PRODUCTS FOR HEALTHCARE

Medisign graduation projects 2016-2018
TU Delft | Faculty of Industrial Design Engineering

M. Melles, A. Albayrak, R.H.M. Goossens

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Foreword

It has been twenty years since we published our first booklet: Products for Healthcare. Since then, more than 1000 innovative ideas for healthcare have been developed, making a major contribution to future health scenarios. We are proud to present this seventh edition in this series, showcasing our most recent healthcare graduation projects.

At the faculty of Industrial Design Engineering (IDE) at Delft University of Technology, one of the world's leading design schools, students learn to develop products and services that address society's major challenges. In our Medisign master specialization, we specifically address health care.

In this booklet, we showcase 127 examples of healthcare innovations where our students demonstrate how to map complex healthcare scenarios, involve users and stakeholders to discover their needs and expectations, identify opportunities, and create meaningful and sustainable solutions to improve quality of care. The students are supported in this process by a team of supervisors with expertise in the domains of the healthcare challenge to be addressed. All of these projects are healthcare graduation projects completed by Industrial Design Engineering Master graduates in the period 2016-2018.

Each graduation project takes 100 days, and students are challenged to approach the projects from different perspectives of the three pillars of IDE: human-technology-organization. They apply different research techniques and design methods to discover, define, develop, and deliver products and services that match user requirements, positively impacting societal challenges.

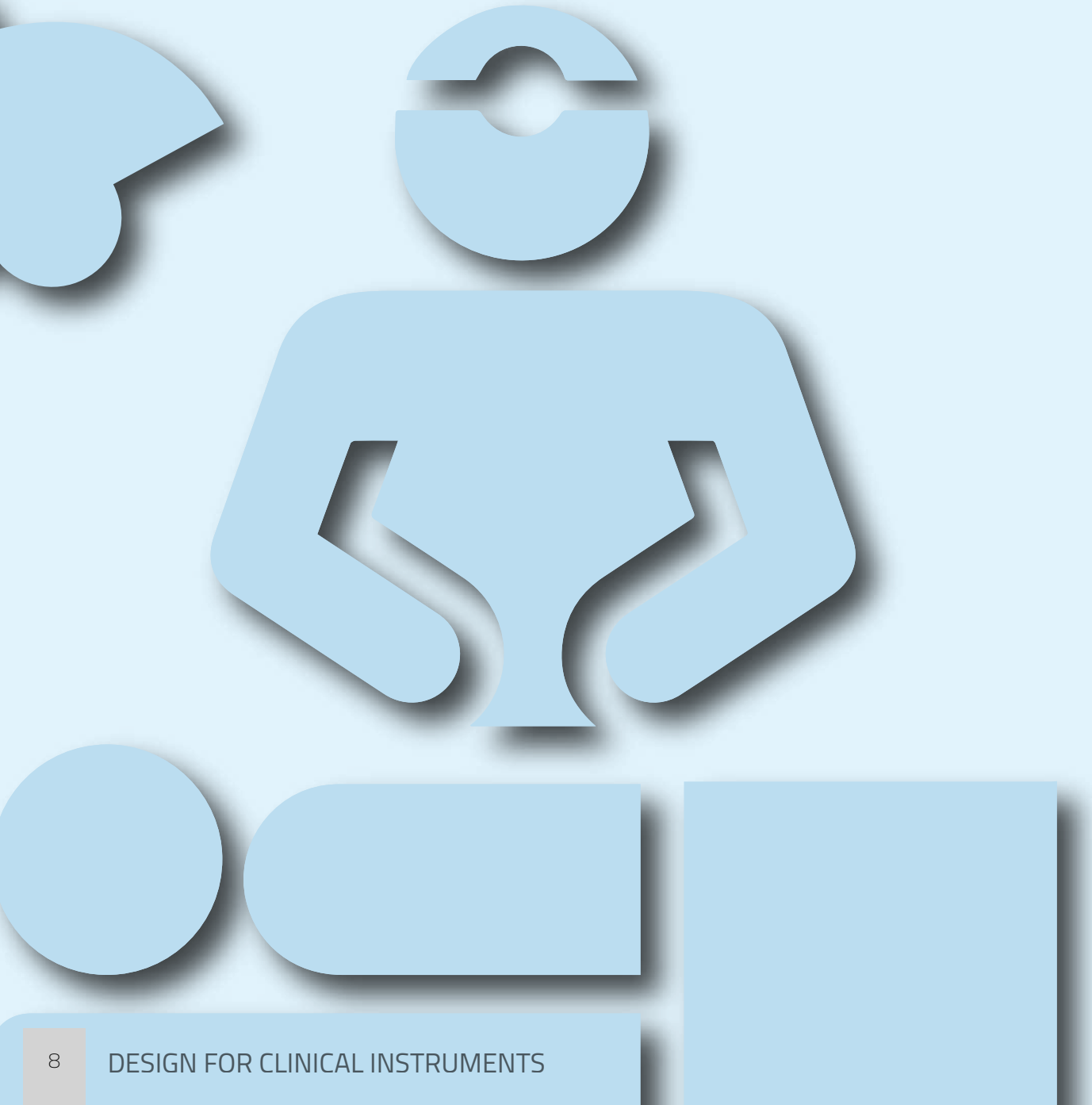
The projects are divided into twelve categories, reflecting on-going developments in society, healthcare and the IDE design research portfolio. The categories range from design for healthcare professionals' clinical and professional skills, to patient empowerment, design for ageing, and developing innovative healthcare business models. We have seen an increase in the number of projects on topics like healthcare facilities and patient empowerment, in line with healthcare trends and developments. The categories in this book are closely related to our research portfolio. New topics are defined in our research programs, are explored in education projects, and the results are fed back into our research. In this way, research and education feed each other with new topics, insights and partnerships.

Once again, we trust that this booklet will inspire you to establish valuable collaborations and create new and exciting healthcare futures.

dr.ir. Armaĝan Albayrak
Coordinator Medisign MSc specialisation

Faculty of Industrial Design Engineering
Delft University of Technology

Delft, November 2019



DESIGN FOR CLINICAL INSTRUMENTS

THE STETHOSCOPE AS AN IMPROVED PRE-DIAGNOSTICS DEVICE

Graduate: Kolja van der Laan (2018)
Supervisory team: A. Albayrak, E.W. Thomassen, T.A. Bruning
Partner: Maasstad Hospital

This graduation project presents a design proposal for a product-service system that helps cardiologists better perform auscultation. Currently, auscultation is usually performed with an acoustic stethoscope, in which the cardiologist tries to recognize abnormalities concerning the patient's heart through attentive listening. Modern healthcare efficiency-driven practices have forced cardiologists and other medical professionals to use their time more effectively, would lead to improved health economics. It is important to note that heart-disease is still responsible for 45% of European annual deaths.

Working together with doctors, a product-service system was created that makes use of Artificial Intelligence, seamless automation, improved ergonomics, and feedback loops in order to help the cardiologist during auscultation. The aim was to design a diagnostic tool that improves medical effectiveness and diagnostic potential, facilitating cardiologists conducting auscultation. The resulting design is an electronic stethoscope that unobtrusively improves the efficiency of the auscultation process; benefiting both the cardiologist and the patient.

A working prototype was built and qualitatively evaluated with several cardiologists during a presentation at Maasstad Hospital. It was extremely positively received regarding both its appearance and the presented functionality.

A CUSTOMIZABLE IMPLANT FOR THUMB ARTHROPLASTY

Graduate: Karel Bramer (2017)
Supervisory team: R.H.M. Goossens, Y. Song, A.A. Zadpoor, G.A. Kraan
Partner: Reinier de Graaf Hospital

The lifespan of the current thumb base prosthesis to replace the trapeziometacarpal (TMC) joint is low; only 5-10 years compared to 15-20 years for a hip arthroplasty. This is due to the complex biomechanics of the carpometacarpal joint. In this graduation project, the focus was on the design of a novel and customizable prosthesis with a durability similar to the hip and knee implants.

To find the parameters to build a customizable implant, the variation of the trapezium, the metacarpal and the TMC joint were analyzed using a Statistical Shape Modelling tool. Furthermore, the kinematic characteristics of the joint using 4D CT technology were studied. This technology enables the visualization of the motion of the bones in-vivo after segmentation. The TMC joint of three healthy subjects were investigated; the resulting transformation matrices were then used to evaluate the concepts.

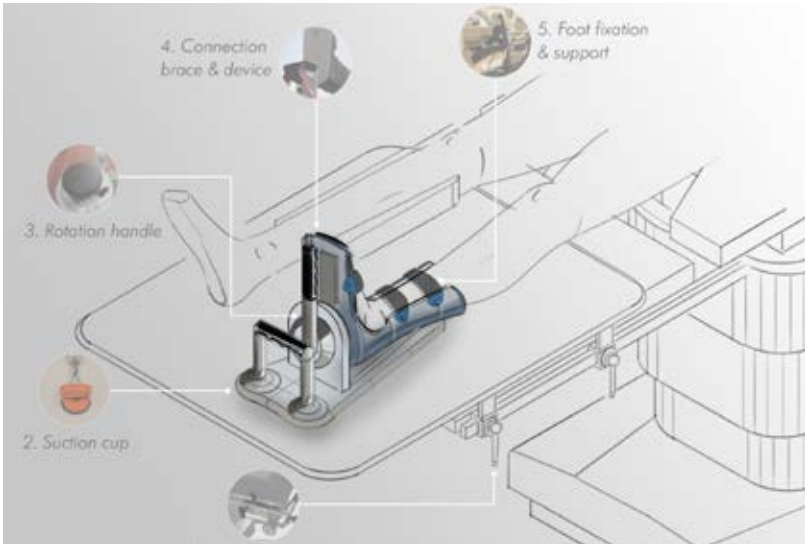
A customizable implant was designed to generate personalized implants that resurface the trapezium. The method accurately mimics the trapezium articular surface but needs to be developed further to mimic the kinematical characteristics.

THE SURGEON IN THE DRIVER'S SEAT

Graduate: Adriaan Bovendeert (2017)
Supervisory team: R.H.M. Goossens, S.G. Van de Geer, G. Mangan, S. Nash
Partner: Zimmer Biomet, Reinier de Graaf Hospital

There are many different surgical approaches when performing a total hip arthroplasty. One of these, the anterior supine intermuscular (ASI) approach, is less invasive than other approaches and has advantages like a quicker and less painful recovery. However, due to its intermuscular nature, surgeons experience difficulties approaching the hip joint. To improve access to the hip joint, table attachments are used however, these are not optimally designed to position the leg as desired and to manually execute checks of the prosthesis during surgery. Furthermore, the table attachments can cause discomfort for the patient due to mechanical fraction. Moreover, an extra person is needed to handle the table attachment.

To solve these problems, the Float was designed and a working prototype was built. The Float enables orthopedic surgeons to position and hold the operative leg of hip-patients using an ankle brace to fixate the patient's foot and shank. While the leg is fixated, a 'ball socket nipping mechanism' enables the surgeon to move the leg with three degrees of freedom. A fourth degree of freedom is reached by sliding the Float over a plate. A suction cup can fixate the device in its current position. In addition, the ankle brace can be detached from the Float device to check the leg length and impingement. The third check; stability of the joint, can be executed when the ankle brace is attached to the Float. Because of its compact size, Float can be easily moved in and out of the OR.



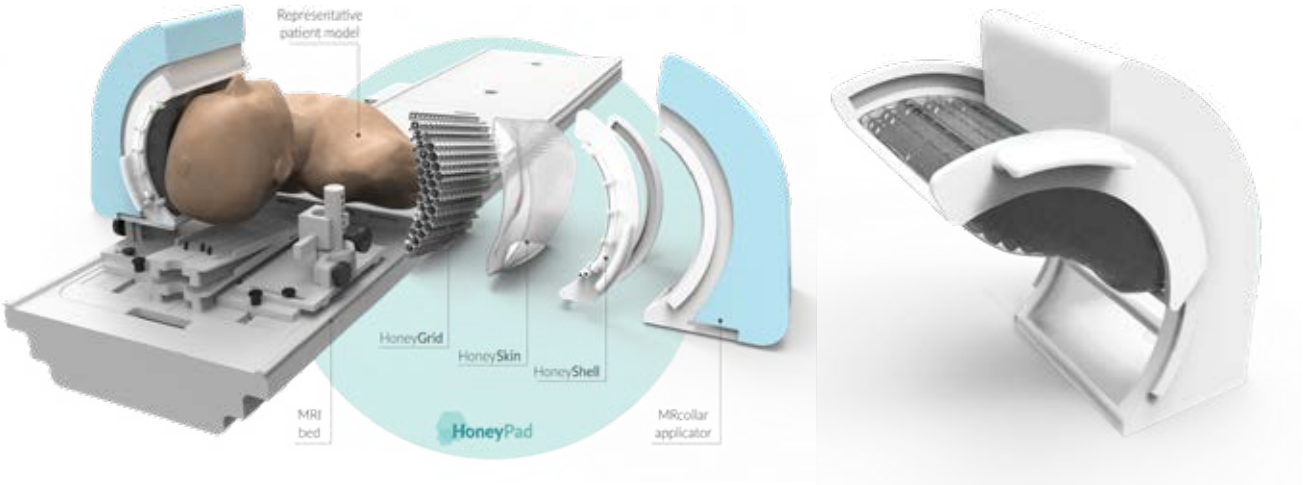
ERGONOMIC WATER BOLUS DESIGN FOR HYPERTHERMIA TREATMENT OF HEAD AND NECK CANCER PATIENTS

Graduate: Lisa van den Berg (2017)
Supervisory team: I.A. Ruiter, N. Bogerd, M.M. Paulides
Partner: Erasmus Medical Center

Hyperthermia is a clinical cancer treatment method that relies on the principle of selectively heating tumor tissue at temperatures between 40 - 44 °C. For most head and neck tumors, Deep Hyperthermia Treatment (DHT) is applied, in which electromagnetic energy is emitted to the tumor tissue located ≥ 4cm below the skin surface. At Erasmus Medical Centre Cancer Institute in Rotterdam, electromagnetic energy is applied from a circular-shaped applicator placed around the patient's head or neck. A water bolus is placed between the applicator and the patient's skin to act as a cooling medium to prevent skin burns and as a transferring agent to conduct the electromagnetic energy to the internal tumor tissue.

The goal of this graduation project was to redesign the water bolus currently applied in DHT at the Erasmus MC to increase patient- and operator comfort. The focus was on the design of an ergonomic fit for the water bolus and development of a method for uniform skin cooling and pressure control.

For an optimal ergonomic fit of the water bolus, a 4D anthropometric model of the head and neck was developed based on the 3D images of head and neck cancer patients treated at Erasmus MC. Additionally, to secure appropriate cooling and pressure, a honeycomb grid was developed. The pattern of cavities in the grid guides circulating water through the entire volume to uniformly cool the skin. Furthermore, the grid itself provides shape stability to the water bolus, whereas the sides of the grid in contact with the patient's skin provide flexibility. In addition, the water bolus was designed in a manner to enable an easy attachment to the deep DHT equipment using a sliding mechanism.



THE HYDROGEL APPLICATOR: PREVENTING THE RISK OF PERIPROSTHETIC INFECTIONS

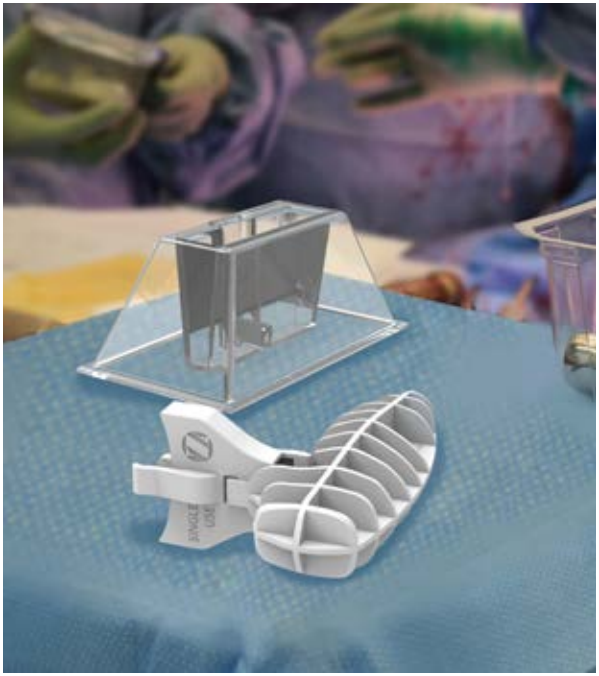
Graduate: Karlien Kleissen (2017)
Supervisory team: R.H.M. Goossens, I.A. Ruiter, H. Bodewes, I. Khan
Partner: Reinier de Graaf Hospital, Zimmer Biomet

The risk of infection for primary joint replacement (PJI) is estimated between 0.5-1.5%. These periprosthetic infections are a burden for the patient as they require extra treatment or in some cases, even a new implant. These infections also add to the current costs of the healthcare system.

Zimmer Biomet is working on a new system to reduce the risk of periprosthetic infections. The new system aims to prevent the formation of a biofilm by covering the surface of the implant. This hydrogel layer has to prevent bacteria from attaching to the implant.

This graduation project focusses on the development of a design proposal consisting of a bearing dip tool and a hydrogel dip tray. The surgeon uses the dip tool for dipping the bearing in the anti-bacterial gel before insertion into the patient's knee.

The bearing dip tool is made of medical grade Acrylonitril-Butadieen-Styreen (ABS) by use of injection molding. The length of the clamper and the geometry of the attachment pins are optimized by making use of a mathematical model in the software tool Maple. The ergonomic design ensures comfortable use of the handle.



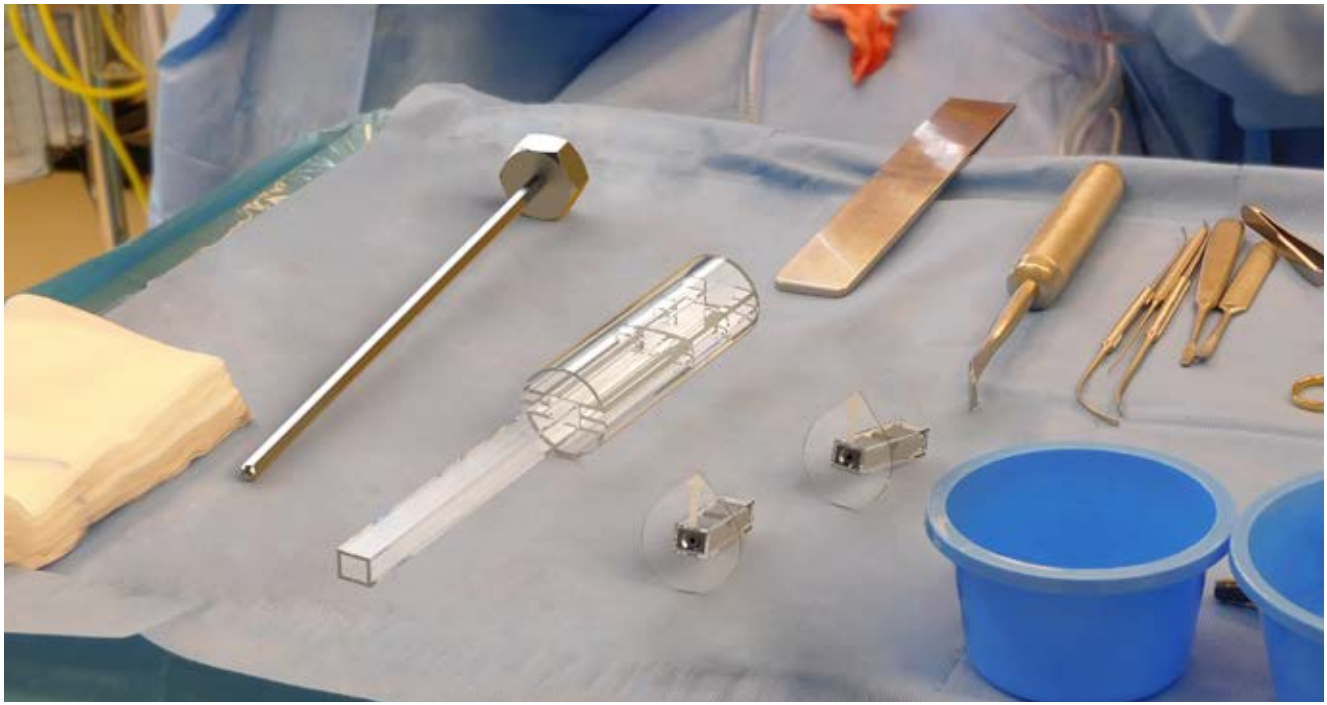
CLEARFIX: A MINIMALLY INVASIVE SPINAL CAGE APPLICATOR

Graduate: Mark Hoedemaker (2017)
Supervisory team: R.H.M. Goossens, Y. Song, S.M. Ahmadi
Partner: TU Delft

When the intervertebral disc herniates in a specific spot, the herniation can press against the exiting nerve root, possibly causing pain in different leg areas. To treat these symptoms, an interbody fusion can be performed. During the surgical procedure, two or more vertebrae are fused together at the location of the intervertebral disc. This is achieved by removing the intervertebral disc and replacing it with one or more fusion implants (spinal cages) to maintain spine height and alignment, and bone graft.

Spinal cages are implanted using applicators. The conventional applicator is cumbersome, especially for the scrub nurse who prepares the instrument before insertion.

Clearfix is a minimally invasive spinal cage applicator designed with a low workload in mind. It comes with a cartridge containing the spinal cage that can be easily inserted into the applicator, greatly reducing the time and workload needed to prepare the instrument.



FIXATION TECHNIQUE FOR PERIPROSTHETIC FEMUR FRACTURES

Graduate: Bo Koperdraat (2017)
Supervisory team: R.H.M. Goossens, M. Stijntjes, H. Verburg
Partner: Reinier de Graaf Hospital

This graduation project focusses on the design of a new fixation technique that bridges the femoral component of the TKR and the healthy bone above the fracture, enabling a solid fixation. As a result, an expansion clamp that makes use of a fixation device between the longitudinal surfaces was developed. An additional locking plate was designed to fit the expander and bridge the component to the healthy femur above.

The final design and its main features have been validated with experts, reflecting on requirements, safety and usability. In conclusion, it is likely that the expander, together with the additional locking plate, will provide a more solid fixation of a periprosthetic fracture by integrating the femoral component of a TKR.

IV SET FOR NEONATAL INTENSIVE CARE

Graduate: Myra Vreede (2015)
Supervisory team: R.H.M. Goossens, A. Albayrak, L. Evers
Partner: UMC Utrecht, Pontes Medical

Pre-term infants and newborn babies that lack the physical mechanisms to survive on their own are cared for in the Neonatal Intensive Care Unit in incubators. This field of healthcare requires the highest level of accuracy in drug administration, relating to this very special group of patients. Therefore Innofuse, an innovative Pontes Medical project, developed a principle for an Intravenous (IV) set. It merges the various fluids like nutrients and drugs, and improves the accuracy and immediacy of administration.

In this graduation project, the focus was on the development of the principle of the IV set. The result is Tulive, a disposable IV set designed by incorporating the nursing staff's perspective. Its design is based on the concept of shape completion. It is self-explanatory and intuitively guides users through the required actions.

Tulive is connected to several infusion lines containing drugs or nutrition to be infused into the patient. Critical drugs can be connected directly to the Tulive manifold. The enclosed connectors prevent wrong attachments of lines in the Tulive, ensuring safe product use.

A prototype of the final design proposal was built and evaluated with the nursing staff. User testing showed the need for feedback of human actions on more levels, and the value of simplistic and unambiguous use cues.

THE SURGICAL TAG APPLICATOR

Graduate: Kenneth Tan (2017)
Supervisory team: H. de Ridder, C.L. Nauta, C.G.F. van Lanschot
Partner: Erasmus Medical Center

For head and neck cancer, the main treatment is surgery. Its goal is to remove the tumor with adequate margins; these comprise healthy tissue. Communicating the location of a margin on the tissue is difficult due to the complex anatomy and three-dimensional structure of the wound bed. A 'pairwise parallel tagging' method is under development at Erasmus MC that involves placing pairs of physical markers ('tags'). As this method's first implementation is time-consuming as it requires suturing small plastic tags onto tissue by hand. Therefore a product is required that will streamline the application process.

The result is a product system consisting of the tags, an applicator and a remover. The tags have tiny metal staples that anchor themselves into tissue by folding inwards; a quicker and more reliable method than using sutured tags. The applicator features two sets of jaws in order to apply tags in pairs; this improves accuracy and reduces application time. A tag remover allows extraction of the tags when the surgery is completed.

A user evaluation and risk analysis was conducted to evaluate the tag applicator. It gave valuable insights for further development in e.g. tag dimensions and actuation force.


CEMENT APPLICATION GUIDE
TIBIA - SIZE 6

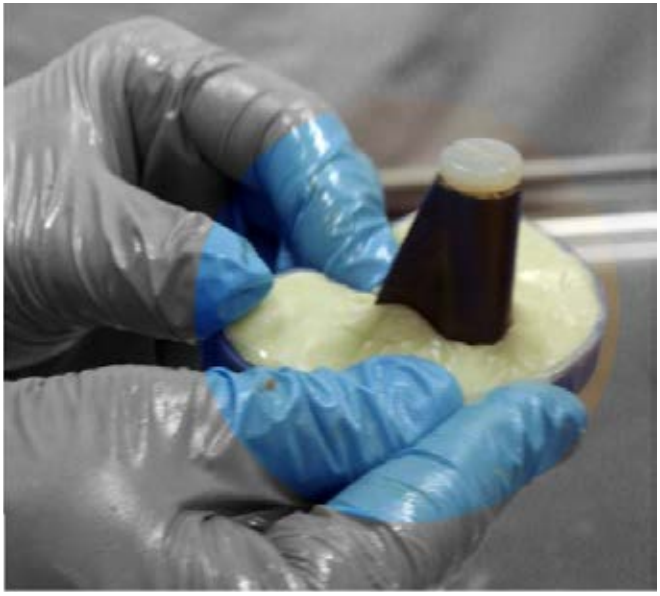
CONTROL OF CEMENT PENETRATION IN TOTAL KNEE ARTHROPLASTY

Graduate: Rinze Venderbosch (2015)
Supervisory team: R.H.M. Goossens, E.R. Valstar
Partner: Maatschap Orthopedie en Traumatologie Delft, Reinier de Graaf Hospital

Total Knee Arthroplasty (TKA) is a successful surgical intervention; the degenerated cartilage layers of the knee are replaced with a metal and plastic knee prosthesis. Survival rates of knee prosthesis are generally in the range of 90% - 95% implant survival after 10 years.

Although optimal cement penetration is an important determinant of long-term prosthesis fixation, different cementation techniques are used in clinical practice. These techniques all have one thing in common: proper cement application mostly relies on the surgical experience of the surgeon rather than on any guiding tools.

A cement guide was designed in order to improve cement penetration. It introduces an optimal method to apply a predetermined volume of Polymethylmethacrylaat (PMMA) bone cement. The cement pocket is filled before the tibial component is implanted keeping the cement guide firmly pressed onto the resected proximal tibia. Cement leakage is therefore reduced and the effective pressure on the cement increased. In combination, this allows the cement to irrigate deeper into the trabecular bone structure. Furthermore, the guide improved reproducibility and cement penetration, without significantly increasing current procedure costs. The design was validated by in vitro product testing.



IMPROVING HIP REVISION SURGERY

Graduate: Paulien Klap (2017)
Supervisory team: J.E. Oberdorf, S. Dehli, M. Paalman, O.P.P. Temmerman
Partner: VU University Medical Center

When people experience pain, discomfort or limited mobility in their hip joint they can get a hip implant. This implant improves movement and reduces pain and discomfort. These implants need revision after ten to fifteen years for a number of reasons; however revision surgery is long and invasive. Especially, the removal of cement around the implant can be challenging.

In order to improve hip revision surgery, a new set of instruments was designed to remove the cement and restructured the procedure. The instrument set supplies the surgeon with the right number of instruments needed to perform cement removal. The Guido, a drill guide that helps the surgeon remove the cement that is hardest to reach, reduces cement removal time and improved safety. The procedure and instrument set were validated with medical professionals. A prototype of the Guido was developed and tested on fake bones by three orthopedic surgeons. The procedure and instrument set including the Guido drill guide were all well-received by the participating surgeons.

INTRAOPERATIVE ASSESSMENT OF TISSUE PERFUSION

Graduate: Jan Okkerse (2018)
Supervisory team: R.H.M. Goossens, Y. Song, J.J. Jakimowicz, D. Schaap
Partner: Catharina Hospital

When someone has colon cancer, parts of this organ can be surgically removed to eliminate the cancer. The residual parts are connected by suturing. This must be done carefully as poor healing of the surgical wound can lead to a leakage of the colon, causing severe complications. These can be life-threatening.

Adequate blood perfusion plays a key role in the healing process and thus lowers the risk of such leakages. A good understanding of tissue perfusion is therefore of the utmost importance. By means of a contrast dye, a special light and camera, the perfusion can be visualized even when under tissue. The imaging technique provides the surgeon with essential information via screens that is not visible by the naked eye during an open surgical procedure. However, these images are still subject to various external factors like the perception of the individual surgeon. Ideally, the information should be objective and not susceptible to these factors. To achieve this, both software and hardware developments are needed.

In this project, the focus was on hardware development. Factors affecting objectivity were assigned and investigated how design could control or even eliminate them. The project focused on two of the main factors namely; external light and the manner of acquisition. The proposed design includes features that exclude the external light, and propose a manner to standardize the distance from the laparoscope to the surgical site. The design serves to assess if controlling these factors truly improves the imaging technique's objectivity in a pre-clinal setup.

DESIGN FOR PROFESSIONAL SKILLS

SEAMLESS INTERACTIONS BETWEEN MEDICAL PROFESSIONALS IN STRESSFUL ENVIRONMENT

Graduate: Ewoud Komen (2018)
Supervisory team: M. Melles, A.Q. Beekman, V. Pijl
Partners: Offroad: Apps & Things

The Royal Netherlands Army often works under highly demanding circumstances, ranging from peacekeeping missions to supporting domestic emergency services during mass casualty incidents. Combat medics (in Dutch AMV-er) are deployed at the front line: as first responder, they need to oversee triage, treatment, and evacuation of casualties in which local resources and medical treatment facilities are overwhelmed by the number of casualties. Currently, they maintain an oversight of all the medical processes within the designated casualty treatment area by relying on paper triage tags and their own cognitive abilities, which are tested to the limit, especially during combat operations. To understand this highly complex environment in which a multitude of stakeholders are interlinked, great emphasis was placed on the analysis phase. Through participatory observations and expert interviews, a concept was created and tested with combat medics of the army's 43 Mechanized Brigade.

StatIQ is an application that can be used on a smart watch, providing combat medics with a much-needed oversight. Vital signs of their patients are measured through sensors integrated in the uniforms. This data is then provided to combat medics on their smart watch, ranking casualties at the scene of the incident with the highest priority (in need of immediate evacuation) to those with a low priority. StatIQ acts as the link between the data of the patient status and the situational awareness of the combat medic.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EFFORTLESS INTERACTIONS FOR EMERGENCY CARE

Graduate: Valeria Pannunzio (2016)
Supervisory team: N.A. Romero Herrera, A.Q. Beekman, M. Heesemans
Partner: Philips

Ambulance nursing activities require focus, control, cold blood and quick decision making. At the same time, they require the ability to capture and report all relevant medical data from the scene to ensure an effective transition into long-term care. Currently, reporting necessities take up an excessive share of nurses' time, effort and focus, with suboptimal effects on direct patient care.

The design process was characterized by a strong focus on analysis, in particular on user research including intensive data collection activities such as direct observation of ambulance shifts. After an iterative conceptualization phase, a final product idea was detailed and its interaction tested with real users.

The final design is an earpiece enabling the nurse to file relevant information about the rescue by voice command, enabling nurses to maintain constant visual and tactile contact with the patient. Other hand and eye-free interactions permitted by the device are calls and protocol checking.

ALLERGENIE: FINDING POSSIBLE CAUSES OF ALLERGIC SYMPTOMS

Graduate: Marieke Lous (2017)
Supervisory team: H. de Ridder, A. Albayrak, S. Kos
Partner: Maasstad Hospital

The aim of this project was to create a product to implement a newly developed algorithm to aid in the diagnosis of allergies. Interviews with allergy patients, allergists, and other specialists were conducted to gain information on their experiences. Literature research was conducted on recent allergy diagnosis discoveries. Information was clustered, and a specific target group was chosen: general practitioners and their patients. Two concepts were developed and discussed with the target group. One concept was chosen and an interactive prototype developed. A user test was conducted to test the usefulness and usability of the design.

Allergenie is an app used to keep track of food intake, use of care products, and symptoms. The patient can scan product barcodes with the app which is linked to a database containing all ingredients. At the end of the tracking period, the patient exports their input into a timeline which links symptoms to possible allergens consumed in the timeframe, before the symptoms arose. If an allergen is suspected of causing the patient's symptoms, the GP orders a blood test using the algorithm.

MANAGEMENT AND PREVENTION OF PERIPROSTHETIC JOINT INFECTION CASES

Graduate: Michaël Vijfvinkel (2018)
Supervisory team: A. Albayrak, A.Q. Beekman, H. Bodewes
Partner: Zimmer Biomet

Periprosthetic joint infection (PJI) is a severe complication that can follow total joint replacement. PJI has a tremendous impact on patients, causing physical and mental strain, and the patient's health never returns to what it was prior to the complication. Furthermore, it places a major financial burden on hospitals and society. Research in this thesis shows that one of the greatest problems concerning management and prevention of PJI cases is the knowledge gap between the guidelines defined by PJI experts and the applied knowledge by staff.

The multidisciplinary team (MDT) dashboard helps in the diagnosis and treatment decisions of PJI cases. It is used both prior to and during the MDT meeting, where a team of physicians from varying disciplines discuss PJI cases to discuss diagnosis and decide on the optimal treatment. The dashboard provides visual aids to help all members communicate their expertise and viewpoint and to ensure that every aspect is discussed. In addition, it gives a non-binding advice based on patient data and guidelines developed by PJI experts. A digital prototype and implementation strategy of the dashboard have been developed and evaluated.

IMPROVING MULTIDISCIPLINARY TEAM MEETINGS IN NEURO-ONCOLOGY

Graduate: Jesse Beem (2016)
Supervisory team: M. Melles, T. van Rompay, S. Peerdeman, M.C. de Bruijne
Partners: VU University Medical Center

Multidisciplinary meetings (MDMs) in neuro-oncology serve the purpose of discussing complex patient cases for which input and expertise from different medical disciplines is required. High quality communication and collaboration during these weekly meetings are essential for shared situation awareness, decision making, and action planning. The aim of this project was to investigate how design and technology can help create conditions in which the various medical specialists can make optimal use of the multidisciplinary aspect of an MDM.

The impact of the environmental context in which MDMs take place on communication and collaboration was investigated as well as interaction patterns between the different specialists. Using work modelling techniques based on observations and interviews, design directions for improving MDMs were defined.

MDM PLUS+ consists of two parts; MDM Blueprint and Viscom. MDM Blueprint is a list of MDM room layout requirements which can be used to optimize current MDM rooms and guide the construction of new rooms. Guidelines include seating arrangement, lines of sights and spatial layout of the room. Viscom is an application that serves to bring differences in perspectives between disciplines in line to improve shared situation awareness. Viscom visually explicates the viewpoints of the different team members by dynamic drawing on live-synced tablets.

STRESS REDUCTION AMONG NEONATAL NURSES: PERSUASIVE GAME DESIGN

Graduate: Pascale de Rond (2017)
Supervisory team: V.T. Visch, W. Schermer, C. de Boer
Partner: Erasmus Medical Center, Sophia Children's Hospital

Interactive Mood is a digital solution that raises awareness of stress among neonatal nurses, and stimulates social support within the team. Neonatal nurses encounter a great deal of stress, ranging from a high workload and a shortage in staff to the emotional burden deriving from the contact with newborn babies and their relatives. This may lead to mental and physical health issues, and in the long term, absenteeism. Addressing this issue not only benefits nurses' health, but also increases the quality of patient care, thereby bringing benefits to the organization. Therefore, the goal of the project is to contribute to a reduction in perceived stress of neonatal nurses.

Interactive Mood is a digital application in which the NICU is displayed in a cartoon-like design. Nurses' team mood is metaphorically presented by means of the weather. Sunny weather stands for a positive mood in the NICU, whereas rain represents a negative mood. Nurses enter their mood manually and the application thereafter displays the average weather as the mean of all the input. A beta-version of the application was programmed to evaluate the design, usage and effects of Interactive Mood among NICU nurses. Initial results were positive, with recommendations to test Interactive Mood in the long term to improve the desired effect.

REFRAMING EMERGENCY CARE: A PATIENT CENTRIC INFORMATION SYSTEM

Graduate: Kathrin Höfer (2017)
Supervisory team: M.B. van Dijk, A.Q. Beekman, F. Goethals
Partner: UMC Utrecht, Pontes Medical

In this project, the focus was on designing a patient-centric information system that facilitates a seamless dialog between care teams and patients in emergency care.

The result is MED Dialog, a communication system for emergency care to support healthcare professionals in their continuous information exchange across teams and towards patients. The initial treatment is directly communicated from ambulance to hospital, where a care coordinator uses MED Dialog to receive new patients. On arrival, paramedics use a digital handover board to accurately brief the care team. Throughout the entire treatment, data is logged and can be used for effortless reporting.

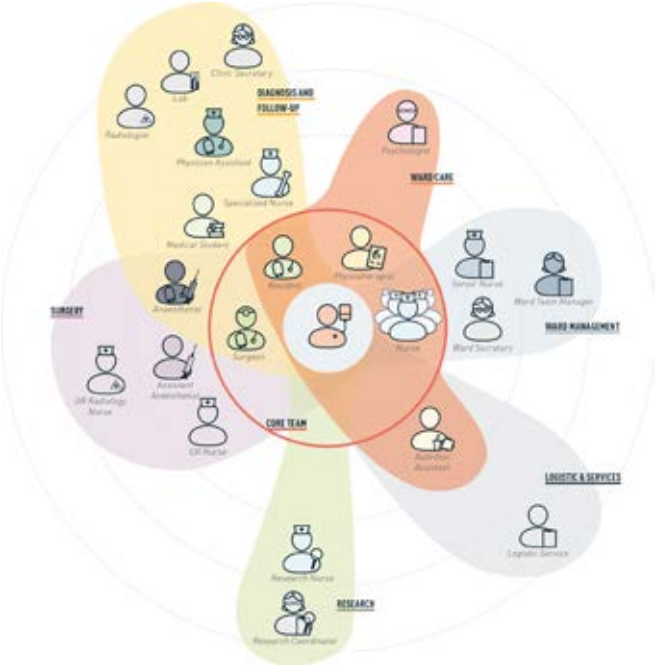
The coordination app features two modes: nurses use the MED mode to view their tasks, make entries to a patient's timeline and exchange information with colleagues. They switch into the Dialog mode to facilitate personal conversations with stable patients to keep them clearly informed about their situation and progress. The patient app facilitates this by visualizing who their care team is, what the next steps are, how their long-term care plan will be effected, and how patients can let their relatives know what is going on.

IMPROVING TEAMWORK IN THE ORTHOPAEDIC CLINIC

Graduate: Eleonora Caprari (2016)
Supervisory team: M. Melles, P. D'Olivo, R.M. Bloem, S.B.W. Vehmeijer, N. Stolk
Partner: Reinier de Graaf Hospital, Zimmer Biomet

Communication and teamwork failures contribute significantly to the number of adverse events in healthcare. Moreover, it has been found that the patients' experience of good team coordination is correlated to their overall satisfaction. Therefore, enabling and supporting good teamwork is a way to foster quality and safety of care. To gather insights on the topic, a field research was conducted in the hospital's orthopedic department.

Different professionals involved in the care of orthopedic patients were shadowed and interviewed. Relations among them were derived and a design framework was created to guide ideation. On a behavioral level, ideation focused on facilitating a proactive and open attitude, fostering the right climate for collaboration. On a task level, ideation focused on providing processable information between team members. The resulting interaction between the members should be collaborative, effortless and meaningful.



The result is Patient Portrait, a monitor-based application designed to provide value for the nurses and the doctor at an individual and team level. By means of graphic representations, the concept provides a structure for the exchange of information between nurses and from nurse to doctor in a to-the-point yet narrative fashion. Individual needs are supported by providing specific features for the professionals to accomplish their tasks while, at the same time, providing processable information to the next actor in the chain: night nurse, day nurse and doctor.

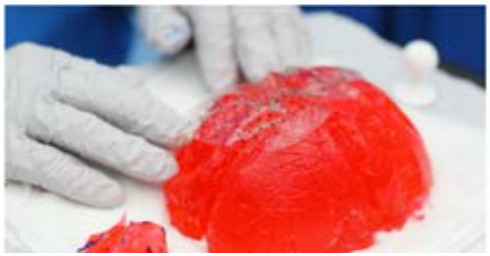
EPI-OUT: AN IMPROVED WORKFLOW FOR EPILEPSY SURGERY

Graduate: Tessa Souhoka (2016)
Supervisory team: R.H.M. Goossens, E. Tempelman, R. van Merkerk
Partner: Pontes Medical, UMC Utrecht

Each year, between 5,000 - 8,000 people in the Netherlands are diagnosed with epilepsy, resulting in a total of more than 80,000 people suffering from this affliction. Most of these require treatment with anti-epileptic drugs that (partly) suppress epilepsy. Unfortunately, these drugs can have severe side effects such as nausea, kidney damage, and infertility.

Surgery is an alternative, but only if the epileptic source is identifiable and can be surgically removed. Currently, approximately 75 patients undergo epilepsy surgery every year in the Netherlands. The reason for the extreme reluctance to perform surgery is that the procedure is difficult and dangerous. Multiple studies currently being conducted on how to improve the surgical outcome, which if successful, will increase the number of patients eligible for surgery. One of these studies addresses the so-called "High Frequency Oscillations", or HFOs, as a superior biomarker for the state-of-the-art biomarker: spikes.

This graduation project, initiated by Pontes Medical Utrecht, investigated what kind of medical devices would need to be developed to put HFO-guided epilepsy surgery into practice. Active involvement of the clinical team and the research team resulted in the development of EPI-OUT: a flexible electrode grid that can measure both the surface of the brain and the inside of the resection area, and a projection system to communicate the location of the biomarkers to the clinical team during surgery.



AUGMENTED REALITY FOR TELEMEDICINE IN THE MARITIME SECTOR

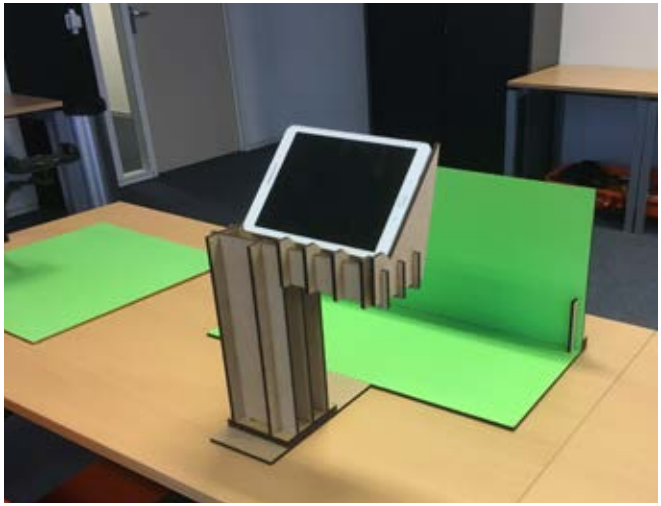
Graduate: Tom Slijkhuis (2018)
Supervisory team: J.E. Oberdorf, M. Li, R. Huigen
Partner: MedAssist.online

Captains in the maritime sector are responsible for the medical care of their crew members. To do this, they receive one week of training every five years in which they study the knowledge and practice the skills and processes to handle on board medical incidents. This one week of training is not enough for captains to confidently handle medical incidents, and they are in need of extra support. Currently, this additional support is limited to phone calls and email with a doctor from the Radio Medical Services.

MedAssist.online developed 2-way augmented reality technology, a method of merging two realities into one using tablets and a green screen. The merging of two realities creates the opportunity to give instructions to the captain using hands as an overlay on the video. This approach is expected to boost confidence, which is essential to help the captain be decisive.

Different tablet and camera positions on both sides of the communication was researched. In the doctor set-ups, four different tablet positions were designed and tested to provide optimal hand control and to give instructions. On the captain side, the camera position and tablet position were explored, built and tested. The set-up was evaluated on the doctor's understanding of the captain's situation, the ability to interpret and implement the instructions, and the flexibility of the set-up for multiple medical scenarios.

After testing various set-ups, it was concluded that an additional camera on the captain side would improve the doctors' ease of understanding and their ability to give instructions. At the same time, the captain can place the tablet in a position so it is easy to switch between the patient and tablet to implement the instructions, without the tablet obstructing the work area. The final test showed improvements in the new design set-up.

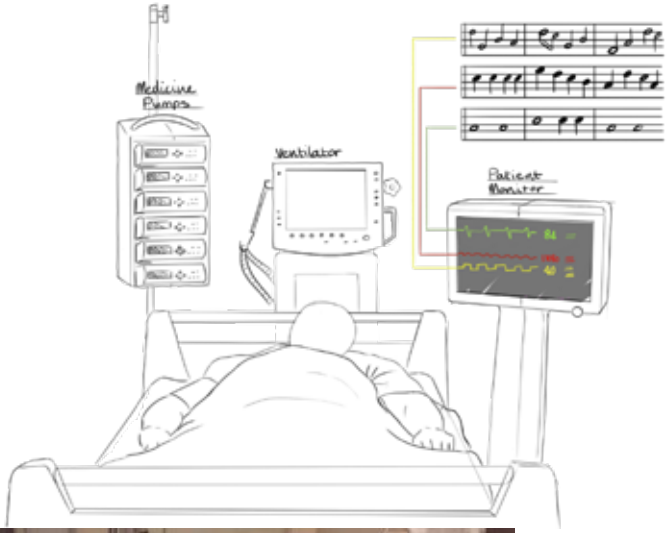


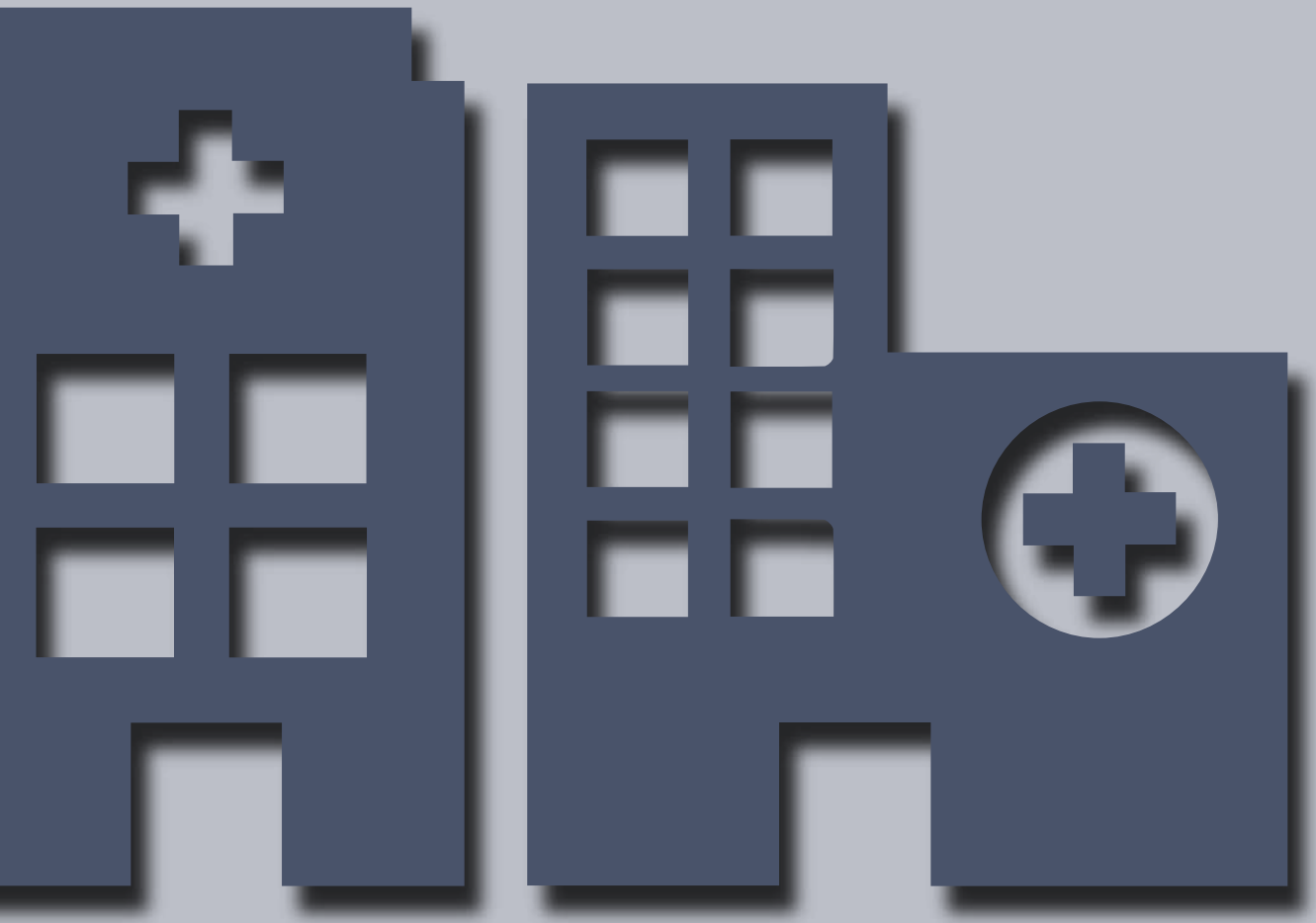
CARE TUNES: MUSIC AS A NURSES' MONITORING TOOL

Graduate: Koen Bogers (2018)
Supervisory team: A.J.C. Van der Helm, E. Ozcan Vieira, J. Schlesinger, Y.K. Sen
Partner: Erasmus Medical Center

Nurses working in the intensive care unit (ICU) are exposed daily to a wide range of sounds from medical equipment. The number of alarms nurses have to cope with may result in alarm fatigue, which desensitizes them to alarms. Not only is this a threat to patient safety, it also causes stress.

Care Tunes allows nurses to listen to music to monitor their patients. By wearing an earpiece that plays the music, nurses are constantly aware of their patients' health without having to listen to the cacophony caused by alarms. In an iterative design process, several versions of this concept were designed, tested and evaluated. Simultaneously, research was conducted into the experiences ICU nurses have regarding sounds. This research gave insights in the experience and underlying mechanisms of alarm fatigue. Among them are the low level of information that alarms carry, and the range of personal preferences nurses have when it comes to setting boundaries for their alarms. Alarms also tend to be used as a reaffirmation by using narrow alarm limits, causing more alarms to sound. Care Tunes offers more information regarding the sonification of patient data. This lets nurses listen to a pleasant musical stream to get all the information required about their patient.





DESIGN FOR HEALTHCARE FACILITIES

MARGINGUIDE: A RAMAN SPECTROSCOPIC PROBE FOR SURGERY GUIDANCE IN HEAD & NECK ONCOLOGY

Graduate: Tine Hoogterp (2018)
Supervisory team: R.H.M. Goossens, S.F.J. Flipsen, L. Ottevanger
Partner: Surguide

Each year, 300,000 people worldwide are diagnosed with oral cavity cancer. Its main treatment is surgery with the main goal of removing the complete tumor with a safe margin of healthy tissue around the tumor. Currently, surgeons use their feeling and visual capabilities to distinguish the tumor from healthy tissue, rather than using technology.

In this graduation project, the focus was on the design of a functional and user-friendly Raman-spectroscopic instrument for rapid assessment of the surgical margin in a tumor, providing surgeons with adequate information to ensure complete tumor removal. Raman-spectroscopy is an optical technology which can differentiate tumor from healthy tissue.

The design proposal was tested on several aspects. One of these tests was to check whether the design complied with accuracy requirements. In addition, user tests were conducted to discover which concept is preferred. Furthermore, studies were performed to provide first suggestions for manufacturability and maintainability.

For further development of the MarginGuide, it is important to focus on the influences on the Raman measurement and the needle depth determination, both of which can influence margin accuracy.

A SUPERFICIAL HYPERTHERMIA SYSTEM FOR CANCER TREATMENT LUCITE CONE APPLICATOR

Graduate: Anh Khoa Nguyen (2016)
Supervisory team: A.H. Jellema, J.F.M. Molenbroek, V.G. Rhoon
Partners: Erasmus Medical Center

The Lucite cone applicator is a Superficial Hyperthermia cancer treatment system used at Daniel den Hoed Cancer Centre in Rotterdam. The system has been used for more than 20 years and is still in use, however its mounting system is not user-friendly for both patients and staff. Therefore, the focus of this project was on the usability of the system and improving patient experience.

After analysis of the current workflow, environmental factors, conducting user interviews, and a literature search, the team created a design framework based on human factors and usability issues. Different concepts were developed and finally the concept C-curve mounting arm was chosen to develop further. The experts indicated that the concept should be a stand-alone arm for hygienic reasons and for compliance with existing patients beds. A working prototype was built of the final design proposal; this was evaluated in different user scenarios. The system was evaluated positively on usability and the value add to the workflow.

A CARE PATH FOR THE VIDEO CAPSULE ENDOSCOPY AT MAASSTAD HOSPITAL

Graduate: Susan Starre (2016)
Supervisory team: L.W.L. Simonse, A. Albayrak, L. Agnes, J. de Goeij
Partner: Maasstad Hospital

Healthcare is becoming more customer driven. Patients are becoming more involved with their own health and developing their own expertise. Thus, patients' needs are changing with regard to both doctors and hospitals. Healthcare has therefore to become more person-centered; this requires great changes to currently available health services.

At the Maasstad hospital, a new leading clinical hospital in Rotterdam, with an annual turnover of approximately 500,000 patients, it is important to provide patient-centered care. The hospital therefore initiated this graduation project as a case study: to redesign the health services around video capsule endoscopy.

One of the current clinical protocols at the gastrointestinal and liver center (MDL department) is Video Capsule Endoscopy (VCE). By interviewing patients, VCE nurses, and doctors, observing the current VCE care path, and conducting a literature search, new insights were gained and ideas were developed to create a better experience. Patient journey mapping was used to find the friction points in the current care path, resulting in design specifications. It was found that many patients feel lonely, bored and uncomfortable during the examination, which takes up to 8 hours.

The service "Op pad in het Maasstad" (on my way in the Maasstad) was developed to improve the patient experience. This includes three different routings that are communicated via a flyer with a map. These include a life-story route, an art route, and a puzzle-route. A user test was performed and the different routes evaluated. Both patients and healthcare professionals appreciated the new designed care path which is more interactive and engaging than the existing one.

THE MEDIACT APPLICATION: STIMULATING PATIENT HEALING IN THE PATIENT ROOM AT THE RADBOUDUMC

Graduate: Denise van Bavel (2017)
Supervisory team: S.U. Boess, T. Dekkers, I. Hobo-van der Graaf
Partner: RadboudUMC

Medication and treatment make healing possible. However, other factors also contribute to a patient's healing process and wellbeing. These can be integrated in a healing environment: a complete environment for a patient that contributes to that person's complete healing.

The goal of this graduation project is "to improve the wellbeing and healing of patients in their patient room at RadboudUMC by applying a healing environment that can be personalized".

The MediAct is an application that offers patients two services that can help them stimulate their own healing process. One is an external healing environment that facilitates health-stimulating activities. In the application, this environment can be adjusted to the patient's own preferences, thus giving patients control over their environment. The second is a behavioral healing environment which provides knowledge on what patients can do to heal themselves, thus giving them a sense of ownership regarding their healing process.

Both services can be personalized based on the patient's current condition and personal preferences, and therefore only provide fitting activities.

ONE LAST WISH: IMPROVING THE EXPERIENCE OF A RIDE WITH THE WISH-AMBULANCE

Graduate: Chenyi Shao (2018)
Supervisory team: M.H. Sonneveld, J.M.W. Weerdesteijn
Partner: WensAmbulance Brabant

Effective and appropriate care of people in their last stage of life has become a priority in current healthcare delivery. Everyone has a different perspective of what a "good death" is: many patients consider a sense of completion important for a good death, attaching value to maintaining their dignity, and to the affirmation of their whole person. Enabling people to make one last wish come true during their final stage in life contributes greatly to their quality of dying.

The focus was on optimizing the wish ride experience facilitated by WensAmbulance Brabant, whose aim is to grant the last wish of terminally ill patients (and their loved ones) to visit a special place. In order to establish an understanding of the complex context of the different stakeholders, literature and field research was conducted simultaneously. These provided insights regarding the important aspects when designing for End of Life, and problems currently occurring during the wish event. This enabled to create a comprehensive example of a wish ride and establish a Patient Journey Map. The journey map revealed multiple aspects that could be improved regarding the wish journey. The aim of the design project then became to provide terminally ill patients with a more comfortable and reassuring experience, without compromising patient and volunteer safety, in order to increase the likelihood of patients meeting their set wish goals.

The concept, the Patient Wrap, reduces the patient's anxiety prior to engaging in the wish ride and when the first goodbyes are being said. It is envisioned to improve the patient's ability to rest or even sleep during the wish ride, and provides an accessible solution for WensAmbulance Brabant to ensure patient and volunteer safety.

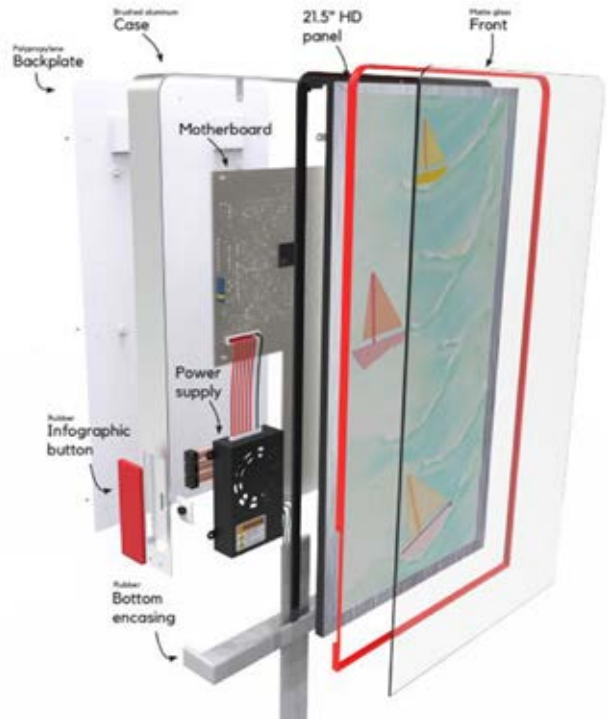
DOPLOR: ARTFUL WARNINGS TOWARDS A MORE SILENT INTENSIVE CARE

Graduate: Roel Redert (2018)
Supervisory team: E. Ozcan Vieira, T. Dekkers
Partner: Erasmus Medical Center, Quietyme

Being an Intensive Care (IC) patient is a chaotic and uncertain experience, and unfortunately sleep is not always possible. Alarms and other sounds keep patients from achieving deep-sleep, which is of great importance for recovery. On the other hand, nurses are continuously surrounded by noises of all sorts, resulting not only in alarm fatigue but even in a complete sound-fatigue.

Doplor was designed to allow nurses' to regain their sensitivity for sound. Doplor is like an artwork, showing how the status of the auditory environment. Sensors measuring decibels in the IC environment are implemented in Doplor. Streams of decibel-data are sent to Quietyme, an American company, where an algorithm calculates how many conversations, incidents and alarms occurred in the past hour. Using these calculations, Doplor decides what sort of artwork to display. Generally speaking the artwork becomes more hostile as the environment gets louder. Should an emergency occur, then patient safety is obviously prioritized over auditory quality.

By introducing Doplor in the IC environment, nurses will have a greater awareness of the fact that sound is an important aspect of patient recovery and their own well-being. Doplor will help nurses be more mindful in their interactions by displaying the auditory conditions in the IC.



WORKSTATION FOR THE MARGINGUIDE

Graduate: Tom van den Bogaard (2018)
Supervisory team: H. de Ridder, Y. Song, L. Ottevanger
Partner: SurGuide, RiverD, Erasmus Medical Centrer

With over 300,000 new cases each year and a survival rate of 50%, oral cancer is a major public health issue. The primary and best treatment option for oral cancer is surgery, but most of these procedures are difficult due to the complex anatomical and functional structures in the oral cavity. Currently, surgeons can only judge the surgical margins by visual inspection and palpation, without much support from technology or other diagnostic techniques.

The MarginGuide system is currently under development by SurGuide. It will provide surgeons with clear and objective information about the resection margins using an optical technique to distinguish healthy tissue from tumor tissue.

This graduation project focused on the design of the work and information flow of the MarginGuide system, including the device's workstation. The system was analyzed from multiple angles (product, information and workflow) verifying the results with Erasmus MC surgeons, pathologists and researchers.

A software design and workstation were developed, including several anatomical templates now in use at Erasmus MC with patients. The design supports the team to easily and correctly measure and report margins during surgical procedure.


Measurement Report

SUPPORTING THE SITUATIONAL AWARENESS AT THE EMERGENCY DEPARTMENT

Graduate: Yvonne Gillis (2017)
Supervisory team: N.A. Romero Herrera, A.Q. Beekman, F. Goethals, J. Tukker-Swijnenburg
Partner: UMC Utrecht, Pontes Medical

The focus of this graduation project was on designing a product-service that supports emergency nurses to maintain Situational Awareness at the Emergency Department with the aim of reducing incidents and increasing patient safety.

Different design exploration activities have shown that emergency nurses believe that technology such as sensors collecting patient information and receiving effective patient information through notifications can contribute to effectively observing patients at a distance. Innovative technology should save time by replacing current computer-interactions, and they want to have access to clearly ordered information.

HOLO was designed to support nurses to retain insights in the conditions of their patients. It allows emergency nurses to observe patients from a distance and to keep patients who are under their supervision safe. HOLO's innovative product feature is the ability to review the trend of patients' vital signs from all parts of the department. If vital signs become risky, the device alarms the emergency nurse who can then intervene in time. The top display allows efficient care reprioritization and the central display automatically gives additional information as a response to an alert.

DEALING WITH DECUBITIS

Graduate: Joep Wijnands (2016)
Supervisory team: H.J. Hultink, G. Calabretta, E. Vrijland
Partner: NightBalance

In this graduation project, the options for developing a new product based on NightBalance BV's existing technology was investigated. NightBalance is a start-up which has patented the technology able to reliably determine the position of a person while sleeping or lying in bed. In order to expand the company, they are looking to extend application areas, for example the decubitus market.

A concept with NightBalance technology that aids caregivers in nursing homes with the prevention of decubitus by facilitated repositioning of patients through sleep positioning monitoring was developed. The final concept is a multi-part system that consists of a sensor module and a connectivity module. The sensor module is attached to the patient's chest and monitors bed positions over time. It automatically plots the correct repositioning for nurses and it logs patients' movements; both their own and caregiver induced. The connectivity module connects to the Wi-Fi, LAN and the nurse alarm to facilitate remote bed monitoring and alarm in emergencies

In the final part of the project, a business plan was developed. Research shows that the market-size is large enough to develop a retail strategy. The team presented a distribution chain and a commercial roll-out plan. The estimates show that the business case can be an attractive proposition for NightBalance BV.

A SAFE TRANSPORT SITUATION FOR INTENSIVE CARE PATIENTS

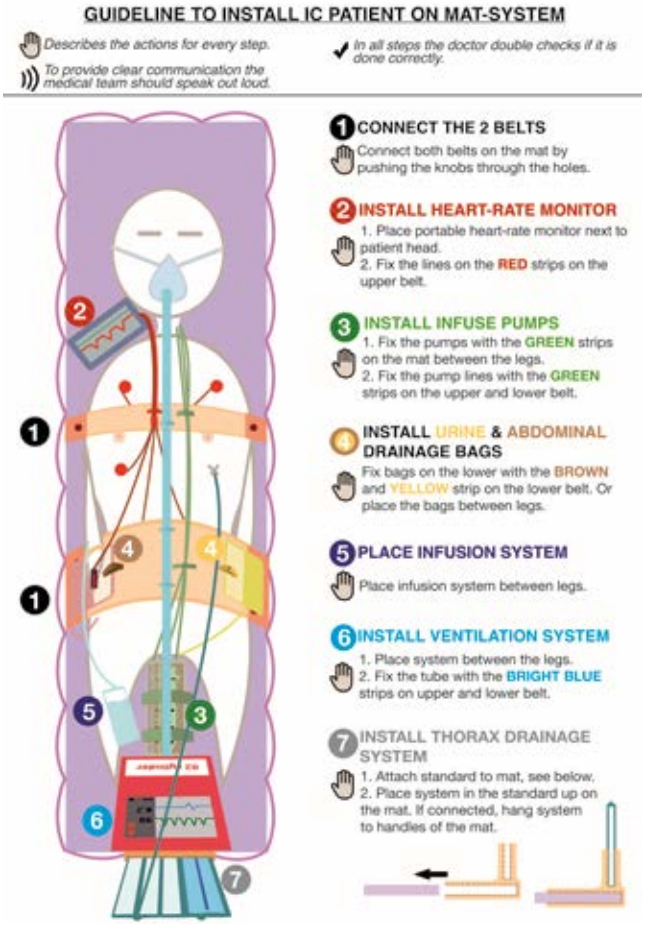
Graduate: Anne Toorneman (2016)
Supervisory team: P. Vink, M.H. Sonneveld, J. van den Bosch
Partner: Electronic House Rotterdam

In recent years, more Dutch citizens have been travelling around the world. Unfortunately, this has led to more Dutch patients in foreign hospitals.

This results in more requests by Dutch patients to be repatriated by airplane. Some of these patients are intensive care (IC) patients who are in a fragile state and require continual medical monitoring. Since existing medical transport services are expensive and time-consuming, a new safe and fast service was designed, the Guardian Journey.

The final design consists of two parts, a mat-system and two accompanying guidelines. The IC patient, medical devices and lines are installed on the mat-system according to one configuration. As a result, the medical devices and lines are in a stable position, ensuring the vital connection between patient and medical devices. The fixed configuration of the patient and medical devices in the mat-system allows a safely transfer between bed or stretcher as one package in one go. The accompanying guidelines support a coordinated working procedure and clear communication for using the mat-system. The first guideline tells the medical team step by step how the IC patient and the medical devices need to be installed in the mat-system. The second guideline describes the installation steps of the IC patient on mat-system in the medical cabin of the airplane. Color-coding is applied to indicate how the medical devices and lines should be connected to the mat-system. The same color-coding is also applied in the interior of the Guardian concept to indicate the positions of the medical devices on the wall and medical unit.

A prototype was developed for the mat-system and was, together with the guidelines, evaluated in a user study. The final design can offer a solution to safely transport IC patients.

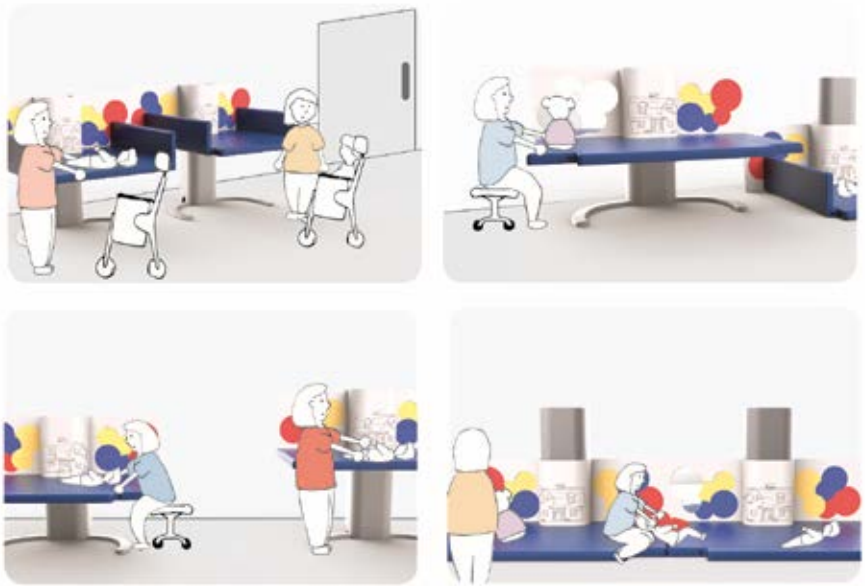


EMPOWERING THE CAREGIVERS OF TODDLER REHABILITATION GROUPS

Graduate: Paula Gerlag (2016)
Supervisory team: J. F. M. Molenbroek, I.A. Ruiter, T. Westendorp
Partner: Rijndam Revalidatie

This graduation project was conducted at Dikkie Dik, the therapeutic toddler group at Rijndam. This is a group of children with cognitive and physical limitations. During these toddler classes, caregivers and therapists play and exercise with the children. The therapeutic toddler classes take place twice a week, for three hours. Due to all the different activities in this timeframe, a toddler needs to be transferred by a caregiver approximately 8 times every hour. Many of these activities take place on the rehabilitation mat, on the floor. Lifting the children that often and from a low height can cause back and knee problems for the caregivers and therapists; it is the heaviest form of lifting. Currently, no tools are available to support caregivers and therapists when lifting the children.

'UP' is a mat which can be operated at different heights and support the caregivers and therapist during the toddler transfer process. The mat makes it possible to work on the floor, as well as at sitting and standing height. The children are still able to crawl on and off the mat when at floor level. The mat has railings with adjustable hinges on the sides of the mat to prevent the children falling when at a raised position. With the UP, vertical lifting of toddlers can be avoided, which reduces the pressure on caregivers' backs and knees.



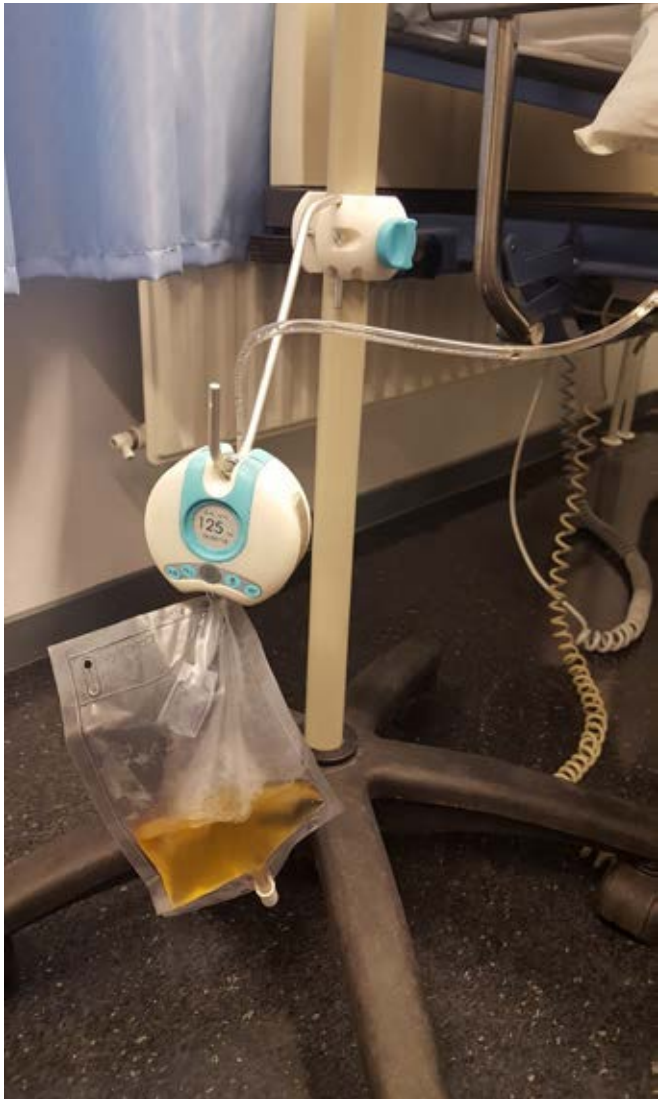
A PRODUCT-SERVICE SYSTEM FOR ACCURATE AND EFFICIENT FLUID BALANCE MEASUREMENTS ON HOSPITALIZED PATIENTS

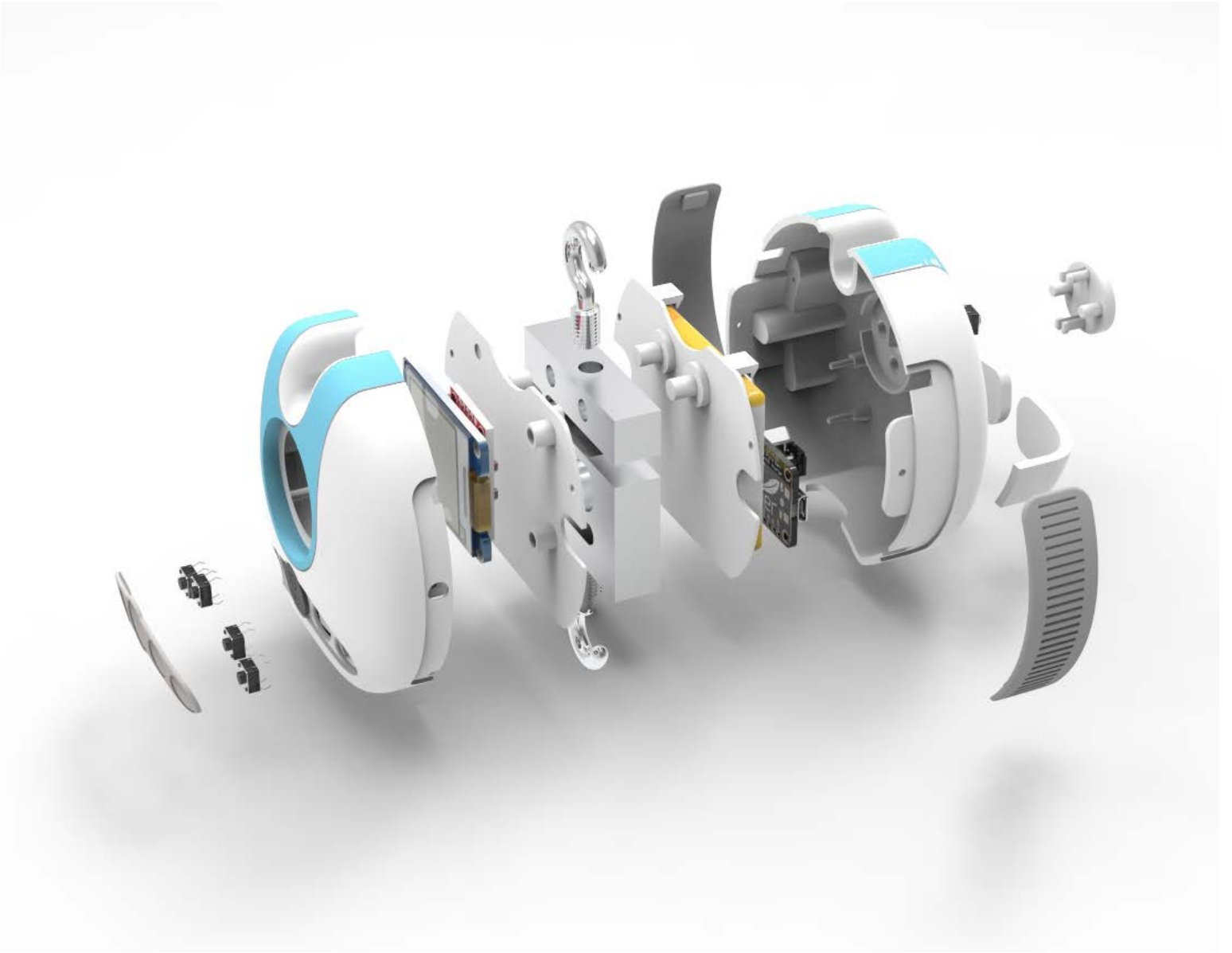
Graduate: Renate Hulst (2018)
Supervisory team: S.G. Van de Geer, R.J.H.G. van Heur, D. Vervoorn
Partner: Pezy Group Houten, TIM Solutions

Fluid balance is the balance between all the fluids entering the body minus all the fluids exiting the body. Due to multiple factors like illness, undergoing an operation, etc., this balance can be disturbed and patients can become dehydrated. In order to restore fluid balance, the patient is connected to intravenous bags with fluid. Fluid balance measurements serve as input for the treatment plan; an inaccurate fluid balance can lead to complications or a longer hospital stay.

In this graduation project, the focus was on the development of a product-service system which can regularly measure the patient's fluid balance, informing the nurse when needed. The concept was developed iteratively with stakeholders, with compatibility with existing systems as a precondition.

The final design is a fluid bag holder which can be attached to the infusion pole. It can be managed by the nurse and, if the nurse approves, also by the patient. A working prototype was built and evaluated with the different stakeholders. The concept was well received by the users. Further development is needed to optimize the interface.






vascoscope

VASCOSCOPE: A PORTABLE ECHO DEVICE ENCOURAGING ULTRASOUND-GUIDED CANNULATION IN DIALYSIS CENTERS

Graduate: Marleen Backus (2016)
Supervisory team: I.A. Ruiter, A. Kooijman, H. Tjabbes
Partner: Novioscan

Miscannulation during dialysis is the cause of shunt damages such as scarring, narrowing, blocking, infection and internal bleeding. Miscannulation increases the difficulty of flawless follow-up puncturing, and can reduce the shunt's lifetime, leading to more invasive surgeries and higher costs. Ultrasound devices are used to simplify the cannulation of these shunts by visualizing them on a monitor. However, the device currently used in dialysis centers is large and clumsy, and is not specifically designed for visualizing dialysis shunts, so nurses only use it for severe cases.

The goal of this graduation project was to design an echo device that stimulates the use of ultrasound visualization for cannulating dialysis shunts. The final design, the Vascoscope, is a highly portable device consisting of a lightweight probe containing an ultrasound transducer and a screen, a battery pack containing the battery and CPU, and a wire connecting the two. The screen is placed on top of the probe, which allows the nurse to see the echo visualization and the needle entering the shunt in the same visual field. In addition, the device is designed for optimal usability with all different cannulation habits; it enables both longitudinal and transversal cannulation by allowing flexible screen rotation, and offers the possibility to fixate rolling shunts. Lastly, the Vascoscope is free of any edges or corners that are difficult to clean; an essential property in infection-prone environments.

With these properties, the Vascoscope has been designed for portability and ease of use, lowering the threshold for incorporating the use of ultrasound in the default dialysis cannulation routine. This is supported by user research on the final design. The participating dialysis nurses were enthusiastic and noted several improvements compared to their current echo device. The main improvements mentioned were portability, ease of use, flexibility for different cannulation methods, and simplicity of working with the device. Therefore, the expectation is that dialysis nurses will be keener to perform ultrasound-guided cannulation when having an on-site Vascoscope.

CREATING A COMFORTABLE WORKING ENVIRONMENT FOR CATH LAB PHYSICIANS

Graduate: Jette Mul (2017)
Supervisory team: R.H.M. Goossens, A.Q. Beekman, A. Brosens-Kessels
Partner: Philips

This graduation project is about developing a solution for cath lab physicians. A cath lab physician is a medical doctor with a background in cardiology, neurology, electro physiology, or radiology who performs cath lab procedures. Cath lab physicians often suffer injuries due to the heavy physical workload.

The lead apron they wear to protect themselves against radiation used during the procedures, in combination with long periods of standing, are the main cause of injury. After analyzing the nature of the injuries and the physicians' environment, an updated stool with new features emerged.

The stool is specially designed to support the cath lab physician. The seat prevents radiation on the legs while the integrated sternum support reduces the forces in the back muscle. A test was performed to validate the effect of the sternum support; this resulted in a reduction of between 10% - 15% of the pressure in their back muscles.

SECURITY-SERVICE FOR HOSPITALS: DESIGNING A MODULAR APPROACH

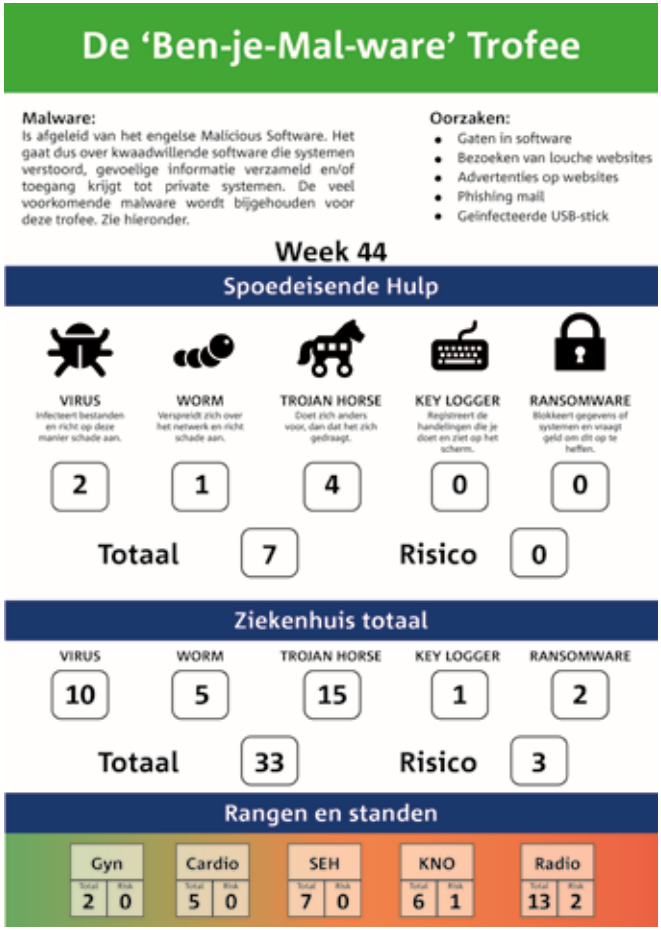
Graduate: Janrein Jöbsis (2015)
Supervisory team: L.W.L. Simonse, S.C. Mooij, S. de Jong
Partner: KPN

Currently, increasing numbers of cybercriminals are active, and the healthcare industry is under attack for valuable information. In the research phase of this thesis, it became clear that this was an opportunity for KPN is to get a foothold in the hospital security market.

SIEM is the cybersecurity category at KPN and stands for Security Information and Event Management. SIEM gathers logging data from network devices and centralizes the so-called log management. By defining correlations between events that have occurred earlier and may cause damage, warnings can be derived from the logging data. Through Security monitoring, as this service is called, KPN can contact their customers when something notifiable happens. Scanning for weakness in the network according to norms such as NEN 7510, is called compliance monitoring. To set this all up, and constantly control these settings, KPN offers risk-based scoping to determine the service configurations.

The service was tested with a number of resulting opportunities and threats. One of the threats is not security systems' software, but the users. Users are vulnerable to hacking attempts such as phishing mails and malicious USB-sticks. As enough technological security solutions are available, the weakest security link is not on the prevention side, but on the user side.

A solution is to introduce collaborative working within a hospital. Employees are involved and become more aware of any malware. KPN provides hospitals with the information and thereby aims to reduce the number of incidents within the hospital.



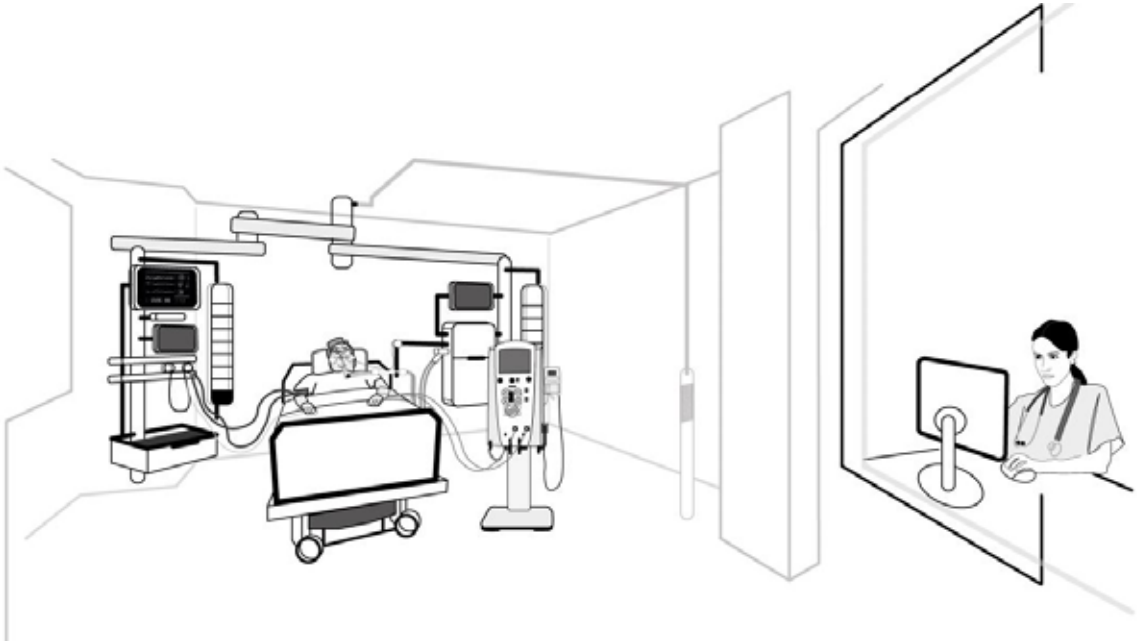
A PERSPECTIVE ON PATIENT MONITORING: EXPLORING POSSIBILITIES FOR PATIENT MONITORING IN THE FUTURE CARE CONTEXT

Graduate: Dilip Birdja (2018)
Supervisory team: E. Ozcan Vieira, L.W.L. Simonse, A. Struijs
Partner: Erasmus Medical Center

This project is about shaping the context of critical care in a world where simplicity and consistency is expected from product- user interactions, while the implications of these interactions are becoming more complex.

Nurses and clinicians rely on monitoring devices to take the right decisions for the patient. However, there is only so much that nurses or clinicians can do, and participating in the time-consuming process of looking for delicate relationships between different vitals of patients is not their highest priority. Keeping the patient alive however is, and finding subtle trends in patients' data could well make the difference between life and death. Thus, there is a need for structures that make use of patient data precisely for the reason of facilitating predictive care, seamlessly integrated in the hospital structure, and synchronized with the hospital's monitoring devices.

This project explores the possibilities for making use of patient data in the hospital context, while taking the history, the current state, future trends, and technological developments of patient monitoring in consideration. The aim is to propose a structure that sparks discussion about the future direction of patient monitoring, and the challenges that lie ahead.



A POSITIONING SYSTEM FOR THE MINIMALLY INVASIVE MANIPULATOR IN THE OPERATING ROOM

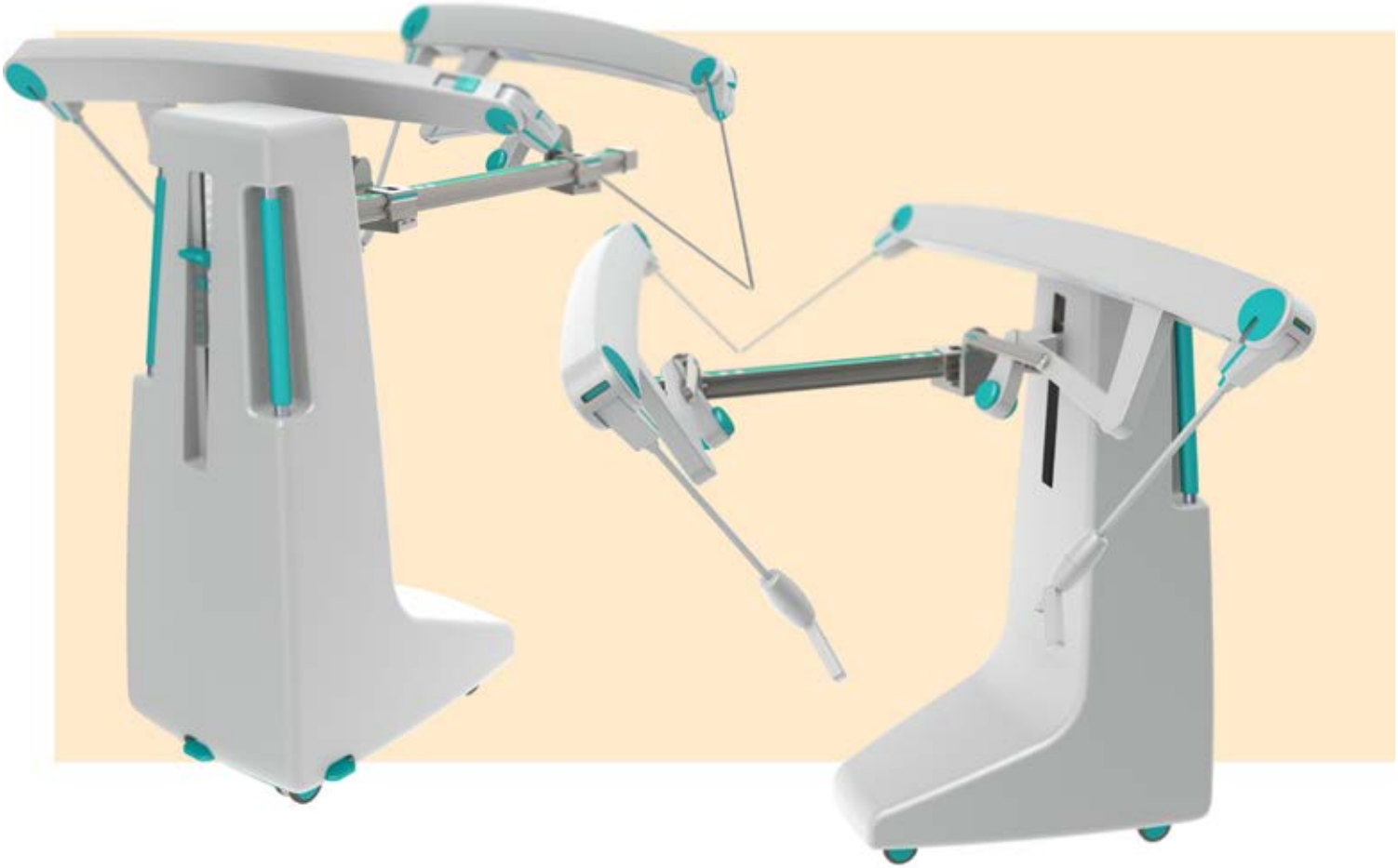
Graduate: Renée Molman (2016)
Supervisory team: J.J. Jakimowicz, A. Albayrak, L. Evers
Partner: Pontes Medical, UMC Utrecht

Laparoscopic surgery is a surgical procedure in which a surgeon uses extended instruments to operate through small incisions. Even though laparoscopy has many patient benefits, it is a difficult procedure for surgeons. The main problems are the high learning curves and ergonomic discomfort caused by mirrored movements, awkward body postures, and an eliminated wrist function, which is needed for quick suturing.

The Minimally invasive manipulator is a mechanical device that helps surgeons operate more ergonomically and reduce their learning curve. This is achieved by providing surgeons with a 'wrist' function and by eliminating mirrored movements. One of the key features of the MIM is its low cost. The MIM can be manufactured and sold for 10% of the price of current robotic manipulators.

The focus was on the contextual factors needed for integrating the MIM in the current OR workflow. The result is the design of a positioning system that describes the necessary steps, and a preliminary design of the MIM foot.

The arc was chosen as the most promising concept as it provides the surgeon with the best overview of the surgical field, while ensuring a fast and easy positioning of the arms. The design consists of the MIM arms, a carrier which positions the arms above the patient, and a foot. To test the calculated product dimensions, a functional prototype was built which was tested in an operating room. The system can be further developed with a focus on engineering aspects, as well as on gaining user feedback related to medical aspects.



DESIGN FOR HOMECARE FACILITIES

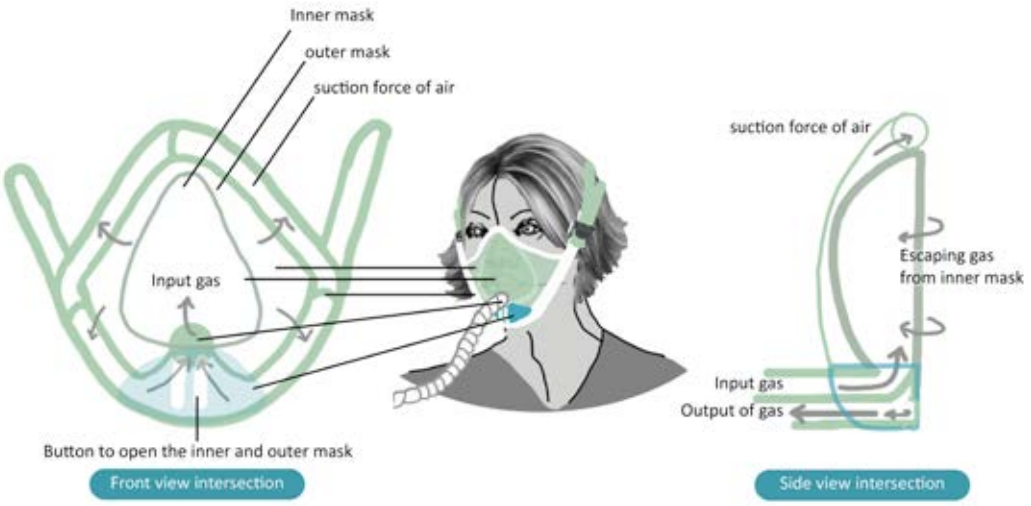
PROVIDING ANALGESIC LAUGHING GAS DURING BIRTH IN A HOME ENVIRONMENT

Graduate: Eva Schuurmans (2016)
Supervisory team: M.H. Sonneveld, I.A. Ruiter
Partner: TU Delft

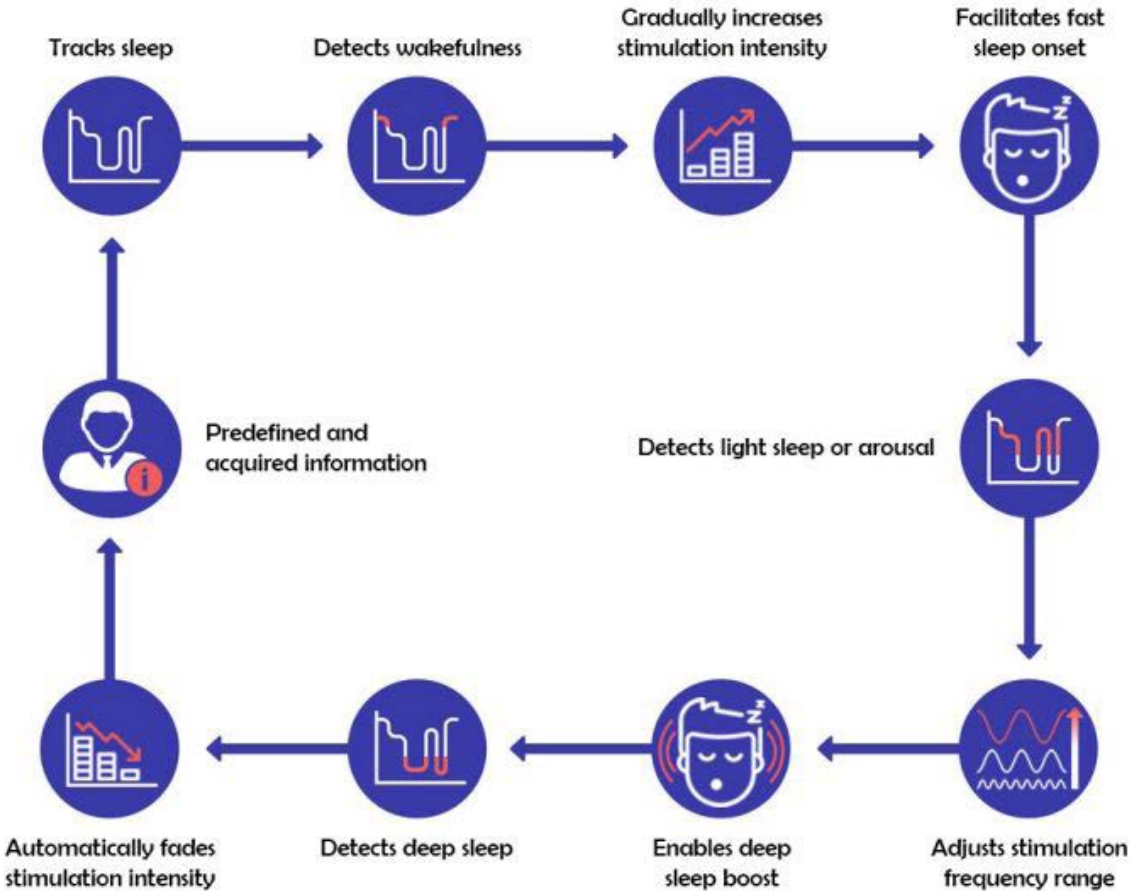
This graduation project, focus on developing a product that enables Dutch midwives who facilitate home-births to administer analgesic laughing gas. This gas is used to relieve women's pain when giving birth. A product concept was presented that meets the strict Ministry of Health regulations and that takes the working environment and user-needs into account. The team conducted a literature research on the subjects of pain and N2O. The users, midwives and women giving birth were involved through the complete design process. A mock-up was built and shown to several companies and users to gain feedback and test the model's potential. The final design proposal consists of a double mask with a casing.

The product is simple to use. The woman giving birth controls the supply with a button, giving positive feelings of personal control and satisfaction. The amount of N2O being used is limited, but enough to manage the pain. The three wheels on the casing make it possible to move the product up the stairs.

The product has the potential for further development. It offers a way to deliver analgesic laughing gas at home, something that is not yet available. The product's benefits include the rapid onset and the low costs involved.




Scrubber

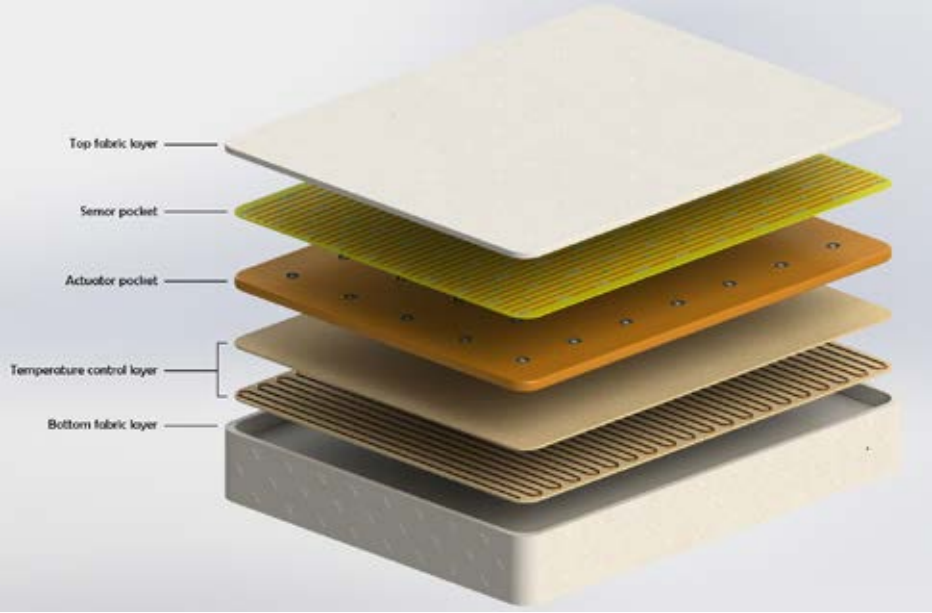

Tracks sleep
Detects wakefulness
Gradually increases stimulation intensity
Facilitates fast sleep onset
Predefined and acquired information
Detects light sleep or arousal
Automatically fades stimulation intensity
Detects deep sleep
Enables deep sleep boost
Adjusts stimulation frequency range

A NON-PHARMACOLOGICAL SOLUTION FOR PEOPLE SUFFERING FROM INSOMNIA

Graduate: Indy van der Heijden (2016)
Supervisory team: P. Vink, R. van Egmond, T.R.M. Leufkens
Partner: Philips

Insomnia is often a highly persistent condition and refers to recurring troubles with initiating or maintaining sleep. In addition to pharmacological treatments, non-pharmacological treatments are available, however their effectiveness has not been scientifically proven. A very promising and scientifically-proven direction used by mothers to help their babies sleep is rhythmic rocking and gentle singing techniques, for example when riding in a car or train.

This graduation project, focus on the combination of auditory and vibrotactile stimulation and applied this to their design. SoundSleep encompasses a non-invasive mattress cover packed with smart responsive technology which is able to provide a fully personalized and invisible experience of monaural beats and vibrations. It incorporates technology capable of accurately tracking sleep and delivering stimulation to specific parts of the body without the user having to be fixated to a device during the night. So when the SoundSleep detects light sleep or arousal, it adjusts the stimulation frequency range. SoundSleep introduce a familiar way of falling asleep from a different context in the daily sleeping routine; it can be easily used with every type of mattress, with the aim of improving insomniacs' quality of sleep.

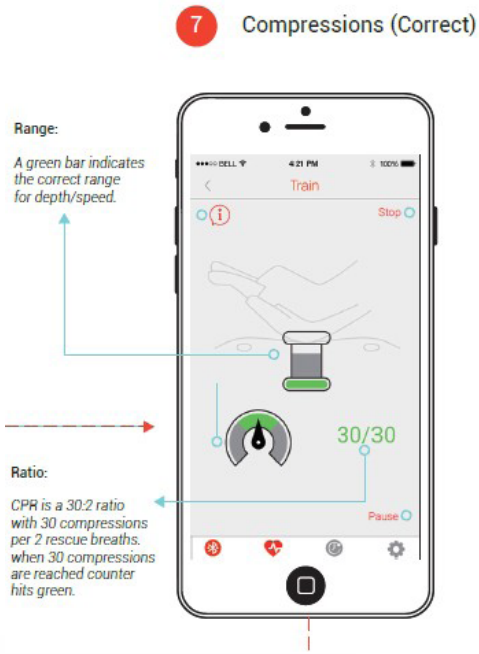


PUTTING HEART IN CPR: A NEW WAY TO PRACTICE CARDIOPULMONARY RESUSCITATION

Graduate: Amy Collins (2018)
Supervisory team: J.E. Oberdorf, T. Dekkers, I. van der Eijk
Partner: Livis

Most cardiac arrests happen at home and only 10% of victims survive. If a victim receives CPR within the first 6 minutes of a cardiac event, then their chances of survival increase to 45%.

This graduation project, focus on the development of LivisOra that helps people prepare to act on the moment of a cardiac arrest. Ora is a CPR training aid that helps learners master chest compressions and rescue breaths without attending a lesson. It has electronics that monitor the learner's CPR performance and deforms to mimic the elasticity of a human chest. It is compact, portable and optimized for individual home training. There is no longer any need to worry about scheduling and lesson costs as people learn to use it at home. The accompanying App provides audio and visual feedback on the learner's CPR performance. Everyone has heard the saying "Practice makes perfect": regular training with Ora is the most effective means of learning and retaining skills.



Integrated Product Design
Medisign specialisation

THE SENSISTEP: TO MAKE REHABILITATION POSSIBLE AT HOME

Graduate: Christa Leihitu (2017)
Supervisory team: W.F. van der Vegte, A.H. Jellema, L. Derks
Partner: TU Delft

Patients with lower extremity fractures often have trouble keeping the load on their affected leg within the prescribed weight bearing limits. Moreover, healthcare professionals do not have proper insights into their patients' partial weight bearing performance. Due to changes in the health services, more and more patients are now being encouraged to manage their rehabilitation at home. In order to support the patient in their home rehabilitation process, the SensiStem Home was developed.

SensiStep Home is a product service system which makes it possible for patients and healthcare professionals to get insights into the patient's partial weight bearing performance during home-rehabilitation. SensiStep Home is composed of an inner shoe and an outer shoe and is designed for both patients with or without a cast. The sole of the outer shoe contains two sensors which measure the load put on the affected leg without disrupting the natural walking motion. The measured load can be reviewed via a smartphone application. It is also possible to check the partial weight bearing performance real-time or to get notifications when exceeding the prescribed weight limit.

In this way, healthcare professionals can more accurately advise their patients based on the measured data, thereby working towards a patient's optimal home-rehabilitation.

DESIGN FOR PATIENT EMPOWERMENT


PHILIPS Afi

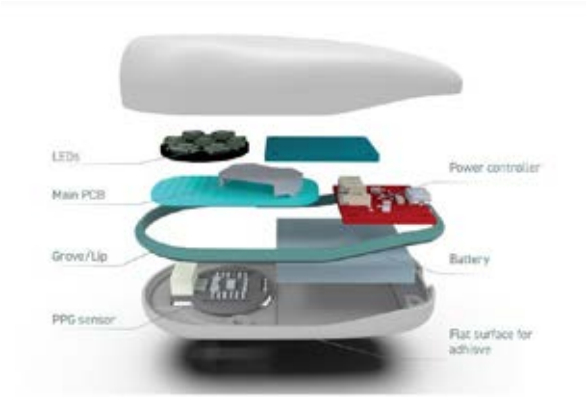
UNOBTRUSIVE LONG-TERM MONITORING FOR ATRIAL FIBRILLATION

Graduate: Leonard Moonen (2017)
Supervisory team: M.S. Kleinsmann, H.M.J.J. Snelders
Partners: CardioLab, Hartstichting, Philips

This master thesis project explores the use of Photoplethysmogram (PPG) technology to detect Atrial Fibrillation (AF). This project proposes a product-service system (PSS) for AF detection and diagnosis in the current Dutch healthcare system. The PSS was based on interviews with cardiologists, general practitioners (GP) and literature research.

One in four middle-aged adults in Europe and the US will develop Atrial Fibrillation. Philips propose to monitor patients for longer periods using Philips' HealthWatch. However, the PPG technology integrated in the current HealthWatch is too sensitive to movements on the wrist position. This can result in an inaccurate diagnosis.

After an initial exploration of the subject, the following design proposal was formulated: To provide a low threshold tool to support the initial diagnosis of (paroxysmal) atrial fibrillation for the GP, collecting useful data for further treatment, and providing patient support. This led to the creation of Afi, a small diagnostic tool based on PPG placed on the patient's upper arm. It can then be deployed by the GP for unobstructed longer-term monitoring. User evaluation showed that Afi has excellent potential as a new way of diagnosing AF.



SHARED DECISION MAKING IN CANCER CARE

Graduate: Siemon van Opstal (2018)
Supervisory team: M. Melles, H. de Ridder, G. Geleijnse
Partner: Integraal Kankercentrum Nederland (IKNL)

Shared Decision Making (SDM) is currently advocated by both healthcare professionals and patients as the 'ideal' decision-making process. However, SDM is difficult to implement. This also applies to decisions on adjuvant chemotherapy treatment decisions for patients with colon cancer.

To prepare both patient and physician for making the treatment decisions based on SDM, a web application IPD (Inform, Prepare, Decide) was developed. The main functions are to provide general information which stimulates interaction between patient and physician and provides life expectancy prediction information from IKNL (Integraal Kankercentrum Nederland, Netherlands Comprehensive Cancer Organization).

The SDM process as facilitated by IPD consists of four steps. Firstly, the patient is invited by email to IPD by the oncological surgeons' portal. The next step is at home where, through a portal, the patient can access IPD and prepare for the treatment decision. Oncologists also have to prepare; they check a patient's preferences and values concerning quality of life before consulting the patient via the portal. The last step takes place in the hospital. By using IPD during the consultation, both patient and oncologist are supported and a final treatment decision is made.

DECISION MAKING ON PARTICIPATION IN BREAST CANCER SCREENING

Graduate: Hanna van der Ploeg (2018)
Supervisory team: M. Tassoul, N. Tromp, E. Uiters
Partner: Rijksinstituut voor Volksgezondheid en Milieu (RIVM), VU University Medical Center

Breast cancer is the most common cancer among women in the Netherlands. From 1989 onwards, the RIVM has organized a two-yearly breast cancer screening program for women aged between 50 and 75. In recent years, the RIVM screening policy mostly focused on the interests of the public as a whole. However, at an individual level, the advantages do not necessarily outweigh the disadvantages (e.g., over-diagnosis, false positives, false negatives). Recently, RIVM introduced a more responsible role towards the public in its policy, adopting a more individually-centered approach, supporting women with informed decision-making.

The user-centered research in this project shows that women do not make a well-informed decision and, perhaps more importantly, are not supported in doing so. Noteworthy is that women receive a regular envelope when entering the program at the age of 50 which includes both the information and the invitation. In addition, women do not only base their decision to attend the screening on rational models; beliefs also appear to influence the decision-making process.

This project focus on the development of a periodic intervention of 3 magazines to be sent to women when aged 49 and 50. These magazines are designed to activate and guide the decision-making process regarding participation in breast cancer screening. The magazines offer women's stories which represent living scenarios, different choice options, and different motivations for decisions. After the third magazine, the woman receives the first invitation. Whether this design concept will achieve a well-informed decision making in the long-term needs to be further tested, but the tested concept demonstrated that the magazine offers the possibility to emphasize 'communicating on an emotional level'.

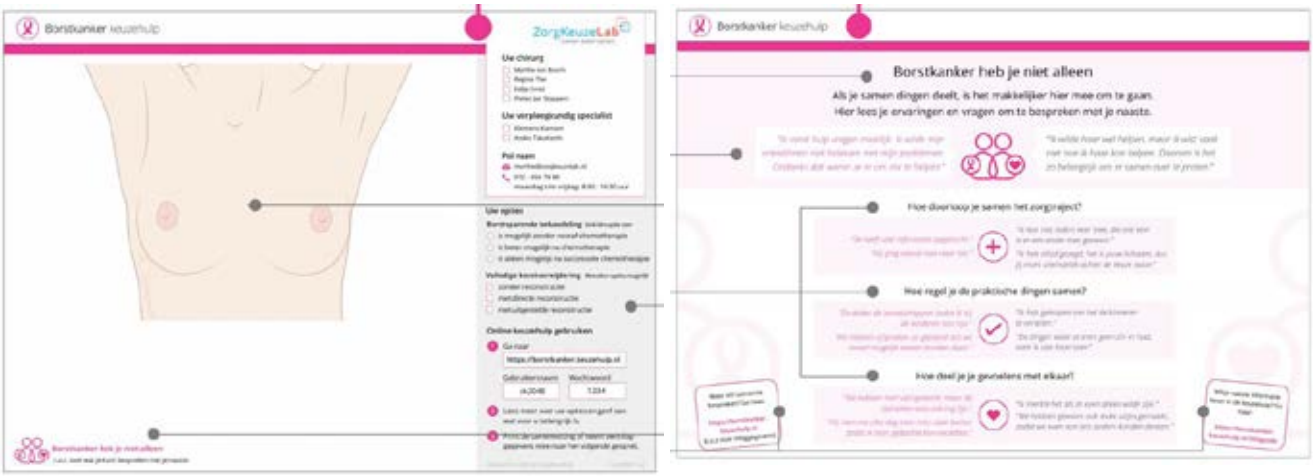
SHARED DECISION MAKING AFTER A BREAST CANCER DIAGNOSIS

Graduate: Myrthe ten Bosch (2018)
Supervisory team: P.J. Stappers, E. Ernst, R. The
Partner: ZorgkeuzeLab

Annually, 14,500 Dutch women are diagnosed with breast cancer. There are several treatment options, and currently it has become more common that the treatment decision is made by the patient and physician together, a process called Shared Decision Making (SDM). But breast cancer is something a patient endures together with their 'significant other'; their partner, family members, and friends, and their involvement is also important at this time.

In order to improve SDM in this context, a hand-out template was designed to improve the interaction between professionals, patient, and family, as well as the experience during the period following the diagnosis.

This hand-out is introduced to the patient and significant other during the diagnosis consultation. On the front side of the hand-out, the "Borstkanker heb je niet alleen" (Breast cancer is not only yours) part is added to make the patient and significant other aware that it is important to involve partners, family members and friends. On the rear of the hand-out, experiences of other patients and their significant other are detailed, which is expected to help patients 'open up' about their dilemmas.

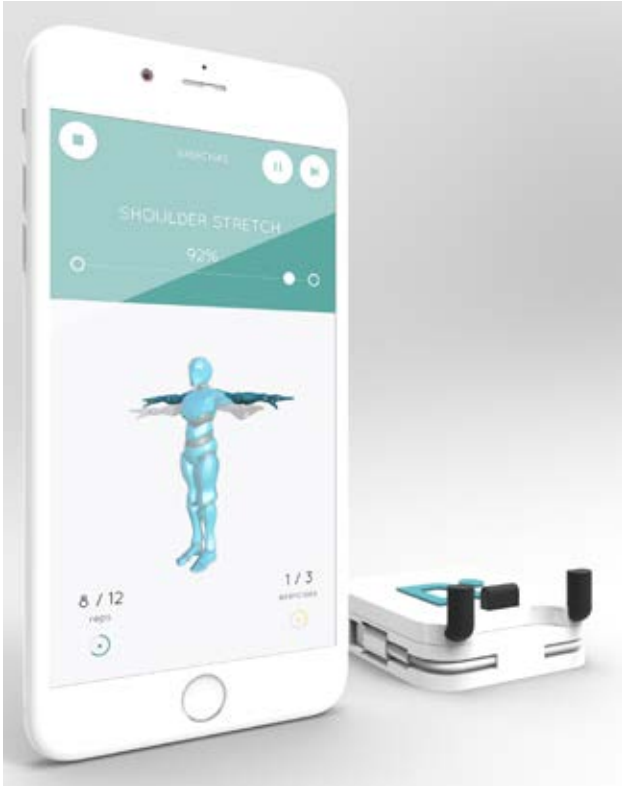


UNIPHY: INCREASE PATIENT COMPLIANCE IN PHYSICAL THERAPY

Graduate: Rik Burger (2017)
Supervisory team: C.C.L. Wang, R. van der Horst
Partner: TU Delft

Annually, about 20% of the Dutch population visit a musculoskeletal therapist. Of these, 80% conclude the treatment without their initial injury. The therapy is effective, but not efficient, entailing three main categories: massaging, exercise therapy, and physical technology. The first and the latter are executed by the therapist. The exercise therapy needs to be executed by the patient at home. Unfortunately, 70% of the patients do not comply with the exercise program recommended by their therapist.

Uniphy is a product-service system that aims to help the patient at every step in the therapy process. It is a smartphone application that uses technology from Google's Tango project to record the exercise in 3D at the therapist's practice. This recording can be played back to the patient at a later time. When the patient executes the exercise, Uniphy is able to measure whether the patient correctly performs the exercise and gives both visual and audio feedback.



UNIPHY: A HYBRID EXERCISE THERAPY

Graduate: Bas ter Haar Romemij (2017)
Supervisory team: J.I. van Kuijk, A.Q. Beekman
Partner: TU Delft

Annually, 3 million patients in the Netherlands are prescribed with an exercise regimen by their physical therapist. However, for 99% of the time, these patients are not supervised by their therapist. For this reason, the following problems arise: (1) the patients do not act as advised (50-70%), (2) patients exercise with a wrong posture, and (3) the exercise program needs adjusting which cannot be provided. Currently, therapists and patients meet weekly for checkups and adjustments.

The UNIPHY smartphone application supports the patient via communication with the therapist for additional information. Through personalized feedback, the chance that the patient exercises correctly increase. By making the treatment insightful, the patient is stimulated to keep on exercising. Therapists are enabled to monitor their patient's activities, experience and progress via their own therapist dashboard. Notification outlier settings enable the therapist to only spend online time on necessary issues. When desired, contact can be made in order to further discuss evaluations. The properties of the exercises can be adjusted, to make sure that there is no over or under-training, meaning the patients follow the optimal path towards their own rehabilitation.

REDESIGNING THE MS PATIENT EXPERIENCE - IT'S ALL ABOUT PREPARATION

Graduate: Zoé Martial (2018)
Supervisory team: M. Melles, G.J. Pasman, B.A. de Jong, O.C. Damman
Partner: VU University Medical Center

Annually, 270 people in the Netherlands are diagnosed with Multiple Sclerosis (MS), adding to the total MS population of 16,000. Between 40% and 70% of this group suffer from cognitive complaints. To research these issues, the MS Center Amsterdam has started a new Second Opinion Multiple Sclerosis and COGnition screening (SOMSCOG) outpatient clinic for MS patients suffering from cognitive problems.

The needs and the underlying values of MS patients visiting the SOMSCOG outpatient clinic are fundamental values; they long for transparency, clarity and honesty. Additionally, the user study exposed an interesting problem: patients have difficulties preparing for visiting the outpatient clinic which results in the help request (which forms the basis for diagnosis) often being suboptimally formulated. Building on the patient journey and insights from literature, a toolkit was developed - De Gids - with which patients can prepare themselves for the SOMSCOG outpatient clinic screening day.

De Gids includes a folder, an information guide and a preparation sheet. The guide contains information of the screening day, e.g. the schedule, possible outcomes and treatment options.

EMPOWERING THA PATIENTS TO MANAGE THEIR RECOVERY PROGRESS

Graduate: I-Chu Liao (2016)
Supervisory team: A. Albayrak, F. Sleeswijk Visser
Partner: TU Delft

In this project, the focus was on improving the experience of Total Hip Arthroplasty (THA) patients along their entire treatment journey. A vision was created for the next three to five years. It was found that communication is one of the key factors in the patients' healthcare experience; this greatly influences whether patients perceive their experience as being effective, positive or supportive.

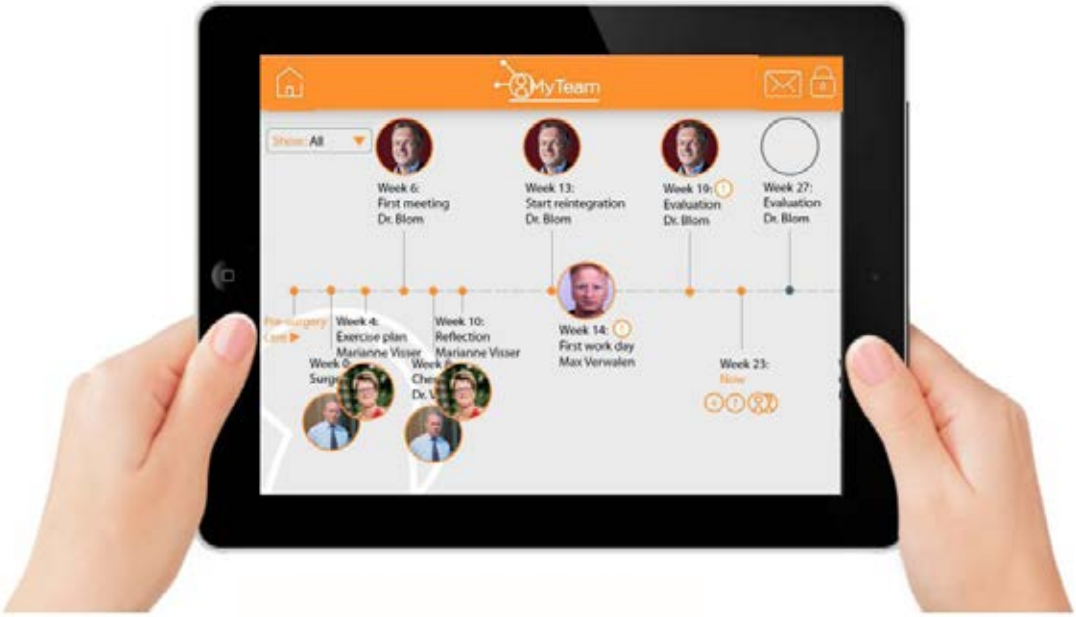
Research resulted in a strategy to provide personalized services regarding the dynamics of THA patient's treatment information communication. The final designed BiSmart application enables patients to communicate their personal needs to the healthcare professionals, find timely support, and alternate their rehabilitation behavior according to instant feedback from the THA healthcare team.

COLLABORATION IN THE WORK-DIRECTED CARE FOR KNEE-REPLACEMENT PATIENTS

Graduate: Anna Spaenij (2017)
Supervisory team: M. Melles, B. Groeneveld, M.H.W. Frings-Dresen
Partner: Coronel Instituut voor arbeid en gezondheid

Currently, 30% of all knee prosthesis patients do not return to work after surgery. This is partially due to insufficient guidance and collaboration by the patient's care provider; i.e. the occupational physician and the orthopedic surgeon. Collaboration is experienced by both the occupational physician and orthopedic surgeon as impersonal, uninvolved and inefficient. This leaves the patient feeling insecure and uncertain before and during rehabilitation.

A platform was developed with the main focus of allowing both care providers and patient to form expectations based on information and insights in the complete work-directed care process. This new platform combines all information concerning the patient's functional recovery and work reintegration in one overview, and is available to both the care providers and patients. The platform stimulates direct communication and mutual support based on their separate areas of expertise.



SELF-MANAGEMENT IN CARDIOVASCULAR RISK PREVENTION PROGRAMS

Graduate: Guillermo Meza Pérez (2018)
Supervisory team: H.M.J.J. Snelders, M.S. Kleinsmann, V. Pannunzio
Partner: CardioLab, Hartstichting

Cardiovascular diseases (CVD) are the leading cause of death worldwide. While metabolic factors such as age and gender affect CVD greatly, most CVD events can be prevented by addressing behavioral risk factors such as physical inactivity, smoking or bad diet. CVD prevention programs aim to reduce the burden of these conditions by providing guidance to individuals and predict negative outcomes, but adherence to these programs relies heavily on individual capabilities and intrinsic drivers. By integrating individual traits and responding to intrinsic needs, adherence can be increased and the system can deliver a more tailored message that addresses individual concerns and motivators.

This graduation project proposed a digital system to facilitate pro-active involvement and self-management of modifiable risk factors for individuals aged 40 – 50 and assessed with a high CVD risk. The characteristics of the concept are developed under a 2-axis model, focusing on intrinsic or extrinsic motivators and supportive or challenging message tones. The system filters out preferences based on an initial self-evaluation at the beginning of the prevention program, and later on by analyzing the amount of interaction with the different triggers and system layers.

TELEMONITORING AND SELF-MANAGEMENT OF HEART FAILURE PATIENTS

Graduate: Roeland Reitsema (2016)
Supervisory team: H. de Ridder, M. Melles, M. van Leengoed, E. Ronner
Partner: Philips, Reinier de Graaf Hospital

This project presents a new proposal to improve telemonitoring and self-management for heart failure patients: The Health Dashboard. The Health Dashboard aims to reduce the chance of readmissions, to reassure heart failure patients about their health, to increase adherence to daily monitoring, and to provide reliable insights about a patient's health to the medical team. It is designed for use in the patient's bathroom for a period of 30 days following hospital admission.

The Health Dashboard tailors its behavior towards individual patients by using both explicit and implicit profiling. It has four main functions: (1) Prepare (increasing motivation and ability), (2) Trigger (providing reminders with the right content on the right time), (3) Measure (measuring weight and respiration rate with use of a weight scale and bed sensor) and (4) Feedback (reassuring patients and adding context information to measurements).

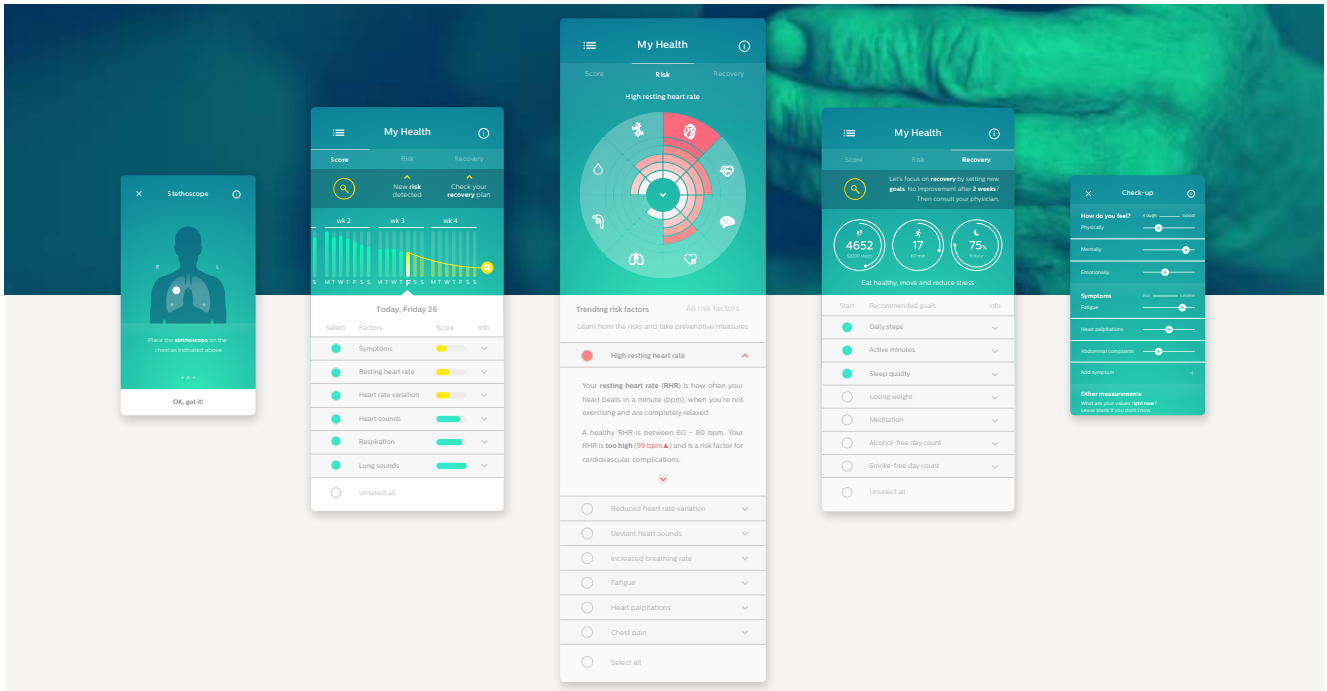
SELF-MONITORING SOLUTION TO DETECT COMORBIDITY IN CARDIOVASCULAR DISEASE

Graduate: Saskia Mosterman (2018)
Supervisory team: M.S. Kleinsmann, A. Albayrak, M. van Leengoed, E. Janssens
Partner: CardioLab, Philips, Hartstichting

Chronic diseases often come together. A coexisting disease, also known as a comorbidity, drastically reduces a patient's quality of life. Timely detection of the first disease signs can ensure timely help and intervention. Therefore, screening for other diseases than the one diagnosed is essential for the health and well-being of patients. This project aimed to improve secondary prevention of cardiovascular disease by design.

The project proposes a self-monitoring solution which enables patients to monitor their risk of complications and comorbidity by using a home-use stethoscope and a smartphone application. The smartphone application visually demonstrates the future risk of complications and gives patient-tailored action points to reduce this risk. The proactive feedback intends to evoke a well-considered patient response, ranging from encouraging healthy lifestyle habits, to reassurance when seeking help.

The proposal aims to engage and empower patients in the ambiguity of risk management by providing insights into the "whys and how" of preventative self-management strategies which apply to their situation.



MONITORING DEVICE FOR CARDIOVASCULAR PATIENTS

Graduate: Daniel László-Deli (2018)
Supervisory team: M.S. Kleinsmann, S.G. Van de Geer, F. Borgonjen, D. Smeekes
Partner: CardioLab

Due to rapid technological progression, digital stethoscopes will be more commonly used in the near future. Not only are they valuable for general practitioners and cardiologists, but they are also highly promising for the early detection of lung infections in COPD (Chronic Obstructive Pulmonary Disease) patients. A strap-based self-monitoring device was designed to detect pulmonary edema (fluid retention in the lungs) at an early stage and prevent damage.

The device has a double stethoscope set-up, which enables patients to listen to the sounds of both lungs at the same time, halving the measurement time. The inner structure of the device was detailed: hidden lights in the strap help patients to remember measurements and provide feedback about measurement accomplishment.

The fabric-based strap design provides a friendlier and more comfortable look and increases comfort during use. The vision on the use integrates breathing exercises and the measurements. By conducting the measurements, users can unlock new exercises, thereby making more diverse use of the monitor over time. The device is stored on a wall-mounted charger.

INVOLVING PATIENTS IN DATA DECISIONS

Graduate: Micha Lionarons (2016)
Supervisory team: E. Giaccardi, F. Sleeswijk Visser, R. Peters
Partners: Deloitte, Minuut

Data from health wearables promises to add value to all stakeholders with their potential to improve the quality of care, while making the technology more convenient and cost-friendly. However, many companies in the health wearable industry are currently collecting data without a clear purpose, expecting it to 'pay out' tomorrow. They tend to handle the data as a currency, with similar risks and benefits, often leaving their customers in the dark about data-related practices. Moreover, they focus on complying with security and privacy rules and regulations, providing users with long terms of agreements that nobody reads or understands. Meanwhile they leave their customers uneducated, often leading to a growing reduction in trust.

The goal of this project was to develop a strategy for the health wearable industry to make strategically sound data-related decisions together with their customers.

Health wearable companies will achieve better results if they do not handle security and privacy as risks, but as a brand differentiator. They should focus on complying with trust frameworks inside the minds of patients by actively engaging them through good communication. In order to reach digital trust, patients need to be involved in four consecutive steps: 1) education on data use, 2) providing transparency in data use, collection, sharing and storage, 3) allowing the user to control and intervene in their privacy, and 4) addressing the value that users 'trade' for personal data.

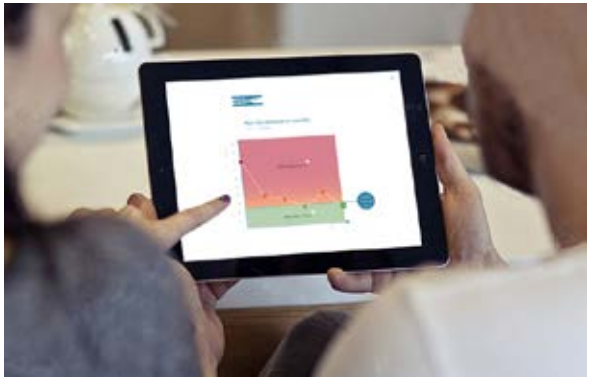
DESIGNING FOR SHARED DECISION MAKING

Graduate: Karen Thomson (2016)
Supervisory team: M. Melles, A.Q. Beekman, O. Damman, C. Brouwers, M.C. de Bruijne
Partner: VU University Medical Center

Currently, Shared Decision Making (SDM) between a physician and a patient is something desirable and is considered best practice. The emphasis is on patients taking on a more active role and being more involved in decision making regarding their treatment. However, making health-related decisions can be a complex matter for both physician and patients. This project focused on improving SDM by means of design for patients with the genetic disease Familial Hypercholesterolemia (FH), for whom the prescription and intake of medicines is a lifelong process.

An explorative user study was conducted to research how the current FH process is organized, how FH patients and physicians interact in practice, how they experience the consultations, and the patient's perspective of their treatment.

MIK is a shared application that gives physicians and FH patients a more equal way of communicating by sharing information and sharing decisions. The patient is expected to prepare for the consultation by filling in short questions regarding lifestyle factors, their values, as well as their treatment preferences. In this way they provide the physician with a more complete picture of themselves. To encourage patients to become more active partners in the conversation, they are triggered by the design to select one item they want to discuss. MIK serves as supportive communication tool during consultation by presenting easy to understand graphics of the medication options and cholesterol results.

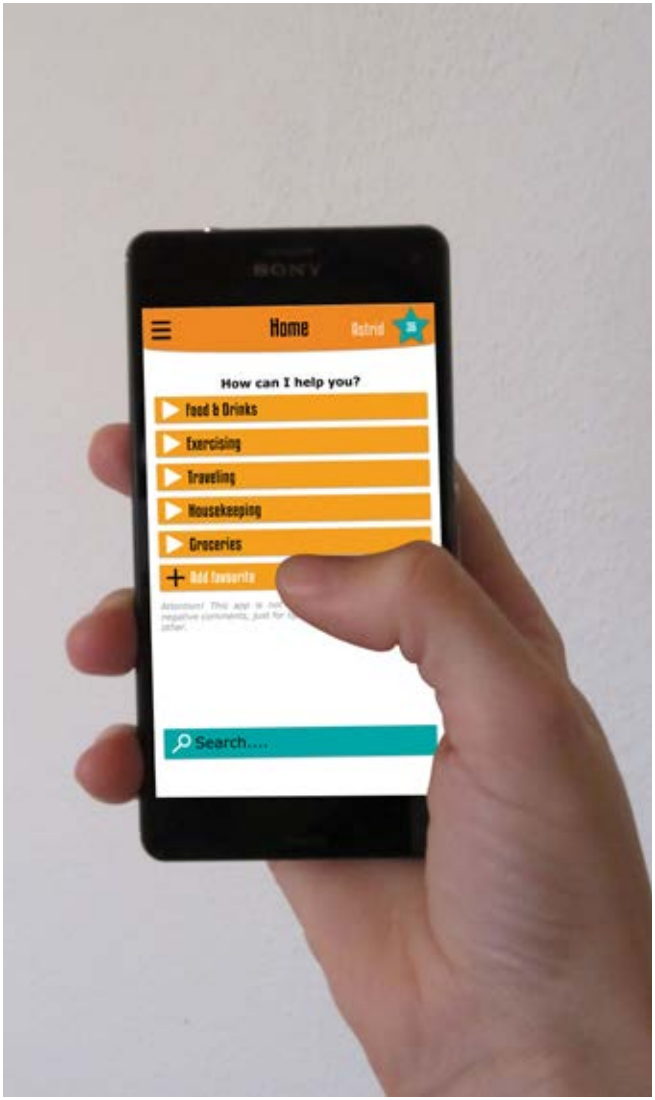


TAILORED SELF-MANAGEMENT SUPPORT FOR PEOPLE WITH TYPE 2 DIABETES

Graduate: Astrid van Smoorenburg (2017)
Supervisory team: M. Melles, T. Dekkers, A.M.J. Elissen, D.F.L. Hertroijs
Partner: Maastricht University

The number of type 2 diabetes mellitus (T2DM) patients is rapidly increasing. As patients are increasingly expected to self-manage their disease, it is important to provide them with appropriate self-management support. In this way, success of self-management will increase and T2DM complications and related costs can be reduced. Currently, self-management support is developed mainly from the perspective of health professionals and caregivers, rather than patients. This project focused on gaining a better understanding of patients' perspectives on self-management and support.

'Deel Diabetes' ('Diabetes Sharing') is a smartphone application that facilitates sharing daily life experiences amongst T2DM patients. It combines factual information about type 2 diabetes from health professionals' websites with tips from peers on how to deal with type 2 diabetes in daily life. Experienced users of the application, who are thus experienced T2DM patients, are invited to share tips, tools and answers which could support recently diagnosed patients in learning how to deal with their diabetes. What makes this application unique, is that it is designed to stimulate sharing possibilities and solutions, instead of issues and problems which currently serve only to discourage newly diagnosed patients.



ESTIMATING CARBS FOR IMPROVED DIABETES SELF-MANAGEMENT

Graduate: Myrthe Büskens (2017)
Supervisory team: M. Sonneveld, F. Sleeswijk Visser, G. Bergman, T. Hofker
Partner: Roche Diabetes Care

People with diabetes undergoing an intensive insulin treatment have to manage their disease independently. The success of an intensive insulin treatment depends on the ability of patients to determine their carbohydrate intake: by being aware of how much carbohydrates are consumed, patients know how much insulin to inject. However, determining carbohydrate intake is experienced as ambiguous, complex and confusing.

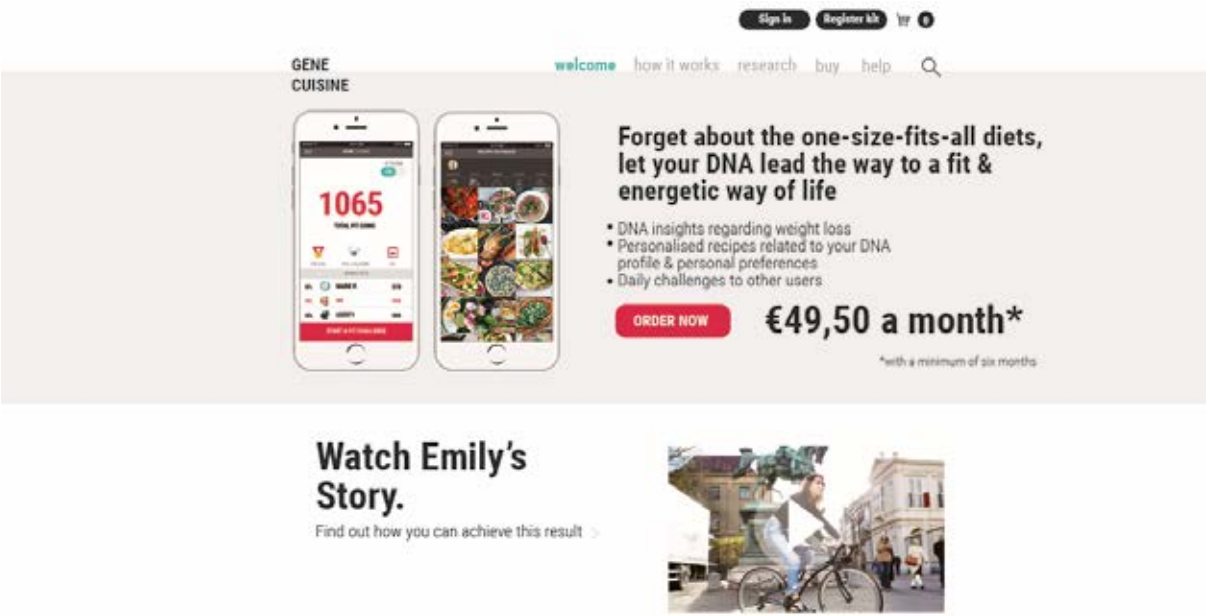
This assignment focused on people with intensive insulin treatment who have to enter the grams of carbohydrates that they are about to eat into a blood glucose meter. Research showed that people need more support at home to be able to determine their carb intake than is currently offered. Four design research cycles revealed how and when people need extra support the most. A final design proposal was made to train people with intensive insulin therapy to estimate their carb intake by supporting them with exercises and insights so they can learn to intuitively apply their knowledge and skills.

DNA-BASED HEALTH SERVICE

Graduate: Stephanie Woudstra (2016)
Supervisory team: H.M.J.J. Snelders, L.W.L. Simonse
Partner: TU Delft

In this project, the design of a DNA-based health service was reviewed, focusing on the connection between the technology of DNA testing and the consumer. Science has developed far enough to now to be able to work out what suits humans personally in terms of food, exercise and lifestyle, for example how a particular kind of exercise benefits one person more than another, how a Mediterranean diet can be more appropriate, and how people react differently to an emotional situation.

A positioning statement was the result of an advanced analysis and ideation. Based on this, a service blueprint was created together with a visual prototype of the service. A business model and implementation strategy were developed in order to launch this service into the market. Gene Cuisine is an app that helps users to lose weight and get control over their bodies by giving them DNA insights regarding weight loss, providing them with personalized recipes based on these DNA insights, and offering them the tools to feel energetic.

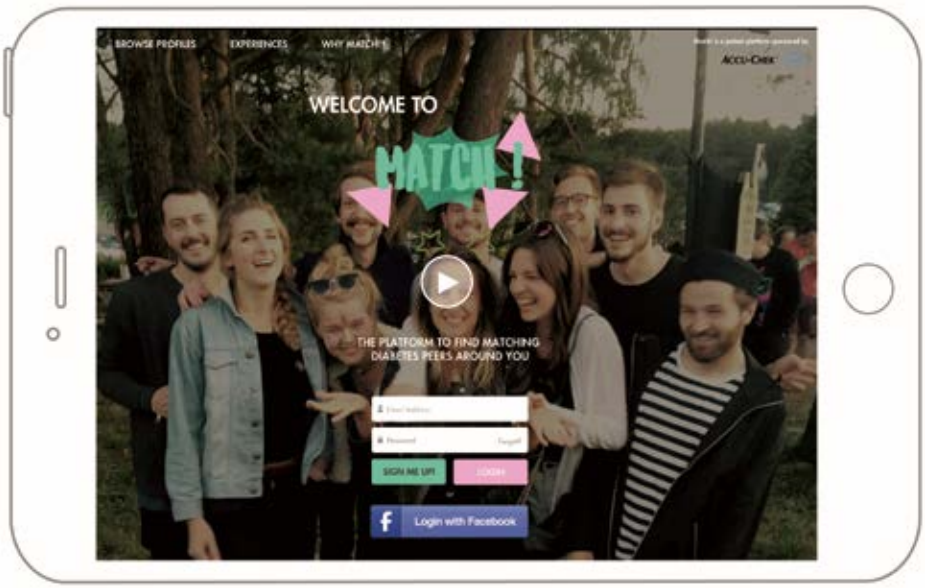


MATCH! A DIABETES PATIENT PLATFORM TO FACILITATE NEW PEER FRIENDSHIPS

Graduate: Julia Brinkmann (2017)
Supervisory team: S.U. Boess, A.Q. Beekman, M. van Gool
Partner: Roche Diabetes Care

Diabetes is a disease that is mainly managed by the patients themselves. Having to deal with this disease every day, each patient develops an individual diabetes management style that is influenced by his/her personality, the surroundings, and the relation with the professional caregiver. As every patient has a different personality, the interviewed patients showed great differences regarding their management and mindset. As in real life when searching for new friends, the patients expressed the wish to get in contact with other peers who matched their diabetes mindset so that they can better recognize problems.

Match! is an online patient platform that enables every diabetes patient to create an individual profile and display his/her diabetes mindset together with other additional info that shows 'the person behind the diabetes'. Match!'s goal is to let peers find contact points and similarities with other peers in order to increase the chance of developing a friendship with the matching peer. The concept focused on the profile creation process, the display of the mindset, and facilitation between peers.



PATIENT EMPOWERMENT IN TYPE 1 DIABETES CARE

Graduate: Vincent Laagland (2017)
Supervisory team: A. Albayrak, J.W. Hoftijzer, W. van der Beek, R. van den Berg
Partner: Novo Nordisk, VanBerlo

Diabetes is one of the largest health care problems globally in terms of prevalence, cost and burden placed on individuals living with diabetes. It impacts the patients and the people around them every day, and remains one of the leading causes of death. The difficulty of diabetes treatment lies in its complex and personal character. This project presents a proposal for a product-service system to support type 1 diabetes patients in the first stages of treatment after diagnosis.

Together with patients, a holistic design was developed to support patients in their self-management. The design consists of a physical product supported by a smartphone application. The essence of the design is described in three key user benefits.

1. Simplify, by providing one place for everything in one clean and simple design, automatically logging the most relevant data, and enabling the user to effortlessly log relevant contextual factors. 2. Structure, by providing the user with an action plan for self-management, personalized information, and meaningful data overviews. 3. Support, by guiding the user with nutrition support, dose calculators, reminders, automation of repetitive actions, and personalized feedback and messaging.

The product serves as a personal insulin injector. It measures the glucose level in the blood first, then determines the carb intake, and as a result, the right amount of insulin is put into the injector. In this way the diabetes patient always has the right amount of insulin.

INTUITIVE WEARABLE FOR RUNNERS WHICH HELPS TO PREVENT INJURIES

Graduate: Eva Dijkema (2017)
Supervisory team: A.J. Jansen, A.L.M. Minnoye, R. Zandbergen
Partner: ASICS

The goal of this project was to provide ASICS with insights into their current innovation processes and provide recommendations on how these could be improved. The focus was on injury prevention. A design project was executed to illustrate the strategic recommendations.

Vibe is a wearable device which provides the user with meaningful and more intuitive feedback based on data gathered by the RunKeeper app on the user's smartphone. Vibe is especially designed for the recreational runner. This target group are unlikely to buy an expensive running watch, and will get all their needed run information from an app like RunKeeper. However, Vibe can give them real time feedback about their performance, and helps them to run with a healthy rhythm.

Increasing the running cadence is one of the simplest yet least known ways to prevent common running injuries. Vibe supports runners in achieving a higher cadence by cueing them with vibrotactile and visual feedback. Without showing any data about their performance, these forms of feedback can cue the runner to run better, more naturally, and more intuitively.

BLOCKCHAIN-BASED SOLUTION FOR CONSUMER-CENTRED PRIVACY CONTROL

Graduate: Anna Klapwijk (2017)
Supervisory team: F.E.H.M. Smulders, M.C. Sääksjärvi, J. Boersma
Partner: Deloitte

In recent years, control over personal health data has become an important issue due to the increase in data collection and analytics. Data control is essential for privacy and the ability to protect the individual identity. Solutions to give consumers more control have failed in the past due to security and privacy concerns.

In this thesis, a new measurable definition was proposed of control that constitute the access, bookkeeping of access, clarity of use, the possibility of decisions, effort to access, and the freedom to make decisions as components of control. Furthermore, the obstacles that currently prevent consumers from controlling their data are identified, and the possible gateways around those obstacles. Finally, practical functionalities are proposed for the implementation of a solution that takes the perspectives of different stakeholders in the healthcare industry into account.

Blockchain technology is proposed as part of the infrastructure for the registration of consent to health data. The final design is an infrastructure that facilitates convenient control for the consumer by integrating health data from different sources. The consumer is at the center and can control with whom to share a part, or complete set, of their health data within the complex network of stakeholders involved.

ECGRAPH: A 12-LEAD ELECTROCARDIOGRAPHIC SYSTEM FOR HOME USE

Graduate: Annemarijn Steijlen (2016)
Supervisory team: K.M.B. Jansen, A. Albayrak, D. van Wijk, D. Verschure
Partner: Academic Medical Centre Amsterdam (AMC)

Patients with arrhythmias often have symptoms for a short period of time. Timely diagnosis is difficult because symptoms often do not occur at the time that an electrocardiogram (ECG) is made in the hospital. This project focused on the development of a product-service system to enable patients to make a reliable 12-lead ECG at home, in order to diagnose arrhythmias and ischemia faster.

An ECG belt was created with four limb straps and integrated electrodes. The product contains ten wet electrodes that are placed at the standard locations according to the general procedure of making a rest ECG in the hospital. The product can be worn by people with different shapes and sizes as the belt stretches and the electrodes automatically move to the right locations relative to each other. The product is controlled by an app on the user's smartphone where the user can record the ECGs and send them, together with a description of the complaints, to the hospital. The cardiologist can then interpret the results and send an advisory message to the patient.

BREAK: USING A SHARED MUSIC EXPERIENCE TO EMPOWER ADOLESCENT CANCER PATIENTS DEALING WITH POWERLESS FEELINGS

Graduate: Minon Rosier (2017)
Supervisory team: M.C. Rozendaal, P. D'Olivo
Partner: Prinses Maxima Centrum

One of the main challenges for adolescents (15 – 20 years old) suffering from cancer is to understand and accept the person they are. This led to the following design question: How can adolescent cancer patients be empowered to develop and maintain a positive self-image? Adolescent cancer patients were interviewed using context mapping methods in order to understand their needs and wants.

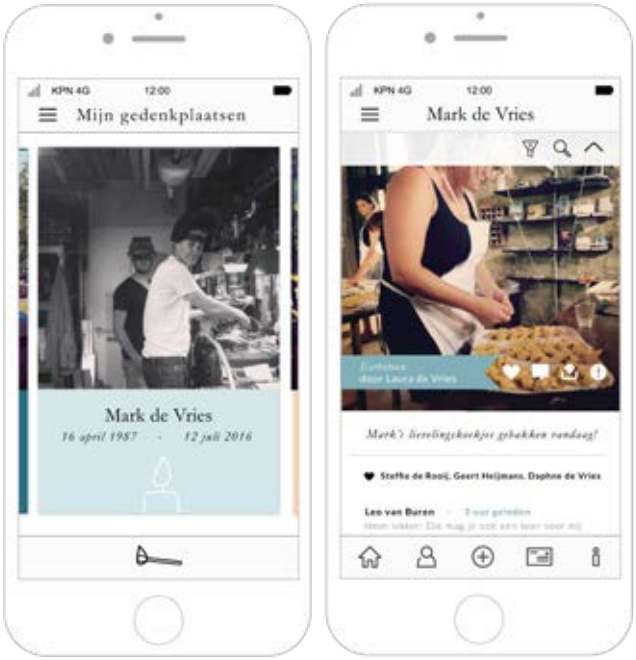
'Break' is a wearable device that can be attached to the wire of existing earbuds. Adolescent cancer patients can distribute 'Break' to their loved ones and friends, thereby building an empowering social framework. Within this social network, users can listen to and share a song of personal meaning with others. The device is based on the interaction of bending ('breaking') the device. When bending, a song from the selection will be played. In this way, adolescent cancer patients can actively influence their emotions in a situation of distress.

RECONSIDERING LOSS: THE FUTURE OF BEREAVEMENT

Graduate: Sofia van Oord (2016)
Supervisory team: N. Tromp, P.M.A. Desmet, B. van Buren
Partner: Monuta

The underlying question was to develop a human-centered strategy for Monuta's services based on a vision of the needs of people around the death and funeral of a beloved in 2025. This project aims to contribute to Monuta's services by making them more meaningful to their customers in the future. By doing so, it responds to the current desire for innovation in the funeral context in the Netherlands.

GedenkApp is a mobile memorial platform that allows people to share their love and grief for a deceased mutual friend or relative. It stimulates the bereaved to make explicit how the deceased still has a place in their heart and thoughts, by honoring him or her with tributes. For people around the bereaved (the so-called supporters), GedenkApp provides a channel to show their sympathy, also when life returns to normal. The platform has three main features: a post wall, a funeral page and a personal space.



BINA: A PATIENT-CENTERED TOOL FOR IMPROVED COMMUNICATION IN ONCOLOGY

Graduate: Annabel Nosrati-Moons (2016)
Supervisory team: I.R. Ruiter, A. Ramkumar
Partner: Erasmus Medical Center

During treatment, cancer patients receive a lot of information regarding their progress, the treatment, and future prospects. This information overload is too much for them to take when undergoing such a heavy subject. Moreover, the communication between patients and their family is important. The family do not want to confront the patient by asking too many questions about the disease, whereas patients do not know if everyone wants to be continually updated about their condition.

BINA is a Bracelet-App combination aimed at contributing to better communication and information provision. The BINA bracelet is intended to be worn by the patient and his family. With the help of a light interaction on the bracelet, they can empower the patient by showing that they are there, as a token of moral support. By all wearing the same bracelet (available in different colors) a unity is created, symbolizing how they will be strong together and fight the tumor. By pushing a button, the pattern will change on all bracelets. Inspired by the carbon chains of happiness hormones, the patterns give a positive vibe to the product and work as an extra way to brighten the patient's mood.

With the BINA app, the patient also has access to data related to the disease. In this way, everything explained by the oncologist is structured and categorized for easy access, which allows the patient to ask more specific questions at the oncologist's next visit. In addition, the app allows family members to receive the data from the patient. This helps them to anticipate on how to approach the patient and provide extra support when needed.

COMFORT FOR PEOPLE DEALING WITH ALOPECIA

Graduate: Tessa Majenburg (2017)
Supervisory team: P. D'Olivo, H. de Ridder
Partner: TU Delft

This project focused on how to help people with disruptive life events, and how to create strategies to empower them in coping with the situation. The target group are alopecia patients; alopecia is an auto-immune disorder which causes hair loss.

Different research and design methods were applied including interviews, surveys, a co-creative session, and design evaluation with assistance of the Alopecia Association. It was evident that the communication between the person with alopecia and anyone close to them should be stimulated and improved. Different design explorations combined with a concept evaluation study and a co-creative session led to the desired features of the final design.

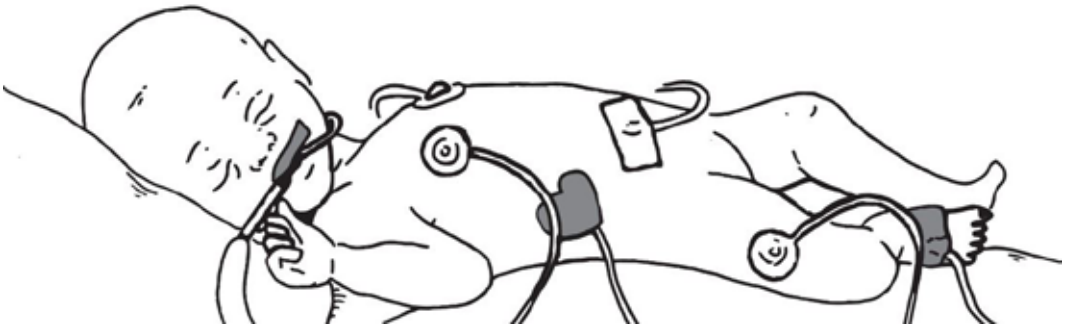
'Imagine alopecia' is an app that gives people close to someone with alopecia a better understanding of the impact of the condition, and stimulates communication between them. Features include 'Imagine... your hair loss', 'Imagine...my activities', and a hair and make-up filter.

A MESSENGER APP FOR PARENTS WITH AN INFANT IN THE NEONATAL INTENSIVE CARE UNIT

Graduate: Aniek de Jong (2015)
Supervisory team: M. Melles, A. Albayrak, I.K.M. Reiss
Partner: Sophia Children's Hospital, Erasmus Medical Center

Becoming a parent of a premature infant is overwhelming and stressful. Parents need to deal with difficult themes such as their fears for the infant's survival chances, the appearance of an extremely ill infant, the alteration of the parental role, and the separation from the infant due to hospitalization. They experience significant stress and are therefore at risk of developing serious mental and/or physical health issues.

The babyUPdate is a messenger service system which informs the parents about their infant's well-being and reminds them of their infant's progress by means of sending messages, twice daily. The content of each message, written in name of the infant, focuses on medical improvement and milestones. Parents might find solace in the messages during the difficult times in the neonatal intensive care unit. Moreover, each message contains a reflective component regarding the parents' behavior. This component helps motivate the parents to take good care of themselves. The babyUPdate offers other functionalities, such as keeping a digital diary and sharing experiences with others.



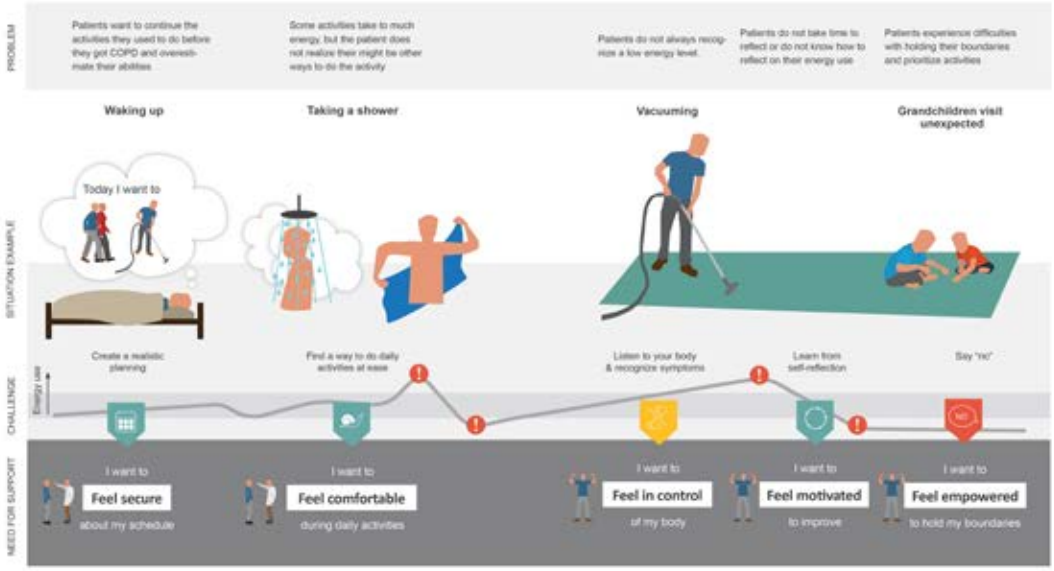
ENERGY MANAGEMENT OF COPD PATIENTS

Graduate: Rozemarijn Klein Heerenbrink (2018)
Supervisory team: H. de Ridder, N.A. Romero Herrera, O.W.R. van Dijk
Partner: Medicine Men

COPD (Chronic Obstructive Pulmonary Disease) is a lung disease that damages the lungs and results in breathing and energy problems. This reduced energy means that COPD patients have to adjust their routines and habits, which can be extremely challenging. eHealth has great potential to support COPD patients with these challenges.

In this project a set of design criteria were developed which can be used by eHealth designers to develop and evaluate digital solutions that support COPD patients in their energy management.

COPD patients have two general needs regarding self-management: autonomy and security. They want to feel in control of their life and feel secure about their abilities. In order to adjust their routine, patients meet several challenges which can be clustered in three groups: 1) keep focus on energy level and act if needed, 2) find new applicable routines, and 3) put yourself in first place. All these challenges lead to specific needs and needs for support, which in turn can be translated into criteria for e-health solutions that help COPD patients with energy management. Designers can use the criteria to evaluate concepts as well as a source of inspiration.




1973
Denim

EMBODYING MOVEMENT FOR CHRONIC PAIN

Graduate: Pranav Balasubramanian (2017)
Supervisory team: R. Wormgoor, D.I. Brand, G. Flint
Partner: Enriched Environments

Chronic pain is a global health concern that affects one in ten adults. It is associated with pain at certain tender points of the body when staying still for long periods. Performing physical activity is key when combating this illness, but this is also a challenge as patients suffer from fear of movement in the earlier stages, as well as maintaining regular movements.

Recent studies have shown that slow body movement positively correlates with emotion and well-being. This provided a starting point to design a device that fosters happy, full body movements, in people with chronic pain. The design process made use of a human-centered approach to gain first-hand user feedback of how movements and postures are perceived with constant referral to chronic pain research. Many prototypes and interactive technologies were designed and tested to find the correct mechanism for full-body movement and muscle stimulation. The final concept focused on a seating device which can be used for both work and as a rehabilitation tool, in connection with a computer game to practice and visualize movements, serving as a distraction from their pain.

SPARKLING MOMENTS: REDUCING CHANCES OF DEVELOPING POST INTENSIVE CARE SYNDROME

Graduate: Marit van de Kamp (2018)
Supervisory team: E. Ozcan Vieira, M.H. Sonneveld, P. Honig-Mazer, E.W. Ista
Partner: Sophia Children's Hospital

In recent years, it has become clear that many ex-patients and their families suffer from new or even worse health problems after discharge from an intensive care unit (ICU). These problems are the result of a traumatic experience at the ICU and are grouped under the diagnosis: post intensive care syndrome (PICS).

In this research project, the focus was on the mental health issues caused by PICS among pediatric patients and their parents. It was found that the feelings of closeness and security could be strengthened by providing a daily special ritual which children could do together with their parents. Furthermore, guiding the parents in what to do during such a ritual increases their feeling of being in control, which improves their confidence. Specifically, the bedtime moment was chosen as a focus because this often is the last moment of the day the children spend with their parents, and this can evoke many negative feelings.

"Sparkling Moments" uses projection in the ICU room to change the environment and create a special moment for parent and child together. By adding different triggers during the day, parents are able to prepare this moment for their child by bringing objects and asking questions, increasing their feeling of confidence. Moreover, these triggers bring an aura of positivity to the normal intensive care situation.

SURE: INCREASING SAFETY IN MEDICATION CARE THROUGH PATIENT EMPOWERMENT

Graduate: Emma Erkelens (2018)
Supervisory team: A. Albayrak, L.W.L. Simonse, S. Prins, M. Straijer
Partner: Capgemini Invent

Unsafe medication use can cause (preventable) hospitalization; this leads to the need for increasing safety measures in the pharmaceutical supply chain. In this project, the involvement of current and future stakeholders in medication safety and potential e-Health interventions was investigated, and user-centered design opportunities were explored. Focus was on patients that most likely to encounter problems due to medication: patients with polypharmacy and multi-morbidity, taking medication that influences their cardiovascular system.

The Zeker app is the result of an exploration of the opportunities on how patients taking medication can be helped in their daily lives. The research revealed bottlenecks in the medication care process that caused unsafe use of medication. For patients with polypharmacy, the Zeker app gives reliable personalized answers to finding a medication regimen. If medication is restrictive, it reduces negative emotions by taking patients seriously and helping in the search for alternatives.

SMART WEARABLE SYSTEM TO SUPPORT VETERANS WITH POST TRAUMATIC STRESS DISORDER

Graduate: Matthijs Vollebregt (2017)
Supervisory team: K.M.B. Jansen, M.C. Rozendaal
Partner: TU Delft

Settling back into regular life after returning from a mission is not possible for about 1 in 25 Dutch veterans. The events they have experienced have had such an impact that they suffer from Post-Traumatic Stress Disorder (PTSD). The problems they run into vary widely, but there are several prominent symptoms. Even though they are back in relative safety, a part of this group continues to behave like their environment is very dangerous. They are extremely alert and anything that is a reminder of the dangerous situations they have experienced generates a severe reaction, as if they are once more in that extremely dangerous situation. As this is terrifying, they try to avoid reminders as much as possible, and this can often severely limit what they do in their daily activities.

Bas was designed to support these veterans in their daily lives. It is a wearable that has to be wrapped around the waist. It tracks the stress level with sensors for heartrate, electrodermal activity, and breathing rhythm and responds if it senses the need for it. The wearable increases pressure which for three reasons: 1. to communicate the current stress level and to create awareness if this slowly increases; 2. to create a strong distraction to bring attention to the physical stimuli in the present, instead of on flashbacks, memories or reminders of the traumatic events; and 3. To reduce stress by giving comfortable but firm repetitive pressure pulses that helps slower and deeper breathing.

SMART WEARABLE SYSTEM FOR SENSING STRESS OF VETERANS WITH PTSD

Graduate: Xinjie Zhang (2018)
Supervisory team: K.M.B. Jansen, X. Li, M.C. Rozendaal
Partner: TU Delft

Post-traumatic stress disorder (PTSD) is a mental disorder that can develop after having experienced a traumatic event and in which a person experiences trauma-related symptoms or impairments daily. Currently two therapies are proven, but they are restricted to conditions and devices. Self-help wearables for PTSD do exist, but they are based on physiological signals. These signals are relatively easy to detect, but do not accurately show how someone is feeling. This project focused on incorporating the emotional and cognitive aspects of PTDS in self-help wearables.

The result is a chest vest which includes a heart rate sensor, a GSR sensor, a temperature sensor and an accelerometer to detect the physiological signal. In addition, it includes a self-reporting tool which can reflect users' real-time perception of stress. In this way, the final prototype was able to detect stress and body movement to a limited extent. More experiments and research need to be done to develop this wearable product further.

DESIGN FOR YOUNG PATIENTS

CO-DESIGNING A CHILDREN'S GARMENTS FOR SURGERY

Graduate: Thomas Latcham (2017)
Supervisory team: M.A. Gielen, F.A.P. van Doorn, B. Camphuijzen
Partner: Wilhelmina Children's Hospital

The goal of this graduation project was to design a new garment for hospitalized pediatric patients to wear when undergoing surgery by involving these patients throughout the design process. The initial design goal was to design a new garment that was comfortable, fashionable and privacy-respecting, while remaining functional for hospital staff and complying with the stakeholders' demands.

By performing internal and external analyses, conducting interviews with staff and children, and undergoing several design iterations, a final design was released. The new outfit gives patients a sense of control, ownership, safety and assurance, while meeting the staff's functional requirements.

The final design was evaluated with the users regarding their emotional needs as well as the staff's functional requirements. In a final session, all stakeholders were invited to a presentation of the new design in the WKZ. All stakeholders were satisfied with the final proposal and acknowledged the added value of this solution.

BEAGLE: A STIMULATING QUEST THROUGHOUT THE HOSPITAL

Graduate: Bas van Leeuwen (2016)
Supervisory team: M.C. Rozendaal, M.J.B. Boon, J. van der Net
Partner: Wilhelmina Children's Hospital

'Beagle: a stimulating quest throughout the hospital' is a project that focuses on improving the quality of life and the development (physical, emotional and social) of hospitalized adolescents with Cystic Fibrosis (CF) at the Wilhelmina Children's Hospital.

Cystic Fibrosis is an inherited chronic disease that causes slime to thicken. Various organs that use slime such as the lungs and digestive system, are unable to function properly, resulting in several complications. People with CF are often short of breath and quickly exhausted.

In cases of severe infection, patients need to be hospitalized. Patients are tied to their room for a period of up to three weeks, depending on the treatment program. This graduation project focused on the design of a product service system that invites hospitalized CF adolescents (12-16 years old) to act together while being (physically) segregated from each other.

The Beagle is a small product placed in the hospital. An adolescent has to download the app and scan the beagle once one is found. The patient then uploads a picture to its picture diary, and if another adolescent comes by and scans the beagle, the diary is visible. This adolescent then can place the Beagle in another room, take it with him/her, or do something fun for the next finder etc.

It was envisioned that the design should be an activity which is fun to do and, by doing so, activate the adolescent who would not experience it as an obligation. The final design proposal invites and captivates adolescents to interact.

IMPROVING THE SCHOOL EXPERIENCE OF CHILDREN WITH CANCER

Graduate: Inge Bartels (2017)
Supervisory team: G.J. Pasman, P. D'Olivo
Partner: TU Delft

The aim of this graduation project was to design a product/service to improve the psychosocial school experience of children with cancer aged between 8 and 10 (group 5/6 at primary school) and the people around them during the treatment phase.

This graduation project is a part of the 'Meedoen=Groeien!' collaboration. In the current situation, children with cancer and the people around them experience several challenges which affect their school experience. One of these challenges is that teachers tend to underestimate children with cancer, while these children tend to overestimate themselves due to their willingness and enthusiasm. For teachers it is difficult to understand what to expect from ill children, as the child's mood and energy level is affected by the cancer and its treatment and can change during the day.

The 'Gevoelens medaille' stimulates the sick children to think and talk about their mood and energy level. It makes it possible to express this in an easy, quick and unforced way, and reminds classmates and teachers of the impact cancer and its treatment has on the child. Based on the mood and energy level of these children, the teachers can decide which tasks the they could do. This can be written down in the 'Mijn les'. To involve these children and help them regain control, they can mark which tasks they are going to do by choosing from the tasks proposed by the teacher and/or by adding extra tasks. The 'Mijn les' – cards will also be used by classmates so that they feel that the sick child can be treated like a "normal" child and create a sense of belonging.

TRACK ME CHASE ME: AN ENGAGING ENVIRONMENT FOR PAEDIATRIC THERAPY

Graduate: Donna Stam (2017)
Supervisory team: A.J.C. van der Helm, M.J.B. Boon, J. van der Net
Partner: Wilhelmina Children's Hospital

This graduation assignment is about a new playscape for the Child Development and Exercise Center of the Wilhelmina Children's Hospital (WKZ) in Utrecht.

The appropriateness of the center's current exercise room for children's play and ergonomic skills is highly age-dependent, and its possibilities for interaction are limited. Therefore, the relocation of the center in 2018 was used as an opportunity to evaluate the use of 'Playscape 1.0' and design a new 'Playscape 2.0' that supports a variety of interactions for various target groups. The design process resulted in the proposal of a master plan for the whole room, an adaptable environment (Track Me), and an interactive design (Chase Me).

Track Me Chase Me consists of a range of elements that can be placed in various positions and in this way support a number of activities. Track Me can shape a play or training environment and supports activities concerning gross motor skills (e.g. crawling, climbing, jumping or balancing).

Chase Me consists of four smaller, interactive elements that have an irregular shape and can respond to a child's actions by means of LED-light. The design was tested with children aged 2 - 9 at an afterschool care center, and evaluated by the therapists from the Child Development and Exercise Center. These tests only show preliminary results as they were not performed in the actual context of the design. Nonetheless, the tests show promising data for the use of the design during play and training. Therapists expect to regularly use the design thanks to its flexibility and ease of use.

IMPROVING CHILDREN'S EXPERIENCE DURING BLOOD DRAWING PROCEDURE

Graduate: Nuria Vilarasau Creus (2018)
Supervisory team: R.H.M. Goossens, B. Groeneveld, H. Illera Massana
Partner: Sant Joan de Déu Barcelona's Children Hospital, Barcelona

Performing a blood test is a procedure that creates stress and anxiety for patients; it can result in a traumatic experience for children. This raises other issues which make the blood test even more complex. Therefore, it is important to reduce children's fears and anxiety.

An experience design approach was used to conduct the project, focusing on the user experience and involving the patients and stakeholders in the design process in order to design a relevant solution.

The final design proposal consists of a story around the blood-taking procedure. The key purpose of the story is to change the meaning of the blood test into something positive and to give support throughout the process by giving children tools to cope with anxiety and fear.

The story challenges the children to complete all the steps of the blood test and get a 'Superkid' badge. Each step involves an element that brings physical and mental benefits. It strengthens the child's confidence, helps them to take initiative, and to relax.

Reducing the fear and anxiety of patients makes the blood-taking procedure smoother and faster. If the patient doesn't offer resistance, it is easier to find the vein and insert the needle correctly. Time and workload savings result in a reduction in delays and a smoother patient flow, which is beneficial for the hospital. A better patient experience (and parents) will result in improved patient satisfaction.

NAVIGATING A HOSPITAL FOR CHILDREN

Graduate: Rosanne Martens (2017)
Supervisory team: P.J. Stappers, A.Q. Beekman, E. Verkerk
Partner: Wilhelmina Children's Hospital

The goal of this graduation project was to design a positive wayfinding experience for children aged 4-12. It focused on letting children feel in control while they find their way to the right department, in contrast to feeling stressed and scared in the (new) hospital environment.

Children in primary schools were observed and interviewed with regard to wayfinding. Secondly, four idea directions were explored with children from a primary school. These were developed into concepts and shown to children from the Wilhelmina Kinderziekenhuis, the hospital's children's council, and to children on the ward, in order to provoke reactions and gain feedback. With these insights, the initial concepts were combined into a single concept, the so-called 'Hospital world'. The system uses natural metaphors for its spatial layout, which children can understand. Each department is represented by an animal which lives in a specific area. The building is divided in five layers, the bottom of the sea, the sea, the sand layer, the forest layer and the sky layer. In the hospital, children can ask all the animals in the hospital for help. In this way, 'Hospital World' enables children to find the way themselves, instead of following their parents.

The final design was tested with the target group in the hospital environment. Children responded positively regarding the idea, they experienced greater control as they were able to find the right department.

IMPROVING THE PATIENT EXPERIENCE FOR CHILDREN AT THE PAEDIATRIC ACUTE MEDICAL UNIT

Graduate: Rochelle Simons (2018)
Supervisory team: M. Melles, L.W.L. Simonse, E. Elsbeek
Partner: Academic Medical Centre Amsterdam (AMC), VU University Medical Center

During an acute admission a child patient most often arrives at the hospital in the Emergency Department (ED). If more tests or treatments are necessary, the child patient is transferred to the Pediatric Acute Medical Unit (P-AMU). Instead of solely focusing on the P-AMU, design research has shown that in order to improve the patient experience at the P-AMU, it is necessary to address the problems at the ED. Child patient and parents indicated experiencing two problems during the acute admission; feeling unsure; not knowing what, who, where, and when to expect things to happen, and boredom; because of the long periods of waiting.

The 'Mijn Buddy' application helps 8 - 13 year-old child patients by giving an overview of the journey through an acute admission. The children can create their own buddy or avatar that guides them through the hospital; their journey is personalized along the way. The application is connected to EPIC, the electronic patient record, so when a medical professional puts an order in the system, for example 'blood test', the application provides information about this step.

'Mijn Buddy' puts child patients in control so they actively participate instead of letting it all happen around them. By providing information in a playful and understandable way, child patients as well as their parents gain a better idea of what to expect, which leads to reduced uncertainty about the acute admission process, ultimately leading to a better patient experience.

FLOWY: AN ASSISTIVE WEARABLE TECHNOLOGY FOR CHILDREN WITH AD(H)D THAT INCREASES ATTENTION IN CLASS

Graduate: Jesper Voorendt (2018)
Supervisory team: J.E. Oberdorf, J. Bourgeois, H.W. Hogenbirk
Partner: Pilotfish Nederland

This graduation assignment investigated the management of focus for children with Attention Deficit/Hyperactivity Disorder (AD(H)D). Currently, behavioral treatment shows long-term success among children with AD(H)D, but this is often expensive and hard to bring into practice.

Flowy is a wristband design that supports behavioral interventions by giving rhythmic vibrations as reminders for behavioral change. Rhythmic vibrations on the wrist have shown to have a calming effect, and can alert users to think of behavioral interventions. Different vibration patterns can foster self-regulating thoughts such as asking, "Am I behaving as I intended to do?" or "Am I still focused?". This increases the self-regulating ability of a child during individual tasks at school. Flowy is designed like a buddy for children with AD(H)D. It aims to act like helping a friend and motivate them to study longer. It also gives the child ownership of self-regulation, because it lets children create their own vibration patterns for activities. This is achieved by providing an app that brings the 'buddy' alive, explains self-regulation techniques, and involves parents to monitor the process to create a positive reinforcement within the family.

The proof of concept has shown the feasibility and desirability of vibrating wearables to foster self-regulating behavior. This enhances behavioral therapies by educating families about AD(H)D, resulting in exercises a device that is appealing to children.

THE VALUE OF ENHANCING THE HEALTHY ROUTINES OF KIDS IN 'SMART HOME' ENVIRONMENTS

Graduate: Bastian Schultes (2016)
Supervisory team: H.J. Hultink, L.W.L. Simonse, R. Beyhl
Partner: Philips

Philips is looking for opportunities to translate the application of IoT technology into a valuable business proposition in the domain of health. The needs of young families in the context of healthy routines for their children were identified by an explorative study with observations and interviews. Based on the insights, product ideas were generated and evaluated with the users. The ideas to increase children's motivation and time awareness in the context of healthy routines proved to have a high user value and were used in concept development.

The final design proposal is a product service system (PSS) consisting of a wearable and a portable product that can communicate, together with an app for the children and their parents. Together they can set a new healthy journey in the app and the products will help them achieve that journey. In this way, the child is motivated and constantly challenged with new journeys.

The PSS creates 'user value' by offering support for the children's daily activities. The values have been identified and validated in the project's research phase. The direct 'business value' for Philips can be generated through a multisided business model, which is based on B2C and B2B business propositions.


HealthyKidsRoutines


HealthyKidsRoutines

DESIGN FOR AGEING

A CUSTOMIZED SHOE FOR OLDER PEOPLE AS A SOLUTION FOR FALL PREVENTION

Graduate: Hadeer Dinha (2016)
Supervisory team: T.J.M. van der Cammen, J.C. Verlinden
Partner: TU Delft

Falls among the elderly is a major and ever-increasing problem in the Netherlands, with 800,000 fall incidents and nearly 3000 fall-related deaths every year. In addition, the elderly often use inappropriate footwear in and around the house, and therefore increase their risk of falling. Why do elderly people use inappropriate footwear and how can this problem be solved?

The reason for their use of 'unsuitable' footwear is often convenience and comfort. Because they often have deformed feet, difficulties in bending and/or difficulties in applying force with their hands, they use comfortable footwear that is easy to put on and take off. There is a lack of footwear which is suitable to wear and affordable, and that firmly supports the feet and reduces the risk of falling.

The graduation project focusses on the design of the so-called 'ComfyStab'. ComfyStab is custom-fit footwear for indoor use. It consists of two parts: ComfyStab-wing (midsole) and MagneTies (for opening and closing). The midsole is produced by a 3D printer based on the scan of the foot. It is possible to print multiple layers with different properties for a firm and optimal support. The opening and closing system with magnets makes it easy to use.

AN ERGONOMIC REDESIGN FOR SCOOZY

Graduate: Debbie Rouw (2018)
Supervisory team: I.A. Ruiter, S. Hiemstra-van Mastrigt, J.W. van Gent
Partner: Scoozy

The founders of start-up Scoozy saw an opportunity in the market for electric mobility. The mobility scooter has been electric for over 40 years, but has barely been innovated. The start-up has developed an alternative for the current mobility scooter: Scoozy.

A first working prototype was built in 2017 and tested with potential users. This led to many useful insights for the required improvements before Scoozy could go to market. One point of attention was the seat's ergonomics; it was not adjustable and thus not suitable for all users.

This graduation project focuses on the adjustability of the seat regarding ergonomics and usability aspects. The final design proposal is a redesign of the seat with focus on the backrest, seat height, arm rests and joystick position. All these parts are adjustable according to the P5-P95 percentile. All these parameters of adjustablilty were tested in a mock-up. The seat can now rotate, allowing the user to step-in and out easily. The comfort of the seat was rated positively during a user study. Overall the redesign has been positively evaluated and the company views the ergonomic aspect of the redesign as a unique selling point.


TOVERTAFEL

STIMULATING THE ELDERLY IN CARE HOMES TO MOVE : TOVERTAFEL GAMES

Graduate: Nina van Adrichem (2016)
Supervisory team: T.J.M. van der Cammen, R.H.M. Goossens, J.M. de Groot
Partner: Active Cues

The goal of prevention for the elderly is to keep older adults healthy, autonomous, and independent for as long as possible, even if they already need daily care.

A preventive measure which has increasingly gained popularity in recent years is physical exercise. Physical activity can help reduce disease-progression, delay emerging disabilities, have a positive influence on cognitive functioning, increase emotional well-being, and reduce the risk of loss of independency.

From the observations and interviews during contextual research, it became clear that one of the most valuable things for the elderly in terms of physical well-being is to maintain as much functional mobility as possible. Functional mobility refers to a person's ability to carry his/her own weight while standing, make transfers, and move independently in order to perform personal care and Activities of Daily Living (ADL). Based on insights, an exergame focusing on lower extremity activity was designed with the following interaction qualities in mind: immersive, experience-focused, social, skill-independent, pleasurable.

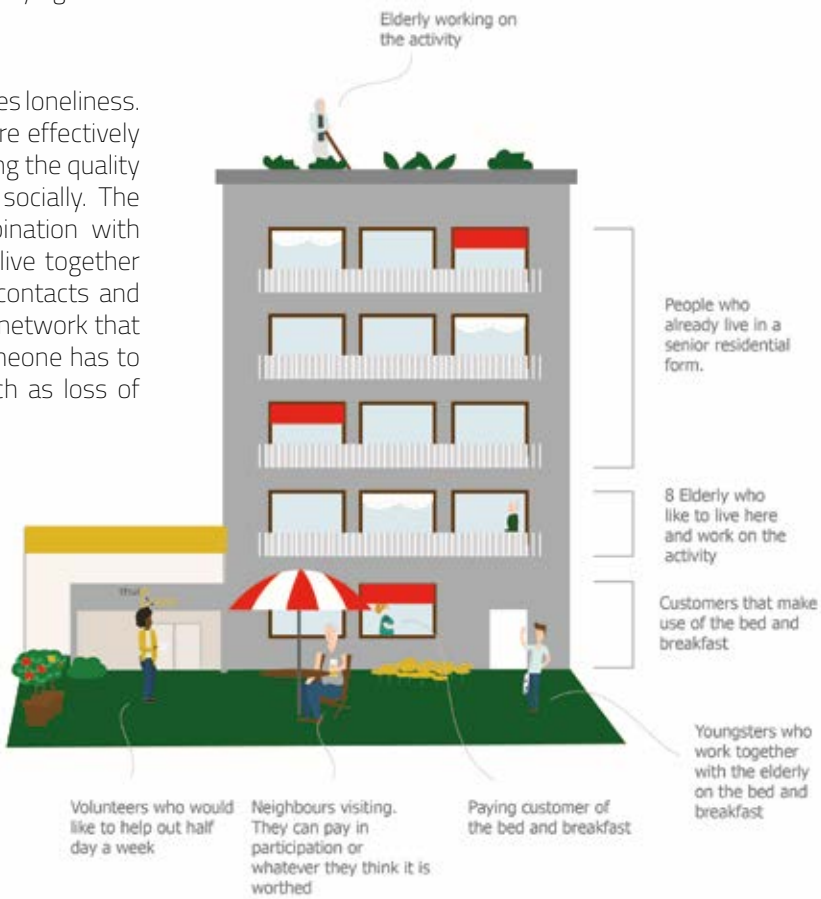
The final concept can be described as a rhythm game in which players need to stamp on glowing cues in order to turn on a single instrument track of a song. The players cooperate to hear all the instruments, thus when they all play well, the complete song is the ultimate result. The difficulty level of the glowing patterns (which follow the beat) is dynamically adjusted based on the performance of the individual player. This challenges all players at their own level of physical and cognitive abilities.

A HOUSING CONCEPT FOR ELDERLY IN ROTTERDAM THAT PREVENTS LONELINESS

Graduate: Nienke van der Straten (2016)
Supervisory team: P.M.A. Desmet, H. Kuipers
Partner: Factory of Things

'Thuis &' is a new form of housing where people can grow old. Together with youngsters, the elderly own and manage a small business. The addition of a café helps to create a neighbourhood and is managed by volunteers. This lowers the threshold for locals to be involved. The design includes multiple variants to fit the varying needs of the target group.

This new residential form prevents and reduces loneliness. The higher the level of participation, the more effectively loneliness is prevented, significantly increasing the quality of life, physically and mentally as well as socially. The main goal of running a business in combination with social activities undertaken by people who live together is to stimulates the creation of emotional contacts and avoid multiple risks of loneliness. The social network that people build up works as a safety net if someone has to deal with possible causes of loneliness such as loss of their partner or physical deficiencies.



PUZZLED: A STRESS LOWERING INTERACTION FOR ELDERLY WITH DEMENTIA

Graduate: Andreas D'Hollandre (2017)
Supervisory team: P.M.A. Desmet, W. Schermer
Partner: TU Delft

This graduation project focuses on stressful moments experienced by the elderly with dementia, caused by changes in their environment. A research through design approach was followed with the aim to design a product that reduces the amount of stress experienced by the people with dementia. The context of stress before dinner time was found as being a most valuable issue to change the interaction. This context is described by the caregivers and observed by the designer as a daily occurrence, multiple times per day. The elderly struggle to cope with the fact that they might not be able to sit at their usual spot at the dining table.

'Puzzled' supports the cognitive abilities of people with dementia and uses distraction as a main tool to lower the amount of stress experienced before dinner time. The concept was introduced in the dining process by the caregivers right after the table had been set. The concept consists of a box with several games.

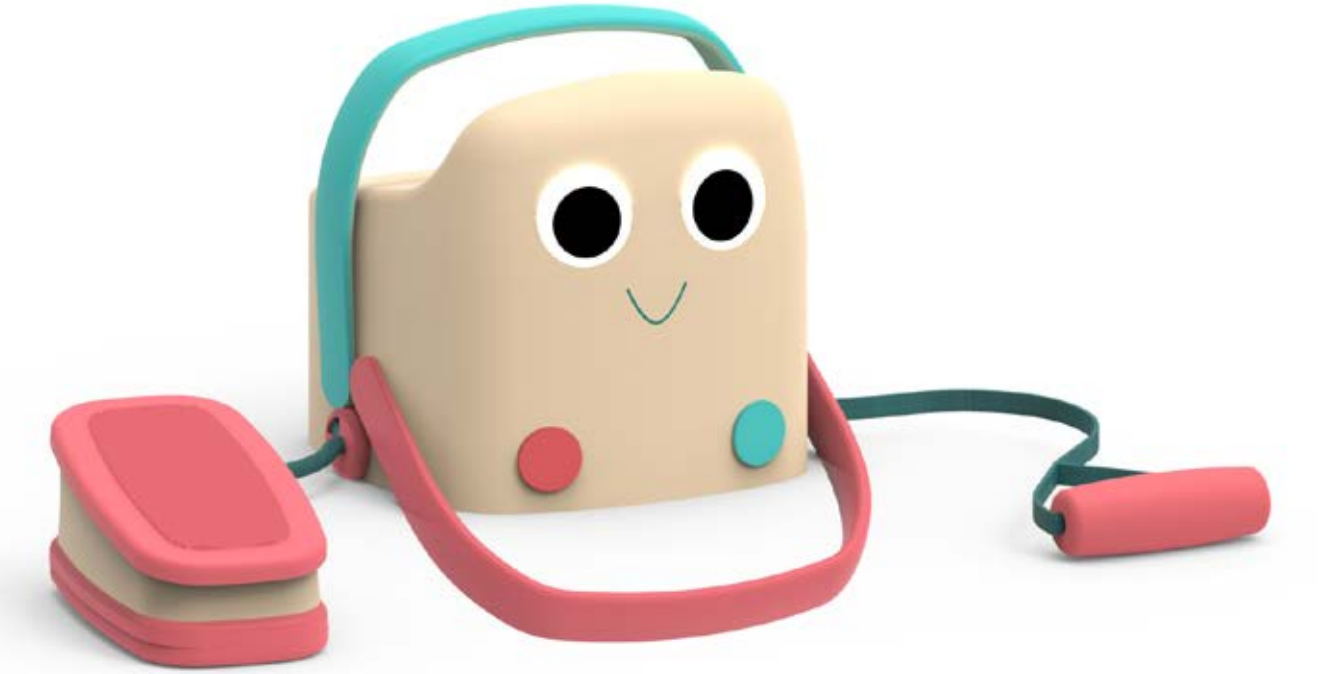
Many design iterations and tests at elderly home 'de Herbergier' in Delft led to the final design proposal. During the user study, the elderly responded positively to the puzzle and had fun playing it. 'Puzzled' is a playfull way to reduce stress and stimulate interaction among users.

INDEPENDENCE FOR OLDER PEOPLE WITH AN AT HOME EXERCISING COMPANION

Graduate: Karlien Berghman (2016)
Supervisory team: T.J.M. van der Cammen, J.F.M. Molenbroek, J.P. de Beer
Partner: Springlab

Due to the new Dutch healthcare system, 96% of older people now live independently. They often experience the recurring problems of inactivity and limited mobility. National and international standards for physical activity recommend strength training twice per week for older people. Progressive strength, flexibility, and balance training can help increase and maintain mobility and thereby independence. Motivation is the key factor for older people to exercise. Self-efficacy, prompts and social support are key to motivation. Older people with little to no limitations generally stop exercising in the age group 75-85, therefore this is the project's target group.

Through intensive brainstorm sessions and analysis, the team develop new concepts. Finally the 'workout body' concept was chosen. This is an 'at home' exercise companion, a low technology affordable robot that provides a variety of progressive strength, flexibility, and balance exercises through audio explanation. The product provides audio prompts, encouragement, and feedback on the user's progress. The product is designed for home use and provides social support. It is small, affordable and has smart functions like feedback, recording, etc. Testing with the user group has shown that the interaction with the product is effective; users enjoy the product and could easily follow the exercises.



CONNECTED RESOURCES: A RESEARCH THROUGH DESIGN APPROACH TO DESIGN FOR OLDER PEOPLE'S RESOURCEFULNESS

Graduate: Masako Kitazaki (2018)
Supervisory team: E. Giaccardi, I. Nicenboim
Partner: TU Delft

This project is a part of the 'Resourcefull Ageing' collaboration and aims to encourage "young-older people" to age resourcefully. Although they are better at appropriating artefacts, technologies, and use other people around them to solve challenges as they age, the current smart products for this age group do not allow them to do so because of their rigidly prescribed use scenarios. To challenge this situation, a concept of Connected Resources was purposed, artefacts with internet connection to support older people's inherent resourcefulness. The project involves two studies to discover the guidelines needed to design for resourcefulness using a Research through Design approach.

The first study addressed artefactual dimensions of openness necessary to support resourcefulness. It revealed that some dimensions, such as interfaces to expand capability and accessibility of knowledge, needed to open up; while other dimensions, such as newness, signifiers, and structural simplicity, are required to close. In this way, artefacts gain familiarity and become an entry point to explore personal adaptations.

The second study approached a variety of uses in which a workshop was held with older people using working prototypes of Connected Resources. They imagined seven use scenarios of Connected Resources in their everyday practices, resulting in identifying six dimensions of the variety of uses, e.g., use in both fixed and mobile space, use with both user-generated and crowd-generated content.

With these design guidelines, the final Connected Resources was designed: the four combinable objects which have different digital and physical capabilities, and the online platform which encourages older people to learn each other's strategies to find new uses. They are designed with the principle of simplicity, familiarity, and playfulness to fit into the older people's everyday practices.

PUSHING THE ENVELOPE IN ORAL CARE: DESIGNING THE NEXT GENERATION TOOTHBRUSH

Graduate: Joppe van Dijk (2016)
Supervisory team: R.J.H.G. van Heur, M. Verwaal
Partner: Academisch Centrum Tandheelkunde Amsterdam

Poor oral care by the elderly is a pressing problem in our current healthcare system. Poor oral health can leads to pain, frustration, problems with eating, underfed elderly, problems with speaking, and low self-esteem. Additionally it increases the risk for pneumonia, diabetes, organ infections, osteoporosis, cardiovascular disease, and gastrointestinal and pancreatic cancers. Many studies show the poor oral health of the elderly in care institutions, both in the Netherlands and worldwide. In the Netherlands 50-70% of the elderly in institutions have poor oral health.

The main reason why oral care is currently not performed properly is that nurses and caregivers think that brushing the elderly's teeth is difficult. Tooth brushing was mentioned as the worst task to perform in elderly care. The reasons why tooth brushing is seen as a hard job are: difficult to perform under high time pressure, oral care is perceived as dirty work, nurses are afraid to hurt the elderly, lack of feeling for it, and the lack of patient cooperation.

To solve these problems a new oral care product was designed that uses a novel, inventive way of tooth brushing. The product uses a new way of actuation as well as a novel brushing method. The new method enables all teeth to be brushed at the same time, therefore enabling faster and easier brushing. The product consists of an electronic handle with a disposable flexible bit. It is now easy and quick for nurses to brush teeth; the handle helps even the elderly to brush their own teeth again.

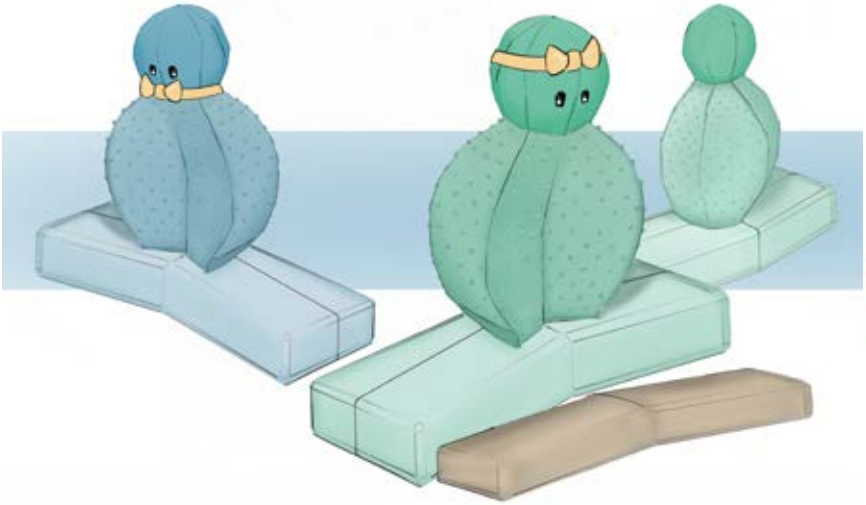
DEMENTIA AND DESIGN: WORKING TOWARDS IMPROVING QUALITY OF LIFE FOR NURSING HOME PATIENTS WITH DEMENTIA

Graduate: Amarins Bellinga (2018)
Supervisory team: T.J.M. van der Cammen, A. Albayrak, M. Koekoek
Partner: FUNDIS WelThuis

The number of patients with dementia worldwide is continually increasing. In the Netherlands, this has grown to 1 in 5 people suffering from dementia. This is due to factors like better diagnosis and the aging generation. Nevertheless, there is no solution to cure this disease. This means that a closer look needs to be taken in how the wellbeing of patients with dementia could be improved to make sure that this last part of their life is experienced with no insecurity or fear.

My Favourite is a product that helps patients with dementia calm down by providing them with enough stimuli. This is done by presenting the My Favourite to the patient. Beforehand, formal caregivers or family members can choose the type of fabric they want to have for the product, by ordering samples. With these samples they can test which fabric and texture give the patient the most stimuli and the option to connect with it through reminiscence. Next to deciding on the fabric, formal caregivers or family members can decide if they want the product to have an electronical part, simulating the breathing regulation of an elderly. This gives the patient an extra stimuli if they get restless.

A user study showed that My Favourite was well received. It evoked a positive response at all the different patient profiles. Female patients were more attracted to it and gained a positive experience with the product.



DESIGN FOR THE PHYSICALLY CHALLENGED

A NEW 3D PRINTED VOLUME ADAPTIVE PROSTHETIC SOCKET FOR BELOW-THE-KNEE AMPUTEES

Graduate: Misja Van Sitteren (2016)
Supervisory team: J. Geraedts, A. Albayrak, G. Smit
Partners: Centrum Orthopedie Rotterdam

The volume of a lower leg stump is unstable. As a day progresses, the volume can change between -10% and +5%; this is due to movements of fluids and soft tissue in and around the stump. These volume changes can result in fitting problems of the prosthetic socket, leading to pain and injuries. A new invention called "Unimode Beams" aims to solve this issue by placing beams with hinges in the socket wall.

The beams can contract and expand, and thus reduce or enlarge the socket size. In addition, any socket compression can be temporarily released. Stump fluids can thus easily be recovered at moments of rest without the amputee having to take off the whole prosthesis.

An amputee-specific prototype was built based on the 'Unimode Beams' principle using a Connex3 3D printer and evaluated with the user. The user indicated a 'bouncing' feeling within the socket, and that the compression was 'circular' indicating that the beam principle was working as expected.

The 'Unimode Beams' principle seems to be a promising way to deal with daily volume changes, offering the user more comfort.

PROSTHETIC SOCKET DESIGN FOR FUSED DEPOSITION MODELING

Graduate: Wybren ten Cate (2017)
Supervisory team: R.H.M. Goossens, E.L. Doubrovski, C. Jongenengel, K. Jensen
Partner: Centrum Orthopedie Rotterdam

This graduation project explore the use of 3D printing sockets for orthopedic companies. Research into manual and digital manufacturing methods resulted in an overview of the possibilities for integrating digital tools in the socket production process. Together with the finding that Fused Deposition Modeling (FDM) is a cheap and fast 3D printing method for which sufficiently strong filaments are now available, the choice to design an FDM printable socket for an orthopedic company was made. The proposed production process combining manual and digital production activities has, in cooperation with a prosthetic engineer, been successfully applied to the production of a socket.

Four socket designs have been designed in consecutive iterations, each one being a significant improvement on the previous. Printing time was reduced from 45 to 15 hours and assembly time reduced from 30 to 5 minutes. Socket durability has increased from 4 minutes to 10 days and lastly, to 33 days. The prototype has been used by the user for 10 days without failing. The design has undergone a dynamic test of 500,000 cycles according to the ISO 10328 norm. However, although the socket started to crack at 90,000 cycles, the approach and design seems a promising direction for orthopedic companies.

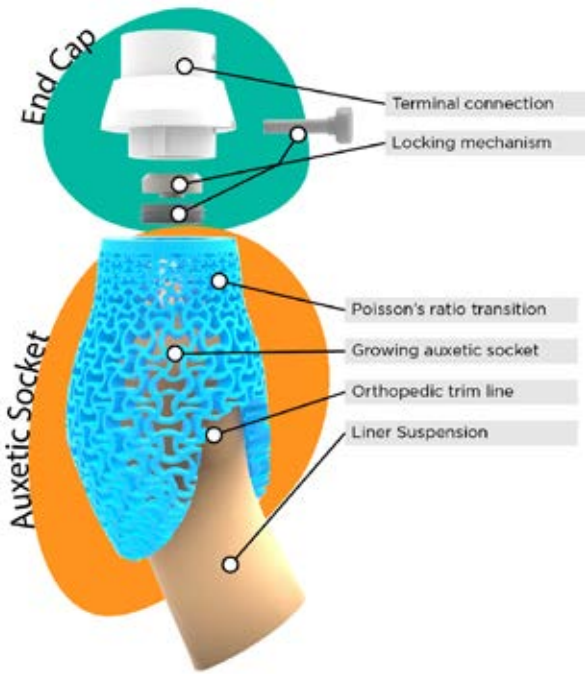
A 3D PRINTED PROSTHETIC SOCKET THAT ACCOMMODATES PEDIATRIC GROWTH

Graduate: Tim Snijder (2017)
Supervisory team: C.C.L. Wang, Z. Doubrovski
Partner: Orthotics De Hoogstraat

The inability to adapt to growth is a recurring problem in the field of pediatric prostheses. Current prostheses do not adapt to the normal growth of children's limbs and require constant visits to healthcare providers for adjustment or replacement.

To solve this issue, a new socket was designed making use of auxetic metamaterials. The residual limb of the pediatric user is scanned and a growth prediction made based on the input scan. A thermo-adaptive socket is designed by 3D-printing an auxetic cell structure of Polycaprolactone (PCL) which accommodates two years of growth. PCL was selected as the building material for the socket. With a melting temperature of 60 degrees Celsius, the socket can be adjusted to the limb after being placed in a bath of water at 55 degrees Celsius.

A socket prototype was designed using an Ultimaker and was based on a scanned limb. The results of the user test was promising. New insights were gained to improve both the approach and the process.



TIME PERCEPTION AMONGST (DEAF)BLIND AND MENTALLY IMPAIRED PEOPLE: A SOLUTION FOR WAITING

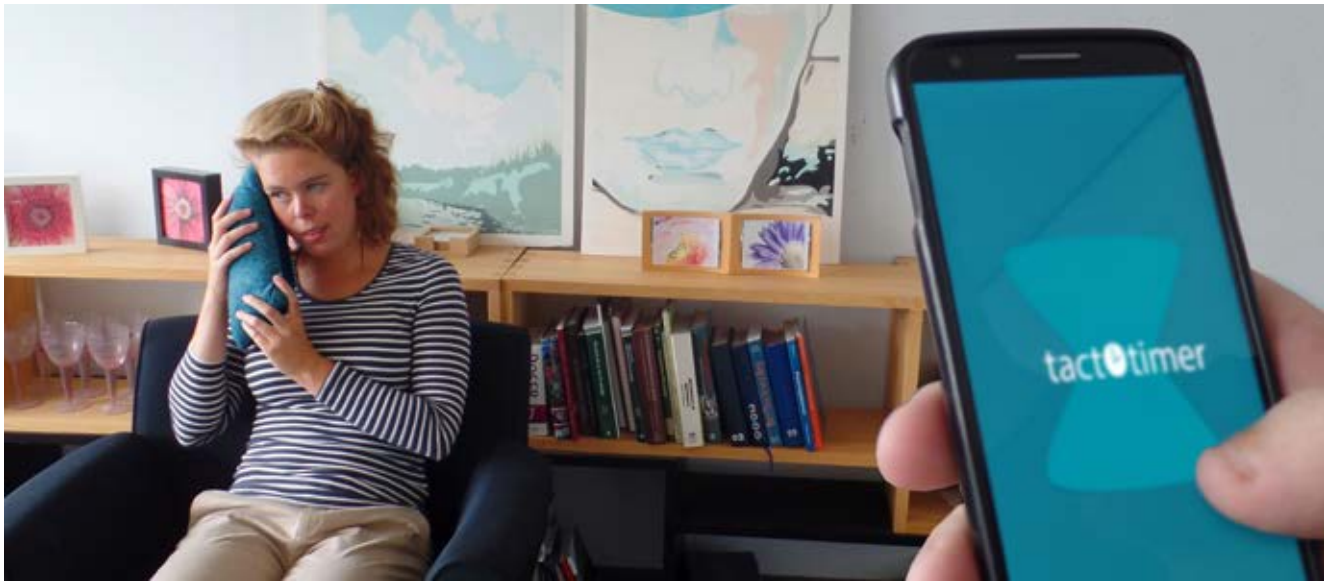
Graduate: Emma Heitbrink (2016)
Supervisory team: M.W.A. Wijntjes, S. Kistemaker, P. de Nooij
Partner: Bartimeus

One of the difficulties encountered by the visually impaired is a disrupted time perception; their sensory input is limited and their perceived time is often longer than expected.

The literature on the cognitive processes of time perception shows that perception is influenced by the sensory stimuli, the attention to time, and the memory. When applying these processes to the situation of waiting, it is assumed that visually impaired clients get tense and confused due their limited time understanding and therefore have an increased focus on waiting. With these insights as starting point, the project team aimed to design a product that assists deafblind clients to get a better grip on waiting times while making the experience more pleasurable.

The final design is the so-called 'TactoTimer', a tactile timer that consists of a vibrating pillow and an application to control the timer. It makes the duration of waiting tangible via vibrations and thus supports users in their understanding of waiting time. The interaction with the pillow distracts the user from the waiting itself.

The final design was evaluated by users; they were enthusiastic about the concept. The effectiveness of the design proposal still needs to be tested in a study where the product can be used for a longer period.



AUGMENTED REALITY GAME FOR THE IMPROVEMENT OF PARKINSON'S DISEASE ASSESSMENT

Graduate: Erik van der Meulen (2016)
Supervisory team: V.T. Visch, A.J.C. van der Helm
Partner: Faculty of Technology, Policy and Management (TBM)

There is a great need for an assessment tool in a clinical setting that allows an objective, quantitative and valid measure of motor dysfunction in patients with Parkinson disease (PD). The aim of this graduation project was, on the one hand, to develop an assessment tool for the clinician, and on the other, to support the PD patient to exercise their affected arm.

Principles of serious gaming and augmented realty were applied in the design to engage PD patients with dysfunction in their upper extremity (hand/arm) movements.

The game uses augmented reality to show virtual moving targets (i.e. candy falling from a conveyor belt) and a haptic game controller to catch the candy. The clinician is able to acquire quantitative data about the patient's movement, which can then be used to analyze the patient's health and adjust the treatment, if necessary.

A small-scale quantitative user study was performed regarding the system's usability, the task load, and the game's user experience. The findings show that the system has a relatively good usability and the game is engaging. With regard to tracking the controller in 3D space, some improvements need to be made to create more realistic scenarios.

A BRAIN CONTROLLED EXOSKELETON FOR THE UPPER EXTREMITIES

Graduate: Guus van Mastrigt (2016)
Supervisory team: R. van Heur, S. Dehli, J. Luijten
Partner: Adjuvo Motion

Motor Neuron Diseases (MND) is a collection of diseases that damage the motor neurons, resulting in reduced muscle function. Amyotrophic Lateral Sclerosis (ALS) is the most common MND. It often starts with the hands or feet, and it progresses over time. Losing the ability to move body parts has a major impact on activities of daily living (ADL). Technology could help sufferers to regain and retain as much quality of life as possible. While suffering from reduced mobility, ALS patients' brains remain fully functional, which makes Electroencephalography (EEG) sensing extremely valuable.

With the appropriate EEG sensing equipment, using the Exoten it is possible to capture thoughts of movement and transform this into actual movement. The Exoten is an exoskeleton that provides functionality to the upper extremities of the patient. It uses electric motors to reel in cables that pull the body parts to generate the desired motion, in a comfortable fashion. The EEG sensing equipment is integrated in a baseball cap to improve its esthetic value.

A prototype was designed which, supported elbow flexion and extension and it was controllable with the software EmotivEPOC. Users were able to control the Exoten and move their arms. The Exoten enables the patient to regain independence and with it, quality of life. In the future the design of the Exoten will improve, and the application will be extended.

ABLE1: DESIGN INCLUSIVE RESEARCH TOWARDS AN ASSISTIVE BIONIC LOWERLIMB EXOSUIT

Graduate: Tigmanshu Bhatnagar (2016)
Supervisory team: I. Horvath, Z. Rusák
Partner: TU Delft

In 2012, a new genre of 'soft exosuits' became popular. These devices, unlike traditional exoskeletons are extremely lightweight as they are not made of rigid materials. In the field of assistive wearable robotics for rehabilitation, there is a need for lightweight, cosmetic, adaptable, and cost-effective solutions to provide assistance to the lower limbs. The foremost biomechanical motion which needs to be assisted is the sit to stand transition.

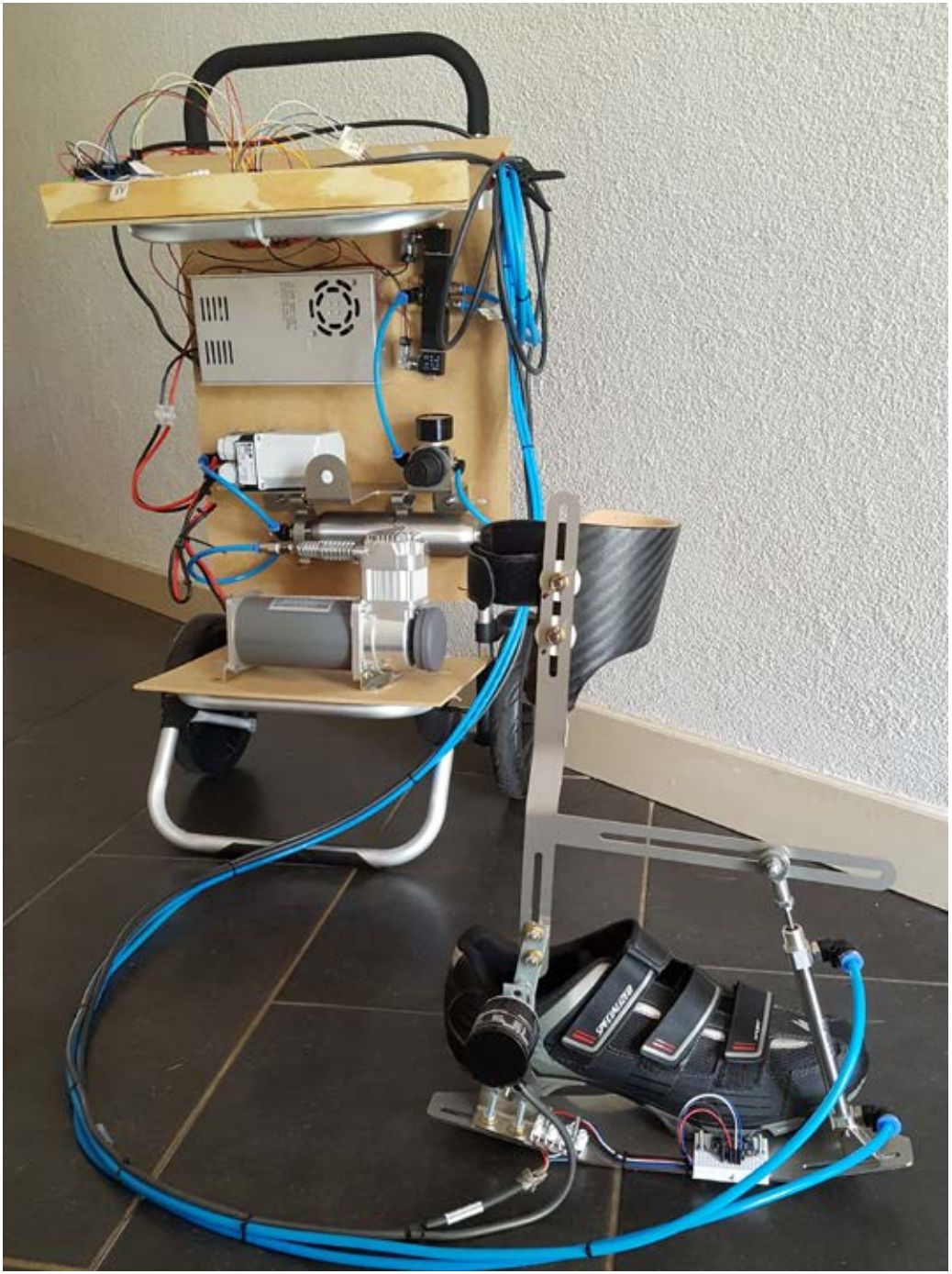
A highly detailed computational model was designed which can provide almost 60% of total assistance at the hip and 57% of assistance at the knee in the sit to stand motion. Along with this theoretical finding, a prototype was made to test on a human scale. Electromyography measurements were conducted to observe the behavior of the muscles in the quadriceps group (upper legs) with assistance. The results of the study were positive and showed up to a 37% dip in the muscle activity with assistance. This shows that the system is promising and capable of providing assistance.

AN ASSISTIVE CYCLING ANKLE-FOOT ORTHOSIS FOR CHARCOT-MARIE-TOOTH PATIENTS

Graduate: Patrick Raedts (2018)
Supervisory team: Z. Rusák, E.E.J. van Breemen
Partner: TU Delft

In this graduation project, the aim was to develop the first active ankle foot orthosis design for use on a bike. The product includes sensors and other electronic components that are able to gather patient-specific data about physical performance, and it can control the application of torque for pedal assistance. It is designed for patients suffering from Charcot-Marie-Tooth (CMT), which is a hereditary motor and sensory neuropathy.

With the criteria set, a simplified design with integrated mechanical, electronic, and pneumatic components was developed. The functionality of the exoskeleton was demonstrated in a proof-of-concept test exercise with a CMT patient. The prototype showed the potential to achieve the proposed working principle of the exoskeleton by providing assistance torque while performing a full pedal cycle. This was supported after analyzing the measurements as well as verbal feedback given by the CMT patient while executing the cycling exercises.



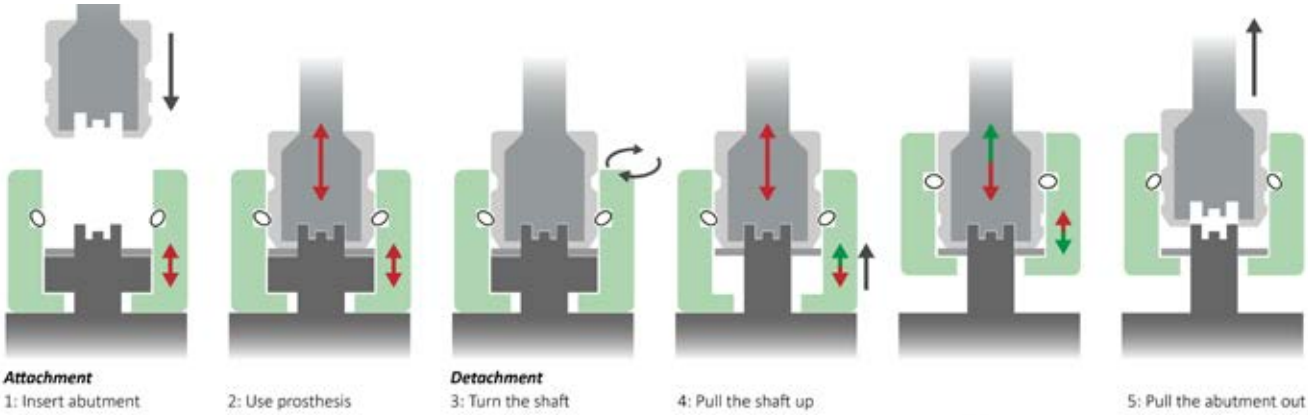
E-AD: A NEW ATTACHMENT BETWEEN A MYOELECTRIC PROSTHESIS AND A BONE ANCHORED IMPLANT SYSTEM

Graduate: Eefje van der Kaaden (2018)
Supervisory team: R.H.M. Goossens, Y. Song, E.L. Doubrovski, J. Millenaar
Partner: Integrum AB

This project focused on the development of the OPRA, a bone-anchored implant system for prosthetic attachment. One of the latest developments is the e-OPRA system; it has implanted electrodes embedded in the bone-anchored implant for the neural control of a myoelectric prosthesis. However, some problems arose with the e-OPRA: the alignment of all components is extremely critical and misalignment can cause damage to the connectors and failure of prosthesis control. Therefore, the e-AD (enhanced attachment device) was designed.

The e-AD consists of an adapter mounted on the abutment, and a base and shaft mounted on the prosthesis. With new kind of mechanics, alignment is ensured and the conventional OPRA system can be used with the new e-OPRA system.

The e-AD provides a secure prosthesis attachment, safe electronics' alignment, is easy for the patient to use, and has the potential to add a cover to make it more personal.

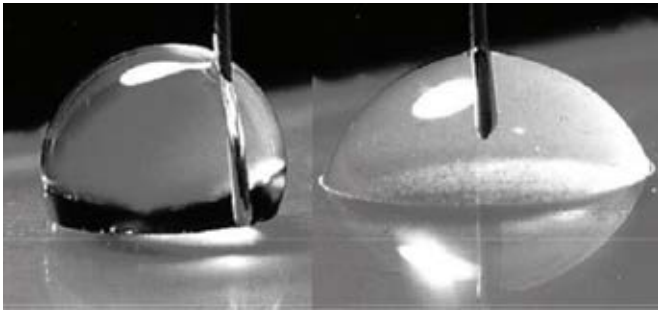


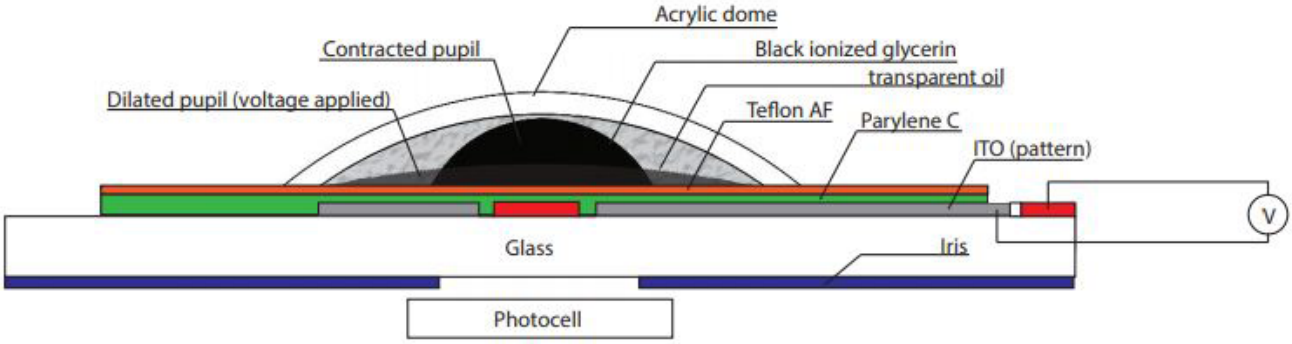
PROSTHETIC EYE WITH DILATING PUPIL

Graduate: Ronald van der Beek (2016)
Supervisory team: K.M.B. Jansen, A. de Smit
Partner: TU Delft

In this assignment, the focus was on a prosthetic eye that can dilate. Currently available ocular prosthetics do not sufficiently resemble the natural eye as the pupil does not dilate and contract. To make patients feel more complete, the prosthesis should look as much like a natural eye as possible. So the assignment was: improve the ocular prosthetic by making the pupil dilate and contract so that it closely resembles the natural eye.

After analyzing and discarding numerous technologies, electrowetting was finally chosen as a technology. Electrowetting allows the wettability of a solid surface to be modified by applying a voltage across a droplet and an electrode. An ionized liquid droplet of black fluid represents the pupil. A transparent repelling fluid surrounds the black droplet. The black droplet and an electrode separated from the fluids by a dielectric layer are then charged. The black fluid extends its surface area and is dilated. A light sensor is used to tailor the voltage applied. A prototype has been developed and will be used to demonstrate a proof of principle.





A REDESIGN OF ASSISTANCE DOG VESTS

Graduate: Gabriëlle Ribbens (2018)
Supervisory team: P.M.A. Desmet, S. van Dommelen, N. van Hasselt
Partner: KNGF Geleidehonden

The assistance dogs provided by KNGF Geleidehonden (guide dogs) are extremely valuable for people with physical disabilities and needing a wheelchair. The dogs wear assistance vests, with which there are a number of issues. It was found that the assistance dog vest has three functionality goals for the clients; to show that the dog is an official KNGF Geleidehonden dog, to communicate that the dog should not be distracted, and to explain that the dog is helping the client. However, many guide dogs are frequently distracted; this is a functionality issue. Furthermore, it was found that the clients have many different physical disabilities often with limited strength in their hands and arms. Because of this, putting the assistance dog vest on the dog and taking it off is difficult for clients, mainly because of the bellyband; this is a usability issue.

A redesign was created to solve both the functionality and the usability issues. A concept for an assistance dog collar was created instead of a new vest. In order to solve the distraction issue, the shape of the redesigned product was inspired by human uniforms, to convey authority and empathy. Furthermore the imprint chosen clearly explains the situation. To solve the usability issue and improve client friendliness, the functionalities are integrated in the collar. This solution has removed the issues with the bellyband. Furthermore a magnetic snap-lock fastener, a Fidlock, was added to the product to enable the client to easily open and close the collar.

In order to validate the concept, three user tests were conducted focusing on the wearability of the collar for the dog, the usability for clients and the functionality for other people. This resulted in recommendations for the physical design of the concept and for further research.

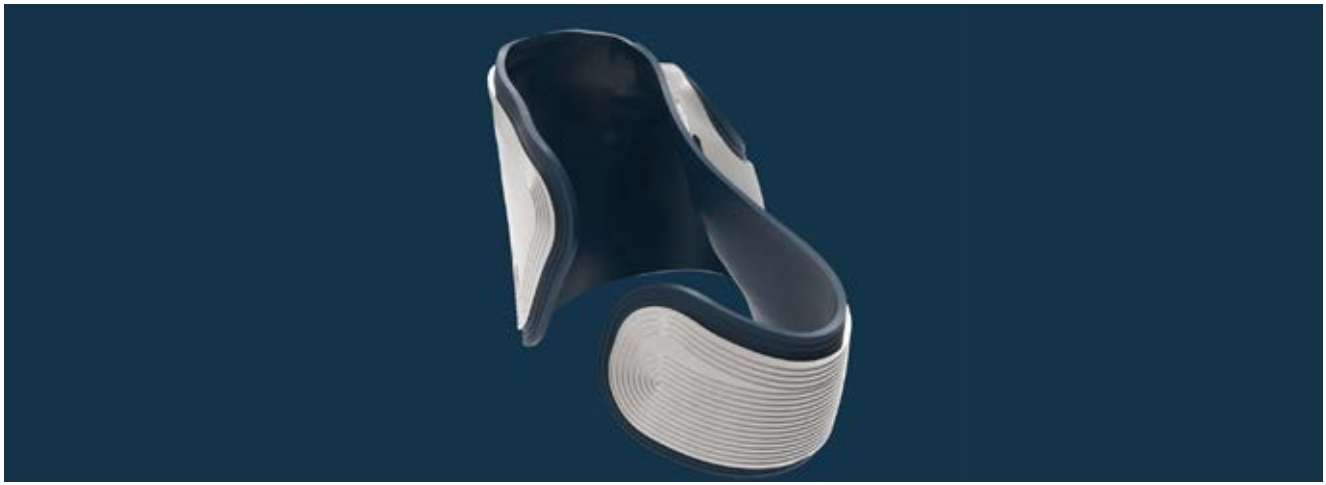
THE QUANTIFIED WHEELCHAIR

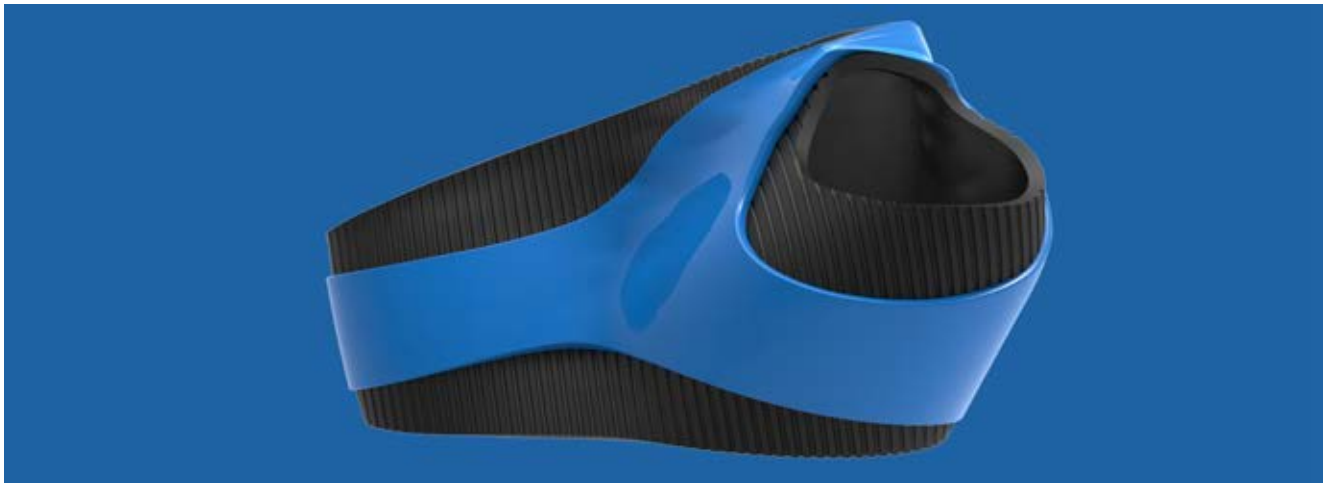
Graduate: Songshan Liu (2018)
Supervisory team: G. Kortuem, D. Lomas
Partner: TU Delft

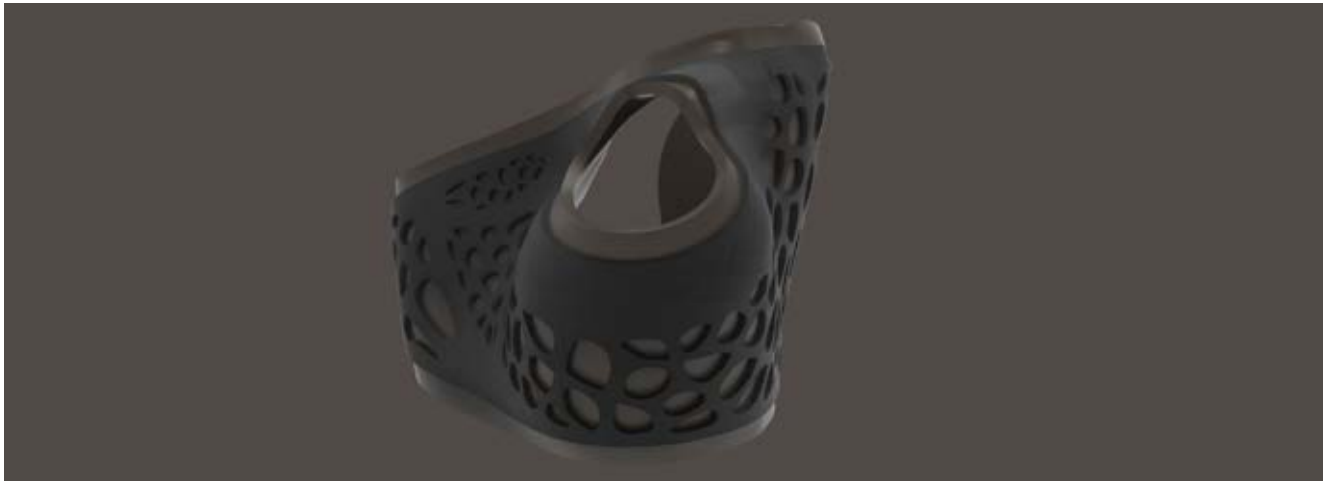
In this graduation assignment, thefocus was on changing wheelchair users' habits, as they encounter many problems. They experience common physical issues such as body pain, pressure sores, muscle injury and weakness, and cardiopulmonary weakness because of a range of poor long-term habits including, improper sitting postures, prolonged sitting, upper extremity overuse, and lack of exercise engagement. To solve these problems, wheelchair users have to change their habits. Self-tracking based on emerging sensing technologies combined with personal informatics appears promising to motivate behavior change.

To solve these problems, a smart connected wheelchair system was designed which applies emerging self-tracking technologies and machine learning. The wheelchair can monitor postures, sedentary time, upper extremity muscle load, exercise level, and energy expenditure. The associated app records and reports this data to improve users' self-understanding. Various strategies for motivating behavior change, including goal-setting, reward, self-monitoring, and sharing, have also been integrated into this system. In this way, wheelchair users can make new plans according to their data and move towards a healthier lifestyle.

An agile design approach in combination with technology-driven rapid prototyping, which includes multiple iterations of technology experimentation, prototype development, and user testing, was adopted throughout this project. Three generations of the prototype were then built, focusing on validating the sitting aspect of the concept from a technical perspective. By utilizing a simple machine-learning algorithm, the function was developed with a relatively satisfying accuracy. Preliminary results show that the concept has great potential for benefiting wheelchair users.







BRACE YOURSELF: UNDERSTANDING THE ESTHETICAL IMPORTANCE FOR PERSONALIZED ORTHOTICS

Graduate: Rutger Schönfeld (2018)
Supervisory team: C.C.L. Wang, S.G. Van de Geer, R. Jones
Partner: ManoMetric

Patients suffering from Carpometacarpal (CMC) Arthritis are prescribed a hand brace. For many reasons, patients are discouraged from prolonged wearing. This project focuses on the esthetics of these braces and their stigma.

The result is a medical aid which is not perceived as a crutch, but as a clothing accessory. By giving patients afflicted with CMC Arthritis the ability to choose which brace fits their style, they have the ability to 'brace themselves'.

The design is completely dependent on the shape of the user's hand. This is made possible with the use of 3D-scanning and parametric modelling. This custom-fit ensures that there are no specific pressure points in contact with the hand, which creates optimal comfort. The design's inner layer consists of a 2 mm thick glove made from flexible Nylon. The material is Selective laser sintering (SLS) printed and contains plasticizer to feel soft in contact with the skin and allow some freedom of movement. The design's outer layer consists of a 2 mm thick glove made from rigid Nylon. The material is SLS printed and acts as the exoskeleton to the inner layer. The design can be printed in twelve different colors. This provides the user with a choice and thereby a personal brace.

DESIGN FOR REHABILITATION

PATIENT SELECTION TOOL FOR 1-DAY RAPID RECOVERY TOTAL HIP ARTHROPLASTY

Graduate: Petra Oláh (2016)
Supervisory team: A. Albayrak, M. Melles, N. Stolk, S. Vehmeijer
Partner: Zimmer Biomet, Reinier de Graaf Hospital

Osteoarthritis (OA) is a degenerative joint disease and OA of hips and knees tends to cause the greatest burden to sufferers. In the case of hip joint failure, a Total Hip Arthroplasty (THA), a surgical replacement of the hip joint with an artificial prosthesis, is required to relieve pain in patients and to restore mobility. In order to deal with the growing number of THA operations, optimize cost effectiveness, reduce length of hospital stay, and minimize risk, rapid recovery protocols have been introduced worldwide for elective primary THA. The next challenge outpatient THA: to send the patient home on the day of surgery. To improve patient safety and managing their expectation and those of medical professionals, the current outpatient THA care pathway was analyzed and redesign suggestions made.

COMPASS is a digital application which integrates patient characteristics (mental & physical condition, life circumstances, etc.) in the preassessment phase with the clinical patient data. It gives both the orthopedic surgeon and the patient get better insights in optimal treatment options, and increases patients' involvement throughout the process. The application supports the orthopedic surgeon when selecting patients for the most appropriate THA program.

IMPROVING SPORT REHABILITATION

Graduate: Javier Rosales (2016)
Supervisory team: R.H.M. Goossens, A.L.M. Minnoye, R.J. de Vos
Partner: Erasmus Medical Center

Dealing with sport injuries is hard, and having control over recovery is vital. The Rev is a product service system that helps athletes recover from traumatic ankle injuries. It does so by calibrating strength and stability of the unaffected leg, comparing it with exercises for the affected leg. The Rev achieves this through three essential components: wear, view and mote.

Wear, is the sport sleeve embedded with Electromyography (EMG) sensors to register strength and stability of the muscles. View is the app where all the data is collected. Mote is the integrated control platform for the user to register exercises. The three components allow the user to conduct exercises in a comfortable yet unobtrusive manner. Rev Wear can be worn underneath any training gear and does not conflict with the user's clothing. The combination of Rev View and Rev Mote has been designed to allow the user to focus when exercising; the rehabilitation process can be monitored in the Rev View smartphone app. Strength progression measured by Rev Wear can be reviewed through the Rev-View smart phone app; the app gives users an overview over their rehabilitation progress.

A REHABILITATION TOOL FOR HIP PATIENTS BASED ON PATIENT PROFILING

Graduate: Lisanne van Dijk (2018)
Supervisory team: M. Melles, B. Groeneveld, S. Vehmeijer, H. Bodewes
Partner: Zimmer Biomet, Reinier de Graaf Hospital

This graduation project was conducted in the context of the 'Tailored Healthcare through Customer Profiling' research project at TU Delft, in collaboration with the Reinier de Graaf Group Hospital in Delft, and medical devices company Zimmer Biomet. The focus was on the rehabilitation journey after a total hip replacement.

The main goal of this project was to find out how different patient profiles benefit from different interactions. The needs and wishes of three different patient profiles were identified: the 'optimistic' patient; the 'managing' patient; and the 'modest' patient.

The Biobuddy was designed for the 'modest' patient: a product-service system that supports self-management during the total hip rehabilitation. The product has two parts: The monitoring part, a sensing plaster, is worn on the patient's pelvis and upper leg. The plaster can recognize and measure exercises for muscle strength and mobility. The monitoring data is transmitted to the Biobuddy: a booklet including a touchscreen with an application, tailor-made for the modest patient profile.

A successful rehabilitation starts with a good preparation. The Biobuddy helps with goalsetting and process visualization.

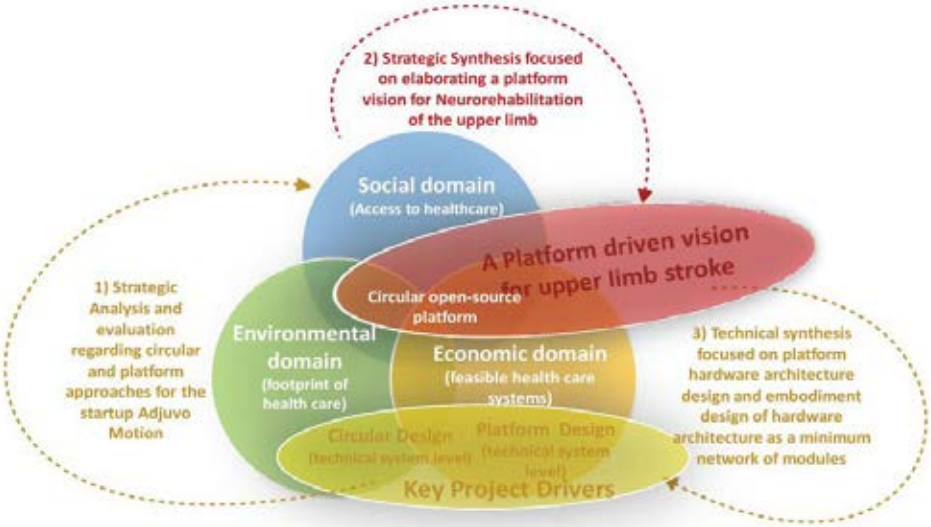
A CIRCULAR PLATFORM DESIGN FOR UPPER LIMB STROKE REHABILITATION

Graduate: Jose Urra Llanusa (2016)
Supervisory team: Z. Rusák, A.R. Balkenende, J. Luijten
Partner: Adjuvo Motion

This project was developed within the context of a Dutch startup company aiming to improve limited stroke recovery of the upper limb.

The company's value proposition addresses this problem by means of artificially assisted therapy. The specific project mission was to explore how circular and platform design strategies can be articulated in such a way that leverage the company's activities towards its main goal. As a result of a multilevel design approach, a sustainable platform business model was proposed.

A circular open-source platform strategy was proposed as a means to develop the platform infrastructure. A technological vision of this infrastructural development proposes a tool kit composed of a set of subsystems which include different Human Machine Interfaces and Active Assistance Devices that support varying treatment modalities. This set of subsystems were designed to be highly open, adaptable, upgradable, and reconfigurable. Within this strategic framework, a showcase application of circular and platform design strategies was achieved by means of modular architecture. This technical application demonstrates how the vision can be systematically implemented in the short term, within the value creation activities of the startup company.



A SMART BRACE TO SUPPORT SPASTICITY MANAGEMENT IN POST-STROKE REHABILITATION

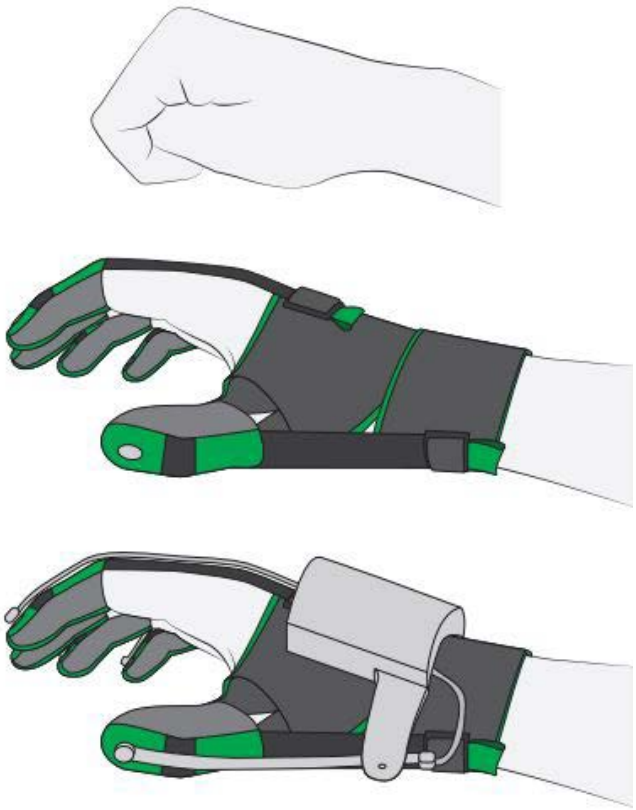
Graduate: Max Lammers (2016)
Supervisory team: Z. Rusák, R.B.M. Scharff, J. Luijten
Partner: Adjuvo Motion

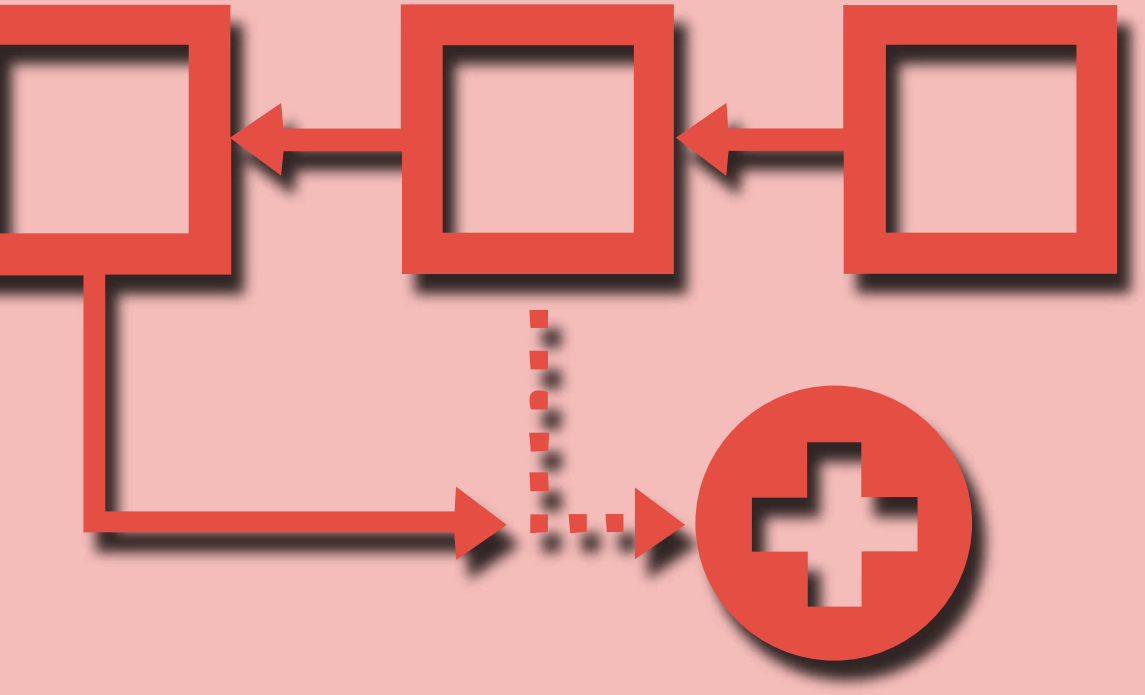
This project presents the design of a product to help stroke survivors suffering from chronic spasticity to manage their everyday activities.

Adjuvo Motion, a young start-up, aims to improve the situation of stroke survivors by bringing the rehabilitation center to their home through the Adjuvo Platform, allowing them to perform exercises in the context of virtual tasks. They proposed an assignment to extend their product portfolio with a Range of Motion assessment device especially suited to those suffering from spasticity. Spasticity occurs in roughly 60% of stroke survivors with varying degrees of intensity. It is caused by the damaged parts of the brain sending conflicting signals to the muscles, causing them to contract.

Based on a quantified use case, the four sub-assemblies; the Wrist Wrap, Finger Modules, Sensor Module, and Connections, were materialized in the embodiment design stage. When selecting production methods, the main challenge was the small batch size of 1000 units, which made conventional techniques for mass production, such as injection molding, less attractive. Auxilius passed most theoretical requirements, however the user tests on healthy subjects could not be used to draw any conclusions regarding its effectiveness on spastic stroke patients. As the product's working principle is based on that of existing spasticity compensation products, we predict that the Auxilius will be an effective therapy supplement.

The final design is the Adjuvo Auxilius; a spasticity-compensation glove with modular sensors which can be added to allow virtual (stretching) exercises through the Adjuvo Motion's platform. The results of these exercises can be used to remotely assess patients motor skills, and to adjust the therapy if needed.





DESIGN FOR NEW HEALTHCARE BUSINESS MODELS

CONSUMER-DRIVEN BUSINESS MODELS FOR HEALTHCARE

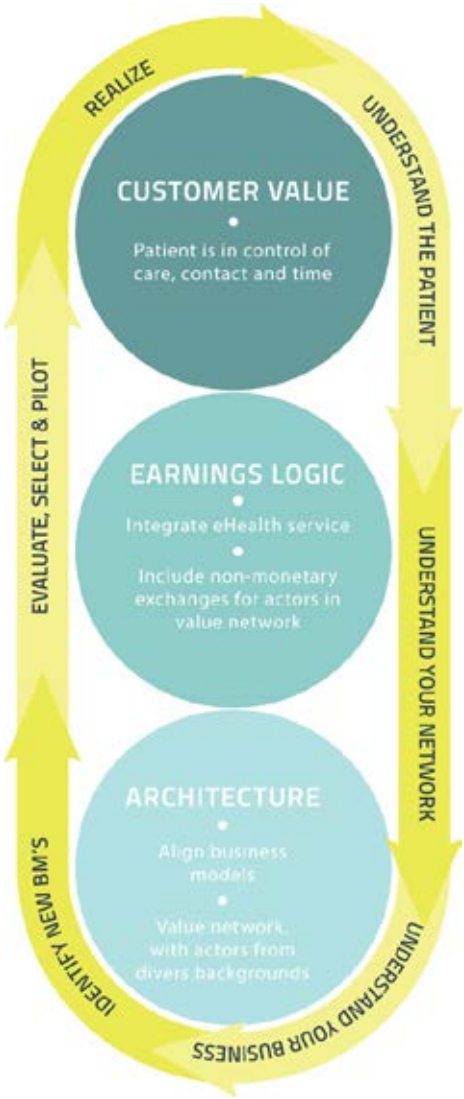
Graduate: Corette Arts-Posthoorn (2017)
Supervisory team: L.W.L. Simonse, M.S. Kleinsmann, S. Prins
Partner: Capgemini Consulting

The current Dutch healthcare system has to undergo fundamental change to maintain its current level of high quality, affordable and sustainable care. The rise of digitalization offers new opportunities to transform the system, with less focus on product innovation and more on patient needs. However, problems arise when translating the social case for ehealth to a business case.

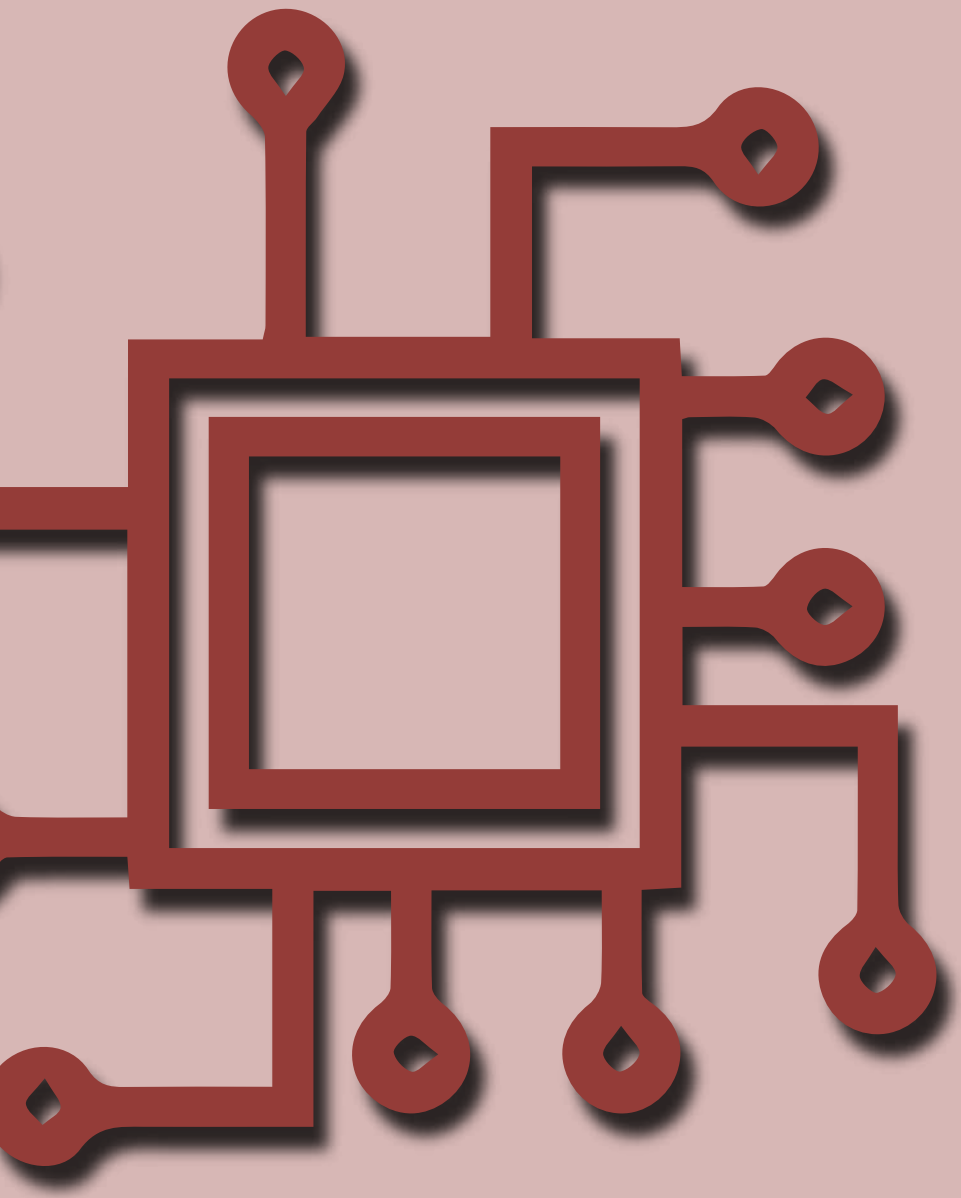
A sustainable business model can ensure the longevity of an eHealth solution. The general problem can be defined as: How can Capgemini apply business modelling to determine, together with stakeholders, which financial and non-financial elements enable value to be extracted from consumer-driven eHealth solutions?

eHealth provides a unique opportunity for actors in healthcare to connect and form networks that functionally work together to optimize both treatment and care. A crucial issue is to include the patient in this network. This can lead to a more satisfying healthcare experience with associated cost reductions, and it can narrow the gap between demand and supply. A business model can serve as a platform to connect the individual actors and shape the value network. These actors can then exchange goods, relevant resources, and skills with each other, which will strengthen the network.

This graduation project presents a new take on the process of designing a new business model; it is an adapted version of the current Capgemini business model process. Existing steps were evaluated and several alterations and additions proposed. A major innovation is the emphasis on the patient's role in multiple steps of the process.



ACTIVITY	DESCRIPTION
UNDERSTAND THE PATIENT	
■ Identify what your target patients will be.	To be able to identify the needs and network of your patient it is important to first decide which patients you want to develop a new service for. The process could be repeated for multiple groups of patients.
■ Identify what customer needs you want to accompany with the new business model.	In consumerism healthcare, the patient plays a major role in defining his or her healthcare path. It is therefore important to include de clients' needs and wishes from the start of a new business model design.
■ Identify relevant patient interest groups	Patients interest groups can help to create a representative group of patients to help in the co-creation process.
UNDERSTAND YOUR VALUE NETWORK	
■ Analyse industry value network and identify relevant actors and their roles.	In consumerism healthcare, the care for a client is delivered by a network of actors (including the client) instead of a chain. Together they create and exchange value, it is therefore important to know which actors play a role in the care of the client.
■ Identify most important capabilities of network actors	What capabilities do the actors bring to the network, why are they a part of it?
■ Identify missing capabilities of network actors	Are there still missing capabilities to fulfil the needs and wishes of the client?
■ Identify relevant opportunities & threats	-
UNDERSTAND YOUR BUSINESSES	
■ Understand strategic intent of own company and value network actors; including current customer segmentation/dynamics and strategic drivers.	-
■ Specify current business models of value network, making all elements explicit.	-
■ Assess current business model performances.	-
■ Analyse capabilities, identify strengths and weaknesses	-
■ Compile list of strategic criteria the value network wants to achieve	To be able to make a founded choice for a business model further in the process, it is necessary to come up with a list of criteria the business model should meet. Weights can be added to the criteria to indicate importance.



DESIGN FOR HEALTHCARE TECHNOLOGIES

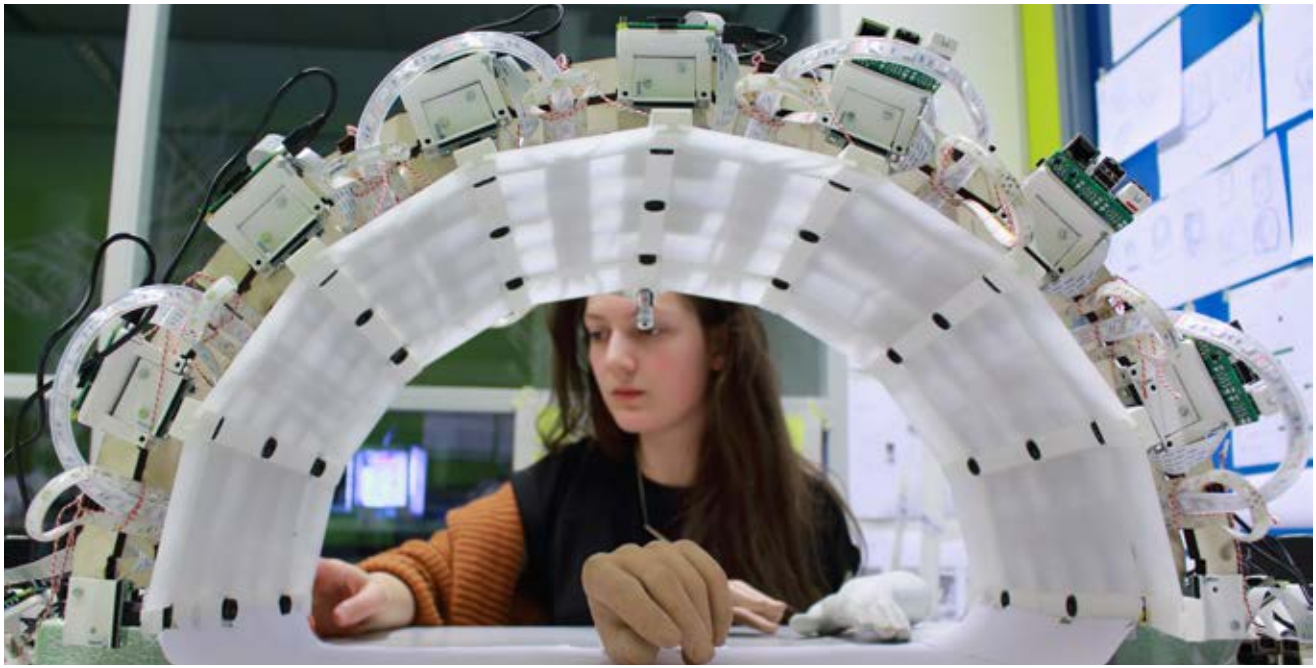
DEVELOPING THE EMBODIMENT OF A HUMAN-ORIENTED 3D SCANNER

Graduate: Dolores Hilhorst (2016)
Supervisory team: J.F.M. Molenbroek, Y. Song, M.P.A.J. de Hoogh, P. van der Zwan
Partner: Vectory3

There are many applications which would benefit from a digital 3D-model of the hand. In this project, the goal was to produce 3D surface scans suitable for use in the fields of anthropometry, orthotics, and ergotherapy and revalidation.

To achieve this, a new design iteration of a photogrammetry-based 3D hand scanner was developed , with the focus on improving functionality and reliability: the Curatio Ommanu. The result is a pre-production prototype consisting of 48 low-cost camera modules, an LEDstrip illuminated softbox, and 49 Raspberry Pis that wirelessly transfer signals and files to each other.

By utilizing the characteristics of the relation between 3D scanner geometry and photogrammetry software functionality, the process of accurately reconstructing and cleaning the 3D scans was streamlined. The performance of the prototype (in terms of object coverage, discernible surface detail and dimensional accuracy) was assessed in a series of evaluative tests conducted with a diverse group of subjects.



A 3D SCANNER FOR THE HAND

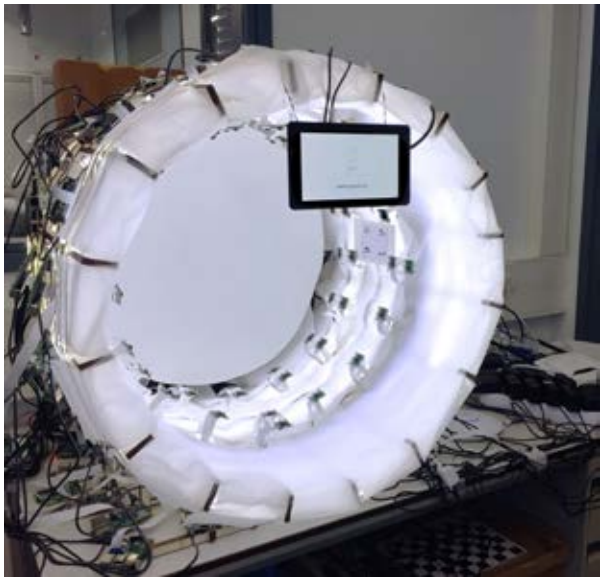
Graduate: Alexander Weiss (2017)
Supervisory team: J.F.M. Molenbroek, Y. Song, P. van der Zwan
Partner: Vectory3

In this graduation project, a design for an affordable 3D scanner that can easily capture accurate 3D models of the human hand was proposed.

These 3D scans are necessary when designing and manufacturing personalized products; they open up a new world of design possibilities by tailoring products specifically to the single person. An example is Carpifix, a personalized wrist orthosis that takes away key usage problems present in current orthoses. In addition, 3D scanning can be used to objectively track progress of hand therapy or to gather detailed anthropometric data, including multidimensional shape information for product design or other medical purposes.

A highly iterative approach was used to further develop the photogrammetry-based scanning technology and integrate it into a comfortable and easy-to-use product. Key aspects of the scanner are a practical, secure and reliable system architecture and low-cost components. In addition, it includes an interface and a separate application to facilitate an effortless and structured process of scanning, processing, utilizing and archiving 3D models in the relevant contexts. This enables anyone, including people who are not skilled anthropometrists, to obtain accurate measurements.

Evaluation of the prototype showed the design is capable of producing accurate and complete reconstructions of the hand and ±15 cm of the arm, with a 90% success rate. Defects in the remaining 10% of scans are generally limited to a section of the arm. The integrated design developed as part of this project is sufficiently robust to be evaluated in a real-world pilot application. The product's embodiment design should be further optimized for manufacturing and the interaction concept further evaluated and implemented. Finally, improved software features like automatic measurement and treatment progress-tracking that unlock the potential of 3D scanning and cloud processing should be considered.



COMBINING 3D HAND SCANNING AND MEDICAL THERMOGRAPHY

Graduate: Bart Peeters (2017)
Supervisory team: J. Geraedts, J. Wu, P. van der Swan
Partner: Vectory3

The Curatio is a low-cost hand scanner which permits fast capture of accurate 3D hand scans, developed at TU Delft in cooperation with Vectory3. Research done by several graduate students has resulted in reliable and accurate hand scans. Adding infrared thermographic imaging was deemed the next step forward in the scanner's development.

Combining 3D hand scanning with medical thermography creates opportunities for product designers and medical professionals to better help people with hand conditions such as those suffering from rheumatoid arthritis, diabetes, and Raynaud's syndrome. This thesis explores potential applications and the technology needed to combine both modalities by presenting the development of a thermal camera module and its integration into the existing scanner workflow.

The first thermal hand scan, a so-called 3D-thermogram, was created using the developed module. Several people with hand conditions were imaged to strengthen the proof of concept and to frame future project directions. Initial findings demonstrate that a low cost thermal module can be successfully integrated into the Curatio, and that it can provide relevant medical insights.

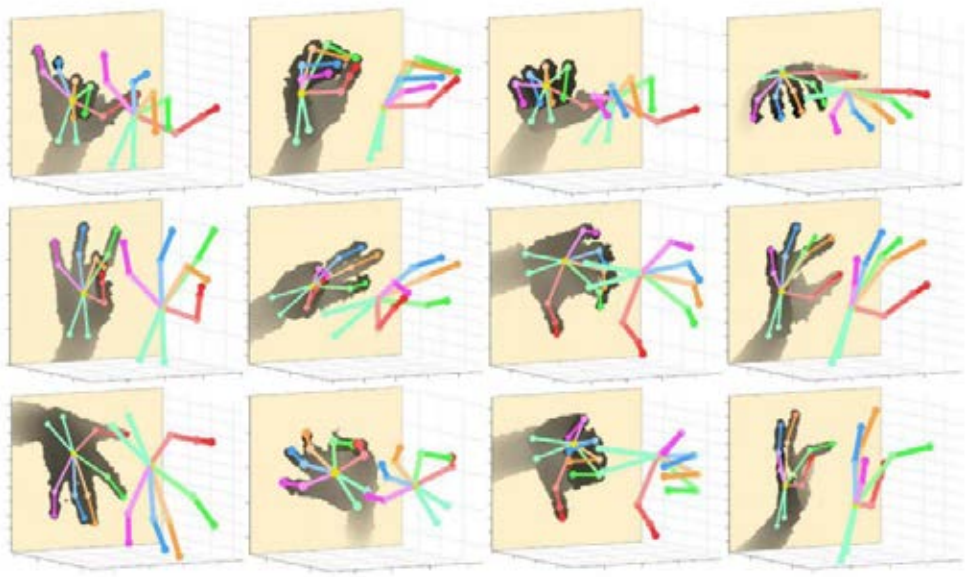
HANDS CAN: DETERMINING THE LOCATION AND RANGE OF MOTION OF DIGITAL JOINTS IN 3D SCANS

Graduate: Timo Dijkstra (2018)
Supervisory team: J. Geraedts, J. Wu, P. van der Zwan
Partner: Curatio

The versatility of a hand is revealed in its movements, but this is often not appreciated until a trauma occurs. A measure to track disease progress is joint range of motion. For years, researchers have envisioned a digital workflow for 3D data in medical appliances. The aim of this research was to develop a method that reliably and reproducibly determines the range of motion of the digits.

In current practice, angles are measured using a goniometer, a fairly inaccurate process. Three methods to determine the location of joints in 3d hand scans can be distinguished: using heuristics, computer vision, and deep learning. Of these, deep learning is the most flexible, modern and accurate method, and was therefore applied by the research team.

The end result is a matrix containing the range of motion per joint which can be applied to manipulate a 3D model in an anatomically correct way. For ease of manipulation, a physical manipulator was purposed. The results of this novel method show less inter-rater differences than when taking measurements with a goniometer.



HOW IOT CAN IMPROVE THE AMBULANCE SERVICE IN THE NETHERLANDS

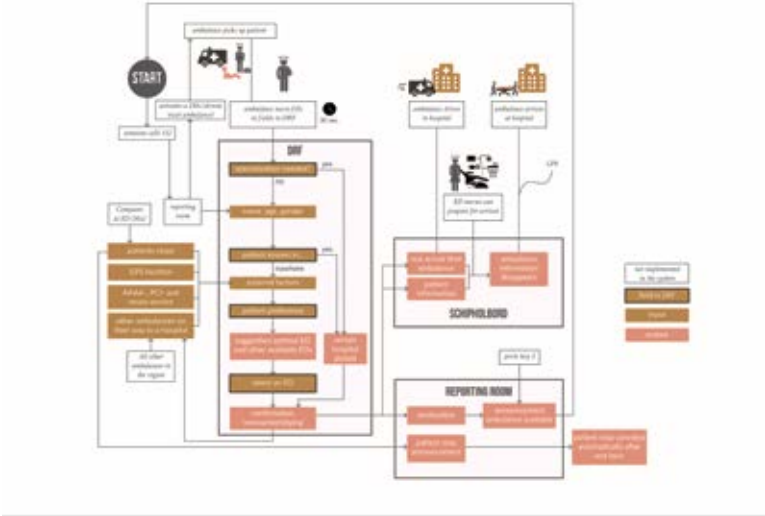
Graduate: Reinee Heutink (2018)
Supervisory team: H.J. Hultink, A.Q. Beekman, M. de Jong
Partner: VodafoneZiggo

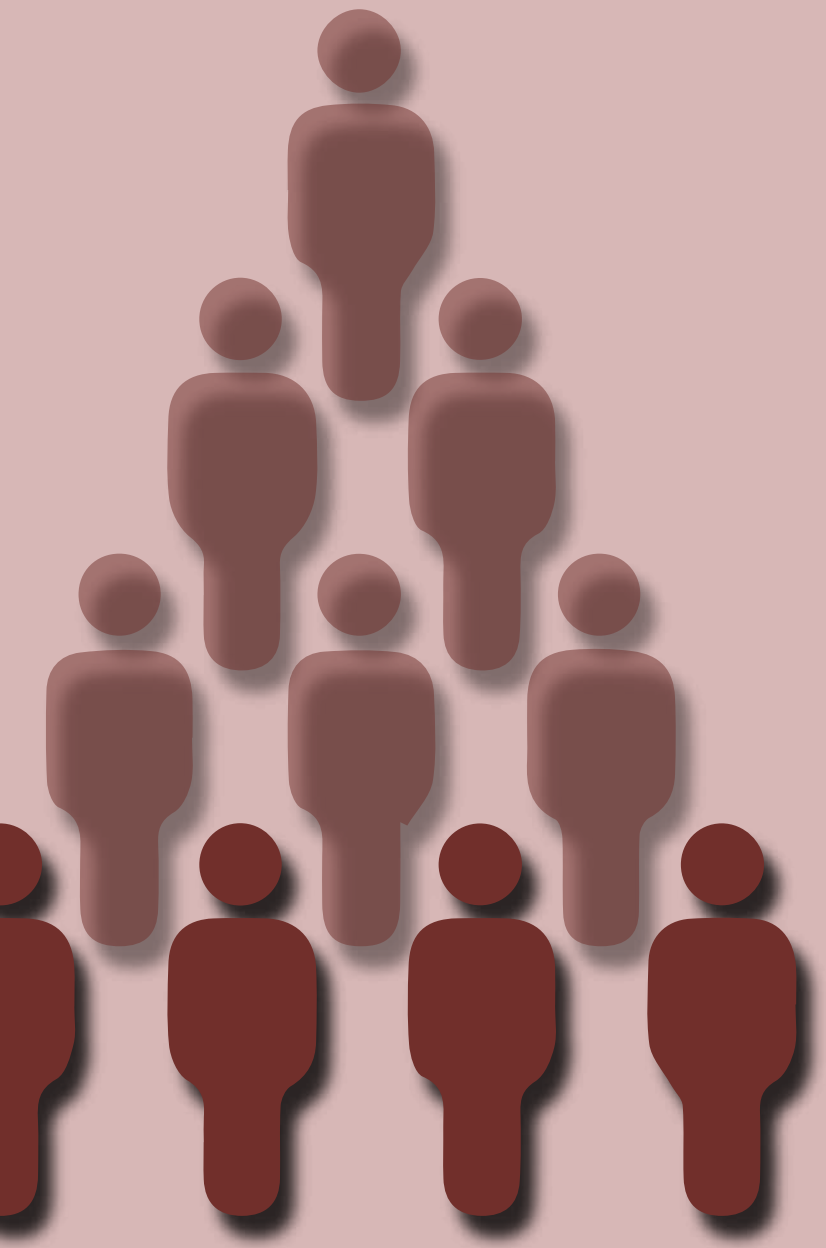
Emergency services often arrive too late; only one in three ambulances succeeds in meeting the standard. Collaboration between ambulances, the reporting room, and emergency departments (EDs) needs to be improved in order to improve both efficiency and ambulance arrival times.

The goal was to 'Design an IoT-based logistic concept that improves collaboration between reporting room, ambulance staff, and EDs by giving the ambulance staff direct insights in patient stops set by EDs, and giving EDs insights in arriving ambulances'.

With the CommunicAid, the ambulance nurse fills in several fields in the 'digitaal ritformulier' (DRF; digital-trip-form). Based on this and several external factors, the system decides which ED is most eligible. The real-time information is shared with the ED in question and with the reporting room. With the CommunicAid, patient stops at the ED are set digitally after which the reporting room receives an announcement and the DRF notifies it. IoT is required for the information flows between the different devices.

However, there are a number of complications associated with implementing the proposed system. In the healthcare sector, all parties work using their own systems that cannot 'talk' to each other. An additional complexity is that the systems differ between regions. Unless the research team starts from scratch, a national solution is complicated, expensive and therefore unrealistic. However, an important future goal should be to harmonize the operations in acute healthcare to improve collaboration and increase efficiency.





DESIGN FOR THE BASE OF THE HEALTHCARE PYRAMID


mitre
mitre

MAJICAST: A HYDRO PRESSURE CAST SYSTEM

Graduate: Jessica Mills (2016)
Supervisory team: R.H.M. Goossens, E.L. Doubrovski, M. Rumping
Partner: ProPortion Foundation

The World Health Organization estimated that there are 30 million amputees worldwide of which about half have lower leg amputations. Low income, (rural) populations in developing countries have limited access to prosthetics, even though their livelihood depends on their mobility and ability to work. Access is limited by two factors: affordability and availability of technical skills.

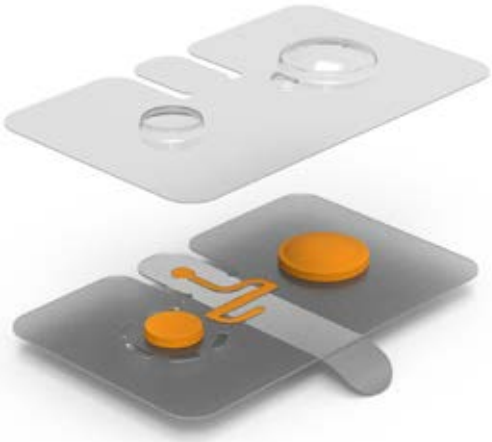
A possible solution for amputees could be a new way of producing the prosthesis. The final prototype system tested at Gilete (a prosthesis lab in Colombia), indicates that Hydro Pressure Casting has the potential to be operated by entry level Certified Prothesist and Orthesist (CPO), reducing the required technical skill level. Additionally, as this process eliminates resection time, the production time to create a socket has been reduced by a minimum of 4 hours for indirect casting. If direct casting is used, potential time savings are approximately 10-14 hours, requiring only 3 - 4 hours for the entire process, from casting to alignment.

These findings show that CPOs are positive about the method. However, before conclusions can be drawn, they indicated they would like to see how the socket fits after a month and after 2 months. The preliminary results also indicate that patients prefer the Hydrostatic pressure casting system above hand casting, and would like their next socket to be made in this fashion. Three of the four amputees are still using their Majicast prosthesis.

AN AUTONOMOUS MALARIA DIAGNOSTIC SYSTEM

Graduate: Niek Marks (2015)
Supervisory team: B. Ninaber van Eyben, M. Verwaal
Partner: Amplino

Malaria is responsible for 200 million infections a year, resulting in 580,000 deaths worldwide. Patients are often women and young children. Although malaria is not contagious, it is still endemic in a large part of Africa. Worldwide non-governmental organizations (NGOs) such as the World Health Organization (WHO) all agree that proper diagnosis and corresponding treatment could eventually eradicate the disease.



'Scout', a simple yet sufficient solution enabling mobile malaria detection was developed. Efficient contactless heating and cooling techniques were applied to create a battery-powered mobile device capable of analyzing a human blood sample for the presence of the malaria parasite. The Scout uses specially designed disposable cartridges that incorporate most of the procedures a medical professional would normally do by hand. Due to this integration, the cartridge can even by used by people with basic medical training. The final detection and diagnosis is based on sample fluorescence; by using specific fluorophore and enzymes in the cartridge, Scout is able to detect the presence of malaria.

In a field scenario, a doctor would take a sample from a droplet of blood of a patient and load this in the cartridge through the blood port. By deforming the water reservoir, the water washes the blood into the reaction chamber and mixes the reagents. The cartridge is now ready to be placed in the machine and analyzed. For cartridge materialization, the focus was on mass production techniques. Simple manufacturing principles enable true mass production of the cartridge.

DETECTING MOSQUITOES-BORNE DISEASES IN INDONESIA

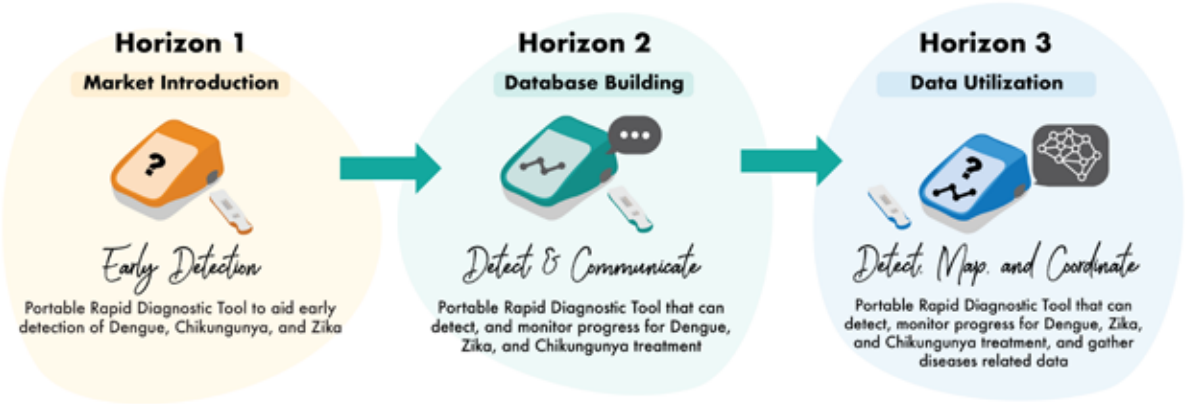
Graduate: Vinda Zheilla Hardikurnia (2018)
Supervisory team: J.C. Diehl, J.M.L. van Engelen, E. Mendes
Partner: TU Delft, faculty of Applied Sciences

The first goal of this project is to investigate a local healthcare context for implementation of a technology under development at TU Delft. With this technology, a smartphone-based Rapid Diagnostic Test that can detect Dengue, Zika and Chikungunya was created. The local healthcare context was researched to discover the essential characteristics that match the characteristics of this new technology.

Dengue, Zika, and Chikungunya all possess non-specific symptoms. Hence, making a clinical diagnosis through symptom recognition is challenging; a supporting diagnostic test is needed to verify the diagnosis. However, a reliable and easy to use diagnostic test for Dengue, Zika, and Chikungunya is not always available.

A case study was performed in Indonesia to understand the situation in a local healthcare context. In Indonesia, Dengue is rarely diagnosed through a specific Dengue diagnostic test for affordability reasons. Hence, the healthcare professionals prescribe a complete blood count test instead of a Dengue antigen detection test. However, nurses and midwives have difficulties understanding the Blood Count test results; they need a quick definitive result.

From three concepts, a strategic roadmap with three horizons was developed. Each horizon brings the product innovation process a step closer to the future vision. The first horizon focuses on market introduction, the second on engaging more people and building a database, and the last on database utilization.



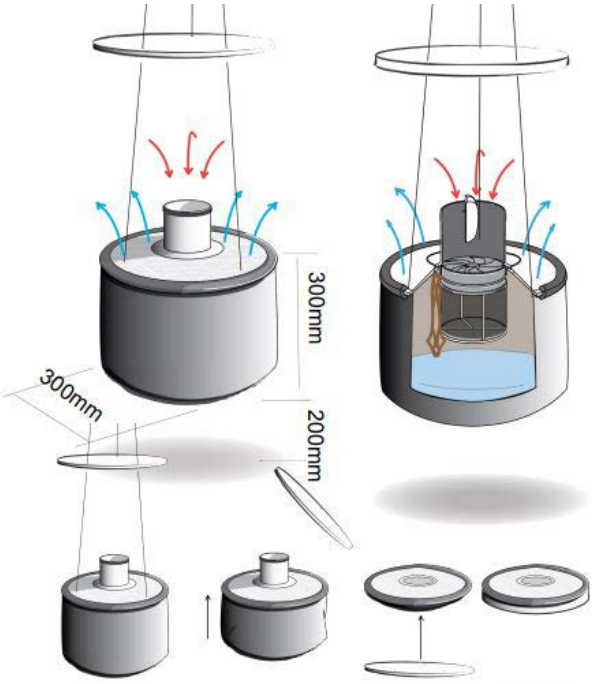
AN ODOUR-BAITED MOSQUITO TRAP FOR MALARIA PREVENTION IN AFRICA

Graduate: Henry Fairbairn (2018)
Supervisory team: J.C. Diehl, H. Kuipers, F. Muijres
Partner: Wageningen University and Research

This graduation assignment focused on a mosquito trap to prevent malaria. Studies show that the implementation of mosquito traps across the island of Rusinga, Kenya can lead to a 30% reduction in cases of malaria and a 70% reduction in the Anopheles population. However, further research into mosquito escape behavior showed the Suna-Trap, used in the SolarMal Trial, had a poor capture performance, with less than 4% of approach flights resulting in capture. Furthermore the traps were difficult to maintain. To be an effective tool for malaria prevention, users in Africa must be able to ensure the trap's working condition to reduce mosquito-bites and prevent resurgence.

Based on the team's findings and an iterative process outlined, it was possible to design a concept for an innovative mosquito trap with a high capture performance suitable for further lab and field testing. A number of concepts were tested in order to highlight how variant factor effect performance compared to the Suna-Trap. Although the testing was not thorough enough to make definite conclusions, enough data were gathered to demonstrate whether incorporating the feature in a new design would increase capture rate. Well-performing principals can be further tested in the future.

From hypothesis evaluations, it was shown that the addition of heat and moisture increases capture rate in comparison to a standard Suna-Trap under lab conditions. Considering the context factors as well as performance factors highlighted in the research, the team aims to develop a final design for a high-performance mosquito-trapping solution suitable for use in Africa.

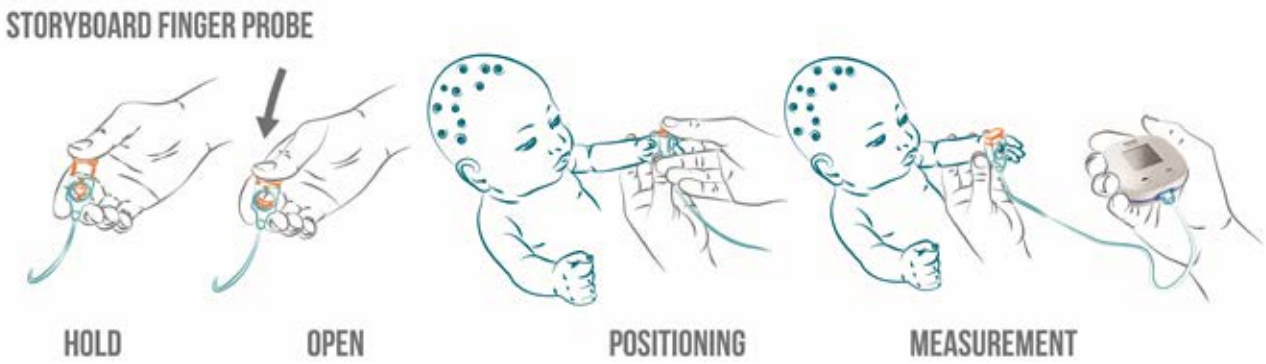


HYPOXEMIA DIAGNOSIS FOR RURAL INDIA

Graduate: Sandra Ramirez Herrera (2015)
Supervisory team: J.C. Diehl, J.F.M. Molenbroek, P.M. Dadlani
Partner: Philips

One of the leading causes of children's deaths in rural areas in India is pneumonia, which can be diagnosed by measuring the level of oxygen in their blood and heavy breathing. If the oxygen level is abnormally low, this is called hypoxemia. In this graduation assignment, the focus was on the development of a pulse oximeter probe for Philips for use by community health workers in India. These ASHA (Accredited Social Health Activist) workers are trained to determine which children need immediate attention and/or which children need to go to a higher health facility. Unfortunately ASHAs have difficulties detecting hypoxemia; their illiteracy/innumeracy causes them to miscount breaths.

Therefore a new generation of the pulse oximeter probe was designed. Two probes, one for the head and one for the finger were designed, iterated and prototyped. An expert evaluation and a user test were performed to compare the probes and test the children's reaction. Even though the probes were tested on healthy children and not in the context, the results were translated into recommendations to modify the forehead and finger probe to enable further field testing.



BABY VIEWER: AN ULTRASOUND DEVICE FOR THE AFRICAN MEDICAL WORLD AND THE WESTERN CONSUMER MARKET

Graduate: Susanne van Gils (2016)
Supervisory team: J.M.L. van Engelen, W.C. Kersten, F. Posthumus
Partner: Delft Imaging Systems

This graduation assignment presents a new design for the Baby Viewer, an ultrasound device produced by Delft Imaging Systems. The Baby Viewer can be used in two contexts, in Africa and in western countries; the user scenario is different in both contexts.

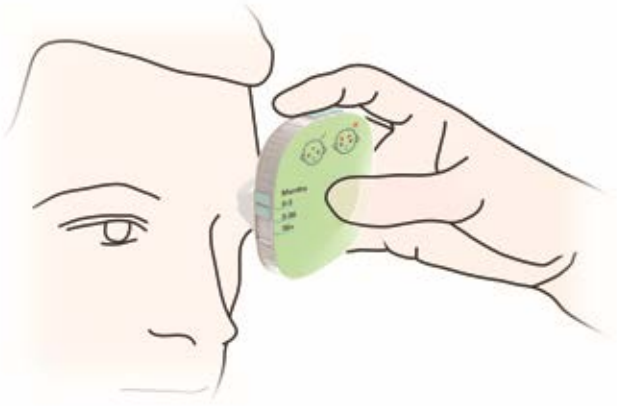
Maternal mortality is a major problem in sub-Saharan Africa, especially in rural areas. Ultrasound imaging has proven to be an effective tool for identifying pregnancy risks. However, ultrasound equipment is scarce because of the costs and the lack of trained users able to examine and interpret ultrasound scans. In contrast to the medical use in Africa, Western consumers will not use the Baby Viewer as a medical device, but as an at-home device to create an extra fun factor during the pregnancy. Parents-to-be love seeing their unborn, and the Baby Viewer can fulfil this need.

In the final design, one device for both context scenarios, but with a context dependent interface was designed. For the users in Africa, a new interface was created which helps during an examination with the Baby Viewer. The focus for the interface is on clear communication about how to use the Baby Viewer. Each step is explained and a step by step (swipe by swipe) routine was created. The suggestions for the physical device make it more intuitive to hold the Baby Viewer in the right position. The new color and form give the Baby Viewer a more modern and playful, but still a medical appearance. For the West, the Baby Viewer Diary was created which enables parents to store their memories of the pregnancy using the ultrasound images made with the Baby Viewer.

FRUGAL THERMOMETER INNOVATION

Graduate: Rikako Iwamoto (2016)
Supervisory team: J.M.L. van Engelen, J.C. Diehl, A.L. Rodrigues Santos
Partner: TU Delft

Self-assessment of fever by means of tactile contact with skin is inaccurate and results in misdiagnosis and neglecting treatment for patients with febrile illnesses. To provide reliable fever diagnostics and access to complete and relevant diagnostic information in remote Ugandan communities, a frugal fever diagnostic product service system (PSS) and a frugal thermometer was designed.



The PSS incorporates fever management in the service system of Healthy Entrepreneurs, offering access to health information and reliable, affordable, essential medications and health products for households in a resource-constrained setting. Within the PSS, the frugal thermometer enables a free temperature-taking service and a thermometer rental service.

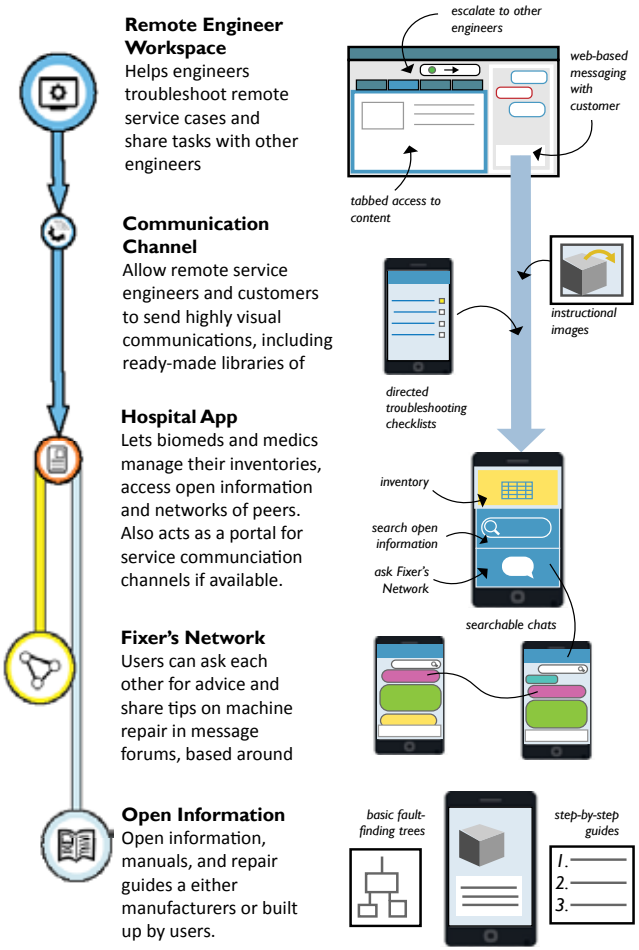
CADENCE: A PRODUCT-SERVICE FOR REPAIR & MAINTENANCE OF MEDICAL IMAGING EQUIPMENT IN AFRICA

Graduate: Grace Kane (2016)
Supervisory team: C.A. Bakker, A.R. Balkenende, K. Govindarajan, M. van Herpen
Partner: Philips

Up to 40% of medical equipment used in the developing world is damaged. Studies have shown that a major reason for this lack of functioning equipment is the inadequacy of repair and maintenance in low resource clinics. Repair and maintenance are performed on medical equipment as a matter of course. However, in much of the developing world, preventative maintenance is not performed or even budgeted for, and repair is hampered by the lack of skilled technicians and the difficulty of accessing spare parts.

This report investigates the possibility of improving repair by making use of remote communication technologies. Research was performed at a User Interaction and Systems level, and combined to create the design of a remote servicing platform for service providers in the African market.

The result is Cadence, a platform tool designed to connect different stakeholders involved in medical equipment repair support in Africa, and to enable a diverse range of contracts, transactions, and information sharing between them. The building blocks to do this are two basic software tools. Cadence has two user environments – one for remote support engineers and one for hospital end-users –specifically designed to support the workflow of medical equipment service and repair.



Integrated Product Design
Medisign specialization

A ROADMAP FOR DEVELOPMENT OF A SMART MALARIA DIAGNOSTIC DEVICE

Graduate: Julia Stoevelaar (2017)
Supervisory team: J.C. Diehl, B. Groeneveld, O. Oladepo, O. Abiona
Partner: Philips

Malaria is a life-threatening parasitic disease and the leading cause of high morbidity rates in developing countries. In Nigeria (the chosen context for this study) over 90% of the population is at risk of malarial infection, causing 60% of outpatient visits in Nigerian healthcare facilities. Accurate diagnostics are unavailable to majority of the population and drugs are prescription-free, leading to misdiagnosis, overtreatment, and drug resistance. The Excelscope is a smart malaria diagnostic device that leverages the functionalities of a smartphone to capture magnified images of a blood smear and provide a remote or automated diagnosis.

The goal of this study was to find barriers and enablers for use and acceptance of the Excelscope by healthcare professionals in Nigeria.

The different scenarios were discussed during interviews with stakeholders, as well as local perspectives on malaria management in general. This resulted in a roadmap where technology, context and user are connected, providing recommendations for the device's further development.

SELF-HELP CARD TO SUPPORT MENTAL HEALTH OF PEOPLE ON THE MOVE IN MEXICO

Graduate: G-Young Van (2017)
Supervisory team: J.C. Diehl, M. Melles, A. Jansen
Partner: Doctors Without Borders (MSF)

In Central America, the migrant crisis has become more complicated in recent years. It is estimated that about 500,000 migrants cross the Mexican border every year. Most are escaping from the extreme violence in the countries known as the Northern Triangle of Central America - Honduras, El Salvador and Guatemala. Since 2012, Medicines Sans Frontiers (MSF), the international medical humanitarian organization, has been providing medical and mental health care to the migrants in Mexico. Their aim is to address the needs of the displaced people in Central America who escaped from violence, conflicts, or life-threatening policies or practices. These migrants travel in order to achieve refugee status in the destination country, mostly the United States of America.

MSF has already implemented emergency health posts for patients during their migrant journey. However, these only provide limited access to medical support, which cannot be more than once-only intervention.

This project started by exploring this challenge together with the MSF Displacement Unit. In order to better understand the context, field research was conducted in Mexico. Four opportunity areas were explores and different ideas were developed. The solutions were briefly tested in the field to determine the final direction. After returning to the Netherlands, the idea was developed further into the concept. Communicating with the field team, the design was then evaluated and iterated. The final design is a card-set "Taking care of your emotions." It includes information about MSF, with self-facilitated psychological exercises to serve the mental health needs of the migrants during the journey in Mexico. The concept serves two different objectives; (1) to support the current consultation and (2) empower the resilient ability of the migrants. The final design was received positively by the MSF field team and some of the migrants who participated in the evaluation study.

INTEGRATED PRODUCT SYSTEM FOR CHILDREN UNDER FIVE FOR INDIA AND KENYA

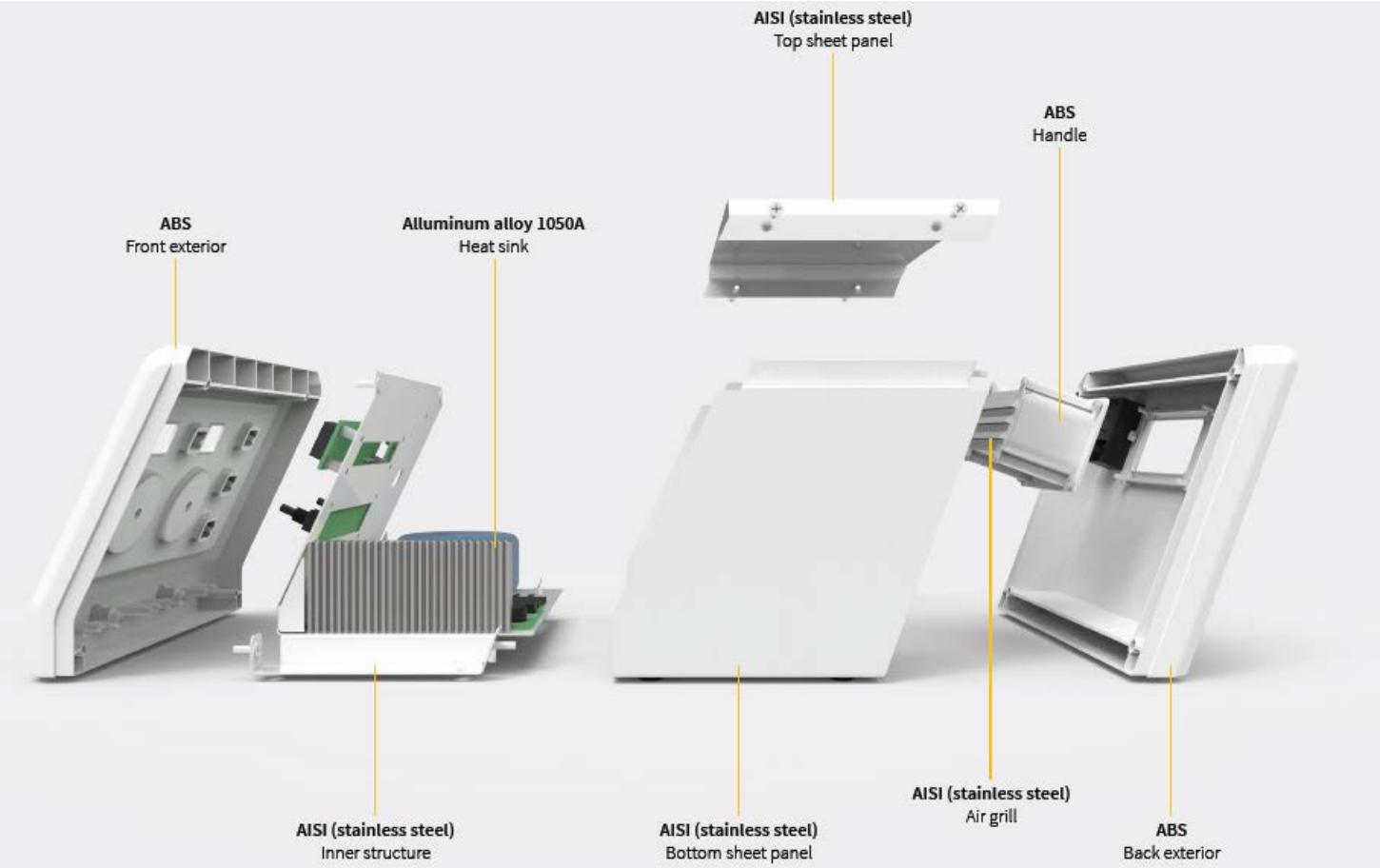
Graduate: Vinay Bhajantri (2017)
Supervisory team: J.C. Diehl, J.M.L. van Engelen, P.M. Dadlani
Partner: Philips

Low- and Middle-Income Countries (LMICs) face major issues throughout the continuum of primary healthcare for childcare (0-5 years). Altogether, more than 10 million children die each year in LMICs before they reach their fifth birthday. WHO and UNICEF created an Integrated Management of Childhood Illness (IMCI) strategy to tackle this global issue.

This graduation project aimed to improve this strategy at user level across India and Kenya. A Context Variation by Design approach was used to focus on usability and scalability. With this approach, insights from different contexts were studied to find shared or opposing requirements.

The final design of the product system consists of a diagnostic device that can provide four diagnostic information sets within the IMCI workflow. It measures respiration rate, temperature, heart rate, and oxygen saturation. The workflow is guided through the smartphone application. The product is designed to be scalable across a range of user types with varying expertise, and in the geographical contexts of India and Kenya.

The final design concept was validated with the users: community health workers and clinical officers. Although the design was well received by the health workers, the clinical officers stated a need for more advanced algorithms. The final design can be considered highly scalable and usable across users with different expertise.


AISI (stainless steel)
Top sheet panel
ABS
Handle
ABS
Front exterior
Alluminum alloy 1050A
Heat sink
AISI (stainless steel)
Inner structure
AISI (stainless steel)
Bottom sheet panel
AISI (stainless steel)
Air grill
ABS
Back exterior

EMPOWERING THE ACCESSIBILITY OF SAFE GLOBAL ELECTROSURGERY

Graduate: Koen Ouweltjes (2018)
Supervisory team: J.E. Oberdorf, J.C. Diehl, R. Oosting
Partner: Global Health Design Lab

Roos Oosting and the Global Health Design Lab initiated the development of affordable and high-quality electrical surgery units (ESU) as a step towards improving surgical care. The ESU is used as an operating tool to assist the surgeon in a wide variety of essential surgical procedures. The ESU consists of a high frequency generator with an interface to adjust power settings, and a monopolar handheld and electrode tip used to perform the surgery. In general, the underlying principles of electrosurgery are not widely known and experience with the ESU is limited. Hence, this forms a potential risk for both operator and patient. The majority of the surgeons interviewed in the Netherlands, Brazil and Kenya noted that the risk is even greater in low and middle income countries (LMICs) where routine surgery does not exist and a broad spectrum of surgical knowledge is required.

The design goal of the project was the development of a reliable, safe and intuitive user-interaction with the ESU system and a tailored design for maintenance in a variety of use-contexts in LMICs. The new design of the electrosurgery unit should be understandable for all electrosurgery users, thus surgeons with limited electrosurgery experience as well as specialists and surgery assistants. The ESU system increases safety and provides an intuitive user interaction for those with limited electrosurgery experience, thereby improving maintenance reliability in the variety of use contexts in LMICs.

The high frequency was designed to enhance a safe and intuitive user interaction by integrating co-created guidelines on appropriate power settings related to a specific surgery. This empowers the clinical outcomes, reduces check-ups, and minimizes safety risks.

The monopolar handheld and electrode tip have been designed to enhance control, safety, and intuitiveness during the surgical procedure. Moreover, the monopolar handheld is resistant to the wide range of cleaning procedures used in LMICs, thereby significantly increasing the ESU system's sustainability.

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Number of projects:
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Number of projects:
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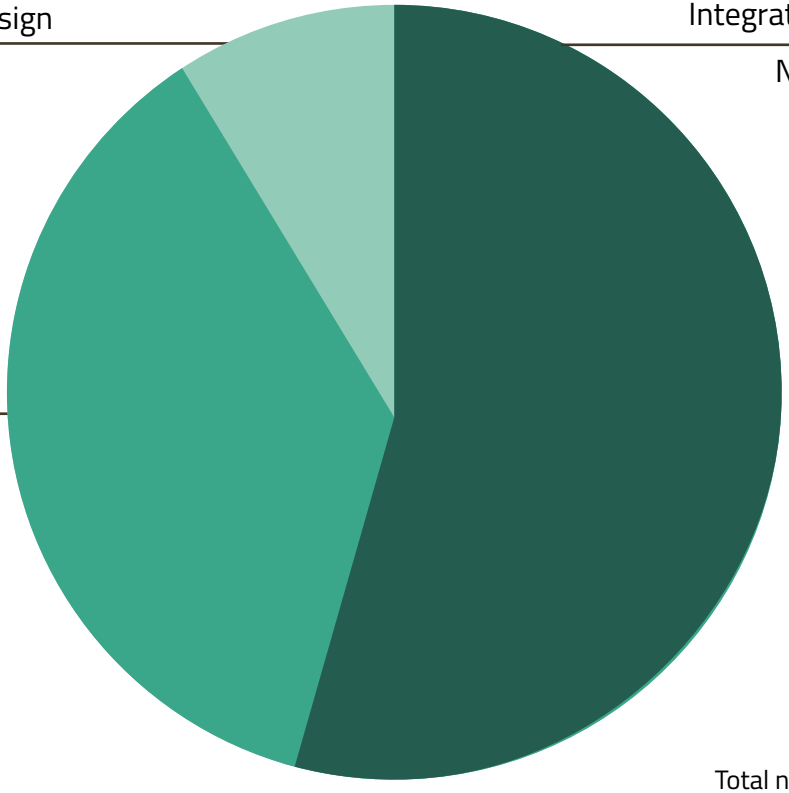

Total number of projects: 127

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medis+gn

This booklet showcases 127 healthcare graduation projects completed by Industrial Design Engineering Master's students in the period 2016-2018. The projects are divided into twelve categories, reflecting on-going developments in society, healthcare and the research portfolio at Delft University of Technology's faculty of Industrial Design Engineering.

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