DSC/e brings together over 30 research groups working on various aspects of data science at Eindhoven University of Technology. Data science is not only relevant for business and society, it is also rapidly changing the way we conduct research.

This brochure contains a concise “one-pager” per research group, describing the research interests, the key involved staff, and the main fields of expertise.
data science

- algorithms
- statistics
- privacy, security, law & ethics
- behavioral / social science
- business models & marketing
- visualization & visual analytics
- distributed systems
- databases
- predictive analytics
- process mining
- data mining
- machine learning
- binnenflap
DSC/e research groups

What is Data Science?
Data science is an interdisciplinary field that uses a variety of techniques to create value based on extracting knowledge and insights from available data. Data science is applied everywhere: in business, health, industry, finance, government, education, and also scientific research. Data scientists use state of the art approaches from statistics, data/process mining, machine learning, visualization, algorithms, databases, security, privacy, and distributed computing. The successful and responsible application of these methods highly depends on a good understanding of the application domain, taking into account ethics, business models, and human behavior. Data science can be used to identify patterns and regularities in huge data streams, combine various data sources and answer questions at a scale previously not possible. Questions that could not be answered in the past can now can be answered immediately and at any point in time. Therefore, data science is becoming an integral part of most types of engineering and scientific research.

Data Science Center Eindhoven - DSC/e
The Data Science Center Eindhoven is TU/e’s response to these challenges and possibilities. By bringing top scientists and students from over thirty research groups from different TU/e departments together on specific topics, we can tackle the most challenging scientific and societal challenges. All of the involved groups made one-page descriptions of their main research interests and the involved staff with their key expertise. This information is collected in this brochure. We hope that this will help you to find the right data science expertise within DSC/e. Feel free to contact us via dsce@tue.nl.

Enjoy reading!

Prof.dr.ir. Wil van der Aalst
Scientific Director DSC/e
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Innovation, Technology Entrepreneurship & Marketing  
Industrial Engineering & Innovation Sciences  

Mathematical Image Analysis  
Mathematics and Computer Science  

Medical Image Analysis  
Biomedical Engineering  

OPAC: Freight Transport & Logistics  
Industrial Engineering & Innovation Sciences  

OPAC: Maintenance & Manufacturing  
Industrial Engineering & Innovation Sciences  

OPAC: Supply chain management  
Industrial Engineering & Innovation Sciences  

Philosophy & Ethics  
Industrial Engineering & Innovation Sciences  

Probability  
Mathematics and Computer Science  

Real Estate Management & Urban Planning  
Built Environment  

Security of Embedded Systems  
Mathematics and Computer Science  

Signal Processing Systems  
Electrical Engineering  

Software Engineering & Technology  
Mathematics and Computer Science  

Statistics  
Mathematics and Computer Science  

Stochastic Operations Research  
Mathematics and Computer Science  

System Architecture & Networking  
Mathematics and Computer Science  

Urbanism and Urban Architecture  
Built Environment  

Visualization  
Mathematics and Computer Science  

Web Engineering  
Mathematics and Computer Science
Main research interest

Effective analysis and processing of large data sets requires efficient algorithms, and fast retrieval of relevant information requires efficient data structures for storing large data sets. Our research focuses on the development of efficient algorithms and data structures, with an emphasis on:

- algorithms for geographic data or other types of spatial data
- algorithmic questions arising in robotics and automation
- optimization problems related to networks
- I/O-efficient algorithms
- data structures for efficient retrieval of (in particular) spatial data

Our goal is to develop algorithms and data structures that have a firm theoretical basis, with guarantees on their efficiency and on the quality of the computed solutions, which are also effective in practice.

Scientific staff

Prof. Mark de Berg (head of the group)

Dr. Kevin Buchin
  Trajectory and spatial data analysis

Dr. Herman Haverkort
  I/O-efficient algorithms and data structures

Dr. Bart Jansen
  Network algorithms and parameterized complexity

Furthermore the Algorithms Group currently has one part-time professor, 6 PhDs and 1 PD.

Success stories

Kulicke & Soffa is a leading provider of semiconductor packaging and electronic assembly solutions. We have worked together with the optimizer team from their Eindhoven branch to further improve the efficiency of their pick-and-place machines.

An increasing amount of movement data are being collected in a wide range of applications. Focusing on applications in animal tracking we have worked together with ecologists to develop algorithms for trajectory analysis that help them understand animal behavior.

Project examples

- **Networks funded by Dutch Ministry of Education, Culture and Science**
  The goal of Networks is to address the pressing challenges posed by large-scale networks with the help of stochastics and algorithmics. The focus is on modeling, understanding, controlling and optimizing networks that are complex and highly volatile. Partners: TU/e, University of Amsterdam, University of Leiden, CWI.

- **A framework for progressive, user-steered algorithms in visual analytics funded by NWO**
  The highly interactive visual analytics process bears unique challenges and requires a novel perspective on how to measure the performance of an algorithm. The aims of the project are to develop algorithms, which (i) give a fast response and then refine the solution progressively, (ii) provide the user with the means to steer the computation and are flexible enough to adapt to changing objectives, and (iii) provide a guarantee on the quality of their results.
Main research interest

Geometric algorithms is the field within algorithms research that is concerned with the design and analysis of efficient algorithms and data structures for problems involving geometric objects in 2-, 3-, and higher-dimensional space. The Applied Geometric Algorithms group mainly focuses on geo-metric algorithms for spatial data and applications of geometric algorithms in the areas of GIScience and Smart Mobility (including automated cartography and moving object analysis), geo-visualization, visual analytics, and e-Humanities.

Our approaches frequently combine the rigorous methods from algorithmic research areas such as computational geometry - which give performance guarantees with respect to both the quality of solutions and the running time of algorithms - with efficient engineering to achieve results of both theoretical and practical significance.

Success stories

WorldCat by OCLC has 2 billion entries describing more than 321 million bibliographic records. It used to offer only a textual user interface for searching and browsing. Together with OCLC’s research scientists, we develop visual analytics tools that meet humanities researchers’ needs as well as concrete demands from libraries. The tools provide visual interfaces for data cleaning, clustering, and analysis, and intuitive and interactive representation of search results.

Together with the eScience Center we are developing an online platform and open-source code library to move our advanced information-visualization and mapping techniques from theoretic concepts to practical tools that can be used by anyone.

Project examples

- Algorithmic Foundations for the Analysis and Visualization of Complex Moving Objects
  NWO – VICI
  Going beyond the basic setting of moving point objects, we study moving complex, non-point objects such as moving polylines (e.g. modeling changing coastlines or glacier termini), polygons (e.g. hurricanes), and geometric networks (e.g. river networks).

- Visual Analytics for the World's Library Data
  NWO – Creative Industry
  Together with OCLC we develop an interactive visual analytics toolkit to explore millions of bibliographic records.

- Algorithmic Geo-visualization: from Theory to Practice
  Netherlands eScience Center
  Together with the eScience Center we are developing advanced stable geo-visualization techniques for time-varying data and make our results available in a professional software library.

Scientific staff

Prof. Bettina Speckmann (head of the group)
  Applied geometric algorithms

Dr. Wouter Meulemans
  Algorithms for GIS and geo-visualization

Dr. Ignaz Rutter
  Network algorithms and visualization

Dr. Kevin Verbeek
  Spatial data analysis and algorithmic visualization

Furthermore the Applied Geometric Algorithms group has 6 PhDs and 1 PD.
Main research interest

Investigation of methods, techniques and tools for the design and analysis of process-aware information systems (PAIS), i.e. systems that support business processes (workflows) inside and between organizations. We are interested in:

- Information systems
- Process modelling
- Process mining (process discovery, conformance, extension)

We also actively maintain and develop several (open-source) software packages:

- ProM (process mining and process analysis)
- YAWL (workflow management)
- Declare (workflow management)
- CPN Tools (model-based analysis, simulation)

Success stories

The group closely collaborates with various software vendors, consultancy firms and end-user organizations. An example of this was the CoSeLoG project in which 10 municipalities and 2 software vendors participated. Applying process mining on selected processes revealed certain key employees for which no back-up was available.

The group also organizes the yearly business process intelligence challenge where a real-life data set is published and analyzed by contestants. One of the datasets described loan applications, where it was found that for loans totaling to €38,000 no approval was registered, while the loan was granted.

The work of the group on workflow patterns also influenced industry standards such as BPMN.

Furthermore, two spin-offs in the area of process mining (Future Process Intelligence and Fluxicon) demonstrate the practical relevance of the groups' research.

Scientific staff

Prof. Wil van der Aalst (head of the group)
Process mining, process modeling, process analysis

Dr. Joos Buijs
Process mining in healthcare, learning analytics

Dr. Boudewijn van Dongen
Process discovery and conformance

Dr. Dirk Fahland
Distributed systems and processes, process repair, conformance

Dr. Marwan Hassani
Process mining on data streams

Dr. Massimiliano de Leoni
Multi-perspective process mining, process aware decision support

Dr. Renata Medeiros de Carvalho
Modeling and mining declarative processes

Prof. Hajo Reijers
Case management, configurable process models, social BPM

Dr. Natalia Sidorova
Process modeling, verification

Furthermore 15 PhDs and 3 PDs are working on various Data Science projects.

Project examples

- **DeLiBiDa** NWO
  New process mining techniques that are able to handle huge event logs in variable and heterogeneous contexts.

- **Philips Flagship Philips & TU/e**
  Data science research in product-centric consumer data analytics, predictive analytics for healthcare workflows, and radiology workflow optimization and orchestration.

- **Process mining in logistics Vanderlande**
  Analyzing event data to improve the performance of package handling systems and warehouse automation systems, both online and offline.
Main research interest (DSC/e related)

Major technology advances enable smart lighting solutions. LED technology links lighting technology to the digital world. Embedded sensors and actuators communicate with their environment. This leads to the challenge of analysing the data collected to optimize the lighting system’s performance.

Human Centric Lighting refers to lighting systems with some kind of intelligent behaviour aiming at enhancing the quality of the built environment for the users. Application domains include but are not limited to work environments, public outdoor spaces and private homes.

Smart lighting solutions must be based on a balanced optimum between Light & Energy, Light & Visual Environment and Light & Health. Our goal is to help develop applications that balance these three aspects in Human Centric Lighting.

Scientific staff (DSC/e related)

Approximately 60 % of the BL group is focusing on data driven research. Key involved staff:

Prof. Alexander Rosemann (head of the group)
Human centered lighting, lighting applications, smart lighting

Prof. Evert van Loenen
Smart lighting, light & health, intelligent controls

ir. Mariëlle Aarts
Light & health, data & lighting applications, process modelling, verification

Dr. Rajendra Dangol
LED lighting & applications, Subjective preferences from data collection and analysis

Furthermore 5 PhDs are working on various Data Science projects.

Success stories

The group works closely within the Intelligent Lighting Institute and associated industrial partners. In 2016, dr. Bernt Meerbeek was awarded his PhD “cum laude”. In his thesis “Studies On User Control In Ambient Intelligent Systems” he investigated user control in the domains domestic robots and intelligent office buildings. His work contributed to a large number of patents.

Connected lighting system with integrated sensors left: Installation at “The Edge” in Amsterdam; right: lab setup at TU/e.

Project examples

- **CHEO Spark Impulse II - ILI Flagship project**
  Creating Healthy Environments – Offices
  Enhancing environmental conditions for office occupants and their clients via energy-efficiency, user comfort and well-being, work pleasure, safety and improved staff effectiveness.

- **OptiLight STW**
  Large scale application of automatic control algorithms based on quantified models on how humans perceive and experience lighting.
  Multidisciplinary ILI collaboration, project lead: prof. Linnartz.
Main research interest (DSC/e related)

The Design Innovation Strategy group focuses on interdisciplinary collaboration between design and engineering technology to develop innovative products, especially on applying design insights to envision and interpret emerging technologies in future scenarios. We have been working on designing the user experience for Internet of Things since 2013. Data Science plays an important role in the research e.g. in combining subjective user input with multiple streams of sensor data collected by Internet of Things to gain in-depth understanding of user behavior and preferences, as well as making use of data collected by things to augment people’s senses. We aim to re-define the role of designers in designing the interface between data/things and people.

Another topic is the dynamics between multiple users in a smart environment. How can smart environment make use of multiple streams of data to facilitate and mediate among different users? This includes the dynamics between people and the intelligent agency of machines. How to balance the control between people and the intelligent machines?

Scientific staff (DSC/e related)

Roughly 70% of the BPD group is involved in Data Science related work. Key involved staff:

Prof. Lin Lin Chen
  - IoT, learning user behavior and preference, augmenting human senses

Dr. Yaliang Chuang
  - IoT, multiple user negotiation in a smart environment, dynamic balancing of human and machine control

Furthermore 2 PhDs are working on projects relating to sensor data fusion for learning user behavior patterns, and robust user scenario detection.

Project examples

- **Apps 4Kid** and **Apps4Home**. We developed future user scenario films to propose the idea of offering IoT solutions as Apps that can be purchased and installed to a home, and to envision how smart technologies can interact with people to provide better decision support and to mediate conflicts among the users. We conducted these projects are in collaboration with NTU IoX Center (formerly Intel-NTU Center) in Taipei, Taiwan.

Success stories

Dial: a toolkit for designing intuitive interaction between people and smart things. We developed a set of physical objects which can display lighting patterns and play sound effects in a synchronized manner. We then used the toolkit to test user understanding of designed vocabulary of smart objects.

Visualization of User Preferences from Apps4Home project. We designed ways to visualize machine understanding of user preference and conflicts among different users.

Visualization of Alternatives and Trade-offs from Apps4Kid project. We designed an interface to let users make decision based on visualization of predicted consequences.
Main research interest (DSC/e related)

We design systems to initiate and analyze interaction between complex designed intelligent artifacts / probes and large groups of highly diverse (groups of) users in the field to:

- Capture data
- Analyze and model the obtained data
- Translate this data into design information

One of the major challenges of designing intelligent/adaptive systems in a societal context is that, in the field, both the system and the user(s) will continuously adapt. For most design interventions, little is known on how these processes evolve. We concentrate on how to support design for everyday life, capture behavioral data and model this information as well as to translate this information into “designable parameters”. We focus on the field of recreational sports / vitality / active living.

One of the major challenges of modern society is that many people (elderly but also adults and even children) land into a vicious circle of a largely sedentary lifestyle, decreasing physical activity and increasing weight. Leading a sedentary lifestyle combined with being overweight may cause, often chronic, diseases and a low quality of life. Not only for people themselves but also for society as a whole this situation is far from desirable.

Designers have the ability to break through this cycle provided that they understand the underlying mechanisms and find handles to design for this. Intelligent, interactive systems have opened a totally new design space that can not only create new and attractive propositions but can also act as a probe to observe the effects achieved.

Success stories

Aymée: a data capturing and representation system integrated in a bra in order to recover self-esteem for women who suffered from breast cancer.

SmartGoals: a distributed interactive system to improve and analyze training of young football players.

Scientific staff (DSC/e related)

Roughly 70% of the BPD group is involved in Data Science related work. Key involved staff:

Prof. Aarnout Brombacher  
Vitality & recreational sport, IoT, preventive health care

Prof. Steven Vos  
Design and Analysis of Intelligent systems for Vitality and Leasure Time Sports

Dr. Carl Megens  
Data driven design

Furthermore 7 PhDs are working on various Data Science projects.

Project examples

- Marathon Eindhoven (partner since 2013) analyzing and supporting the behavior before, during and after the event especially for (starting) recreational runners.

- Inspirun personalized coaching for recreational runners based upon individual activity data

- Bouncers: the use of social media techniques to analyze and improve physical activity patterns in social groups.

- Social Stairs analysis of physical activity patterns in an office building for use of the design of motivational interventions.
**Main research interest** (DSC/e related)

**Model predictive and evidence based clinical decision support**

Evidence based medicine aims to use the results of population-based data for decision making in clinical practice. Evidence based decision support systems provide an IT solution to integrate the best and most up-to-date research evidence with the individual patient’s data and the clinical expertise of the attending physician. Rather than experience based evidence, the group typically uses *mathematical models to predict* the future behavior of a process or design depending on internal (time dependent) behavior and possible external influential factors. This strategy has emerged into means to deal with control of dynamic systems, where large multivariable constrained processes are optimized dynamically by the use of *model predictive control* (MPC). The model predictive controller uses the model as well as current system-specific measurements to determine the interventions that will result in the desired behavior.

A clinical support system would ideally combine *evidence based medicine and a patient-specific model* predictive control strategy and heavily depends on shared population based as well as measured personalized medical data.

**Success stories**

Coronary flow reserve

A number of research projects, dedicated to the analysis of blood flow in the coronary circulation, have been carried out in close collaboration with the Catharina Hospital in Eindhoven (CHE).

These studies comprised computational and experimental analysis of the pressure-flow relation in healthy and diseased coronary artery trees. These analyses were used to verify the concept of fractional flow reserve (FFR), first introduced by prof. Nico Pijls at CHE as an important clinical index to decide upon the physiological severity of a coronary stenosis. Validation studies based on randomized clinical trials have shown the value of the FFR and changed the guidelines for treatment of coronary artery disease.

**Project examples**

- **VPH-Share** has the ambition at the end of its effort to provide to the community a set of tools that will help the VPH and biomedical community in sharing information and build new knowledge. [https://portal.vph-share.eu](https://portal.vph-share.eu)
- **EurValve** will implement, test and validate a modelling based decision support system (DSS) for aortic and mitral valve diseases that allows simulating, comparing and understanding the effects (outcomes) and risks of different treatment strategies. [http://www.eurvalve.eu/](http://www.eurvalve.eu/)

**Scientific staff** (DSC/e related)

Approximately 20% of the CB group is focusing on data driven research. Key involved staff:

**Prof. Frans van de Vosse**  
*Medical Engineering*

**Dr. Richard Lopata**  
*Medical Ultrasound*

**Dr. Peter Bovendeerd**  
*Physiological models*

**Dr. Marcel Rutten**  
*Experimental models*

Furthermore 15 PhDs and PDs are working on various projects in which Data Science is important.
Main research interest

We work at the intersection between computational intelligence and network science, to address network complexity, high-density telecommunications, and massive-scale sensing in the Internet of Things. Complex ICT systems such as Smart Cities will soon generate data on the Zettabyte scale. Such data volumes at the network edge will be largely unstructured, uncorrelated, noisy and incomplete, posing Data Science problems that current methods cannot master. We have made breakthroughs in distributed data mining, miniaturized machine learning, and networks mining, with practical applications to Smart Cities, Environmental Monitoring, Smart Energy, Smart Health, and Cyber-Physical Systems.

We have extensive experience in collaborating with the Telecom industry, including projects on: cognitive IoT communications; energy efficiency; software defined networks; user localization; Quality of Experience management; and cognitive video streaming.

Fig 1: We have developed new methods to miniaturize deep learning and online learning, which is essential in IoT applications.

Scientific staff

Prof. Antonio Liotta (Group Leader)
Network analysis, cognitive networks, smart sensing, urban informatics, IoT communications, QoE management

Prof. Sonia Heemstra
Vehicular networks, beyond-5G communications, cognitive wireless

Prof. Ignas Niemegeers
Cognitive networking, cognitive radio, wireless sensor networks, IoT communications

Dr. Georgios Exarchakos
Dependable IoT, IoT infrastructures, cyber-physical systems

Dr. Oded Raz
Ultra low-latency data centers

Dr. Nicola Calabretta
Software Defined Networks, Network Functions Virtualization

Furthermore 10 PhDs are working on various Data Science projects.

Success stories

The ambition is to connect 1 trillion objects in the Internet of Things. At this scale, connectivity and data mining are distributed prediction problems which start inside the devices. We have recently achieved miniaturized machine learning processes, such as anomaly detection and interference prevention, in sensors having as little as 10 Kbytes of memory.

Fig 2: We have developed a distributed network-analysis tool, which computes IoT centrality metrics in real-time, making it possible to figure out the importance of all nodes and links in massive-scale networks.

Project examples

We have collaborations both at TU/e (DSCe; CWTe; EIRICT; ILI; IPI) and internationally

• Inter-IoT is an EU funded project with focus on open data and interoperability (ranked #1 in the EU Horizon 2020 ICT-30 domain). We have pilots in the Port of Valencia (Smart Logistics) and at Turin Hospital (Smart Health).

• The Joint Intellisensing Lab connects our smart-sensing facilities to an ocean monitoring platform in Shanghai, and an e-health system in Brisbane.

• ACCUS, EU Artemis project developed a smart city pilot in Gdańsk, Poland.

• DEMANES, EU Artemis project developed a smart logistics pilot in the Port of Rotterdam, the Netherlands.

Facilities

We maintain an Open IoT facility that allows deployment of applications, generation of datasets, and IoT Big-Data analytics.
Main research interest (DSC/e related)

The aim of the Computational Biology group is to understand biomedical processes in living systems by using a variety of computational data analysis and modeling techniques. The systems range from atomic interactions within a single molecule, membranes and vesicles, to cellular interactions, metabolic pathways and networks of organisms. Current research areas comprise systems biology, synthetic biology, modeling self-assembly of biomaterials, data analysis, and modeling drug delivery and radiation therapy.

Typical examples of diseases being studied are diabetes, psoriasis and metabolic disorders such as tryptophan deficiencies in patients suffering from autism.

We use a variety of techniques such as:

- Design of algorithms, graphs, neural networks, data analysis, clustering and classification algorithms
- Multiscale modeling, differential equations, numerical methods, parameter estimation, parameter sensitivity analysis
- Large scale parallel simulations, molecular systems
- Mathematics and computer science for biomedical applications including our own original methods

Success stories

We developed original computational methods in proteomics analysis in type 2 diabetes to establish the potential disease state and intervention specific biomarkers. This results of this research elucidate the underlying mechanisms of the improvements observed in low calorie diets and exercises to improve in obese type 2 diabetes patients.

Scientific staff (DSC/e related)

Approximately 25% of the CB group is focusing on data driven research. Key involved staff:

Prof. Peter Hilbers (head of the group)
Computational modeling, computer science, mathematics

Prof. Natal van Riel
Systems biology and medicine, metabolism, computational modeling

Dr. Huub ten Eikelder
Neural networks, computational modeling, computer science, mathematics

Furthermore 2 PhDs are working on various Data Science projects.

Project example

HUMETICS (Human Metabolic Syndrome)
Public-private-partnership ApeT and TU/e

The aim of the project is to develop a software platform for the automated analysis of human metabolome data. Our group develops the computational models, numerical algorithms and the software. The prototype of the platform was tested on metabolomics data from about 1500 subjects obtained from Erasmus MC.
Main research interest (DSC/e related)

As part of the systems and control field, that is targeted at controlling and optimizing the operational performance of dynamical systems, the data-related research of CS focusses on **data-driven modelling of dynamical systems** involving:

- Linear and nonlinear (continuous) dynamics
- Experiment design
- Model uncertainty quantification
- Approximate modelling and model reduction
- Structured systems, in both interconnections and physics-based dynamics
- Performance monitoring and predictive maintenance
- On-line model (parameter) estimation
- Adaptation and learning; data analytics

Driven by applications in:

- High-tech mechatronic systems
- Industrial process control systems
- Power networks and energy systems
- Automotive / smart mobility systems

Scientific staff (DSC/e related)

Approximately 35% of the CS group is focusing on data driven research. Key involved staff:

**Prof. Paul Van den Hof** (chair)

*Data-driven modelling in dynamic networks, data-analytics, machine learning, system identification, experiment design, industrial process control and optimization, power networks, hydrocarbon reservoir engineering*

**Prof. Siep Weiland**

*System theory, model reduction, spatio-temporal systems in systems and control, tensors, distributed control*

**Dr. Roland Tóth**

*Nonlinear identification, machine learning, linear parameter-varying (LPV) models, Bayesian estimation, data-driven control, high-tech mechatronic systems, process control*

Furthermore 6 PhDs and 2 PDs are working on various Data Science projects.

Success stories

- Basic reference for identification of Linear parameter-varying models (Springer).
- Toolset for tensor decompositions.
- 2 ERC projects granted in 2016.

Project examples

- **APROCS** Automated linear parameter-varying modeling and control synthesis for nonlinear complex systems ERC Starting Research project (2017-2022).
- **Verification and control of physical systems, data-driven and model-based approaches** (DISC/NWO, 2012-2016).
- **INSPEC** Integrating sensor-based process monitoring and advanced process control (TKI-ISPT, 2017-2021).
Main research interest

The chair studies data mining (DM) techniques and knowledge discovery approaches that are at the core of data science. The group is known for its contributions to the areas of predictive analytics, automation of machine learning and networked science, subgroup discovery and exceptional model mining, and similarity computations on complex data. Its research is inspired by theoretical computer science, systems development and real-world applications of (big) data-driven discovery in healthcare, banking, energy, retail, telecom, and education among others.

We develop generic approaches and specialized techniques that cover a wide range of descriptive, predictive and prescriptive analytics and work effectively with text, image, transactional, graph and time-series data in a responsible manner. E.g. we use Deep Learning methods to develop models for high dimensional heterogeneous, unstructured and evolving data and apply this models to areas such as medical imaging, genomics, anomaly detection and sentiment analysis. We further work on methods for analyzing and explaining the model’s decisions and performance and facilitate effective DM with domain expert in the loop.

The group is actively involved in DCS/e, leading the Customer Journey and taking part in Smart Manufacturing and Maintenance research programs and collaborates with Data Engineering, Visualization, Security, HCI, and Process mining research groups.

Scientific staff

Prof. Mykola Pechenizkiy (head of the group)
Predictive analytics, Evolving data streams, Handling concept drift, Complex networks, Responsible data science

Dr. Anne Driemel
High-dimensional computational geometry, Clustering and classification in non-Euclidean spaces, and Information retrieval for time series and trajectories data

Dr. Wouter Duivesteijn
Supervised learning, Subgroup discovery, and Exceptional model mining

Dr. Vlado Menkovski
Machine learning, Deep learning, Representation learning, and Reinforcement learning

Dr. Joaquin Vanschoren
Automation of machine learning, Meta-learning, and Deep learning

Furthermore 9 PhDs and 1 PD are working on various Data Science projects.

Success stories

We have created OpenML: an online collaborative platform for studying machine learning techniques. OpenML is used by almost 2,000 researchers, students, and practitioners world-wide, and contains around 20,000 datasets, 3,000 machine learning workflows, and 1,7 million shared experiments. It has won the Dutch Data Prize, as well as backing from Microsoft Research. It is crucial for the development of automated machine learning that is adopted by companies such as Philips.

Further information at www.OpenML.org

Project examples

• NWO RATE-Analytics (with Tilburg University, Rabobank and Achmea) “Next generation predictive analytics for data-driven banking and insurance”.

• Impulse KYC-Analytics (with Rabobank) “Know your customer predictive analytics” project aims at developing approaches for effective DM on heterogeneous and evolving data sources with expert-in-the-loop.

• STW CAPA (with Advertisment and StudyPortals) “Context-aware predictive analytics” advanced the current state of the art in Web analytics.

• NWO Veni “Detection methods for similarity structures in time-dependent data” develops foundations for advanced time series and trajectories clustering.

• H2020 SODA (ICT-2016-1; Big Data PPP) “Scalable Oblivious Data Analytics” facilitates secure DM; together with Crypto group we develop practical approaches for DM with multi-party computation.
Main research interest  (DSC/e related)

We design, develop and evaluate technologies to support data collection in everyday life through wearable systems, ecological momentary assessment, games in order to support people to learn about themselves, to change behaviors for the purposes of healthy living, prevention or rehabilitation.

We are interested in:

• Tailoring and personalization in technologies supporting behavior change
• Serious Games / Games with a Purpose
• Supporting longitudinal studies involving self-report and activity logging
• Understanding the effects of self-monitoring on individuals and groups

Scientific staff  (DSC/e related)

Approximately half of the group is focusing on data driven research. Key involved staff:

Prof. Panos Markopoulos (head of the group)
End-user development, shape changing interfaces, rehabilitation technology, interaction design and children

Prof. Jean-Bernard Martens
Signal and image processing, statistical modeling, psychophysics, augmented reality, visual interaction with complex data

Prof. Ben Schouten
Playful Interactions, Games with a Purpose

Dr. Sebastian Overeem
Sleep Medicine

Dr. Tilde Bekker
Playful interactions, design based learning, interaction design and children

Dr. Javed Khan
Mobile and ambient intelligence applications & crowd sourcing

Dr. Daniel Tetteroo
End-user development, rehabilitation, tangible user interfaces

Furthermore 3 PhDs are working on various Data Science related projects.

Project examples

• GHOST - FP7 IST-FET Open
  Generic Highly Organic Shape-Changing Interfaces.
• i-PE - NWO
  Intelligent Play Environments project.
• Zishi: a smart garment for posture monitoring and correction. (CSC, Wang Qi).
• STEC Project - NWO
  Culturally-situated dynamics of human behavior.
• Advanced Sleep Monitoring - IMPULS II: Philips, Kempenhaeghe & TU/e.
• ILLMO - Interactive Log Likelihood Modeling software.
  see http://illmoproject.wordpress.com
Main research interest (DSC/e related)

As more and more “everyday life” data are collected through sensors embedded in personal tools, accessories and wearables, it becomes increasingly important to give appropriate meaning to those data, extract the essence and visualize them. In our view, it is important to give those data back to the users and make them accessible for purposes of self-management and bio-feedback.

We explore novel societally relevant applications of smart garments, algorithmically designed garments, parametric design, human-patient simulators, life-style management tools and bio-feedback systems. Our vision is to combine aesthetics and meaningful data, often in physical form.

Success stories

Our work on the smart jacket and Origo (with Philips), contributed to the construction of a world-class research ecosystem in perinatology.

The heart bloom biofeedback system was shown at Dutch Design Week (DDW) and Dubai Design week.

In the Do CHANGE project we develop a health ecosystem for integrated disease management for hypertensive and cardiac patients. see also http://www.do-change.eu/about

Scientific staff (DSC/e related)

Approximately half of the DI group’s activities are focusing on data driven research. Key involved staff:

Prof. Loe Feijs (head of the group)
Realization of intelligent systems

Dr. Peter Peters
DO CHANGE project

Dr. Jun Hu
Social computing and IoT

Dr. Rong-Hao Liang
Sensor systems

Dr. Frank Delbressine
Actuators for feedback

Moreover 6 PhDs are working on various Data Science projects.

Project examples

• DO CHANGE, EU funded H2020 project. The primary goal is to develop a health ecosystem for integrated disease management for hypertensive and cardiac patients, www.do-change.eu/.

Main research interest (DSC/e related)

Interactions with systems, products and services yield enormous amounts of data that can improve the design and help create better products and services in the future. Our focus is on highly interactive systems, engaging people through games and (complex) social interactions to express themselves and enact positive change. Through thorough data collection, analysis and modeling, the impact of real-world interventions can be quantified and made relevant for researchers and design stakeholders.

We explore novel interaction concepts targeting the subconscious, learning and education, serious games and well-being – and use data to apply machine learning in the design of interactive systems. Our vision is to generate new insights, often as design knowledge, that help scale contextual, situated and personalized modes of interaction.

Scientific staff (DSC/e related)

Approximately half of our group activities are focusing on data driven research. Key involved staff:

Prof. Matthias Rauterberg (head of the group)
Designing Interactive Systems

Dr. Jun Hu
Social Computing and IoT

Dr. Emilia Barakova
Social Robotics

Dr. Mathias Funk
Adaptive Data Design in a Systems Context

Dr. Erik van der Spek
Serious Games

Furthermore 8 PhDs are working on Data Science projects.

Success stories

TIMO was designed as a computer game specifically for diagnostic purposes with immersive environments, and multimodal interaction being used as part of the psychological assessment in ADHD diagnosis. This project was a collaboration between University of Genoa and TU/e under Erasmus Mundus Joint Doctorate in Interactive and Cognitive Environment (EMJD-ICE) Program, and Kempenhaeghe, Center for Neurological Learning Disabilities.

Automatic Mental Health Assistant project was part of the MARS-500 experiment carried out at the Institute for Biomedical Problems in Moscow. The European Space Agency and the Russian Academy of Sciences jointly conducted this large scale experiment in order to simulate a manned mission to Mars. We contributed with a diagnostic game based decision tool to measure crew coherence in subconscious states.

Project examples

- **Smart Technologies for Stress Free Air Travel**, sponsored by EC ‘Aeronautics and Space’. Development of a new service for the Inflight-Entertainment-System based on bio-signals (e.g., heart rate) to reduce passengers’ stress on long haul flights.

- With **Learning Analytics** in the context of puzzle games we empirically showed how different players converge towards different winning or losing strategies. This analysis was supported by fully deterministic instrumentation of the game play and the combined application of clustering analysis and process mining.
Main research interest  (DSC/e related)

The group consists of two chairs: Transformative Qualities and Everyday Interactions. The first focuses on how the aesthetic qualities of interactive artefacts in embodied interaction are transformative, i.e. elevate people’s personal and social ethics and influence their behaviour, and how to support designing for these qualities. The second focuses on the role of interaction design in our actual and future everyday practices, as our everyday technological and social lives continue to emerge.

We are developing and applying the (data-enabled design) approach. We offer various prototypes, observe and sense people’s situated behaviour, and explore how to measure transformation through various forms of data. Moreover, we innovate in emerging areas of wearable technologies, digital fabrication and personalization, and the Internet of Things. We use data based co-design processes for ultra personalized products, services, and systems and investigate social practices of families in their homes.

Scientific staff  (DSC/e related)

Approximately 50% the DQI group is focusing on data enabled research. Key involved staff:

- Prof. Caroline Hummels  
  Embodied interaction, transformative practices & DED
- Prof. Ron Wakkary  
  Everyday interactions & material speculation
- Dr. Stephan Wensveen  
  Constructive design research, ultra personalized systems
- Dr. Joep Frens  
  Rich interaction, growing systems & DED
- Dr. Pierre Lévy  
  Kansei design, rituals and vitality
- Dr. Oscar Tomico  
  Wearable technologies, PSS & co-reflection

Furthermore 6 PhDs are working on various Data Science projects.

Success stories

The Data Enabled Design approach is developed in collaboration with Philips Design, and applied to at least eight cases within Philips and presented to companies like Coca Cola, Airbus, Philips Avent and Stokke. Based on this project of our PhDs, Philips Design aims at setting-up a dedicated group around Data-Enabled Design.

For the Prinsjesdag Project, we integrated body-scan technologies, 3D printing, parametric design, and novel textile techniques to design a dress and shoes based on the 3D body scan of Minister Bussemaker.

Project examples

- **Family Health (Data-Enabled Design)**  *Impuls 1 Perinatal Monitoring / Philips Design*  
  Developing a data-enabled design framework and tools to support and discover meaningful experiences in the context of family health.

- **[X]changing perspectives**  *Impuls 1 / Necker van Naem / City of Eindhoven*  
  Developing a product service system that stimulates participatory sensemaking between different stakeholders about public issues.

- **Embodied Smart Textile Services**  *CRISP program Dutch Ministry of Economic Affairs*  
  The integration of design, technologies, and creative industries in product service systems that are healthy, sustainable, and personalized, such as Vigour and Textales.
Main research interest  (DSC/e related)

Along with research on uncertainty and complexity of the development of smart energy systems, our data-relevant interest is two folds. On the one hand, availability of measurement data from various actors including customers, network operators, and energy suppliers opens up possibilities for accurate and reliable energy analytics. We are researching advantages of machine learning, especially deep learning, for energy and price predictions. On the other hand, we aim to enhance real-time system awareness for network operators as well as involved stakeholders using (IoT) data integrity. This would lay a foundation to sustainable energy systems with high levels of automation and security.

Scientific staff  (DSC/e related)

Approximately half of the EES group is focusing on data driven research. Key involved staff:

Prof. Guus Pemen (group chair)
Prof. Sjef Cobben (part-time)
Prof. Han Slootweg (part-time)
Prof. Rene Kamphuis (part-time)
Dr. Madeleine Gibescu
Dr. Phuong Nguyen
Dr. Wilbert de Krom

Furthermore 5 Phds and 2PDs are working on various Data Science projects

Success stories

Supervised energy predictions for smart grids and smart buildings based on deep learning, e.g. advanced Restricted Boltzman Machine based methods, with less than 2% error.

Effectively overcome the ICT intermittent and data lost to retrieve real-time data, interpolate missing figures and predict behavior of solar PV inverters using MQTT protocols and cloud-based programs.

Automatically alter the transformer’s on-load tap changer according to the operation modes and status of various location of solar PV inverters. Successfully deploy and verify cross-platform communication with contemporary industrial distribution automation platform, OPC-UA.

Applying Bayesian for fault location in medium voltage grids with underground cables.

Project examples

- **INCREASE EU-FP7 project**
  Increasing penetration of renewable energy sources in the distribution grid by developing control strategies and using ancillary services.

- **Smart Grids (B2B & B2C) BEMS TKI Switch2SmartGrids**
  Advanced Optimization for comfort level and energy consumption between the smart grid and built environment.

- **DISPATCH & DISPATCH 2 NWO URSSES & URSSES+**
  Distributed intelligence in smart power routing and matching.

- **m2M-GRID ERA-NET Smart Grid Plus**
  From micro to Mega grid — Integration of micro-grids in active distribution network.
Main research interests (DSC/e related)

Psychological research regarding people’s interaction with technology, with a focus on interaction with systems and services using a data centered approach. Focus areas are:

• The role of data and human-data interfaces in human decision making, including:
  • Understanding the relative strengths and weaknesses of human- and machine-based decision making, and how to harmonize human decisions with machine learning
  • Understanding the potential and impact of ‘Quantified Self’ data on human self-awareness and self-improvement, including steps toward behavior change
• Human-centered and value-sensitive design of digital media, ICT and product interfaces including:
  • Evaluate and improve human-data interaction to allow intuitive and effective data usage, and to support and promote positive behavior change (e.g., e-coaching)
  • Explore novel forms of interaction, including virtual and augmented reality interfaces, IoT, etc. to support intuitive exploration and understanding of data and their real-world implications

Scientific staff (DSC/e related)

A substantial part of the HTI group is focusing on data driven research. Key involved staff:

Prof. Chris Snijders
Human vs. machine expertise, internet science, decision-making

Prof. Wijnand IJsselsteijn
E-coaching, Quantified Self, digital tools to enhance psychology research, value-sensitive design, UX design

Dr. Martijn Willemsehn
Cognition, decision making & consumer behavior, process tracing, recommender systems, user-centric evaluation

Prof. Joyce Westerink
Quantified Self, health & wellbeing, psychophysiology

Dr. Uwe Matzat
Online behavior, learning analytics, social media research

Furthermore 7 PhDs and 1 PD are working on various Data Science projects.

Success stories

Every decision that humans make in situations of uncertainty or incomplete information (which is almost always) is subject to a number of natural and unavoidable biases. For example, we humans tend to cherry-pick data that is in line with our preconceived notions, and ignore data that is at variance with such notions.

Insights emerging from big data and machine learning have the potential to provide a new lens on reality that forces us to be more systematic about our decision making processes. However, despite the great promise of data science, new types of biases may be introduced through the nature of the data and algorithms, and machine learning may lack the transparency to be held accountable for its decisions.

We promote a hybrid approach that combines the best of both worlds – humans and machines –, based on a deep understanding of cognitive psychology, artificial intelligence, data science, as well as specific domain knowledge. This is the approach that informs research, applications, and teaching in the HTI group, in collaboration with other groups in DSC/e and JADS.

Project examples

• Philips-TU/e Flagship on Data Science, Data-Driven Value Propositions Systems supporting customers and coaches.
• Philips-TU/e Flagship on Data Science, Continuous Personal Health
  Improving health for hypertensive patients.
• Mine Your Own Body
  Psychological effects of the Quantified Self.
• Cocoon H2020 CHIST-ERA grant
  Emotion psychology Meets IoT cybersecurity.
• Exploring the click-stream
  Understanding user traces in online settings.
• NWO – MVI grant
  Mobile support systems for behavior change.
• NWO – Research Talent grant
  Social recommender systems for energy conservation.
• NWO – PRICE grant.
  Using process tracing to improve household IoT users’ privacy decisions.
• 4TU Center for Humans & Technology
  Smart social systems and spaces for happy and healthy living.
Main research interest (DSC/e related)

Data mining, process mining, machine learning and computational intelligence methods are essential to design information systems for intelligent decision support, so that organizations can fulfill their goals of operational excellence and improved decision making. For this purpose, our group develops methods, techniques and tools for advanced analysis of business processes and optimal data-driven decision making in their execution. The group’s research centers on computational intelligence methods for decision models in which qualitative, linguistic information can be combined with quantitative, numerical information from data. Research involves the following topics:

- data-driven logistics, healthcare analytics, retail operations
- computational intelligence (fuzzy systems, neural nets, evolutionary computation)
- business applications of data mining and machine learning
- data-intensive business process optimization and services development

Scientific staff (DSC/e related)

Approximately half of the IS group is focusing on data driven research. Key involved staff:

Prof. Uzay Kaymak (head of the group)
- Fuzzy modeling, computational intelligence, healthcare analytics

Prof. Paul Grefen
- Business process engineering, business information systems architecture

Dr. Remco Dijkman
- Process optimization, data-driven logistics

Dr. Anna Wilbik
- Linguistic summarization, healthcare analytics, learning systems

Dr. Yingqian Zhang
- Machine learning-based optimization, circular economy, retail operations

Dr. Pieter Van Gorp
- Model-driven architectures, privacy-based health data storage

Furthermore 5 PhDs are working on various Data Science projects.

Success stories

The practical relevance of the context-aware, adaptive decision support systems that we develop are studied in industry cases from e-commerce, logistics and healthcare. For example, the GET Service (Green European Transportation Service) project provided transportation planners with the means to plan transportation routes more efficiently and to respond quickly to unexpected events during transportation. Two startup companies originated from the project.

In another project, machine learning predictive models for decision support have been studied in intensive care units of multiple health centers in different countries.

Project examples

- DaiPeX Dinalog (Dutch Top Institute on Logistics)
  New algorithms and software that can handle time-dependent, stochastic planning problems, based on high-volume information in Cross Chain Control Centers (4C).

- GameBus EIT Digital
  Valorization focused project to stimulate physical, cognitive and social healthy behavior across communities and generations of people.

- Continuous Personal Health Philips, TU/e Flagship.
  Develop data-driven, predictive solutions for the whole care continuum.

- Clinical Pathway Analysis Philips, TU/e, Zhejiang University BrainBridge Program
  Develop tools to analyze and study the performance of clinical pathways and clinical workflows.
Main research interests (DSC/e related)

To develop innovative and improve existing (components of) Design and Decision Support Systems for applications in architecture, building and urban planning. Today sensor data are used as input additional to building/city information models.

We are interested in:

- Energy Neutral Cities
- Urban Management
- Building Information Management

These research areas pertain to users of the systems (planners and designers) as well as users of built environments that are the subject of planning and design decisions. Data is used based on combinations of questionnaires, web services that offer building and geographical data and real world sensors. The data sets are analyzed using state-of-the-art data mining techniques and statistics.

Scientific staff (DSC/e related)

Approximately 30% of the ISBE group is focusing on data driven research. Key involved staff:

**Prof. Bauke de Vries** (head of the group)
- Systems Engineering

**Dr. Jakob Beetz**
- Building Information Modelling

**Dr. Qi Han**
- Sustainable urban (re)development

**Dr. Gamze Dane**
- Spatial Behavioral Analyses

**Dr. Dujuan Yang**
- Energy behavior modelling

**Ir. Aant van der Zee**
- Robotics

Furthermore 11 PhDs are working on various Date Science projects, varying from applied to fundamental.

Success stories

The group contributes to the strategic area Energy, focusing on the formulation of urban energy simulation models. This includes establishing a link between energy and transportation.

Our group is furthermore contributing to the theme - Smart Living Environments by developing personal information and recommendation systems that aim to enhance experiences of users in built environments through new ICT technologies. Data is used to generate district maps that show changes in the built environment over time, visualizations of buildings including abstract data about its performance and environmental conditions.

We are developing models of cities, districts and buildings that allow parties to communicate about these subjects and that provide open standards to give access to these data.

Project examples

- **Triangulum Horizon 2020**
  Demonstrate, disseminate and replicate solutions and frameworks for Europe’s future smart cities. In total, 22 partners from six countries.

- **DESENT ERA-NET COFUND Smart Cities and Communities**
  Integrated decision support system for energy use of buildings and transport, ensuring maximum efficiency with respect to supply and distributed energy generation.
  Main partners: TU/e, Weiz, RSG, SINTEF, 4ER.

- **okstraOWL TU/e & TU Munich**
  A Linked Data representation of the German information model for roads. This enables information sharing between parties in the design, engineering, construction and maintenance stage.
Main research interest (DSC/e related)

The ITEM group’s research, educational and valorization program focuses on means for improving the efficiency and effectiveness of new product and business development processes within high-tech firms, organizations and institutions. It entails all the strategic and operational activities involved in identifying and exploiting new business opportunities, including new product, service, business model, or platform development, as well as their launch and promotion. The multiplicity of research projects conducted by the ITEM group focus on high-tech product-service systems, which demonstrate increasing connectivity, digitization and the related capacity to generate novel data. Volume, velocity, variety and veracity of such data do not immediately translate into value. The ways to discover, exploit and utilize those valuable data while developing new businesses and products represent the unique focus of the ITEM group in DSC/e. The group employs both qualitative and quantitative research designs.

Scientific staff (DSC/e related)

Approximately one third the ITEM group is involved in data driven research. Key involved staff:

Prof. Fred Langerak (head of the group)
Product and business model innovation

Prof. Ed Nijssen
Technology marketing and sales

Dr. Ksenia Podoyintsyna
Data-driven business models and ecosystems

Dr. Shantanu Mullick
Structural modeling and Bayesian inferences

Dr. Isabelle Reymen
Venture design and technology commercialization

Dr. Elke den Ouden
Business development in value networks

Dr. Sarah Gelper
Quantitative marketing research and statistics

Dr. Alex Alblas
Data driven innovation

Dr. Myriam Cloodt
Open innovation and entrepreneurship

Dr. Boukje Huijben
Demand side management, regulatory influences, business model innovation

Dr. Michel van der Borgh
Data-driven sales process engineering and innovation selling

Furthermore 6 PhDs are working on Data Science projects.

Success stories

The ITEM group is involved in several projects, with European, national, industry and university funding, on a range of topics. For these projects, we collaborate with researchers worldwide, with industry partners like ASML, Philips and Océ and institutions like ESA, NSO, KIC InnoEnergy and STW.

The aim of our research projects is to contribute scientifically, but also perform research that is relevant and useful for practice in that it improves the success rate of new product and business development.

Project examples

- TU/e impuls Business Model Innovation in Mobile Apps.
- Philips / ILI Business Model Innovation in Smart Urban Lighting.
- EU FP7 Digitization and the Reconfiguration of Architecture.
- KIC InnoEnergy Disruptive Innovation in Dynamic Eco-Systems.
- ASML Accelerating Innovation and Service through Learning.
- NSO/ESA Synergies in Sustainable Space and Energy.

www.item-eindhoven.nl/
Main research interest

Development of new methodologies and algorithms for the representation and analysis of complex imaging data ('big images') for healthcare applications. We are interested in inverse problems, such as:

- Inference of brain anatomy from diffusion weighted magnetic resonance imaging (tractography, connectivity).
- Extraction and analysis of vascular trees from retinal fundus imaging
- Detection, enhancement, completion, and geometric analysis of elongated structures in 2- and 3-dimensional images
- Myocardial motion, deformation and strain analysis from tagging magnetic resonance imaging

Our methodological approach relies on a broad spectrum of mathematical techniques, such as:

- Finsler geometry
- tensor calculus
- Lie group theory
- calculus of variations
- geometric control theory
- semigroup theory for multiresolution representations
- the theory of ordinary and partial differential equations

We are also interested in methodological tangencies with other scientific disciplines, such as theoretical physics, e.g. mathematical relativity.

Scientific staff

Prof. Luc Florack (head of the group)
- Structural brain connectivity, myocardial deformation

Dr. Andrea Fuster
- Structural brain connectivity, mathematical relativity

Dr. Remco Duits
- Vasculature, structural brain connectivity

Furthermore 4 PhDs and 1 PD are working on various Data Science projects.

Success stories

The group has conducted several feasibility studies establishing proof of concept for clinical applications, such as:

- Myocardial motion, deformation, and strain can be obtained for myocardial function analysis from tagging magnetic resonance imaging.
- The optic radiation can be delineated including the Meyer’s tip for temporal lobe resection therapy planning and risk analysis from diffusion weighted magnetic resonance imaging.
- Isotropic and anisotropic resolution of images can be ameliorated for global deblurring or enhancement of elongated structures.
- Retinal vascular trees can be robustly extracted and analyzed from retinal fundus images.

Project examples

- Lie Group Analysis for Medical Image Processing ERC StG, Remco Duits.
- Riemann-Finsler Geometry for Human Brain Connectomics NWO, Luc Florack & Andrea Fuster.
- Differential Geometry in Complex Medical Imaging & Relativity Theory FOM, Andrea Fuster.
Main research interest  (DSC/e related)

The Medical Image Analysis group (IMAG/e) at TU/e concentrates on automatic analysis methods of medical images to support clinicians in diagnosis, prognosis and treatment. The focus is both on methodological development and clinical application. Methods are generally based on features or biomarkers derived from large sets of medical data or on models verified on extensive clinical datasets. With the rapidly increasing amount of medical data used in practice, the trend is towards learning-based techniques to improve the accuracy and robustness of classification, segmentation and detection tasks as well as towards finding novel biomarkers of disease from the wealth of data available.

Scientific staff (DSC/e related)

Approximately 80% of the MIA group is focusing on data driven research. Key involved staff:

Prof. Josien Pluim (head of the group)  
Medical image analysis

Prof. Bart ter Haar Romenij  
Biomedical image analysis

Prof. Marcel Breeuwer  
Algorithms in clinical image analysis software

Dr. Mitko Veta  
Deep learning / digital pathology

Dr. Veronika Cheplygina  
Machine learning / crowdsourcing

Furthermore 10 PhDs and PDs are working on projects related to Data Science.

Success stories

In pathology, digitization of stained tissue slides is becoming commonplace. This allows enlisting image analysis to support the pathologist with additional information and to relieve him/her of tedious tasks. Visual analysis of slides is a time-consuming and subjective process, with large variability between observers. Image analysis has the potential to substantially improve the process.

We have developed techniques to automatically determine the characteristic features of cancer tissues that are used to grade cases and to subsequently select treatment. We have shown that the automatically estimated features have prognostic value similar to human-defined features. Recent results include deep learning approaches to feature estimation and automatic prognosis that show a performance approaching that of pathologists.

We are currently discussing with industrial partners how to incorporate these techniques in the clinical workflow of the pathologist.

Project examples

- **DLMedIA** is a consortium in which the TU/e collaborates with Radboud UMC, UMC Utrecht, Erasmus MC, UvA as well as clinicians and seven companies. Goal is to advance the clinical application of medical image analysis techniques based on deep learning.

- **RetinaCheck** is a Sino-Dutch research and screening program for early detection of diabetic retinopathy through automatic image analysis of retinal fundus images. Aim is to screen a large population in China, where diabetes has become epidemic. The analysis is based on brain-inspired geometric methods, and new deep learning techniques.
Main research interest (DSC/e related)

Freight Transport & Logistics involves the process of transporting commodities and goods and cargo. ICT infrastructure is an enabler for planning and scheduling via providing the right information resources at the right time and place.

Nowadays, larger quantities along with more detailed and faster data and information are available. This allows for better planning and scheduling. But this is also a challenge as many planning and scheduling tools are not able to handle this amount and quality of information. This is exactly the focus of this stream of research.

Research involves:
- Urban logistics (or first/last mile logistics)
- Transport network design
- Omnichannel logistics
- Public transportation
- On-demand transportation (e.g. Uber for people and freight)
- Retail operations

Scientific staff (DSC/e related)

Approximately half of the OPAC group is focusing on data driven research. Key involved staff:

**Prof. Tom Van Woensel**  
Freight transport, city logistics, e-commerce, omnichannel logistics, retail operations

**Dr. Luuk Veeleuturf**  
Public transport and freight transport

**Dr. Nico Dellaert**  
City logistics, long-haul transport and healthcare logistics

**Dr. Nevin Mutlu**  
Revenue management

Furthermore 5 PhDs are working on various Data Science related projects.

Success stories

City Logistics serious game

Data-driven logistics MSc projects with DHL, Deliveroo, Royal FloraHolland, Trunkrs, Nabuurs, etc. leading to important insights and deliverables based on a data-driven approach to understand problems and to support improved decision making.

Project examples

- **DATAS NWO Vitale Logistiek**  
Multi-channel and multi-company decision support systems involves connectivity, allowing data to be exchanged, shared and connected.

- **CONCOORD JPI Urban Europe**  
Integrated logistics system for CONsolidation and COORDination of urban distribution flows.
Main research interest (DSC/e related)

OPAC research on maintenance and manufacturing revolves around improvement and integration of manufacturing and maintenance planning, thus facilitating the optimization of a factory as a whole, instead of sub-optimizing business units and processes separately. Integrated planning will lead to higher and more flexible production capacity and more efficient maintenance. The focus is on high-tech industry. Data driven research is centered around the following challenges:

- Development of data-collection and data-aggregation techniques for production and maintenance models
- Implementation of advanced prediction and estimation techniques (e.g. failures, wear out, demand)
- Creation of data-driven integrated prediction and optimization models

Our mission is to produce high quality research results that lead to the development of a data-driven decision-making framework at operational and tactical level to support integrated production planning and predictive maintenance, and to publish these research findings in high impact refereed journals.

Scientific staff (DSC/e related)

Approximately half of the OPAC group is focusing on data driven research. Key involved staff:

Prof. Geert-Jan van Houtum (head of the group), Maintenance and reliability
Prof. Ivo Adan
Manufacturing networks
Dr. Alp Akcay
Integrated predictions and optimization
Dr. Joachim Arts
Predictive maintenance and optimization
Dr. Rob Basten
Predictive maintenance and spare parts supply
Dr. Simme Douwe Flapper
Manufacturing networks and re-manufacturing
Dr. Tugce Martagan
Bio-manufacturing
Dr. Henney van Ooijen,
Manufacturing networks

Furthermore 12 PhDs and 4 PDs are working on various Data Science projects.

Success stories

Introduction of data mining tool at NXP semi-conductor assembly plant to steer daily maintenance operations resulted in an increase in overall equipment efficiency of several percent, which equals an increased output of millions of products per day.

Implemented operational planning support tool at ASML to visualize and align the actual spare parts stocks with the planned stocks at the tactical planning level. Resulted in better service, lower inventory holding costs, and a more efficient planning process.

Project examples

- Dynamerge NWO, with e.g. Philips, Brandweer Amsterdam, CWI
  Emergency service logistics, dynamic planning at operational level, network design.
- MANTIS EU project, 60 partners
  Predictive maintenance, maintenance service platform architecture.
- Philips Data Science Flagship Philips & TU/e
  Predictive maintenance for healthcare systems.
- Productive 4.0 117 partners: Data-driven manufacturing.
- ProSeLo Next TKI Dinalog, with e.g. Marel, Océ, ASML, Vanderlande
  Predictive maintenance, control towers, new business models.
- Poultry Processing Marel Stork:
  Layout design, integrated production planning and scheduling.
- OPTBIOMAN EU Horizon2020 project:
  Optimal decision making in bio manufacturing.
- Campione field lab Smart Industry, 60 partners:
  Integrated planning in digital manufacturing.

http://opac.ieis.tue.nl/
Main research interest  (DSC/e related)

The Internet of Things and low-energy sensors enable full transparency of supply chains: we know of each item its location and condition real-time, resulting in an immense amount of real-time data. Ever-increasing computing power enables us to exploit this data to improve responsiveness, efficiency and sustainability of future supply chains. New encryption technologies and anonymous hosting ensure data privacy. This opens possibilities for unprecedented close collaboration between companies in B2B supply chains and between companies and consumers in B2C supply chains. Optimization of supply chains starts with detailed knowledge of market characteristics and demand signals. Efficient and effective response to demand signals requires transparency of product availability over time. Based on this transparency supply chain management can be linked to both the customer journey (all events / touchpoints related to a customer order) and the product/service journey (all events narrowing down the decision space available to match the supply chain content with future sales). Given the events constituting the customer and product journeys, the supply chain and its markets are permanently in a transient state. This requires fundamentally new methods for determining optimal decisions. Data-driven methods are the foundation for optimization.

Scientific staff  (DSC/e related)

Approximately half of the OPAC group is focusing on data driven research. Key involved staff:

Prof. Ton de Kok  
Data-driven supply chain optimization and management

Dr. Zumbul Atan  
Data-driven supply chain optimization and management

Dr. Karel van Donselaar  
Data-driven optimization of retail operations

Dr. Willem van Jaarsveld  
Data-driven planning and control of supply chains

Dr. Alp Akcay  
Data-driven Optimization of Operations

Dr. Nevin Mutlu  
Data-driven revenue management

Dr. Sarah Gelper  (ITEM group)  
Quantitative marketing research and statistics

Furthermore 6 PhDs and 1 PD are working on various Data Science projects.

Success stories

Between 2000 and 2010 research on SCM has generated close to 1 billion € additional profit to companies involved in research projects. This number is based on publications in journals and newspapers.

Big Data “avant-la-lettre” has been the basis of these projects. Collaboration with industry has continued and expanded.

Examples of SCM projects are;

- Support in the design and implementation of master planning at ASML.
- Design and implementation of collaborative planning in the semiconductor industry.
- Application of system dynamics to predict cyclical sales patterns in process industry demand.

Project examples

- Complexity in High-Tech Supply Chains NWO, with ASML, Philips, Hilti, VDL, Océ  
  Decentralized control of high-tech supply chains.
- European Supply Chain Forum with 25 multinational companies, e.g. Nike, DHL, Heineken, Bayer, Shell.  
  Platform for knowledge exchange on supply chain management and supply chain innovation.
Main research interest (DSC/e related)

Data science aspires to change society by creating value. With this aspiration comes the need to reflect on how data-based technologies and services can be designed and implemented responsibly. The P&E group has deep expertise in ethics and the philosophy of science, and applies this expertise to understand technological developments from a societal and humanistic perspective. Our research in the area of data science focuses on responsible innovation, an approach that aims to “identify the ethical and societal aspects of technological innovations at an early stage so that these can be taken into account in the design process” (NWO). We work closely with other departments on projects where philosophical insight can help data science realize value more responsibly. Some key concepts that we work with are:

- Autonomy and privacy (data sharing, quantified self, ubiquitous sensors)
- Responsibility (networked decision-making, social robotics)
- Sustainability (smart meters, mobility, logistics)
- Trust and trustworthiness (data sharing, personal data analytics, electronic coaching)

The group has extensive experience with multidisciplinary responsible innovation projects.

Scientific staff (DSC/e related)

Approximately 30% of the P&E group is focusing on data driven research. Key involved staff:

Prof. Anthonie Meijers
Epistemology and ontology of engineering, ethics of technology (specifically behavior change technologies), speech act theory, theory of collective action

Dr. Philip Nickel
Trust and trustworthiness, electronic coaching, biomedical ethics

Dr. Elizabeth O’Neill
Moral epistemology, moral psychology, applied ethics, data science ethics, moral enhancement, and ethical AI

Dr. Lambèr Royakkers
Ethics, law and technology (especially in the domain of robotics) Furthermore 3 PhDs are working on Data Science projects

Furthermore 3 PhDs are working on Data Science projects.

Success stories

We’ve created a new conceptual framework for moral responsibility which makes it possible, by thinking ahead, to solve the ‘problem of many hands’. It can assist those who are concerned with practical issues of responsibility distribution in institutions, especially networked systems.

Together with the Rathenau Institute, we’ve provided consultancy on the future of the traffic system in the Netherlands. The report explores the potential of smart mobility, including ICT and persuasive technologies to influence the driver’s behavior in order to improve safety and sustainability, and minimize congestion.

The book Just Ordinary Robots identifies social and normative questions about robotics to be addressed in the short and long term, and highlights key points to be discussed in the public sphere by politicians and policy makers.

Project examples

- **Quantified self and self-tracking**: Project identifies ethical concerns raised by surveillance, quantification, and enhancement dimensions of self-tracking technologies. Issues include privacy, profiling, and preventing threats to free citizens’ right to an “open future”.

- **Value trade-offs of interoperable big data in medical contexts**: Project develops a framework for analyzing value trade-offs associated with rendering cloud-based big data sets interoperable for the sake of health. The framework will provide input for interoperable information system design and specification.

- **Mobile support systems for behavior change**: Philips, NWO-MVI Grant
Multidisciplinary project identifies social and technological innovations that increase intrinsic motivation and trust in the use of personalized, data-enabled coaching technologies, and rethinks the practice of informed consent in mobile health.
Main research interest

The Probability Group (Van der Hofstad) investigates complex network data and random graph models for them, as well as network functionality. A key problem is to entangle the relationship between the topology of the network involved and the behavior of processes on them. Particular research themes are the dynamics on and of networks, with the aim to predict their evolution on the basis of data. We apply our methodology to various real-world networks, such as citation and social networks, and the brain.

We collaborate with the Stochastic Operations Research group (Van Leeuwaarden) on analyzing the community structure of complex networks, and with the Statistics Group (Castro) on community detection.

Success stories

In collaboration with Prof. Bert Meijer and his team, we use super-resolution microscopy data to find that exchange patterns of one-dimensional aggregates are rather different than expected.


Jointly with Ludo Waltman at CWTS Leiden, PhD student Alessandro Garavaglia uses Web of Science data to analyze citation patterns in networks of scientific papers, so as to quantify the citation evolution of papers in various disciplines, so as to predict success early on.

Scientific staff

Prof. Remco van der Hofstad (head of the group)
Complex networks and models for them, random graphs, network functionality, probability models for complex data

Prof. Nelly Litvak
Algorithms for complex networks, random graphs

Dr. Tim Hulshof
Statistical physics, random walks

Dr. Júlia Komjáthy
Complex networks, random graphs, random walks

Dr. Francesca R. Nardi
Dynamics on networks, metastability, statistical physics

Furthermore 4 PhDs and 2 PDs are working on various Data Science projects.

Project examples

- VICI program ‘Random networks: universality in structure and function’
Discovering the universal aspects of complex network evolution and functionality.

- NETWORKS Gravitation program
Bringing together stochastics and algorithmics to model, understand, control and optimize large-scale networks, with applications to traffic, communication, healthcare, service engineering and energy networks.

- VENI program ‘Explosive propagation and community formation on networks’
How does information spread in highly heterogeneous networks containing highly connected nodes?
Research interests (DSC/e related)

Urban Planning and Real Estate Management are two research groups within the unit Urban Systems and Real Estate. We use big data and real world data to understand where people want to live, work and spend their free time. We turn these insights into solutions for smart cities and buildings.

Our team is multidisciplinary and includes: engineers, urbanists, transportation experts, psychologists and economists. We work with applied models and statistical techniques.

Our research areas include:
- Housing research and modelling
- Urban and real estate management
- Smart mobility
- Livable and healthy cities
- Smart working environments

Scientific staff (DSC/e related)

Approximately 80% of our groups focuses on data driven research. Key involved staff:

Prof. Theo Arentze (head Real Estate Management)
Real estate and behavior research

Prof. Harry Timmermans (head Urban Planning)
Urban planning and transportation

Dr. Rianne Appel
Smart working environments

Dr. Pauline van den Berg
Livable and healthy cities

Dr. Tao Feng
Big data & smart mobility

Dr. Ioulia Ossokina
Economics of cities and real estate

Dr. Soora Rasouli
Complex systems

Furthermore some 30 PhDs are working on various data-related projects.

Success stories

Transportation model Albatross was developed for the Ministry of Transportation. Using micro-simulation, the model predicts the trips people make in the context of their daily activities. It can be used for transport policy analysis.

A model of the land market in shopping centers predicts location of vacancy and most favorable spots for trans-formation. It is used by the Ministry of Economics to stimulate transformations of vacant retail properties into other use.

An app offers information on cultural objects in one’s surroundings and advises smart cultural routes to tourists. The route planner accounts for the individual interests, the available time and transport modes.

Project examples

- **Happy senior living** In cooperation with architects from Delft and financed by 4TU. We use big data to study housing preferences of senior citizens and design two or three best 65+ living concepts.

- **Smart working environments** In cooperation with (and partly financed by) a consortium of real estate companies. We study what building concepts optimally stimulate knowledge exchange between individuals at work.

- **Scripts** In cooperation with a consortium of several companies, we develop models for Mobility as a Service solutions, using big data.

- **Transportation** Several projects are based on multi-million trip records using smart cards, taxi GPS data and phone data.
Main research interest

The mission of the Security group (SEC) is to realize a more secure and privacy-preserving digital infrastructure. Our research spans two areas vital to the security of distributed systems, namely policy compliance in decentralized systems and security of networked embedded systems. We are interested in:

- Network monitoring and intrusion detection
- PUFs and privacy-preserving biometrics
- Whitebox Crypto and software security
- Access control and a-posteriori policy compliance
- Formal methods for security

Success stories

The group has a strong valorization record: it cooperates closely with several successful companies and start-ups (Philips, NXP, Thales, SecurityMatters, Intrinsic-ID, …), and it regularly produces patents. For example, the spin-off SecurityMatters (www.secmatters.com) was founded by the head of the group and is now bringing to the intercontinental market network cutting-edge monitoring systems based on research on intrusion detection.

SEC also develops software that finds its way in industrial applications, for instance SAFAX, is a novel architectural framework that offers authorization as a service and has been adopted and integrated in Thales key management service for secure distributed data spaces.

Scientific staff

Prof. Sandro Etalle (head of the group)
Network monitoring, critical infrastructure protection

Prof. dr. Milan Petkovic
Secure data management

Prof dr. Wil Michiels
Software security, whitebox crypto

Dr. Nicola Zannone
Privacy protection, access control

Dr. Boris Skoric
Physical unclonable functions, information-theoretic security

Dr. Jerry den Hartog
Network monitoring, trustworthy collaborative systems

Dr. Luca Allodi
Risk quantification

Furthermore 9 PhDs and 1 PD are working on various Data Science projects

Project examples

- **CITADEL (EU H2020)** aims to create resilient systems that maintain safety and security in dynamic environments. Partners include ATB, Ikerlan, TTech, SYSGO, Kaspersky Lab, TU/e, etc.

- **SpySpot (NWO)** concentrates on the detection of advanced attacks using a combination of visualization and anomaly detection techniques. Partners include SecurityMatters, SynerScope, TNO, and Dutch Ministry of the Interior.

- **iDentification for the Internet of Things (Chist-era, NWO)** This project will develop identification and authentication techniques for high-volume low-power devices in the Internet of Things. Partners: TU/e, INRIA, University of Geneva.
Main research interests

Investigating fundamental aspects of data science from the perspectives of Probabilistic Modeling and Information Theory. Applications to streaming data processes such as medical and multimedia signal processing systems, and communications systems. Specific research interests include:

- **Universal data compression** technology for data modeling. Models can be widely applied to solve problems such as anomaly detection, classification and forecasting. Our research builds on the Context-Tree Weighting algorithm, which is a best-in-class modeling algorithm that was invented in SPS.

- **Bayesian machine learning** technology to support data-driven design and personalization of wearable computing systems (http://biaslab.org).

- **Advanced Communication Techniques** e.g. for wireless transmission in automotive settings. Intelligent Lighting systems that have, besides illumination, other functionalities (e.g. communication, sensing, positioning). Authentication and Identification Techniques based on biometric modalities but also on hardware intrinsic properties (PUFs). Sensing, Mapping and Localization for highly automated driving. Medical Information Processing (patient data, signals, images, video).

The group is a key player in the broad Eindhoven innovation eco-system, with strong links to key companies and hospitals. As such the group is also a major prosumer of massive data sets and streams in the above application areas.

Scientific staff (DSC/e related)

The entire SPS group focuses on streaming data (=signal) processing research. Key involved staff:

- **Prof. Jan Bergmans** (head of the group)  
  Signal processing, data transmission and storage

- **Dr. Gijs Dubbelman**  
  Computer vision, pattern recognition, robotics, sensor fusion

- **Dr. Tjalling Tjalkens**  
  Information theory, data compression, machine learning

- **Prof. Bert de Vries**  
  Bayesian machine learning, reinforcement learning, wearable computing

- **Prof. Frans Willems**  
  Information theory, data compression, communication theory

- **Prof. Peter de With**  
  Information and communication systems, video systems and video-architectures

Furthermore 10 PhDs and 6 PDs are working on various Data Science related projects.

Success stories

Our Context-Tree Weighting (CTW) algorithm is a universal data compression algorithm for the class of tree sources that combines an excellent performance with a straightforward analysis. In an information-theoretical sense it is optimal. It received the IEEE Information Theory Society Best Paper Award.

Bayesian optimization for audiogram elicitation in minimal number of trials.

The SPS staff includes 5 IEEE Fellows and 10 part-time full professors with joint appointments in industry or clinical institutes. Six staff members are advisors in industry.

The SPS group has spun out 9 startup companies: Medecs, CED, ViNotion, Iphion, Livassured, Medsim, Nemo, Hipermotion, 3Sense Innovations.

Project examples


- **PATRIOT Eurostars project**. PUFs Anchors of Trust in Resource Constrained Environments.

- **i-CAVE** STW Perspectief Integrated Cooperative Automated Vehicles.
Main research interest (DSC/e related)

Software evolves and continuously grows in:
• size in terms of lines of code, methods, classes, modules
• complexity
• provided features
• costs to develop, and
• languages used

Analysis of data originating from software models, systems and ecosystems and translation of the insights obtained into industrial applications. In particular, we are interested in:
• how developers create and maintain systems and their models
• how developers communicate and collaborate
• and what hinders or facilitates those processes

Answering those questions requires application of data science techniques to software engineering data. We build publicly available tools and provide data supporting further research!

Success stories

The group closely collaborates with major high-tech companies and research institutions worldwide. An example of such a successful collaboration was the CRYSTAL projects with 72 partners from all over Europe. We have discovered that bottle-necks in the bug resolution process were related to organizational issues rather than engineering challenges.

In collaboration with University of California, Davis, USA, we have analyzed 23,000 open source projects, studied various kinds of diversity and established that gender diversity is a positive predictor for productivity. This suggests that added investments in professional training efforts and outreach for female programmers is likely to result in added overall value.

Scientific staff (DSC/e related)

Approximately 50% of the SET group is focusing on data driven research. Key involved staff:

Prof. Mark van den Brand (head of the group)
Model-driven software engineering

Dr. Alexander Serebrenik
Socio-technical analysis of software ecosystems, software evolution

Dr. Tom Verhoeff
Model-driven software engineering

Prof. Jurgen Vinju
Automatic software analysis

Dr. Ramon Schiffelers
Software for high-tech systems

Furthermore 4 PhDs and 1 PD are working on various applications of data science techniques to software engineering artifacts.

Project examples

• MLSAVE-A (NWO)
Data-science research of social aspects of collaboration in online software development communities.

• MMP (EU FP7)
As part of the study of smart design of nano-enabled products, data science techniques have been applied to study large collection of meta-models.

• CPS (Company-funded)
Using data science techniques we study evolution of meta-models in a large industrial ecosystem.
Main research interests

The Statistics group develops and compares data-analytical methods for analyzing and sampling complex structured correlated data sets. It includes parameter estimation, model fitting, latent variable models, mixed models, missing data, statistical process control, survival & reliability theory, time series analysis, and statistical learning methods.

One of the central themes is the analysis of high-dimensional temporal data sets and other large data sets. The group actively explores new research lines in Data Science and maintains many strong ties with industry, including biopharmaceutical companies, chemical industry, medical centers and international research institutes.

Scientific staff

Prof. Edwin van den Heuvel (head of the group)
Non-linear, Generalized, Linear Mixed Models, Measurement Reliability, Missing Data Analysis

Dr. Alessandro Di Bucchianico
Statistical Process Control, Reliability Theory, Maintenance

Dr. Rui Castro
Adaptive sensing and sequential experimentation, High-dimensional statistics, Sparse data models

Dr. Nazanin Nooraei
Longitudinal Categorical Data Analysis, Latent Variable Models, Joint Modeling

Dr. Paolo Serra
Bayesian Statistics, Time Series Analysis, Recursive Estimation

Furthermore 6 PhDs and 2 PDs are working on various Data Science projects.

Success stories

Framingham Heart Study A long-term longitudinal data set on more than 5000 participants (started at 1948) has been brought to the TU/e to collaborate with Boston University on new statistical methods.

Strong collaboration with the Academic partners of Maelstrom Research a leading international institute on harmonization of data from multiple cohort studies.

Industrial collaboration with pharmaceutical industry on validation and implementation of rapid microbiological methods to test medicinal products and processes.

Continuous Personal Health as part of the Philips flagship Data Science, is currently developing new methods for monitoring heart characteristics and sleep.

We are leading a Big Data & Reliability Platform together with industrial partners.

Project examples

OFF/ON is a Dutch PTA-COAST3 project on novel on-line analysis methods for factories of the future.

An EU ITEA3 project on health monitoring through wearable devices.

An EU Artemis project on new simulation tools for LED design.

A Dutch TKI project on maintenance of offshore wind turbines.

Software

A software reliability tool developed together with the Refis company.

Main research interest

The Stochastic Operations Research group (Borst, Boxma) and the Stochastic Networks and Applied Probability group (Van Leeuwaarden) focus on complex systems that operate under randomness and uncertainty, and develop mathematical models and techniques for the analysis and optimization of such systems.

The results provide key insight in the design of resource management strategies and data-driven learning schemes to improve the performance of vital societal networks (internet, wireless networks, dimensioning of large-scale service systems, energy, smart road traffic, healthcare).

We are interested in exploiting the increasing availability of high-volume high-quality data to make better strategic, tactical and operational decisions.

Success stories

MSc student Paul Krijger (Spyker Prize 2013 of Kivi) used TomTom floating car data to predict traffic light green-red cycles, with the ultimate goal to improve routing recommendations to drivers.

850 traffic light intersections in Portland (Oregon).

Scientific staff

Prof. Onno Boxma
Queueing theory, insurance risk, performance modelling

Prof. Sem Borst
Performance analysis/optimization of computer- and communication networks

Dr. Marko Boon
Performance of road traffic

Dr. Stella Kapodistria
Energy networks, smart maintenance

Prof. Johan van Leeuwaarden
Large-scale stochastic networks, applied probability

Dr. Jacques Resing
Insurance risk, smart maintenance

Dr. Maria Vlasiou
Layered networks, healthcare management

Prof. Bert Zwart
Revenue management, energy networks, queueing theory

Furthermore 5 PhDs are working on Data Science related projects.

Project examples

• DYNAFLOAT Topsector Logistics
  Optimization of road traffic.

• HSM (Healthcare Smart Maintenance)
  Datascience Flagship with Philips
  Optimizing maintenance of medical equipment.

• NETWORKS Zwaartekracht program
  Bringing together stochastics and algorithmics to model, understand, control and optimize large-scale networks; applications to traffic, communication, healthcare, service engineering and energy networks.

• Services and flows in hospitals project with
  Mandelbaum (using real hospital data from SEE Lab, Technion).
  Real-time locating systems track the flow of both patients and providers in hospitals. Mathematical models describing these flows can detect bottlenecks, and assess the impact of routing and scheduling decisions to improve hospital design.
Main research interest

We are interested in networked embedded system, with time and resource constraints, with focus on:

- *the Internet of Things*, where we address resource and life cycle management, and the embedded analysis of large data streams
- *real-time systems*, scheduling and resource management to make networked platforms predictable, as well as aspects of predictability in composition during system development and deployment

Our research concerns analysis, modeling, design methods, and prototyping, and often is in collaboration with industry, inspired by practical problems.

Our results are often associated with application domains, which are intelligent lighting, automotive, as well as industrial, software-intensive systems in healthcare and manufacturing.

Scientific staff

**Prof. Johan Lukkien** (head of the group)
- Embedded real-time systems, IoT: architectures protocols

**Dr. Reinder Bril**
- Real-time systems, resource management

**Dr. Tanir Ozcelebi**
- IoT: embedded networking, management and protocols

**Dr. Pieter Cuijpers**
- Modeling and performance analysis of embedded systems

**Dr. Rudolf Mak**
- Distributed systems

**Dr. Mike Holenderski**
- IoT: embedded analytics, predictive maintenance

**Dr. Dmitri Jarnikov**
- Media distribution, media analytics

**Prof. Kees van Berkel** (part-time full professor)
- Low power, high performance computing and architectures

Furthermore, around 10 PhDs and 2 PDs contribute to various projects in this domain.

Success stories

SAN research has practical relevance, as shown by many research projects with industry. A recent example is the OpenAIS EU project in which a new architecture is defined for IP-based lighting. The project attracts increasing attention and is the basis for standardization.

Another example is the Mantis project (with the department of IE&IS and Philips) in which we improve the maintenance of manufacturing equipment by interpreting large sensor data sets.

At any time, more than five large projects are running. We closely collaborate with the security group (SEC), and the Software Engineering group (SET).

Project examples

- **OpenAIS Horizon2020**
  - Goal: create an open architecture and prototype for IP-based lighting.

- **Enables-53 succeeding Crystal ECEL**
  - Goal: improve the engineering of large industrial software intensive systems, with focus on specifying timing and other properties at interfaces and managing those.

- **Lighting Flagship Philips & TU/e**
  - Goal: propose life cycle management within IoT, with connections to the OpenAIS project.

- **rCPS NWO/STW**
  - Goal: determine response times in switched real-time ethernet.

Project presentation at EIT Digital, a collaboration with Philips and ST Microelectronics on intelligent street lighting.
Main research interest (DSC/e related)

The Chair of Urbanism and Urban Architecture (UUA) is embedded within the research-program Living Cities of the Unit Architectural Urban Design and Engineering (AUDE) within the Faculty of the Built Environment. The research directions of UUA focus on sustainable transformation through the formulation, implementation, and evaluation of urban planning and design concepts, strategies and tools. UUA for instance monitors patterns of use and motives, mapping and analyzing main characteristics of the urban environment, and modeling statistical correlations between these datasets on behavior and physical living environment. The research areas include: Sustainability and Smart Cities, Active Mobility and Health, Cultural Heritage and Reuse. Within this framework the Chair collaborates with regional, national, and international researchers on fundamental and applied research. The research approach is interdisciplinary, bridging from the spatial sciences towards the social and technological sciences. Defining the city as a socio-spatial system undergoing evolutionary change.

The applied research within the UUA is carried out through the Urban Lab, where assignments from external parties are carried out by the Urban Lab researchers and students. The Lab aims at:

- sharing public knowledge
- facilitating (co) creative processes
- cultivating research in context
- developing research through design
- stimulating and giving input to a reflective practice

Scientific staff (DSC/e related)

Approximately 20 % of the UUA group is focusing on data driven research. Key involved staff:

Prof. Pieter van Wesemael (head of the group)
- Sustainable development, active mobility, health, co-creation, urban design and planning

Dr. Sukanya Krishnamurthy
- Sustainable development, participatory practices, comparative urban research

Ir. Marcel Musch
- Sustainable development, cultural heritage, health, urban design and planning

Furthermore 3 PhDs are working on various Data Science projects.

Success stories

NWO Smart Urban Region Future (SURF) 2016-2020. Cycling booms in many Dutch cities. Smart cycling innovations promise to increase cycling’s modal share in the (peri-) urban transport system even further, but little is understood of their impact or cost and benefit. The Smart Cycling Futures (SCF) program investigates how innovative smart city technology impacts cycling through for instance the emergence of e-bikes, sensing and big data, mobile devices and nudging or social media and commons.

How these innovation affects aspects of governance, business models, urban design strategies and cycling behavior, and ultimately contributes to more resilient and livable Dutch urban regions.

Project examples

- **Smart Cycling Futures** (2016-2020), NWO SURF *Smartness, Society, Stories.*
- **Platform Gezond Ontwerp** TU/e, RIVM, ministry I&M, NISB, GGD.
- **Living Lab Genneper Park.**
- **Living Lab Bicycle Highway Oss.**
- **From inactive to active transport** TU/e, VU, RIVM.
Main research interest

Data visualization aims to provide insight in large and complex data sets using interactive computer graphics. We develop new methods, techniques, and systems that exploit the unique capabilities of the human visual system, and enable people to interactively explore data. We specifically focus on

- **Information visualization**: concerning data such as tables, hierarchical data, network data, event data, and combinations of these

- **Visual analytics**: the use of combinations of automated methods (from data mining, machine learning, statistics) and visualization, to deal with even larger data sets

We take inspiration from and seek challenges in a variety of different application areas, such as health care, software engineering, sports, security, finance, and forensics; and ultimately aim at finding new approaches that are effective for many of these.

Success stories

Our early work on visualization of large hierarchical data sets led to SequoiaView, a tool for visualizing hard-disks, which was downloaded more than 1M times. Generalization of this approach to business data led to the start-up MagnaView BV, which now for instance provides many high schools in the Netherlands with clear views on their data.

We have done much research on the visualization of network data. The award winning Hierarchical Edge Bundling technique led to the start-up SynerScope BV, which currently provides high end visual analytics technology to a variety of customers in finance and insurance. One highlight was the visualization of telecom traffic in Ivory Coast, where SynerScope and TU/e showed how variations in traffic could be linked to incidents and events in that country.

Scientific staff

**Prof. Jack van Wijk** *(head of the group)*
- Information visualization, visual analytics

**Dr. Andrei Jalba**
- Simulation, geometry, GPU-computing

**Dr. Michel Westenberg**
- Visual analytics, health care

**Dr. Huub van de Wetering**
- Information visualization, sports visualization

Furthermore 6 PhDs and 1 PD are working on various Data Science projects.

Project examples

- **Sort It Out STW.** How to make sense of huge image collections, especially for forensic purposes? We study this in cooperation with UvA and various prospective users.

- **SpySpot NWO/STW** We aim to detect sophisticated computer network attacks by developing new visual analytics methods, in cooperation with our colleagues from the Security group and various institutes and companies.

- **Philips health care** Philips – TU/e flagship
  In close cooperation with Philips we study how workflows in health care, especially for radiology and digital pathology, can be visualized and improved.
Main research interest

In the early 1990’s the world of “information” shifted from so-called administrative data to textual and later multi-media data. For roughly a decade the new information world became a Web of documents. The Web Engineering group was one of the pioneering groups studying how to do automatic personalization (aka adaptation) on websites in many different application areas. In the most recent decade (and even before that) the research interest is shifting from a Web of text (and other media) to a Web of semantic data, in which bits of data are linked together, using RDF as its main language, and URIs (and URLs) for identifying and locating these data. This has led to huge distributed (and unreliably linked) data stores for which the issue of querying and retrieval becomes a serious challenge. The Web Engineering group has achieved fundamental groundbreaking results in the design and development of the technology for handling (indexing, searching, retrieving) this huge amount of graph-structured data.

Success stories

Already in 1993 the first open on-line course (on the topic of hypermedia) was launched and delivered through the then still new Web. In 1996 this open course was made adaptive, or personalized based on the learner’s browsing behavior. Where a successful MOOC today would hope to reach around 0.0001% of the Internet population the open on-line hypermedia course easily reached 0.001% (i.e. 10 times more).

The work on our generic adaptation platform, initially called AHA! and later GALE lead to a number of world’s firsts: an adaptive research paper, an adaptive conference presentation, even an adaptive keynote talk (all around 2006) and the first adaptive PhD thesis (2012). The research field on user modeling and adaptation is being “served” by User Modeling Inc. (that organizes the yearly ACM UMAP conference) and prof. De Bra is president of this organization.

In the data engineering area, the group has developed one of the first structural-index-based triple stores and have their results on indexing and querying in graph data regularly appearing in flagship data management conferences and journals. Their investigations are in close collaboration with leading and cutting-edge database companies such as Oracle and Neo Technologies. Further impact is also made through scientific membership in the LDBC Graph Query Language Standardization task force, an international academia-industry collaboration.

Scientific staff

Prof. Paul De Bra (head of the group)  
Databases, hypermedia, personalization

Dr. George Fletcher  
Data engineering, graph database languages and technology

Dr. Nikolay Yakovets  
Design and implementation of core database technologies, management of massive graph data

Dr. Natasha Stash  
Adaptive technology in cultural heritage and education, digital humanities, adaptation to cognitive styles

Furthermore 5 PhDs and PDs are working on various Data Science projects.

Project examples

• **AHA! (Adaptive Hypermedia for All)** Nlnet Foundation. This early funding marked the start of the development of the later AHA! and GALE platforms that have been used for research on adaptation all over the world.

• **CHIP NWO CATCH.** This Cultural Heritage project demonstrated how access to cultural information and visits to museums can be personalized using semantic metadata.

• **GRAPPLE EU FP7.** This (5M€) project with 15 partners showed how user modeling and personalized learning can be extended across multiple organizations to enable continuous personalization in life-long learning.

• **SeeQR NWO.** This project is the first to study engineering of sophisticated structural-indexing and query processing solutions for massive RDF and graph data, on solid theoretical foundations.