure: The resulting new organizational structure of Idiap is foreseen to be as illustrated in Figure 5, page 29. The right "pillar" covers the current **Research Groups (RGx)**, as described in more detail in Section 3.3, possibly enriched by a couple of new groups. The middle "pillar" covers the new multi-disciplinary groups, referred to as **"Cross-Research-Groups" (CRGx)**, and covering the application domains discussed above. As part of that pillar, we also have all technology transfer ecosystem, including our startup incubator (IdeArk), affiliated centers (Biometrics, CREM), or our industry oriented training activities (Industry-driven AI Master). Finally, the left "pillar" brings together all the administrative services necessary for the proper operation of the institute.

Intensification of R&D and technology transfer: Although Idiap has always been particularly active in the field of technology transfer (IdeArk incubator, many Innosuisse projects, successful spin-off, etc.), the targeted structure aims at significantly increasing this activity. While preserving the quality of research (the right-hand pillar of the organization chart), a new pillar (central) now explicitly groups all activities related to technology transfer. It develops around "Centers" (Biometrics, CREM), specific initiatives (International Create Challenge), or incubators (InnoPeaks, Ideark). These already existing initiatives will be revitalized and complemented by industry-led application-oriented groups and projects.),

Autonomy of fundamental research: Fundamental research will be preserved through RG activities, however encouraged by more application-oriented projects. While ensuring a good level of independence, researchers active in the right pillar (research/RG) will also be encouraged to align as much as possible on the priorities coming from CRGs. To do this, we intend to use a portion of the sought additional public funding (as well as industrial funding) to increase the amount of matching funding of research projects (typically SNSF and EU) that would be well aligned with the CGR needs., i.e., encourage the alignment of fundamental research (RG) with more applied research (CRG).

3.3 Research Activities

3.3.1 RG1: Speech and Audio Processing

Overview

Heads: Prof. Hervé Bourlard (MS and PhD, Polytechnic University, Mons, Belgium, 1982 and 1992), Dr. Philip N. Garner (MEng, University of Southampton, UK, 1991; PhD, University of East Anglia, UK, 2011), Dr. Mathew Magimai-Doss (MS by Research, Indian Institute of Technology Madras, India, 1999; PhD, Ecole Polytechnique Fédérale de Lausanne, Switzerland, 2005), and Dr. Petr Motlicek (MS and PhD, Brno University of Technology, Czech Republic, 1999 and 2003).

Speech processing has been one of the mainstays of Idiap's research portfolio for many years. Today it is still the largest group within the Institute, and one of the largest academic speech technology oriented groups worldwide.

The expertise of the group encompasses statistical (multilingual) automatic speech recognition (ASR) (based on hidden Markov models, or hybrid systems exploiting connectionist approaches, recently revisited under the popular name of "Deep Neural Networks"), (multilingual) statistical text-to-speech (TTS), and generic audio processing.

Main focus over the last Research Program (2017-2020)

During this period, the group has grown to around 28 people, typically comprising 1 head of group, 3 principal investigators, 1 research associate, 11 postdocs, 13 PhD students, and 9 interns. The group also works closely with several developers in the context of industry-driven projects.

Multilingual speech recognition: We have always used (and pioneered) both deep neural network (DNN) and hidden Markov model (HMM) based speech recognition, especially for leading-edge multilingual speech modelling. For instance, in the context of a US-IARPA project, we have been dealing with multiple (low resourced) languages, where we were recently ranked first during the last evaluation campaign.

Speech synthesis and prosody: We had previously identified prosody as being important for translation, especially given the multi-lingual focus of the group. More recently, the translation focus has moved towards a general multi-lingual approach to synthesis and prosody, and with a particular focus on physiologically plausible models.

Pathological speech processing: Over the last couple of years, Idiap has initiated new projects towards the early detection of neurological pathologies (like Parkinson and Alzeihmer) through speech analysis. This important field of speech-based medical applications is currently funding 3 PhD students and one postdoc, through one SNSF Sinergia project and a new EU Marie-Curie project (coordinated by Idiap).

General audio processing: Several key contributions were made in source separation, using microphone arrays, ad-hoc microphone arrays, and sparse recovery modeling. The group has also contributed to speaker recognition and other identification and detection tasks (e.g., language/accent/gender) through research and innovation projects, or by participating in international challenges (e.g., organized by NIST U.S.).

Dissemination activities: Much of the group's recognition has come from multiple contributions (data and open source libraries) to the speech and audio community. Finally, the work in this group also resulted in a couple of spin-offs, including more recently recapp IT (https://www.recapp.ch).

Main research themes over 2021-2024

Speech, audio and language technology continues to be taken up by industry. Advances such as voice search on Android, SIRI on iPhone and the forthcoming voice translation in Skype serve not only to define the state of deployment, but to guide the future of the field. The flourishing "deployment" field drives a diverse technical field along with a healthy demand for suitably qualified PhD graduates.

With numerous improvements, the state-of-the-art for the building blocks can be rather complex, raising the entry level significantly. This requires that we make use of available leading-edge toolkits, and contribute to them where possible.

Multilingual speech recognition (ASR), text-to-speech synthesis (TTS), and adaptation: The application of speech to speech translation, along with the unification of technologies for ASR and TTS, has seen TTS become as important as ASR in Idiap's technology portfolio. We envisage that this will continue as both ASR and TTS take advantage of recent "deep" neural approaches. The activities in this domain will be driven by demands from government or industry, focusing on multi-lingual, or under-resourced scenarios, underlying fast adaptation techniques in both ASR and TTS. The near future will require integration of these technologies to operate on small low-energy, embedded devices. We also intend to keep focusing of the peculiarities of the Swiss language scenario (covering particular accents or dialects, especially of Swiss German), but in a manner that generalises to under-resourced and difficult languages worldwide.

Emerging neural Architectures for speech & audio: Deep neural architectures have advanced the fields of both ASR and TTS to the level that they work well enough for commercial applications; sometimes indeed indistinguishable from human performance. Whilst there is still research in this area, we also intend to use this good performance to invert the direction of inference: Rather than use deep architectures for engineering performance, we use the engineering performance to help infer something scientific about the underlying biological systems. To this end, we aim to build ASR and TTS systems that use *biologically inspired* or *physiologically plausible* components. These include models of muscles, the cochlea and the vocal tract.

General audio and speech processing: This will certainly require further research, including: microphone array and multi-channel sensing, or signal enhancements, all important in noisy or hands-free environments.

Paralinguistic speech processing: This R&D theme focuses on conducting fundamental research on paralinguistic aspects. Example areas of research include assessment of emotion, stress, speaker traits, speaker state, speaker personality, degree of nativeness, speech quality, audio quality.

Assistive speech technologies: This theme includes pathological speech processing, computer aided language learning, hearing aids, automatic assessment of online learners, speech-based clinical diagnosis, voice-enabled technologies for handicaps and robot interaction. Specifically, we plan to conduct research involving perpetual interaction and collaboration with researchers from other disciplines such as clinical medicine, teaching (pedagogy), health care, social science, computer vision.

Speaker and language recognition research: Automatic speaker identification and audio information structure (speaker turns, language, accent, gender) on massive databases will also be a target for Idiap in the next years. The topic is strongly aligned with the security applications, e.g. technologies to enhance the fight against crime and terrorism. In this context, we will have to focus on the fusion and correlation of evidence from multiple, heterogeneous, data sources.

Coupling speech and language technologies with natural language understanding: Quality of automatic speech recognition systems has significantly increased over the last years, allowing its integration into multiple type of applications. On the other hand, new technologies (from our NLU group) are also emerging in language understanding (linking recognized word sequences into application semantics). However, new technologies will now be required to properly link and exploit semantic information to further improve automatic speech recognition systems.

3.3.2 RG2: Biometrics Security and Privacy

Overview

Head: Dr. Sébastien Marcel, ***IEEE Senior member****, h-index 47 (PhD, University of Rennes, France, 2000)*
The Biometrics Security and Privacy (BSP) group investigates, develops and evaluates novel pattern recognition and machine learning methods to process measurable distinctive human characteristics (physiological or behavioral) and to improve the security of biometric recognition systems that are becoming more prevalent on personal computers and mobile devices. More particularly the BSP group has expertise in face recognition (2D, 3D and near-infrared), speaker recognition, vein recognition, anti-spoofing (presentation attack detection), privacy (template protection) and emerging biometric modes (ECG/EEG). The research finds applications in many areas ranging from access control, video surveillance, border control, humanitarian, forensics, privacy-enhancement and e-Health.

The BSP group prioritises reproducibility in research using its own open source signal-processing and machine-learning toolbox (BOB), the BEAT platform and using rigorous methodologies for the collection and the distribution of biometric datasets.

Main focus over the last Research Program (2017-2020)

The BSP group was pioneering the work in face, speaker and vein anti-spoofing. In the context of Swiss, European and DARPA/IARPA research projects the group has co-Edited books, special issues, has published 40+ papers and submitted several patents. During this period, the group was composed on average of 3 PhD students, 6 post-doctoral students and 5 research associates. The main achievements of the BSP group for the 2017-2020 period are briefly summarised below.

Spoofing and Anti-Spoofing (aka Presentation Attack Detection): Attacks on biometric systems can be divided into two types: direct and indirect. The direct attacks (also called spoofing or presentation attack) are performed at the sensor level. Biometric systems are especially vulnerable in this case since the attack is performed outside the control of the biometric system. In a presentation attack (PA), a person seeks to gain an illegitimate advantage by masquerading as another individual, i.e. by claiming another person's identity and by deliberately falsifying their biometric characteristics. In contrast, indirect attacks are performed within the biometric system. We developed multi-channel (VIS, NIR, Depth or Thermal) Deep Neural Network (DNN) architectures to classify Bona Fide presentations from different types of PAs. This research topic was funded by Norwegian Research Council, EU H2020 and US IARPA as well as from the industry.

Heterogeneous face recognition: One of the most challenging task in automated face recognition is the matching between face images acquired in heterogeneous environments. Use-cases can cover matching of faces in unconstrained scenarios (e.g. at a distance), with long time lapse between the probe and the gallery, with faces sensed in different modalities, such as thermal infrared or near infrared images (NIR) against visible spectra images (VIS) or even in situations where no face even exists (forensic sketch recognition). The key difficult in matching faces from heterogeneous conditions is that images of the same subject may differ in appearance due to changes in image modality (e.g. between VIS images and NIR images, between VIS images and sketches images) introducing high intra-class variations. We investigated machine learning methods such as manifold learning or deep learning to find a joint mapping that project face images, of different modalities, into a subspace where these projections can be compared directly. This research topic was funded by the Swiss National Science Foundation.

Many other research topics have been investigated during this period (finger/wrist vein recognition, deep-fake detection, speaker diarization, speaker recognition, template protection) but can't be described in length for lack of space.

Main research themes over 2021-2024

For 2021-2024, and besides developing the "Swiss Center for Biometrics Research and Testing"[10], the group is planning to follow several R&D avenues, as briefly discussed below.

Privacy leakages about human identities: We will investigate privacy leakages from data or models carrying personal information. For instance, a face doesn't contain only identity specific information but ancillary information can also be inferred such as gender, age, ethnicity, hair color, height, weight and Body Mass index (BMI). It was shown recently that the face can reveal symptomatic indications of specific diseases. More than 30 medical conditions, such as Bell's palsy, Parkinson, fetal alcohol syndrome, Cushing's syndrome, hepatitis, torticollis or dyslexia to mention a few, can be diagnosed from automatic detection of their symptoms (skin color, skin lesions, facial paralysis and asymmetry, abnormal muscle response, abnormal iris, abnormal heat in orbital or mandibular area). The analysis of eye movements can be used to detect Attention Deficit Hyperactivity Disorder (ADHD), Schizophrenia, Bipolarity, Autism or Social Phobia. The heart rate can be inferred from face videos through remote Photoplesthymography (rPPG) by measuring the skin color variation due to the blood flow. Similarly audio recording from human data subject can exhibit speech disorders such as dysarthria, voice disorders, cleft, functional or organic articulation disorders, laryngectomy or lossectomy. Research in this area is mostly focused on the modelling of a specific information: identity information for biometrics, gender information for marketing, symptoms information for computer-aided diagnosis. It is assumed that ancillary information can be extracted from raw data (i.e. images) but is it true as well for AI models: can we extract gender or ethnicity information from a deep face recognition classifier? can we extract identity information from a deep biomedical imaging classifier? Hence the aim of this work is to study and evaluate systematically how much ancillary information remains in AI models for a large variety of tasks, models and ancillary information.

Security of biometric templates: Current research in face and speaker biometric recognition systems is focusing on the use of compact vector representations of identites. These embeddings shows superior accuracy compared to traditional approaches, so it seems reasonable to assume that future state-of-the-art face and speaker recognition systems will be primarily based on these embeddings. This introduces a new challenge to the development of suitable biometric template protection techniques to preserve the privacy of our biometric data. We will investigate the application of biometric template protection to embedding-based face and speaker recognition systems. More particularly we will explore the suitability of current methods and homomorphic encryption applied to binarised "embeddings".

Combatting the vulnerabilities of AI-based biometric systems: We envision that future state-of-the-art face and speaker biometric systems will be largely AI-based. Likewise, we anticipate new challenges in dealing with such systems' security aspects. We will investigate the vulnerability of AI-based face and speaker biometric systems to various attacks, including primarily: (i) presentation attacks to bypass recognition using an altered biometric sample ("obfuscation/evasion" or "impersonation"), and (ii) manipulation of the training data to change the classification outcome to suit the attacker's motives ("poisoning" or "trojan"). We will also investigate methods to detect efficiently forged or synthesised malicious examples. Current methods are considering this detection problem as a multi-class classification problem where each class is a known attack. This paradigm suffers from an essential limitation as all possible attacks are not actually known leading to an obvious open set problem. Machine learning propose already a scheme for the detection of unknowns using abnormal detection. Unfortunately this scheme is not used largely today for the detection of forged or synthesised examples. For instance, in face recognition, fake faces forged with paper, display or 3D masks or morphed are detected with binary classifiers (real vs fake). To keep ahead in the arm race against attackers, we will first focus on the detection of novel attacks, such as Deep-fakes for instance, as research in this field is still in its infancy.

[10] http://www.biometrics-center.ch

3.3.3 RG3: Machine Learning

Overview

Head: Dr. François Fleuret (MS École Normale Supérieure de Paris and University of Paris VI, 1995; PhD, University of Paris VI, France, 2000; Habilitation, University of Paris XIII, 2006; EPFL MER)

Machine learning encompasses computer techniques that modulate their behavior according to exemplar data. It has resulted in technologies at the core of many modern every-day data-processing software and apparatus.

The objective of the Machine Learning group is to develop novel machine-learning techniques of general use, with a particular interest in algorithmic efficiency and training from small data-sets. The research we conduct can be motivated by a general and fundamental problem, but can also come from a concrete industrial application or use case.

Over the last five years, the group has been composed on average of four PhD students, and one or two developers working on industrial applications. We also maintain a sustained collaboration with EPFL's CVLab.

Main focus over the last Research Program (2017-2020)

Re-sampling for deep models: The computational requirement for deep neural networks is one of their most problematic characteristics, even though most of the computation is spent on samples that are properly handled, and could be ignored. For training, we have derived a tractable upper bound of the per-sample gradient norm that allow to prioritize re-sampling examples and reduce the variance of the stochastic gradient estimates. During inference, we have designed a new model to handle megapixel images, composed of a first network that computes an attention map on a downscaled input, and a second network that processes the full resolution input at locations sampled according to the attention scores.

Jacobian matching and regularization: Transfer learning aims at taking advantage of pre-existing models to facilitate the training of new models, either by speeding it up, or by allowing it with very small amount of training data. The key notion is to "transfer" structures learned by the existing network. Our algorithm consists of a novel penalty that not only forces the new model to mimic the response of the existing one, but to also mimic the dynamic of change of the output, given changes of the input. This can be envisioned geometrically as forcing curves not only to match in certain points of passage, but also to have the same slope there.

Depth estimation for planetary surface reconstruction: End-to-end deep-learning networks are now the most efficient method for stereo matching. However, existing networks are memory-hungry and unable to process even modest-size images, and they have to be trained for a specific disparity range. The Deep Stereo network that we developed addresses both issues: First, its architecture relies on novel bottleneck modules that drastically reduce the memory footprint in inference, and additional design choices allow to handle greater image size during training. This novel architecture demonstrates state-of-the-art performance on standard benchmark data-sets.

Deep learning for multi-camera detection: We have developed a new approach to adapt a monocular deep-learning detector to a multi-camera context. We first fine-tune it to the problem of person detection, and then fine-tune a Siamese network with one such monocular structure per view on a small multi-view data-set. This staging from a very large generic data-base to a small specific multi-view person data-set allows to beat existing state-of-the art multi-view methods.

Stable Adversarial Optimization "Generative Adversarial Networks" rely on training jointly two models, one synthesizing realistic signals (images, sound, text) and another trying to discriminate synthetic from genuine examples. Such techniques have demonstrated striking performance in many application domains, but involve a complex and unstable optimization problem. We have developed a new method that consists of training several

such pairs in parallel, and maintaining carefully their statistical independence. This insures that their joint behavior has a good "covering" property, and we show experimentally that the resulting synthesis is less likely to miss sub-families of samples.

Main research themes over 2021-2024

The plan for the next four-year period follows the trend we have initiated over the recent years regarding computation and training from small sets, with additional axes in the domain of interpretability and robustness that fall under the general topic of "Trust" in artificial intelligence.

Fast and energy-efficient inference: We are interested in two key elements of the computational cost of inference with large-scale models: The overall computational load, and the requirement for a real-time processing system.

Our approach will consist of developing a new type of architectures, composed of multiple computational pathways and to investigate both the use of lazy evaluation, that is inference processing able to drop entire sub-parts of a network when sufficient confidence is reached, and asynchronous processing where different parts of the network are evaluated with independent scheduling. This latter approach will aim in particular at developing a model such that "heavy" subparts are evaluated at low frame-rate to provide high-level reliable contextual information, and "light" sub-parts use the mots recent information provided by the first, and combine it with high-frame rate computations to extract accurate localization in space and time.

The key notion of asynchronous processing will allow to develop a new family of methods more adapted to embedded, low-computing, and interruptable computational backends.

Playground Learning: Over the recent years we have introduced and refined the idea of pose-indexed features. Instead of designing features invariant to undesired perturbations of the signal (e.g. changes in illumination and geometrical pose), we modulate the measurement of the features with a parametrization of the said perturbations. Doing so, we maintain the joint information between measurements, and shift the difficulty from modeling to computation.

We are interested in pushing this concept forward, first as a means to obtain high accuracy on well-defined applied problems such as the tracking of surgical instruments, and second to extend this idea to more complex latent parametrization. In particular to incorporate richer geometrical poses and a modeling of external nuisances. Such extension will require dealing with a difficult optimization scheme during the evaluation of the detector, since it has to visit a high-dimension and complex latent space.

Interpretability for trust: While most of the work regarding interpretability of machine-learning systems consists of *post hoc* analysis of models whose architectures are not selected specifically to ease that task, we will tackle the issue in the design of the models themselves to facilitate their statistical analysis. The core idea here is that "trust" in an inference system for real-world problems requires to split it into two components. On the one hand, inference with large-scale models over quantities learned in a quasi-unsupervised manner, and on the other hand a final compact inference rule combining these quantities, for which trust is synonymous for compactness, and interpretability. Such a segmentation will strongly constrain the capacity of the "problematic part" of the inference, and make the model amenable to standard analysis from learning theory.

We will try to derive PAC-bounds or other exact control of the generalization error, taking inspiration in the micro-choice bound. We may also design novel learning procedures in that context, to modulate the training of the high level features through such compact models to attain optimal generalization errors. This approach will later be extended to come with a proper formal framework to modulate the amount of information allowed in each part of this compound model, for instance by adding noise to the gradient flowing from the compact part to the representation part.

3.3.4 RG4: Social Computing

Overview

Head: Prof. Daniel Gatica-Perez (PhD, University of Washington, USA, 2001; EPFL Professeur Titulaire)

Social computing is an interdisciplinary domain that integrates theory and models from ubiquitous computing, social media, machine learning, and social sciences to analyze human and social behavior in everyday life, and to create devices and systems that support interaction and communication. In the last period, the Social Computing group was composed of 8-10 members each year, including one group head, 2-3 postdoctoral researchers, 3-4 PhD students, and 1-2 academic visitors and master students.

Main focus over the last Research Program (2017-2020)

The main focus and research themes covered over the 2017-2020 period can be summarized as follows.

Ubiquitous face-to-face interaction: We developed computational models to automatically analyze pair-wise, in-the-wild interactions, building upon emerging wearable and ubicomp technologies. This has included a variety of sensors: cameras, Kinect, microphone arrays, smartphones, and wearables. Three research problems we have addressed are the following. First, we have advanced the understanding of social cognition (i.e., how people reason socially about others) in everyday life situations like job interviews and service encounters, by developing online, crowdsourced experimental methodologies. Second, we developed automatic audio-visual analysis methods to extract subtle human behaviors and infer nuanced attributes related to social skills. Third, we developed social sensing technologies to support interaction in real-time. Some of this interdisciplinary work was pursued through joint projects with academic partners in social psychology.

Social video analysis: Porting and expanding the knowledge derived from the first research line, we developed methods to automatically characterize users of conversational video in social media platforms like YouTube as well as new platforms for online video resumes, through the automatic extraction of behavioral features and the use of video crowdsourcing techniques to enable high-level social analysis at scale. The work in this domain has also resulted in technology transfer projects working with Swiss startups.

Mobile social media and crowdsensing: Using large-scale smartphone sensors and social media, we developed crowdsourcing and machine learning methodologies to analyze and interpret everyday phenomena related to mobility, health, and citizen participation. The work has spanned analysis of mobile social media like Instagram to characterize youth eating and drinking practices; analysis of mobile crowdsensing campaigns in Swiss and Latin American cities to discover and interpret phenomena related to youth mobility and health; and applications of crowdsensing in social innovation projects with local communities, cities, and other stakeholders.

Main research themes over 2021-2024

The research lines envisioned for the new Research Program period are briefly described below.

Ubiquitous conversational interaction: While deep learning is capable of extracting behavioral cues of interacting people with high accuracy, several fundamental challenges remain open to build machines capable of inferring high-level social constructs. We plan to work on three of them. The first one is how to develop methods to robustly infer attributes (like soft skills) that are inherently subjective. Such methods have to take into account models of subjective labels as part of the learning process. The second issue is how to introduce notions of fairness in the development of models of social inference. This is a critical matter for the ethical application of these technologies in practice. Third, we will continue to develop research on machine

learning-based feedback of behavioral insights that support both transparency and interpretability to users of these technologies.

Social media: All major social media platforms face fundamental challenges due to limitations on how algorithms are designed and developed, including biases that are amplified through AI and network effects. We will continue our work on social media analytics (mobile social media and social video) with emphasis on two lines of research. The first one is about increasing the diversity of populations and phenomena we study, especially in the developing world, in the contexts of public health and youth. The second line is on developing machine learning methods that are diversity-aware, which by design are able to account for diversity attributes and mitigate negative effects of bias. This work is well aligned with emerging initiatives worldwide on AI for social good, and impactful scientific work could be generated by connecting it to concrete social innovation applications.

Urban computing: We plan to design data analysis and machine learning methodologies that integrate social participation and a variety of urban data to understand phenomena in communities and cities, and develop applications for citizens and other urban stakeholders related to human activity, public space, public health, and civic participation. Data sources will include phone data, social media, and urban open data, ideally in partnerships with government representatives and companies. Starting from current research supported by the European Commission, our objective is to contextualize the developed methodologies at the Swiss and European levels, and also extend them in cities in the developing world.

Crowdsourcing: Crowdsourcing will continue to be a transversal theme to our research. This spans the design of theories and algorithms to incentivize participation in social and urban experiments, to collect and label data, to understand how such data is perceived and used, and to solve practical problems. Our work will blend theoretical and empirical work, and include both online experiments (e.g. to label and validate large-scale data) and physical experiments (e.g. mobile crowdsensing that connect people to the physical world in urban computing applications).

3.3.5 RG5: Perception and Activity Understanding

Overview

Head: Dr. Jean-Marc Odobez (Engineer degree, ENST Bretagne, 1990; Master and PhD, University of Rennes, France, 1990 and 1994; EPFL MER)

The Perception and Activity Understanding group conducts research in human activities analysis from multimodal data. This entails the investigation of fundamental tasks like the detection and tracking of people, the estimation of their pose or the detection of non-verbal behaviors, and the temporal interpretation of this information in forms of gestures, activities, behavior or social relationships. These tasks are addressed through the design of principled algorithms extending models from computer vision, multimodal signal processing, and machine learning, in particular probabilistic graphical models and deep learning techniques. Surveillance, traffic and human behavior analysis, interaction analysis between humans and with robots, and multimedia content analysis are the main application domains.

Over the last period, the group was composed of 10 members in average per year: a group head, 2-3 postdoctoral researchers, 4-7 PhD students, and one full research engineer from the development team working on industrial applications and demonstrators for research projects.

Main focus over the last Research Program (2017-2020)

Deep learning has been one of the main drivers for research in the given period. Methodological aspects and their connection with the specific task at hand were studied and led to innovative solutions. Amongst these, one common thread was to alleviate the need for very large fully annotated training dataset by investigating unsupervised or weakly supervised approaches, or the use of various synthetic data sources along with strategies to adapt models trained with this data so that they perform well on real data. Some main achievements are summarized below.

Physical cue extraction. We developed a robust and accurate head pose tracking framework from RGB-D data, making head tracking a commodity for situations up to 1.5m, and improving much other the state-of-the-art. It combines the benefits of an online fitting of a 3D face morphable model with the online 3D reconstruction of the full head, providing more support when handling extreme head poses. We addressed fast person and body landmark detection, investigating lightweight and efficient CNN structures, synthetic data, or knowledge distillation at several architecture levels to enhance the performance of these lightweight models.

Gesture recognition. We proposed a multimodal Deep Dynamic Neural Networks (DDNN) for the segmentation and recognition of short spontaneous communicative gestures. An interesting contribution was the use of a semi-supervised hierarchical approach fusing high-level spatio-temporal gesture representations trained using modality specific DDNN architectures (skeletal joint dynamics, depth and RGB image batch). Regarding head gestures, we proposed a frequency and head-centered rather than camera-centered representation of the head dynamics allowing to capture the subtle and large variety of nods from any view-point.

Gaze and attention modeling. Idiap has been pionneereing this research line since 2005, studying all methodological aspects of this problem. We are currently investigating deep learning models for gaze estimation, including several strategies to build user specific models. For instance, we designed a differential approach (patented) predicting gaze differences from the same eye, better eliminating in this way all nuisance parameters (eye shape, illumination conditions, inaccurate cropping), which can impact gaze prediction. Other works include robust eye segmentation using DNN and leveraging colorisation; online adaptation techniques leveraging social situations for weak target labeling; or user-specific retargeting for generating user-specific training data.

Audio analysis. In the context of social robotics, we investigate different DNN architectures for sound processing. We have proposed an efficient multi-task approach for the joint localization and categorization of multiple

sound sources. Compared to traditional signal processing methods, they require less assumptions about scenes, signals, sound sources, and can be optimized for the task, and proved to work much better both on benchmarks and in practice. Methods for adapting models trained from synthetic data to real data using only weak (partial) labels have been successfully developed, allowing to quickly learn models for new sensors.

Multimedia and multimodal analysis: Along this line, we have investigated deep learning methods for the detection, segmentation, semantic categorization and recognition of text, as well as multimodal face and person diarization and naming where, besides face tracking, clustering, audio-visual association, we also investigated deep-temporal representations for voice representation like the modeling of audio-visual speaking activities, e.g. to differentiate dubbing from genuine talking situations, or cross-modal domain adaptation and transfer learning methods for improving the estimation of speaker embedding leveraging face embeddings.

Main research themes over 2021-2024

Model unification. Currently, most of the tasks in scene analysis and human sensing are dealt with separately, and often call for different DNN architectures (and there are many of them for each task already). This presents the advantage of being modular, but at the same time is rather inefficient (a DNN needs to be run for each task) and does not take advantage of potential complementarity and redundancy between them. Standard multi-task approaches exist but encounter difficulties due to many heterogeneities like in networks and tasks (segmentation, regression, categorization), datasets available (all annotations are not available on a unique dataset), scale at which each phenomenon is captured (localizing a face vs identifying its gaze), modalities (depth, image, audio, sequence). Building a unique yet modular and efficient model, able to handle these heterogeneities is a challenge which will require the application and investigation of novel grounded principles for architecture design of networks of networks.

Unsupervised and weak learning. Supervised learning is still the dominant approach for learning new tasks, but usually needs a large amount of training data. While transfer learning can sometimes alleviate this need, approaches usually do not exploit the large amount of data available or which can be collected easily, but for which no or only partial weak annotation exist (e.g. there is a sound source, but we don't know where). However, being able to exploit such data is crucial to allow better generalization to new situations. We will further extend our work on this topic and plan to investigate new models and methods for learning semantic structures and representations from data in an unsupervised fashion. Of particular interest in the context of our application (activity and interaction sensing, social robotics) cross-modal and temporal approaches (audio vs video, robot proprioception vs perception outputs, cross-activity predictions) in which one modality is exploited for predicting other modality features will be explored.

Active perception and personalization. Human sensing methods still suffers from several limitations. In HRI where the cameras are usually placed on board of a robot head to allow for space exploration, or when using wearable sensors like google glass, mobile sensing negatively impact the captured signal (reduced field of view and visibility, blur, short or long sensing interruption). In another direction, it has become clear that a major driver for more accurate sensing is by personalizing generic models to individuals (e.g. for gaze tracking, emotion or gesture recognition), or to given set-ups or situatins. To address these issues, lines of research include for instance the design of gesture and interaction aware sensing strategies, or behavior synthesis and active sensing including speech synthesis and dialogue to make users implicitly or explicitly aware of perception uncertainties to elicit human responses and behaviors allowing to collect the required information.

Interaction models. While improving the extraction of non-verbal behaviors in natural interactions needs further robustness, exploiting them to analysis interactions and better characterize the social state the intent and events (moment to speak or perform a backchannel) represent another challenge with high value in HRI or HHI. We will move into this direction, investigating sequence classification methods to derive higher semantic interpretation of the multimodal streams of non-verbal features (prosody, head and body gestures, gaze) in the context of different scenarios.

3.3.6 RG6: Robot Learning & Interaction

Overview

Head: Dr. Sylvain Calinon (MSc, EPFL, 2003; PhD, EPFL, 2007)

The Robot Learning and Interaction group, created in 2014, focuses on human-centered robotic applications in which the robots can learn new skills by interacting with the end-users. From a machine learning perspective, the challenge is to acquire skills from only few demonstrations and interactions, with strong generalization demands. It requires the development of intuitive active learning interfaces to acquire meaningful demonstrations, the development of models that can exploit the structure and geometry of the acquired data in an efficient way, and the development of adaptive control techniques that can exploit the learned task variations and coordination patterns.

Main focus over the last Research Program (2017–2020)

For 2017–2020, the research themes and achievements concerned the development of robot learning and adaptive control algorithms, for robots that are either close to us (assistive robots in I-DRESS project, CHIST-ERA, SNSF), parts of us (prosthetic hands in the TACT-HAND project, D-A-CH, SNSF), or far away from us (manipulation skills in deep water in the DexROV project, EU H2020, SEFRI). Attentive to reproducible research, the group regularly releases open source codes accompanying its publications at www.idiap.ch/software/pbdlib/.

Task-parameterized models of movements: Task-parameterized models of movements refer to models that can adapt to external task parameters describing the current context. By encoding movements from the perspective of different objects, we showed that generative models could be used to generalize manipulation skills to new positions of objects. we then showed that this principle is not limited to objects in Cartesian space and could be extended to other forms of task parameters, including projection and prioritization.

Generative models of manipulation skills: After having collected demonstrations, the aim is to synthesize new movements that can generalize the task to new situations. The different projections of the demonstrated data reveal regularities that are exploited to adapt the task to new objects position in a probabilistic manner (including variations and options).

Autonomous regulation of robot impedance: The retrieved variability and correlation information is exploited to generate safe and natural movements within an optimal control strategy (minimal intervention principle). Moreover, this approach enables haptic communication capability that has great potential in human-robot collaboration.

Online learning from partial demonstrations and corrections: Online learning allows the user to provide partial demonstrations and to correct the robot skill without interrupting the execution of the task. For industrial robots, this approach provides refinement capabilities that do not require to stop the production lines.

Main research themes over 2021-2024

For 2021–2024, we will enforce the perspective that action-level and goal-level imitation should be combined to transfer skills from humans to robots, but also from robots to humans and in-between robots.

Learning by combining imitation, emulation and practice: Most efforts in robot learning are turned toward developing algorithms for specific learning strategies. Examples of such strategies include action mimicking (without understanding the objective), goal-level emulation (by discarding the specific way in which a task is achieved), exploration with self-assessed rewards or feedbacks. The ways in which these learning modalities

should be organized remain unaddressed. We plan to explore this meta-learning perspective by taking into account the social structure of skills acquisition, where both actors in the teacher-learner interaction can influence the success of the skill transfer.

Learning and synthesis of communicative gestures: In collaboration with the *Perception and Activity Understanding* group, we plan to extend the use of task-parameterized models to the generation of communicative gestures. This includes movements of head and torso (extraction and reproduction of coordination patterns involved in natural gaze shifts and behaviors such as looking away, addressing people, switching role in the conversation, etc.), as well as hand gestures to accompany speech or to point at objects or locations. We will similarly explore how this generative model can be exploited for active perception. This technology aims at providing service robots with the capability to initiate and follow conversations in a socially acceptable manner.

Anticipation through optimal control: Model predictive control (MPC) is ubiquitous in robot control, but it is less known that it can be combined elegantly with probabilistic representations of movements. This approach allows the retrieval of smooth and natural movements by taking into account variation, coordination and prioritization constraints. Instead of learning trajectories directly, it provides a framework to learn the underlying controllers to move the robot. For example, by learning to reject perturbations only in the directions that would affect task performance (minimal intervention control). We plan to exploit this capability to endow torque-controlled robots with the capability to modify autonomously the tracking gains and compliance required to reproduce a task.

Geometry-aware learning and control: Data encountered in robotics are characterized by simple but varied geometries, which are often underexploited when developing learning and control algorithms. These data can be related to rigid body motions, orientations represented as unit quaternions, sensory data processed as spatial covariances, or other forms of symmetric positive definite matrices such as inertia or manipulability ellipsoids. Moreover, many applications require these data to be handled altogether. The use of Riemannian manifolds will be explored as a way to broaden common optimization problems in robotics that are currently restricted to standard Euclidean spaces, by inherently taking into account the geometry of the data.

Tensor-variate regression: Sensory data in robotics are typically organized as multidimensional arrays (arrays of sensors, multiple channels, time evolution of data, multiple coordinate systems, etc.). This leads our group to investigate the field of tensor methods, also called multilinear algebra. Tensors are generalization of matrices to arrays of higher dimensions, where vectors and matrices correspond to 1st and 2nd-order tensors. When data are organized in matrices or arrays of higher dimensions (tensors), classical regression methods first transform these data into vectors, therefore ignoring the underlying structure of the data and increasing the dimensionality of the problem. We plan to investigate the use of expert models (product of experts, mixture of experts) relying on tensorial representations. The goal is to devise models and algorithms that can take into account the underlying structure of the data, and that remain efficient even when only few training data are available.

Intuitive human-robot teaching interfaces: The development of collaborative robots comes along with the development of intuitive user interfaces. We plan to explore the use of augmented reality devices, including head-mounted display and less intrusive solutions based on smartphones. The target is to replace the teaching pendants classically used in industrial robotics with these uprising technologies. We plan to exploit these interfaces in a bidirectional manner, namely, as a way to visualize data directly in the robot workspace, and as a way to re-program robots by selecting objects and points/trajectories of interest.

3.3.7 RG7: Computational Bioimaging

Overview

Head: Dr. Michael Liebling (MS, EPFL, 2000; PhD, EPFL 2004); Postdoc, Caltech, 2004–2007; Assistant Professor, University of California Santa Barbara (UCSB), 2007–2013; Associate Prof., UCSB, 2013–2017, Adjunct Prof., UCSB, 2017–2020

Research in the Computational Bioimaging Group focuses on developing image acquisition devices combined with reconstruction and analysis algorithms to study live biological systems. Practical tools aim at (i) extending the physical limits of imaging hardware via techniques including super-resolution imaging and multi-view, space variant deconvolution, and (ii) quantitative analysis of complex biological systems, including motion-based image analysis, cell tracking, microscopic fluid flow estimation, and integration of multi-modality images.

Main focus over the last Research Program (2017–2020)

Dr. Liebling has been with Idiap full-time since January 2015. Recent highlights and current activities in his group for the period 2017–2020 are summarized below.

Development of high-speed fluorescence microscopes leveraging temporally-structured illumination: Computational imaging allows complementing optical setups to push performance beyond direct measurement capabilities. We have developed combined hardware-software device to break the temporal resolution limit imposed by how slow sensitive fluorescence cameras are and how scarce fluorescence photons are in dim samples. To achieve this goal, we implemented a spatio-temporally-structured illumination device and super-resolution image reconstruction algorithms, inspired by spatial super-resolution techniques that have recently been shown to enable sub-diffraction-limit spatial resolution.

Imaging Cardiac Development Within the joint SNSF and French ANR project "liveheart: The cellular basis of cardiac development revealed by live imaging," our group developed methods for virtual high-framerate microscopy of the beating heart in live animal embryos and larvae, via a computational methods. These methods include temporal image registration of image sequences acquired over multiple heartbeat, still image sorting methods, and compensation for scanning artefacts. We characterize our approaches by evaluating their accuracy both on synthetically generated data and high-speed reference movies.

Learning-based Computational Microscopy Optical microscopy allows biologists to acquire both qualitative and quantitative data about cellular function, organ development, or diseases, even within live organisms. Light diffraction (both within the sample and the microscope) limits achievable resolution. We developed a semi-blind, spatially-variant deconvolution technique that combines a local estimation step of the point spread function (PSF; which fully characterizes the optical properties of the imaging system that lead to image degradation) followed by a deconvolution step based on a spatially-variant, regularized Richardson-Lucy algorithm. To find the local PSF map in a computationally tractable way, we devised a convolutional neural network (CNN) that performs a regression of a parametric model of the PSF. We trained the CNN by synthetically blurring a library of image patches, using point spread functions of known parameters. This approach does not require labor-intensive measurement of experimental PSFs and has low computational complexity. This research is part of the SNSF funded project "COMP-BIO Computational biomicroscopy: advanced image processing methods to quantify live biological systems" and was carried out on Idiap's imaging platform, SNSF R'Equip project "Platform for Reproducible Acquisition, Processing, and Sharing of Dynamic, Multi-Modal Data."

Platform for Reproducible Acquisition, Processing, and Sharing of Dynamic, Multi-Modal Data In this project, a joint effort between groups at Idiap, we assembled a platform for reproducible acquisition, processing, and sharing of dynamic, multi-modal data. This modular platform consists of four layers: sensing, positioning,

computing, and storage. It accepts a wide range of sensing devices and complements Idiap's already existing infrastructure for collecting data in the areas of computer vision, biometry, and speech processing. Concretely the platform consists of the following components

Main research themes over 2021-2024

Research in the Computational Bioimaging group will continue to complement Idiap's current research areas with a focus on computational imaging, specifically in the areas of biomedical imaging (bio-image processing, analysis) and microscopy. The group will build upon and extend its collaborations with biologists, biophysicists, and optical engineers in Switzerland, Europe, and the United States. It will also leverage, through internal collaborations, the strong expertise of Idiap in the related areas of statistical modeling, computer vision, robotics, and machine learning.

Inverse Problems in Computational imaging We will continue our efforts to develop algorithms to model light propagation and image formation in optical systems, an essential component of making computational imaging methods practical. These algorithms could directly benefit deconvolution (blur reduction), lens-less imaging (such as digital holographic microscopy with partially coherent light), or image restoration tasks. Our work will model optical systems within the context of sparse function representation spaces, inverse reconstructions via non-linear optimization methods, learning approaches, and fast implementations on GPU architectures.

Image-guided Optical Microscopy Systems and Protocols: Microscopes are increasingly fully computer-driven, which opens the possibility to combine image acquisition, processing, and analysis early in the imaging chain. We will continue our efforts of leveraging the capabilities of existing (and develop new) computational imaging systems (systems where the instrument does not produce the image directly, but rather, the data that enables reconstruction of an image). Examples include task-specific and optimally allocating imaging resources (to minimize sample exposure or imaging duration) . The procedures could be applied in high-throughput observation systems to characterize biological function in larger sample populations. This area will particularly benefit from collaborations within Idiap in the areas of machine learning, computer vision, and robotics, specifically with the Robot Learning & Interaction group (automated microscopy platform) and the Computer Vision and Learning group (multi-view object tracking).

Computational Imaging with AI: Opportunities, Limitations, and Trust Imaging plays a central role for scientific discoveries: beyond their illustration role, images are increasingly used as a basis for extracting quantitative information. A specific example is optical microscopy, which has benefitted from several transforming advances in recent year, with the combination of both hardware (optical) and computational tools, from which research in biology and medicine is already benefitting. Inclusion of AI methodologies to break additional barriers is both the source of high expectations and concerns. One area of research of the group will seek to quantify possible biases arising, for example, from the use of image training set with minimal connection to the imaging modalities of interest, a practice common for its convenience. We will focus primarily on optical microscopy as it provides a concrete, highly controlled and controllable imaging environment where the impact of including AI methodologies into established biological or medical research methodologies can be systematically studied.

Combining multi-dimensional, multi-modal imagery with non-imaging physiology or gene expression data Combining both imaging (optical microscopy, electron microscopy) and non-imaging data sources (e.g. genomics) is both an area with high innovation potential for systems biology and medicine yet remains very challenging. Combining data from multiple sources, of variable quality or scope make a highly variable environment. We aim at developing tools to assist in the systematic integration of such heterogeneous data (e.g. from high-throughput genomic plates, high-resolution fluorescence images or high-speed functional signals). This research could leverage and build upon frameworks developed at Idiap in the context of heterogeneous data analysis (speech, text, video).

3.3.8 RG8: Uncertainty Quantification and Optimal Design

Overview

Head: Prof. Dr. David Ginsbourger (Habilitation in Statistics and Applied Probability followed by a Titular Professorship (University of Bern, resp. 2014 and 2018), Ph.D. in Applied Mathematics (Mines Saint-Etienne, 2009), MSc. in Applied Mathematics and double diploma in Engineering (Mines Saint-Etienne and Technische Universität Berlin, 2005), Licence in Mathematics (Grenoble, 2002)).

The Uncertainty Quantification and Optimal Design (UQOD) group focuses on quantifying and reducing uncertainties in the context of natural and artificial complex system modelling. Application domains notably include energy and geosciences, with a number of collaborations ranging from safety engineering to hydrology and climate sciences. In all these fields, the study of complex systems often relies on expensive high-fidelity experiments and/or numerical simulations depending on a number of inputs including both controlled design parameters and uncontrolled environmental variables.

Uncertainty Quantification encompasses a set of mathematical, statistical, and algorithmic approaches at the interface of complex modelling of processes and data, with the aim to elicit and characterize inherent uncertainties. Optimal Design deals with the choice of controlled design parameters relying on global optimization. Elaborated model evaluation strategies are needed for making optimal decisions, be it for deterministic numerical simulations or for design under uncertainty. The main focus of UQOD is on Gaussian Processes (GP) methods and adaptive design of experiments for optimization, inversion, and related problems.

Main focus over the last Research Program (2017-2020)

While a number of UQOD's methodological approaches are inscribed in Idiap's core competences such as machine learning and optimization, UQOD puts a focus on complex systems stemming from contemporary societal challenges (notably arising from geo- and climate sciences, industry, etc.), calling for mathematical and interdisciplinary developments towards parsimonious algorithms. The main research themes and achievements of the UQOD group over the years 2017-2020 are briefly summarized below.

Quantification of uncertainties on critical regions: A number of applications from science and society require circumscribing regions of parameter spaces of natural and artificial systems which associated response values may cause a danger (catastophes such as floods, hail storms, etc. but also industrial incidents) or, conversely, regions leading to beneficial states (e.g., physical stability/safety, economical viability, or allowing a "good fit" in model calibration). Yet, estimating such regions can be very intensive in terms of system evaluations (often performed via numerical simulations), so that estimates typically come with remaining uncertainties. Bayesian set estimation, primarily relying on Gaussian process models, has been one of our main research topics. Following up the defense of Dario Azzimonti's PhD (Moser award 2016, IMSV, University of Bern), we have conducted a short project funded by the Hasler foundation on "Learning and visualizing dangerous regions in multivariate parameter spaces" resulting in the publication of a new method developed with the French Geological Survey (BRGM) in the context of flooding simulations, and in the R package "profExtrema".

Stepwise Uncertainty Reduction strategies have also been a topic of interest of UQOD, as refelect notably by a long-standing theoretical work DG has been involved in with colleagues from Centrale-Supélec and Toulouse Institute of Mathematics. Recent and current work include conservative extensions of Bayesian set estimation and related sequential design strategies, as well as original applications in contexts (like volcano geophysics) where sets of interest and/or measurements are only indirecly linked to a reference property field.

Bayesian global optimization: Recent contributions in the vivid field of Bayesian Optimization (BO) include a research collaboration with colleagues from hydrology around contaminant localization, having not only lead to a publication but also to an original data set that can be notably used in optimization benchmarks. On

the theoretical side, the paper mentioned above on the SUR strategies establishes in turn consistency of some BO algorithms in a supermartingale set-up. Besides, DG has been involved in further related works, e.g., in approaches relying to random embeddings, one way to extend the applicability of BO to higher dimensions.

Modeling and prediction of non-stationary functions and phenomena: Another bottleneck of methods appealing to time- and/or space-dependent statistical models is the account for non-stationarity, ranging from the design of adapted models to the inference of related parameters. One research thread in the last few years has been incoporating data-driven heterogeneities within GP models, be it in a multidimensional context with one or several oblique warpings estimated together with their associated directions (Cf. "WaMI" GP models) or in a signal processing framework with links to wavelets. On a different note, UQOD has been involved in climate-related research where non-stationarity was key, for instance in the modelling of hailstorms in Switzerland (collaboration with colleagues from the Oeschger Center of Climate Change Research, University of Bern).

Main research themes over 2021-2024

Uncertainty Quantification and sequential design of experiments in the context of inverse problems: Inverse problems are one of the cornerstone of applied sciences, notably geophysics but also engineering, medecine, and many other disciplines. For non-linear phenomena, such problems are increasingly addressed using Bayesian approaches, where inputs of interest are endowed with a prior distribution, which is then sequentially updated as (noisy) observations of some observable output(s) are assimilated. A number of issues make it challenging to apply this methodology on realistic applications, including expensive to evaluate likelhoods, high- or infinite-dimensional priors that can be hard to elicit, large-scale data volumes, and the complexity of encoding uncertainties when it comes to non-Euclidean random variables such as random sets. One of the aspects that we will work on in the coming years is the transposition of modern Bayesian set estimation approaches to inverse problems arising in domains such as geophysics, where advanced spatial statistics approaches are already in place but their outstanding potential for target-oriented sequential design has been underexploited.

Pushing the limits of expressiveness in random field modelling: While it has been shown that Gaussian Process and related model could incorporate various structural properties such as symmetries, additivity, harmonicity and more, a number of questions remain open regarding ways to unveil their potential to substantially reduce on hand the number of observations needed to reach a wished prediction accuracy thanks to prior information, and also on the other hand how to question/investigate such properties relying on scarce, unbalanced, potentially noisy data. Likelihood-based approaches will be considered as well as alternatives, reyling for instance on fast K-fold cross validation. Novel developments are expected to help coping with high-dimensionality and sensitivity analysis, model misspecification, and also ultimately allow a better interpretability of Gaussian process and neighbouring methods via variations on the multiple kernel learning set-up.

Distance and kernel methods in non-Euclidean contexts: For *very complex inputs* (e.g., geological/materials media, but also uncertain parameters encoded as probability distributions), it sometimes makes more sense to appeal to elaborated mathematical distances but also to non-metric notions of similarities –based for instance on expert judgement– rather than traditional analysis in terms of Euclidean distances between input vectors. While some classic approaches like Multi-Dimensional Scaling appeal to Euclidean approximations of non-Euclidean distance matrices, other recent developments in the vein of Reproducing Kernel Hilbert Space embeddings consist instead in adopting metrics that enjoy a number of convenient properties. In the next years, similarity- and distance-based prediction and experimental design approaches relying on both paradigms and variations thereof will be further researched on, with applications ranging from hydrology to mechanical engineering.

Random fields of probability density functions will be investigated towards improved noise modeling in non-stationary contexts, which could prove beneficial in stochastic optimization and inversion, e.g. via speeding up procedures such as Approximate Bayesian Computing or hyperparameter tuning in Deep Learning.

3.3.9 RG9: Natural Language Understanding

Overview

Head: Dr. James Henderson (BSc, Massachusetts Inst. Technology, USA, 1987; MSE & PhD, Univ. Pennsylvania, USA, 1991,1994; MER & Chargé de Cours, Univ. Geneva, 2008–2012,2012–2018)

The Natural Language Understanding (NLU) group was created in September 2017, in part as a continuation of the previous Natural Language Processing (NLP) group. The NLU group studies deep learning for natural language processing tasks, focusing on models with learned representations of the meaning of text. Some tasks are studied because they indicate different aspects of the meaning of text, such as textual entailment, syntactic and semantic parsing, coreference resolution, and language modelling. Other tasks are also important applications, such as machine translation, opinion summarisation, information extraction, and text classification, applied to both text and speech.

Idiap's NLU group is rare in making contributions to these tasks at many different levels, ranging from novel deep learning architectures, to capturing linguistic generalisations, to exploiting the latest advances and insights for each application. We develop recurrent and attention-based neural network models, because they capture the unbounded nature of language. We develop vector-space models of entailment (rather than similarity), because entailment is fundamental to the semantics of language. We take unsupervised and multi-task approaches to representation learning, because no one task embodies the full meaning of language.

Main focus over the last Research Program (2017–2020)

For 2017–2020, the main research themes and achievements of the NLP and NLU groups have combined a continuation of the projects started by the NLP group with new themes introduced by the NLU group. The NLP group demonstrated that the semantic analysis of noun phrases is beneficial to neural machine translation (MT), that word sense disambiguation can be combined with statistical and neural MT, and that coreference resolution is helpful to statistical MT. Their hierarchical attention neural networks proposed for cross-lingual transfer on document classification in 8 languages met with considerable success, earning a best paper award at one of the main NLP conferences. The NLU group continued work on neural MT, including work on using word sense disambiguation, adding an attention mechanism over the previous target-side words, and using hierarchical attention to condition on previous sentences. In addition, the research themes have shifted to more work on deep learning architectures for NLP, in particular since the awarding of two SNSF projects on NLU. The NLU group currently includes the head of the group, two postdoctoral researchers, and 4 PhD students.

Capturing the Structure of the Output Space: In many NLP tasks, both the input and the output of a model are text. For the output, this ranges from text labels for text classification to entire sentences for machine translation. In a series of papers, the NLU group has shown that it is useful to learn the structure of the output space as reflected in the output's associated text. We showed improvements on both outputs with no training data ("zero-shot" learning) and outputs with training data, and that deep models of the output space improve over shallow models. Currently we are investigating embedding outputs in a bag-of-vector space, instead of a single vector, so as to handle larger more complex output structures such as parse trees.

Semantic Representation Learning: Representation learning is central to deep learning architectures, especially for the nebulous objective of learning the meaning of text. In recent work (under review), we have shown that entailment-based vector representations of sentences are effective for textual entailment, and that adversarial training to remove annotation artefacts in sentence embeddings can improve the portability of textual entailment models. We have also developed models for identifying discourse entities in text and their coreference chains, with the objective of learning entity embeddings for use in other tasks. Current work investigates the use of entailment-based vector representations in recurrent and attention-based deep learning models, and the use of bag-of-vector representations in graph-to-graph deep learning architectures.

Main research themes for 2021–2024

For 2021-2024, work in the NLU group will continue to focus on semantic representation learning, but with a greater emphasis on task-universal semantic representations, and more applied work on opinion summarisation.

Multi-task semantic representation learning: The meaning of text is as complex as human thought itself. Each NLP task only provides us with one view on this semantics. We need to combine as much data from as many views as possible to learn the real nature of meaning in text. This calls for multi-task learning, where different models of different tasks share a common semantic representation, which is trained jointly on all data. This contrasts with the traditional approach of training separate models with bespoke representations for each task, but is in line with recent results showing large improvements by pre-training powerful architectures on language modelling tasks. This approach raises many challenges, including the fundamental issue of the structure of a task-universal semantic representation of natural language, which has implications for not only NLP technology but also psycholinguistics and neurosciene. We believe that bag-of-vector representations (as in attention-based models) will form the basis of such a representation, as discussed further below. Our work on this problem will include training large joint models of several tasks, including language modelling, machine translation, textual entailment, syntactic-semantic parsing, and coreference resolution. Our objective is to develop, train and release an integrated NLU toolkit which can be quickly adapted to solve any task involving the meaning of text.

Multi-level bag-of-vector semantic representations: Attention-based deep learning architectures (such as the Transformer architecture) have shown great performance in many NLU tasks, especially with pre-training on language modelling. These models rely on bag-of-vector (BoV) representations, with content-based addressing (attention) used to access the elements in the bag. This contrasts with both traditional neural network representations, where everything is encoded in a single vector, and with traditional linguistic representations, where multiple levels of representation each consist of graphs of symbols. We hypothesise that the vectors in the bag can be identified with the "entities" in the linguistic representations, which are the vertices of the linguistic graphs. We plan to devolop new deep learning models which demonstrate the empirical adequacy of such bag-of-vector representations for the semantics of language.

One important difference between BoV representations and linguistic graphs is the lack of an explicit representation of the relationships between entities. We will therefore study graph embedding models, where the edges of the graph can be predicted from the pair of vectors for their associated vertices. Many existing attention-based NLP models can be viewed as such models. Another difference is the use of continuous vectors instead of discrete symbols to label entities. We will investigate how such continuous models can still explain categorical perception effects, for example using categorical Bayesian priors over vectors.

Another important difference between current BoV representations and linguistic representations is the lack of multiple levels of representation (e.g. phonology, morphology, syntax, semantics, discourse). Different levels have different entities, as well as different types of graphs (e.g. sequences, trees, sparse graphs), thus suggesting multiple BoV representations. Important open questions include how to integrate multiple levels in a single model, how to induce entities for one level given the entities for another, and how to measure similarity or entailment between multi-level BoV representations.

Opinion summarisation: Opinion summarisation is the task of producing a comprehensible summary of a large set of opinions. It differs from summarisation and multi-document summarisation in that the distribution is important, since it is not assumed that all the opinions are consistent with each other. Although this task has received relatively little attention, it is fundamental to improving the way societies communicate, in that it allows everyone to directly hear the opinions of everyone else, through a representative summary. Current work in the NLU group is addressing this task through the inference of consensus opinions using textual entailment, and clustering on that basis. Our goal in the next years is to build deployable opinion summarisation systems which support large-scale public opinion collection, communication and prediction.

3.3.10 RG10: Biosignal Processing

Overview

Head: Dr. André Anjos (BSc, MSc & PhD, Federal University of Rio de Janeiro, Brazil, 1999, 2001, 2006; Visiting Professor, State University of Bauru, 2015; Lecturer, EPFL, 2013-)

Biosignals are signals from living beings and their analysis to support medical or related research. This group focuses on biomedical-related areas such as the analysis of e-Health records, human-signal and imaging sensing for healthcare and similar applications. Current trends in the field show refreshed interest on the use of machine learning techniques, complementing basic signal and sequence processing, all of which are key domains of research at Idiap. It leverages and contributes to Idiap's expertise on human subject handling, data acquisition, open science and data processing.

Main focus over the last Research Program (2017–2020)

Dr. André Anjos, the head of the group, transitioned from his role in the Biometrics and Security Group to this permanent position through 2018, to build this new research direction at Idiap. Recent highlights of his group's activities, during the period 2017–2020, are summarized below, and overlap with his previous activity with the Biometrics Group.

Spoofing Detection in Biometric Recognition: With world-wide deployments of biometric recognition technologies in smart devices and border control, the detection of attacks to these systems has become one of the main challenges in this domain. Most systems work discriminatively, trying to separate attacks from *bona fide* presentations. Dr. Anjos's work showed this technique does not generalize well to unseen attacks. Together with the Biometrics Group, they explored, for the first time, alternate approaches by joint-modelling client identity as a way to calibrate PAD output scores, showing increased robustness to unseen events. They demonstrated candidate presentation attack instruments and biometric recognition systems must undergo a vulnerability assessment to quantify the pertinence and quality of attacks. They also devised a way to tune protected biometric systems to various different applications, with changing security requirements. Finally, we showed it is possible to add sensors to PAD systems to improve their robustness without affecting its usability.

Reproducibility in Data Sciences: Dr. Anjos has been actively looking at the reproducibility of published work and how to lower the entrance barrier of publication readers, converting them into engaged users of methods they create. He argues it is insufficient, in most cases, to only publish software leading to results if original data remains inaccessible. He noted that reproducibility should imply in the following characteristics: repeatability, shareability, extensibility and stability, which are not guaranteed by most published material to date. They proposed a software suite called Bob (https://www.idiap.ch/software/bob) that possesses such characteristics, demonstrating its flexibility to various tasks including Biometric Person Recognition, Presentation Attack Detection, Remote Photoplethysmography, and Speech Processing. Together with other groups at Idiap, they built an open platform for research in computational sciences related to pattern recognition and machine learning, to help on the development, reproducibility and certification of results obtained in the field. The BEAT platform is distributed under an open-source license (https://www.idiap.ch/software/beat/).

Main research themes over 2021-2024

Research in the Biosignal Processing group will complement Idiap's current application areas to include a focus on health-related applications. The group will pursue Swiss and international (France, Norway, Brazil, Tanzania) collaborations with medical doctors and health-care workers. It will leverage and contribute to Idiap's expertise on human subject handling, data acquisition, open science, signal processing, pattern recognition, and machine learning.

Robust and Interpretable Biomedical Image Analysis (Ophtamology): Many important eye and systemic diseases manifest themselves in the eyes, and specifically in the human retina. We have particular interested in 2D fundus photography, and on methods for segmenting, analysing and understanding data within. Ethinical and acquisition diversity, together with the lack of interpretability are possibly the main barriers for technology spread. Our goal is to develop both robust and interpretable systems for screening and diagnosis from fundus images.

Continual Lifelong Learning for Medical Applications (Lung Diseases): Tuberculosis is the first cause of death from infectious diseases worldwide, with one quarter of the population infected but with no symptoms. Contributions to this field of medicine are sought for the elimination of the disease by 2050, according to the World Health Organization. Recruiting the right set of patients that accurately represent the diseases/medical conditions under study is challenge, let alone acquiring and managing private data (patient records) across institutions. These constraints hinder deployment and development of intelligent models in the health sector. Our aim is to develop techniques allowing a continual lifelong learning process that does not stop after the deployment of artificial intelligent solutions, and can learn on the job, directly from medical staff.

Regression for Medical Care (Patient Screening): Patient triage is a life-saving process of prioritizing medical consultations for those who need it most. In low-resource settings the most, triage is often not practiced or is limited to a generic, snapshot assessment performed on arrival. Solutions are needed that empower patients to better communicate their changing medical urgency without burdening limited healthcare staff. Our goal is to develop techniques for patient-led self triaging using artificial intelligence, bridging self-reported symptoms and patient outcomes in secondary and terciary care. After clinical validation, such systems may be also deployed in mobile applications and serve patients remotely.

Vital Signal Acquisition and Anomaly Detection (Personalized Health Care): Deteriorating medical conditions and cardiac arrest are often preceded by a period of increasing abnormalities in the vital signs (respiratory rate, oxygen saturation, temperature, blood pressure, pulse/heart rate, AVPU response). Measurements in patients by nurses or in self-monitoring regimens are time consuming and prone to operational errors. Our aim is to develop robust intelligent solutions that can detect anomalies based on these signals, and warn patients and medical staff as early as possible of deteriorating health conditions. Main challenges in this domain lie in the unreliable accuracy of devices, and the lack of synchronicity between measurements.

Reproducibility in Data Sciences: Continuing on existing efforts from the Idiap Research Institute to better tackle reproducibility in data sciences, our aim is to pursue the development of the BEAT framework. BEAT is now the core framework of projects in Robotic simulation, Machine Translation and Speech technologies, in partnership with other groups at Idiap and abroad (France, Italy, Spain). The BEAT framework also participates in the pan-european H2020 project AI4EU, with the goal to unify artificial intelligence (AI) platforms across Europe. Our ambition is to expand the BEAT framework so it becomes a federated system of AI resources and becomes the *de facto* way to describe experimentation and deployment in artificial intelligence.

3.3.11 RG11: Energy Informatics

Overview

Head: Dr Jérôme Kämpf (BSc. in Physics, UKC, 1999; MSc. in Physics and Computer Science, UNIL, 2001 and 2003; MSc. in Teacher Education, HEP-VD, 2005; Ph.D., EPFL 2009); Postdoc, EPFL, 2009–2011; Research and Teaching Associate, EPFL, 2011–2016; Professor of Building Energy Efficiency, HEIA-FR/HES-SO Fribourg, 2016–2019.

Research in the Energy Informatics group focuses on the exploitation of state-of-the-art Information and Communication Technology (ICT) to tackle global warming and climate change challenges. Applications include studies: (i) to increase integration of renewable and distributed energy sources by making energy systems smarter, (ii) to increase energy efficiency beyond what improvements at component level can achieve, and (iii) to develop appropriate management plans that optimize energy resources while protecting the environment. The developed methodologies intend to bring ways to simulate energy transition pathways with intelligent control and adjustment mechanisms of evolving buildings with retrofitting and use, renewable energy production and energy storage in a changing climate.

Main focus over the last Research Program (2017–2020)

Dr. Kämpf has been with Idiap part-time from September 2018 to February 2019 and full-time since March 2019. Recent highlights of his group's activities at the University of Applied Sciences in Fribourg (HEIA-FR/HES-SO) during the period 2016–2019 are summarized below. These activities are now being carried over to Idiap, where they will tie in with local expertise, more specifically in smart sensing, data mining, uncertainty evaluation, and machine learning.

Smart luminaire, shading control and thermostat: Through a project financed by the Smart Living Lab in Fribourg, a new Smart Luminaire developed by the EPFL start-up company Insolight was tested. Its unique technology to adapt light intensity and directionality was assessed regarding light quality, energy consumption and controllability through a mobile app. The results of the project were presented within the IEA SHC Task 61 / EBC Annex 77 "Integrated Solutions for Daylighting and Electric Lighting: From component to user centered system efficiency" and publications. In the meantime, Dr. Kämpf's PhD student Yujie Wu successfully defended his thesis in 2019 at EPFL on the topic of "Automated Daylighting Control System based on Sky Luminance Monitoring and Lighting Computing". Yujie's work was related to the development of an embedded control system to optimize the blinds position or electrochromic glazing transmission to avoid glare while preserving a maximum of daylight penetration in buildings. Additionnaly, through a collaboration with the start-up company SimplyHome, an algorithm to predict with a few indicators the physical behaviour of the air temperature within buildings was developed in order to provide a smart control of thermostats for classical radiators. Finally, through a collaboration with the University of Texas at Austin, a smart control algorithm based on machine learning was developed in order to optimize dynamically the setpoint temperature of a storage tank for cooling according to the photovoltaic generation and outdoor air temperature.

Urban energy and comfort simulation: As 68% of the global population is forecasted to live in cities by 2050 (UN projections), major energy challenges reside in urban areas. With a renovation rate of about 1% per year related to long term investments and a consumption of about 40% of the total primary resources, the building sector is where simulation tools are most valuable. With those facts in mind, continuous developments of the http://citysim.epfl.chCitySim Solver, and urban energy simulator initiated by Dr. Kämpf while at EPFL, were carried out in the last years. Recently, with the increase of heat waves in summer due to climate change, the research topic slightly shifted his focus to include the evaluation of outdoor urban comfort. To add this dimension to the software, Dr. Kämpf's PhD student Silvia Coccolo studied in her thesis defended at EPFL in 2017 "Bioclimatic Design of Sustainable Campuses using Advanced Optimisation Methods" ways to quantify

evapotranspiration processes to evaluate and optimize pedestrian comfort. Finally, to get more precise insights about micro-climatic effects on urban comfort and energy consumption of buildings, an effort of co-simulation between air flow models and CitySim was carried out through a collaboration with EPFL (Canopy Interface Model), KADK (Dragonfly) and ETHZ.

District heating and cooling networks optimisation: District and cooling networks are often seen as a good vector to transport energy from one building to another. However, as a fluid is used to carry the heat, complex thermal and hydraulic phenomena are at stake. Through a project with BlueFactory in Fribourg, where a future campus will be created, the potential of an anergy network to provide heating and cooling to the buildings by distributed heat pumps running on photovoltaic and solar thermal production was studied. Futhermore, a simplified simulation tool was developed with the company RWB Fribourg SA to simulate tree-based district heating networks. The simulation platform allows for a manual testing of diverse control procedures to optimize the energy needed by the pumps, and of different options for network extensions supporting important embedded energy savings.

Main research themes over 2021-2024

Research in the Energy Informatics group will complement Idiap's current research areas to include a specific focus on Artificial Intelligence applied to the Energy domain. The actual energy efficiency and integration of renewables challenges (specifically to be adressed within the Swiss Energy Strategy 2050) will benefit from the strong expertise of Idiap in areas of smart sensors and data mining, uncertainty quantification, and machine learning.

Smart integrated building controls for energy and comfort: While building control strategies mainly focus on energy efficiency of buildings, a user centric approach is essential to mitigate the rejection of all-automated systems. Our proposed approaches will involve a trade-off between energy and comfort by including the users' preferences in the control decision process. Both low-tech buildings (majority of the housing stock) and high-tech buildings will be targeted, through mobile app notifications for the users and/or control of mechanical and electrical systems (HVAC, blinds/electrochromic and electric lighting).
Collaborations within Idiap in the areas of smart sensors and data mining are foreseen to benefit from the strong existing expertise in the other research groups.

Smart cities with renewables, greeneries and networks: Smart cities involve an advanced control of their infrastructure to minimize non-renewable energy consumption and renewable energy losses, while maximizing local energy production and transport. To achieve this goal, we need to develop ways to dynamically evaluate the energy production (mainly by renewables), the energy consumption (mainly by the built environment), the energy transport (by networks) and the storage capacities (batteries or heat tanks). Our aim is to develop hybrid physical and statistical models to predict possible evolutions of actual cities towards smart cities. The models will include urban energy but also urban comfort, to commit to liveable cities adapted to climate change.
In addition to international exchanges we foresee collaborations within Idiap in the areas of machine learning and uncertainty quantification.

Digitalisation and open-data to support energy challenges: Researchers generally face a lack of data relating to the infrastructures of cities, even with the most digital ones. This lack is not only related to the energy sector, but covers data ranging from building cadaster to public space use. Our goal is to work on an open-data framework to support the digitalisation of the energy-related infrastructure of the cities. The digitalisation foreseen is intended mainly to support the energy simulation but may not be restricted to it. A trade-off will be established between the amount, quality and importance of the data to support predictions with both physical and statistical models.
We foresee collaborations with the "Centre de Recherche Energétiques et Municipales" (CREM) to establish partnerships with stakeholders in cities. Internally at Idiap, collaborations will extend to the the legal and data managers expert in biometric security.

3.3.12 CRGx (example): Cross-Media Indexing for Multimedia Information Retrieval

Overview

Head: To be hired (possibly based on the current search around the Idiap Female Fellowship programme

Given the deluge of multimedia data in multiple industrial sectors, more and more companies have urgent needs in terms of intelligent cross-media indexing enables to enrich and augment the indexing of multimedia information, such as for example videos or web documents, by linking together all indexing information obtained from the different single media that compose a specific multimedia item (e.g. a video story segment or a web page).

Past research has shown that cross-media indexing can greatly augment and enhance the value of single media indexing for multimedia documents by cross linking information found in different media types within an uncertain evidence framework. However, while this problem has already been extensively researched there is yet no clear solution since this require

Main research themes over 2021-2024

A video segment could contain speech, music, images, text (e.g. captions, subtitles), faces, and so on, with different indexing information attempting to characterise the content of the video segment can be extracted from these media. So, speech can be translated into text and can be used to partially identify the topical content of the video segment by extracting index terms or facts, but can also be used, when possible, to identify the speaker or, in some cases to discern the speaker's emotions. Images can be used to characterise the scenes (e.g. indoor vs. outdoor, urban landscape vs. countryside) or to identify specific objects or buildings appearing in the video. Other media can provide additional information. However, speech recognition, image or face recognition and in general all of these single media analysis technologies are far from perfect and often produce errors.

The power of cross-media indexing is in linking the information provided by the analysis of the different single media so that errors produced by specific different single media processors can be compensated by the results of other analysers and a more precise and more comprehensive indexing of the video segment can be obtained.

Indexing features extracted from the different single media processors can be combined to boost each other or to compensate each other, so that detection or recognition errors can be recovered from. This requires mathematical models to combine multiple uncertain evidence that will have to be evaluated within a proper evaluation framework.

Building upon strong speech, video, text and social media analysis tools (all available research in current RGs), we should aims at investigating different mathematical models of cross-media indexing and to evaluate them using a purpose built test collection of multimedia material (videos) where each single media material as well as the multimedia material have been indexed and assessed for relevance separately and independently.

This type of application would require significant research into additional, cross-group, areas, including:

- Data Sets and Resources; identification and collection of data sets and knowledge bases
- Analysis and Metadata: Effective parsing and understanding of sources whose content is distributed across multiple input modes:
  - Further development of analysis tools within groups: person identification, multi-lingual speech recognition, activity recognition, text understanding, etc.
  - Development of analysis tools and their integration across groups targeting specific multi-media data sets

- Assimilation and Unified Indexing: Embedding information extracted from different modalities plus information from a knowledge base in a single vector-augmented knowledge base
  - Shared vector-space representations across modalities, languages, etc.
  - Embeddings of large graphs of information
  - Computational scalability
- User Interaction and Applications: Providing users with the information access methods they need
  - Identifying user requirements
  - Retrieval and browsing of integrated information
  - Visualisation and generating textual descriptions of integrated information

3.4 Academic and Training Activities

Idiap's academic and training activities are usually acknowledged through several indicators: (1) the quality, productivity, and visibility of our PhD students; (2) our tight relationship with EPFL, reinforced through the EPFL-Idiap Joint Development Plan (initially signed in 2008 and renewed in 2012); (3) our formal teaching activities at EPFL and less formal training activities within the institute; and (4) the increasing number of joint EPFL-Idiap initiatives in terms of academic activities or joint project proposals.

3.4.1 Academic anchoring

EPFL: Since 2008, Idiap has benefited from a Joint Development Plan with EPFL (founding member of Idiap). Although its implementation has proved more difficult and slower than expected, it is now clear that both institutions benefit greatly from this common plan, especially in the important area that has become Artificial Intelligence. At a recent meeting of the entire EPFL management (President + all the Vice-Presidents) at Idiap, EPFL clearly reiterated its desire to see relations between the two institutions tighten, and to do everything possible to go in this direction, within the limits of their own statutory and institutional constraints. The same will is continuously acknowledged from the EPFL STI (School of Engineering). We recall here that apart from the director of Idiap (Prof. Hervé Bourlard, regular professor at EPFL), three other Idiap researchers (Daniel Gatica-Perez, François Fleuret, and Jean-Marc Odobez) also have EPFL academic titles. In addition, 10 courses are also taught at EPFL by Idiap's permanent staff.

UniGe and others (incl. NCCR in "Human Trust in AI"): Of course, the academic relations of Idiap extend to almost all the universities (federal, cantonal and HES) with which we have regular collaborations. However, a second privileged and particularly dynamic partnership seems to be emerging with the University of Geneva. Reinforcing this trend, our NCCR proposal (still in evaluation) in "Human Trust in AI" has the unconditional support of the University of Geneva which will also be co-leading house of this NCCR in case of acceptance. But even without this, several common initiatives are currently being implemented, including in the framework of our "AI Master".

Universities of applied sciences, HES: Idiap has a long experience of collaboration with the universities of applied sciences. For example, since 2010, around thirty projects have been set up with a few HES (Valais, Vaud, Geneva, Fribourg). All projects were related to applied research whose main objectives met the industry needs and were funded by different sources, such as SNSF, CTI/Innosuisse, The Ark, FP7, Hasler Foundation.

Other (UniBe, UCSB, and ICSI/UCB): Moreover, given our "independent" nature, it is much easier to associate with other academic institutions, in various forms. For example, two of our permanent researchers (funded by Idiap, and developing their projects at Idiap) are benefiting from academic titles outside EPFL. Prof. David Ginsbourger is currently Adjunct Professor at the University of Bern, where he teaches mathematics and statistics (as well as at EPFL), and Prof. Michael Liebling is an Adjunct Professor at the University of California at Santa Barbara (UCSB), where he was an associate professor before joining Idiap, and with whom he continues to collaborate) . Finally, Prof. Hervé Bourlard remains a member of the "International Computer Science Institute" (ICSI) of the University of California of Berkeley (UCB).

We are of course convinced that a reinforcement of Idiap's activities would also directly benefit our various academic partners. And institutions such as EPFL and the University of Geneva are ready to confirm and support this analysis.

3.4.2 PhD students

As a reminder, the Idiap Research Institute is hosting and supervising an average of 35 EPFL PhD students, most of them being registered at the EDEE (Electrical Engineering Doctoral Program), set up in collaboration between EPFL and Idiap. Those students are all funded by Idiap through SNSF, EU, or Hasler Foundation projects, sometime (but rarely) in the context of CTI and/or industrial projects.

As of the signature of the Idiap-EPFL Joint Development Plan (and even before), those students are fully integrated in the EDEE selection process, have all the rights and duties of any EDEE PhD students. They take (mandatory and optional) EPFL courses, including courses taught by Idiap's employees at EPFL (see below), as well as internal skill development courses.

The quality of our PhD students is usually recognized through their very high performance (h-index, publication records, best paper awards, etc), as well as a very strong alumni network (resulting in a strong international network).

More quality indicators can be found in our last Self-Assessment Report, available at: Annexes/1246_Self_Assessment_Report_2018.pdf.

As stated above, there is also an official involvement of Idiap in the EDEE Program Commission (Prof. Bourlard was a member until late 2011, Dr. Gatica-Perez was a member between 2001 and end of 2014, and Dr. Fleuret is a member since end of 2014.) This presence reflects the number of Idiap/EPFL PhD students: an average of 35 in 2017-2018, most of them registered at EDEE, and a minority at EDIC. This accounts for about 25% of the PhD student body at EDEE.

3.4.3 Relationship with EPFL (and others)

Idiap-EPFL Joint Development Plan: The anchoring of the Idiap Research Institute in the Swiss academic landscape, in particular through an increased collaboration with EPFL, has seen major achievements over the last years. After the "Convention de collaboration" signed in June 2003, a first "Idiap-EPFL Joint Development Plan" was signed in July 2008, and renewed in February 2012, where we also included new research themes of strategic importance to EPFL and VS, such as energy, EPFL-Valais, etc.

Although developing slower than expected, this Joint Development Plan is being smoothly implemented and offers a solid ground for common activities, and a good academic anchoring of Idiap and Idiap staff into EPFL, while preserving the independence of its research activities (as well as its administration).

Draft version of the last (2018) annual joint Idiap-EPFL activity report is available here:
Annexes/3431_Vorlage_Kurzbericht_strategische_Allianz_Art.15_FR_2018_23042018.pdf

Academic positions: Prof. Bourlard, Director of Idiap, is also "Professor ordinaire" at EPFL where he is the Director of the LIDIAP (Laboratory of Idiap) laboratory. LIDIAP is a fully operational antenna of Idiap at EPFL, with a few permanent collaborators, and was recently granted additional space to accommodate visitors from Idiap, typically Idiap's employees with academic titles and PhD students.

In addition to the Idiap's director, three permanent researchers now have an EPFL academic title:

- **One "professeur titulaire":** Prof. Daniel Gatica-Perez, who was promoted (December 2014) from MER to "Professeur Titulaire", boosts the collaboration between Idiap and EPFL. Prof. Gatica-Perez is affiliated with the EPFL Center for Digital Science, directly related to a field where he has now been active for about 10 years, and has build a strong group, with a strong reputation.
- **2 "Maîtres d'Enseignement et de Recherche – MER"**: Dr. François Fleuret and Dr. Jean-Marc Odobez.

In addition to this, we are also developing formal relationships with other universities, including:

- University of Bern through Prof. David Ginsbourger who has an Adjunct Professor position at UniBe, is teaching there (also at EPFL), and is registering his PhD students at UniBe.
- University of California in Santa Barbara (UCSB) through Prof. Michael Liebling.

3.4.4 Teaching activities

In general: Idiap was initially affiliated with the EDIC (I&C) Doctoral Programme. However, Idiap was later a key player in the setting up of the EDEE (Electrical Engineering) Doctoral Programme, to which it is now officially integrated (and very active). However, some of our students still prefer to register to EDIC programme. Today, since its inception, we believe that Idiap is playing a big role in the success of EDEE (with one representative on the EDEE Committee – currently Dr. François Fleuret – and about 25% of the PhD students), and is involved in numerous teaching activities.

All EPFL courses are taught on the EPFL campus since they were never approved to be given outside EPFL (hence at Idiap). Only internal (non-EPFL) Idiap courses are being taught at Idiap, or through other channels like Fernuni (see below) or in other universities (UniBe).

However, Idiap still has a strong teaching presence in EPFL. Idiap staff members currently teach 9 courses, 3 at the BS/MS level, and 6 at the doctoral/EDEE level (https://idiap.epfl.ch/courses/):

Bachelor/Master courses:

1. Automatic Speech Processing (EE-554), by Bourlard Hervé: The goal of this course is to provide the students with the main formalisms, models and algorithms required for the implementation of advanced speech processing applications (involving, among others, speech coding, speech analysis/synthesis, and speech recognition).
2. Deep Learning (EE-559) Lecturer(s), by Fleuret François: The objective of this course is to provide a complete introduction to deep machine learning. How to design a neural network, how to train it, and what are the modern techniques that specifically handle very large networks.
3. Probabilities and statistics (MATH-234(a)) Lecturer(s), by Ginsbourger David: This course is an introduction to the theory of probabilities and statistics. Based on fundamental principles of probabilities, the course deals with the notions of statistical inference, as well as simple and multiple linear regressions.

Doctoral courses:

1. Computational perception using multimodal sensors (EE-704), by Odobez Jean-Marc: The course will cover perceptual modalities in computers, models for analyzing people (representation, detection an localization, segmentation, tracking, recognition).
2. Computational Social Media (EE-727) Lecturer(s), by Gatica-Perez Daniel: The course integrates concepts from media studies, machine learning, multimedia and network science to characterize social practices and analyze content in sites like Facebook, Twitter and YouTube. Students will learn computational methods to infer individual and networked phenomena in social media.
3. Digital Speech and Audio Coding (EE-719) Lecturer(s), by Magimai Doss Mathew and Motlicek Petr: The goal of this course is to introduce the engineering students state-of-the-art speech and audio coding techniques with an emphasis on the integration of knowledge about sound production and auditory perception through signal processing techniques.

4. Fundamentals in statistical pattern recognition (EE-612) Lecturer(s), by Anjos André and Sébastien Marcel: This course provides in-depth understanding of the most fundamental algorithms in statistical pattern recognition as well as concrete tools (as source code) to PhD students for their work. It will cover regression, classification (MLP, SVM) and probability distribution modeling (k-Means, GMM, HMM).

5. Machine Learning for Engineers (EE-613) Lecturer(s), by Calinon Sylvain, Fleuret François, and Odobez Jean-Marc: The objective of this course is to give an overview of machine learning techniques used for real-world applications, and to teach how to implement and use them in practice.

6. Statistical Sequence Processing (EE-605) Lecturer(s), by Bourlard Hervé: This course discusses advanced methods extensively used for the processing, prediction, and classification of temporal (multi-dimensional and multi-channel) sequences. In this context, it also describes key links between signal processing, linear algebra, statistics and artificial neural networks.

Undergraduate teaching and supervision of Master students: According to EPFL (as mentioned again in their last report), Idiap should be much more involved in undergraduate teaching. However, Idiap really does not see how more resources could ever be allotted to cover this additional overhead since this has to come from public funding and not from project money. And it is really not clear whether teaching undergraduate courses is really part of Idiap's mission (as agreed by most of the Foundation Council).

However, as part of undergraduate training, it has to be mentioned here that every year, Idiap researchers are hosting and supervising master theses from EPFL students (as well as other Swiss universities).

Unidistance and industry-driven AI Master: Already in 2014, Idiap had started working with Unidistance (http://unidistance.ch/) to develop joint projects, but also joint distance learning courses. More recently, Idiap and Unidistance jointly initiated a very innovative AI Master mainly taught by Idiap researchers for the theoritical parts and by Idiap's developers for the more applied parts, in collaboration with industries (see Section 2.1.2, page 8 for more detail).

As listed in our annual scientific and self-assessment reports, many of the Idiap staff are also regularly teaching various courses as invited "Professors" in multiple universities worldwide.

Finally, we also encourage Idiap senior staff to teach "internal" skill development courses, e.g., on writing and presentation skills, as well as entrepreneurship (including invited speakers). For example, Prof. Hervé Bourlard occasionally teaches an internal skill development course on "Technical Writing". We believe that more courses like this should be developed in the future.

3.4.5 Joint Idiap - EPFL initiatives

As discussed in Section 3 of the latest draft Idiap-EPFL Joint Development Report (April 23, 2019), which can be found at:
Annexes/3431_Vorlage_Kurzbericht_strategische_Allianz_Art.15_FR_2018_23042018.pdf,
numerous joint activities are being developed between Idiap and EPFL, including:

1. Research activities of common interest: Besides the key Idiap R&D activities, we are slowly diversifying to be more complementary to existing activities at EPFL, as well as future activities at EPFL-Valais-Wallis, such as:

   - New machine learning algorithms and courses (by Dr. F. Fleuret, which seems to be highly needed and appreciated by students, and actually one of the biggest strengths of Idiap).
   - Social computing: Development of machines designed to extract and use social knowledge from sensor data and media sources from human interaction in the physical and digital worlds. As already mentioned above this research would perfectly fit into the new EPFL Digital Science Center.

- Multilingual processing of spoken and written information: including multilingual automatic speech recognition, speech synthesis (text-to-speech) and translation. Over the last few years, Idiap became a dominant player in multilingual speech processing, with particular emphasis on "under-resourced" languages. Idiap could be the only institution is Switzerland pursuing this type of ambitious goals, with a worldwide reputation.
- Smart cities and energy.
- Healthcare and bioengineering.
- Digital humanities: Recently initiated through a very large scale, highly visible project, referred to as "Valais-Wallis Digital", involving social computing and many other groups at Idiap. Of course, this initiative is also very much in line with the goals of the newly created EPFL Digital Science Center.
- Security and risk management: Illustrated, for instance by (1) the creation of the "Swiss Center for Biometrics Research and Testing" and (2) the new group on "Uncertainty Quantification and Optimal Design".
- Mobile computing and social media.

2. Joint workshops and projects: Including, e.g., joint workshops on "Swiss Machine Learning Day" or 'EPFL-Idiap-ETHZ Sparsity Workshop" (each attended by around 100 participants), or joint projects in the context of (among others) CTI and SNSF Sinergia projects, as well as EPFL Center for Cooperation and Development (CODEV).
3. Joint patents: Two over the last year.
4. Submission of joint projects.
5. Joint publications: around 20 over the last 2 years.

3.4.6 Joint Idiap - HES-SO

Idiap has been working with HES-SO for a long time and we are collaborating on more and more projects together, taking advantage of our complementarity. Since 2008, we have submitted 29 projects with HES entities:

- Number of projects submitted, grouped by funding scheme:
  - SNSF: 11
  - CTI / Innosuisse: 11
  - The Ark: 3
  - FP7: 2
  - Hasler Foundation: 2
- Number of projects submitted, grouped by HES:
  - HES-SO Valais-Wallis: 16
  - HES-SO Fribourg: 5
  - HE-Arc: 3
  - HEIG-VD: 3
  - HES-SO Genève: 2

3.5 Technology Transfer (TT) Activities

Besides fundamental research, training and education activities, Idiap is also contributing significantly to the economic development of the Valais region (and beyond). To this end, it is very much involved in "Technology Transfer" (TT) activities, transferring research results (technology, software, algorithm, knowledge, know-how, and expertise) to interested industrial partners, startups or direct Idiap' spin-offs.

A dedicated Technology Transfer Office (TTO) works in close collaboration with businesses to realize joint research, and sponsored development programs, aligned with the research areas of Idiap. Today, and thanks to numerous initiatives described below, from small startups to large corporations, Idiap is often considered as an ideal partner in "avant garde" technology and research!

This technology transfer is usually done by giving the grant of rights on the commercial exploitation of this technology (through license) to industries or spin-offs (which could then have favorable and privileged access rights). We can therefore consider the process of technology transfer as a creation of economic value out of scientific discoveries. If the concept sounds simple, the path that leads from a technology demonstrator to an industrial product is highly complex. One reason is that researchers and industrialists do not speak the "same language" and their aim could be totally different. This multi-faceted, and extremely challenging technology transfer mission thus requires numerous initiatives and instruments, including:

1. **TT-aware research environment:** A TT-aware research environment, where all employees (including researchers!) always keep the applications in mind, when doing research, developing software libraries and platforms.
2. **Specific dedicated development group:** A specific, fully dedicated, team of people, able to listen to the needs of the industry, society and market, aware of (and excited about) the research outcomes, and able to bridge the gap between research results and specific industry needs.
3. **Clear IPR policy**: Our technology transfer is usually done by giving the grant of rights on the commercial exploitation of this technology (through licenses). It is thus of paramount importance to have a clear IPR policy and technology transfer strategy.
4. **TT instruments and processes:** Multiple instruments and processes, including partnerships with key tech transfer players.

3.5.1 TT-aware research environment

To have a high potential, truly innovative research institution, there is a constant need to stimulate the entrepreneurial mindsets of researchers and to create a more favorable climate for entrepreneurship. Through several instruments (some of them are being discussed below), Idiap keeps highlighting the need to embed creativity, innovation and entrepreneurship within the institution, with the goal to unleash all of its entrepreneurial and innovative capabilities.

Researchers are always in contact with industries, industrial visitors, and are always encouraged to identify the value of their work and, as often as possible, fill "Invention Disclosures", either to clarify the link between research and innovation, or also to open the door to start-ups and spin-offs through the IdeArk incubator.

Entrepreneurship refers to an individual's ability to turn ideas into action. It includes motivation and excitement, creativity, innovation and risk taking, as well as the ability to plan and manage projects in order to achieve objectives.

Idiap thus continuously strives to make employees more aware of the context of their work and better able to seize opportunities, and provides a strong foundation for entrepreneurs to establish social or commercial activities. Continuously nurturing such an innovation mindset thus includes the following objectives:

- Improvement of the entrepreneurship mindset of young people to enable them to be more creative and self-confident in whatever they undertake.
- To improve their attractiveness for employers.
- Encourage innovative business start-ups and spin-offs.
- Making them fully aware of their responsibility and potential of their role in society and the economy.
- "Demystifying" startups!

3.5.2 Specific dedicated development group

Composed of a dozen highly skilled engineers, who understand our research domains, but are more motivated in bringing this into working prototypes or products (on multiple hardware platforms and OSs), this group has two main components: (1) the Technology Transfer Office (TTO) being the actual entry door to the development group, as well as the official contact point for development service/industrial requests and (2) the development group itself.

TTO – Technology Transfer Office (Dr. Joël Dumoulin): Idiap is very active in multiple, national and international, technology transfer activities, and is also involved in numerous projects with industries, ranging from large institutions such as Samsung, Google, Facebook, etc, as well as SMEs and startups.

The TTO represents the key link between researchers, development engineers, and industry. Besides maintaining Idiap's technology portfolio (discussed below), and responding to industrial needs and contacts, the TTO also pro-actively investigates new opportunities. In this context, it assists Idiap researchers and industries to develop joint projects, including Innosuisse projects. As discussed below, the TTO is also responsible to maintain a clear IPR strategy and track IP status across licenses. The TTO is thus a key entry link between the scientists, the industries, and the Development Group discussed below. Finally, the TTO is also responsible of the partnerships with TT institutions, as discussed in Section 3.5.4.

As already mentioned in Section 2.2.3, page 16, tasks and duties of the Technology Transfer Office are available at: Annexes/1222_Cahiers_des_Charges.pdf#page=27, Part 3, page 27.

Idiap generally starts collaborating with industrial partners as the result of three types of process. The most direct way is when a company contracts the institute to carry out research or development, in the form of a thesis for example, and finances the project. Another possibility is that the company files an application for support with the Innosuisse, the Federal agency responsible for supporting innovation through financial assistance of combined industrial/academic projects. The third option is via The Ark Foundation which can support technology transfer projects between Idiap and a company usually established in Canton du Valais.

During an industrial partnership, the company may either finance the research work for a certain period, or buy the technology directly from Idiap. In this way it acquires use and marketing rights. It can also obtain exclusivity rights for a certain time and for its area of activity. However, in order to be able to use its results to carry out other research and therefore keep its autonomy and innovative strength, the institute has to retain the intellectual property rights to its inventions. Therefore, usually it sells non-exclusive licenses, as would the author of a book or a photograph.

Development Group (Mr. Olivier Bornet): Since the end of 2006, Idiap also maintains an active group of a dozen of highly talented developers, all working in the same room, and sharing multiple responsibilities, including:

- Industrial projects: Development of prototypes, and adaptation of research software to the needs of industries, with the goal to demonstrate feasibility of new products and systems, and in direct response to a contract with the industry or the needs of one of the Idiap' spin-offs (always in the framework of well defined projects and IPR contracts). This also includes the development part of Innosuisse projects, where responsibilities are then shared by the PI researchers and one of the developers (all managed by

Olivier Bornet).

- Academic projects: The development group is also responsible for the development of demonstration systems, either of general interest to Idiap (in which case efforts are funded by Idiap) or in the context of projects, e.g., EU project involving specific development efforts going beyond what researchers are able or willing to do.
- Internal support: The development group is also responsible to respond to in-house requests, e.g., helping out colleagues in resolving complex code issues, contributing in research or collaborative platform development, etc. In this context, the group is also responsible for the quality control and maintenance of the open source libraries made publicly available. As discussed in Section 5.2, page 76, 70 open-source libraries are currently available from https://www.idiap.ch/en/scientific-research/resources/libraries Each library has to be thoroughly tested and validated before being released, and nobody at Idiap is allowed to release open source software without prior permission of the management and without doing this through the development group, who will make sure of the quality of what is being delivered, perform version control, etc. Of course, since this distribution is done through the Idiap platform, this is also done in close collaboration with the IT group.
- Stable software and platforms: This is not only part of the internal support discussed above but also for "close source" software which is being licensed to industries. There also, the development group is responsible for quality control, version control, and maintenance (if necessary). In collaboration with the TTO, they also have to make sure that we all follow the same IPR policy and keep track of the licensing and IPR status.

The Development Group is now a very efficient and key component of Idiap's development strategies. Indeed, based on Table 2, page 73, the Development Group today is predominantly self-funded, entirely devoted to contract-driven development activities. Given the high demand, actually increasing everyday, we believe this group still has a big potential for expansion, with benefit to Idiap, as well as to the economic development in Valais and Switzerland.

Figure 6: Idiap Technology Portfolio, available at https://www.idiap.ch/en/tech-transfer/idiap_portfolio.pdf.

3.5.3 Clear IPR policy

Our technology transfer is usually done by giving the grant of rights on the commercial exploitation of this technology (through licenses). It is thus of key importance to (1) keep track of our technology portfolio (technologies ready for licensing), the IPR status of those technology components, and path towards exploitations of those components by industries (e.g., through corporate sponsorship).

Our main exploitation mechanisms are thus based on the Idiap Technology Portfolio: a regularly updated list of Idiap Intellectual Property (IP), associating an IPR access policy with every IP item, from the following options: open source (for open distribution through our platform), closed source (proprietary) for licensing to third parties or to a start-up (e.g., one time fee, royalties, exclusivity, etc., to be discussed on a case-by-case basis), and services for either open source or license customers (e.g., application toolkits, custom programs, support, etc.).

Technology portfolio: Available from our website at https://www.idiap.ch/en/tech-transfer/idiap_portfolio.pdf, we also strive to maintain an up-to-date list of stable software which, we believe, are available and ready for exploitation and licensing to industry. This document currently contains 40 entries, each entry containing a *one-page* description of a technology component containing a short functionality description, keywords, innovative aspects, potential application examples, and contact researcher. During the next 4 year period, we will aim at further developing this tools, possibly linking it to patents and a few key publications, since it seems to attract a big deal of interest from industry.

Corporate sponsorship program: In addition to the above, Idiap also has a specific corporate sponsorship program to boost long-term interaction with industries through training of industrial visitors, joint research programs, etc.

While depending on the level of sponsoring and the goals being sought, the main mission of the present sponsoring programs can be summarized as follows:

- To ensure complementary funding for Idiap.
- To allow the industry to be involved with current research.
- To offer a platform for information, cooperation and interaction between industrial and research partners.
- To encourage meeting and interaction between scientific collaborators from different industries.
- To provide privileged access to advanced research through sponsoring or exchange programs.

A full version of our Corporate Sponsorship Program can be found at:
https://www.idiap.ch/en/tech-transfer/idiap_portfolio.pdf.

3.5.4 TT instruments and processes

Partnerships with TT institutions:

- **The Ark and its incubator IdeArk SA:** Since Dr. François Foglia (Deputy Director of Idiap), is also Director of IdeArk (as also recommended by the Audit Committee), he is mainly responsible of the relationships between Idiap and IdeArk, in close collaboration with the TTO. As part of the Valais initiative The Ark, IdeArk relays the concerns of companies to the scientists, identifies market trends and facilitates the conversion of research results into innovative solutions. IdeArk's task is also to support start-ups and SMEs active in Idiap-related fields. As part of the services of the Incubator there are free office space with furniture, internet connection and coaching support. Many technologies from Idiap were developed into startups (KeyLemon, Klewel, AudioSearch, Koemei, recapp, ...) and naturally benefit from Idiap's proximity and expertise.

- **Polytech Ventures and Fintech Fusion:** After a fruitful collaboration, Polytech Ventures invited Idiap to take part in their ambitious project; to build a complete ecosystem around the Fintech industry (economic industry composed of companies that use technology to make financial systems more efficient). To reach this objective, Polytech launched, end of 2015, a new fund of 20 million with a 10 year term and the first Fintech incubator (www.fusion.xyz) in Geneva whose primary mission is to identify young entrepreneurial talents with start-up projects and provide them with tools to become the next leaders in the Fintech industry .
- **Innopeaks:** In 2018, Idiap decided to join forces with the Swiss insurance company Groupe Mutuel to collaborate in the context of their new innovation initiative Innopeaks (https://innopeaks.ch/); an open innovation hub entirely devoted to developing startups in the healthtech, fintech and insuretech sectors. Start-ups benefit from Idiap's global research into artificial intelligence, algorithms and deeptech, which substantially allow them to accelerate their technologies and products. Idiap also provided start-ups with office space.
- **VentureLab:** Since 2015, venturelab is a private initiative dedicated to entrepreneurship encouragement, also leveraging on the experience of successful entrepreneurs and VCs. Initiated in 2004 as a national training programme, it offers coaching and training tailored to support innovative start-ups and introduce young engineers to entrepreneurship, in close collaboration with Swiss high schools and universities, including Idiap. Since its inception, ventulab has organized more than 200 high-tech entrepreneurial events and 3000 training modules for particularly innovative projects.
- **Alliance:** Idiap is also part of the technology transfer group of Alliance, a national consortium which aims to create networks between academic institutions and companies in the Western Switzerland. This group meets regularly to exchange experiences and formulates "Best Practices" in technology transfer.
- **HES-SO Valais/Wallis:** In 2006, Idiap and HES-SO Valais/Wallis signed a collaboration agreement to encourage and facilitate joint projects between both institutions, especially targeting industrial applications. In 2010, an additional agreement has been signed to allow bachelor students from HES-SO to do their diploma at Idiap. Today, many projects involving development and industries are often done in collaboration with HES-SO Valais/Wallis.
- **Customer relationship management (CRM)**: As already mentioned in Section 2.2.6, page 19, Idiap has developed its own Customer Relationship Management (CRM), providing us with an up-to-date list of institutions and industries we have already worked with in the past. This list currently contains 1382 entries of contacts and 948 company entries.
- **Invention disclosure**: See Section 2.2.6, page 19.
- **Patent Committee**: See Section 2.2.5, page 19.

Idiap Showroom: In order to make Idiap's work more accessible to the general public, as well as to industry, politicians, and students, Idiap is maintaining (since 2009) a fully operational showroom to demonstrate the research carried out at the Institute. More information can be found at:
http://www.idiap.ch/technology-transfer/introduction/showroom.

As illustrated in Figure 7, the showroom provides a rich environment to see, play, discuss and understand different technologies. For example, as soon as visitors enter the room, four cameras and eight microphones capture their arrival. Their presence is modelled by avatars in a three-dimensional representation of the room, displayed on a large screen. When they change position, the respective avatars move accordingly and their mouths are animated when they speak. There is no doubt that human presence is being monitored, analyzed and modeled. In this case, this demonstrates a technology developed in the field of video surveillance.

Instead of sitting visitors in front of a passive presentation, we invite them to interact with the different demonstrations. It is a space that is just as useful to well-informed partners as it is to novices. Four interactive

Figure 7: *Idiap showroom: The "Showroom" concept is an interactive showroom which aims to highlight and illustrate the results that emerge from Idiap's research. This "Technology Showcase" is a tool used for public communication. It focuses on the different institute's visitors such as researchers, industrialists and students. This room is interactive, which means it includes touch screens with mini-film presentation, demonstrators (using technologies such as speech processing, biometric authentication, object recognition, etc.). In addition to this, the room is equipped with microphones and cameras that record the visitors' movements and actions in order to enable the detection of people (including their mutual interactions).*

demonstrations are currently accessible on the showroom's computers (object detection, voice activity detection, biometric access control, stone-breaker game controlled by face tracking). Visitors can also familiarize themselves with the world of Idiap via five short theme-based films. These presentations describe the Institute's different areas of research in simple and tangible terms. These tools are easy to export and can already regularly be seen at exhibitions or specialized trade fairs.

The showroom meets a considerable need for visibility and communication. Every year, it welcomes around thirty groups of visitors from all over the world. However, the showroom needs to be constantly updated, and a "mobile" version should also be available, which are all important challenges for the years to come.

International Create Challenge (8th Edition, ICC'2019): Besides industrial collaborations, Idiap continuously encourages researchers to be involved in technology transfer activities and fosters entrepreneurship and company creation. In that spirit, Idiap launched in 2012 the first International Create Challenge (ICC, http://www.createchallenge.org), which is now in its eighth edition, becoming more and more attractive and successful.

ICC is a free of charge, 3-week immersive super accelerator program that gives entrepreneurs and potential entrepreneurs the opportunity to drive their projects to a "Minimum Viable Product" (MVP). It is a unique program combining state-of-art technologies, cutting edge research, mentors-led coaching, and micro-seed investment (in collaboration with VCs and KickVenture). In 2014, Idiap set up a crowdfunding portal (funding.idiap.ch/funding) to financially support the selected projects of the ICC accelerator program in their quest to become a viable start-up. Idiap/ICC is proud to be on the map of the crowdfunding industry in Switzerland in 2015 according to the recent study of Lucerne University of Applied Sciences and Arts[11].

Organised every year in the Idiap premises, it attracts more than 100 people, mixing scientists, developers, entrepreneurs, and venture capitalists, with the sole goal of fostering collaboration, test new ideas, and boost the winning teams through diverse incentives to start their own start up.

[11] http://blog.hslu.ch/retailbanking/crowdfunding/?sourceurl=/crowdfunding

The International Create Challlenge gave a new and additional twist to its 2018 edition by providing an optional theme to the challenge. This year, ICC partnered with Groupe Mutuel, a leading health insurer in Switzerland. Groupe Mutuel is at the crossroads of two changing industries which will be strongly impacted by Artificial Intelligence : Health and Insurance. Therefore, Groupe Mutuel, partnering with ICC, is looking for teams and projects focusing on " AI for Health and Insurance".

ICC combines the availability of state-of-the-art technologies, cutting edge research, mentor-led coaching, and micro-seed investment. The winning team(s) will share global awards amounting to more than 100'000 CHF out of which 15'000 CHF provided by IdeArk SA (http://www.ideark.ch, Idiap's incubator) and 13'000 CHF provided by Groupe Mutuel, 3 years of free access in the The Ark incubator program (around 100'000 in kind coaching, office space, etc) and seed VC money (through our partner Polytech Ecosystem Ventures (http://polytechecosystem.vc). The Jury is, as usual, composed of a dozen of high-level people coming from the financial, innovation and scientific worlds (http://www.createchallenge.org/who-we-are).

The ICC events resulted in 2–3 startups per year. Some of them are quite successful, such as:

- Recapp SA (http://www.recapp.ch)
- Eyeware SA (http://www.eyeware.tech)
- BioWatch (https://biowatchid.com/)
- AdvAIsor (https://www.advaisor.io/)
- Horus (http://horus.tech)
- Anemomind (http://www.anemomind.com/)

3.5.5 Future activities

Besides the quality of our research activities, our technology transfer processes and instruments are also excellent and, as a result, significantly impact the growth of the economy at the regional and national levels. However, the demand is also continuously increasing and it is clear that we often have difficulties to follow-up on all opportunities. While Idiap does not want to turn into a service company and since it benefits tremendously from the availability of a stable and reliable development group, we also feel much more can be done in this area. The recent set up of a Technology Transfer Office, representing one single TT entry point at Idiap (tto@idiap.ch), is a first step in that direction. Around the TTO, and in collaboration with the development group, we now need to further strengthen the instruments discussed above, and possibly hire a few more developers, to significantly increase our efficiency. The current initiative around our new "Industry-Driven Master in Artificial Intelligence", as discussed in Section 2.1.2, page 8, is definitely a good step in that direction.

4 Budget, Funding Distribution, and Financial Planning for 2021-2024

4.1 Overview

In the following, we briefly discuss Idiap's funding structure, funding portfolio, and growth hypotheses foreseen for 2021-2024. The **foreseen budget for 2021-2024** is presented here: Annexes/3102_Template_plan_financier_2021_2024_b_institutions_de_recherche.xlsx.

Discussion of the operational rationales, and general funding context behind this budget can be found in the Appendix "Plan Financier 2021-2024", available here: Annexes/3101_2019_PlanFinancement_2021_2024.pdf.

According to this financial planning, Idiap's application for the federal grant according to art. 15, al. 3, let. b LERI amounts to **CHF 15'427'525.- for the period 2021-2024**. This amount represents a significant increase of nearly 60% compared to the amount requested for the 2017-2020 quadrennial period which had not been granted in spite of the recommendation from CSSI, since priorities had been given to LERI Art.15, al. 3, let. a and let. c. However, as required by law, the amount requested is still less than the sum of the contributions from the other third public parties, i.e. State of Valais, City of Martigny, and other public (LoRo) and private sectors. The 50% (public/competitive funding) rule is respected.

4.2 Main funding sources

Four funding "pillars": Idiap's funding is built around four main "pillars":

1. Public funding
2. Sponsored research (CH and international)
3. International, national and local industrial collaboration (technology transfer)
4. International exchanges and internships

4.2.1 Public funding

- Federal funding: The Swiss Confederation provides partial funding to a limited number of research facilities of national importance under Art. 15 LERI (Loi Fédérale sur l'Encouragement de la Recherche et de l'Innovation). The main purpose of this research funding instrument is to establish a strong basis of research conducted autonomously and outside the higher education sector, but having a big potential impact in terms of research, training of young researchers, and technology transfer, all missions perfectly matching Idiap's goals.

  This funding, coming from the State Secretariat for Education, Research and Innovation (SERI, http://www.sbfi.admin.ch/org/), is based on 4 year budgetary periods (now synchronized with quadrennial Research Programmes from other academic bodies, including Swiss NSF, ETH Council, EPFL, ETHZ, CRUS, etc), and conditional on the approval of a "Contrat de Prestation" (Contract of service), now also linked to a synchronized Idiap-EPFL Joint Development Plan (initially signed in 2008, and renewed in 2013 and 2017).

  For Idiap, this federal contribution for the 2017-2020 budgetary period amounted to 9'700'000.- CHF (2013-2016; 9'940'000.- CHF). **For the next 4 years (2021-2024) period, an amount of 15'427'525.- CHF is sought, which represents an increase of 60% (percentage based funds requested) annual raise during the period**.

Of course, and following Federal regulations, this raise will also be matched by additional funding from the State of Valais, the City of Martigny, and other public bodies (e.g., Loterie Romande–LoRo). The rationale behind this budget raise is discussed in the detailed budget table in the appendix, and briefly discussed below.

As often suggested by the Idiap Foundation Council, including the EPFL and EPFL-Valais representatives, as well as in the EPFL report relative to the Idiap-EPFL Joint Development Plan, the increase of the public/structural funding will be used to fulfill some minimum needs and requirements to guarantee sustainability of the institute, and the quality if its activities, including:

- Slowly improving the wage prospects for its permanent staff:
  - In 2019, Idiap mandated CEPEC http://www.cepec.com/fr/ to perform our first full auditing of our internal structural (positions and titles) and associated salary scales. The conclusions are presented in a long and detailed report, confidential, but available on request. Comparing titles and salaries across different regions of Switzerland and different fields (ICT, admin, etc), the conclusions of the report are quite satisfactory, demonstrating that the current salary practices at Idiap are well aligned, and competitive, with respect to other institutions in Switzerland. However, of course, it is still possible to improve over the current situation, as briefly discussed below.
  - For the young researchers, typically beyond PhD, we cannot simply be satisfied with salary raises solely linked to the cost of living. We may want to be more aggressive, to further motivate them, and encourage them to become more independent.
  - It is foreseen that more academic titles should be granted to Idiap staff in the future. Hence, Idiap has to be able to financially assume this access to academic titles for one or more of its researchers, often resulting in more responsibilities, hence a fair request for wage revision. This was recently experienced with the appointment of Prof. Gatica-Perez, who required (quite fairly enough!) a major salary raise (while also being more and more busy at EPFL, soon being affiliated with the EPFL Center of Digital Science, hopefully with increased visibility and funding opportunities for *both* institutions!).
  - At the senior level, we have to make sure to remain competitive in an always more financially competitive research environment. While there will always be departures of key senior researchers, we have to make sure to remain competitive when hiring new ones, and being able to keep them long enough! Today, it is worth *and important* noting that Idiap salaries are not competitive compared with those that are practiced in Swiss universities for equivalent levels of researchers, still resulting in excellent motivations and performance. Even the salaries of PhD students and postdocs are strictly aligned with those prescribed by the SNSF, and Idiap has no structural margin to align these salaries with those in other Swiss universities. In spite of this, we are still able to attract excellent PhD students, concluding excellent PhD thesis, and hired in the best universities, research institutes, or industries (Google, Facebook, MIT, etc. See alumni in Self-Assessment report).
- Respond to the continuously increasing needs and/or requests for collaborations, including with EPFL (even asking for more undergraduate teaching), EPFL Valais, and multiple industrial partners. Unfortunately, we currently cannot face and positively answer (or properly handle) all those requests and seize all those opportunities, resulting in a loss of funding.
- Directly related to the above, Idiap's role seems often important for the success of joint initiatives and collaborations. As mentioned in the Research Programme, and confirmed by the Audit Report, Idiap provides availability to its platforms, software, and databases, and/or develop others to support, for instance, research activities in Energy (EPFL Valais) or Digital Sciences (EPFL), which always seems much more difficult in the context of large institutions. But this significant and unique contribution also requires more and more resources (hence funding).

- Be able to deal with uncertainties and structural changes, while also maintaining a minimum diversification of our research activities to complement actions in promising and strategic domains at the cantonal and national level (energy, smart cities, digital sciences, bio-technologies, etc), as suggested by EPFL, EPFL-Valais-Wallis, as well as to answer increasing industrial demands, we will need to continue slowly expanding our team of permanent researchers (funded at 75% on public money and the rest through projects). Incrementally (over the next 4 years 2021-2024), and "opportunity-driven", Idiap thus plans/needs to expand its team of permanent researchers (currently very small in comparison to our mission, performance, and amount of non permanent staff, including an average of 35 PhD students to supervise) by 3-4 additional permanent researchers.
- As part of the above and in continuity with past recruitments, Idiap will emphasize the hiring of young and promising researchers, offering them a career path in research and academia.

  Furthermore, Idiap has recently opened two positions (budget as been assigned for a 5-year period), https://www.idiap.ch/en/join-us/job-opportunities:

  * Idiap Fellowship Program for Female Researchers
  * Idiap Academic Visitor Program (for sabbatical visitors): our first sabbatical professor will join Idiap for one year, starting on Sep.1, 2019, till end of August 2020.
- As rightly underlined in one of the past Audit Reports, and since the end of its IM2 NCCR, as well as "giant" EU projects (like AMI and AMIDA), Idiap is somewhat lacking integration in big, long-term, research projects. We are currently working on this aspect, including through the submission of the (currently under review) NCCR proposal on "Human Trust in AI". Idiap is also one of the key members of the large EU initiative around the development of a EU AI-on-demand platform (AI4EU). Finally, and conditional on the additional funding sought in the present proposal, the new "Cross Research Groups" (CRGs) are also aiming to address this problem by developing large scale, cross-group, research projects, well aligned with industrial needs, and often in collaboration with large industrial groups (like Airbus and Swisscom currently in discussion).
- Finally, and thanks to the initial seed funding (CHF 400'000.-) from the State of Valais and the City of Martigny, Idiap is now further developing its *Center for Biometrics Research and Testing* (see Section 5.3, page 78) and positioning itself as a center of excellence at the national and international levels. Recently[12], the reference in authentication standards, the FIDO Alliance has confirmed the accreditation of Idiap's Biometrics Center as only the third member of what remains a very exclusive club, placing it at the heart of those security issues that make up the sensitive and fast-growing domain of biometric certification. We believe this also provides Idiap with more opportunities for developing large scale national and international initiatives. Ideally, this effort could also be part of large national initiatives, including the Cyber Security Alliance (http://www.cybersecurityalliance.ch/).

The budget is available here:
Annexes/3102_Template_plan_financier_2021_2024_b_institutions_de_recherche.xlsx
and discussed in detail in:
Annexes/3101_2019_PlanFinancement_2021_2024.pdf.

- **State (VS) + City (Martigny) funding**: Following Federal regulations, these two state-level funding sources together should always (and always did) match the above Federal funding, **and this should also be the case for the 2021-2024 period, as discussed in:**
Annexes/3101_2019_PlanFinancement_2021_2024.pdf.

[12] https://www.idiap.ch/en/allnews/idiap-becomes-only-the-world-third-biometrics-certification-center

4.2.2 Sponsored research (CH and international)

- Swiss NSF: After the end of the IM2 NCCR, Idiap kept benefiting from many other SNSF individual/collaborative (Sinergia, Ambizione) projects, as well as international research projects (e.g., Indo-Swiss). For the future, we aim at increasing the amounts coming from this funding source, especially given the new permanent senior hiring.

- Multiple EU projects (as coordinator or partner): Although this is becoming more and more difficult, actually close to impossible (see discussion in Section 4.3), we will keep submitting high quality proposals to all relevant EU calls, on average a dozen per call[13]. If this situation does not change we will have to focus on different funding sources, with better chance of acceptance and less overhead (given the amount of time required to prepare any single EU proposal).

- US projects (currently DARPA and IARPA): Idiap is currently involved in three major, high-visibility, and very competitive US DARPA (1) and IARPA (2) grants around multilingual speech processing, forensic videos, and cyber-security (biometric identity spoofing). Although those projects are a bit more politically sensitive, and potentially less stable than other projects, they are extremely visible, and highly competitive, which is good for Idiap's reputation.

4.2.3 International, national and local industrial collaborations

- Research contracts with big industries: This includes or included, for instance: Swisscom, Logitech, NEC, Yahoo, NTT, Samsung, HP, Thales, Google, Facebook, Airbus, Huawei, etc. Given the instruments being developed towards technology transfer, as discussed in Section 3.5, we believe the funding coming from this source should increase in the future.

- Collaboration with IdeArk SA[14], our technology transfer incubator: See Section 3.5 for more information about this. Expansion of these IdeArk activities are currently a bit limited because of space, but this should be fixed very soon, providing new opportunities for developments.

- Corporate sponsorship program[15]: this has never been properly (pro-actively) exploited, but with the new TT structure and Technology Transfer Office (TTO), also discussed in Section 3.5, we believe we should be in a better position to exploit this track in the future.

- Innosuisse projects involving industries, including SMEs and Idiap's startups. Here too, we believe there is space for further improvement and increased funding. Actually, demands are increasing, and several project proposals are currently in the pipeline.

4.2.4 International exchanges and internships

- Funded visitors from other research institutions or industries: Working quite satisfactorily.

- Funded international visitors, e.g. through EU Marie-Curie grants, were quite successful in the past, but like for all EU-related projects, this also became much more difficult over the last year.

[13] The last review outcome, received in May 2015, resulted in no project accepted, out of 8 high-quality proposals. And we had experienced the same outcome at the end of last year for the previous call, for 12 proposals, always submitted with very high quality collaborators. It is hard to believe that Idiap became so bad just "overnight"!

[14] http://www.ideark.ch

[15] http://www.idiap.ch/technology-transfer/corporate-sponsorship-program

4.2.5 Public/Competitive funding ratio:

All the above together, the public funding used to represent about 30% to 40% of the total Idiap funding, which was considered as "excellent" by the State of Valais but "unsustainable" by EPFL (too dependent on project funding, at the risk of jeopardizing the research quality or the stability of the institute).

More recently, though, and mainly due to a continuous increase in the number of competitive projects, hence competitive funding, this ratio is now closer to 50/50 for public/competitive funding, which we aim to maintain as a (still very challenging) target, even in the case of the significant raise in public funding, as sought in the present document.

4.3 Evolution of budget and funding sources over time

As illustrated in Figure 8, Idiap's funding has been steadily increasing over the last 25+ years, with a good "portfolio" of funding sources.

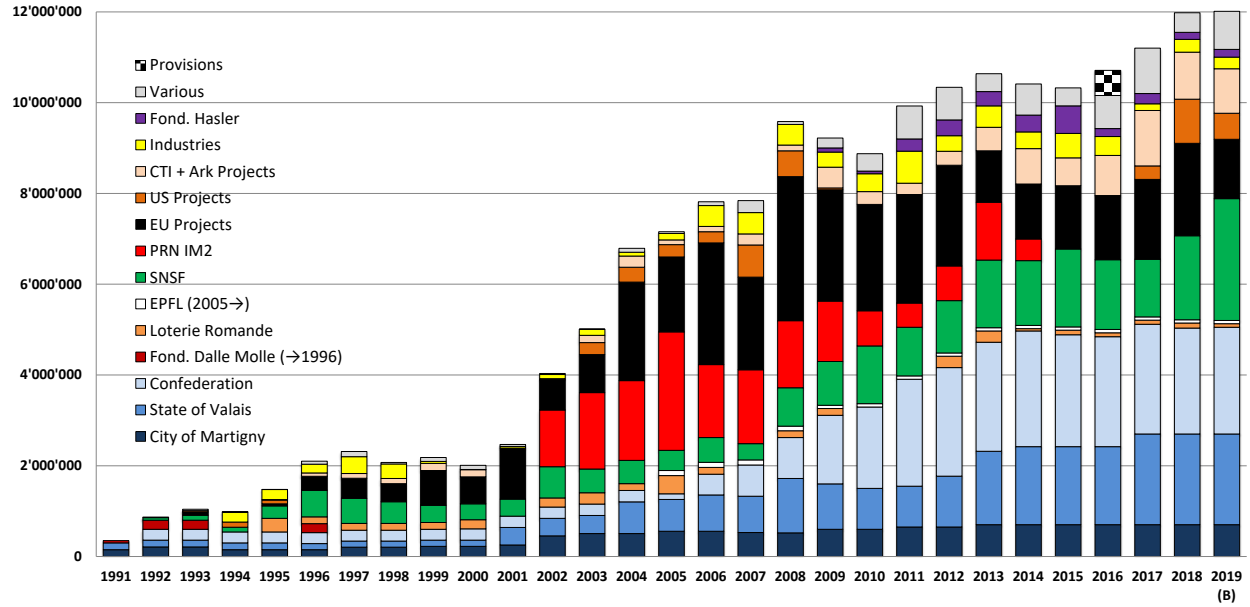

Figure 8: Evolution of Idiap budget and funding sources over time

It has to be noted here that the Idiap total budget has always been stable or increasing over the last years, and this in spite of several challenging factors, including the end of the IM2 NCCR (in 2013). One of the key missions of NCCRs was to build a critical research mass and a sustainable research environment in the funded area. We can safely state here that this goal has been fully reached with IM2, and Idiap in particular.

As discussed in Section 2.3.3, we also have to deal with regular staff turnover, sometimes resulting in funding loss.

Satisfactory budget evolution over the last 20 years: As a consequence, Idiap's budget is still evolving satisfactorily, thanks to a regular increase (or, at least, renewal) of the project portfolio, both from public institutions (competitive funding) and industries (research contracts with industries), resulting in the financial trend summarized in Table 1 below.

	Final accounting result (MCHF)	Comments
2009	9.2	
2010	8.9	strong CHF impact
2011	9.9	strong CHF impact corrected
2012	10.3	
2013	10.6	end of IM2 NCCR
2014	10.4	swiss immigration referendum, February 9
2015	10.3	audited, minimum Euro/CHF exchange rate discontinuated
2016	10.7	according to the new accounting law, the short-term provisions has to be reactivited. The amount corresponds to 550k for 2016
2017	11.2	no increase from SEFRI, Art.15 budget, increase from State of Valais
2018	12.0	
2019	budget > 12.0	

Table 1: **Final accounting results from 2009 to 2018, approved budget for 2019**

More funding opportunities: There is also a regular, but significant, increase from small and large scale (Airbus, Huawei, and Swisscom most recently) enterprises to develop long-term relationships with Idiap, although Idiap is currently forced to refuse/postpone many of those requests since (1) Idiap doesn't have the necessary manpower available, and (2) Idiap doesn't want to turn into a "service company" since its primary mission should keep focusing on research.

Need for more public funding: However, this "constant" annual budget is currently realized through a significant increase of smaller budget projects, and a lack of longer-term projects (as also rightly underlined in the Audit Report, Section 6.4, page 81). Also, to properly answer more and more industrial needs would require (1) more public funding to guarantee a minimum manpower availability, and (2) availability of the required personal (and this is one of the reasons why Idiap initiated the Industry-Driven AI-Master, as discussed in Section 2.1.2, page 8, and to the shortage above all in engineering/AI sector identified by SECO).

The public/competitive (hard/soft) funding ratio is currently still around 50/50, which can be considered as excellent, given several factors:

1. This is being considered as a guideline/requirement from VS, requiring competitive funding to be always higher than public funding, which has also been adopted as an Idiap internal "rule".

2. This VS requirement is however "contradicted" in the last EPFL Evaluation Report, stating that we are relying too much on competitive funding, at the risk of decreasing the research quality, and generating additional management challenges.

Finally, the current budget evolution strongly limits:

1. The growth of Idiap, which can only be achieved through more competitive funding, with the risk of quickly becoming more and more difficult to manage, constantly increasing our overheads, while spending more and more time on writing grant proposals.

2. The potential for salary raises of permanent research staff, since we always avoid to (entirely) rely on soft funding to build salary raises, assuming that a minimum of 75% of the permanent staff salaries are covered by hard funding, as evidenced in Table 2, next page.

4.4 Internal funding distribution

As reported in Table 2 below, we also regularly keep track of the internal distribution of the funding between the different units (Admin-Finances-HR, Admin-Services, Legal Adviser, System Admin, R&D Engineers, Permanent Researchers, and other researchers, i.e. post-docs and PhD students).

In the left hand side of Table 2, we present the relative amount (in %) of Idiap's total budget going to each type of activities. From that information, it can be concluded that most of the funding goes to R&D activities (developers and researchers), while about 20% (good practice recommendation), goes to general admin activities, although those activities also include services and direct support to researchers for project submission and management. Indeed, we always make sure that the budget of plain admin services never go above 15% of the total budget.

In the right hand side of of Table 2, we also provide the distribution ratio of each of the unit's funding in terms of core (public) funding, referred to as "*Idiap*", and project-based funding, referred to as "*Projects*". From this, it can now be seen that within each unit the associated funding amount either mainly comes from "Idiap" (admin, services, and permanent researchers), or from "Projects" (postdocs, PhD students, and developers).

	Salary Mass			Funding sources in % for 2018	
Version 08.04.2019	**2018**	**2017**	**2016**	***Idiap***	***Projects***
Administration	9.1%	10.6%	9.8%	95	5
Administration Service	3.3%	2.0%	2.7%	73	27
Administration System	7.2%	8.5%	8.2%	95	5
R&D Engineer	10.8%	14.1%	14.8%	25	75
Permanent Researcher	23.4%	19.9%	20.6%	87	13
PhD	19.7%	17.9%	18.2%	5	95
Post-Doc	20.4%	20.5%	18.0%	4	96
Stagiaire/Intern	2.4%	2.3%	1.0%	25	75
Research Associate	2.8%	4.2%	6.7%	6	94
Other	1.0%	0.0%	0.0%	28	72
Total	**100.0%**	**100.0%**	**100.0%**	44	56

Table 2: Internal funding distribution (over units), also split in terms of structural funding (Idiap) and competitive project funding (Projects). It can be concluded that most of the funding goes to R&D activities (developers and researchers), while about 20% (good practice recommendation), goes to general admin activities, although those activities also include services and direct support to researchers for project submission and management.

4.5 Institutional Supports

The State of Valais and the City of Martigny have always demonstrated their unconditional support for Idiap's activities. In fact, their financial support has regularly been above budget planning, certainly going beyond the financial allocations established by the LERI.

More recently, the State of Valais has further strengthened its support through numerous projects, including:

- The Biometrics Center (http://www.biometrics-center.ch/)
- The rapprochement between CREM (https://www.crem.ch/) and Idiap, with CREM soon joining Idiap's facilities
- The development, in collaboration with Unidistance, of the first "Dual/Industry-Driven AI-engineering Master" program to educate a new generation of engineers with modern AI concepts and tools:
  - Teaching and hosting at Idiap
  - Master diploma degree provided by UniDistance
  - 3 semesters intensive courses and industry-driven projects
  - 90 ECTS: 50 ECTS from 14 courses, 40 ECTS from industry-related projects
  - Program started in January 2019

For its part, the City of Martigny, in addition to its financial support, always deploys the infrastructure necessary for the harmonious development of Idiap and its technology transfer activities:

- Since August 2018, the City of Martigny has acquired a new building (SFS) just opposite the current premises of Idiap. It is now in the process of major renovation to accommodate startups and spin-offs of IdeArk (for fall 2019) working in collaboration with Idiap.
- This will free up additional office space in the main Idiap building, currently occupied by these companies.
- It is clear that if Idiap is developed as part of a larger AI Competence Center, this planning will be revised upwards.

Although Idiap has always enjoyed significant support from the State of Valais and the City of Martigny, it seems that, for the first time, all the conditions are fully in place to transform a regional research center into a true Competence Center at the national and international level.

The full financial support from our local public authorities are clearly set out by our respective political representatives (VS + Mty) in the Letters of Commitment appended to this document.

5 Contribution to the Swiss Research and Innovation Activities

5.1 Idiap added value at the national level

Overview: From the content of the present 2021-2024 Research Programme, further confirmed by the recent International Audit results, it is clear that Idiap is bringing significant added value at the national level, along multiple facets, including scientific excellence, teaching and training young researchers, and in technology transfer.

Actually, we believe that our activities do not have an impact only in the realm of science and technology, but raise also a strong interest from society in general, as witnessed by the significant presence of Idiap in the Swiss and international media.

A complete listing of other high-impact activities at the national level is out of purpose here, but most of the relevant information can be found from the Idiap Web site, as discussed in Section 5.2.

Quite unique: It is important to note here that while most countries (to our knowledge) are encouraging the development of independent (but affiliated to one or more universities) research institutes like Idiap (the directors of three of them were part of the Audit Committee), Switzerland still seems to have difficulties to fully exploit this unique instrument, providing excellent dynamics and usually unique return on investment. This is particularly true for a non-university state like Valais.

Effective solutions to meet industry needs: Adapting research findings to the needs of the industry (technology transfer) is part of Idiap's mission. The institute is particularly effective in establishing influential practice (developer groups, the IdeArk business incubator, the International Create Challenge, etc.), to the great benefit of its numerous industrial partners. Our recent AI-Master initiative (see page 8) further developed strong links with industrial partners.

At the Service of the national and international R&D community: Attentive to local, cantonal, and federal economic development, Idiap also places its expertise at the service of the international R&D community. Highly active in the transfer of knowledge between academic and industrial institutions, Idiap creates and makes available a significant number of professional software packages—a service that a traditional university structure has more difficulty to deliver.

Innovation driver: Idiap is clearly recognized (in Valais and beyond) as a key innovation driver, and we are always adopting strategies that benefits Swiss industry first. The recently created biomedical image processing research group and Swiss Center for Biometrics Research and Testing illustrate the institute's intention of remaining in tune with contemporary economic and societal needs.

Swiss societal impact: The commitment of Idiap even goes beyond its research, training, and technology transfer missions, also aiming at having a larger potential impact on the Swiss society. This can be illustrated by two examples:

1. Dalle Molle Foundation: The central role that Idiap recently played in giving a new impetus to the Dalle Molle Foundation (see http://www.dallemolle.ch). The foundation, which has presided over the birth of Idiap about 25 years ago, has been constantly attached to quality of life; therefore, an annual competition has been created (3 years ago) to reward original ideas on how technology, and in particular information processing, can improve quality of life, balance the social system, and address environmental concerns.

2. Valais-Wallis Digital (https://www.valais-wallis-digital.ch/en/about/): In 2015, the State of Valais celebrated the 200th anniversary of its entry into the Swiss Confederation. To celebrate this bicentenary, the State of Valais had launched a call for ideas to which the Idiap Research Institute, together

with its partners (including Migros, also significantly contributing in cash to the project), has responded by submitting the "Valais-Wallis Digital" project. In March 2013, this project was selected by the State government as one of the 13 "Star Projects". "Valais-Wallis Digital" is still fully operational and active. Such an initiative is also in line with the "Digital Sciences" center initiated at EPFL.

"Valais-Wallis Digital" aimed to:

- Digitize the collective memory of Valais.
- Create an Internet platform on which the population, the communities, the schools and the societies are able to deposit archives and documents worthy of interest.
- Create and distribute a family card game which serves as support and trigger element for the depositing of archive documents.
- Develop an interactive smartphone app for iPhone and Android. This app allows to scan your game cards, manage your card collection and discover the historical context of the pictured event.

5.2 International Web presence and statistics

Idiap maintains a very rich Web site (http://www.idiap.ch) presenting the Institute, our research and technology transfer activities, and making multiple resources available to (and extensively exploited by) the research communities,

The statistics on the number of visits of our Web site (excluding publication, discussed later) are summarized in the table below.

Year	Sessions	Users	Visited pages
2018 (Feb-Dec)	48'813	30'709	124'003
2019 (Jan-Jun)	26'194	17'570	64'501
Total	75'007	48'279	188'504

From	visitors 2018 - 2019)
Switzerland	15'557 (32.1%)
United States	4'892 (10.1%)
India	4'010 (8.3%)
France	3'185 (6,6%)
China	2'332 (4.8%)
Germany	2'044 (4.2%)
United Kingdom	1'733 (3,6%)
Italy	1'066 (2.2%)
Japan	909 (1.9%)
Spain	820 (1.7%)

Table 3: Statistics over the number and origins of the visits of the Idiap Web site, excluding publications (below).

The Idiap Web site also includes multiple resources made available to the community:

1. **Publications:** All our publications in books, scientific (peer reviewed) journals, scientific (peer reviewed) international conferences, Idiap Research Reports (IDIAP-RR), and Idiap Communication Reports (IDIAP-COM) are always available online (and regularly synchronized with the EPFL InfoScience server). The statistics below show a very dynamic web site, attracting quite a lot of interest.

Year	Sessions	Users	Downloads
2018	25'402	17'342	53'343
2019	10'109	7'891	17'423
Total	35'511	25'233	70'766

Table 4: Statistics over the number and origins of the publication downloads from the Idiap Web site.

2. We maintain a (well advertised and used worldwide) list of datasets and open sources libraries at: https://www.idiap.ch/en/scientific-research/resources.
   - **Open source libraries:** All open-source libraries (currently 70 available) are available from https://www.idiap.ch/en/scientific-research/resources/libraries.
   - **Data repositories:** A total of 52 international benchmark datasets are currently distributed through the Idiap Web site from https://www.idiap.ch/en/scientific-research/resources/datasets. we also note here that all public datasets requiring clearance based on the new EU General Data Protection Regulation (GRDP) are submitted to the Federal official responsible for data information and transparency ("Préposé aux données"). For copyright, legal or ethical issues, all downloads are controlled and subject to approval.
3. **Online Recruitment System (ORS):** All our job openings are always published though different media, but also through our ORS system, through which candidates have to apply to allow us to manage the large number of applications. Here below we give some interesting statistics about this ORS, where "Positions" is the number of positions published during the year, "Primary App" is the number of different candidates having submitted a valid application file, and "Sub. App." is the number of second choice applications (where the valid candidates apply to multiple openings.)

Year	Open positions	Apllication received
2013	29	713
2014	30	936
2015	32	893
2016	43	1002
2017	39	1270
2018	40	1607

4. **General news:** From that web site, copies of the public Annual Reports can also be found at: https://www.idiap.ch/en/about/idiap-annual-reports, in addition to other news, such as:
   - Press review: Collected press review and several news threads are available and updated weekly;
   - Idiap general news: https://www.idiap.ch/en/allnews;
   - Research news: https://www.idiap.ch/en/allnews;
   - Technology transfer news: https://www.idiap.ch/en/allnews.

5.3 Swiss Center for Biometrics Research and Testing

In 2014, and thanks to an initial support of CHF 300'000.- from the State of Valais and CHF 100'000.- from the City of Martigny, the Idiap Research Institute launched the "Swiss Center for Biometrics Research and Testing" (http://www.biometrics-center.ch), a competence center within the Institute following recent successes in coordinating International research projects in Biometrics (MOBIO, TABULA RASA and BEAT). The aim of this center is to serve as a legacy for these projects and to push for industry-driven research and testing in biometrics.

The missions of the center are (1) to carry out high quality research, (2) to train talented researchers and engineers, (3) to foster technology transfer from academia to industry, and (4) to propose a biometrics evaluation and testing service. To fulfil its missions, the center will mainly promote two instruments: (1) the coordination of a cooperative research consortium, and (2) the deployment of the BEAT evaluation platform[16].

The cooperative research consortium is an alternative industry-driven instrument inspired by a successful model running in the US: the Center for Identification Technology Research (CITeR). The main idea of this cooperative research consortium is to create an environment with mutual benefit between partners (academic researchers) and affiliates (companies or governmental organisations) where partners submit fast-track research proposals and affiliates drive and fund the research carried out by the partners.

In 2017, the State of Valais invested again CHF 500'000.- to strengthen the development of the testing activities.

Current situation: These instruments were presented in November 2014 to researchers and stake-holders (40+ participants), where it was decided to elevate the visibility of the cooperative research consortium to a more European level. We concluded an agreement with the European Association for Biometrics (composed of 160 members) to transform the cooperative research consortium initiated in Switzerland into a European cooperative research consortium (EAB-CITeR) but still coordinated in Switzerland by the center. We expected to attract a critical mass of partners/affiliates to fund research projects through the European cooperative research consortium. As an immediate consequence, four academic researchers (Norway, Germany, Finland and Netherlands) accepted to join as partners. In addition we are in discussion with two interested affiliates (France and Switzerland).

The BEAT evaluation platform (https://www.beat-eu.org/platform/) is already operational and used in many projects including the large European **H2020 AI4EU**. The BEAT platform is also a cornerstone of the Open Science aspect of the **Swiss NCCR proposal "Human Trust in AI"** (HTAI) currently under final evaluation.

The "Swiss Center for Biometrics Research and Testing" was chosen to host at Idiap in January 2016 a meeting of the International Organisation for Standardisation (ISO) Sub-Committee "Biometrics" (SC 37 Biometrics). During one week, Idiap hosted around 80 delegates from National Bodies including researchers, companies and organisations.

With respect to training, the "Swiss Center for Biometrics Research and Testing" and Idiap prepared with UniDistance (http://unidistance.ch), a distance learning university, the program for a new Certificate of Advanced Studies (CAS) on "Biometrics and Privacy". This training program is currently running. Based on this experience we are currently preparing a "Biometrics" module for the "AI Master" which started early this year.

[16]The BEAT platform is an online reproducible research environment. It allows researchers to run comparative evaluations and to certify results from scientific publications.

Future program:

The "Swiss Center for Biometrics Research and Testing" has been chosen in May 2019 by the **FIDO Alliance**, an open industry association whose mission is to develop and promote authentication standards, and has been accredited (the 3rd Certified laboratory world-wide) to perform **certifications** of biometrics products. We obtained a complementary funding from Loterie Romande to set-up a FIDO accredited laboratory. Operations to certify biometric products will start in September 2019.

We are considering to join the US-CITeR as an external site in 2020. We already secured an Affiliate (IDEMIA, the global leader in Augmented Identity with 3 billion USD revenues) to join US partners such as the Department of Homeland Security, the Federal Bureau of Investigation, or the U.S. Army Armament Research Development and Engineering Center.

6 Specific Requirements

6.1 Networking with academic institutions

Idiap-EPFL Joint Development Plan: As already discussed in Section 3.4, page 55, and more specifically in the context of the Idiap-EPFL Joint Development Plan (Section 3.4.5, page 58), Idiap is actively collaborating with EPFL and developing multiple joint activities, including PhD supervision, joint publications, joint projects, and teaching.

The resulting joint activities are summarized in the draft version of the last (2018) annual joint Idiap-EPFL activity report available here:
Annexes/3431_Vorlage_Kurzbericht_strategische_Allianz_Art.15_FR_2018_23042018.pdf.

HES-SO: There is also a collaboration agreement between Idiap and HES-SO Sion/Sierre, signed on April 10, 2006 and also very active, resulting in multiple projects.

University of Bern: Dr. David Ginsbourger (currently Docent at UniBe) started at Idiap on Sep.1, 2015, while keeping his affiliation, as well as the affiliation of his PhD students (although funded by Idiap in the future), with UniBe. Although all of Dr. Ginsbourger's activities will be deployed at Idiap, we will certainly keep/extend our collaboration activities with UniBe, as well as ETHZ also involved in several common projects.

6.2 Regional (VS) impact

All the points the Idiap-VS "Contrat de Prestation":
Annexes/5211_Idiap_VS_Contrat_de_Prestation_2019.pdf.

6.3 International positioning

There is no doubt that Idiap is contributing to the Swiss scientific positioning, as well evidenced through multiple indicators, including (among many others):

1. Our annual factual Self-Assessment Report, including publications, scientific awards, services to the scientific community, h-index of research staff, professional leadership and awards, best paper awards, editorial boards, success rates of project proposals, etc, is available from:
   See Annexes/1246_Self_Assessment_Report_2018.pdf for the last version, updated in March 2019.

2. The conclusions of our 2018 International Auditing exercise:
   See Annexes/1245_Audit_Report_2018.pdf for the audit report.

3. The amount and quality of publications.

4. The amount of open source libraries (70) and distributed data repositories (52) made available (and actually exploited) by the international research community, as available from:
   https://www.idiap.ch/en/scientific-research/resources.

5. The international reputation of our senior research staff, but also of our PhD students and postdoc, as well as an impressive alumni.

6. The Idiap Web presence, content, statistics, and international visibility, as discussed in more detail in Section 5.2, page 76.

6.4 International auditing

Over the years to come, and with the aim to further boost the standing of the Institute, and further improve both scientific and technological excellence, while having a positive impact on society and industry, we will also fully take into account the recommendations of our International Advisory Board (last Audit Report in 2018), briefly summarized, and used in a conclusion in Section 7.

The fully Audit Report can be found at:
Annexes/1245_Audit_Report_2018.pdf.

6.5 Most important (25 max) scientific publications over the last five years

In each of our Annual Scientific Report, each of the Idiap group lists its 5 most significant publications. The **last version of the Scientific Report (March 2019), with key publications form 2018, can be found here: Annexes/1247_Idiap-Scientific-Report-2018.pdf.**

In the following, and as requested by SEFRI, we provide the most (maximum 25) impactful publications over the last 5 years, with a brief explanation of the reasons. All publications are available online as open source publications at:
http://publications.idiap.ch/index.php.

1. Anjos, A., El Shafey, L., and Marcel S. (2017), "BEAT: An Open-Science Web Platform", *International Conference on Machine Learning (ICML)*, 2017.
   https://publications.idiap.ch/index.php/publications/show/3665.

   Reason: We built an open platform (https://www.idiap.ch/software/beat/) for reproducible research in computational sciences related to pattern recognition and machine learning, to help on the development, reproducibility and certification of results obtained in the field.

2. Azzimonti, D., Ginsbourger, D., Rohmer, J., and Idier, D. (2019), "Profile extrema for visualizing and quantifying uncertainties on excursion regions. Application to coastal flooding.", *Technometrics (Published online)*, 2019.
   doi: https://doi.org/10.1080/00401706.2018.1562987.

   Reason: The main outcome of the Setvisu project ("Learning and visualizing dangerous regions in multivariate parameter spaces", short project funded by the Hasler foundation in 2017), along with the associated R package ProfExtrema (Azzimonti, 2018). Features a novel method useful in estimating and visualizing excursion sets relying on profile functions, with an emphasis on cases where such profile functions are surrogated in a probabilistic framework, and application to coastal flooding simulations. Interdisciplinary collaboration with colleagues from BRGM, the French Geological Survey.

3. Baqué, P., Remelli, E., Fleuret, F., and Fua, P. (2018), "Geodesic Convolutional Shape Optimization" *Proceedings of the International Conference on Machine Learning (ICML)*, pp. 472–481, 2018.

   Reason: This paper describes the use of a deep model to approximate a costly physics simulation and allow to optimize the design of aerodynamic shapes. This is the key technology of Neural Concept, which was incorporated in 2018.

4. Bect, J., Bachoc, F., and Ginsbourger, D. (2019), "A supermartingale approach to Gaussian process based sequential design of experiments." Bernoulli (Accepted author version posted online), 2019.

   Reason: Important consistency results for classes of Sequential Uncertainty Reduction strategies in the Gaussian Process framework. Result of a long-standing collaboration with two colleagues from Centrale Supéléc and Toulouse Institute of Mathematics, respectively. Comes as a theoretical confirmation that methods we had been working on in various settings can enjoy mathematical guarantees.

5. Calinon, S. (2016), "A Tutorial on Task-Parameterized Movement Learning and Retrieval", *Intelligent Service Robotics* (Springer), 9:1, 1-29 (2016).

   Reason: This publication is a tutorial on a probabilistic approach encoding movements from the perspective of multiple coordinate systems, with the goal of fusing this information during reproduction to generate movements that can adapt to new situations such as new locations of objects. This paper won a Best Paper Award.

6. Chan, K. and Liebling, M. (2017), "A direct inversion algorithm for focal plane scanning optical projection tomography", *Biomedical Optics Express*, Vol. 8, No. 11, pp. 5349–5358, 2017.
   DOI: https://doi.org/10.1364/BOE.8.005349

   Reason: In this paper, we derive an exact inversion method for a form of optical projection tomography (a technique that uses visible light instead of X-rays) enabling the use of high resolution microscope objectives. With an IF of 3.482, BIO-E is one of the leading gold open access journals in biomedical optics.

7. de Freitas Pereira, T., Anjos, A., and Marcel S. (2018), "Heterogeneous Face Recognition Using Domain Specific Units", *IEEE Transactions on Information Forensics and Security*, 2018.
   doi: 10.1109/TIFS.2018.2885284
   http://publications.idiap.ch/index.php/publications/show/3963.

   Reason: While Deep Neural Networks typically require millions of examples to learn statistical properties of a domain from scratch, we developed instead a mechanism to adapt the parameters of models pre-trained on large visual spectral face datasets to any domains (near-infrared, thermal or Forensic sketch).

8. Do, T.M.T. and Gatica-Perez, D. (2014), "Where and what: Using smartphones to predict next locations and applications in daily life", *Pervasive and Mobile Computing*, Vol. 12, pp. 79-91, 2014.

   Reason: Novelty and impact - key outcome of Nokia long-term collaboration, basis for other funded projects (EU WeNet), 99 citations google scholar.

9. Funes, K. and Odobez, J.-M. (2016), "Gaze Estimation in the 3D Space Using RGB-D sensors: Towards Head-Pose And User Invariance", *Int. Journal of Computer Vision (IJCV)*, Vol. 118(2), pp. 194–216, June 2016.

   Reason: This IJCV (impact factor 11.54) paper summarizes the results regarding an important line of research pioneered by Idiap, attention and gaze processing in the 3D space as opposed to gazing at screens (google scholar, more than 220 citation including conference papers). It led to several patents as well as the creation of the Eyeware SA company.

10. Hadid, A., Evans, N., Marcel, S., and Fierrez, J. (2015), "Biometrics systems under spoofing attack: an evaluation methodology and lessons learned", *IEEE Signal Processing Magazine*, 2015.
    http://publications.idiap.ch/index.php/publications/show/3225.

    Reason: We provided the first tutorial article with an introduction to presentation attacks (PAs) and presentation attack detection (PAD) research research ranging from vulnerability assessment, evaluation methodologies and countermeasures.

11. Henderson, J. and Popa, D.N. (2016), "A Vector Space for Distributional Semantics for Entailment", *Proceedings of the 54th Annual Meeting of the Association for Computational Linguistics (ACL)*, 2016.

    Reason: This paper reports the initial work introducing a novel framework for modelling entailment in a vector space, and associated unsupervised models of the meaning of words. The current work of the NLU group builds on this pioneering work, incorporating it in deep learning models and models of textual entailment.

12. Mutani, G., Coccolo, S., Kämpf, J., and Bilardo M. (2019), "CitySim Guide: Urban Energy Modelling", *CreateSpace Independent Publishing Platform*, 2019, ISBN-13: 978-1987609738.

    Reason: This book is a dynamic guide, particularly designed for students, researchers and planners, to the urban energy simulation tool CitySim.

13. Newling, J. and Fleuret, F. (2017), "A Sub-Quadratic Exact Medoid Algorithm", *Proceedings of the international conference on Artificial Intelligence and Statistics (AISTATS)*, pp. 185–193, 2017. (Best paper award).

    Reason: We propose in this article the first sub-quadratic algorithm for the estimation of a medoid, which is a very important operation for many real-world data processing.

14. Nguyen, L.S., Frauendorfer, D., Mast, M-S., and Gatica-Perez, D. (2014), "Hire me: Computational inference of hirability in employment interviews based on nonverbal behavior", *IEEE Transactions on Multimedia*, 16 (4), 1018-1031, 2014.

    Reason: Novelty and impact - key outcome of SNSF-funded project, basis for other funded projects (SNSF, Innosuisse), 91 citations google scholar.

15. Palaz, D., Magimai-Doss, M., and Collobert, R. (2019), "End-to-End Acoustic Modeling using Convolutional Neural Networks for HMM-based Automatic Speech Recognition", *Speech Communication*, 108:15–32, 2019.

    Reason: One of the first works in the speech community on modeling raw speech signal using neural networks for speech recognition.

16. Pappas, N. and Henderson, J. (2019), "GILE: A Generalized Input-Label Embedding for Text Classification", *Transactions of the Association for Computational Linguistics (TACL)*, 2019, https://arxiv.org/abs/1806.06219

    Reason: This paper proposes a model of how to compute embeddings of each text class from descriptions of a very large number of output classes, which both allows classification into classes with no data and improvements on classes with data. It is part of a line of work in the NLU group on output embeddings, which changes the way we think about supervised structured classification.

17. Pappas, N. and Popescu-Belis, A., (2015), "Adaptive Sentiment-Aware One-Class Collaborative Filtering", *Expert Systems with Applications*, Vol. 43, pp.23-41, 2016.
    doi: 10.1016/j.eswa.2015.08.035

    Reason: This paper presents a novel, and quite unique, application of sentiment analysis to recommender systems relying on explicit one-class user feedback (favorites or likes), namely joint models of unary feedback and sentiment of free-form user comments.

18. Ram, D., Asaei, A., and Bourlard, H. (2019), "Sparse Subspace Modeling for Query by Example Spoken Term Detection". *IEEE/ACM Transactions on Audio, Speech, and Language Processing*, 2019.

    Reason: Major improvements over leading-edge query-by-example Spoken Term Detection technologies, using advanced methods based on sparse model recovery and deep neural network.

19. Santani, D., Biel, J.I., Labhart, F., Truong, J., Landolt, S., Kuntsche, E., and Gatica-Perez, D. (2016), "The night is young: Urban crowdsourcing of nightlife patterns", *Proceedings of the ACM International Joint Conference on Pervasive and Ubiquitous Computing*, 2016.

    Reason: Novelty and interdisciplinarity - example of innovative research across social computing, public health, and human geography, 26 citations google scholar.

20. Shajkofci, A. and Liebling, M. (2018), "Semi-blind spatially-variant deconvolution in optical microscopy with local point spread function estimation by use of convolutional neural networks," *25th IEEE International Conference on Image Processing (ICIP)*, Oct. 2018, pp. 3818–3822, DOI: https://doi.org/10.1109/ICIP.2018.8451736

    Reason: This paper describes the use of convolutional neural networks to improve focus in optical microscopy. received the "Best Student Paper Award, 1st Place" at the 25th IEEE International Conference on Image Processing (ICIP), one of the largest and most comprehensive technical conference focused on image and video processing and computer vision.

21. Silvério, J., Calinon, S., Rozo, L., and Caldwell, D.G. (2019), "Learning Task Priorities from Demonstrations", *IEEE Transactions on Robotics (T-RO)*, 35:1, 78-94 (2019).

    Reason: This publication presents a probabilistic approach to learn task hierarchies from demonstration, providing robots with the capability to reproduce manipulation skills while taking into account task priorities. T-RO is the journal with second highest impact factor in robotics (source: Google Scholar).

22. Taghizadeh, M.J., Parhizkar, R., Garner, P.N., Bourlard, H., and Asaei,A. (2015), "Ad hoc microphone array calibration: Euclidean distance matrix completion algorithm and theoretical guarantees", *Signal Processing* (Elevier), Vol. 197, pp. 123-140, 2015.

    Reason: Well cited paper, presenting new approaches and mathematical bounds in the new and important area of "ad-hoc" microphone arrays.

23. Tanwani, A.K. and Calinon, S. (2019), "Small Variance Asymptotics for Non-Parametric Online Robot Learning", *International Journal of Robotics Research (IJRR)*, 38:1, 3-22 (2019).

    Reason: This publication presents a Bayesian approach to learn manipulation skills in robotics by combining both model selection and model parameters estimation. IJRR is the journal with highest impact factor in robotics (source: Google Scholar).

24. Vázquez-Canteli, J.R., Ulyanin, S., Kämpf, J.K., and Nagy, Z. (2019), "Fusing TensorFlow with building energy simulation for intelligent energy management in smart cities", *Sustainable Cities and Society (SCS)*, 2019.
    doi: https://doi.org/10.1016/j.scs.2018.11.021.

    Reason: This paper is the first attempt to combine machine learning algorithms with the urban energy simulator CitySim through Keras (API for TensorFlow). It was employed to investigate novel learning control algorithms and demonstrate their robustness for applications in the built environment.

25. Yu, Y., Funes, K., and Odobez, J.-M. (2018), "HeadFusion: 360 degree Head Pose tracking combining 3D Morphable Model and 3D Reconstruction", *IEEE Trans. on Pattern Analysis and Machine Intelligence (PAMI)*, Vol. 40(1), pp. 2653-2667, Nov. 2018.

    Reason: This IEEE-PAMI (impact factor 9.45) paper describes the first 3D head pose tracking framework from RGB-D data which can track the head of person from any view point with high accuracy (around 2 degrees), improving much over the state-of-the-art and allowing to apply the methodology as a commodity to handle large amounts of data with high reliability.

7 Conclusion

In September 2014, seven scientific world's leading figures conducted an extensive audit of Idiap at the request of the institute's director. Of course, this was exceptional (once every ten years) and in addition to the bi-annual meeting of our International Advisory Board[17] The seven experts were unanimous in highlighting Idiap's qualities, and also indicated some avenues that could lead to even further progress. In addition to documents provided by Idiap, the committee carried out the audit thanks to three days spent on site at the institute, from 3 to 5 September 2014. On the agenda, presentations by researchers, managers, and members of the scientific college, and face-to-face interviews with young researchers, postdocs, and graduate students. A few weeks later, the committee submitted a detailed report highlighting Idiap's strengths, and made suggestions regarding further improvements.

The full audit report is available from Annexes/1245_Audit_Report_2014.pdf.

Some of the main conclusions, still valid today, as of this writing (June 2019), are summarized below:

1. Research activities:
   - Scientific projects provide half of the Institute's budget: The number of projects undertaken by the institute is growing while their size and duration have decreased, large projects such as IM2 or AMI/AMIDA having come to an end. Currently, more than half of Idiap's annual budget is drawn from national and international research projects. That Idiap, in this context, continues to increase its research budget is a positive sign.
   - Quality resources and an open-source philosophy: The best specialist journals publish articles by Idiap researchers, which reflects the degree of excellence of the institute. Its researchers also contribute in a remarkable manner to the creation of quality resources, particularly databases and software, often open-source in nature.
   - Constant development of new research domains: In parallel to consolidating its pioneering activities in the field of speech recognition, now also applied to dialects, such as that of Upper Valais, for example, without lexicons, Idiap pursues its development activities in new research domains including robotics and biomedical imaging.
2. Managerial and structural activities:
   - The collegial atmosphere helps new arrivals: The friendly, collegial atmosphere, a culture of excellence, and the quality of the infrastructure present combine to make the Idiap research institute a great place to work. Students were particularly pleased with the help they received during their settling-in period in Martigny, and with the various measures aimed at encouraging social interaction.
   - High-profile and attractive: The 40 posts advertised in 2018 attracted more than 1600 applications. This illustrates the excellent visibility and attractiveness of Idiap, where no fewer than 34 different nationalities rub shoulders.
3. Relationship with EPFL:
   - Significant participation in EPFL's academic mission: Creating course materials, teaching, publishing scientific articles – Idiap's researchers play an important role in the academic mission of EPFL. Not to mention that they are training, at any one moment, over 40 PhD students.
   - Idiap – a unique setup that deserves a higher profile: The diversity of its scientific domains and the scope of its mission (research, technology transfer, and training) make Idiap a unique setup that deserves greater recognition from its various partners. The committee recommends, in particular, that Idiap researchers be appointed to academic positions at EPFL.

[17] https://www.idiap.ch/en/people/international-advisory-board

4. Knowledge and technology transfer:

    - Effective solutions to meet the needs of industry: Adapting research findings to the needs of the industry (technology transfer) is part of Idiap's mission. The institute is particularly effective in establishing influential practice (developer groups, the IdeArk business incubator, the International Create Challenge, etc.), to the great satisfaction of its partners, including industrial giants such as Nokia, Logitech, Yahoo, Samsung, and HP.
    - At the Service of the international R&D community: Attentive to local, cantonal, and federal economic development, Idiap also places its expertise at the service of the international R&D community. Highly active in the transfer of knowledge between academic and industrial institutions, Idiap creates and makes available a significant number of professional software packages – a service that a traditional university structure has more difficulty to deliver.
    - Innovation driver: By positioning itself as an innovation driver, Idiap is adopting a strategy that benefits Swiss industry. The recently created biomedical image processing research group and Swiss Center for Biometrics Research and Testing illustrate the institution's intention of remaining in tune with contemporary economic and societal needs.

In concluding its report, the audit committee presented certain recommendations for improving Idiap's productivity and impact:

- To complete its organizational structure, Idiap could establish an advisory group—including scientists—tasked with planning future infrastructure investments.
- An intensification of the relationship with EPFL can be achieved by securing EPFL academic appointments for Idiap researchers and by establishing better connectivity between the two entities.
- The committee encourages Idiap to continue its exploration of new application domains (medicine, energy, etc.) and to create a partnership with those European organizations that are likely to facilitate Idiap's integration into major projects in the long term.

« La force première de l'Idiap réside d'abord dans la qualité de ses employés, […] la diversité de son portefeuille de recherche, l'étendue de son talent technique ainsi que la qualité de l'innovation […] »

« Die entscheidende Stärke von Idiap liegt in der Qualität seines Humankapitals, [...] der Vielfalt des Forschungsportfolios, in seinem fundierten technischen Wissen und der Qualität der Innovationen […] »

« Idiap's key strength is the quality of its human capital, […] the diversity of its research portfolio, the depth of its technical talent, and the quality of innovation […] »

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