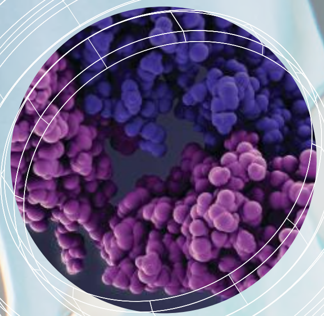
Technische Universiteit
Eindhoven
University of Technology

Engineering Health

Achieving Impact

Where innovation starts



// Preface //

Carmen van Vilsteren

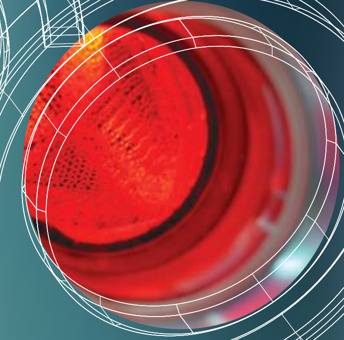
At the end of 2015, when I was appointed Director Strategic Area Health, a number of strategic focus areas within Engineering Health had just been defined. But, during my introduction period, I soon found out there were more research areas within TU/e Engineering Health in which we excel.
It gives me great pleasure to now present you this overview of the research activities of over 400 PhD and PDEng students, supervised by 7 professors in 7 focus areas. The topics cover a broad range within healthcare: from keeping healthy people healthy, to diagnostics and treatments, right down to biomolecular level solutions.

All research conducted within TU/Engineering Health is:

- Demand driven - All our research is based on patient or doctor needs.
- Innovative - Breakthrough technologies drive our search for adequate solutions.
- Collaborative - Research is done in close collaboration with general hospitals and academic hospitals, the industry sector and patient organizations.
- Goal oriented - Researchers aim to achieve real, positive impacts on health improvement.

Despite our achievements and successes, there still remain many opportunities where we can bring positively impacting solutions. Just think of the societal challenges and the rising cost of healthcare due to the growing number of elderly. We believe that here also excellent, high-tech research will continue to bring easy-to-apply, affordable solutions with high impact.
I trust you will be inspired and enthused by the many ways in which our research has resulted in successful applications.
Happy reading!

ir. Carmen van Vilsteren
Director Strategic Area Health



// Table of contents //

Strategic Area Health

Society faces numerous challenges in the field of healthcare. Populations are ageing and lifestyle related diseases such as obesity and diabetes are increasing, as are other chronic diseases. Adding to this is a growing shortage of healthcare staff.

Technology can play a crucial role in addressing these challenges, enabling new products and services in the healthcare industry. This is why TU/e since many years considers Health a key focus area. In fact, TU/e was the first Dutch university to offer a bachelor's degree in Biomedical Engineering. Currently, Health is one of TU/e's three Strategic Areas, underpinning the university's ambition to maintain and strengthen its leading position in this field.

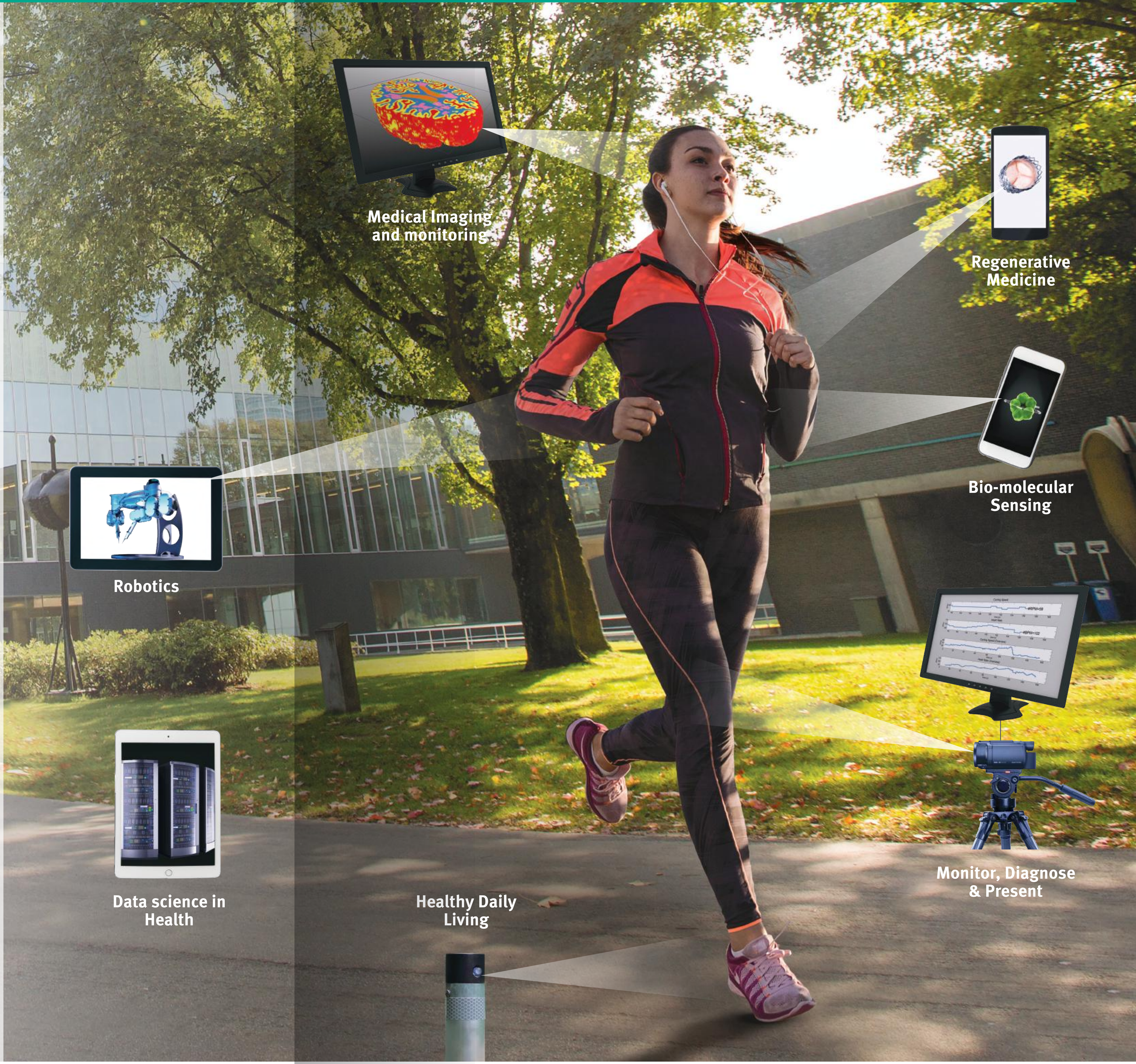
Technology with a human face

TU/e aims to develop healthcare technology that is all about people, being self-explanatory and user-friendly. High-end technical knowledge provides a firm base for the development of people-oriented technological solutions. These will improve care in the complex and expensive hospital environment, but also - more importantly even - in first-line care and self-care. The ultimate goal is to increase quality of life and lower costs for everyone.

Another important aspect is the organization of care and the development of associated IT systems. At TU/e, this all revolves around increasing patient independence. We want to render technology more accessible, which in turn will make self-care easier.

Open innovation and sharing knowledge within our ecosystem is a crucial aspect of TU/e healthcare research. We take an integrated approach, working together with other universities, medical centers, hospitals, care facilities, healthcare insurers, companies, and governments, both nationally and internationally.

TU/e's Health research focuses on 7 areas, across nine departments: Bio-molecular Sensing, Data Science in Health, Healthy Daily Living, Medical Imaging and Monitoring, Monitor - Diagnose and Present, Regenerative Medicine and Robotics.



Measuring biomarkers in bodily fluids and tissues for monitoring and diagnosing patients.

Measuring biomarkers

Bio-Molecular Sensing

Biomolecular Sensing is an area of research where technologies are being developed for measuring biomolecular markers in bodily fluids and tissues. The so-called biomarkers are biochemical substances that are strong indicators for health and disease. Healthcare is in need of new biomarker sensing technologies because of the demand for real-time, precise and reliable data. New technologies will allow patient testing and monitoring in the hospital, at the general practitioner's office, and even at home: the challenge is to enable testing at any place and at any time.

TU/e develops sensing technologies for point-of-care testing and for continuous patient monitoring. A point-of-care sensor measures biomarkers outside the body, e.g. in a drop of blood or in a drop of saliva. A sensor for continuous patient monitoring, measures continuously and automatically a bodily fluid, by being integrated in a catheter, situated on or in the skin, or by being implanted inside the body. Such continuous sensors are commercially available only for the sensing of glucose, but not yet for the continuous monitoring of other important biomarkers such as hormones, drugs, electrolytes, peptides, proteins, and DNA. However, in order to be able to personalize healthcare, such sensors are needed, for the monitoring, treatment and coaching of patients. Biomolecular sensors are based on molecular interactions and physical transduction principles, so the work is highly multidisciplinary. Important areas of research at TU/e are: optical detection technologies, sensing methods with single-molecule resolution, the engineering of protein and nucleic-acid based molecular constructs, biochemical coupling techniques, the use of nanoparticles for signal generation, and microfluidic device technologies. To stimulate education and innovation in the field of bio-sensing on a worldwide scale, TU/e organizes SensUs, the international student competition on biosensors for health. Annually, teams from universities all over the world compete in developing the most innovative biosensors.

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Bio-Molecular Sensing

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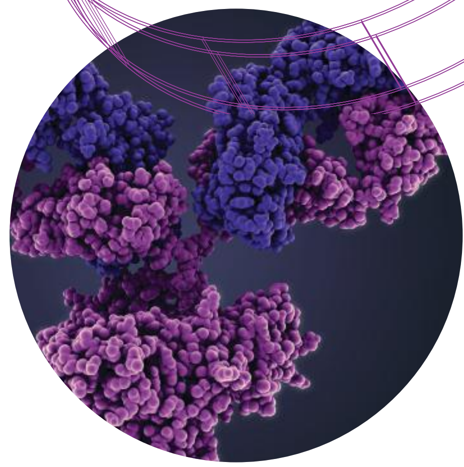
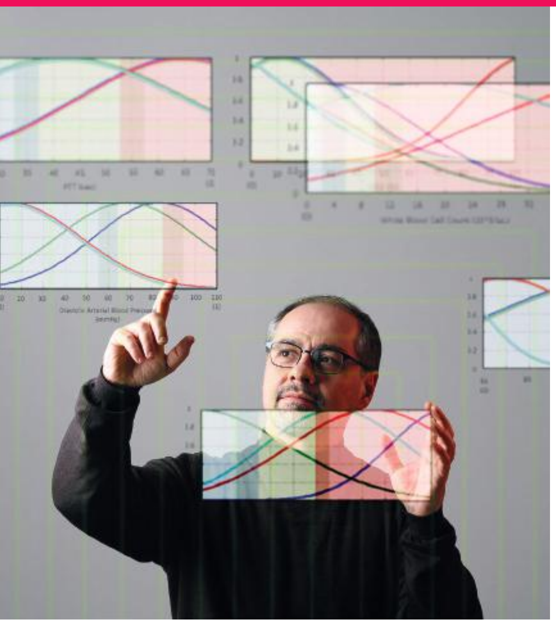


Data Science is an interdisciplinary field that applies numerous techniques to create value, based on extracting knowledge and insights from available data. The successful and responsible application of data science depends on a good understanding of the application domain, taking into account ethics, business models, and human behavior.

Data Science in Health

Data Science in Health



prof.dr.ir. Uzay Kaymak

Revolutionizing healthcare through data sharing

Advances in Information Technology, IoT, cloud computing, big data and high-performance computing are having a major impact on health services. While advances in the information sharing of medical knowledge results in better diagnoses and treatments, information management is also affected by trends such as increased patient-centricity (with shared decision making), self-care and integrated care delivery. The way in which health services are delivered is being revolutionized through the sharing and integration of health data across organizational boundaries.

Via research on health analytics, we deliver new approaches to merge, analyze and process complex data and gain more actionable insights, understanding and knowledge at individual and population level.

Our research is focused on three themes:

1. Decision support for better health
2. Visual health analytics
3. Healthcare process and environment innovation

We are working in close collaboration with leading healthcare institutes and industry players that provide healthcare products and services. Based on real-world data, we are developing data-driven analyses which take into account operational processes and decision rules. The techniques are applied at the level of individual patients and within the context of the whole care continuum.

Cooperations
Catharina Hospital, Deloitte, Jeroen Bosch Hospital, Maastricht University Medical Centre, Meander Medical Centre, Philips, Utrecht Medical Centre University, Zhejiang University.
We also collaborate with Tilburg University in the Jheronimus Academy of Data Science (JADS).

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Data Science in Health

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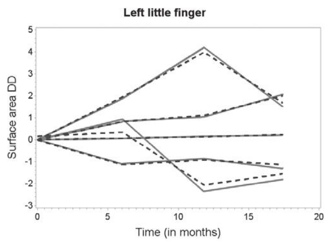
Longitudinal Statistical Research

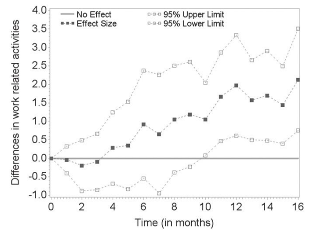
Understanding the time dynamics of risk factors, exposures and treatments over time, as well as the causal relationship to the occurrence of diseases can only be determined with longitudinal data on research participants using appropriate statistical methods.

Estimating the causal effects from such longitudinal data is challenging as it needs to take into account heterogeneities between and within participants, time-dependent correlations, possible confounding and selection bias, and incompleteness of data.
Complication increases even further when multiple longitudinal studies are pooled from different sources. Variables may be studied using different instruments, leading to inconsistencies across studies. What's more, if data cannot be transferred to a single location, it sometimes has be analyzed in a federated or distributed manner.
The Statistics Group, part of the Mathematics & Computer Science Department, develops appropriate statistical models for longitudinal data analysis (e.g. latent variable models, joint models, cluster analysis, time serie models, survival analysis). Such data is acquired from cohort studies and clinical trials. The group develops statistical models for harmonization and meta-analysis of multiple studies. In this way, we contribute to understanding disease processes and progression and, ultimately, to improving patient health.



Cluster analysis of noduli areas of Dupuytren disease in the left little finger

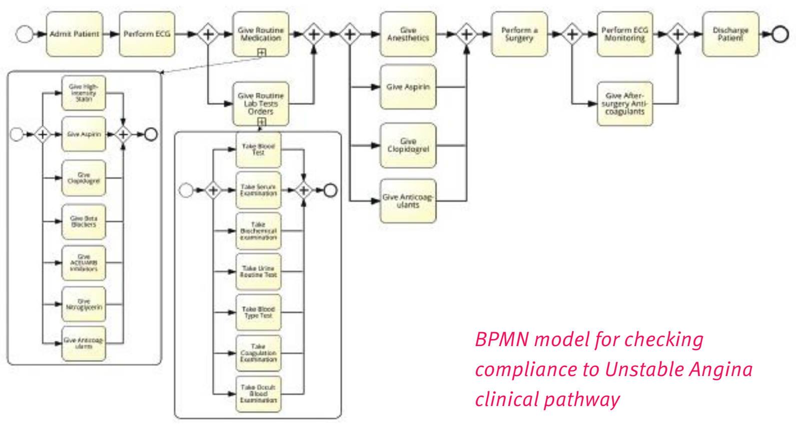
The effect of cognitive adaptive training on functional outcomes



Personalisation

The development of standards of care play a central role in providing the best healthcare solutions based on the latest medical evidence. However, every patient is unique and requires personalized solutions for the best treatment for their specific situation. Such solutions should not be in conflict with the applicable standard of care.

The Information Systems Group of the Department of Industrial Engineering and Innovation Sciences, develops data-driven decision support approaches, methods, models and tools for the personalization of healthcare services and standards of care.
The group develops models based on patient data. This is done using advanced data mining, machine learning and computational intelligence techniques. Models can be used for clinical decision support at the point of care. Specific attention is paid to the interpretability and transparency of such models, so that the model behavior remains understandable to humans.
In this way, the group ensures maximum value can be created from healthcare data in order to improve the care a person receives. In addition, the group works on intelligent rule-based adaptation and configuration of clinical processes and the development of process management solutions for personalization of clinical processes.
The group's work has contributed to the development of flexible compliance analysis to clinical protocols, as well as a context-aware, dynamic checklist system called Tracebook.

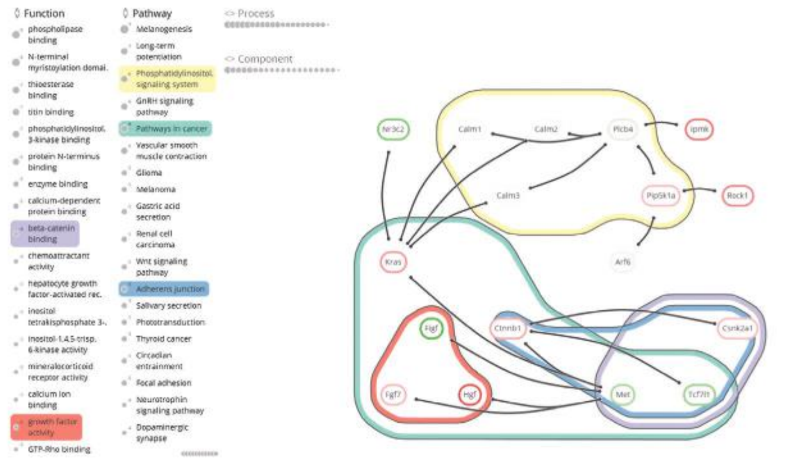


BPMN model for checking compliance to Unstable Angina clinical pathway

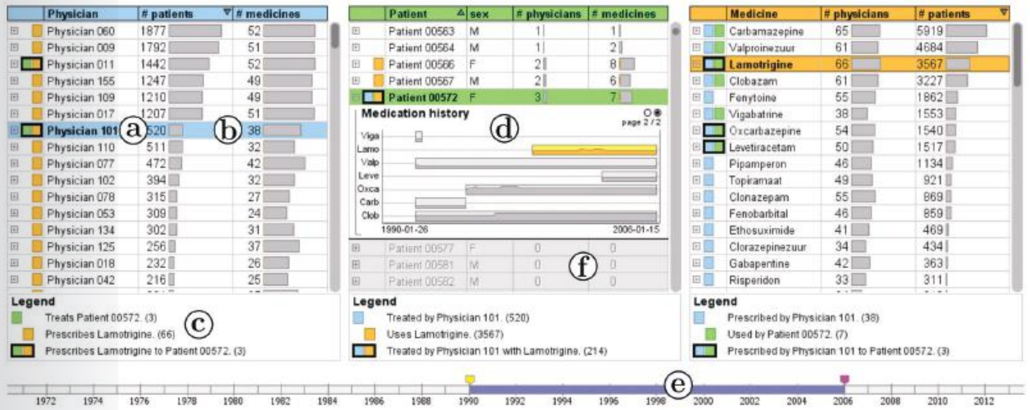
Visual Analytics

The Visualization group of the Department of Mathematics and Computer Science aims at developing novel methods and techniques for enabling experts to deal with large amounts of data using visualization, often in combination with automated methods.

For instance, in collaboration with Kempenhaeghe we have studied how to visualize collections of 300,000 medicine prescriptions; in collaboration with RIVM we have worked on the visualization of patterns in multi-drug resistant bacteria, based on 600,000 samples; in collaboration with CWI and VU we have studied how to give insight into submodules in complex gene regulation networks. These cases illustrate how we aim to make steps forward by using a combination of careful analysis of the problem at hand and solutions based on carefully designed custom presentations and interactions.



Visualization of interacting proteins and their biological roles in metabolic pathways and pathways related to various types of cancer. The colored contours delineate groups of proteins that correspond to the highlighted biological functions and pathways in the list on the left. The black lines show which proteins can have physical interactions. This visualization allows biologists to get insight into the complex (multiple) roles that proteins have in humans



Visualization of Medicine Prescription Behavior

Quantified Self

In the Quantified Self research program we research the role of personalized and context-aware technologies that help to:

- better understand relations between people's vitality and their behavioral patterns in daily life (including but not restricted to sports);
- better understand relations between actual (sports) achievements and activity patterns before, during and after being physically active;
- better understand the contextual motives shaping active behavior, conditioned as this is by routines shaped by our social peer group and our physical everyday living environment.

Our society is faced with a number of major challenges including health-related ones, such as aging, obesity, cardio-vascular diseases or social isolation.

Participatory Health and Wellbeing

Healthy Daily Living

Transformative Practices for Dementia

When looking at the field of public health, we are currently faced with a situation where, if no fundamental change takes place, an increasing number of people will ask for an increase in quality of life while having to rely on increasingly expensive healthcare paid by a decreasing number of people, up to a point that it is no longer suitable and maintainable.

Technology can support us in addressing societal challenges. It can stimulate certain behavior and discourage other behavior, as well as amplify or reduce specific aspects of reality, thus supporting us to improve our health. However, addressing these major societal challenges is not that straightforward: they often ask for systemic change and require many different stakeholders to tackle the challenge.

The Healthy Daily Living research area aims at empowerment for wellbeing and healthy living: from prevention to care. It aims to bring about systemic change and support quality of life by developing and optimizing personal and value-centred complex health systems. We do so by integrating personal, contextual and technological elements with innovate complex health systems.

Healthy Daily Living targets three areas:

1 human vitality and technology
2 healthy cities and smart societies, and
3 interactive technologies and health continuum

We develop devices, systems and living environments, as well as related theories, methods and tools to support quality of life in these three areas. Within this research area, we aim to develop solutions for healthy daily living through design, system thinking and co-creation in real-world environments. For this, we use Fieldlabs and Experiential Design Landscapes to explore, use, test and validate new innovative processes and systems in real-world situations. In this way, we can also address the systemic character of challenges and solutions.

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Human Vitality & Technology

Improving health through understanding human behavior.

In the Research Roadmap 'Human Vitality & Technology', we look into the role of personalized and context-aware technologies that help to:

- Better understand relations between people's vitality and their behavioral patterns in daily life (including but not restricted to sports),
- Better understand relations between actual achievements and activity patterns before, during and after being physically active,
- Better understand the contextual motives shaping active behavior, conditioned as this is by routines shaped by our social peer group and our physical everyday living environment.

This will not only provide new opportunities to improve people's vitality, health and sports performance, but it will also enable early detection and minimize the impact of possible injuries, as well as slow down the onset of chronic diseases. Insights into personal health will provide individuals with relevant informing for gaining control over their potential disorder. It will also enable people to manage their personal health with much greater effectiveness than previously was the case. And such at a fraction of the cost of traditional, curative intramural care.

For researchers, policy makers, health professionals, planners and designers, such personalized and context-aware technologies deliver valuable real time and individual data on correlations between an active lifestyle and health outcomes. These are contextualized for lifestyle groups and living environments. Based on this information, intervention strategies can be developed, which in turn can be monitored and evaluated regarding their effectiveness. In this way, we expect to be able to counter epidemic illnesses such as obesity, burn-outs and dementia to mention but a few.

Genneper Parken - smart pylons stimulating children to be physically active

Interactive Technologies and the Health Continuum

Research within Interactive Technologies and the Health Continuum, addresses those technologies which support people to stay healthy and, if ill, to cope with the disease and self-manage their life.

It incorporates the health continuum, from home to hospital, from healthy living and prevention to diagnosis, and from treatment and to home care.

Within this research area, two perspectives are covered. One is the perspective of the individual, their family, care takers and other related stakeholders. The other perspective is that of a person's environment in the broadest sense of the word. Research focuses on the human-technology eco-system with an emphasis on indoor and outdoor environments, as well as the social dynamics and processes that smoothen the health continuum and strengthen empowerment and a person's quality of life. Research in this sub-area focusses on identifying facilitators and hindrances in a person's eco-system (outdoor and indoor environment, both physical and social) and examining the impact of changes on indoor environments, social structures, collaboration and inclusion, and health.

Current research is aimed at finding ways in which to:

- Improve the hospital environment and information systems
- Smoothen the transition between hospital and home
- Enhance social contacts and cohesion in neighborhoods
- Support aging-in-place and prevent loneliness for the aging population
- Create healthy indoor and working environment
- Create dementia-friendly environments

Example of poor lighting in a medication room in a hospital: dimmed light as not to disturb the sleeping patients at night, diminishes working conditions and makes prone to mistakes

Interactive Technology – Hospitals: stress & mental health under care professionals.

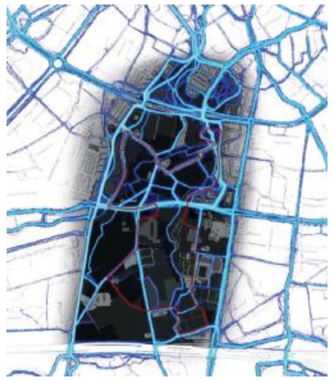
Healthy Cities & Smart Societies

Improving health through understanding the impact of the living environment, both physical and digital, on peoples lifestyle.

Genneper Parken - spatial collage (physical intervention); promote physical activity by an interactive route for individual sporting

The Healthy Cities and Smart Societies research network combines research from the fields of urban planning, digital technologies and behavioral sciences to develop new understanding and innovative strategies on how to create the right conditions for people to adopt a healthier lifestyle - both physically, mentally and socially.
In order to be able to change people's routine behavior, integral approaches focusing on systemic changes in the contextual aspects defining these routines are necessary.
Such integral approaches should combine physical, digital and social interventions. Aim is to create everyday urban living environments that stimulate people to be physically active, stimulated cognitively and engage socially. Creating healthy cities through a combination of urban planning, gaming and persuasive technologies and supported by social awareness programs. Both for academics, professionals and policy makers the program delivers data on actual (un-)healthy behavior, related to the characteristics of the urban environment, as well as integrated intervention strategies aiming at behavior change. Smart City Technologies enables not only to monitor and nudge this behavior but also to evaluate the results of these combined intervention strategies.
By creating living labs this program explicitly involves the quadruple helix actors actively into the research and the development of the interventions.
The research network comprises faculty members from TU/e (Industrial Design, the Data Science Center Eindhoven and IE&IS, but also from other universities and institutes. These include the University of Utrecht and Vrije Universiteit Amsterdam, as well as Platform Gezond Ontwerp. Collaborations are ongoing with almost all knowledge institutes on public health and healthy cities, RIVM, TNO and Kenniscentrum Sport. Moreover, we collaborate closely with the Smart Cities program of the TU/e and the Urban Development Institute, the Frauenhofer Institute and Brainport region. Please feel free to contact us for information or collaborations.

Genneper Parken - digital device/ app (gaming intervention)

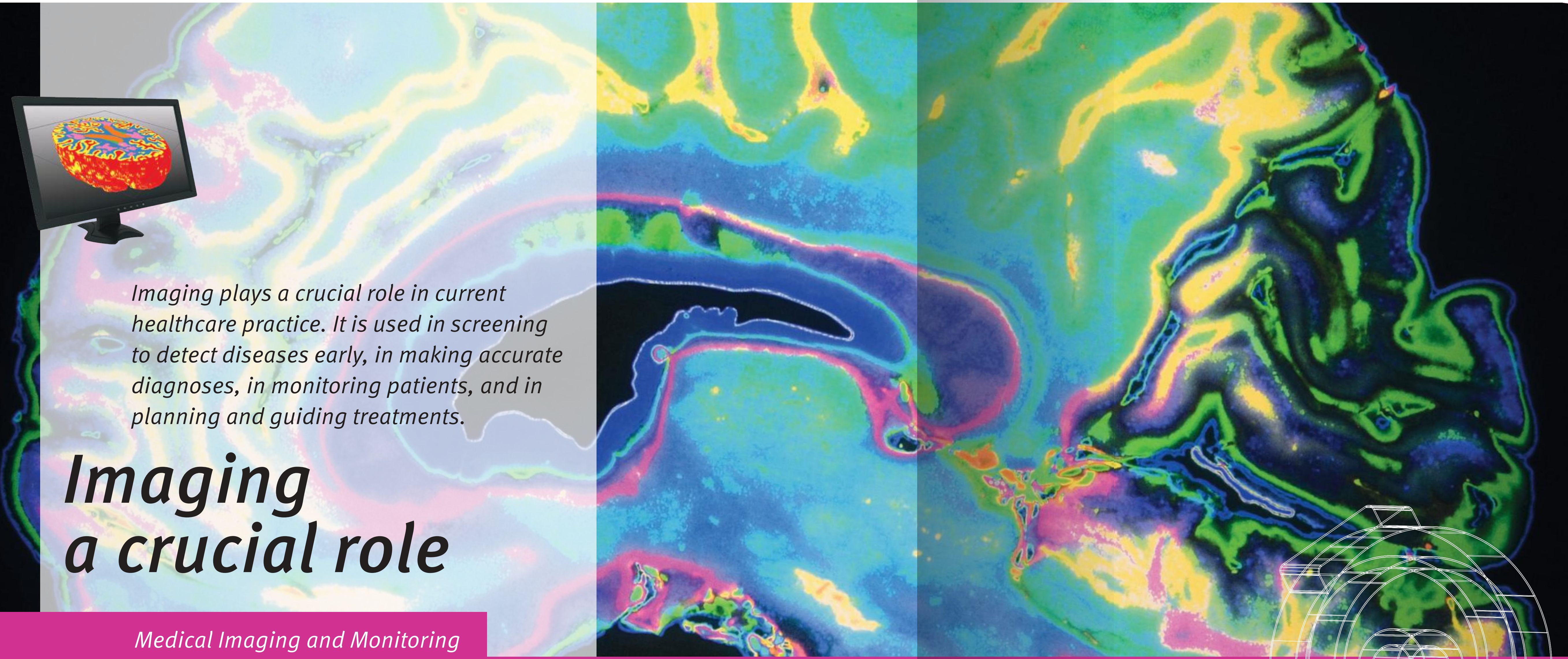


Genneper Parken - Strava kaart (data analytics)

STEC: tangible play objects used for urban planning

Some of our projects:

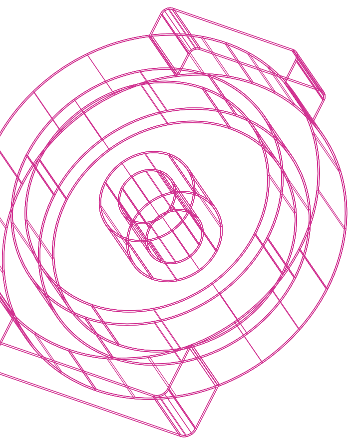
SOULMATE: Secure Old people's Ultimate Lifestyle Mobility by offering Augmented reality Training Experiences.
GOAL: Gamification for Overweight prevention and Active Lifestyle.
Genneper Parken: Sports and vitality district. An integral a pproach as to enhance an active lifestyle by designing sports and vitality into the daily living environment by a mix of landscaping, probes and smart city technologies.
Bike2School: Studying the factors influencing cycling behavior of teenagers.
Smart Technology, Empowering Citizens (STEC): Understand how technologies and practices can empower citizens, and organize them around collective societal issues.
Smart Cycling Futures: How cycling innovation and urban planning strategies contribute to the stimulation of cycling.
Transformative Practices Program for Social Resilience: Empowering citizens and enhancing their resilience through socio-technical systems.
Creating Healthy Environments – Hospitals: To gain more insight into the relation between indoor environmental parameters on one side and users well-being (patients) and performance of users (staff) in a hospital environment.
Creating Healthy Environments – Offices: The general approach is to identify solutions for the built environment that form a balanced consideration of energy- and health-related aspects for the building occupants in open office environments.



Imaging plays a crucial role in current healthcare practice. It is used in screening to detect diseases early, in making accurate diagnoses, in monitoring patients, and in planning and guiding treatments.

Imaging a crucial role

Medical Imaging and Monitoring



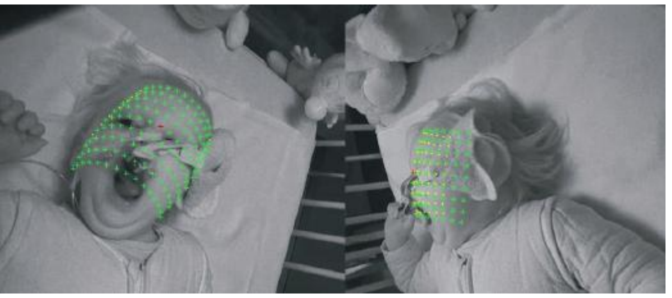
Screening of large populations benefits enormously from computer-aided image analysis, providing automatic triage of patients and second opinions.
Imaging is also essential in diagnosis and prognosis; in determining the specific type of disease, its causes, progress and the outlook for the patient. Based on these outcomes, the most appropriate treatment can be selected for an individual patient.

Determining the best treatment

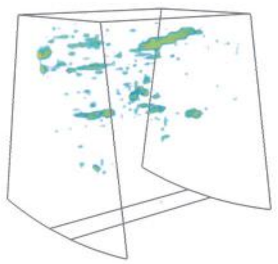
Imaging is used to create patient-specific treatment plans: for instance, helping to define the outlines of a tumor that is to be removed or irradiated, and in determining the safest, least invasive path to that tumor.
Such treatment plans can be used to guide clinicians, resulting in safer and minimally invasive therapy. After treatment has taken place, imaging is also important: to measure the efficacy of the procedure and, potentially, to switch treatment policies quickly.

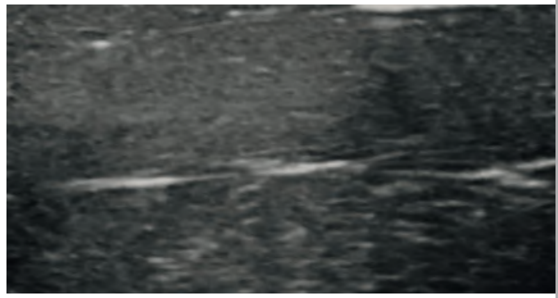
Monitoring

Medical monitoring is concerned with the temporal evaluation of a person's health. This applies to clinical settings, for instance, in an intensive care unit or in evaluating the effectiveness of a treatment, but also to home settings; for example research of sleep disorders.

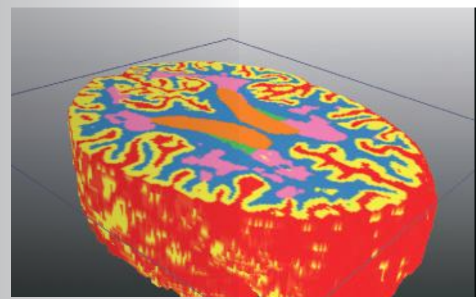


Dual camera views for tracking of the infant's face with 3D facial model

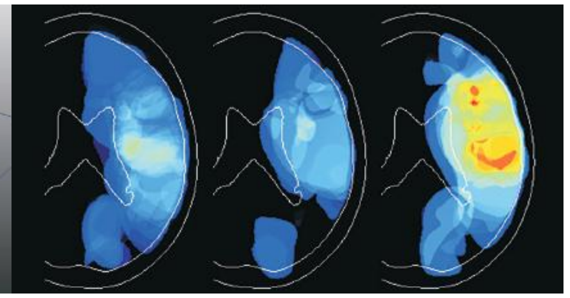




Needle detection in 3D ultrasound, vca.ele.tue.nl



Automatic segmentation of brain tissues by deep learning



White matter tracts from Diffusion Weighted MR

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Machine learning for quantitative imaging, prognosis and diagnosis:
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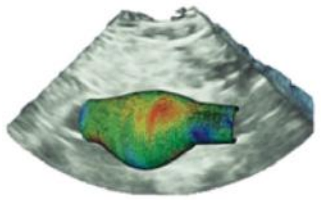
Diagnosis & treatment

Imaging plays a crucial role in current clinical practice. It is essential in determining the specific type of disease, as well as the outlook for the patient. Together these largely define treatment choice. Imaging is used to create patient-specific treatment plans and to guide clinicians for safer and minimally invasive therapy.



Ultrasound imaging

New 3-D and 4-D ultrasound techniques are developed and used for patient-specific assessment of arterial and myocardial properties, whereas photo-acoustics is currently being tested for imaging of superficial arteries and validated pre-clinically to assess its applicability and merit. Mathematical models of cardiovascular physiology are used to enhance diagnosis and predict treatment outcomes (e.g. bypass surgery, stent placement, fistula creation) patient-specifically to provide model predictive clinical decision support.

www.tue.nl/en/university/departments/biomedical-engineering/the-department/organisation/research-groups/cardiovascular-biomechanics/

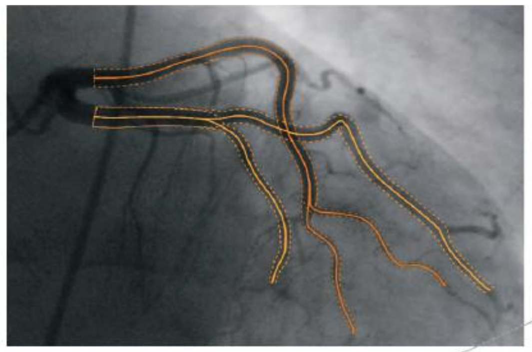
Determining pathology boundaries

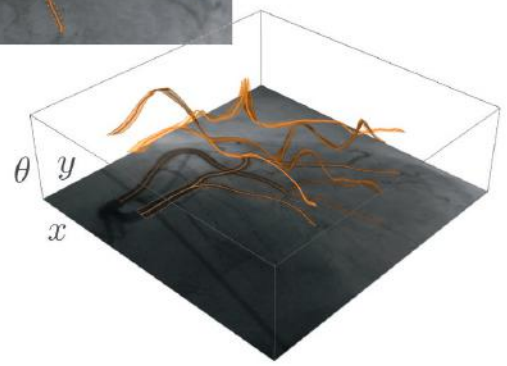
Medical image analysis facilitates computer-aided decision support for clinicians. Automatic precise determination of pathology boundaries in the tissues is followed by semantic analysis of the images, so that the treatment outcome can be foreseen in advance and in such a way the best treatment can be chosen for the patient. We create original technologies and exploit novel imaging techniques. We apply supervised machine learning and deep learning algorithms, regularization and filtering designed per imaging technology, hyperspectral and multi-modal imaging. Example medical application areas are: esophagus cancer, colon cancer, bladder cancer, vestibular schwannoma and multi-spectral tissue analysis.

www.vca.ele.tue.nl

Structural analysis for diagnosis

Geometric paradigms for image modalities in which the tissue or object of interest has an intrinsically elongated structure, such as the vascular system (MRI, CT, X-Ray) and brain white matter tissue (Diffusion MRI) allow spatially interfering structures to be pried apart so as to admit local enhancement, analysis or completion without orientation confusion at spatial junction points or other spatially complex configurations (high curvature points). Example applications are in retinal vasculature analysis and myocardial deformation and strain analysis. This enables diagnosis and prognosis of diabetes and other systemic diseases affecting the retinal vasculature and early diagnosis of myocardial dysfunction as a precursor of heart disease respectively.





The spatial vascular configuration can be lifted to a higher dimensional domain to disentangle crossings, thus facilitating vessel-wise local processing

www.win.tue.nl/casa/research/imageanalysis

Visualization of Big Data

The Visualization group of the Department of Mathematics and Computer Science aims at developing novel methods and techniques for enabling experts to deal with large amounts of data using visualization, often in combination with automated methods. For instance, in collaboration with Philips, we are looking into how to improve the workflow of pathologists using digital pathology, by superimposing results of automated feature extraction, tracking the exploration of the pathologists, offering support for low level tasks like counting elements, and supporting reporting.

www.tue.nl/en/university/departments/mathematics-and-computer-science/research/research-programs-computer-science/section-algorithms-and-visualization-av/visualization-vis/research/

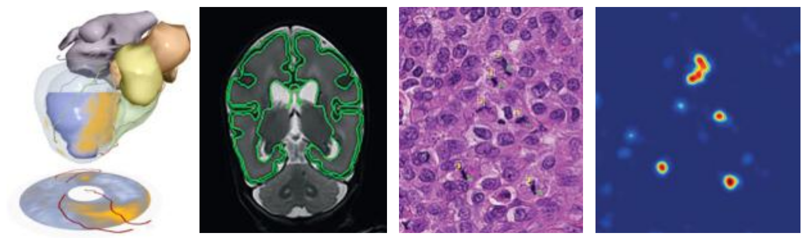
Neuroengineering

Neuroengineering focuses on neuro-degeneration, neuronal networks and neurostimulation in epilepsy-induced accelerated cognitive aging.
An example is real-time fMRI neuro-feedback, which aims to make someone aware of his own neuronal activity. The idea is that by making someone aware of his mental state, he may learn how to control or modify this. Real-time fMRI neurofeedback puts high demands on data quality and filtering, and requires robust and fast data analysis. fMRI neurofeedback is developed for (complete) neuronal networks, with the aim of treating cognitive impairments.

www.neu3ca.org

Machine learning for quantitative imaging, prognosis and diagnosis

Machine, and in particular, deep learning techniques have shown tremendous power in analyzing generic images. We work on extensions of these techniques to overcome the specific challenges of complex, medical images in order to have the methods perform equally strong on those. Learning methods are applied, for instance, to improve diagnosis and prognosis (and hence patient outcome) of histological images of breast cancer patients, to predict developmental problems of prematurely born babies, to detect retinal and vasculature-related diseases very early and to accurately measure heart volumes.



From left to right: Automatic annotation of cardiac structures and scar tissue (yellow), outline of brain in MRI scan of prematurely born baby, automatic count of mitoses (dividing cells) in breast cancer tissue

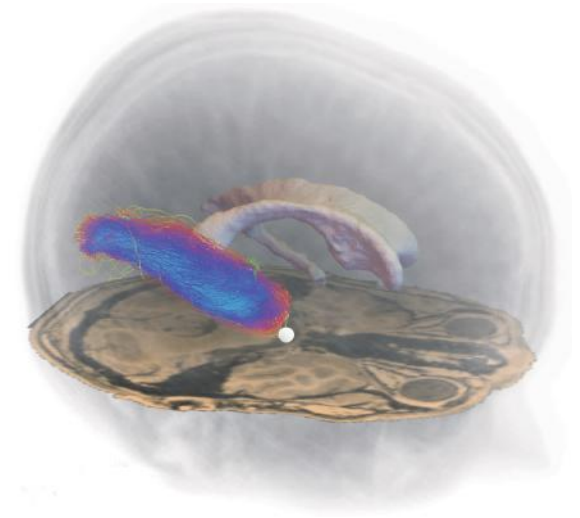
www.tue.nl/image

Image-guided Therapy

Image-guided therapy supports interventions, potentially making them safer, more accurate, more efficient and it allows minimal invasive surgeries.

Tracking elongated structures

Geometric paradigms provide an excellent way to study elongated structures, such as the vascular system and brain white matter tissue. We have conducted rigorous feasibility studies and built convincing pre-clinical applications in the context of real-time X-Ray monitoring and white matter tractography. This enables accurate catheter detection, despite significant dose reduction during prolonged interventions. We have also supported temporal lobe and brain tumor surgery planning using 'tractograms' for mapping brain networks.

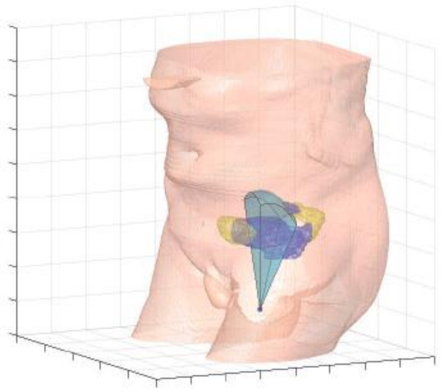


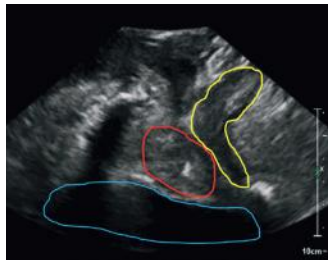
Optic radiation and the Meyer's tip is crucial for temporal lobe resection in epilepsy patients

www.win.tue.nl/casa/research/imageanalysis

Ultrasound probe setup

The curative treatment of prostate cancer based on radiotherapy aims at irradiating tumor tissue using ionizing radiation. Research has shown that frequent imaging during treatment improves the accuracy of the radiation delivery. Ultrasound (US) imaging allows for real-time volumetric organ tracking and is not harmful. In this research, we pursue automation of the US probe-setup procedure, which will potentially decrease the operator dependence and enable patients to fully benefit from US.





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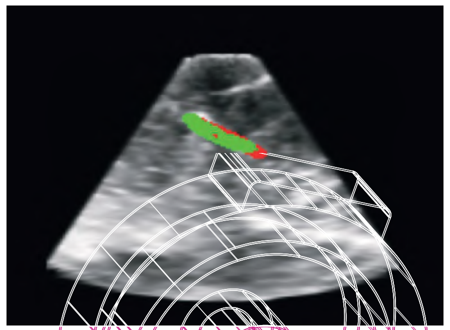
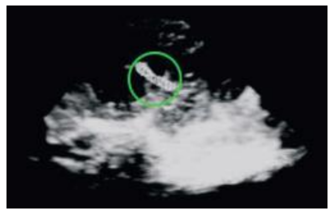
Detection and tracking in 3D ultrasound

The use of three-dimensional ultrasound (3D US) during cardiac catheterization is increasing. However, limited by spatial resolution of cardiac transducers and complex anatomical structure inside the heart, image-based catheter detection is challenging. Our research is developing a method for automated detection of the catheter using a 3D algorithm. This will significantly reduce cardiac surgery time.





Images of 3D catheter detection with US

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Neurosurgical guidance

Symptoms of Parkinson's disease can be alleviated by electric stimulation of structures within the brain, so-called deep brain stimulation. A widely used structure is the subthalamic nucleus. For effective treatment, electrodes need to be placed within this structure with great accuracy: a challenging task. Imaging-based navigational systems can improve the accuracy of placement and the success rate of brain surgery.

STN indicated in MR image of the brain (left) and visualization of implanted electrode in STN (right)

www.tue.nl/image

Monitoring

Monitoring patient well-being is a vital task in health care, both continuous monitoring, as in an intensive care unit, and monitoring over a prolonged period of time, for instance, to evaluate treatment efficacy or disease progress.

Neonatal monitoring

The Neonatal Monitoring & Simulation Track develops new techniques for safe and quiet care of the newborn, facilitating family-centered care and mother-child bonding, in order to improve patient outcome. We focus on the development of new parameters and on unobtrusive measurement ways of these parameters. Moreover, we investigate techniques for predictive monitoring using big data to find patterns in data useful for prediction for the individual patient. To investigate the effects of clinical interventions on neonatal outcome, we develop mathematical and physical simulation models.

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Monitoring neonates' wellbeing

Monitoring very young children for pain and discomfort is important in many clinical contexts. The research cooperation with Máxima Medical Centre Veldhoven focuses on two specific applications: monitoring of preterm neonates in the Neonatal Intensive Care Unit (NICU), and monitoring of infants for diagnosis of Gastro-Esophageal Reflux Disease (GERD). The objective is to realize real-time monitoring by way of video analysis of the facial expression of neonates and infants.

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Sleep disorders

Concerning sleep research, the focus is on multi-modal home monitoring of sleep and sleep quality for the diagnosis of sleep disorders. Projects may involve using EEG or sensors embedded in the mattress.

Alarm enhancement for neonatal monitoring

Preterm infants in a neonatal intensive care unit (NICU) require continuous monitoring as their life is at serious risk. In current patient monitoring based on vital signs, however, multiple alarms are generated for the same critical event, causing alarm fatigue amongst caregivers and stress for patient and parents. Moreover, detection of clinical deterioration with vitals crossing predefined boundaries can only be done in hindsight, whereas an early warning of such deterioration would be much more valuable. Furthermore, current monitoring involves a variety of obtrusive sensors and wiring, interfering with baby wellbeing. This projects aims to bring patient monitoring beyond current state-of-the-art, by fusing the vitals and using video monitoring to reduce false alarms; employing data analytics to detect deterioration earlier; and using video techniques for robust motion detection and unobtrusive monitoring.

The area Monitor Diagnose & Present, although not specific to any disease or sub-area of Health, is characterized by a methodology concerned with accumulating knowledge during a care & cure cycle, which involves both patients as well as healthy people.

Developments and Trends

Monitor, Diagnose & Present

Wireless-connected belt with sensors for neonatal monitoring

Image-based detection of cancer using Computer-based analysis vca.ele.tue.nl

The application of sensors within or on the body, or in the vicinity of a person, is used to monitor a person and collect data about his/her health status. The obtained data allows a diagnosis to be made of the person involved. The presentation of the results can be done at various levels of specialization, right up to the most extensive levels of detail.

There are several strong societal and technological trends that support and drive this Health focus. Firstly, due to the decreasing cost of sensors, they have become now so inexpensive that they can be widely used - also for large studies - in, on or near to research subjects. This trend is further fueled by the smartphone, which is a perfect and powerful device for mobile computing of sensed signals to perform a partial or full diagnosis. Such monitoring is a valuable, additional option to the high-quality hospital environment. Nomadic monitoring of people, at any place and time, creates the opportunity to collect far more health status data than monitoring in a conventional hospital environment only. This points to another extremely promising development: e-Health.

e-Health is based on an online platform where patient data is collected from numerous sources for diagnostic or even disease prevention purposes. These new and advanced health monitoring options are also pushing hospitals and care centres to look at more advanced and better monitoring, diagnosis and presentation methods.

This e-Health development - sometimes called digital health – makes it possible to gather, store and work with more personal data than ever before. This opens up new opportunities for creating structural approaches for data analysis (such as used in machine learning) to improve patient and health status diagnostics. The emergence of Convolution Neural Networks (CNNs) is just one example of important learning features made possible by data collection in a database. This development can be explored in multiple ways, e.g. to improve the diagnosis and its accuracy, or for interventions because the instruments and context information is better accumulated and more reliably understood.

A number of sub-areas have been mapped onto diseases, rather than technological stages, as they are typically applied in combination and are specific to the type of sensor data available. These sub-areas offer excellent and interesting examples of the broad scope of Monitor Diagnose & Present. Obviously, with the use of sensors and data processing, this focus area has a strong foothold within Electrical Engineering, but it also extends to other faculties such as Biomedical Technology, Industrial Design and Computer Science. In addition, because it also regards the prevention of diseases, there is a strong connection to the area of sports and vitality: areas that reside primarily outside the hospital environment and in day-to-day life of people. This is discussed elsewhere.

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Monitor, Diagnose & Present

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Neurology

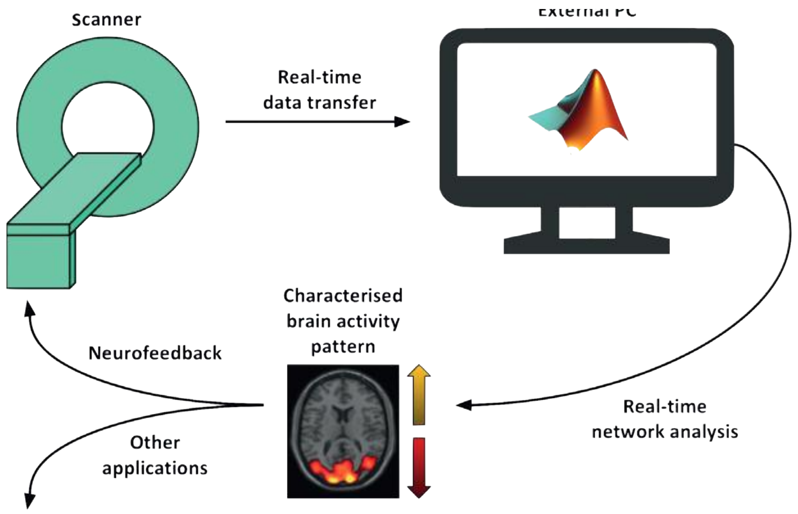
Neuroengineering research

Neuroengineering is a field of science that aims to understand, treat or enhance the brain function. Important research includes epilepsy and sleep disorders. This research is carried out in collaboration with major research partners: the Epilepsy and Sleep Referral Center Kempenhaeghe and the Neurology Department of Ghent University Hospital. The key research program is Neu3CA, which involves neurodegeneration, neuronal networks and neuro-stimulation in epilepsy-induced accelerated cognitive aging. The research considers how epilepsy affects overall brain organization and associated cognitive performance. Research results are likely to be more broadly applicable than epilepsy alone, as many of the observed changes in brain networks can occur during healthy aging as well, albeit to a lesser extent. Neu3CA is a multidisciplinary program, in which researchers with diverse engineering and clinical backgrounds cooperate within innovative and clinically relevant studies.

The Neu3CA research is mainly based on neuro-imaging using MRI. We use advanced MRI data (functional MRI and diffusion weighted imaging) to study brain connectivity and network organization (functionally and structurally, respectively). Our goals are to find imaging biomarkers for disease and to gain more insight into disease mechanisms in order to improve treatments.

A first example of research is the work into real-time fMRI neurofeedback. In conventional fMRI, a full series of brain scans is acquired while, the test subject is performing a task in the scanner. In a post-hoc analysis, it is investigated which brain regions showed activity fluctuations in correspondence with the task, which are then depicted in a so-called activation map. On the other hand, in real-time fMRI neurofeedback the ongoing brain activity is assessed during (instead of after) scanning. This puts high demands on data quality and filtering, and requires robust and fast data analysis. The idea is that by giving a test subject real-time insight into his or her brain activity, they can be trained to control it to a certain extent. This may lead to normalization of aberrant brain activity patterns and alleviation of associated symptoms. This research is performed at Kempenhaeghe with prof. dr. Aldenkamp and prof.dr. Paul Boon, using a Philips 3 Tesla MRI scanner, and in close collaboration with Philips Research & Healthcare.

A second research project focusses on neurostimulation, more specifically transcranial magnetic stimulation (TMS). In TMS, a stimulation coil is held over the scalp, which is driven by an alternating current. This induces tiny currents in the underlying brain tissue, which modulate local brain activity. Electromagnetic simulations are performed to investigate how exactly the corresponding fields couple into the tissue, so it is known exactly what brain tissue is stimulated and at what strength. Furthermore, neurophysiological experiments and simulations are performed to check how such stimulations affect neuronal firing patterns, both locally and in interconnected neurons. Other epilepsy research lines focus on non-invasive and ambulatory seizure prediction, for example based on ECG-based assessment of heart rate variability using a smart watch. The senior researchers involved here are prof.dr. Johan Arends and Dr. P. Cluitmans.

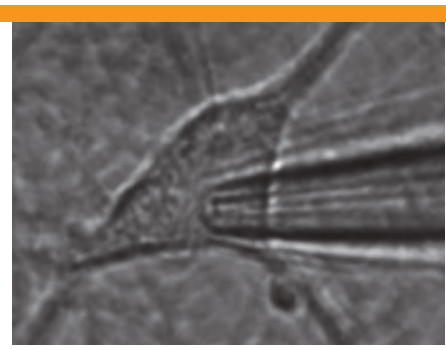


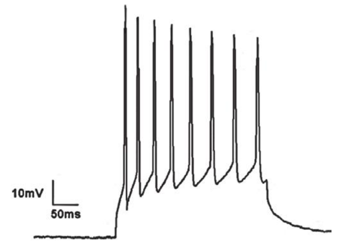
Real-time fMRI neurofeedback set-up; the test subject is continuously scanned, while the resulting images are exported to and analyzed on an external PC. Measures of ongoing brain activity are presented back to the subject in order to modulate it

www.neu3ca.org

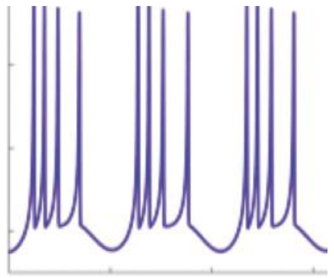
Sleep monitoring

A third research area on sleep is focusing on the diagnosis, long-term monitoring and treatment of prevalent sleep disorders, several being neurological in nature. The team headed by Prof.dr. S. Overeem, is composed of about 25 researchers, in a close collaboration with the departments of Electrical Engineering, Industrial Design, Sleep Medicine Center Kempenhaeghe and Philips Research. Insomnia is one of the most common sleep disorders (e.g. OSA), affecting 4-5% of the population. The aim is to use advanced monitoring technology (e.g. PPG) to capture the natural variability in insomnia symptoms, including patterns over time. The ultimate goal is to identify subtypes of insomnia, for specifically tailoring treatment. Newly developed bed sensors are used to track pressure patterns on the mattress overnight. This technology enables the detection of body turns and motor activity across the night. This is especially relevant for patients with Parkinson's disease, which often suffer from nocturnal hypokinesia. In this area we are exploring depth-camera technology for detailed tracking and analysis of movement patterns in full darkness. The newest techniques involve multi-wavelength infrared video recordings to obtain vital signs during the night, including heartrate, respiration and even oxygen saturation.





NEURON

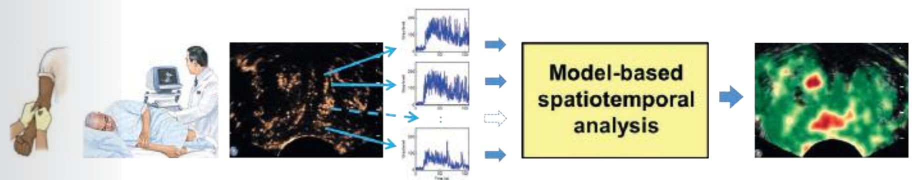


***Top:** in vitro recoding of neuronal firing pattern*
***Bottom:** corresponding simulation of neuronal activity*

Oncology

Prostate cancer diagnosis by contract-enhanced ultrasound imaging

Prostate cancer is the form of cancer with the highest incidence in western males. Because of the limitations of current imaging technology, diagnosis still relies on blind random biopsies, where 12 or more tissue samples are extracted with a core needle through the rectum for subsequent histopathological analysis. Because of poor patient selection by blood testing, 3 in 4 patients receive unnecessary biopsies. Moreover, biopsies are not suitable for guidance and targeting of the available minimally invasive focal treatments. As a result, the full prostate is usually removed or treated, with associated high risks for the patient to remain impotent and incontinent.
CUDI (contrast ultrasound dispersion imaging) is a novel ultrasound techno-logy being developed at the BM/d labs of the Signal Processing Systems group for localization of those changes in the microvascular architecture that reflect cancer angiogenesis. This technology is based on the spatiotemporal analysis of dilution curves measured in the prostate by ultrasound imaging after the peripheral injection of a small bolus of ultrasound contrast agents. ››



Measurement chain to perform contrast-ultrasound dispersion imaging (CUDI) of prostate cancer
www.bmdresearch.com

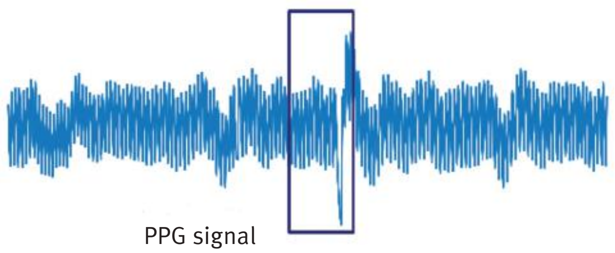
Oncology

« Along this research line, early signs of the angiogenic switch are also being investigated by ultrasound molecular imaging through quantification of the binding kinetics of ultrasound contrast agents that are targeted to specific angiogenic expressions. The validation is promising and large clinical trials are ongoing where image-guided biopsies are targeted by use of CUDI images through accurate image registration and fusion.

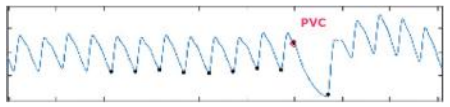
Cardiology

Ambulatory cardiac monitoring

PPG-watch



PPG signal



Zoom of PPG signal at time of a premature ventricular contraction (PVC)

PPG Watch and generated PPG signal to detect ventricular contraction

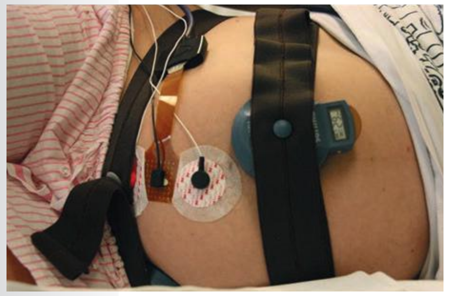
The prevalence of cardiac arrhythmias is strongly increasing because of the ageing population and improved survival of patients with cardiovascular disease. Atrial fibrillation (AF) is the most common arrhythmia, affecting 5.5% of the population of 60 years and older. AF is associated with increased mortality and increased risks of stroke and has been labeled a 'silent epidemic' because often patients do not experience symptoms. When AF is detected timely, the risks of stroke can be managed by treatment. Unfortunately, existing screening devices for AF, such as Holter monitors, do not allow for continuous, long-term monitoring of AF.

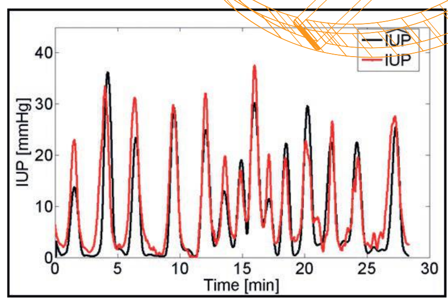
A first project explores a new approach, based on a smart-watch with embedded wrist photoplethysmography (PPG), for long-term home monitoring. In the project, we are developing novel signal processing methods for PPG-based detection of AF that will pave the way to unobtrusive, cost-effective and long-term AF screening and prevention of AF-related stroke.

As second project aims at reducing risks and costs involved with heart failure, especially after cardiac surgery. The costs of re-admission of such patients are very high, while intensive nomadic monitoring in a the first months after surgery would enable the prediction of emerging failure risks as function of medication and actual patient health status. The cooperation with Catharina Hospital (the premier Dutch clinical heart disease treatment center) enables database access to analyze large-scale patient data and establish a reliable prediction model with the newest learning techniques.

Perinatology

Perinatology





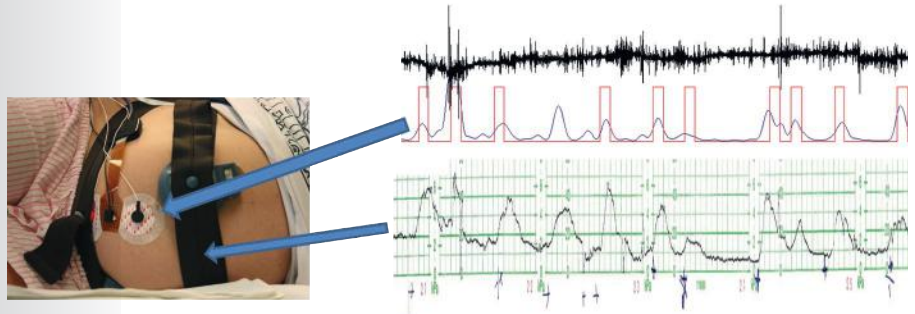
Sensing and corresponding signal analysis unit for monitoring of pregnant women
www.bmdresearch.com

High-risk pregnancies are on the rise because of the progressively higher age at which women get pregnant. For such pregnancies, continuous assessment of fetal wellbeing is critical to reduce fetal mortality and morbidity rates. Various projects aim to enable unobtrusive long-term monitoring of pregnancies and fetal wellbeing by looking to both sensor/circuit technologies and smart signal processing.

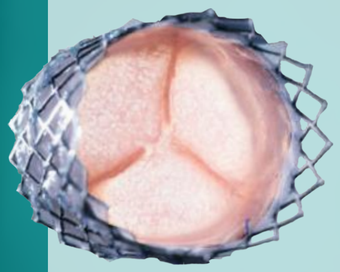
Non-invasive electrophysiological monitoring of the fetal condition has the potential to outperform current technology in availability, safety, and reliability and accuracy of the provided information. The first project aims at developing signal processing methods to enhance the fetal electro-physiological measurements and provide diagnostic information that can aid in better clinical decision making.

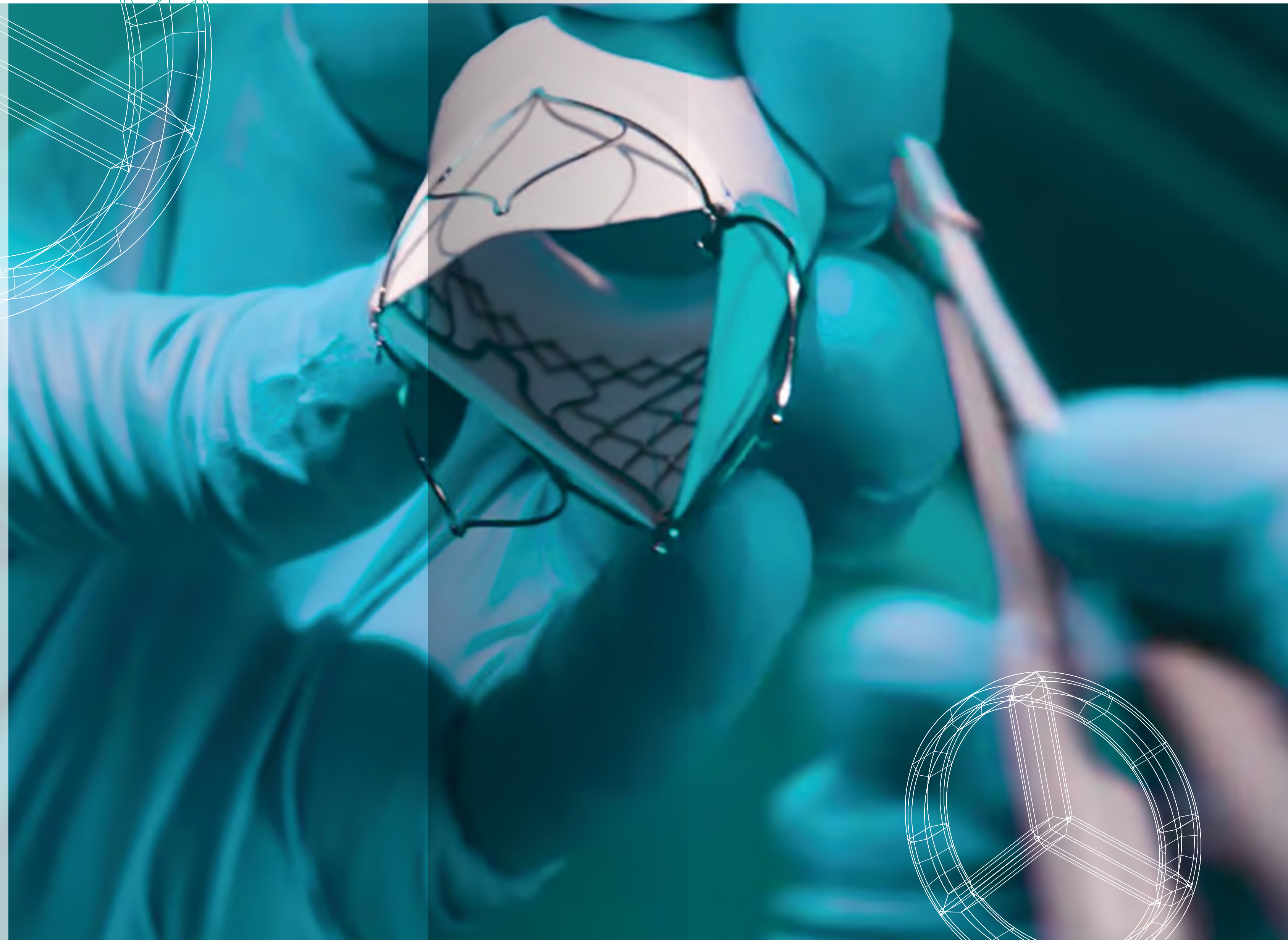
In the SEBAN project (Smart Energy Body Area Sensor Networks), methods and technologies were developed that are needed for low power, non-invasive, reliable body area networks, applied to continuous mobile monitoring of the fetus throughout the pregnancy at home. The focus is to conserve energy by optimal integration and cooperation between frontend, data converters and digital signal processing (DSP).

The EWAM project (Enabling Widespread Ambulatory Monitoring for Improved Pregnancy Outcome) aims to develop technologies towards reliable continuous pregnancy monitoring (of the fetal heart rate) in ambulatory settings, by strongly improving the unobtrusiveness and user-friendliness of the sensors, by increasing signal quality and by exploiting supplementary information to improve diagnostic quality. Capacitive sensors are used for comfortable long-term use; sensor arrays are employed to exploit redundancy for motion-artifact cancelling and, more in general, for enhancement of the system reliability. Provision of reliable, continuous signals are introduced to pave the way for home monitoring of high-risk pregnancies, supervised from the hospital, so that high-risk pregnant mothers can remain with their family and limit hospitalization costs.



Advanced signal processing improves the quality of monitoring fetal signals





Regenerative medicine, at the interface of engineering and life sciences, exploits the properties of living cells, in combination with biomaterials, drugs or genes, to repair or replace living tissues and organs.

Seducing the body to repair itself

Regenerative Medicine

Building on our expertise in biomaterials and biomedical engineering, the main focus at TU/e is on materials-based in-situ tissue engineering for cardiovascular and orthopedic applications, as well as for functional organ repair, where so-called ‘instructive materials’ are being used to stimulate the regenerative capacity of the body itself. Next to this, we use our engineering skills to design computational models and in-vitro engineered tissue models that deepen our understanding of tissue development, malformation (including cancer), degeneration and regeneration.

Research is performed by highly creative multidisciplinary teams that operate at the cross-section of bioengineering, materials science, and cell and tissue biology. These teams collaborate with patient organizations, clinical partners and industry, to develop regenerative strategies that can outrange existing therapies in terms of costs and effectiveness.

Alliances with strategic partners, such as the UMC Utrecht offer opportunities to improve our impact through long-term and focused research collaborations. In addition, the educational programs in Biomedical Engineering (BME) and Regenerative Medicine and Technology (RMT) offer possibilities to train students in this multidisciplinary field.

Collaborations together

The focus area is supported by various individual and consortium research grants (e.g. ERC, FP7, H2020, NWO, CVON) and many projects are performed within public-private-patient partnerships. Members participate in large regional (Chemelot-InScite) and national or cross-border inititiatives (RegMed-XB, hDMT). From 2017-2026 the Focus Area will be supported by the NWO Gravitation program “Materials-Driven Regeneration”, spearheaded by Carlijn Bouten, in which internationally leading scientists in organoid biology, materials sciences, complex tissue engineering, and clinical sciences convene to regenerate tissues and organs to cure what are now chronic diseases.

This focus Area is strongly linked to the Dutch National Science Agenda (NWA) as it is at the heart of the NWA route “Regenerative Medicine” (route 2) and strongly connects to the route “Materials” (route 20).

Focus Area
Regenerative medicine

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Cooperations
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Funded
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Orthopedic

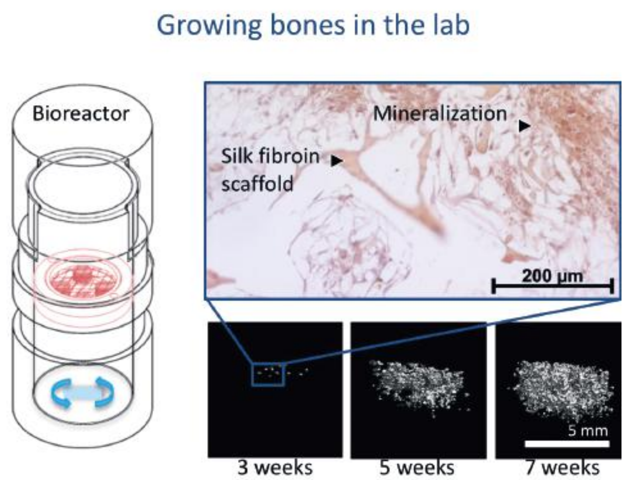
Degenerative musculoskeletal diseases have become more prevalent with an increasing socioeconomic impact. With increased longevity and a higher level of activity, current treatment methods with purely synthetic devices are limited. Because the main function of these tissues is biomechanical to which they are responsive, we combine engineering to explore and develop regenerative treatment strategies for musculoskeletal tissues.

To study bone regeneration, human cell-based, functional, 3D in vitro tissue engineered bone is grown in bioreactors. Longitudinal micro-computed tomography and computational approaches are combined to understand the effect of the physical environment on tissue formation and adaptation.

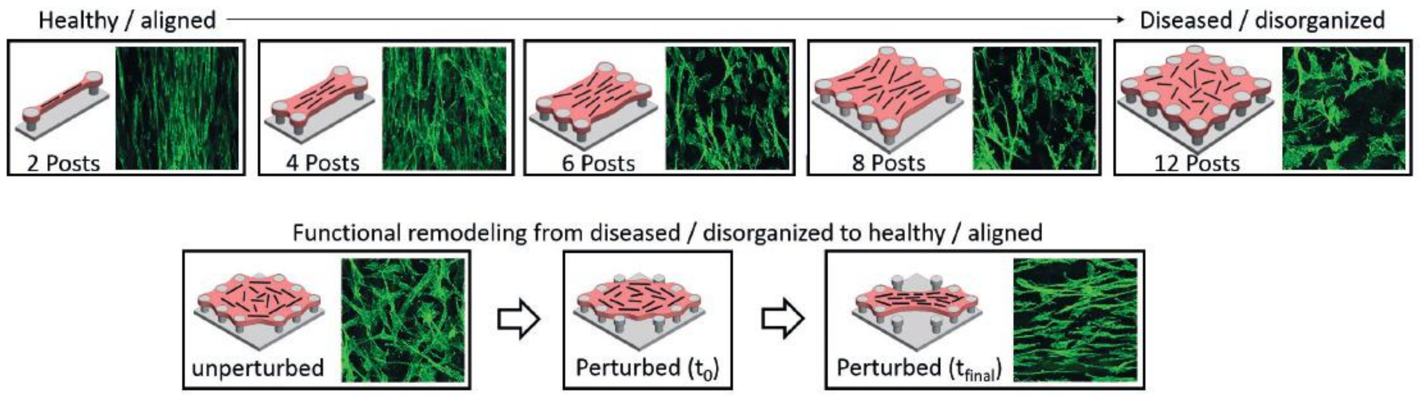
Once damaged or degraded, articular cartilage does not heal without intervention. Using a multidisciplinary approach, computational models are used to optimize functional regenerative implants and combined with in vitro experiments for model development, validation and final proof of concepts studies.

Because disc degeneration is such a common source of disability, we investigate how mechano-biological mechanisms cause disc dysfunction and how it can be applied towards disc regeneration. For moderately degenerated discs we are developing natural matrices that can turn the clock back on disc aging and for more severely degenerated disc we are developing biomimetic artificial discs.

Tendon and ligament injuries are involved in over 30% of all musculoskeletal consultations, but its poor innate regenerative capacity makes treatment of tendinopathy and ligament reconstruction difficult. We explore mechanobiological processes that initiate degeneration and promote healing of tendon/ligament. Experimental platforms are exploited in combination with numerical models to develop strategies to improve its structure and functionality.



When human bone marrow derived stromal cells are differentiated along the osteogenic lineage on silk fibroin scaffolds in spinner flask bioreactors, they will deposit a mineralized matrix resembling bone-like tissue. The growth of this matrix can be followed over time with micro-computed tomography



***Tendon:** Tendinopathy associates with progressive matrix disorganization (tissue scarring), of which the cause and consequences remain unclear. Tissue platforms are therefore designed and exploited that (upper row) mimic 'unscarred' tendon tissue (left), towards progressively more 'diseased and scarred' tendon tissue (right), and (lower row) mimic functional healing of scarred tendon tissue*

Emerging field: lab-on-chip /disease-on-chip

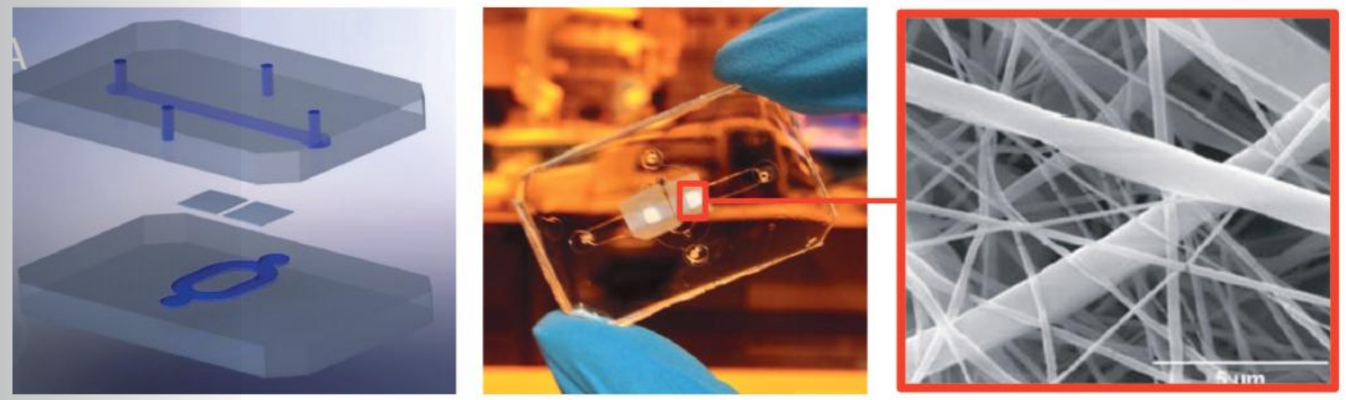


Figure A

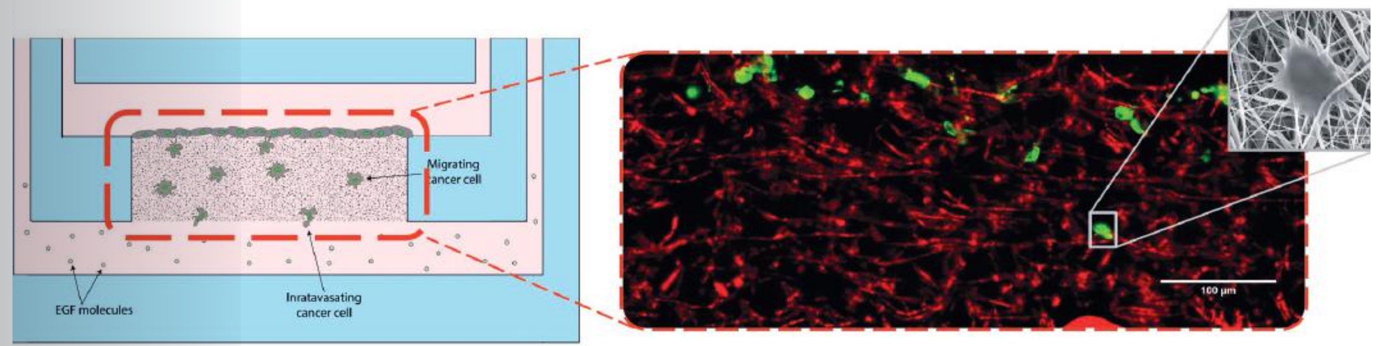


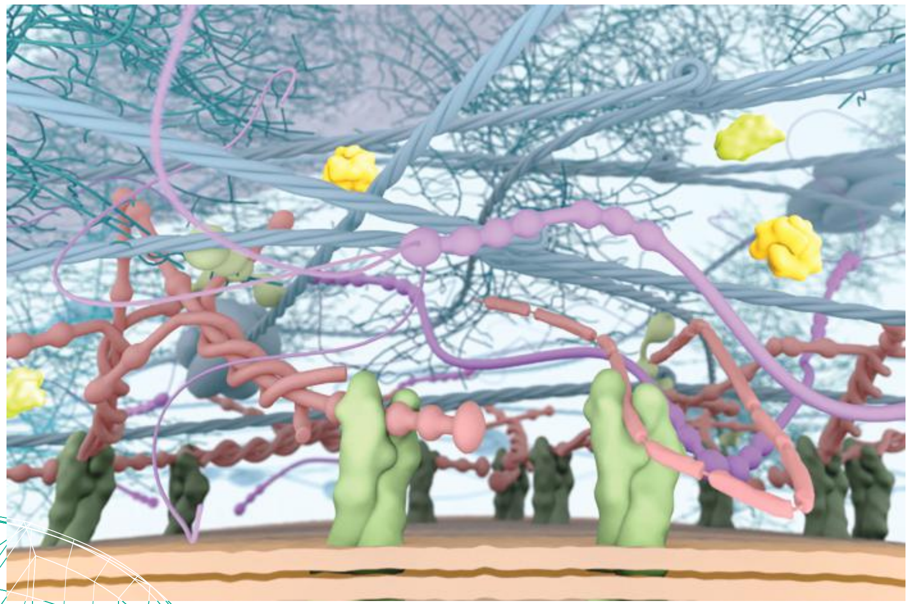
Figure B

The relatively new fields of lab-on-chip and disease-on-chip are enabled by the combination of microfluidic technology, biomaterials, and advanced cell culture. Microfluidic chips are cm-scale transparent devices that contain mm-scale chamber connected by microscopic fluid channels. In these chips, fluid flow can be precisely controlled, biomaterials, sensors, and actuators can be integrated, and biological content can be studied in a well-defined environment. In lab-on-chip devices, biochemical processes that are conventionally run in large-scale labs are miniaturized and integrated. Lab-on-chip can be applied to carry out fast and sensitive analysis of biological samples, including the characterization of single cells. In disease-on-chip on the other hand, the microfluidic devices are used as advanced miniature cell culture systems; by culturing multiple cell types in the controlled environment of the chip, biological function can be created that truly mimics (patho)physiology of the human body. In particular, we are creating tumor-on-a-chip to understand the invasive behavior of cancer cells, and we culture neurons in 3D to understand brain disease.

Example of "Cancer-on-a-chip". A. Microfluidic chip with integrated electrospun PCL matrices. Different porous matrices with different architecture can be integrated in one chip

B. Cancer cell migration in the ECM-containing CoC device. MDA-MB-231 human breast cancer cells are cultured in the upper chamber and migrate through the artificial ECM under the influence of a precise chemotactic gradient. The migration distance of the cells (in green) through the ECM (in red) can be imaged and quantitatively determined. The inset shows an electron micrograph of a migrating cancer cell. (Amirabadi, den Toonder, et al.)

Emerging field: Biomedical materials with life-like properties



Schematic representation of the extracellular matrix, a source of inspiration for the development of synthetic, life-like biomaterials

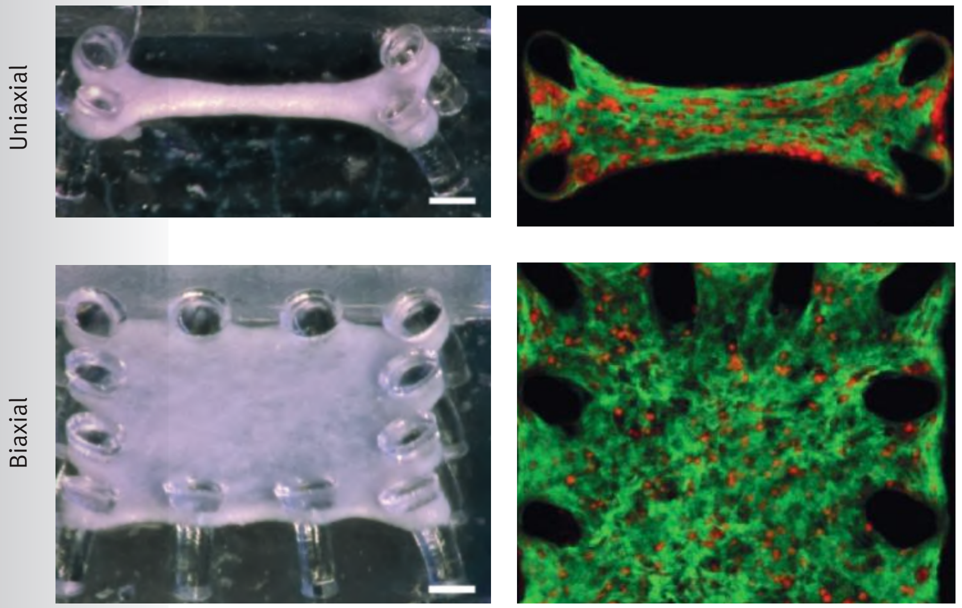
Synthetic biomaterials that interface with body cells and tissues are being developed in the field of regenerative medicine.
In order to support regenerative body processes, such materials should interact in a life-like manner. However, to achieve this, besides control of such materials at molecular level, control at other length scales is also necessary. A source of inspiration for the development of such life-like biomaterials, is the material that surrounds the cells in our tissues, the so-called extracellular matrix.
This specialized biological material is composed of thousands of different molecules. These are held together by way of non-covalent, supramolecular interactions. This extracellular matrix displays the sought-after, life-like behavior, at various length scales.
Using an engineering approach to rebuild this extracellular matrix synthetically, it is expected to be able to develop with materials with emerging behavior and that are able to execute complex functions.

Emerging field

In our synthetic biology program we work on the design and construction of new biological entities such as enzymes, genetic circuits, and cells or the redesign of existing biological systems.

The image shows a synthetically enhanced cell

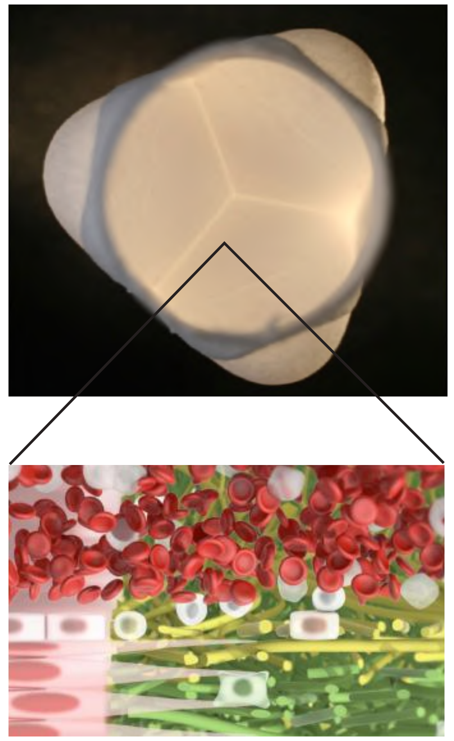
Cardiovascular Regeneration



Engineering the cardiac niche: *Micro-tissues created in the lab to investigate the effects of tissue organization on cardiac muscle contraction*

Driven by the ambition to regenerate the load-bearing tissues of the cardiovascular system (valves, vessels, cardiac muscle) the group addresses both the fundamental and the translational aspects of cardiovascular regenerative medicine.
An important example, with potentially high clinical impact, is the development of a synthetic supramolecular, biodegradable heart valve implant that 'seduces' the body to create a new, living heart valve at the site of implantation by recruiting cells from the environment.
A first clinical trial with the technology started in 2016 under guidance of the group's spin-off company Xeltis.
Other main research lines address the biophysical (stem) cell niche and the restoration of tissue organization in compromised heart valves, vessels and heart muscle.

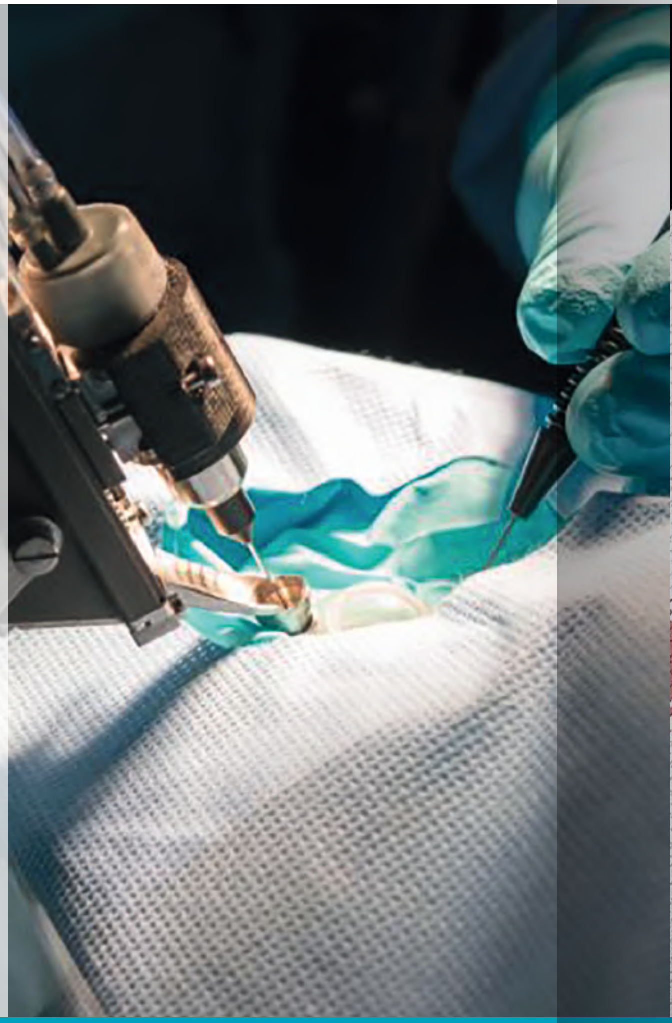
To achieve its goals, the group targets a fundamental understanding of tissue growth, adaptation, regeneration and degeneration through a combination of experimentation and computational modeling.

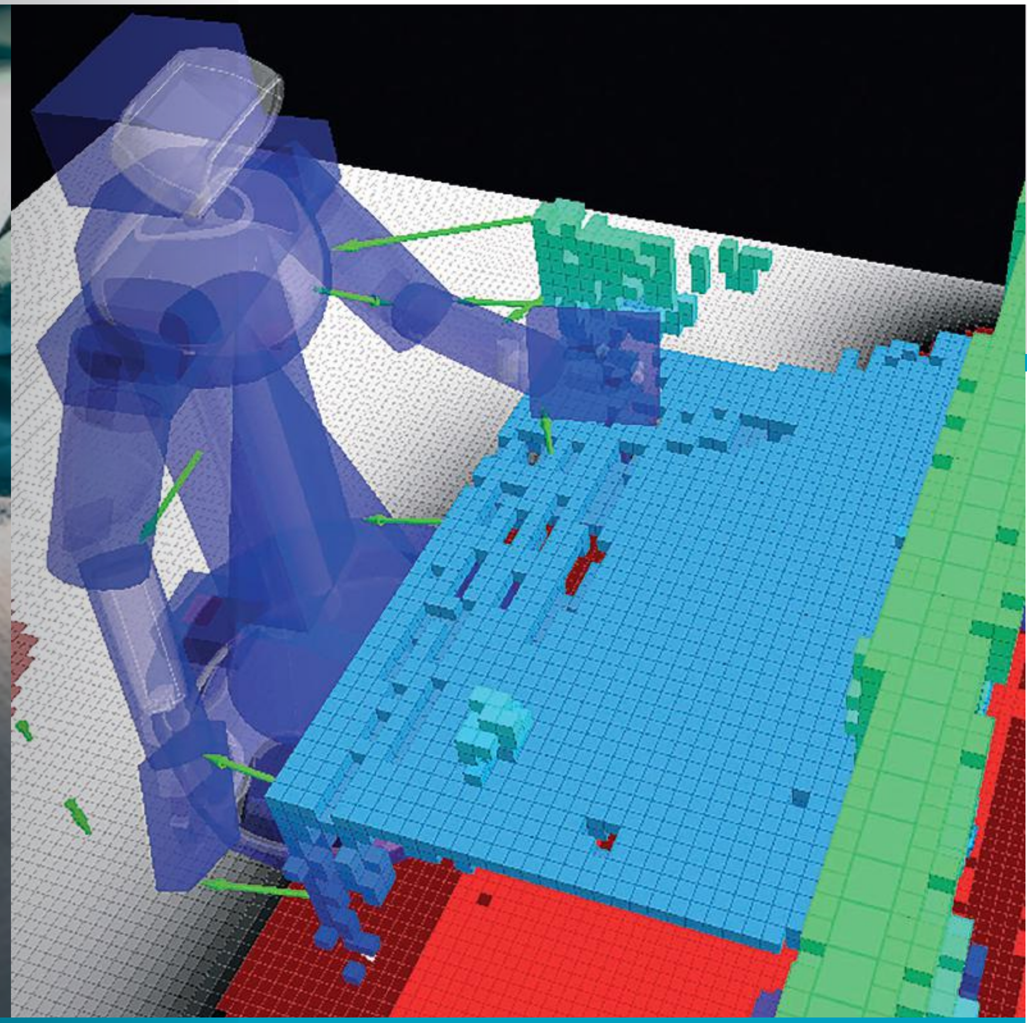


Self regenerating heart valves *Synthetic supramolecular, biodegradable heart valve implant that 'seduces' the body to create a new, living heart valve at the site of implantation by recruiting cells from the environment*

The robotics research group, part of the faculty of Mechanical Engineering, focuses on both healthcare and surgical robotics. In surgery, robotics technology is related to creating assistive devices that enable new surgical procedures. Healthcare technology is aimed towards enabling sustained independent living for elderly people or people with physical impairments at home.

Robotics





Focus Area
Robotics

Focus Area leader
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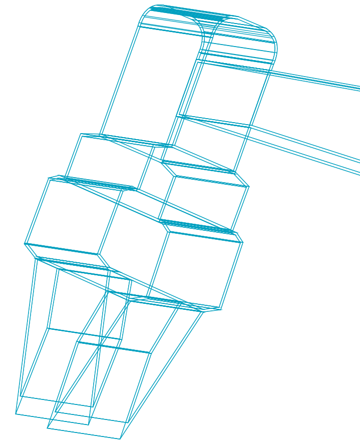
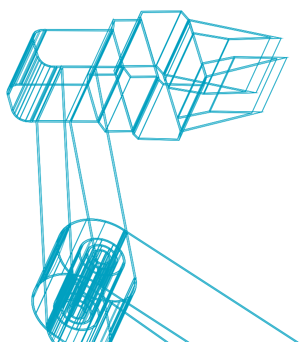


Cure Robotics:

Precision technology instruments

The group utilizes its mechanical and control design knowledge for creating precision technology instruments in (primarily) the semiconductor industry towards medical applications. Since 2001, the group continuous to collaborate with frontrunners in the medical field to create innovative solutions that either greatly improve existing procedures or enables the creation of completely new ones.



Current examples are the Sophie robot for minimal invasive surgery in the abdominal region, an eye-surgery robot that maximes the surgeons precision, a micro-surgery robot for treatment of Lymphedema and lately the finalization of a robot for automated CNC bone milling surgery of the jawbone and a robot for deep brain stimulation surgery. The group holds a firm reputation in spinning out research via medical startups. Currently, spinoffs, Preceyes and MicroSure have had world firsts with the clinical treatments of respectively robot- assisted eye surgery and treatment of Lymphedema. The spin-off Eindhoven Medical Robotics is preparing clinical trials for bone and brain surgery.

Care Robotics:

Providing personal assistance

The major driver for healthcare robotics comes from the fact that the Netherlands will have a big shortage in nursing personnel in the future. In 2040 it is expected that 50% of the people will be retired. Implying a decrease of available care givers and a larger amount of people requiring care in itself. Here, robotics is believed to be one of the technologies that could help either decrease the physical strain for care givers (e.g. people movers and automated lifting devices) and also to provide assistance for people living at home. For example, for picking up items from the refrigerator, providing walking assistance, opening the door.
From a technology perspective, robots are now 'coming out of their cages' and enter a world where each room or object differs from one and another, they need to interact with people and its 'working' environment can change day-by-day. Focus of our research is to create robots that can function in unstructured, dynamic environments, physically interact with people in a safe way, but also can communicate with people in order to make them useful.

Our research results are benchmarked with the world top on a yearly basis at the RoboCup World Championship. Here, the developed technology is tested in the @home league in robots completely designed and made by the TU/e. Since 2014, TU/e maintains a top-3 position in the world, with 2 vice-championship result. Also, since 2017, the group was chosen by Toyota to use their service robot platform as the only university in Europe.

Previous project have been; RoboEarth, Bobbie project, R3COP and R5COP. Currently TU/e is involved in one healthcare project called ROPOD.

Student Team

Tech United

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Improving quality of life @Home

The Tech United @Home team is a student team developing autonomous robots that can enable people to live longer in their home.

This technology is typically aimed at elderly people with loss of physical abilities or physically impaired people (injury or from birth). With the current aging society, it is expected that in 2040, 50% of the people in the Netherlands will be 65+, implying a larger increase demand for personal health care and fewer people to provide this care.

Care robots

Robots are believed to be one of the solutions used to increase the level of independent living people in their current homes, creating a major impact on sustained quality of life. Care robots need to do a lot of different tasks. These are focused around interaction with people and manipulation of the environment. Both require a safe operation to prevent injury people, damage its surroundings or the robot itself. The robot is only as good as the product of all skills. Therefore developing robust, safe and advanced robots is very challenging and complex.

AMIGO

AMIGO (Autonomous Mate for IntelliGent Operations) is the first care robot of Tech United. Currently SERGIO is in development with among others a bigger reach. The focus is on the following scientific disciplines: Human-Robot-Interaction and Cooperation, and Navigation in a dynamic environment, Computer Vision and Object Recognition with normal light conditions, Object Manipulation, Adaptive Behaviors, Behavior Integration, Ambient Intelligence, System Integration and World-modeling.

RoboCup

Our research is focused on all aspects of the care robot. To improve and measure our progress, we annually compete in the International world cup of robots: RoboCup. In this world-wide event many teams participate. After the competition we share all our developments to increase the rate of development. The @Home team has been vice-world champion for three years in a row.

BlueJay

Your future drone assistant in healthcare

BlueJay is a multidisciplinary team founded and formed by ambitious students from all over the world. Next to the daily routine of following courses and enjoying the student life, the team is highly motivated to translate theoretical knowledge into creative, innovative and unique drone-related products.

Drones: friend or foe?

Currently the subject of a public debate, drones are often considered dangerous and intimidating: violating our privacy. At BlueJay, we believe technology is here to serve and help people increase their quality of life. Our team is researching ways in which drones could be used inside hospitals, health institutes and home settings, with the purpose of reducing the high workload of healthcare professionals and making the life of patients easier and more comfortable.

Matching needs and technology

The drone's agility and ability to safely negotiate objects, makes it suitable to work fast and efficiently. A patient who is handed his medicines by a drone, a grandfather who has a drone fetch his shoes upstairs, or a nurse who asks a drone to help out. We are currently exploring the needs and wants of patients, care workers and medical experts. The next step will be to align these requirements with technical solutions: resulting in interactions that are useful in daily life.

We are looking to create partnerships with key organizations, and pitching our product and vision to earn sponsorship deals. Our goal: to build BlueJay, the world's first personal drone assistant in healthcare.

Team Blue Jay is developing a drone that understands you and helps you with daily tasks. It's safe and operates completely autonomously

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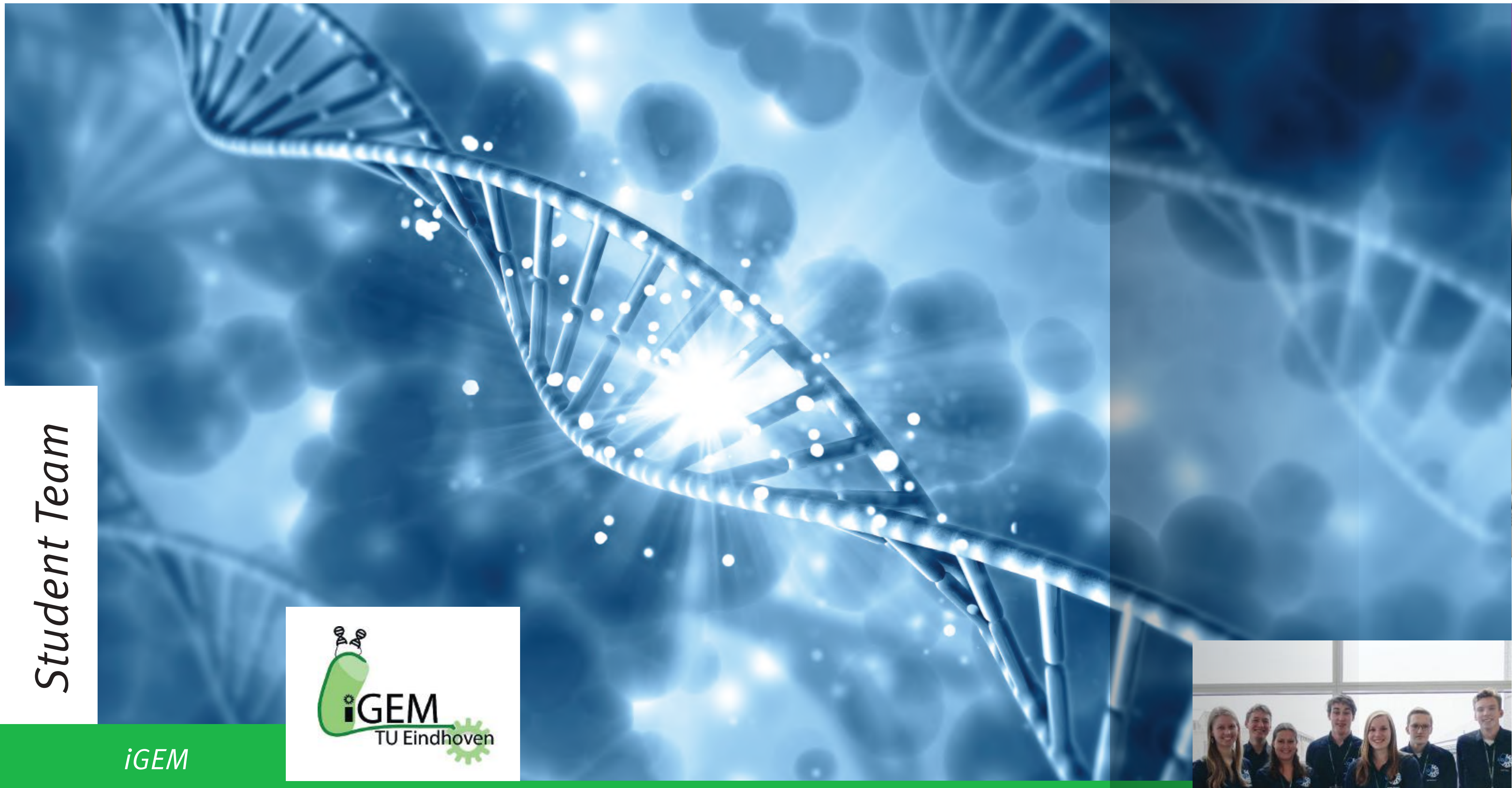


Student Team

iGEM

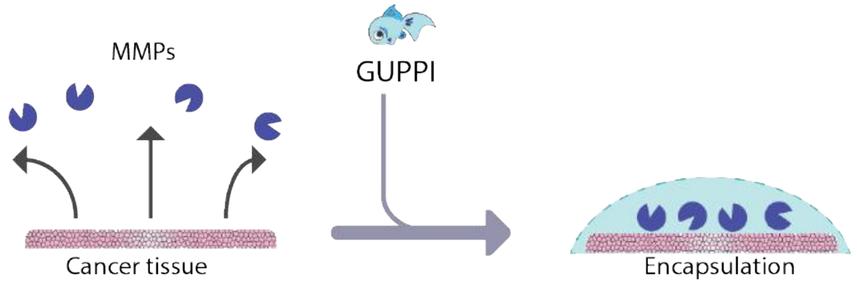
Advancing synthetic biology

iGEM stands for Internationally Genetically Engineered Machine. iGEM is an academic competition aimed at improving peoples' understanding of synthetic biology while also developing an open community and collaboration between groups.

It is the most renowned Synthetic Biology competition for students. The competition began in 2004 and now has over 300 teams competing from locations around the world. the various teams all aim to design and engineer a new, improved method of system using synthetic biology. Projects range from improving the environment to producing new medicines or materials to colonizing other planets.

With this year's project, GUPPI, we hope to set the basics of a system that can encapsulate the cancerous tissue to prevent metastasis in an early stage. GUPPI utilizes Protein Protein Interactions and is inspired by the formation of membraneless organelles by multivalent interactions. A designed protein scaffold and its binding partner, both having sequential repeating units, will respond to an inducer and form a gel-like structure.

Project of iGEM Eindhoven 2017: GUPPI



Team competing in the iGEM competition in 2016. Attribution to iGEM Foundation, Justin Knight

We envision that later on, GUPPI can respond to extracellular conditions that will act as an inducer of the gelation to specifically target and encapsulate the desired tissue. The GUPPI system has some major advantages, such as the tunability of the protein's multivalency and the possible adaptation of interactions. Furthermore, a rule-base-model is developed to predict, verify and characterize the wet-lab experiments and act as an additional support.

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T.E.S.T

Sensor prototype measuring during the SensUs competition

TU/e Sensus Team

Using our knowledge of technology to give severe heart failure patients more control over their health, that is our aim at student team T.E.S.T. (TU/e Sensus Team).

In 2017 we developed a biosensor prototype which can detect NT-proBNP (a biomarker for heart failure) in only a single droplet of blood plasma. With this device we empower and involve the patient in managing their disease and give health care professionals the opportunity to monitor their patients from a distance. Also by frequent monitoring, early signs of deterioration can be identified and treated, which will prevent unpleasant and costly hospitalization.

Detecting this one protein amongst all other molecules in our blood is quite challenging. How do we tackle this challenge? Our sensor uses an optomagnetic cluster assay, in which magnetic particles play a key role. These particles are covered with antibodies, to make sure that only NT-proBNP binds to them. For our application, we need clusters consisting of two of these particles with the NT-proBNP in between. After the incubation phase, the sample consists of clusters (with NT-proBNP) and single beads (without NT-proBNP). During the detection phase we will illuminate the sample using a laser, rotate the clusters using an external magnetic field and measure the scattering intensity on a photodetector. The rotation of the clusters induce a time-dependent scattering signal, whereas for single beads this is not the case. This allows us to quantify the number of clusters in the sample, which is related to the amount of NT-proBNP. And with this elegant technique we have managed to measure that one particular protein in picomolar range.
In short, our biosensor is your laboratory at home!. Our target for 2018 is antibiotics.

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Number of Health related PhD and PDEng researchers

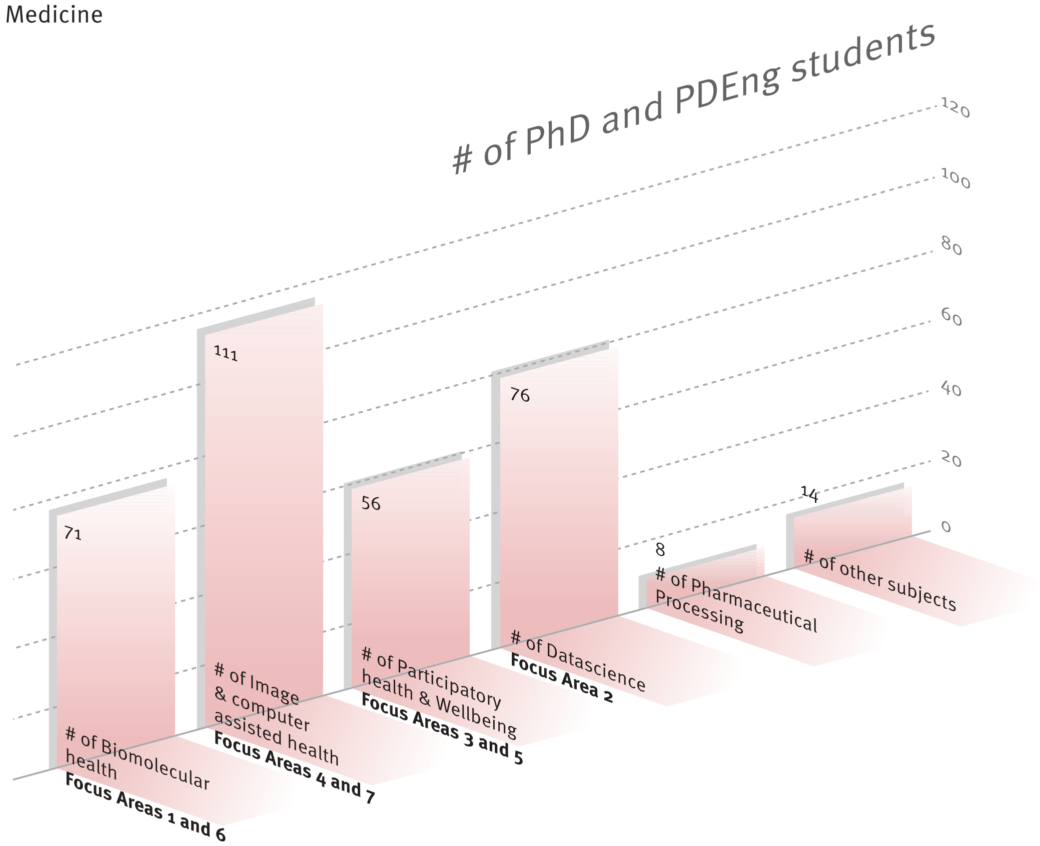
These graphs show the number of PhD and PDEng students that are part of the Strategic Area Health.

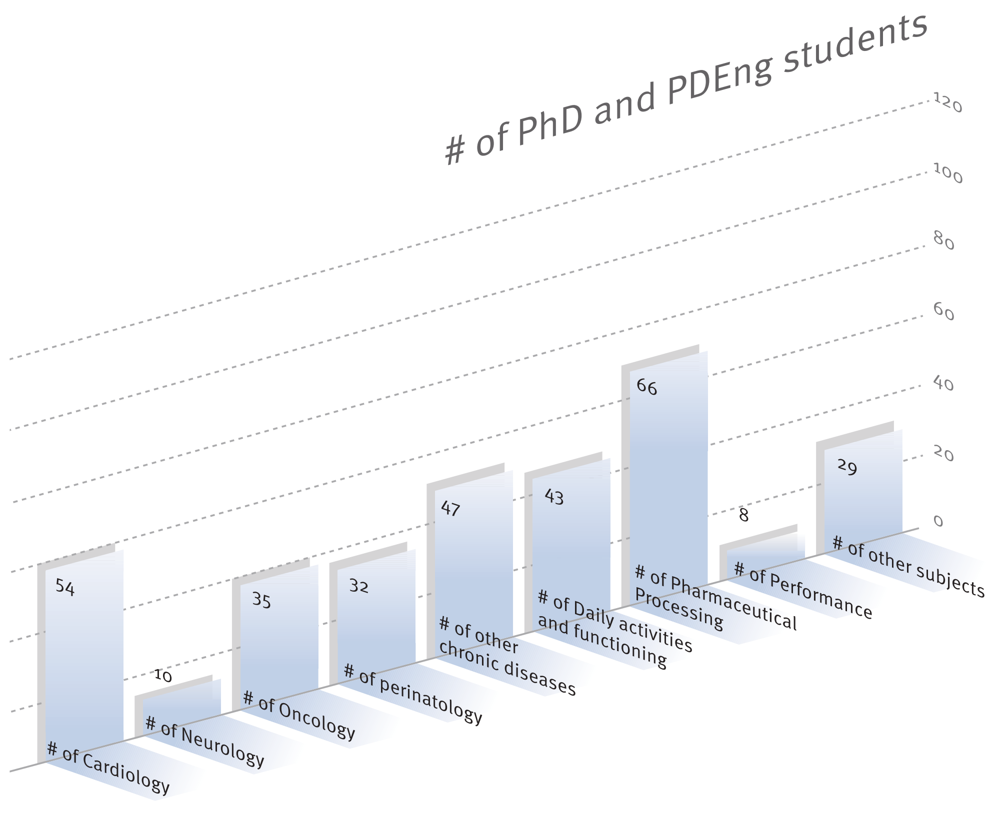
They are shown per:

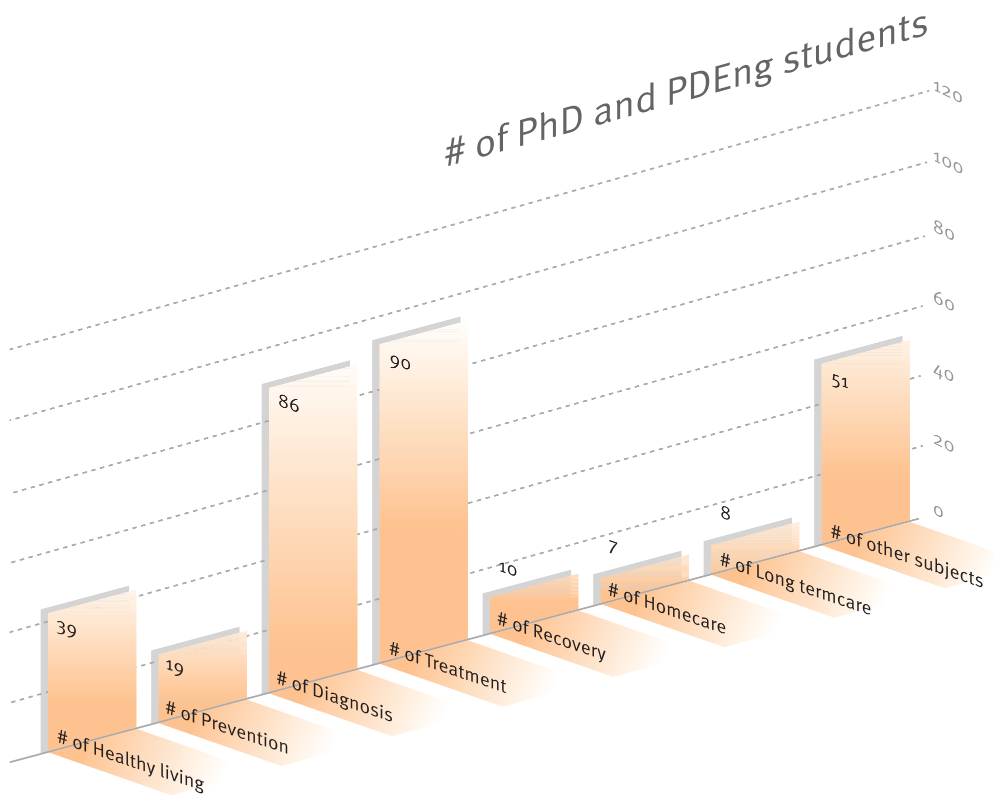
- Focus Area
- Application Area
- Continuum of Care area

There are 7 focus areas:

1. Bio-molecular Sensing
2. Data Science in Health
3. Healthy Daily Living
4. Medical Imaging
5. Monitor, Diagnose and Present
6. Regenerative Medicine
7. Robotics







Bio-Molecular Sensing

Focus Area Leader
prof.dr.ir. Menno Prins

Sub Areas

Molecular Biosensors for Medical Diagnostics
prof.dr.ir. Menno Prins

Chemical Biology
prof.dr. Maarten Merkx

Protein Engineering
prof.dr. Maarten Merkx

Departments
- Applied Physics
- Biomedical Engineering
- Chemical Engineering and Chemistry
- Mechanical Engineering

Data Science in Health

Focus Area Leader
dr. Pieter Van Gorp
prof.dr.ir. Jack van Wijk

Sub Areas

Business process analytics for healthcare
prof.dr.ir. Uzay Kaymak

Cognition and affect in human technology interaction
prof.dr. Wijnand IJsselsteijn

Designerly solutions for vital people
prof.dr. Steven Vos

ICT Platforms for Health and Care
dr. Pieter Van Gorp

Longitudinal health studies
prof.dr. Edwin van den Heuvel

Health in the built environment
prof.dr. Helianthe Kort

Computational biology
prof.dr.ir. Natal van Riel

Linguistic summarization
dr. Anna Wilbik

Program director human vitality & technology
drs. Marieke van Beurden

Urban planning and design for healthy cities
prof.dr.ir. Pieter van Wesemael

Visual Analytics
prof.dr.ir. Jack van Wijk

Vitality & recreational sport
prof.dr.ir. Aarnout Brombacher

Departments
- Industrial Engineering and Innovation Sciences
- Mathematics and Computer Science

Healthy Daily Living

Focus Area Leader
prof.dr.ir. Caroline Hummels

Sub Areas

Healthy cities and smart societies
prof.dr.ir. Pieter van Wesemael

Human vitality and technology
drs. Marieke van Beurden

Interactive technologies and the health continuum
prof. dr. Helianthe Kort

Departments
- Built Environment
- Industrial Design
- Industrial Engineering and Innovation Sciences

Medical Imaging and Monitoring

Focus Area Leader
prof.dr. Josien Pluim

Sub Areas

Diagnosis & Treatment

Automatic precise determination of pathology boundaries
prof.dr.ir. Peter de With

Machine learning for quantitative imaging, prognosis and diagnosis
prof.dr. Josien Pluim

Neuro-engineering
prof.dr.ir. Jan Bergmans

Ultrasound imaging
prof.dr.ir. Frans van der Vosse

Visualization of Big Data
prof.dr.ir. Jack van Wijk

Image-guided Therapy

Cardiac catheter detection and tracking in 3D ultrasound
prof.dr.ir. Peter de With

Neurosurgical guidance
prof.dr. Josien Pluim

Tracking elongated structures
prof.dr. Luc Florack

Ultrasound treatment guidance
prof.dr.ir. Frans van de Vosse

Monitoring

Alarm enhancement for neonatal monitoring
dr.ir. Carola van Pul

Monitoring well-being of neonates
dr. Sveta Zinger

Neonatal monitoring
prof.dr.ir. Ward Cottaar

Sleep disorders
prof.dr. Sebastiaan Overeem

Departments
- Applied Physics
- Biomedical Engineering
- Electrical Engineering
- Industrial Design
- Mathematics and Computer Science

Monitor, Diagnose and Present

Focus Area Leader
prof.dr.ir. Peter de With

Sub Areas

Cardiology
prof.dr. Ronald Aarts

Neurology
prof.dr. Bert Aldenkamp
dr.ir. Rob Mestrom
dr. Sveta Zinger

Oncology
dr. Massimo Mischi
prof.dr. Hessel Wijkstra

Perinatology
dr. Pieter Harpe
prof.dr. Guid Oei
dr. Chiara Rabotti

Department
- Electrical Engineering

Regenerative Medicine

Focus Area Leader
prof.dr. Carlijn Bouten

Sub Areas

Cardio Vascular
prof.dr. Carlijn Bouten

Emerging field: Biomedical materials with life-like properties
prof.dr. Patricia Dankers

Emerging field: Lab-on-chip / disease-on-chip
prof.dr.ir. Jaap den Toonder

Emerging Field: Synthetic Biology
dr.ir. Tom de Greef

Orthopedic
prof.dr. Carlijn Bouten
prof.dr. Keita Ito

Departments
- Biomedical Engineering
- Chemical Engineering and Chemistry
- Mechanical Engineering

Robotics

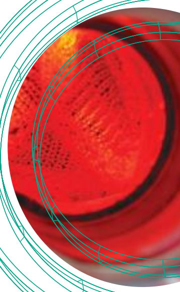
Focus Area Leader
prof.dr.ir. Maarten Steinbuch

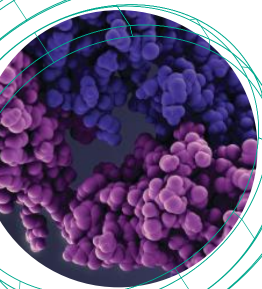
Sub Areas

Care Robots: Providing personal assistance
prof.dr.ir. Maarten Steinbuch

Cure Robots: Precision technology instruments
prof.dr.ir. Maarten Steinbuch

Department
- Mechanical Engineering





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