Big Data Research
The matters covered by this prospectus are subject to change. Details included here are correct at the time of publication in 2015. The university is not responsible for the content of any websites whose addresses are given in this publication which do not form part of the Vrije Universiteit Brussel domain (vub.ac.be).
Big Data, game changer for many companies

Health data, transport data, energy consumption data, geographical information, statistics, weather data, consumer and financial data, research data, cloud based applications... the need to make sense of “Big data” is leading to innovations in technology and development of new tools and new skills.

Big Data will be a game changer for many companies affecting innovation, competitiveness and productivity. Generating value at different stages of the data value chain will be at the center of the future knowledge economy. Challenges include analysis, capture, data curation, search, sharing, storage, transfer, visualization, and information privacy.

With this brochure, we invite you to discover Big Data research performed at the Vrije Universiteit Brussel (VUB). You will also find examples of VUB’s success stories in the domain of big Data.

For any further questions concerning innovation and valorization, we invite you to contact the Knowledge and Technology Transfer Interface of the VUB.

Hugo Thienpont
Vicerector Innovation and Industrial Policy
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How can we help you?

The VUB is a Flemish university situated in Brussels, international decision center and talent pool. VUB’s research is conducted with a strong motivation to positively impact society, enabling technological innovation and attracting economic activity in Brussels and the Flanders Region. The VUB (co-)owns more than 100 patent families. Its expertise and strategic location makes the VUB an ideal partner for research in collaboration with industry. VUB’s applied research resulted in about 20 active spin-offs in many domains.

Knowledge and Technology Transfer Interface – Connecting science and society –
The Knowledge and Technology Transfer Interface (KTI) is your unique entry point for any university-industry-society interaction.

The Knowledge and Technology Transfer Interface (KTI) is a multidisciplinary team, offering a one-stop-shop office/helpdesk for companies, that facilitates collaboration. They take care of technology scouting and business development, contract negotiation, funding resources, IP management, marketing and event organization.

[ ‘We strive to deliver innovations that positively impact our society’ ]

Prof. Hugo Thienpont

We can be your partner in

• applied and industrial research
• contract research
• consultancy & testing facilities
• licensing of technologies
• new spin-off companies
• accommodation & infrastructure (incubators)
• training & entrepreneurship

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VUB’s Incubation Centers

**ICAB – Brussels Region**

icabrussel.be

‘Incubatiecentrum Arsenaal Brussel’ (ICAB) is located in the Arsenaal site next to the VUB campus in Etterbeek. ICAB is a business and service centre for entrepreneurs who want to launch a company in ICT or engineering. In order to offer start-ups logistic and operational support and a strategic service package, ICAB can rely on a multi-leveled network of technical, legal and financial expertise.

**IICB – Flanders**

www.iicb.be

The ‘Innovation & Incubation Centre Brussels’ (IICB) is located in the Research Park of Zelik, close to the VUB University Hospital of Brussels. IICB offers young and dynamic enterprises, active in or planning to enter the market of high-technology products or services, the possibility to grow in an environment stimulated by the presence of other enterprises already active in similar fields.
The computer science department of the VUB explores how to make computers do things for society. The software languages group investigates ways in which we can create programming languages and software engineering techniques for making computers do what we want them to do in a reliable way. The web and information systems group develops innovative and intelligent information systems, as well as modeling and design techniques and methodologies to ease their creation. The artificial intelligence group investigates techniques with which computers can discover and learn interacting with the real world as well as with humans in a more natural way. Together this expertise enables us to find and teach about ways in which modern computers and smart devices can be used more optimally.
The Software Languages Lab is a research lab within the Department of Computer Science of the Vrije Universiteit Brussel (VUB). The Software Languages Lab was founded in 2009 as a merger of the Programming Technology Lab and the System and Software Engineering Lab. The Software Languages Lab is currently headed by Prof. Dr. Theo D’Hondt, Prof. Dr. Viviane Jonckers and Prof. Dr. Wolfgang De Meuter.

Broadly speaking, the lab is active in the design, implementation and application of better languages to support the software engineering life cycle. This includes programming languages, formal languages, design languages, meta languages, modeling languages, domain specific languages, etc. The Software Languages Lab covers all aspects of the research spectrum, including:

- Design of languages (advanced modularity, distribution, concurrency, context, ...)
- Formal study of languages (type systems, abstract interpretation, static analysis, contract systems, ...)
- Efficient implementation of languages (virtual machines, parallelization, scheduling, ...)
- Tool support for languages (IDEs, debuggers, versioning tools, evolution support, refactoring, ...)
- Applications of languages (android applications, RFID enabled applications, web applications, embedded applications, city-ware, ...)
The research activities of the Web and Information Systems Engineering lab (WISE) are centered on innovative and intelligent information systems. There is a strong focus on developing new engineering methodologies, tools and software frameworks for the rapid prototyping and efficient realization of innovative information environments and new forms of human-computer interaction. Furthermore, there is an emphasis on conceptual modelling and design, semantics, adaptivity and personalization, accessibility and usability in general. Important technologies that we use in this context are web technologies, ontologies, graphical and visual design languages, rule engines and design patterns.

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Research on big data at the Vrije Universiteit Brussel
The WISE lab does research on processing large amounts of data in a number of domains:

**Internet of Things (IoT)**
In the context of the Internet of Things (IoT), a massive amount of sensor input data is generated. We are investigating how information from various sensors can be combined in order to enable smart home and office settings. Such reactive environments can only be realized if some form of meaning can be generated out of the large amounts of raw data that is generated by various sensors. Part of our research is focusing on complex event processing and how a declarative rule-based approach can be applied to derive high-level contextual information. Thereby, special attention is given to frameworks and visual tools that enable end users to define how various input events should be combined and which actions should be triggered, in order that they can easily author and customize their personalized automated home and office settings.

**Personal Information Management**
In the context of personal information management, we are investigating how the storage, management as well as retrieval of large amounts of personal information can be improved. Thereby, we pay attention to digital information (e.g. digital documents or emails) as well as physical information (e.g. books, printed documents or handwritten paper notes) and search for new ways of organizing large amounts of digital and physical information in so-called cross-media information spaces.

**Next Generation User Interfaces**
Over the past few years, we have seen a large number of emerging input technologies that might be used for realizing new forms of human-machine interaction via natural user interfaces. Often these interfaces are not limited to a single modality and we therefore need efficient ways to process and fuse information from various input sensors in order to realize multimodal user interfaces. We are working on general multimodal frameworks that enable the rapid prototyping of innovative forms of human-information. A question that we are investigating is whether new interaction techniques can potentially reduce the mental workload associated with large datasets. For example, in our research on cross-media information systems and architectures, we have implemented the ArtVis tangible user interface (http://wise.vub.ac.be/artvis/) to explore, analyze and browse large digital artwork collections based on the interaction with physical artefacts.
Machine Learning is at the very heart of Big Data. Machine Learning, related to data science, data mining, or predictive analytics, is one of the most important research topics at the VUB Artificial Intelligence Lab (AI Lab) since its foundation in 1983. This research concerns both the Machine Learning techniques and their application to several domains such as credit card fraud detection, health informatics, bioinformatics, music classification, and the smart grid. Over the years the AI Lab has gathered a lot of experience in both 1) the development and application of Machine Learning techniques, and 2) the handling of: how to store, retrieve and merge large amounts of data while taking interoperability, privacy, security and scalability into account. These two aspects are at the core of Big Data. Below we mention a number of projects in which the lab is/was involved, a more extensive overview can be found at the lab’s website.

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The AI lab does research on big data in a number of domains:

Machine learning: extracting knowledge from data
The AI Lab’s expertise covers the entire spectrum of machine learning techniques: when the data are available before learning takes place or when the data are collected online, supervised learning where labeled examples are available, and unsupervised learning where the data are unlabeled and the goal is to discover clusters of similar data. A particular expertise of the lab is reinforcement learning that allows learning decision strategies. Neither exact answer nor model of the environment is needed to apply this online learning technique that can also deal with stochastic as well as changing environments. Feedback on the quality of the decisions made suffices to learn the optimal strategy.

Besides contributing to the state-of-the-art machine learning techniques, the AI Lab always had a strong interest in applying these techniques to a variety of application domains. In 2000, 3 master students compared several machine learning techniques for fraud detection using data from Banksys. They received the Scientific Award Alcatel-Lucent Bell from the FWO for their research. In 2002, a similar study was done for some bioinformatics applications. Another application was the classification of classical music according to composer. The test case was string quartets of Mozart and Haydn. Part of the task was to discover the relevant features that make this classification possible. The same techniques are useful for text mining. More recent projects are described briefly in the next section.

Big Data
Big Data involves more than learning from data alone. Huge amounts of data have to be processed and this has its own challenges: the interoperability, privacy, security, and scalability has to be taken into account. Two projects that the AI Lab co-developed with research labs from the Brussels region in the framework of the Brussels Institute of Bioinformatics, are illustrative for Big Data.

BRIDGEIRIS, short for BRussels big Data platform for sharing and discovery in clinical GEnomics, is a project where all aspects of Machine Learning and Big Data come together. It deals with huge amount of data to be shared among multiple hospitals, in this case the university hospitals of the ULB, UCL and VUB in a secure and reliable way. Also methods are developed to automatically extract relevant information from the available genetic data, up to 20 GB per person, and to extract new knowledge that is transferred to the medical setting.

The InSilicoDb project compiled in a standardized way a database of more than 250,000 microarray samples from public repositories. Users can analyze these data without any programming skills and can upload their own data. This project contributed to Bioconductor, an open source initiative for bioinformatics, and resulted in the spin-off company “Enlighten Bioscience”.

The AI lab is continuously exploring new Big Data applications. Current examples are the use of patient data to simulate HIV epidemics and to analyze the effect of prevention strategies. This is done in collaboration with the Rega Institute.

Scanergy, a European project, uses real life smart meter data to simulate and compare trading strategies between prosumers and consumers for green energy. The demo that simulates online trading in the cloud got the best demo award at the International Conference on Autonomous Agents and Multi-Agent Systems.

C-Cure is a project that learns the right level of security to access data or perform a transaction based on characteristics of the user and properties of the transaction. It uses reinforcement learning in combination with concepts from recommender systems. They are at the core of Netflix, Amazon, etc. and allow to recommend items to customers.
SCOM – Communication Sciences

vub.ac.be/SCOM

The department for Communication Sciences (SCOM) consists of three research units: Studies on Culture, Emancipation, Media & Society (CeMeSo), Studies on Media Information and Telecommunication (SMIT), and Studies of Democracy, Signification and Resistance (DeSiRe).

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Studies on Media, Information and Telecommunication at the Vrije Universiteit Brussel (VUB-SMIT, Belgium) was established in 1990 and is specialized in fundamental, applied and contract research in the area of ICT and media, markets and policy. With currently a staff of over 75 researchers, and an annual turnover of well over 5M €, SMIT is a major research centre in Europe for policy and socio-economic research relating to ICT and media. SMIT specialises in social scientific research on media and ICT, with an emphasis on innovation, policy and socio-economic questions. SMIT research combines user, policy and business analysis with both quantitative and qualitative research methodologies. A continuing dialectic between theory and empirical research is one of the centre’s high-level objectives. In terms of methodology, SMIT is experienced in: (a) user empowerment studies with a focus on qualitative methods; (b) policy analysis, encompassing impact assessment and improvement studies; and (c) market impact assessment & business modelling. SMIT research is playing an important role in policy formulation and implementation at local, regional and national level in Flanders and in Belgium.

SMIT is also part of iMinds and leading the iMinds ‘Digital Society’ Research Group.

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The SMIT lab does research on big data in a number of domains:

**User Empowerment for Enhanced Online Presence Management (USEMP)**  
**Projecttype:** EU-CAPS  
**Promotor:** Laurence Claeyts & Jo Pierson  
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USEMP aims at developing a framework that will empower users by enhancing their control over the data they distribute or interact with. The framework will reduce the existing asymmetry between data processing and control means available to OSNs and those afforded by citizens. USEMP will contribute to the reduction of this asymmetry and will propose a multidisciplinary approach motivated by the following objectives:

- Advancing the understanding of privacy issues on the Web through an empirical approach that combines legal, sociological, media studies and computer science perspectives. These aspects reveal different facets of the problem and are essential to the proposition of innovative privacy and personal data protection models.
- Empowering users through the introduction of semi-automatic mechanisms that assist them in personal data management tasks. Focus will be put on integrating insights from legal and user studies in multimedia information extraction tools in order to enhance user experience.
- Contributing to raising users’ awareness concerning the advantages and risks related to sharing personal data. Particular attention will be given to the proposition of means to understand monetisation processes that take place on OSNs and on the user-controlled licensing of a part of the personal data.

- research on algorithmic accountability
- gathering of user data (access to social media accounts and survey data) for algorithm creation and optimization
- social requirement definition for big data systems

- generation of user insights on feature definition for (personal data) profile transparency
- multistakeholder data protection and privacy assessment
- research on how (economic) value is created with data and on data value networks in particular

**COMBUST – Combining Multi-Trust Business Data**  
**Projecttype:** IWT-ICON  
**Promotor:** Pieter Balbon  
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It is widely accepted that Big Data will be a game changer for many companies, affecting innovation, competitiveness and productivity. Undoubtedly, Big Data is opening major opportunities for new data driven business applications and/or allows offering data-as-a-service to 3rd party players. But efficiently handling huge volumes of dispersed information and hence creating strong value from the data is often hampered by several challenges related to data management. In practice, the integration of new data sources such as social, Open Data KBO, etc. is very cumbersome, requires a substantial ‘manual’ effort for data scientists and often leads to long IT development cycles. COMBUST will leverage these challenges by providing the necessary toolset for automated knowledge discovery.

- identification of all business requirements and the validity of the business ecosystem
- assessment of economic potential of big data and data-as-a-service
- business modeling and opportunity analyses to determine successful DaaS revenue models

**OpenTransportNet – Spatially Referenced Data Hubs for Innovation in the Transport Sector**  
**Projecttype:** Competitiveness and Innovation Framework Program - Pilot Actions  
**Promotor:** Shenja van der Graaf  
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OpenTransportNet creates collaborative virtual service hubs that aggregate, harmonise and visualise open transport-related data to drive the rapid creation of innovative new applications and services. Transport was chosen as a cross border focus-area as it touches upon almost every facet of 21st century living, making it an ideal target for the creation of solutions that can be enhanced by location based. The project addresses challenges such as the need to better aggregate and harmonize data to improve accessibility and use; the need to link spatial and non-spatial data to extract value and increase accuracy; the need to provide innovators with easier APIs and GUIs to stimulate the creation of new services and commercial opportunities.

OpenTransportNet’s innovation hubs overcome the above challenges by using an automated flexible dataset aggregator to integrate and harmonise transport related data, combining spatial (GI), dynamic data streams and non-spatial (OD) data and derive insights from the data through visualisation tools and pattern detection algorithms. OTN Hubs improve the accuracy of data insights by enhancing knowledge with Volunteered Geographic Information (VGI) and deploy a sophisticated Access Control and Identity Management system to manage privacy controls.

- Impact and success assessment of the data project and its pilots
- Research of the use and users of such data
- Creation of a growth manual for the deployment of such data hubs in the future
Open data are non-personal data and datasets, disclosed by the government and the private sector to be used, reused and redistributed by anyone. By ‘linking’ and combining these datasets, data can be enriched and new knowledge can be acquired. In that way, ‘linked open data’ can result not only in a higher level of transparency and citizen participation but also in economic growth, innovation and better public service. However, disclosing ‘Open Data’ is often regarded as a too technical, complex and time-consuming task. Like any Big Data, Open Data is only valuable when it is accessible, understandable, and usable.

In order to lower these barriers and to stimulate (linked) open data, this project will develop a platform that facilitates and automates the disclosure, publication, reuse and linking of data for everyone. Still, in order to have a real impact and to create some kind of value, providing the appropriate technology is not sufficient. The project therefore also studied the corresponding ecosystem and assessed in what manner true accessibility and usability can be achieved. For the data to unfold its positive potential – to enable use, reuse and redistribute.

- research on the value of data, both economic and social
- research on how such value can be harvested from an ecosystem and value network perspective
- research on data standards and licenses

Media Clusters Brussels
Projecttype: Innoviris - Anticipate
Promotor: Ike Picone
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Media Clusters Brussels - MCB - is a collaborative and interdisciplinairy research project of the three leading universities of Brussels, VUB, ULB and USL-B. The aim is to analyze the many facets of the media industry located in the Brussels Capital Region and explore the development of clusters.

The ‘Ontwerp van Gewestelijk Plan voor Duurzame Ontwikkeling’ for Brussels (2013), approved by the Brussels Regional Government in 2013, identifies the cultural and creative industries as one of the four key sectors of the metropolitan economy, and more specifically proposes a Media City at Reyers as the first strategic cluster to develop in the coming five years. However, despite the fact that the Brussels Region is committed to foster the development of the media sector, there is currently hardly any empirical data available about the structure and dynamics of the media industry in Brussels, which is necessary to make the right decision in the development process.

The research project is creating a diverse array of analytic methods for collecting and presenting empirical data about the range and scope of the media industries in Brussels, the profiles and local implication of media workers and the dynamics of communities of practice where they share knowledge. The aim is to build an extensive database of media companies, media workers and communities of practice in Brussels to analyze the processes within the media industry.

- creating an extensive database of media companies / media workers within the Brussels region
- data cleaning through manual processes and surveys
- data visualization and mapping

Organizing Care through trusted Cloudy-like Services (ACCIO)
Projecttype: IWT ICON
Promotor: An Jacobs
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The O’CareClouds team pursued the creation of a platform that can capture, aggregate and enrich loads of data about the medical condition and (real-time) assistance requirements of people in a home care context, and share those insights with formal and informal caregivers alike. The team’s ultimate objective was allowing people to live as autonomously as possible, for as long as possible, while offloading—and maximizing the efficiency of—caregivers. Today, home care often equals old-fashioned ways of sharing information; typically, a simple booklet is used in which brief notes are included. That way of communicating obviously comes with important limitations: it is restricted in terms of capturing observations (so that lots of useful info gets lost), it cannot be shared easily, etc. To address those challenges, O’CareClouds investigated:

- how data can optimally and intelligently be shared between formal and informal caregivers in a home care context;
- how additional data can be captured (through sensors and RFID tags, for instance), and how this can be linked to other (existing / external) data sources such as the Flemish government’s Vitalink initiative;
- how that knowledge can be aggregated and enriched.

- domain analysis for micromanagement in home care with sensor data (Care Data and Information Flow Analysis and the dynamics in the care relationships) and derive user/social requirements from that.
- developing scenarios and personas from these insights to guide the technical decisions on for example architecture, ... making use of the innovation binder approach
- iterative user testing with low through high fidelity prototypes on user experience resulting in feedback on the desired services
Next generation sleep monitoring system (NXT Sleep)
Projecttype: IWT ICON
Promotor: An Jacobs
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NXT_SLEEP will focus on the development of a next generation sleep monitoring platform that is less obtrusive and therefore more comfortable than the traditional polysomnography, allowing recordings for more than one night in a home environment, and using new sensors that deliver complete and useful information regarding the physiological parameters relevant for sleep-related breathing disorders. Continuously throughout the project, medical doctors and software engineers will evaluate the accuracy and relative performance of the test set-up, and consequently provide feedback on how to further improve the system. Moreover, the test will not only give feedback on the data quality itself, but also on the usability and the user experience in order to satisfy the patients’ and doctors’ needs in the best way. In parallel, we worked out in depth an appropriate business model for penetrating the sleep monitoring market including financial and organisational design and the development of a health care model.

• value network analysis looking into the valorization opportunities of these making use of big data on care for the cloud and services discussed in the project

Security and Privacy for Online Social Networks (SPION)
Projecttype: IWT SBO
Promotor: Jo Pierson
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The main objective of the SPION project (http://www.spion.me) is to mitigate the responsibilization of individuals who use or are affected by social networking services. This will be achieved by making the underlying social networking infrastructures and the organizations that run them more accountable. We plan to develop solutions that facilitate better decision-making with respect to the target groups’ privacy and security concerns, and that address the risks, threats and concerns that currently exist in this domain.

• studying the awareness, attitude, capabilities and practices of young users regarding their social privacy and (personal) data which is shared among peers
• socio-technical development and testing of Privacy Feedback and Awareness tool for audience transparency
• investigating contextual privacy on group level (case of youth movements)

User Empowerment in Social Media Culture (EMSOC)
Projecttype: IWT SBO
Promotor: Jo Pierson
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The goal of the EMSOC project (http://emsoc.be) was to critically assess to what extent and how people are empowered or disempowered by their everyday use of social media. We investigated how the vulnerability of these people change(s) through these new forms of online communication and interaction. The issues were addressed from a social, legal, media, educational and policy perspective. A major focus was on privacy, surveillance and commodification of social media and how these challenge user’s expectations and control over their privacy and personal data. Other key topics were inclusion and ‘digital literacy’.

• mapping the affordances of social media for collecting, processing and applying data of users
• political economic analysis of data streams (in relation to market transitions) and the socio-economic consequences (case of social media companies, in particular Facebook)
• studying the awareness, attitude, capabilities and practices of young users regarding their institutional privacy and data which is shared with third parties
From social media service to advertising network: a critical analysis of Facebook’s Revised Policies and Terms

Projecttype: Bilateral contract Belgian Privacy Commission
Promotor: Jo Pierson
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An interdisciplinary research assignment which involves iMinds-ICRI/CIR, iMinds-SMIT and iMinds-COSIC. Facebook rolled out its new policies and terms on January 30th, 2015. In the new data use policy, Facebook authorizes itself to (1) track its users across websites and devices; (2) use profile pictures for both commercial and non-commercial purposes and (3) collect information about its users’ whereabouts on a continuous basis. At the request of the Belgian Privacy Commission, iMinds research groups have drafted a report analysing Facebook’s revised policies and terms.

- investigating Facebook’s changes to their data use policy (since January 30th, 2015) and how this is reflected on their website and behaviour on other websites
- assessing Facebook’s ability to monitor and track data of users’ activities outside Facebook by way of their tracking capabilities, mainly through the spread of social-plugins.

The report forms part of the documentation upon which the Privacy Commission will rely in the course of its further investigation.

This on Facebook’s new Data Use Policy was published in The Guardian:
ETRO – Department of Electronics and Informatics
etro.vub.ac.be

In R&D, ETRO prides itself on its facilities and its willingness to tackle the unknown resulting in innovative and high quality research. ETRO is made up of three research groups (laboratories) that cover a wide range of generic technologies in Micro- and Optoelectronics, Speech & Audio Processing, Multidimensional Signal Processing & Communication.

- **LAMI**: Micro- and Opto-electronics
- **DSSP**: Speech & Audio Processing
- **IRIS**: Multidimensional Signal Processing & Communication

The exciting and enthusiastic collaboration between these three groups has lead ETRO to integrated transdisciplinary R&D and created new challenging possibilities.

With the knowledge and the spirit of collaboration between its 3 research groups, ETRO is not afraid to cross new boundaries, tackle new challenges and make new discoveries by working in the unknown. Thanks in part to its vision, work ethic and results, ETRO is highly regarded and respected in its field. ETRO also has close cooperation with various Belgian research centers and institutes (ETRO is an associated lab of IMEC, co-founder and partner of iMinds and Intel’s Exascience lab,...) and has initiated several spin-off initiatives all of which are successful in their own right. International partnerships include all continents.

Besides its achievements on the level of fundamental and strategic basic research, ETRO is also recognized as a key industrial research pole (IOF) and a group of excellence in Fundamental Research (SRP) at the Vrije Universiteit Brussel.

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The Multidimensional Signal Representation and Transmission Group of the Department of Electronics and Informatics (ETRO) conducts fundamental research on multidimensional signal processing, machine learning, and information theory, with the aim to transfer knowledge to various applications domains and industries such as digital media systems, Internet-of-Things technologies, big data analytics and healthcare. The group is affiliated with strategic research centers such as IMEC and iMinds, has initiated a successful spin-off company, and has provided consultancy services to international institutions. The group is also recognized as a key industrial research pole (IOF) and a group of excellence in Fundamental Research (SRP) at the VUB.

Information theory and coding theory, compression of 3D graphics, image/video, and holography, multimodal camera systems, ad hoc networking, low-power communications, sparse signal processing, compressed sensing, machine learning, distributed computing, and optimization methods.

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Main study areas

Multidimensional Signal Representation and Transmission:
- Sparse representations (wavelets, curves, discrete cosine transform) and coding theory
- Image/video coding: volumetric coding, scalable coding of 3D graphics, 3D video, distributed video coding, and error resilient compression
- Compression of multimodal, multidimensional signals in digital media and medical applications
- Digital media transmission technologies: error resilient transmission, channel models, error correcting codes, interleaving, joint source and channel coding, rate control, distributed source coding, multiple description coding
- High-end 3D and holographic visualization
- Image/video separation/denoising using multimodal side information
- 3D video scene recovery and superresolution

Low-power wireless networking for the Internet-of-Things (IoT)
- Wireless visual sensor networks for environmental, infrastructure, and urban monitoring
- Distributed synchronization algorithms and distributed optimization methods for wireless ad hoc networks
- Low-power multiterminal communications (distributed compression, multiple description coding, channel codes, joint source and channel coding)
- Decentralized medium access control protocols for wireless sensor networks
- Resource allocation for wireless sensors equipped with energy harvesters

Machine Learning and Signal Processing for Big Data
- Sparse signal processing and inference methods for Big Data processing and classification
- Compressed sensing with side information for Big Data acquisition and recovery
- Learning coupled dictionaries for joint analysis of correlated Big Heterogeneous Data
- Optimization theory and algorithms
- Machine learning for Big Data (matrix completion, matrix factorization, robust principle component analysis)

International collaborations
- Media Institute and Big Data Institute at University College London, UK
- Information initiative at Duke (iID), an interdisciplinary center for Big Data research at Duke University, USA.
- University of Oklahoma, Tulsa, USA
- University College London, UK

Equipment & Infrastructure
- Visual Quality Testlab
  - Test room for subjective image quality measurements, conforming to ITU-R Rec. BT.500 specification.
  - Relevant Equipment: Barco Fusion Coronis 6MP DL, Hyundai S465D, 46”, full HD, stereoscopic polarized 3D display, Apple 27” Cinema Display, WQXGA resolution, Philips 46” PFL 3D Full HD with Ambilight
- High-end Visualization Lab (new - under construction)
  - Camera-array based capturing of multiview video
  - Visual sensor network facilities: energy
  - Plenoptic and light-field based rendering equipment
  - Holographic imaging and rendering

Industrial collaboration fields and Industrial Application fields
- Broad scale of 2D/3D imaging HW/SW expertise
- Unique video coding technology
  - Video codec using block-motion estimation techniques (OBMEC)
- Comprehensive encoder/decoder implementation of the JPEG 2000 part 1 (Core coding system) and part 10 (JP3D, coding of volumetric data) standards
- Broad experience in parallel computing by exploiting the increased processing power of GPU’s and FPGA’s for Big Data applications
- IoT and Big Data Industrial contacts and collaborators: Alcatel, Xetal, BAFTA, Fujitsu Labs Europe

Milestones / Achievements
- Spin-offs:
  - Universum Digitalis (UD)
  - Designs solutions for the management of multimedia databases and provides generic data exchange interfaces for distributing data to various client applications.
- Big Data consultancies:
  - British Academy of Film and Television Arts (BAFTA), UK
  - Private technical consultancy on big video analysis and mining, leading to a patent application.
- Recent Projects:
  - FWO project "Sparse representations for restoration and coding of 3D signals"
  - Design of novel adaptive sparse representations for volumetric data and surfaces, and design of novel 3D coding systems based on geometric representations.
  - iMinds ICON project “Little Sister: low-cost monitoring for care and retail”
  - Design of a IoT-based monitoring system for elderly that can achieve a performance similar to state-of-the-art complex systems but at a much lower cost.
  - iMinds ICON project “Telesurgery”
  - Development of technology that enables the distribution of surgical images and video feeds within the hospital, but also to remote locations and mobile devices.
  - VUB Strategic Research Program (SRP) project “Processing of Large Scale Multi-dimensional, Multi-spectral, Multi-sensorial and Distributed Data (M³D²)”
Forensics and Security

homepages.vub.ac.be/~andooms

- **Fundamental Research:**
cryptography, signal processing [in particular sparse representations], mathematics [in particular group and ring theory]

- **Strategic Research:**
big data [compressive sensing, handling high-resolution multimodal imagery, ...], digital forensics [authentication, copyright management, traitor tracing, quality assessment, image processing for art investigation, ...] & security [encryption, watermarking, steganography, signal processing in the encrypted domain, ...]

- **Applied Research Domains:**
broadcasting, medical imaging, cultural heritage, cloud computing, security & privacy

Promotor:
Ann Dooms | ann.dooms@vub.ac.be
Projects in Big Data:

Compressive Sensing for 3D/4D Ultrasound Imaging: a Bayesian approach
Promotor: Ann Dooms
ann.dooms@vub.ac.be

Due to the steady and continuing advances in image acquisition technology an increasing number of applications can benefit from high resolution spatial and temporal data. However, a wide variety of domains, ranging from applications in the medical sector to the broadcasting industry, are faced with the problem of handling the growing amount of data at ever faster rates. The objective of this project is to develop a generic approach to tackle problem of high data rates at the receiver end of 2D+T architectures for the acquisition of 3D/4D ultrasound. We will pursue this goal by using a Bayesian learning methodology in combination with the compressive sensing paradigm. In order to improve on current compressive sensing techniques using the information present in the incoming signals, we propose to use Bayesian modeling techniques. These techniques are typically very flexible and more easily adaptable to different use cases than standard learning methodologies, the drawback being higher computational requirements.

3DUS Strain Quantification using 3D ultrasound imaging for musculoskeletal applications
Promotor: Ann Dooms
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In this project we propose to use 3D ultrasound imaging for the assessment of local deformation in soft-tissues. We will optimize image quality and develop image processing techniques which allow acquiring accurate and reproducible strain measurements, suitable for use in a clinical setting.

Projects in Security:

Perceptual hashing and semifragile watermarking for the discovery, search, recognition and authentication of multimedia content
Promotors: Peter Schelkens & Ann Dooms
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In this research project the robustness and the security of perceptual hash functions is investigated for different media types. Research is conducted on semi-fragile watermarking techniques that - in combination with perceptual hash functions - yield efficient selective authentication mechanisms for multimedia content. Solutions are optimized w.r.t. complexity and accuracy, such that a practical implementation is possible.

WET: Watermarking, Encryption and transcoding
Promotor: Ann Dooms
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Encryption, or cryptography in general, provides means for secure delivery of content to the consumer such that only rightful persons can derive the original information from its encrypted version. Once the content is decrypted, however, this protection is gone. Watermarking can...
High-Performance Computing (HPC) is going to provide solutions to the market. Intel’s novel MIC architecture. Their performance of accelerators, such as GPUs and FPGAs, is an innovative solution to secure multimedia content distribution.

Given the increase in both data volumes and algorithms' complexity, computational performance is one, if not the most, crucial point for a competitive advantage of the future. The framework will provide solutions for exploiting the computational performance of accelerators, such as GPUs and Intel's novel MIC architecture. Their processing power is increasing rapidly at a trend which is not followed anymore by today's CPUs. MACH is going to provide tools for developers of the computation-ally intensive applications, which require High-Performance Computing (HPC) platforms to run. The tools will allow the developers to identify and code the performance-critical "bottlenecks" parts of their applications in a maintainable, future-proof, and hardware independent manner, by leveraging the potential of the domain-specific embedded languages and high performance software libraries.

MACH is an ITEA2-labeled European project with 19 partners from 6 countries. The MACH project is going to meet the challenge of performance portability and ease of programming across different heterogeneous hardware architectures within the given application domains.

To achieve the goals, Domain Specific Embedded Languages (DSEs) and library APIs will be defined by which the performance-critical algorithms of the application domains can be reengineered. Next, compilers and libraries will be developed that can generate high-performing code for different hardware platforms and as such create portable solutions. The best HPC platform for a given application will be automatically identified at compile time or at runtime. The framework will provide an accurate a priori performance estimation and a posteriori performance analysis. Herein, the Belgian academic partner ETRO-VUB plays an important role.

**Watermarking in an end-to-end security chain**

Promotor: Ann Dooms

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Content distribution applications such as digital broadcasting and online press platforms, video-on-demand services (VoD), video conferencing or surveillance are confronted with difficulties with respect to quality guarantees, security measures and intellectual property management. Varying bandwidth conditions, error-prone network behavior and secure delivery through encryption are questions that are successfully addressed in today's practical systems, but no satisfying solution was found until now to copyright enforcement on the end-user’s side. Once the encrypted content is delivered and decrypted by the end-user, the content provider loses track and intellectual property rights are not necessarily preserved. Digital watermarking can complement cryptography in this scenario by imperceptibly embedding information within the content itself. The embedded message can carry ownership information for copyright enforcement, a unique code related to each buyer for trailer tracking (fingerprinting) or even content descriptions, like structural features for authentication or quality assessment. In a typical end-to-end distribution scenario, the content is encrypted at the end creation side, leaving limited possibilities for adaptation. Decryption along the way to perform the required video processing operations (transcoding, watermarking, etc) and subsequent re-encrypting is highly inefficient. Moreover, not all stakeholders might/should have access to the decryption key. Encryption in the network creates a flaw in the overall security of the system, as the unencrypted essence can potentially be intercepted. Efficient integration of watermarking with encryption would bring an innovative solution to secure multimedia content distribution.
MOBI – Mobility, Logistics and Automotive Technology Research Group

mobi.vub.ac.be

The Mobility, Logistics and Automotive Technology Research Centre (MOBI) is nested at the Vrije Universiteit Brussel (VUB) and is a leader in electric & hybrid vehicles and in socio-economic evaluations for urban mobility & sustainable logistics.

With a multidisciplinary team of over 60 specialists, it offers its expertise to the industry, governments and academics, through research collaborations, consulting services and trainings. The strength of MOBI resides in proposing a unique combination of socio-economical, environmental & technical competencies, together with infrastructure and software tools specifically developed for the sustainable transport sector.

MOBI has proven track records in intermodal transport, city distribution, transport users behavior, decision-making support, external costs calculation, energy storage systems, electric vehicles powertrains and infrastructures, and life cycle assessment.

Big Data is of key importance in studying the above fields and in developing sustainable solutions for improved mobility, logistics and automotive technology. MOBI bends on a solid expertise in analytics to explore the use of big data for analyzing real-time and massive data flows originating from diverse data sources such as supply chain information systems measuring detailed demand information, sensors measuring the state, usage, and evolution of electric batteries, iBeacons providing real-time passenger information for smart city applications, etc.

Several successful projects have been set up and are currently running in close collaboration with the industry. The aim of these projects is typically to develop innovative technology or to test and evaluate data driven approaches for improved decision making. The success of these projects is nurtured by merging the knowledge and expertise available within the MOBI research group with industrial know-how and business experience. The centre has a unique position to address the EU roadmapping activities. Apart from regional and national projects, it is currently a scientific partner in 12 European Projects under execution.

MOBI is continuously looking to expand its research and technology portfolio within the aforementioned fields of study and application, and reaches out to all business partners that are interested in setting up a collaboration.

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Directors:
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Relevant projects:

NISTO: New Integrate Smart Mobility Options
Promotor: Cathy Macharis

ENISTO is a transnationally cooperative project consisting of seven partners (United Kingdom, Belgium, France, Netherlands, Germany) and several sub partners who are supported by the European commission in the Interreg IVB NWE program. NISTO will develop a new and smart toolkit to evaluate smart mobility concepts. This includes all initiatives, which enhance the traffic flow by focusing on the integration of different transport modes and not prioritizing one transport mode. The target of the project is the development of a methodical approach, which can be transnationally introduced and used by planners. Furthermore, a transfer of knowledge shall be created to generate guidelines, which aim to improve mobility and safety as well as the European competitiveness and thereby follow the targets of the EU 2020 strategy. The NISTO partners, mainly companies, universities and the local authorities from the mobility sector have already experienced certain issues with the evaluation of existing projects or concepts concerning the guidelines and criteria of intelligent mobility. For the first time, this project will develop a tool kit, which can be used by themselves as well as others in Northwest Europe to plan and evaluate mobility in a sustainable and intelligent way. Website: http://www.nisto-project.eu

OLYMPUS: Electrical vehicles sharing services based on a B2B Service platform. (Platform Living Labs Electric Vehicles)
Promotors: Cathy Macharis, Joeri Van Mierlo, Thierry Clement Coosemans

The new mobility is evolving along patterns quite different from those of the past. People will be travelling around more efficiently, in function of time and reasons for their mobility, orchestrating their own movements as they see fit. Centralized information about all current mobility possibilities will be published on the Internet. Mobility solutions will be combined continuously. Private transport, public transit, and the pooling of vehicles will all mesh seamlessly into one smoothly functioning unit. Olympus examines the possible role of electric vehicles within this networked mobility environment. Via an open service platform, information about various types of electric vehicles, charging infrastructure, power consumption, modes of payment, traffic... will be collected and evaluated. In addition, new service providers will be offered the opportunity to test out and launch their commercial or social projects on this platform. This unified structure will form the basis for an entirely novel offer of networked mobility services such as multimodal route planning, reservations, and modes of payment.

Towards sustainable transport: the development of External Cost Calculator for sustainable transport scenario’s
Promotors: Cathy Macharis, Frank Canters, Koen Putman

Externalities are changes in welfare caused by economic activities without these changes being reflected in market prices. In the field of transport these externalities arise when transport consumers/producers impose additional costs on society and its individuals without having to bear these costs themselves. External costs are externalities expressed in monetary terms and as such are being used in socio-economic evaluation to also take the sustainability aspects of measures into account. They express the costs society has to bear due to the transport activities, such as congestion, accidents, air pollution, noise, upstream and downstream processes, land consumption, and climate change. By internalizing, these external effects become part of the decision making process of transport users, leading to a more efficient use of transport infrastructure. The European Commission has recommended this policy of internalization in several strategy papers such as the Greening transport package (2008) and most recently in the new White Paper of 2011. The European Commission proposes a stepwise strategy for the internalization of external costs in all transport modes. A correct estimation of external costs is in this context essential knowledge to come to more sustainable transport and to be prepared when at the European level more stringent regulations will be implemented. The aim of this research is to develop a generic external cost calculator that can be used in projects in order to provide meaningful insights for both companies and governments on external costs related to transport activities.
Research on big data at the Vrije Universiteit Brussel

BUTO – Business Analytics team

research.vub.ac.be/buto

Analytics for Business Applications

The Business Analytics Team headed by prof. dr. ir. Wouter Verbeke is a small team of big data scientists within the BUTO department at the Faculty of Economics and Social Sciences. The team is closely linked to both MOBI and SMIT research groups and cooperates on a regular basis with several academic and industrial partners.

The team develops, applies and evaluates analytics for business applications such as credit risk modeling, customer relationship management and profitability modeling, demand forecasting and supply chain analysis, fraud detection and human resources management. The objective is to develop and adapt analytical tools to take into account the operational business setting where these tools will be implemented and applied for improved decision making. This is a unique perspective within the field of Big Data which drastically differs from a statistical or IT perspective, since management typically has specific concerns when adopting analytical solutions, such as the interpretability and user friendliness of representations and implementations of analytical models, the impact on revenues, costs, and profits when automating decision making based on a data-driven modeling approach, etc.

The research team has a solid business expertise and a broad experience in setting up projects in cooperation with the industry, ranging from small-scale experimental evaluations of analytical approaches for specific business goals to the development and implementation of novel data driven solutions and techniques to address and explore emerging business opportunities. The goal of these collaborations for the business analytics team is to gain insight and deeper understanding as well as to develop expertise leading to scientific publications, while at the same time delivering as much valuable and useful research insights, knowledge and output to the business project partner.

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Examples of successful project collaborations:

**Human resources analytics:** long term research collaboration with an industrial partner to develop expertise and a set of analytical tools for quantitative human resources management. Project proposal submitted to obtain a Doctiris mandate, which is a fully funded grant by Innoviris to allow a ph.d. candidate to perform research parttime within the enterprise and parttime at the university to develop a strategic innovation.

**Credit risk modeling:** medium term research collaboration to develop an advanced and innovative approach to stress test credit portfolios as a function of macroeconomic evolutions, allowing to simulate future developments and the impact of catastrophic events and crises on the risk profile of the bank.

**Customer churn prediction:** short term research collaboration with a telco operator to assess the potential of social network based learning and data mining algorithms for customer churn prediction, taking into account the costs, benefits and resulting profits of data driven optimized decision-making based upon the output of a predictive model.

**Expertise:**
- Analytics for business applications:
  - Fraud detection
  - Human resources analytics
  - Supply chain analytics
  - Credit risk modeling
  - Marketing analytics (CRM, customer churn prediction, netlift modeling, response modeling)
- Predictive and descriptive analytics
- Social and complex network analysis
- Profit driven data mining
The Department of Interdisciplinary Studies of Law of the Vrije Universiteit Brussels is often referred to as 'Metajuridica'. Metajuridica is the collective term that is used for all the scholarly disciplines that engage in the study of law from an interdisciplinary viewpoint. It hosts research of law from an internal meta perspective (legal theory) and from various external perspectives, such as history, sociology, ethnology, philosophy, gender studies, science studies, science technology and society studies.

Traditionally Metajuridica houses the research on legal history, sociology of law and philosophy of law within law faculties.

Today Metajuridica also gathers new directions in legal research. The VUB Metajuridica group, consisting of about 50 academics, houses several research groups exploring new themes and new disciplinary and interdisciplinary perspectives.
The interdisciplinary Research Group on Law Science Technology & Society (LSTS, created in 2003) at the Vrije Universiteit Brussel (VUB) is devoted to analytical, theoretical and prospective research into the relationships between law, science, technology and society. LSTS’s core expertise is legal, but we also have a strong track record in legal theory, philosophy of sciences and bio-ethics, and we engage in criminological (surveillance & security) and STS-research too. In the broadest wordings: LSTS’s main challenge is to (re)think the constitutive principles of democracy and the rule of law (including principles such as precaution, participation, accountability and responsibility) in relation to contemporary scientific and technological developments that seem to confront citizens with irreversible decision-making processes, with a major impact on their lives.

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- Fundamental rights, privacy, personal data protection, EU law
Finished LSTS projects on big data:

The Future of Identity in the Information Society (FIDIS)
Promoters: Serge Gutwirth, Mireille Hildebrandt
Project type: FP6
Digital identity, identity management, profiling, security, privacy, data protection, information society

The European Information Society (EIS) requires technologies which address trust and security yet also preserve the privacy of individuals. As the EIS develops, the increasingly digital representation of personal characteristics changes our ways of identifying individuals, and supplementary digital identities, so-called virtual identities, embodying concepts such as pseudonymity and anonymity, are being created for security, profit, convenience or even for fun. These new identities are feeding back into the world of social and business affairs, offering a mix of plural identities and challenging traditional notions of identity. At the same time, European states manage identities in very different ways. For example, in Germany holding an ID card is mandatory for every adult, while in the UK state-issued ID cards do not exist. FIDIS objectives are shaping the requirements for the future management of identity in the EIS and contributing to the technologies and infrastructures needed.

Safeguards in a World of Ambient Intelligence (SWAMI)
Promoter: Serge Gutwirth
Project type: FP7
Ambient Intelligence, profiling, security, privacy, data protection, scenarios

This project aims to identify and analyze the social, economic, legal, technological and ethical issues related to identity, privacy and security in Ambient Intelligence (AmI), as called for in the Work Programme. The partners will review existing AmI projects, studies, scenarios and roadmaps to ensure that the SWAMI project captures, as far as possible, the major trends and issues. The partners will compose “dark” scenarios, the aim of which will be to expose key socio-economic, legal, technological and ethical risks and vulnerabilities related to issues such as identity, privacy and security that may emerge from the deployment of AmI technologies and services, many if not most of which will be invisible to the public. The partners will define and study various research and policy options, which could serve as safeguards and privacy-enhancing mechanisms. The aim will be to identify mechanisms, which will ensure user control, user acceptance and enforceability of policy in an accessible manner, as well as to ensure that all Europeans have real equal rights and opportunities of accessibility to the Ambient Intelligence space. The partners will seek to validate their findings through two workshops with other AmI and IST experts before presenting the options to the Commission in a final report. Project results will be disseminated widely and continuously throughout the project and will be presented at a final, high-level conference.

Content in a digital environment.
An interdisciplinary research programme on E-publishing “FLEET”
Promoters: Fabienne Brison, Paul De Hert, Serge Gutwirth
Project type: IWT-SBO
Copyright, e-publishing, online content

The main objective of this project is to identify, understand and prospect the changing role of information and communication providers and users in a networked society. To this end, it aims at mapping the most important drivers of change affecting the Flemish e-publishing sector. In order to do this, 5 interrelated research objectives are identified: * Mapping the development of the professional e-publishing sector in Flanders, identifying actors and analyzing their range of (un) successful products, services and killer applications, their strategies adopted and the business models used. * Identifying the changes affecting the labour force within this e-publishing sector, concentrating on the role, function and work division of the journalist as an individual and as being part of a larger editorial and managerial institution. * Understanding user behaviour towards and user response on new online products and services, paying attention to the user as producer of content as well. * Highlighting the most important legal issues affecting the e-publishing sector in the field of copyright and liability (and if occurring, in other legal fields like privacy and data protection). * Translating, in an interdisciplinary manner, the results of the research in recommendations for policy formulation and regulation in terms of legal, technical, economic, pedagogical and social issues, and in recommendations for the sector in terms of business models.

Law and Autonomic Computing: Mutual Transformations
Promoters: Serge Gutwirth, Paul De Hert, Mireille Hildebrandt
Project type: GOA
Ambient Intelligence, profiling, privacy, data protection, intellectual rights

The project aimed to assess the legal implications of technologies that transform our everyday environment into what has been called an Ambient Intelligent (AmI) environment or The Internet of Things. Such an environment depends on a type of machine intelligence that does not reside in any particular machine, but in the interconnections between sensors, RFID-systems, biometrics and online databases, allowing the inference of habits and desires by means of complex data mining techniques with the objective of adapting the environment to such inferred preferences. The coming about of such intelligence raises a host of practical as well as fundamental legal questions, for instance in the field of privacy, data protection, civil and criminal liability, intellectual rights and concerning fundamental notions such as legal subjectivity, equality of arms, due process, consent and representation.
PRITUIS: Privacy and trust in the ubiquitous information society
Promotors: Serge Gutwirth, Paul De Hert
Project type: Tender EC DG-INFSO
Privacy, data protection, trust, information society, ubiquitous computing

PRITUIS offers an analysis of the impact of convergent and pervasive information and communication technologies on privacy and data protection and needs and options for development of the legal framework.

SENIOR: Social ethical and privacy needs in ICT for older people: a dialogue roadmap
Promotors: Serge Gutwirth, Paul De Hert
Project type: FP7
ELSA studies, privacy, ICT for ageing, roadmap

SENIOR is a 24 month support action which aims to provide a systematic assessment of the social, ethical, and privacy issues involved in ICT and Ageing, to understand what lessons should be learned from current technological trends, and to plan strategies for governing future trends. There are three main ideas that led the consortium to propose the senior 1. inclusion is the goal 2. dialogue is the instrument 3. design is the target. These ideas generated four strategic objectives: 1. definition 2. direction 3. roadmap 4. action plan. Each of these strategic objectives has been encapsulated into specific workpackages and tasks.

INEX: converging and conflicting ethical values in the internal/external security continuum in Europe
Promotors: Serge Gutwirth, Paul De Hert
Project type: FP7
Security, ethics, security technology, profiling

Security and insecurity are social, cultural, political concepts. Nowhere is this more evident than in the challenges produced by the evolving continuum between internal and external security challenges. The interdisciplinary project INEX is designed around two research axes: thematic and geopolitical. On the thematic axis it will study four fields of knowledge of high relevance to the question of the ethics and the value-laden tensions arising along the continuum between internal and external security in Europe: (1) the ethical consequences of the proliferation of security technologies, (2) the legal dilemmas that arise from transnational security arrangements, (3) the ethical and value questions that stem from the shifting role of security professionals and (4) the consequences of the changing role of foreign security policy in an era when the distinction between the external and internal borders grows less distinct. On the geopolitical axis it will study and produce recommendations relative to two geographical theatres of high relevance for ethical issues of internal/external security: the Eastern European ‘neighbourhood’ including Belarus, Ukraine, Moldova and the Mediterranean ‘neighbourhood’ including Morocco, Algeria and Egypt. The project will link directly with representatives of the security technology industry as well as security provision services that implement concretely to the border security arrangements. The state-of-the-art research carried out by the project will result in a variety of different outputs aimed primarily at relevant policymakers, researchers and educators. It will present analyses of current security challenges with particular attention to the human side of the security challenge, and on this basis propose remedial to the new challenges of the internal/external security continuum.

SIAM: Security Impact Assessment Measure, A decision support system for security technology investments
Promotors: Serge Gutwirth, Mireille Hildebrandt
Project type: FP7
Security, impact assessment, security impact assessment, decision-support systems, data protection by design

The SIAM decision support system will ease the complexity associated with the assessment of security measures and technologies. Where today decision makers have to oversee a wide range of relevant aspects from many different scientific fields and national as well as cultural interests, SIAM will pass the needed information in a structured manner to the decision maker. It ties together those strands and reduces their complexity by providing a number of guidelines and a database for easy decision-making. One major impact is that SIAM will continue to close the gap between the perspective of preventing or disturbing criminal threats and the perspective of potential freedom infringements associated with many security measures and technologies. Furthermore by conducting four case studies featuring a significant level of security measures and technologies, SIAM integrates the practical experience with such technologies into the decision support system. As it will be flanked by extensive literature reviewing and the gathering of the wisdom of European leading security and civil rights experts the practitioner perspective will be extended by state of the art knowledge. Beyond that SIAM is building an actor network to initialize the relationships needed for sustained cooperation and future fruitful interaction in the field of security. Participative elements such as stakeholder conferences open up the security field to a wider public and include more actors in the process.

Databases - The promises of ICT, the hunger for information, and digital autonomy
Promotors: Serge Gutwirth, Hildebrandt Mireille
Project type: Assignment Rathenau Institute The Hague
Databases, profiling, technology assessment, technology design, risk, purpose specification

This project examines the possibilities and limitations of the use of databases by comparing six cases studies in the areas of e-health, youth care, public transport and customer profiles. It focuses on the complex dynamics between the design of a database, the purposes it must serve, and the risks involved in the use of it. The study
demonstrates how risks are often overlooked. The security or reliability of – often personal – data is an issue. Incorrect data, mismatches or identity theft may lead to a virtual identity that does not fit reality. But citizens or consumers generally have a weak legal position to inspect and rectify errors. Databases also warn against over-ambitious ICT plans. Simply collecting more data does not as a matter of course lead to greater efficiency or more convenience.

The project stresses that before designing a system, there should be a very clear idea of the goal it should serve, and of the data necessary to achieve that goal. In order to reduce the risks involved in the use of databases, independent supervision of the design and use of databases is needed.

EMSOC: User Empowerment in a social media culture
Promoters: Jos Pierson, Serge Gutwirth
Project type: IWT-SBO
User empowerment, online social networks, data protection, law & media studies

Media and communication are changing fundamentally, with increased convergence and an evolution from mass communication and personal media to mass self-communication. Mediated communication becomes increasingly participative and personalised by means of social computing (Web 2.0). In this realm the user is the central actor, but only to the extent that he or she is actually empowered to grasp the opportunities and face the challenges in the digital media environment. The goal of the interdisciplinary project EMSOC is to critically assess to what extent and how people are empowered or disempowered via their everyday use of social media. We investigate how the vulnerability of these people (does not) change(s) through these new forms of online communication and interaction. The issues are addressed from a social, legal, media, educational and policy perspective. This research about user empowerment in a social media culture revolves around three societal dimensions:

1. Inclusion: to understand the relation between social media and people we need to understand who gets access to which kinds of social media technologies and services and why. That is why we give extra importance to the notion vulnerability (of certain actors) in a social media environment.
2. Literacy: not all users have the same capabilities to use social media to the fullest potential in their own life and work. Only those that are sufficiently digital literate are able to use these media adequately. Therefore the project wants to elaborate on the concept of digital literacy vis-à-vis social media.
3. Privacy: many users lack sufficient understanding of new evolutions and consequences of data mining, analysis and (commercial) diffusion of their digital activities (digital footprint). For this we analyze the (im)permeability between the public and the private for mass self-communication in a legal and user centered way. To achieve optimal valorization our results are communicated and adapted to the needs of EMSOC’s Advisory Committee of Users (ACU). This committee consists of various societal stakeholders who play an important role in Flanders social media debate.

PRESIENT: Privacy and emerging fields of science and technology: Towards a common framework for privacy and ethical assessment
Promoters: Serge Gutwirth, Paul De Hert
Project type: FP7
Privacy impact assessment, ethical impact assessment, privacy, ethics, emerging technologies

Privacy is a multifaceted concept, a moving target and a salient topic in technology policy-making. PRESIENT will provide an early identification of privacy and ethical issues arising from emerging technologies and their relevance for EC policy. It will contribute to the quality of research in the field of ethics, by distinguishing between privacy and data protection and analyzing the ethical, legal and socio-economic conceptualisations of each. The project unfolds in four stages. The first stage is ANALYSIS: the partners will provide a state-of-the-art analysis of privacy and data protection as conceptualised from an ethical, socio-economic and legal perspective. The second stage is CASE STUDIES wherein the partners will identify the privacy, data protection and ethical issues arising from five different emerging technologies and their applications. The third stage focuses on CITIZENS. The partners will analyze various existing surveys to assess citizen concerns and knowledge of the way in which their data are collected, stored and used and their concerns about new technologies and how their concerns have changed over time. The partners will examine 20 top websites and interview data collectors to assess how easy or difficult it is for citizens to access their information and to find out how it is being used. The fourth and final stage focuses on development of a NEW FRAMEWORK FOR PRIVACY AND ETHICAL IMPACT ASSESSMENTS. The partners will develop four scenarios as an element in this new framework, which is based on an integration of the results of this study and on privacy impact assessment guidelines such as those of the UK. The partners will invite a multi-disciplinary panel of 10 external experts to comment on their deliverables and discuss the issues raised in a workshop at each stage. The project will conclude with a final conference to which experts, policy-makers and other stakeholders will be invited in order to debate the project’s findings and recommendations.

REACTION - Remote Accessibility to Diabetes Management and Therapy in Operational healthcare Networks
Promoters: Paul De Hert, Serge Gutwirth
Project type: FP7
E-health, m-health, diabetes management, privacy, data protection

Diabetes is a metabolic disorder characterised by hyperglycaemia (high blood sugar) resulting from defects in the production of or in the body’s response to insulin. There are two types of the disease, type one and type two, but both can cause many complications if the disease itself and associated risk factors (e.g. raised blood pressure and cholesterol) are not adequately controlled. Good glucose control requires frequent measurement of blood glucose levels and complicated algorithms for
assessing the insulin dose needed to adjust for short term variations in activity, diet and stress. On the other hand, good control of diabetes, as well as increased emphasis on blood pressure control and lifestyle factors, may reduce the risk of complications substantially and allow people to enjoy a good quality of life.

This project aims to research and develop an intelligent service platform that can provide professional, remote monitoring and therapy management to diabetes patients in different healthcare regimes across Europe. The REACTION platform can execute various clinical applications for monitoring of vital signs, context awareness, feedback-to-the-point-of-care, integrative risk assessment, event and alarm handling. People with diabetes will be given electronic plasters ("e-patches") which will monitor their glucose levels and data will be sent via a wireless area network to a central store where it can be interrogated by healthcare professionals. The monitoring system will be used both in diabetes clinics in hospitals and in people's own homes. In the case of the latter, personalised feedback will be provided about the impact of lifestyle changes.

**MOVINGLIFE**

**Promotor:** Paul De Hert  
**Project type:** FP7  
**E-health, m-health, medical services, social issues, roadmap**

The MovingLife project will deliver roadmaps for technological research, implementation practice and policy support with the aim of accelerating the establishment, acceptance and wide use of mobile e-Health solutions that will support lifestyle changes among citizens and improve disease management globally. The roadmaps will address a broad group of fundamental issues such as: technology options for applications and services; options for new and improved medical guidelines; user empowerment, acceptance, ethics and privacy; socio-economic environments and policy and regulatory frameworks. Mobile Healthcare (or m-Health) is a term that refers to the provision of medical services through the use of portable devices with the capability to create, store, retrieve, and transmit data via mobile communications. In technical terms, small devices are used to monitor patient-related data and actively communicate with a central information system; in buildings, communication takes place either over a mobile telephony or fixed line network coupled with WiFi. In open spaces, communication takes place via terrestrial (GSM, GPRS, 3G, 4G, WiMax) communication networks or low-orbit satellite communication.

**VALUE AGEING: Incorporating European Fundamental Values into ICT for Ageing: a Vital Political, Ethical, Technological and Industrial Challenge**  
**Promotor:** Paul De Hert  
**Project type:** FP7  
**Fundamental rights, ICT for ageing, innovation, ELSA studies, interdisciplinarity**

VALUE AGEING aims to foster cooperation between non-commercial and commercial entities on a joint research project about the incorporation of Fundamental Values of the EU in Info-Communication Technology (ICT) for Ageing. Good technology is not just about making something better; it is about doing something different and consequently making people think differently. We need to understand both the way in which existing values are driving technology innovation, and how technology in its turn is changing people's standards. Social scientists and ethicists should learn from technologists, and in their turn technologists should learn from scholars working on human values. This makes a project like VALUE AGEING a vital instrument to incorporate fundamental EU principles in industrial strategies and technological awareness in policy setting.

**EPINET - Integrated Assessment of Societal Impacts of Emerging Science and Technology from within Epistemic Networks**  
**Promotors:** Serge Gutwirth, Hildebrandt Mireille  
**Project type:** FP7  
**Integrated assessment, technology assessment, data protection impact assessment, interdisciplinarity, responsible research and innovation**

The EPINET project introduces a new approach to promote integration of technology assessment (TA) methods. It will
Contextual Integrity and the Proliferation of Location Data

Promotors: Mireille Hildebrandt, Serge Gutwirth
Project type: FWO Interdisciplinary Contextual integrity, location data, privacy, data protection

Location privacy has come to the fore due to increasingly widespread practices that involve the storage and analysis of location data. Traffic monitoring, friend finding services, tracking and tracing of mobile communication devices, contextual or behavioural advertising, and location based services all thrive on capturing and mining location data. Location privacy has received much attention from both legal and technical experts. There is, however, a good deal of confusion as to how location privacy is understood, how it relates to notions like contextual privacy, anonymity, unlinkability, autonomy and control. Within the legal domain there is confusion about the difference between privacy and data protection, controversy about which data must be qualified as personal data and about the extent to which consent, purpose limitation and adequate feedback are at stake in particular situations. Within the technical domain we lack a grounded concept of epistemic networks as a way of conceptualizing complex developments within emerging fields of sociotechnical innovation practices. It establishes a “soft” framework within which the plurality of different TA practices can be explored in a concerted and holistic manner. Four cases are investigated along with the development of this framework: wearable sensors, cognition for technical systems, synthetic meat and smart grids. “Integrating TA”, it is claimed, is a task for empirical investigation in which implicit values of TA methodologies, disciplines and practices are spelled out and placed in relation to the practices they are meant to assess. This is the context of innovation conceptualised through the concept of emerging and future epistemic networks. EPINET develops a holistic framework for integrating assessments through gradual co-production of methodologies and concepts (centrally that of “responsible innovation”) together with innovators and policy makers. The challenges of “integrating assessments”, we claim, can only be gradually worked out within such a holistic view of complex intersecting networks and practices.

A Risk to a Right. Exploring a new notion in data protection law
Promotor: Serge Gutwirth
Project type: FWO Law and Criminology Data protection, impact assessment, data protection impact assessment, rights, risk, risk management

The currently proposed European general data protection Regulation will introduce the novel obligation for controllers of personal data processing systems to perform a data protection impact assessment (DPIA). This tool, and in particular the notion of “risks to the rights and freedoms of data subjects” which is at its core, epitomises the shift from classical legal practice to more risk-based approaches. Traditionally, rights and risks belong within different spheres of knowledge and social organisation. Merging them in the proposed fashion could change their meanings into something hardly predictable. This application proposes to explore the nature of the relation between both concepts within the assessment of a “risk to a right”. This will occur by mapping the various relations that exist between risks and rights in different sectors, by deepening the legal insights these relations, and their application to a case study on smart grids technology. This should serve to identify gaps in the way DPIAs are currently operationalized, which can in turn provide opportunities for improvement and for lessons to be drawn from other practices and experiences that strike different relations between risks and rights. In this way this research aims to contribute to more socially robust assessments of the risks to the rights of privacy and data protection.
BYTE – Big data roadmap and cross-disciplinary community for addressing societal Externalities
Promotor: Paul De Hert
Project type: FP7
Big data, social impact, regulation

The Big data roadmap and cross-disciplinary community for addressing societal Externalities (BYTE) project conducts a series of big data case studies to gain an understanding of the economic, legal, social, ethical and political externalities that are in evidence. These case studies are supplemented with a horizontal analysis that identifies how positive externalities can be amplified and negative externalities can be diminished. Building on this research BYTE will consider how big data will develop to the year 2020 using foresight tools to identify future practices, applications and positive and negative externalities. It will develop a vision for big data in 2020 and devise a research and policy roadmap. This will culminate in the launch of the big data community, a sustainable, cross-disciplinary platform that will implement the roadmap and assist stakeholders in identifying and meeting big data challenges.

SeCloud – Security driven Engineering of Cloud-based Applications
Promotor: Paul De Hert
Project type: Innoviris
Cloud computing, mobile devices, apps

Security of Cloud-based applications requires a holistic and proactive approach. The approach lies in good knowledge of security risks specific to cloud-based applications. This knowledge must be built upon different aspects of the security problems, not only technical aspects but also organizational and societal ones. Security is not a purely technical issue, but also an organizational concern and a legal requirement embedded in a broader legal framework concerning the protection of personal data and e-commerce.

The overall goal is to research whether it is feasible to address the above needs by:
• Performing scientific research with respect to the conception of a holistic & coherent set of tools, technologies and techniques that will allow the software industry to proactively think about security in their Cloud-based applications whether SaaS or Mobile. The four considered perspectives are architecture, infrastructure, programming and process (legal issues, management).
• Conceiving a dedicated security risk management model targeted towards Cloud-based application builders (e.g., risk evaluation, mitigation responses to critical risks, vulnerabilities and threats).
• Involving the industry as validator of the two above goals through a dedicated industrial platform.

FORENSOR: FOREnsic evidence gathering autonomous sENSOR
Promotor: Paul De Hert
Project type: H2020
Evidence gathering, autonomous sensors, video surveillance, ethics, fundamental rights, law enforcement

Covert evidence gathering has not seen major changes in decades. Law enforcement Agencies (LEAs) are still using conventional, manpower based techniques to gather forensic evidence. Concealed surveillance devices can provide irrefutable evidences, but current video surveillance systems are usually bulky and complicated, are often used as simple video recorders, and require complex, expensive infrastructure to supply power, bandwidth, storage and illumination. Recent years have seen significant advances in the surveillance industry, but these were rarely targeted to forensic applications. The imaging community is fixated on cameras for mobile phones, where the figures of merit are resolution, image quality, and low profile. A mobile phone with its camera on would consume its battery in under two hours. Industrial surveillance cameras are even more power hungry, while intelligent algorithms such as face detection often require extremely high processing power, such as backend server farms, and are not available in conventional surveillance systems. Here we propose to develop and validate a novel, ultra-low-power, intelligent, miniaturised, low-cost, wireless, autonomous sensor (“FORENSOR”) for evidence gathering. Its ultra-sensitive camera and built-in intelligence will allow it to operate at remote locations, automatically identify pre-defined criminal events, and alert LEAs in real time while providing and storing the relevant video, location and timing evidence. FORENSOR will be able to operate for up to two months with no additional infrastructure. It will be manageable remotely, preserve the availability and the integrity of the collected evidence, and comply with all legal and ethical standards, in particular those related to privacy and personal data protection. The combination of built-in intelligence with ultra-low power consumption could help LEAs take the next step in fighting severe crimes.
Research on big data at the Vrije Universiteit Brussel

FINS – Finance and Insurance

research.vub.ac.be/business/fins-finance-and-insurance

The Finance and Insurance research group at VUB is specialized in the analysis of dependence between high-dimensional financial time series. The analysis is important to understand the functioning of the complex interplay of the determinants of financial market behavior and firm performance, and because many decisions by investors, risk managers or regulators are essentially portfolio decisions, for which both an ex post and ex ante analysis of dependence is of crucial importance. State of the art econometrics are used and developed to combine point estimates with distributional theory to characterize the uncertainty in the found parameter estimates and software implementation (mostly R packages) are distributed. The group has innovated by developing theory and methodology to extract useful information from the high-dimensional dataset of financial variables (e.g. tick-by-tick stock prices, insurance claims, questionnaires on sustainability). Recent contributions involve outlier robust estimates of the (conditional) covariance matrix, shrinkage methods for high-dimensional comoment estimation, the development of a quantitative investment model, pricing of financial products, and rearrangement techniques to explore model risk. The approaches seek to balance efficiency (by imposing minimal model assumptions) and avoiding model risk by making strong parametric assumptions.

FINTECH projects on big data:
• Textual analysis of corporate communications (funding by ICM)
• The analysis of higher order comoments and highfrequency data (funding by Innoviris)
• The analysis of model risk (funding by FWO)
• Credit risk modeling and risk aggregation (funding by private partners)
• Software development in R (Google)
• Measuring sustainability (NBB)
• Forecasting financial risk (NBB)

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FINS develops the technology for big data analysis in finance and insurance.

**High-dimensional price data:**
The analysis of higher order comoments and highfrequency data  
Promotor: Kris Boudt  
Project type: Doctiris - Innoviris

This program aims to develop advanced financial portfolio decision tools that make optimized portfolio decisions incorporating the vast information available in the financial price series and accounting for the stylized facts of the data: time-varying volatility and correlation, higher order comoments and non-linear dependence.

**High dimensional corpus of texts:**
Textual analysis of corporate communications  
Promotor: Kris Boudt  
Project type: ICM

Development of efficient algorithms to interpret texts from various sources (CEO letters, earnings press releases). Algorithms involve the classification of words, the aggregation into sentiment measure and the specification of decision tools that exploit the quantitative information extracted from the various corporate communications.

**High dimensional loss data:**
Credit risk modeling and risk aggregation  
Promotor: Steven Vanduffel  
Project type: funding by private partners

This project has developed the methodology for accurate credit risk scoring, risk capital calculation at different levels of granularity as well the aggregation at the total portfolio level, and the decomposition into the sources of risk. The methodology combines simulation tools with tractable formulas and efficient programming.

**High dimensional loan data:**
Performance of SME finance and public-private partnerships  
Promotor: Lieven De Moor  
Project type: funding by private partners

This project studies the determinants of success for a high-dimensional set of loans and derives scorecards to evaluate them. The focus is on SME finance and public-private partnerships.

**High dimensional corpus of texts:**
Textual analysis of corporate communications  
Promotor: Kris Boudt  
Project type: ICM

Development of efficient algorithms to interpret texts from various sources (CEO letters, earnings press releases). Algorithms involve the classification of words, the aggregation into sentiment measure and the specification of decision tools that exploit the quantitative information extracted from the various corporate communications.

**Reliability of big data versus model assumptions:**
The analysis of model risk  
Promotors: Kris Boudt, Steven Vanduffel  
Project type: FWO

It is unrealistic to believe that a model is an exact description of the process generating the data. In this project we develop robust inferential tools that remain reliable when the data contain outliers and assess the potential impacts of model uncertainty on the decision variables of interest. We further develop methods that aim at optimally combining the information in the data and parametric assumptions, especially in the case when the dimension is high compared to the number of observations. We stress test the models and use rearrangement techniques to investigate the sensitivity of the obtained results to the observed dependence in the data.

**Big data requires efficient implementations**  
Promotor: Kris Boudt

- Software development in R (Google)  
Our team has developed several R packages for financial analysis including portfolio optimization, performance analysis and attributions, simulation based risk analysis, highfrequency financial data analysis and composite index calculation.
Research on big data at the Vrije Universiteit Brussel

**DWIS – Mathematics**

dwis.vub.ac.be

The department DWIS of the faculty of exact sciences and bio engineering performs research and education for all aspects of mathematics. The department is organized in 4 research groups: ALGeBra and incidence geometry (ALGB), Topological Algebra, functional analysis and Category Theory (TACT), Stochastics (STO), Digital Mathematics (DIMA).

Among its various research aspects, the group ALGB investigates fundamental structural problems of several algebraic and geometric objects and its application in modern cryptography, encryption and security. The group STO deals with General limit theorems of probability, Empirical Processes, Levy processes and their application in finance and actuarial sciences. Finally the group DIMA focuses on computational statistics, numerical analysis, signal and image processing with applications in biomedicine Stochastics.

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DWIS projects on big data:

**Generic modeling framework for the processing of biomedical measurements – fractional time series analysis**

*Promotors:* Kurt Barbé, Uwe Einmahl  
*Project type:* FWO

Biomedical applications often require monitoring physiological parameters which are not directly measurable. A statistical model is then applied to extract that physiological information from the possible measurable quantities. The human body regulates most of its processes through various diffusion processes. The mathematical model describing the physiology and the regulating diffusion requires a huge amount of parameters. Such high dimensional models are difficult to estimate and the increase in parameter uncertainty renders predictions often useless. In this project, we study and propose fractional order models which allows to compress a group of parameters to a fractional order parameter. The compressed information is present in the estimated quantity as well as its multiplicity. This reduces the parameter uncertainty and improves the numerical techniques to predict and analyze the data.

**Modeling dynamic effects in fMRI time series disturbed by non-Gaussian noise**

*Promotors:* Lieve Lauwers, Kurt Barbé, Uwe Einmahl  
*Project type:* FWO

Functional Magnetic Resonance Imaging is one of the key diagnostic tools in brain function mapping and assessment. The current statistical regression models characterizing the fMRI signals operate under the assumption that the data follows a normal distribution. This assumption is valid in fMRI in the center of the region of interest due to the low background noise. At the border of the activation region the noise is more dominant such that the normal distribution is no longer valid due to the active presence of Rayleigh noise. This lack of normality implies that the regression models and statistical tests are no longer valid in the sense that their optimal mathematical properties can no longer be guaranteed. In this project, we both assess the impact on these mathematical properties under departures of the normality assumption and study corrections to alleviate the loss in performance.

**Revisiting the mathematical foundation for Cognitive Radios under real operational conditions**

*Promotors:* Kurt Barbé, Jean Vereecken  
*Project type:* BeV a subsidiary of FANC

Cognitive radios is the next generation mobile communication platforms. This is the natural evolution of software defined radios in which different wireless services are combined in a single technology. This implies that various technological solutions must efficiently interact with each other to ensure the quality of the services. The philosophy of this technology establishes a flexible switch of the device its operational conditions depending on the frequency bands occasionally under-used and the service demanded. This implies mathematically that a constant monitoring of the wireless channels is required. This monitoring can be realized through modeling of the wireless channels through a time series model. This project is dedicated towards the real-time analysis of these time series models in which we strive at adaptive estimation techniques for its parameter characteristics.

**Taylor-Fourier transform: a non-parametric characterization of fractional-order dynamical systems**

*Promotors:* Kurt Barbé, Lieve Lauwers  
*Project type:* Keysight Technologies

Fourier analysis for characterizing dynamical systems and measurements is well known. This technique has served well for time invariant measurements. Recently, time varying signals have been reported abundantly in applications where Fourier analysis failed to ensure the quality it is known for. To circumvent the problem and to retain the good applicability of Fourier analyses, we extend the Fourier analysis to the Taylor–Fourier analysis. The main idea of this technique is to describe the time-varying part of the observed signals by a Taylor series while the dynamical part can still be analyzed through the classical Fourier analysis.
**STOχ: Stochastics**

vub.ac.be/nl/stox-stochastics

Within the department mathematics, the research group stochastics focuses on both general probability theory and statistics. The team on probability theory is mainly oriented in the field of finance with an emphasis on:

- General limit theorems of probability
- Empirical Processes and their applications
- Strong approximations and invariance principles
- Levy processes
- Two-sided exit problems
- Risk processes

**DWIS - Stochastics (STOχ)**

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The team on Digital Mathematics is mainly oriented towards computational statistics, numerical analysis, signal and image processing with applications in biomedicine:

- (non)linear regression under non-Gaussian disturbances
- Recursive and adaptive estimation of dynamical systems
- Fractional-order differential equations
- High dimensional parameter estimation problems
- Mathematical modeling and maximum likelihood techniques
- Sparsity constraints and regularization

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Research on big data at the Vrije Universiteit Brussel

Big data study areas:

• **High dimensional regression models:**
  A big data setting leads statistically to large dimensional problems as the law of large number forces an increase in the number of significant parameters. This leads to endogeneity increasing dependence and collinearity among regressors. The collinearity worsens the conditioning of the problem, leading to a higher uncertainty on the estimated parameters which may render prediction intervals completely useless.

• **Crunch computing and parallel statistical data analysis:**
  Large dimensional models with a huge number of parameters in the presence of an even large number of data to process is a computational challenge. One way to deal with this problem is to split the parameters leading to multisplitting least squares as well as splitting the data leading to crunch computing or Kalman filtering approaches. A combination of data splitting and parameter splitting approaches leads to parallelized statistical data analyses.

• **Empirical processes:**
  Many statistical estimators can be modelled as functionals of empirical processes. Non-asymptotic properties and limit results allowing approximations of such functionals are often used. Investigations of the quality of these approximations can give us additional insight about the quality of the used techniques and also show where new techniques are necessary.

Industrial collaborations:

• Keysight Technologies:
  Measurement devices and equipment
• Covidien:
  Electrosurgical solutions
• BEL-V:
  Belgian nuclear safety control
• WTCB:
  Wetenschappelijk en Technisch expertise Centrum voor het Bouwbedrijf
Medicine, Biology and Informatics: The Interuniversity Institute of Bioinformatics in Brussels is a new interdisciplinary research initiative supported by ULB and VUB universities. The (IB)² brings together research groups providing or requiring bioinformatics analysis into an interuniversity, cross-faculty (Medicine, Sciences, and Applied Sciences, of ULB and VUB) laboratory of scientific excellence. The (IB)² research focuses on large-scale omics driven bioinformatics, biostatistics and computational biology. We address pressing needs for data analysis, especially for DNA sequencing, to achieve a better understanding of the physio- and pathological mechanisms of living organisms.
Main study areas

- NGS data, Genome and Exome Sequencing
- Metagenomics and Microbial community modelling
- Structural Bioinformatics
- Prediction and machine learning
- Disease variants in Mono-, Poly- and Oligogenic disorders
- Systems Biology
- Epigenomics
- Computational Biology

Equipment & infrastructure

- Local computer cluster
- Computational and storage resources at VUB/ULB computing centre

Industrial collaboration & Industrial application fields

- Health (genome and metabolic levels)
- Food and Energy (microbial communities and genetically modified organisms)

Milestones & achievements

**BridgeIRIS** project in partnership with Innoviris, InSilico Genomics and UCL to provide bioinformatics solutions to Brussels hospitals, so improving diagnostics and treatment of disease. BridgeIRIS makes use of the Insilico DB platform of the ULB/VUB spin-off InSilico Genomics, for its genome data storage and handling.

The (IB)² is the Brussels representative in the ongoing effort towards forming a Belgian ELIXIR node. ELIXIR is a European high priority ESFRI bioinformatics project that will allow life science laboratories across Europe to share and store their research data as part of an organised network.
VUB success stories
VUBIS
A smart library system co-developed by the VUB

vub.ac.be/BIBLIO

Vubis is a complete portfolio of library software products: V-smart, V-link, V-insight and Iguana. The core product V-smart is an integrated web-based library system with modules for ordering, cataloguing, searching and lending. V-link is a generator of context-sensitive links. V-insight is a browser-based portal for statistical analysis and Iguana a web portal and discovery tool.

Vubis was originally developed at the VUB more than 40 years ago and in 1978, the system became operational in the university’s library. From 1987 onwards, Vubis was licensed to a commercial firm. The current commercial partner is Infor Library and Information Solutions. Infor and VUB are co-owner and develop together the Vubis product portfolio. Vubis software is used in hundreds of libraries worldwide: in Europe, North America, Australia and Africa. Customers include the Amsterdam Public Library in the Netherlands, the University of Nairobi in Kenya, the Swiss Library for the Blind and the Vatican Library.
Collibra, VUB spin-off
Efficient communication between computer systems

www.collibra.com

Collibra is an enterprising software company and a spin-off from the Computer Sciences Department at the Vrije Universiteit Brussel. The company aims to valorize 10 years of experience in application oriented research on semantic technology. Founded by Felix Van de Maele, Stijn Christiaens, Pieter de Leenheer and Damien Trog, Collibra is backed by academic and industry veterans.

Business ecosystems have evolved from rigid value chains towards agile, globalized value networks. Within this reality, the need for exchange, integration and understanding of heterogeneous information has become of strategic and competitive importance for companies all around the world. The ICT world as we know it today is faced with a rampant increase in isolated metadata and a massive load of scattered legacy data.

Collibra is convinced that building the next generation of businesses requires a paradigm shift that reaches beyond the technological level. To this end, the mission of Collibra is to deliver tangible solutions for capturing and sharing business semantics in order to empower efficient and sustainable integration, management and delivery of diverse business information.

www.collibra.com
Genomics datasets are increasingly useful for gaining biomedical insights, with adoption in the clinic underway. However, multiple hurdles related to data management stand in the way of their efficient large-scale utilization. The absolute necessity of software tools to make sense of this huge amount of data and to manage it, causes medicine to be increasingly driven by IT and web-based solutions.

The InSilico Genomics Bioinformatics platform 'InSilico DB' is the foundation upon which to build a pioneering role in 21st century biology, taking care of the data aspects of modern biology and medicine. InSilico DB is used by bench and computational roles alike, which allows each to work independently and together to collaborate powerfully, resulting in a new level of possible results.

InSilico DB is a no-risk, turnkey solution for implementing or expanding genomics capabilities quickly and inexpensively. Using InSilico DB gives peace of mind as data are secure from competitor’s view and safely stored and retrieved whenever needed. A fast, example-based blog makes it easy to get started using InSilico DB (https://insilicodb.org/blog).

InSilico DB has been published in top peer-reviewed journals such as Genome Biology and Bioinformatics, which makes InSilico DB the leading standard, citable, peer-reviewed solution to genome data analysis. By using InSilico DB, you can spend the time you need to contribute to the advancement of medicine through genomics.

users of InSilico DB are riding the genomics wave!

David Weiss, CEO
Universum Digitalis, VUB spin-off
Experts in mobile media management and distribution

www.universumdigitalis.com

Universum Digitalis is an ICT company founded in 2008 by Dr. Iris Vanhamel and Frederik Temmermans, and endorsed by Prof. Jan Cornelis and Prof. Peter Schelkens. Universum Digitalis is a spin-off of IRIS, the Image Processing and Computer Vision research group of the VUB’s Department of Electronics and Informatics (ETRO).

Universum Digitalis develops customized solutions for data management and distribution. More specifically, Universum Digitalis designs solutions for the management of multimedia databases and provides generic data exchange interfaces for distributing data to various client applications. Universum Digitalis develops native mobile client applications for iOS and Android as well as web-based applications based on HTML5 technologies.

Universum Digitalis has built applications for museums, cultural institutions and others. The website ‘Closer to Van Eyck’ (closertovaneyck.kikirpa.be) is a good example of a strong collaboration between art historians, image processing experts from VUB-ETRO and Universum Digitalis. The website brings a huge collection of image data from the masterpiece ‘The Ghent Altarpiece’ to the public in a user friendly way.