Centre Universitaire d'Informatique

2023

Activity Report

CUI UNI GE

Tecday event, Collège Emilie Gourd (Geneva), October 2023

UNIVERSITÉ DE GENÈVE

Foreword

We live in an era of digital transformation with a tremendous impact on our societies. The year 2022/2023 was marked by the massive arrival of tools and services integrating aspects of artificial intelligence, we cannot and must not miss out on generative AI tools like chatGPT, Dall-e, or other aspects of AI like semantic AI or distributed AI. This involves the exploitation of these technologies, a reflection on their use and their limits, but also an updating of curricula in order to best integrate these capabilities/new developments into digital services or processes.

The mission of the Centre Universitaire d'Informatique (CUI), funded in 1975, is more than ever essential to address the issues raised by digitalisation and AI. Our mission at CUI, as scientists, is to be pioneers of technology, to stimulate the digitalization of services in order to promote the progression of society, while keeping in mind key elements and important values such as: digital responsibility, respect for users and a user-centered view or ethics. As teachers, our mission is to transmit these values and knowledge to our students so that they can develop the digital services of tomorrow with full knowledge of the facts and in compliance with these principles. Such an approach is necessarily interdisciplinary in that AI, the digital transformation and digitization of services is necessarily done for the benefit of another field or profession (e.g. health, environment, mobility, energy, education).

CUI federates research and teaching activities at the University of Geneva. For the second time in a few years, we have seen an increase of 25% of the number of BSc and MSc students enrolled at CUI, and thus observed the biggest growth in terms of students of the whole University. Our interdisciplinary BSc in Information systems and service science attracts more students than ever, as our MSc in digital systems and services, a research-oriented program with various specialisations (e.g. Digital transformation, Knowledge engineering, Smart cities, User experience, Information security). A new version of the MSc in Mathematics and computer science led jointly with our colleagues of Mathematics also attracts additional students. A novelty of 2023 consists in the development of a BSc in Computational sciences bringing together computer science and other science fields (e.g. biology). Continuous education is also very present at CUI with programs covering various domains from AI, data protection, information security, blockchain, information systems management, or data science. In that field, we pioneered the notion of micro-certification allowing participants to progressively gather credits, while attending two-days sessions, and personalise their cursus. We developed a series of highly successful sessions on AI: AI for non-specialists, AI and Education, AI and Ethics. In that line, we developed at the end of 2023 the AI Clinic which aims at answering demands from the University or external organisations, providing courses, and hands-on workshops. We intend to cover the whole spectrum of AI from Scientific AI, to AI as a Service, and AI in everyday life.

With more than 200 members of staff, of which approximatively 60 PhD students enrolled in our various doctoral programs, we develop key research competences in several areas, particularly on: Artificial Intelligence, Virtual and Augmented Reality, Services for Smart Cities, Modelling and Simulation, Information Security, E-Health and Quality of Life, Natural Language Processing, or Computational Diplomacy. This research is supported by more than 4.45 MCHF of externally funded money (38% of our total budget).

In addition to research, we developed reach out activities. Started in 2018, the Infoscope offers now 6 workshops for Geneva's school primary and secondary classes. It also regularly goes outside our walls, meeting its public on various places or events, such as La Nuit de la Science or Tecdays.

In 2019, CUI established the Digital Innovation Hub of the University of Geneva. Part of the University's digital strategy the Digital innovation hub has 3 main missions: (1) developing innovative services for the University community, (2) reaching out to the public, private, international sector with innovation activities or proof-of-concepts, (3) supporting students and researchers with digital projects that lead to commercial exploitation or social impact. In 2023, we set up with Egality service, the Bootstrap initiative, aiming at enrolling high-school female students access to University courses. This pilot initiative has seen 4 young women attending two of our courses. In parallel, we pursued the programming club, "Coding Dojo", addressing three public: high-school students (mixed), University students, and researchers. This activity is held in collaboration with the HEG. In 2023, we awarded to 10 high-school students, 3 ECTS they can validate in CUI or HEG programs and provided specific data oriented class to 50 researchers. Together with our students we develop innovative services for the University, first as proof-of-concepts, and second as actual services provided to the whole community. Among our 2023 success stories, we can mention interactive data visualisation for the Careers office and a service compliant with regulations to ensure the follow-up of PhD students.

Since end of 2022, we are also part of the 4EU+ alliance Flagship 3 on Digitisation, modelling and transformation, which provides a source of activities and learning material for our students.

I seize this opportunity to thank all CUI members of staff, students and researchers for their hard
work, commitment, innovation, reach out and research activities, all participating to our national and international visibility and excellence.

The coming years will see the development of interdisciplinary partnerships with other disciplines of the University of Geneva, the establishment of links with the local industry and administration, and a series of digital and AI-based innovations for the University community.

Prof. Giovanna Di Marzo Serugendo
Director of the CUI
University of Geneva

Organisation

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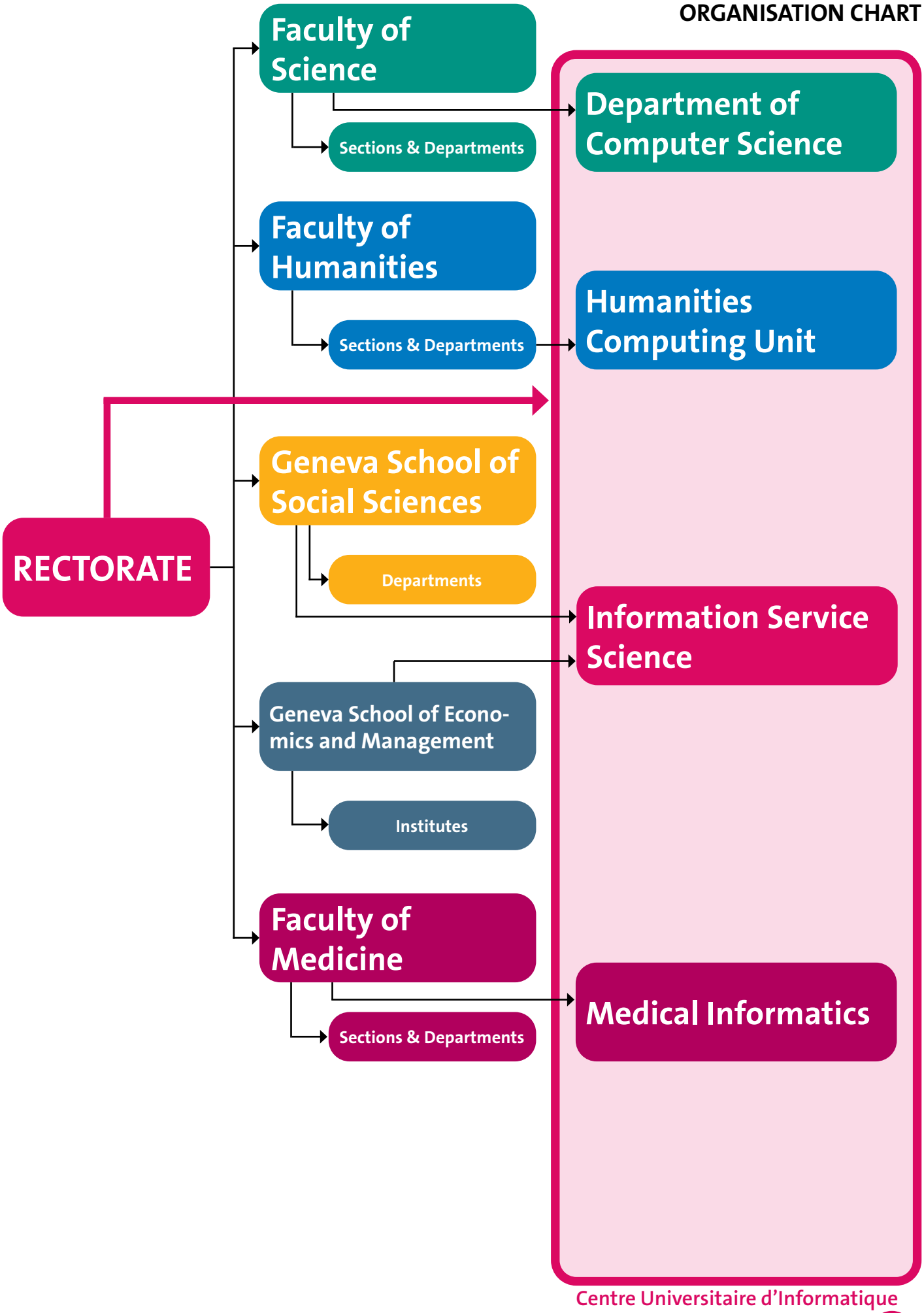
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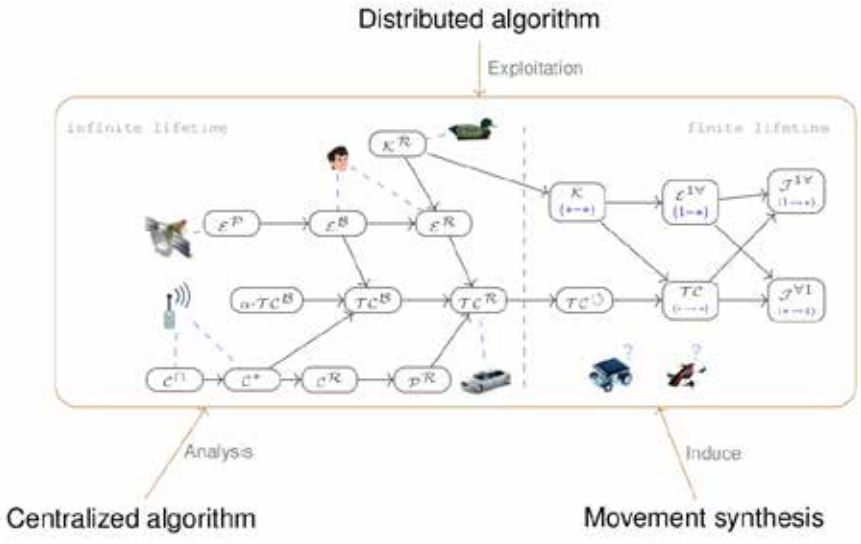
ALGO

Algorithms, Graph theory, and Complexity

Domain activities

Our group is interested in the many facets of theoretical computer science and network science, ranging from distributed algorithms to graph theory, computational complexity, and quantum algorithms. Many real-world networks (e.g. networks of robots/drones, wireless sensors, and vehicular networks) are dynamic, which makes their modeling and study challenging. For this reason, the group has a strong focus on temporal graphs, i.e. graphs that change over the time and whose temporal properties are essential. For example, we study the shape of communication patterns in these new graphs and the computational complexity of related algorithmic questions like connectivity, spanners, and distributed computing in time-varying networks. We also revisit motion planning problems for mobile entities, using a discrete (algorithmic) approach. Finally, we recently started to investigate the connection between graph algorithms and quantum computing, in particular the role played by graph optimization problems such as maximum independent sets in the quantum annealing paradigm.



Director
Arnaud Casteigts
Full professor
H-index: 23

Pierre Leone
Senior Lecturer and Researcher

ACG

Applied Complexity Group

Domain activities

The applied Complexity group (ACG), directed by Prof. Roland Bouffanais (Computer Science & Global Studies Institute, University of Geneva), conducts interdisciplinary research at the intersection of Complexity Science, Multi-Agent Systems, Network Science, Computational Social Science, Data Science, including Artificial Intelligence.

Director
Roland Bouffanais
Associate professor

Our research involves a synergistic combination of computational and theoretical developments, with real-life experimental validations.

We foster cross-disciplinary exploration to gain insights into a range of complex systems including social networks, swarm intelligence, complex urban systems, human dynamics, etc. We maintain a constructive and open dialogue between science, society and industry.

Our team members hail from various fields and have expertise in a vast range of disciplines – including computational science, social sciences, machine learning, network science, robotics, and control theory.

A significant part of our funding comes from industry collaborations, with local industry or government agencies, as well as multi-national companies.

CCL

Citizen Cyberlab

Domain activities

In the domain of Citizen Science, Citizen CyberLab (CCL) aims to design and develop new ways of enabling public participation in research. In 2023, CCL launched a citizen science initiative for gathering data about water resources in Nigeria, as a result of its collaboration with UNICEF and the Botnar Foundation. This initiative, called DonateWater, was co-created with a team of four young Nigerians through an online innovation methodology developed as part of the EU project Crowd4SDG, which concluded in March with a Final Conference at CERN, co-organized by CCL.

In November, CCL coordinated the Geneva Satellite Event of the UN Datathon. The UN Datathon engaged over 1600 participants in more than 400 teams from around the world. As part of the UN Datathon, CCL started a collaboration with UNFCCC (United Nations Framework Convention on Climate Change), regarding the use of crowdsourcing and AI for making UN documents more accessible and the potential use of AI technologies within the organization of diplomatic negotiations.

In 2023, CCL also became part of the Social Media for Disaster Risk Reduction task force created by the European Crisis Management Laboratory. CCL contributed with its expertise on the use of citizen science tools in the field of disaster response and led several publications in the area.

Directors
François Grey
Associate professor
H-index: 38

Jose Luis Fernandez-Marquez
Senior Lecturer and Researcher
H-index: 16

clcl.unige.ch

CLCL

Computational Learning and Computational Linguistics

Domain activities

The Computational Linguistics and Computational Learning (CLCL) Research Group (http://clcl.unige.ch/) is concerned with interdisciplinary research combining linguistic modelling with machine learning techniques.
We participate in two major projects.

Director
Paola Merlo
Associate professor
H-index: 23

In our SNF Advanced Grant project Disentangling linguistic intelligence: automatic generalisation of structure and meaning across languages, we set the challenging goals of investigating higher-level linguistic abilities in machines, in more realistic settings. We identify these abilities as the intelligent ability to infer patterns of regularities in unstructured data, generalising from few examples, using abstractions that are valid across possibly very different languages. We study if current neural network architectures have these properties with a new set of tasks inspired by IQ intelligence tests, called Blackbird Language Matrices. We have developed data for some linguistic tasks, concerning both grammar and meaning, developed new architectures for solving our BLM task, and investigated if current LLM (ChatGPT4) can pass our BLM tests (no, it does not solve it well yet), establishing some interesting parallels with human problem-solvers.
For more information, visit our Github site: https://github.com/CLCL-Geneva/BLM-SNFDisentangling

We continue our participation in the NCCR Evolving Language, where we are studying the basic mechanisms that structure communicative expressions, i.e. the mechanisms of combination and division that distinguish a given expression from a holistic signal in non-human animals and also whether prosody enhances the cortical encoding of syntactic representations.

As a whole, the Swiss National Centre of Competence in Research (NCCR) Evolving Language is a nationwide interdisciplinary research consortium bringing together research groups from the humanities, from language and computer science, the social sciences, and the natural sciences at an unprecedented level. Together, we study how our species developed the capacity for linguistic expression, language in the brain, and for consistently passing down new variations to the next generation. We also ask how our capacity for language will change in the face of digital communication and neuroengineering.
For more information see https://evolvinglanguage.ch/

CVML

Computer Vision and Multimedia Laboratory

Domain activities

The **Computer Vision and Multimedia Laboratory** (CVML, http://cvml.unige.ch), divided into three groups, carries out research in multimedia data processing, multimedia data management and security, as well as in multimodal human-machine interaction. Research applies to media such as text, audio tracks, sounds, images and videos, and to physiological signals.

Information Retrieval and Machine Learning group (Viper, Prof. S. Marchand-Maillet, Prof. A. Kalousis, http://viper.unige.ch): develops strategies for the efficient modeling, indexing, retrieval and exploration of large-scale datasets. The group studies fundamental machine learning strategies to provide efficient and accurate understanding and access to large-scale collections of complex data. Research themes include information retrieval, recommendation systems, data analytics and exploration, learning over sequential and temporal data, structured and kernel learning, regularization techniques for neural networks. Applications are considered in the fields of data visualization, forecasting, IoT, chemoinformatics, biomedicine.

Stochastic Information Processing group (SIP, Prof. S. Voloshynovskiy, http://sip.unige.ch): studies various aspects of information-theoretic machine learning. The applications mostly cover several domains : physical object security, generative models and anomaly detection in high energy physics, astrophysics and next generation imaging techniques for the radio-astronomy.

Social Intelligence and Multi-Sensing group (SIMS, Dr. G. Chanel, http://sims.unige.ch): Social Intelligence and Multi-Sensing group (SIMS, Dr. G. Chanel, http://sims.unige. ch): conducts research in artificial intelligence, socio-affective computing, multi-sensing, human machine interaction, entertainment and games. Our objective is to better understand human behaviors in their daily environment particularly when interacting with machines and multimedia. Our approach is based on multimodal sensing and artificial intelligence to make meaning out of several measures including audio, videos, eye-movements, physiological signals such as EEGs (electroencephalograms), EMG (electromyograms), blood pressure, galvanic skin resistance (GSR), skin temperature, and breathing rate. The SIMS group is also part of the Institute for IT Engineering and Telecommunications from HEPIA and tightly collaborate with the Swiss Center for Affective Sciences (faculties of psychology, literature and medicine).

Co-Directors

Sviatoslav Voloshynovskiy
Full professor
H-index: 35

Stéphane Marchand-Maillet
Associate professor
H-index: 27

Alexandros Kalousis
Full professor
University of Applied Studies, Geneva School of Business Administration
H-index: 33

Guillaume Chanel
Senior Lecturer and Researcher (also affiliated with the Swiss Center for Affective Science)
H-index: 27

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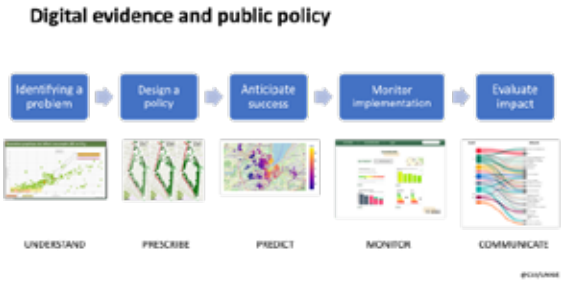
Collective Adaptive Systems

Director
Giovanna Di Marzo Serugendo
Full professor
H-index: 34

Domain activities

Collective Adaptive Systems refer to a form of complex systems where a large number of heterogeneous entities interact without specific external or internal central control, adapt their behaviour to environmental settings in pursuit of an individual or collective goal. Actual behaviour arises as an emergent property through swarm or collective intelligence.



We lead and develop research in the following areas:

- Studying natural systems (e.g. biological, social, human ones) and identifying essential models, mechanisms and interactions at work at the heart of those systems, mostly through agent-based models, simulations and design patterns.
- Designing and developing artificial collective adaptive systems and different forms of emergent behaviour (e.g. swarm robotics, ecosystems of spatial services for smart cities, higher-order emergence)
- Verifying the reliability and trustworthiness of those systems prior to their deployment in real-life settings.
- Developing Digital twins, AI and digital services for evidence-based policy making
- Investigating semantic-based multi-agents systems and digital twins
- Leveraging artificial intelligence techniques for geo-spatial applications.
- Transforming business processes combining various AI techniques (semantic AI, multi-agent systems, GenAI).

We are also active in developing innovative services in the academic field. Leveraging students projects, we set up an accelerator of science and services (https://www.unige.ch/stic/innovation) to devise prototypes, and an R&D unit (https://www.unige.ch/stic/cellule-rd/index) to continue the pipeline of innovation into proper industrialisation of innovative services.

We are pioneer in Switzerland in this field for the academic sector. We regularly coach BSc/MSc students, internships and perform mandates in that field.

http://unige.ch/cui/cas/

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Digital Trust, from Decentralized Finance to Augmented Human & Metaverse

Domain activities

For ages, humans have used the human notion of trust as a means to cope with uncertainty, to engage in an action in spite of the risk of a harmful outcome. More recently, computational models of this human notion of trust have been researched in order to be able to use trust in the digital world as well, between computers and/or digital accounts controlled by remote humans, from direct observations to recommendations and online reputation. Technical decentralized trust solutions such as blockchains are revolutionizing many business domains from finance to supply chain certification. In the near future, it is even envisioned that humans and computers merge together, possibly creating a metaverse. We have contributed to this trend with the organization since 2010 of the augmented human international conferences focusing on scientific contributions towards augmenting or retrieving human capabilities through technology. We are researching how these augmented human technologies can improve computational trust assessment not only of machines but also of humans.

https://www.linkedin.com/in/jmseigneur/

Director
Jean-Marc Seigneur
Senior Lecturer and Researcher
H-index: 22

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Digital Rights & Policy

Domain activities

As our society and economy continues to move towards interwoven digital services and systems, blending the real and the artificial world, our research activities continue to investigate some of the complex challenges and issues towards a more sustainable and responsible digital society. Information Protection and Control (IPC) in general and the growing need for Data Protection have become recognized area where increased research is needed. We continue our work in those areas with a particular look at distributed ledger technologies (blockchain) as a mechanism to support new services and designs to support increasingly complex requirements. Major examples of these research issues we are currently working on include data marketplace ecosystems, dispute resolution and arbitration, data protection and digital rights and policy management.
From July 2016 to July 2017, Jean-Henry Morin is on sabbatical leave in South Korea where he is Invited Professor at Korea University Business School and Yonsei School of Business. During this time, he is also invited researcher at Fasoo.com where he investigates blockchain technologies in Information Security.

Director
Jean-Henry Morin
Associate professor

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Digital Transformation

Domain activities

Director
Jolita Ralyté
Senior Lecturer and Researcher
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Digital transformation is not just the adoption of new information technologies and the computerization of human activities. It embraces much broader strategic ambitions and involves fundamental changes in the activities, structure and even culture of the organization, with the primary goal of innovating and creating value. Service Science plays a driving role in digital transformation by providing key concepts, such as information service and service system, that facilitate business innovation through the integration of digital technologies. The approach for information service and system engineering must be necessarily exploratory, agile, and contributory, as the implementation of new services transforms the daily life of many people, and affects the organisation's activity and even its position in the ecosystem. Such transformation has to be understood, assessed and accepted by all parties. To be successful, it must be value-driven and ensure the involvement of all stakeholders by making them responsible co-creators. The transdisciplinary is another dimension to be considered in service co-creation as it allows to cross the borders of the conventional information system engineering and create new capabilities and new values. To make the approach holistic, we need to consider many other service-related aspects, such as ethics, accountability, compliance to the regulatory framework, and risks. The robustness and sustainability of services will depend not only on the quality but also on the situational-fitness of the approach. Indeed, the context and requirements of each organisation facing the digital transformation challenge is different, and therefore requires a situation-specific approach. We apply situational Method Engineering principles and techniques for developing our approach and defining contextual criteria for its configuration and application.

https://cui.unige.ch/~ralyte/
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https://www.researchgate.net/profile/Jolita-Ralyte

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Information Security Lab (I-SEC)

Domain activities

In the domain of cybersecurity, the institute's Information Security Lab (I-Sec) aims to translate the complex nature of cybersecurity into an easily comprehensible way to understand, monitor, and control the risks of employing current and future technologies. With a strong commitment to co-designed solutions with end-users, we research new ways on how to expose and present the raised implications on privacy, risk, security, and safety. In 2023, I-Sec has been working on three EU projects, namely ULTIMO, ENFLATE, and OPEVA, in the domains of the Internet of Things (IoT), Connected (autonomous) vehicles, Smart Cities, and (critical) infrastructure. I-Sec's research works vary from risk assessment, threat identification, anomaly detection, privacy preservation, usability in security and privacy to mitigation advisory.

isec.unige.ch

Director
Niels Alexander Nijdam
Senior Lecturer and Researcher

Anastasija Collen
Senior Researcher

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ISS

Institute of Information Service Science

Knowledge Engineering

Domain activities

Knowledge Engineering @ ISS is a research laboratory of the Institute for Information Service Science (ISS) within the Center for Computing (CUI) at the University of Geneva. KE@ISS is conducting research on knowledge engineering: knowledge representation, knowledge-based information systems, and interfaces to access knowledge, with an emphasis on ontologies, semantic web, information extraction, and space-related applications.

The main results obtained in 2020 relate to:

- The contextualization of knowledge graphs: a model for representing context types in Wikidata ; many-sorted logic and algebraic specifications to express semantic rules ;
- Representing subsurface geospatial objects: integrating different types of geospatial models ; expressing completion and conformance rules for subsurface objects
- The development of a model for the adaptation of health-related applications based on user psychological profiles

Directors
Gilles Falquet
Associate professor
H-index: 18

Claudine Métral
Senior Lecturer and Researcher

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Mobile Services

Domain activities

The CCAMLab's research results influenced policy-making and regulatory framework adaptation in Switzerland and Europe. In mobility management, the institute contributed to the creation of new legislation in Switzerland, Germany, Luxembourg, and Denmark. Active participation in European Commission high-level strategy think-tanks helped define the European Union policy and strategy in CCAM deployment and research directions for the Horizon Europe program in automated mobility. The most important project of the CCAMLab is the Horizon Europe flagship project, ULTIMO, initiated and led by the institute, and which is the largest EU project in mobility with automated vehicles, receiving a total funding of 40 MEUR involving 24 partners.

Director
Dimitri Konstantas
Full professor
H-index: 31

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Quality of Life Technologies (QoL)

Domain activities

Director
Katarzyna Wac
Full professor
H-index: 27

In the domain of Quality of Life, the QoL Lab is conducting research related to the well-being of citizens at different stages in their lives, financed by the European Commission, the Swiss government, and the industry. Using our large-scale living lab (established in 2012) comprising smartphone users testing various applications and services, we conduct both fundamental and applied research, with a high impact influencing decision-makers and policies.

During 2023, a large-scale study under the Canton of Geneva's initiative to study resident well-being, supported by comprehensive research, our group has yielded recommendations for policymakers that facilitate the sustainable enhancement of well-being in the Geneva area. Furthermore, our pharmaceutical industry-sponsored project in migraine self-management marked a paradigm shift in healthcare delivery, extending beyond traditional pharmacological treatments. Our contributions were pivotal in advancing technology-based disease risk assessment, diagnosis, and therapeutic intervention evaluation.

Addressing the critical issue of mental health in academia, our work, including the Researcher Mental Health and Well-being Manifesto and a widely recognized Nature Mental Health consensus statement, highlights the role of digital technology in mental health. This contributes significantly to nurturing researchers' mental health at various levels, from policy to personal. Finally, through the AGE-INT project, Switzerland has bolstered its research in aging, gaining international recognition and influencing policy with robust research evidence. This marks a significant stride in developing innovative solutions for aging societies.

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Travelling and Mobility (TaM)

Domain activities

The TaM group of the University of Geneva has proved, for many years, that they are able to contribute to the scientific state of the art by publishing in peer review journals or conferences. Machine learning techniques are mastered up to the state of the art. The success of the Innosuisse projects Alina (2023), HorseTrack (2021), QueueForMe (2020) and Recover@home (2018) are the perfect examples of why our team is the most relevant when dealing with machine learning in applied research in various fields. During the last two projects we published in the AI4I conference. One of this work led to a best paper award that was attributed to a member of our team. Beyond machine learning techniques, our group is experienced in working with different kinds of sensors and the special data post treatment they require. Finally our research group is used to working with private companies and their constraints. TaM's infrastructure is perfect for deep learning computing thanks to batch job access to run heavy computation on the cloud.

Keywords: artificial intelligence, machine learning, data processing, sensor data analysis, fusion algorithms, indoor positioning, indoor localisation, indoor navigation, GPS, maps, Geographic Information Systems, health tracking, health monitoring, eHealth

tam.unige.ch

Director
Michel Deriaz
Senior Lecturer and Researcher
H-index: 13

latl.unige.ch

LATL

Laboratory for the Analysis and Technology of Language

Domain activities

LATL (https://cui.unige.ch/latl) has been active in the field of natural language processing since the early 1990's. Its main research focus is the development of a multilingual syntactic parsing model (the Fips parser), as well as the development of large lexicons and dictionaries.

The Fips parser is currently available for several of the main European languages (English, French, German, Italian and Spanish), with several other languages at various stages of development (Romanian, Greek, Japanese). In 2023 the LATL continued the development of the parsers for the above languages. It is based on a grammatical model inspired by Chomsky's generative grammar and on an object-oriented design for its implementation. The parser and its rich lexical database are used in a number of applications, including machine translation, terminology extraction, speech-to-speech translation, and computer-assisted language learning.

The LATL works on a project of digital edition of Ferdinand de Saussure's manus- cripts in collaboration with the Knowledge Engineering group. In 2023 the LATL continued its effort on the automatic transcription of manuscripts. In this task the LATL benefited from two advanced computer science student labour force, under the form of Bachelor's research work. This work was done with the colla- boration of the central computer sciences services of the University of Geneva and the Università della Calabria (Italy).

The LATL was also involved in many collaborations with various University of Geneva Faculties through advanced student's Information and Communication Technologies projects in collaboration with the Department of linguistics, the Department of east Asian studies, the Unige Research and Scientific Information Services and the Digital Services for Students and Teachers among others. These projects end with some remarkable results, e.g. an Interactive linguistic atlas for Arabic dialects, the Petit Prince website, a website for Chinese language learning, CUI projects portfolio, Study on the accessibility of the UNIGE's eLearning tools, etc.

Directors
Luka Nerima
Senior researcher

Eric Wehrli
Honorary professor
H-index: 24

mlg.unige.ch

MLG

Machine Learning Group

Domain activities

The Machine Learning Group of the computer science department investigates the development of novel machine learning methods with a particular interest for their algorithmic cost and sample efficiency.

Learning from data is a key element in modern techniques of artificial intelligence and has demonstrated remarkable performance for real-world tasks that require to deal with complex large dimension signals such as images.

The first downside of these methods is the requirement for very large training sets, recorded sensor data accompanied with a human-generated «ground truth» that specifies the ideal response an AI system should generate. Such ground truth is difficult to generate and often suffers from undesirable and problematic biases. The second downside of high-performance leaning-based AI methods is their computational requirements, that often translate to tens of thousands of computer hours, with the associated financial cost and environmental impact.

We aim at mitigating both to allow a wider use and lesser impact of AI.

Director
François Fleuret
Full professor
H-index: 43

PIG

Proteome Informatics Group

Domain activities

The Proteome Informatics Group (PIG) is involved in bioinformatics. Bioinformatics is a recently created discipline in which computer technology is applied to the understanding and effective use of biological data (see http://www.sib.swiss/bioinformatics-for-all/what-is-bioinformatics). At PIG, we concentrate on the study of proteins that are the active molecules of the cell. Extracting and studying proteins from a cell or a tissue requires the use of sophisticated experimental methods which generate large datasets. The analysis of this experimental data entails the identification and quantification of proteins, the determination of their cellular location, modifications, interactions and, ultimately, their function. This information is crucial to decipher cellular processes. This strongly motivates our group to develop software and databases that support data analysis and knowledge discovery in cooperation with Life scientists. These resources are made available through the ExPASy server (http://www.expasy.org). Our software tools mainly support experimental mass spectrometry data analysis, focused on the detection of post-translational modifications. Our databases store knowledge of carbohydrates (sugars) attached to proteins as well as protein-carbohydrate interactions.

In 2020, the group has been actively involved in collecting carbohydrate-related information describing the Sars-Cov-2 surface protein known as the main target of vaccines (spike protein). It provides a striking example of a phenomenon called the «sugar shield» which helps the virus escape the vigilance of the immune system. The figure below illustrates a 3D model of the bare protein on the left and the shielded protein on the right. Collected data on the sugar shield is made available to the scientific community through our resources.

http://www. sib.swiss/lisacek-frederique

Director
Frédérique Lisacek
Senior Lecturer and
Researcher
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SMV

Software Modeling and Verification

Director
Didier Buchs
Full professor
H-index: 20

Domain activities

Symbolic Model Checking was developed with the idea of verifying complex high level models with a reasonable amount of work for the user. In particular we propose to separate the model to the informations for performing eficiently model checking (clustering, anonymization, partial unfolding). The introduction of new kind of decision diagrams (∑ -DD) based on a generalization of the Shannon decomposition principles allow us to perform model checking for models with huge combinatorial explosion of states (around 10E4500 symbolic states). We are currently exploring the systematic use of rewriting of set of terms principles based on decision diagrams and operational control based on strategies as a metalevel in model checkers.

We currently develop several tools such as StrataGEM for the set rewriting principles, Stew as an abstraction over StrataGEM and Ardoises a meta-environment for managing formalisms and their veri cation tools. We also continue to organize a model checking contest in the conference Petri Nets in order to be able to compare existing model checkers on significant benchmarks. We also study programming language construction that check that the use of memory is alias safe. This language SafeScript is extending JavaScript in an elegant way. We also develop methods to adapt our formalisms (CREST) to the domain of modeling and verification of cyber-physical systems.

Several application domain have been covered by the team such as the development of a domain specific language for computing on sets (Trexmo Tool for the SECO). This language is applied successfully for expressing various models of toxicology analysis in the context of health in the workplace.

spc.unige.ch

SPC

Scientific and Parallel Computing

Domain activities

The Scientific and Parallel Computing laboratory (SPC, https://spc.unige.ch/en/), divided into two groups, dedicates its research to the fields of computational science and high performance computing, with a special focus on the study of complex systems and modelling approaches based on cellular automata, lattice Boltzmann, and multi-agent techniques. Massively parallel programs and algorithms are developed, capable to explain or reproduce natural phenomena with the help of computer simulations executed on CPU and GPU-based supercomputers. The SPC lab develops and maintains the open-source software Palabos (www.palabos.org), which is widely used and acknowledged by the simulation community and has been used as a tool for more than 300 publications by universities world-wide. Palabos is used as a tool to spread the research of the UNIGE internationally, establish collaborations, and assess the expert position of the UNIGE in the field of lattice Boltzmann modeling.

Directors

Bastien Chopard
Full professor
H-index: 46

Jonas Lätt
Professor
H-index: 22

tcs.unige.ch

TCS

Theoretical Computer Science

Director
José Rolim
Honorary professor
H-index: 25

Domain activities

Experimental driven research on Topology Control Protocols for Wireless Sensor Networks (WSN) using transmission power and throughput rate feedback schemes. The goals include link qualification in terms of symmetry and coherence and link quantification. Transmission power constitutes the link «generator» and throughput rate the link «regulator» to meet the qualitative and quantitative criteria for links between WSN nodes .

Research on designing a geographic routing algorithm for large scale networks, which is an extension to the Virtual Raw Anchor Coordinate localization based geographic routing. The goal is to perform routing in wireless ad-hoc network in a hierarchical manner, where in the top level routing is done between two geographic regions and in the bottom level performing routing to the exact node. A randomized protocol is designed and evaluated with simulations.

Design of a distributed publish/subscribe algorithm for an ubiquitous sensing scenario. We consider unstructured and free-geocoordinates sensing networks in which no network protocol is provided. Our solution, which avoids implying all the nodes of the network in the dissemination process, uses a distributed notification service defined by Directional Random Walks (DRW). A DRW is a probabilistic technique able to go forward into the network following a loop-free path. The principle assumed in our research is that two lines in a plane cross.

Also research on Future Networks, Internet of Things and Crowdsensing. Our efforts focus on problem modeling aspects and incentive formulation regarding the crowd participation in tasks that aim at optimizing spatial and temporal coverage issues.

Also, research on radiation aware wireless networking; studying the cumulative impact on ERM caused by multiple wireless sources in terms of numbers, topology, protocol, etc.

Thesis completed

Fayez Alrafeea

Doctor ès Social Sciences, mention Information Systems

24th July, 2023

Directors: Prof. Giovanna Di Marzo Serugendo, Prof. Basile Zimmermann

CERTIFY: A Distributed Framework for Handling Online Misinformation through Crowdsourcing and Fact-checking

The arrival of social media suddenly gave everyone a voice to express their ideas publicly. While this democratization has great potential in allowing everyone to be heard, it has fl ooded the online landscape with overwhelming information. The work of journalistshas changed dramatically as well; with the new model of news consumption pushing for constant novelty, media companies regularly rush to deliver more content in a shorter period, with less time to check for quality.

These factors led to the problem of online misinformation, where information that is wrong or gives a false impression is shared publicly. Or disinformation, as false information that is deliberately posted. Misformation and disinformation are known as information disorder or the popular but politically charged term fake news . Although fake news has existed for a long time, the emergence of the Internet and social media has fueled it to have more serious consequences for the public. In the last decade, theinformation published online has proven that fake news can change dynamics on the ground in elections, revolutions, strikes, natural diseases, and pandemics; fake news can cause damage in real life.

This research addresses the multifaceted issue of fake news using Information Systems approaches. The thesis includes exploring the historical background and current state of fake news, analyzing the challenges that hinder solutions, and developing a modelthat empowers experts and engages users in fact-checking to combat the spread of misinformation. Concretely, the study is divided into four key areas of focus: fi rstly, comprehending the current «fake news problem» by scrutinizing its evolution in today's digitallandscape. Secondly, it critically evaluates the challenges obstructing the development of effective solutions. Thirdly, it contributes to combating fake news by designing a knowledge transfer model. Finally, the research predominantly focuses on thetechnological and technical aspects of implementing and testing the model's effi ciency in curbing the spread and impact of fake news.

Finally, the trajectory of this project has been marked by hard work but also rare opportunities, commencing with a Swiss Excellence Scholarship in 2017, which facilitated its initial development. Three years later, the project received two grants from the SwissInnovation Agency, which allowed further development of the user testing sessions.

Doctorat thesis: Univ. Genève, 2023 - SdS 236 - 2023/07/24
https://archive-ouverte.unige.ch/unige:171727

Alexandre De Masi

Doctor ès Economy and Management, mention Information Systems

24th August, 2023

Director: Prof. Katarzyna Wac

Context-aware Mobile Internet Quality Model: Quantifying and Facilitating Smartphone's Quality of Experience

In 2021, people spent about 20% of their daily time using smartphone apps. The smartphone has become essential for decision-making, entertainment, and communication, especially when mobile. The quality of these activities is infl uenced by the user's contextand network state. Quality of Service (QoS) has been used to study user experience in relation to network metrics like jitter, packet loss, and throughput. However, the complexity of modern smartphone apps and users' rapidly changing environments have madeQoS insuffi cient. Thus, Quality of Experience (QoE) was introduced, focusing on the human element of the system, including user intentions and expectations.

Current QoE research mainly improves network protocols or adapts content to various network situations, often in lab settings with limited participation and duration. There's a gap in understanding the long-term, real-world human factors affecting QoE. Toaddress this, a study was conducted in natural settings, examining connectivity levels and application usage patterns among different user groups. This included a forecasting model based on crowdsourced app usage history to predict app launches, aiming toenhance smartphone app QoE.

The thesis proposed a method to quantify and improve smartphone app QoE by focusing on the context. A mixed-method approach was used to create a QoE quantifying model and a contextual model for predicting expected QoE. Additionally, a QoE notifi cationsystem was tested, showing potential to reduce user annoyance and time spent on smartphones, laying groundwork for future QoE-enabled services

Doctorat thesis: Univ. Genève, 2023 - GSEM 129 - 2023/08/24
https://archive-ouverte.unige.ch/unige:174205

Niccolo Marini

Doctor ès Sciences, mention Computer Science

19th July, 2023

Directors: Prof. Stéphane Marchand-Maillet,
Prof. Henning Müller

Deep learning methods to reduce the need for annotations for the extraction of knowledge from multimodal heterogeneous medical data

Histopathology involves the examination of tissue sections to identify diseases and represents the gold standard for cancer diagnostics. The manual analysis of tissue samples is a time-consuming task, performed by medical doctors specialized in pathology,called pathologists. However, the agreement between pathologists on diagnoses is still often low, due to several factors (the heterogeneous morphologies of tissue structures, the arbitrary selection of the regions to analyze in detail and the fi ndings evaluationthat may be subjective or biased by pathologist experience). Tissue analysis is still usually performed with limited diagnostic assistance in clinical practice, even though digital pathology is becoming more present in clinical routine.

Digital pathology involves acquiring and managing digitized histopathology images, called Whole Slide Images (WSI). WSIs are generally acquired at high-resolution and stored in a multiscale format, allowing pathologists to visualize different details of thetissue structures, from the lowest to the highest magnifi cation levels. Pathological fi ndings, including observations from WSI analysis, are usually described in a pathology case report, which are semi-structured free-text reports.

Computational pathology is a domain focusing on the development of computer-assisted diagnosis tools to automatically analyze digital pathology images. Convolutional Neural Network have become the state-of-the-art algorithm to solve severalcomputational pathology tasks, such as WSI classifi cation, achieving high accurate performance.

However, many challenges are still open in the computational pathology domain. First, CNNs usually need large datasets for training models that are robust to the high data variability of clinical practice data. Second, fully supervised approaches, reaching thehighest performance in several computational pathology tasks, require local annotations that are challenging to obtain in medical contexts as they are time-consuming and require experts performing them. Third, WSIs can be highly heterogeneous in terms ofstain and magnifi cation scale due to the lack of standardization in tissue acquisition, leading to low model generalization on data including different acquisition parameters than those included in the data used to train the models. Finally, linking visual andsemantic information from reports using machine learning is a challenging and currently not a well-solved task.

This thesis aims to alleviate the limitations related to these challenges, that prevent the application of computational pathology algorithms in clinical practice, with the following objectives: 1) alleviating the need for annotations in computational pathology 2)improving the convolutional neural network capability to generalize on datasets including heterogeneous color variations, 3) combining multiple magnifi cation levels to improve the whole slide image representation learnt by convolutional neural networks 4)empowering the histopathology data representation combining textual and visual information from images and reports

Doctorat thesis: Univ. Genève, 2023 - Sc. 5753 - 2023/07/19
https://archive-ouverte.unige.ch/unige:170757

Rémy Valentin Petkantchin

Doctor ès Sciences, mention Computer Science

July, 2023

Directors: Prof. Bastien Chopard,
Dr. Franck Raynaud

Mesoscopic Modeling of Stroke Treatment

Strokes are a leading cause of disability and death globally, and effective treatments remain a critical medical challenge. They are classifi ed into two main types: ischemic and hemorrhagic. Ischemic strokes occur due to the occlusion of a brain vessel by athrombus, while hemorrhagic strokes result from signifi cant bleeding in the brain. The current state-of-the-art treatments involve techniques such as thrombolysis, thrombectomy, thrombus aspiration for ischemic strokes, and coiling, stenting, or slowing downblood fl ow for hemorrhagic strokes. Nevertheless, each treatment's applicability and benefi t-to-risk ratio is still not satisfying. The development of new therapies, often a lengthy, complex, and highly regulated process, could be eased by modeling. This ideamaterializes into so-called in silico trials, where existing or new medical procedures or drugs are simulated and tested numerically, hopefully guiding the improvement of clinical expertise.

This thesis's major work consists of constructing a thrombolysis model within the context of the INSIST project, which aims at simulating and understanding every stage of ischemic stroke treatment and providing a framework for in silico trials.

Doctorat thesis: Univ. Genève, 2023 - Sc. 5751 - 2023/07
https://archive-ouverte.unige.ch/unige:170705

pin.unige.ch

CUI UNI GE

Digital Innovation Hub

DIGITAL INNOVATION HUB
University of Geneva

As part of the University's digital strategy, the **Digital Innovation Hub** (https://pin.unige.ch) active since March 2019, hosts creativity and innovation activities in the field of digital services. The purpose of the hub is to be transverse to the University and to reach the City, i.e. Geneva State as well as companies and organisations of the Geneva area. It is part of the network of innovation hubs of the University (https://www.unige.ch/collaborateurs/innovation/).
The Digital Innovation Hub has the following missions:

- Support students and researchers with digital projects that lead to commercial exploitation or social impact;
- Provide a meeting place and collaboration with the public and private sector in the region;
- Develop innovative services for the university community.

To carry out its missions, the Digital Innovation Center has developed a series of tools.

Accelerator of digital sciences and services

The Accelerator of digital sciences and services (https://cui.unige.ch/fr/pin/accelerateur/) is born from the joint effort of two entities of the University: the Information Systems Division (DISTIC) providing expertise in developing professional digital services to the whole University community, and the Computer Science Center (CUI), providing innovative technologies arising from research.

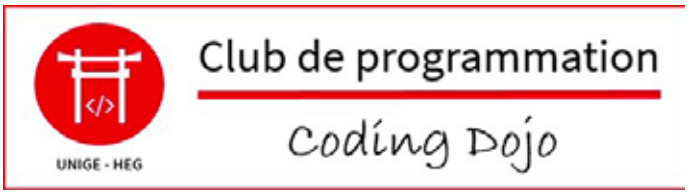
Through the Accelerator and a joint coaching (from DISTIC and CUI), students' or institutional projects undergo an innovation process, going from ideation up to a fully working service prototype. The final user or stakeholder interested by the service takes over the final stages of deployment and maintenance. The Accelerator contributes to the third mission of the Digital Innovation Hub.

Managed by a dedicated team, the accelerator regularly offers new initiatives and innovative projects for the university community. Concretely these projects are put into practice in the form of bachelor's work, internship, research project in coordination with the DISTIC, the CUI, and final users of stakeholders.

Since the start, there have been more than100 projects, of which 10 have been deployed and made available to the university community, 80 functional PoC and 30 pilots.

The 2023 novelties concern the development of conversational agents based on recent innovative technologies and use of different data sources. A focus has been made on Semantic AI using Knowledge representation and open-linked data. The Accelerator focused also on visualising data and built innovative applications such as "Interactive visualisation of universities diploma" and "Interactive visualisation of universities diploma and career".

https://www.unige.ch/stic/innovation



Coding Dojo

In September 2021, the PIN launched a programming club called the Coding Dojo, which is a collaboration between UNIGE, HEPIA, and HEG. The Coding Dojo, based at the FacLab, has a dual mission: to provide coaching, tutoring, and mutual support for students (learning new programming languages, tools, or paradigms, and helping with specific programming problems), and to promote programming awareness among secondary school and vocational training centre students.

Since the start, the Coding Dojo caters with specific programs for the following audiences: High school Students, University Students, Researchers. Since 3 years more than 150 trainees. Girls are well represented, forming 33% of the high-school students.

https://cui.unige.ch/fr/pin/club-de-programmation/

Digital forge

The digital forge is a laboratory of scientific and technical expertise that forges ideas into products. The digital forge is directed towards the technical realisation of proof-of-concepts (POC) and rapid prototyping of digital project ideas. Strongly anchored between digital scientific research and the Swiss economic fabric, the forge joins forces with companies or organisations to support and help them in their phases of ideation, validation and production of prototypes.

The digital forge brings scientific expertise in IoT, Blockchain, IA, Big data, Machine Learning and covers various fields such as smart city, digital health, fintech, cybersecurity, etc. The Digital Forge contributes to the second mission of the Digital Innovation Hub.

In 2023, the Digital Forge organised 2 events and 2 panels with SMEs, Public Cantonal and Federal Administration, Associations, and International organisations. Besides, the Digital Forge contributed to innovation in various forms: teaching sessions for the Swiss Federal Office of Statistics, 5 proof-of-concepts in various research areas such as Generative AI, Digital Twins for different domains such as energy, urban planning.

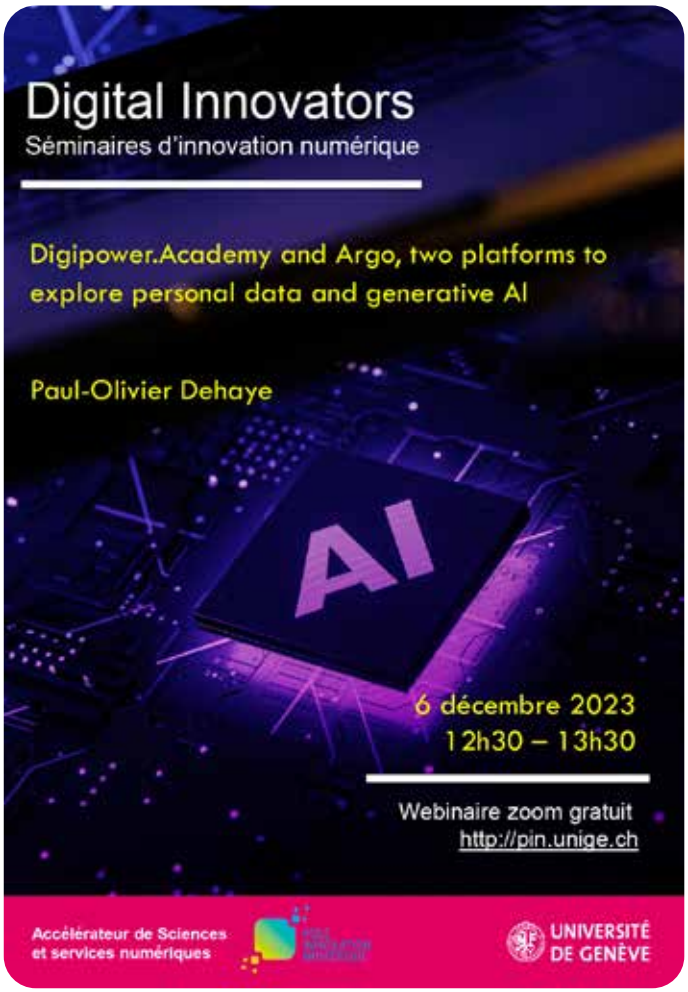
https://cui.unige.ch/fr/pin/forge-numerique/

Digital Innovators

Digital Innovators is a series of monthly seminars, starting in February 2021, describing a digital innovation and its application in a use case.

28 seminars have been organised since the inception of the series, of which 8 only in 2023.

https://cui.unige.ch/fr/pin/digital-innovators/



FacLab

The FacLab is a fabrication laboratory (FabLab) anchored in an academic environment which supports the different actors of the Digital Innovation Hub from ideation to prototyping. It draws on the set of techniques and methods traditionally used in these settings to develop learning and research based on fabrication and prototyping to learn and understand. Fabrication is broadly understood and is not just limited to physical or digital artefacts. It can also be about making economic models, public policies, laws, models, etc. Anchored in the heart of the university, the FacLab is an internal and external network available to the entire academic community. The FacLab participates in the three missions of the Digital Innovation Hub.

The capabilities offered by tangible fabrication include vinyl cutting, laser cutting, 3D printing, CNC milling, an electronics workbench, and a large toolbox. The capabilities offered by the intangible fabrication include the Parkour methodology and pretotyping (or ultra-rapid prototyping) equipment.

Five ephemeral residencies are currently active at the FacLab: Using community intelligence to implement socially sustainable technologies (with the Katametron association); Acquire digital (or computational) skills through project-based learning (with the startup Lesa.teliers); Education and practical tools to better explain the personal data environment to individuals (with the MyData Geneva association); Redesigning how talents and companies match and grow (with the startup Tungxten); Study the benefits of the Beekee Box during study trips (with the startup Beekee).

2023 has seen an increase in service requests for design and fabrication projects. Most notably, the FacLab provided design and fabrication services for 3 public events organised by different teams from University of Geneva:

- Design and fabrication of 2 installations for the exhibit "Italo Calvino à la croisée des sciences et de la littérature", a collaboration with the Scienscope de l'Université de Genève and the Unité d'italien de l'Université de Genève.
- Design and fabrication of a 3D relief of the Alps for the exhibit "Les plis au travers du temps: Regards pionniers sur la naissance des Alpes", a collaboration with the Section des sciences de la Terre et de l'environnement.
- Design and fabrication of the DialoCube an installation for the workshop "D'une mémoire du VIH/SIDA à la bibliothèque d'objets numériques", a collaboration with the Centre Maurice Chalumeau en Sciences des Sexualités.

The FacLab also hosted 3 hackathons and organised 28 training/workshop sessions with 170+ participants from academia and the general public.

https://faclab.unige.ch/

IA clinic

The new AI Clinic of the Digital Innovation Hub established in 2023 serves as a communication platform for exploring Artificial Intelligence (AI). It offers a pipeline of tools and frameworks enabling researchers and other university members to experiment with and use the power of open source LLMs (chatGPT, etc.) with their own data, processed on the University's servers. It addresses various topics, including the explanation of Large Language Models (LLMs), the societal and ethical implications of AI, and the practical application of AI tools.

The expressed needs regarding AI can be categorised into three main areas, that are: "Scientific AI", "AI as a Service"" and "Everyday AI". The AI Clinic addresses these needs by setting itself the following missions:

- Responding to Inquiries: Addressing internal requests from the University of Geneva (UNIGE) or external organisations about integrating AI services into existing or new processes. Experts, students, and researchers from various departments provide concrete answers on the best use of current AI tools.
- Offering Educational Programs: The AI Clinic offers a variety of educational programs designed for a broad audience, available in both short, certified, and non-certified formats. These courses include Applied Data Science, Artificial Intelligence from a pragmatic perspective for non-specialist professionals, Artificial Intelligence and Ethics, and an upcoming course on Artificial Intelligence and Education.

https://cui.unige.ch/fr/pin/clinique-de-l-ia/

Innovation clinic

The development of the Innovation Clinic began in 2019. The Innovation Clinic supports innovative student projects, whatever the field, from ideation to actual impact. These projects benefit from a personalised guidance process, visibility and the opportunity to connect with other interested students. The process is based on proven methods for carrying out innovation and transformation projects. Members of the project team learn while participating in the innovation process, in a spirit of empowerment. The Innovation Clinic allows students to learn how to innovate by actually doing it. The Innovation Clinic participates in the first and third missions of the Digital Innovation Hub.

In 2023 the PIN's Innovation Clinic provided support for a student startup aiming to promote students' internships through specific mandates.

https://cui.unige.ch/fr/pin/clinique-de-linnovation/

SciCoS (Scientific Computing Support)

SciCoS is a team of experts in scientific informatics, dedicated to supporting researchers from the University of Geneva and the Applied Universities of Geneva (HES-GE). The services provided include: operational support for high performance computing (HPC) and data processing, development of scientific applications, consulting and training for researchers. SciCoS contributes to the third mission of the Digital Innovation Hub. SciCoS is a new tool from the Digital Innovation Center which will offer its services from March 1, 2021. The project was initially funded by the State of Geneva (PL12146).

https://www.unige.ch/scicos/

R&D Unit

The R&D Unit, an important element of the UNIGE within the Pôle Innovation Numérique (PIN), offers digital innovations and supports those with high potential to be made available to the University community.

In 2023 the R&D Unit contributed to continuous education, innovation, data utilisation, and AI technology awareness. Key points include:

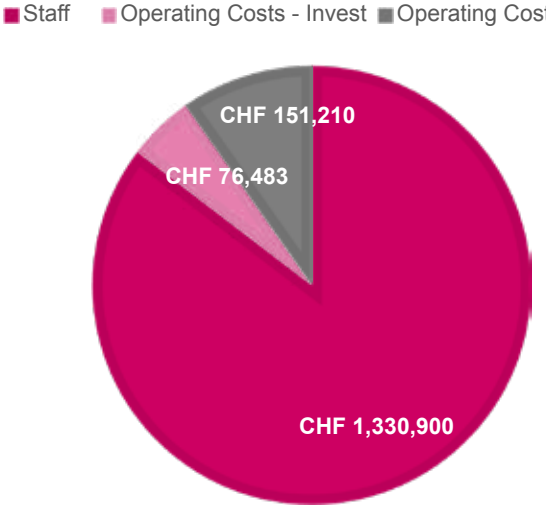
- Data Valorization and Visualization: New tools for data visualisation have been developed to present relevant information simply and accessibly. For example, a new service in collaboration with the UNIGE Career Center visualises the link between education and career opportunities. Continuous training and a programming club are offered to better utilise these tools.
- Generative AI: 2023 marked the rise of generative AI (ChatGPT, Bard, Grok, CoPilot). These platforms' vast potential must be balanced with risk management through informed and innovative use. The R&D Cell has expertise in this area and conducted several introductory workshops in 2023.
- Programming Club for Researchers: This club aims to enhance the data lifecycle, including collection, consolidation, security, processing (e.g., using AI techniques), visualisation, and long-term preservation (with Yareta). Several workshops were held in 2023.

The R&D Cell also contributed to various university courses and events such as the «Unlocking the Power of Data Initiative» including presentations to UNI3 members.

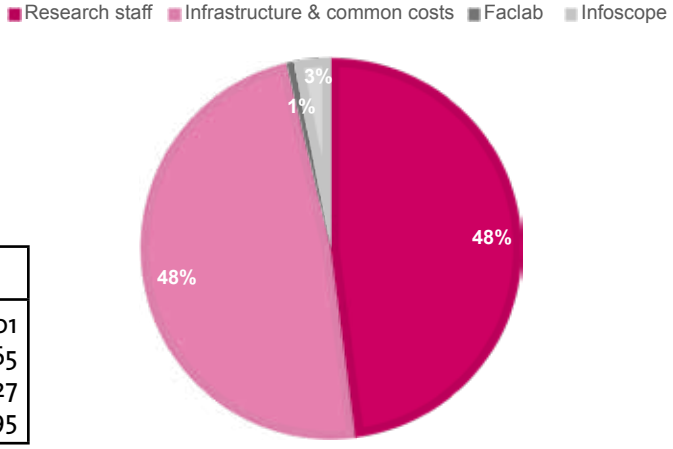
Financial Report

Financial Resources State of Geneva (DIP)

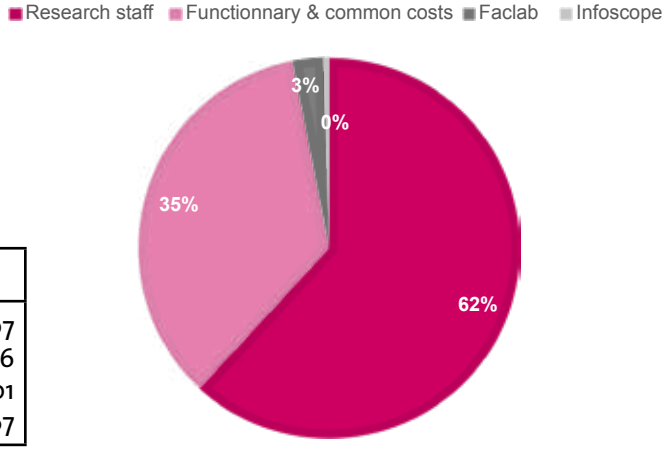
	Budget
Staff • Academic • Administrative and Technical • Employer's social contributions	CHF 1'330'900 CHF 388'364 CHF 655'555 CHF 286'981
Operating costs - Investment	CHF 76'483
Operating costs - Others	CHF 151'210
Total Budget 2023	**CHF 1'558'593**



Main operating costs - Investment	Budget
• Research staff	CHF 39'801
• Infrastructure & common costs	CHF 40'165
• Faclab	CHF 527
• Infoscope	CHF 2'595



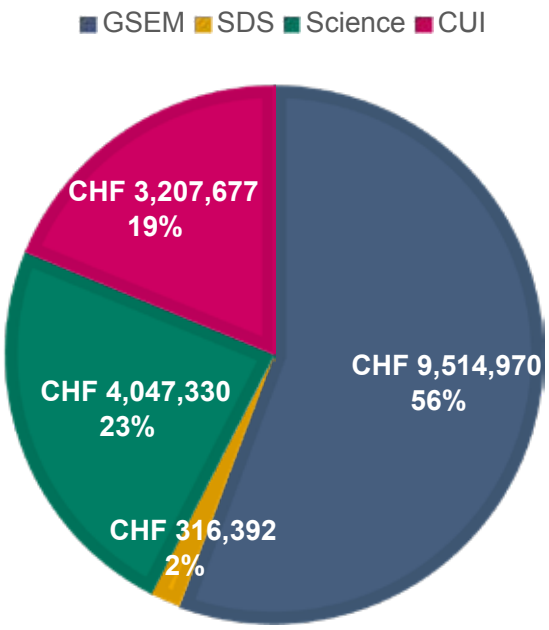
Main operating costs - Others	Budget
• Research staff	CHF 77'607
• Functionnary & common costs	CHF 44'056
• Faclab	CHF 3'301
• Infoscope	CHF 567



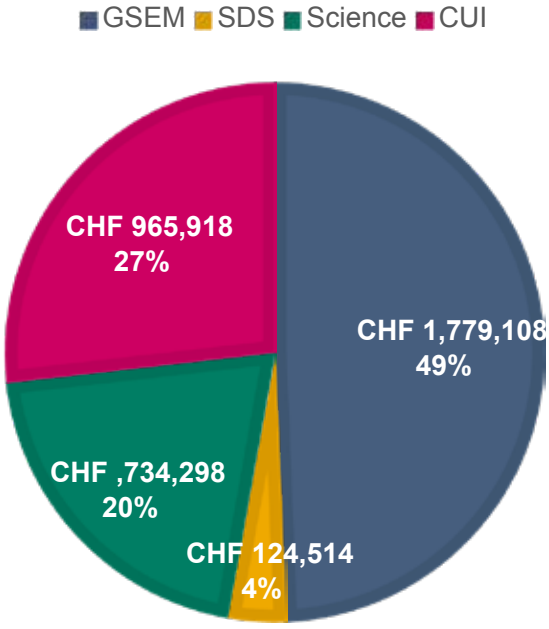
Funds with administrative workload on CUI (Contrats, Finances, Accounting)

	Total allocation for the projects	2023 allocation
GSEM registered projects	CHF 9'514'970	CHF 1'779'108
Science registered projects	CHF 4'047'330	CHF 734'298
SDS registered projects	CHF 316'392	CHF 124'514
CUI registered projects	CHF 3'207'677	CHF 965'918
Total Credit	**CHF 17'086'369**	**CHF 3'603'838**

Total allocation for the projects



2023 allocation



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