BIOMEDICAL SIGNALS AND SYSTEMS (BSS)

overview of research projects for student assignments

November 2020

Project: Smart Sports Exercises

Teachers: Bert-Jan van Beijnum & Fahim Salim

Student assignments: BSc and MSc project assignments

Educational programme: BMT, TG, EE, CS, ATLAS

Topics: Data gathering and processing of volleyball exercises and training; modelling and machine learning of volleyball skills and tactics.

Project Summary:
The proposed project focuses on new forms of (volleyball) sports training. Athletes perform training exercises in a "smart sports hall" that provides high quality video display across the surface of the playing field and has unobtrusive pressure sensors embedded in the floor. A digital-physical training system offers tailored, interactive exercise activities. Exercises incorporate visual feedback from the trainer as well as feedback given by the system. They can be tailored through a combination of selection of the most fitting exercises and setting the right parameters. This allows the exercises to be adapted in real time in response to the team's behaviour and performance, and to be selected and parameterized fitting to their levels of competition and to demands of, e.g., youth sport. To this end, expertise from the domains of embodied gaming and instruction and pedagogy in sports training are combined. Computational models are developed for the automatic management of personalization and adaptation; initial validation of such models is done by repeatedly evaluating versions of the system with volleyball teams of various levels. We collect, and automatically analyse, data from the sensors to build continuous models of the behaviour of individual athletes as well as the team. Based on this data, the trainer or system can instantly decide to change the ongoing exercises, or provide visual feedback to the team via the floor display. In extrapolation, we foresee future development towards higher competition performance for teams, by building upon the basic principles and systems developed in this project.

Email contact: b.j.f.vanbeijnum@utwente.nl & f.a.salim@utwente.nl

Project: Early detection of postoperative complications using continuous vital sign monitoring

Teachers: Mathilde Hermans & Hermie Hermens

Student assignments: MSc project assignments

Educational programme: BMT, TG

Topics: Vital sign monitoring, decision support, signal analysis & trend detection, telemedicine, postoperative hospital care

Project Summary:
Patients admitted to the hospital ward for recovery after surgery are at risk for developing vital instability caused by complications. To identify vital instability, the status of patients is currently monitored using routine nurse observations and intermittent measurements of vital sign such as heart rate and respiration. However, in current practice the first signs of vital instability may remain unnoticed for hours while early intervention is critical to prevent further damage. To promote patient safety, there is a growing interest in wireless sensors to monitor vital signs continuously. In this project, it is investigated what are suitable approaches to measure vital signs continuously in ward patients and identify abnormal trends. For this aim, vital signs of patients in the ZGT and UMCU hospital are continuously tracked during ward stay using mobile sensors to explore sensing methods suitable for measuring relevant parameters. Next, decision support methods are explored to verify how care professionals can be assisted in the interpretation of the large amounts of data. Furthermore, it is investigated whether integration of context data such as activity level or the subjective nurse observations can help to ensure that only clinically relevant events are notified.

Email contact: h.j.hermens@utwente.nl & m.c.hermans@utwente.nl

Project: AMBITION – Minimal sensing and feedback after stroke

Teachers: Mohamed Irfan Mohamed Refai, Bert-Jan van Beijnum, Jaap H. Buurke, and Peter H. Veltink

Student assignments: BSc and MSc project assignments

Educational programme: BMT, EE, CS

Topics: Minimal sensing of quality of movement using inertial (or other) sensors; Studying ideal feedback modalities to improve movement quality.

Project Summary:
A major goal in the rehabilitation of patients with stroke is to achieve optimal motor performance enabling patients to live independently. Understanding phenomena such as neurological repair, and learned compensation and/or non-use is a pre-requisite for the development of patient-tailored interventions. This helps in targeting neurological repair through biofeedback, allowing patients to learn to adapt to existing deficits and learned compensatory strategies. Sensing and action paradigms need to be individualized and based on a limited set of clinically essential metrics. A crucial aspect of biofeedback in the current proposal is the consistent, detailed and individually tailored feedback to the user to induce optimization of motor performance in the context of home-based rehabilitation and self-management.

The goal of the project is to develop minimal sensing modalities (using Inertial Measurement Units) that assess quality of movement. This can be used to enable targeted feedback that helps neurological repair and improves compensatory patterns during movement in daily life.

Students are expected to have basic or preliminary knowledge of inertial measurement units, sensor fusion filtering, and human motion.

Available project titles (not restricted to the following):
1. Minimal sensing of gait using a three IMU setup in subjects with neurological disorder
2. Quality of upper limb movement with minimal sensor setup
3. Arm use with contextual movement
4. Feedback during reaching

Email contact: m.i.mohamedrefai@utwente.nl

Project: Dietary coaching in COUNCIL OF COACHES

Teacher: Janet van den Boer

Student assignments: BSc and MSc project assignments

Educational programme: Health Sciences, BME, TG

The COUNCIL OF COACHES is an EU-funded project that is developing a platform with several embodied conversational lifestyle and health behavior coaches to support older adults to live in greater health and maintain or improve their well-being (see: http://council-of-coaches.eu/). One of the coaches will focus on nutrition. This coach will help the user (i.e. an older adult with diabetes type 2) to gain insight into their diet and will support the user in improving their diet. Would you like to be involved in designing the content of the dietary coaching? Please contact Janet van den Boer (j.h.w.vandenboer@utwente.nl)

Email contact: j.h.w.vandenboer@utwente.nl

Project: EU project Softpro

Teachers: Gerjan Wolterink, Bert-Jan van Beijnum, Peter Veltink,

Student assignments: MSc project assignments

Educational programme: BME, EE, TG

Topics: stroke, inertial sensing of human movements, forces and muscle activation, signal analysis, experiments

Project Summary:
Stroke subjects often have a limited capability of controlling their muscles on the left or right side of the body due to a bleeding or an infarct in part of the brain. They appear that other, non-affected, other neural circuits in the central nervous system take over motor control of the affected brain area. However, control is often not as versatile and part of the muscles cannot be activate independently any more, but show pathological synergies.

It is clinically important to assess the motor control capability of stroke subjects and assess whether it improves or deteriorates over time, depending on training and use. In neurorehabilitation, clinical tests are performed like the Fugl-Meyer test that are subjectively judged by clinicians. However, they prefer an objective measurement that can be performed during such a test, but also has the potential for objective assessment during daily-life.

In the framework of the EU project SoftPro we have developed a sensing system for assessing motor control function of an effected upper extremity (see figure). The sensing system allows measurement of muscle activation (EMG) of key muscles, hand and arm movements using inertial sensing and interaction forces with the environment via the hands.

In this MSc assignment, the student will develop measures for quality of arm and hand movements and pathological synergies during functional movements, and will estimate these measures based on the sensed EMG, movement and forces signals. For this purpose, the student will develop signal processing tools and will evaluate the sensing system, signal processing and measures in experiments performed on stroke subjects in collaboration with clinical researchers of the Neurology department of the University of Zurich Medical Center. For this purpose and in the framework of the EU project SoftPro, we have close collaboration with clinicians and clinical researchers in Zurich. The assignment may involve visits to Zurich for performing experiments.

Email contact: p.h.veltink@utwente.nl

Project: E-manager Chronic Diseases

Teachers: Miriam Vollenbroek, Wendy d'Hollosy en Laura Schrijver

Student assignments: BSc and MSc project assignments

Educational programme: TG, CS, HMI/Create, BME

Topics: technology supported coaching, experimental designs, mHealth, machine learning, human computer interfaces

Project Summary:
Over 5.3 million people in the Netherlands have a chronic disease. Chronic diseases have a high impact on the quality of life but also on healthcare costs. Innovative technologies that focus on self-management of chronic diseases are needed more than ever before. For this reason, this project focuses on the development, implementation and evaluation of the E-manager Chronic Diseases. This e-manager integrates various existing e-coaching apps for patients with COPD, asthma and diabetes mellitus type 2 (DM2) and helps patients and healthcare professionals during consultations easily to measure and visualize the burden of disease, and to set personalized goals that fully fit the patients' needs. In addition, it motivates and helps patients in everyday life to pursue these goals by providing tailored e-coaching that ties in with the patients' behavioural state, character and abilities.

Email contact: w.dhollosy@utwente.nl

Project: Pride&Prejudice – technology to support healthy eating

Teachers: Roelof de Vries (BSS), Juliet Haarman (HMI)

Student assignments: BSc and MSc project assignments

Educational programme: BMT, TG, HMI, CS, ATLAS, EE

Topics: Data gathering and processing of physiological signals; sensor integration; modelling and machine learning of eating events; design of food intake monitoring interventions; design of behavior change interventions; engagement with and compliance to interventions, design of intervention context

Project Summary:
Your eating behavior affects your health. We all know it by now. Not just the type of food you consume, certainly also the quantity of the food, the timing of food intake throughout the day, and the speed with which a meal is eaten are important. The Global Burden of Disease study showed that a suboptimal diet is the second-leading risk factor for disability-adjusted life years and deaths worldwide. This number could drastically decrease when attention is payed to a balanced diet, fitted to the needs of each individual. Many studies have proven that a change in eating behavior can be used as an effective way of gaining control of disease related symptoms, ranging from diabetes, heart and valve disease, to Crohn's disease.

Logically, gaining insight into the current eating behavior of a subject is a first step in accomplishing better health. Professionals still use conventional methods, such as the use of logbooks, for this. They ask the user to manually report on their eating behavior throughout the day. Memory and logging bias are not uncommon factors associated with this method. Often, users simply forget to write down what and when they have been eating. Also, the presence of unknown ingredients in the food, difficulties in estimating portion size or social discomfort while logging the food affect the reliability of this method.

One way to lower the chance for bias, is to use technology that automatically detects events of food intake. Providing the user with a time-based logbook where all the identified eating events are noted as timestamps, might make it easier to recall what they have been eaten during a day. Auditive sensors in the ear, strain gauges on the jaw or RIP sensors that monitor the breathing signal of the subject are examples of technologies that are used to identify swallowing sounds and/or chewing movements – indicating that the user is eating. Many of these technologies are not tested outside of a standardized, laboratory environment yet and therefore their practical validity is often unknown – and should be investigated.

A different approach to lower the logging bias is to use technology that is less tedious in use, compared to the conventional manual logging method. Designing new interventions that engage the user in their reporting task and increase compliance might be a suitable approach for this. Combining different sensors or devices (placed on the body, in a room or in cooking gear) might be one way to do it, and adding a gaming element to the intervention might be another. Other elements to consider adjusting are the context of the communication: who (what is the relationship with the sender) - says what (what is the content of the message) - in which channel (how is this message communicated)- to whom (who is the receiver of the message) – when (what is the timing of the message) – where (what is the location of the receiver) – how (what is the style of the message) - and with what effect (how does the messages come across)?

Lastly, interventions can also be designed to try to influence eating behavior directly: behavior change interventions. Think of interventions that directly inform the user of their unhealthy diet choices (feedback on shopping list), or that indirectly influence the user (smaller portions). To increase engagement and compliance with the interventions, similar approaches can also be taken as explained above, such as adding gaming elements or changing the context of the communication.

A variety of assignments is available within the scope of this broad project. Assignments can be made suitable to your specific backgrounds and interests. Please feel free to contact us to hear about the possibilities.

Email contact: r.a.j.devries@utwente.nl & j.a.m.haarman@utwente.nl

Project: Modeling and analyzing tremor related phenomena of Parkinson's disease

Teachers: Ciska Heida

Student assignments: BSc and MSc project assignments
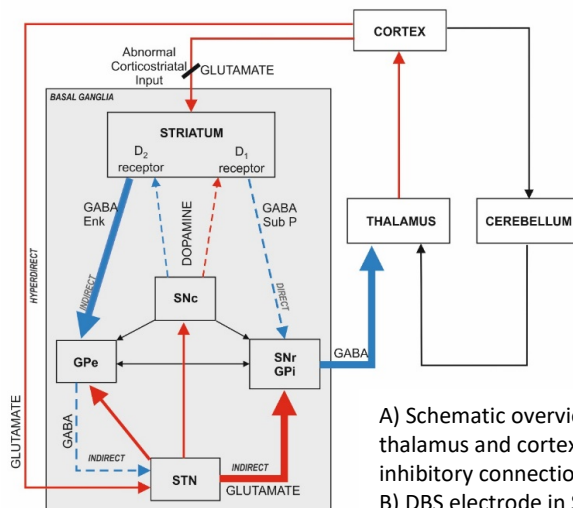
Educational program: BMT/BME, TG/TM, EE

Topics: Modeling and signal analysis

Introduction

Parkinson's disease (PD) is a long-term degenerative disorder of the central nervous system that affects the motor system. The cardinal symptoms are (rest) tremor, rigidity (muscle stiffness), and akinesia/bradykinesia (lack or slowness of movement, resp.). These symptoms result from the loss of cells in the substantia nigra, a region of the midbrain that produces dopamine, an essential neurotransmitter for relaying neuronal information that plan and control voluntary movements.

A number of phenomena occur in Parkinson's disease (PD) that are related to tremor, which have not yet been combined into a single conceptual and/or computational model, but probably all involve basal ganglia and cerebellar circuitry:
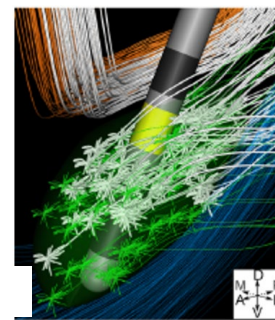
- (Rest) Tremor in PD is hypothesized to involve the basal ganglia as well as the cerebellum with the basal ganglia switching tremor on and off, and the cerebellar circuit modulating tremor amplitude (known as the dimmer-switch hypothesis).
- Rest tremor is reduced/suppressed by voluntary movements.
- Rest tremor disappears during sleep.
- Rest tremor may respond to Levodopa medication, but this is not necessarily the case in all patients. Furthermore, while in a single patient rigidity and slowness of movement may respond well to Levodopa, tremor may not, which may suggest that tremor is not a direct effect of the dopaminergic deficiency.
- Rest tremor responds to deep brain stimulation (DBS) in the STN and Vim.

A)

B)

A) Schematic overview of the connections of the basal ganglia with the thalamus and cortex, and the cerebello-thalamo-cortical circuit. (Blue: inhibitory connections; Red: excitatory connections)
B) DBS electrode in STN: continuous stimulation of the STN reduces tremor.

Assignments

- Development of a computational model of the neuronal networks involved in central motor control and couple a number of the phenomena related to tremor at the neuronal circuit level.
- Analyzing experimental data containing movement registrations performed by PD patients during different (movement) tasks that can be used to validate computational models of the mechanisms and neuronal circuits involved in tremor under different behavioural conditions.

Email contact: t.heida@utwente.nl

Project (RRD/BSS): Virtual Conversational Coaches in Council of Coaches

(http://council-of-coaches.eu/ ; Twitter: @Council_Coaches)

Teachers: Harm op den Akker

Student assignments: BSc and MSc project assignments

Educational programme: BMT, TG, HMI, ATLAS

Topics: virtual coaching; embedded conversational agents; lifestyle changes

Project Summary:
In Council of Coaches, multiple virtual coaches form a personal council that supports the user in their health and well-being. Individual coaches have their own area of expertise, personality and style of coaching. Join a council meeting and learn how you can take control of your own health! Are you interested? Watch this movie explaining more about the concept:
https://www.youtube.com/watch?v=PBAJe6K_gZw

Email contact: h.opdenakker@rrd.nl

Student assignment

Within the Council of Coaches project, we already have a student assignment. Within this study, you will evaluate Council of Coaches. You will assess the user experience, actual use and potential health effect of a fully working Council of Coaches system implemented in a real-life setting among the target population (older adults, and adults with Diabetes Type 2 or chronic pain). This will be an observational cohort study with a pre-test/post-test design, consisting of two rounds. Both rounds will be followed for 6-10 weeks. The first round will start in February 2020, the second round in May 2020. This assignment has a total duration of approximately 8 months, starting from January/February 2020. Speaking Dutch is required.

Email contact about this specific assignment: m.hurmuz@rrd.nl

Project (RRD/BSS): Smart age-friendly living and working environments

Teachers: Miriam Cabrita

Student assignments: BSc and MSc project assignments

Educational programme: BMT, TG, EE, CS, ATLAS, HMI

Topics: physical activity; stress; performance; unobtrusive & pervasive sensing; personalized interventions; eHealth

Project 1: Creating a Physical Activity user profile for personalized coaching of physical activity

Changing behaviour is difficult, and what works for one person does not necessarily works for other. Research has shown that people are more likely to engage in behaviour change when their preferences, context and ambitions are taken in account. Within this project, you will design and implement a model to provide personalized recommendation of activities based on a set of questions answered by the user.

Project 2: Identifying the stress-performance individual curve in the workplace

Stress on the work-floor is often associated with the negative component of stress (distress). The negative consequences of stress on physical and mental health have been extensively investigated. However, the role of eustress (the "positive" stress) in the work environment has been overlooked by the scientific community. The Yerkes-Dodson Law suggests that an increase in stress is beneficial to performance, until an optimal level (tipping point), after which this relation is inverted, following an inverted U shape. Although this inverted u-shape is generalized to all individuals, it is hypothesized that the height and slope of the curve is highly personal. Skill level, personality, trait anxiety and task complexity are factors known to contribute to the height and slope of the curve. Furthermore, physical and mental health are expected to influence the shape of the curve.

The **objective** of this assignment is to propose a method to define the inverted-U shape that represents the relation between stress and performance of the individuals, based on physiological measurements. The results of this assignment in the identification of the individual stress-performance U-shape, will be used in the design of interventions on the work-floor, by alerting the individual to take measures when getting close to the tipping point.
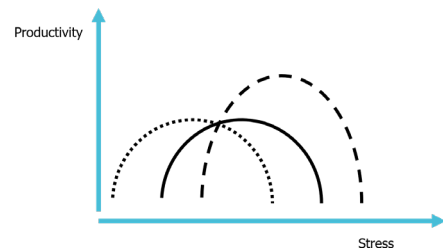
Context: The two projects above mentioned are thought of in the context of the European project SmartWork (http://smartworkproject.eu/), which focuses on the design and realization of age-friendly living and working environments. SmartWork builds a worker-centric AI system to support the older adults keeping at work for as long as possible using novel services for context and worker-aware adaptive work support. Through unobtrusive and pervasive monitoring of health, behaviour, cognitive and emotional status of the worker it is possible to detect early decline of physical and/or cognitive function. The holistic approach for work ability modelling captures the attitudes and abilities of the ageing worker and enables decision support for personalized interventions for maintenance/improvement of the work ability.

Email contact: m.cabrita@utwente.nl

Projecten (ZGT/BSS): DIAMETER (Diabetes)

Educational programme: BMT, TG, HMI, ATLAS

Achtergrond en probleem
Diabetes Mellitus Type 2 (T2DM) is een chronische ziekte waarbij het risico op complicaties is verhoogd door ontregelde glucosewaarden. Deze patiënten hebben hulp nodig om meer grip te krijgen op de diabetes. Een belangrijke factor dat winst kan opleveren bij T2DM is een gezondere leefstijl, echter ontbreekt de tijd in de gezondheidszorg om patiënten hier optimaal in te kunnen begeleiden. Uit vooronderzoek is gebleken dat patiënten niet voldoen aan de norm gezonde voeding en gezond bewegen en de kennis over de voordelen van een gezonde leefstijl ontbreekt. Daarom is het ZGT in samenwerking met de Universiteit Twente bezig om een gepersonaliseerde diabetes coach, in de vorm van een mobiele app, te ontwikkelen die de diabetespatiënt helpt de glucosewaarde op peil te houden. De coach, de Diameter, maakt gebruik van continue monitoring van glucosewaarden, lichaamsbeweging, hartslag, voeding en medicatie op basis waarvan een individueel voorspellend model voor glucoseregulatie wordt ontwikkeld. Dit model dient o.a. als input voor de coaching module die gebaseerd op theorieën van gedragsverandering en motivatietheorieën de patiënt ondersteunt in het maken en volhouden van verantwoorde keuzes. De verwachting is dat patiënten hiervan voordelen zullen merken op de korte termijn (groter gevoel van welbevinden) en lange termijn (verminderde kans op complicaties).

Doel
Het doel van het onderzoek is het ontwikkelen van de mobiele applicatie die diabetes patiënten kan ondersteunen. De ontwikkeling van de app bestaat uit meerdere subonderdelen. De verschillende app versies moeten bijvoorbeeld getest worden op usability, de coachingsmodule moet (verder) ontwikkeld worden en verschillende onderdelen van de app, zoals ziektebeleving en mogelijkheid tot een community, moeten nog vormgegeven worden.

Niveau: Bachelor/master

Begeleiders
Externe supervisor: Dr. G. Laverman
Afdeling: nefrologie, ZGT Almelo
E-mail: g.laverman@zgt.nl

Eerste supervisor UT: Prof. dr. M. Vollenbroek
Department: BSS
E-mail: m.m.r.hutten@utwente.nl
Tweede supervisor UT: N. den Braber
Department:BSS
E-mail: n.braber@utwente.nl

Project (BSS/ZGT): "Up and Go" na een heupfractuur

Educational programme: BMT, TG, HS.

In Nederland worden jaarlijks 19.000 ouderen opgenomen in het ziekenhuis vanwege een heupfractuur, waarvan 350 in ZiekenhuisGroep Twente (ZGT). Bij een groot deel van deze kwetsbare patiëntengroep is er na de heupfractuur kans op onherstelbaar functieverlies, met als gevolg dat zij bijvoorbeeld niet meer thuis kunnen wonen en/of blijvend afhankelijk zijn van anderen.
In 2008 werd in ZGT het Centrum voor Geriatrische Traumatologie (CvGT) opgericht door de traumachirurgen om de zorg aan deze kwetsbare patiëntengroep te optimaliseren en hierdoor het herstel van de patiënt te verbeteren. Één van de initiatieven binnen dit centrum is het "Up and Go" project, waarbij het ZGT en de omliggende verpleeghuizen een gezamenlijk transmuraal zorgpad hebben ontworpen met als doel snelle revalidatie en functioneel herstel te bevorderen. Daarnaast worden er technologische toepassingen ingezet om het herstel na een heupfractuur te kunnen monitoren.

Binnen dit project is er behoefte aan studenten voor
a) *Het implementeren en evalueren van een transmuraal zorgpad in samenwerking met de omliggende zorginstellingen (TriviumMeulenbeltZorg, ZorgAccent, Carintreggeland)*
b) *Het objectiveren van herstel na een operatie d.m.v. bewegingsensoren*
c) *Het ontwerpen van een technologische toepassing om patiënten te stimuleren om te bewegen*

Methodes
- Literatuurstudie
- Opzetten onderzoeksprotocol en METC aanvraag
- Uitvoeren van metingen met patiënten
- Kwantitatieve data-analyse

Niveau
- Bachelor / master

Contact persoon: Prof. Dr. M. Vollenbroek

Projecten (BSS/ZGT): Oncologie

Educational programme: BMT, TG, HS.

a) Optimizing health outcome in (neo)adjuvant treatment for breast cancer patients.

Background information:
In the Netherlands 1 out 7 women will develop breast cancer, in 2017 17.423 new cases were diagnosed. A substantial part of these women are treated with (neo) adjuvant systemic therapy, hormonal- and/or chemotherapy. In case of (neo)adjuvant chemotherapy this is accompanied by significant loss in physical condition and by a substantial weight gain. In part these women experience chronic fatigue afterwards, loss of concentration and difficulty in regaining normal activity at work and at home. Our understanding is that if preventive measures are taken the loss in physical condition and weight gain can be (partially) prevented.
Previous exercise and nutritional habits combined with lifestyle are important factors in maintaining, as good as possible, weight and physical fitness. The majority of women with breast cancer have some overweight and they do not engage in enough physical activity.
Tailoring for which patient and at what moment intervention is needed is difficult at this moment by lack of tools and practical guidelines. Recently a personalized and technology supported coaching system to support the patient' selfmanagement is developed for diabetes patients. A comparable system can be used for oncology patients treated with chemotherapy.

Supervisors: Dr. Laverman, Dr. Oving, Prof. dr. M. Vollenbroek

b) Impact of (Neo)Adjuvant Chemotherapy on Long-Term Performance and Employment of Early-Stage Breast Cancer Survivors in our region.

Background information: Many women with early-stage breast cancer are working at the time of diagnosis and survive without recurrence. The short-term impact of chemotherapy on employment (<1 year) has been demonstrated, but the long-term impact merits further research. Even less is known about long-term impact of cancer treatments on social functioning, physical activity or sports, managing family live and maintaining relationships. Recently a database was made of all our breast cancer patients. This database can be used for further research.

Supervisors: Dr. Irma Oving, Dr. Ester.Siemerink, Prof. dr. M. Vollenbroek

Projecten (ZGT/BSS): Vitaal bedreigde patiënt

Educational programme: BMT, TG, HS.

a) The vitally threatened patient

Background information:
The Modified Early Warning System (MEWS) objectively measures the vital functions of a patient to which a specific numerical score is assigned to the obtained values. The higher the score, the worse the vital functions and the faster the need to act. The MEWS is also used within the ZGT to monitor the patients vital functions during and after a high-risk procedure to be able to faster recognize and treat deterioration and complications.

Level: Bachelor/Masters
Supervisors: Mathilde Hermans (UT, PhD student), Marloes Vermeer (ZGT, epidemiologist)

b) Vroegtijdige herkenning van klinische achteruitgang na slokdarm chirurgie

Met toenemende zorgvraag en zorgkosten, verblijven patiënten steeds minder lang in het ziekenhuis. Hoog-risico patiënten worden hierbij sneller overgeplaatst naar van intensive care units naar verpleegafdelingen of van verpleegafdelingen sneller ontslagen naar huis, waardoor het de kans op complicaties hier toeneemt. Dit geldt voor hoog complexe, hoog risico slokdarmchirurgie, waar 60-70% van de patiënten een complicatie ontwikkelt, en waarbij steeds vaker een fast-track beleid wordt gehanteerd ter bevordering van zorgefficiëntie.
Om de veiligheid van deze hoog-risico patiënten te bewaken, is het essentieel om tekenen van achteruitgang vroeg te herkennen zodat onnodige schade kan worden voorkomen. Daarnaast is het van belang om een patiënt te ontslaan op het moment dat hij/zij voldoende hersteld is en de kans op late, ernstige complicaties klein is.
Om klinische achteruitgang in kaart te brengen wordt op verpleegafdelingen momenteel gebruik gemaakt van Modified Early Warning Score (MEWS), waarbij verschillende vitale parameters routinematig verpleegkundige dienst worden gemeten. Een afwijkende MEWS score indiceert een vitaal bedreigde patiënt, en geeft aanleiding tot direct onderzoek naar de onderliggende oorzaak zodat passende behandeling vroegtijdig kan worden uitgevoerd.
In de praktijk blijkt echter dat het MEWS systeem niet volledig toereikend is in het vroegtijdig identificeren van vitale instabiliteit. Factoren die hierbij een rol spelen zijn de grote tijdsintervallen tussen metingen, en vaak onvolledig uitvoering hiervan. Als gevolg hiervan kunnen patiënten ongemerkt verslechteren.
Om onnodige achteruitgang te voorkomen, beogen het ZGT en de Universiteit Twente een technologie ondersteunde monitoring- en alarm strategie te ontwikkelen om vitale instabiliteit vroegtijdig te herkennen.

Level: Master / bachelor
Supervisors: Mathilde Hermans (UT, docent-onderzoeker), Ewout Kouwenhoven (ZGT, chirurg-oncoloog), Miriam Vollenbroek-Hutten (ZGT, hoofd wetenschapsbureau)

Project (BSS/RRD): Pediatric asthma monitoring

Teachers: Monique Tabak, Mattienne van der Kamp

Student assignments: BSc and MSc project assignments

Educational programme: BMT, TG, EE, TCS, CT, CS, ATLAS

Topic: <u>eHealth in the pediatric asthma care: From smart monitoring to implementing a new care standard for personalized health.</u>

Project Summary:
This project focuses on innovative, personalized eHealth for pediatric asthma patients. Currently, pediatric asthma care heavily relies on information acquired during scheduled visits when children usually are asymptomatic. Relevant (symptomatic) information can therefore be missed due to for example recall bias, hampering the treatment of the child. Smart monitoring (e.g. sensing, ESM, video) allows regular monitoring of asthma control at home and helps to identify worsening of asthma control (e.g. prediction modelling, decision-support). This enables the pediatrician to anticipate timely for personalized treatment and self-management of the child and parents, potentially resulting in less symptoms and a better quality of life.

The challenges of this project lie in;
- finding the right combination of monitoring tools and devices for the right physiological parameters (i.e. spirometry, smart inhalers, activity, EMG, etc),
- developing a child friendly and attractive monitoring platform,
- creating evidence-based clinical decision support algorithms,
- increasing self-management of asthmatic children and parents (with i.e. automated feedback),
- and implementing eHealth in the current clinical practice in a clear and efficient way.

During the course of this project, we as Medisch Spectrum Twente, University of Twente and Roessingh Research and Development devoted ourselves to many of the above mentioned challenges and are working hard to progress towards extending, personalizing and validating eHealth strategies in pediatric asthma care. So that it benefits both the caregivers and the care providers.

Projecten (BSS/RRD): Designing Virtual Coaches for eHealth

Contact person: S. ter Stal (Roessingh Research and Development)

Student assignments: BSc and MSc project assignments

Educational programme: BMT, CS, ATLAS, HMI, IDE, CreaTe

Topics: Aspects related to the design of virtual coaches for eHealth applications, such as the appearance of the coaches, their personalities and the interaction with the coaches.

Project Summary:
Roessingh Research and Development is currently involved in multiple projects that focus on the development of virtual coaches, such as the Council of Coaches project. Virtual coaches are explored as part of eHealth applications used for monitoring and coaching people in daily life. These eHealth applications can support users with multiple aspects of healthy living, such as being physically active, having good nutrition, but also with cognitive tasks and social activities. However, these eHealth applications often face low actual use. Therefore, the use of virtual coaches is gaining interest. Virtual coaches can build relationships with the users and increase user engagement. However, little is known on how these virtual coaches should be designed in the eHealth domain: How should these coaches look like? What personalities do they have, or how can we effectively interact with them? Yet, no guidelines exist. We perform research investigating these aspects to establish user engagement and, eventually, increase the actual use of the underlying eHealth applications.

Projecten (BSS/RRD): Analysis of (marathon) running using a minimal set of inertial sensors

Contact person: Marit Zandbergen (PhD student Roessingh Research and Development (RRD) and BSS), Jasper Reenalda (RRD), Jaap Buurke (RRD/BSS), Peter Veltink (BSS)

Student assignments: BSc and MSc project assignments

Educational programme: EE

Topics: Analysis of (marathon) running using a minimal set of inertial sensors

Project Summary:

Long distance running involves high risks of injuries. It is, therefore, important to identify and detect such risks and inform the individual runner during running.

With this objective in mind, we develop sensing and analysis methods to assess essential metrics that relate to specific risks of injuries. For this purpose, we decided to use a minimal set of three 3D inertial sensors (IMU's: Inertial Measurement Units: accelerometers/angular velocity sensors) on sacrum and both lower legs.

During the Enschede marathon of April 2019, nine marathon runners have participated using a more extensive IMU sensor set. We have developed ideas for the analysis of running using the small 3 IMU set. This analysis is based on knowledge about the meaning of the quantities measured using the IMU's. It will result in multiple parameters which might be related to the risk of running injuries. The analysis uses the approximate cyclical character of running.

A B-project for an interested student is available to carry out this analysis and validate the results.

Email contacts:

p.h.veltink@utwente.nl

m.zandbergen@rrd.nl
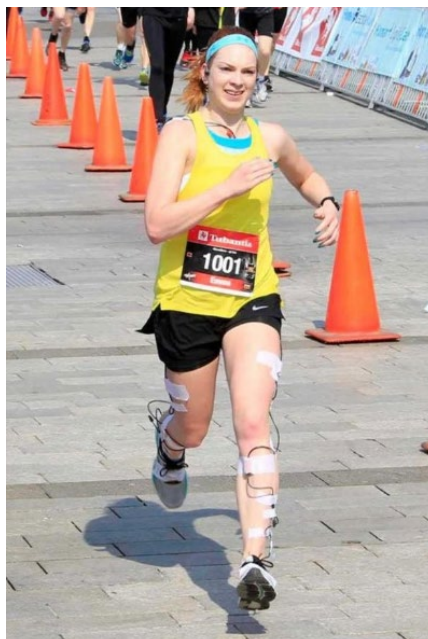
MSc Assignment (BSS): Functional electro-tactile stimulation to augment the postural control: development of rehabilitation technology fall

Contact person: Utku Yavuz

Student assignments: MSc project assignment

Educational programme: BME, TM, EE, Create

Project Summary:

The dramatic increase in average life expectancy during the 20th century is one of society's greatest achievements. In many countries, the oldest age (people aged 85 or older) are now the fastest growing proportion of the total population (the 85-and-over population is projected to increase 351% between 2010 and 2050). As people grow older they are increasingly at risk of falling with resultant injuries. One out of three persons older than 65 and 50% of those older than 80, fall at least once per year (Todd & Skelton, World Health Organization, 2004) based on various reasons. In some cases, fall may be indication of a chronic neurological disorders affecting postural stability and gait (such as Parkinson disease). Therefore, understanding neural mechanism underlying the postural control has utmost importance to develop accurate intervention.

It is well established that the sensory information conveyed from muscle and joint proprioceptors play an important role in the control of posture and gait in humans. In a recent study, we showed that cutaneous mechanoreceptive inflow from the neck is also integrated into the control of posture. More importantly, we showed that the electro-tactile stimulation of cutaneous afferents at neck region, with a subtle (140% of perception threshold) stimulation current intensity, led to a drift towards forward (leaning forward) in the center of pressure (Nunzio et.al., Experimental Brain Research 2018). Within the proposed study, we aim to investigate the integration of cutaneous receptors located at the foot sole and determining the pattern and strength of stimulation current that leads an efficient effect on body-orientation (posture). The findings are relevant for the exploitation of electro-tactile stimulation for rehabilitation interventions where induced body-orientation is desired.

Assingment:

In this study you will use biomedical equipment to record the electrical activity produced by muscles contraction (electromyography - EMG) and to acquire the oscillations of the human body through force platforms during quite upright stance condition. You will then administer a series of electro-tactile stimulation and analyze the postural effects induced by such stimuli.

The acquired data will be analyzed with standardized and validated algorithms to study the physiological basis of these postural effects. This will lead to the development of new rehabilitation protocols and devices to enhance postural control in elderly population and neurological patients. You will learn:

- neurophysiology of postural control
- recording muscle electrical signals and the movement of center of foot pressure using professional biomedical equipment
- developing acquisition systems with stimulation units
- statistically analyze the acquired data

Contact:

The student will work at the laboratory of the Department of Biomedical Systems and Signals, faculty of EEMCS, University of Twente, under the supervision of S. U. Yavuz, PhD. email: s.u.yavuz@utwente.nl , tel:+31534898158

Validatie van biosensoren in gezonde vrijwilligers

Research Question: Wat is de accuraatheid en betrouwbaarheid van de Everion biosensor en de Fitbit Charge 3 in gezonde vrijwilligers?
Department: Chirurgie Universitair Medisch Centrum Groningen
Language: Dutch/English
Educational programme: BME
Description project content and methods:

Bij de chirurgie loopt een groot project waarbij telemonitoring toepassingen worden gevalideerd en geïmplementeerd voor patiënten die grote operaties ondergaan. Het gebruik van telemonitoring, als onderdeel van eHealth, komt tegemoet aan de tendens naar personalized medicine en is geassocieerd met betere klinische uitkomsten en kosteneffectiviteit van zorg in verschillende takken van de gezondheidszorg, met name in chronische ziekten. Het inzichtelijk maken van het welzijn van een patiënt zorgt ervoor dat eerder of beter omgegaan kan worden met veranderingen in gezondheid. De verwachting is dat telemonitoring ook in de perioperatieve periode, van toegevoegde waarde kan zijn. Telemonitoring zou kunnen bijdragen aan de optimalisatie en individualisatie van het perioperatieve (herstel)proces en daarbij te vroeg ontslag, onnodig lange ziekenhuisopnames of ongeplande heropnames kunnen reduceren.

Op dit moment zijn draadloze biosensoren beschikbaar om fysieke parameters te monitoren. De Everion biosensor van Biovotion (Biovotion AG, Zürich, Switzerland) is een CE-gecertificeerde sensor die op de bovenarm wordt gedragen (zie afbeelding) en vitale parameters en activiteit meet met een frequentie van 1Hz, waaronder: hartslag, hartslag variabiliteit, oxygenatie, huid temperatuur, ademhalingsfrequentie, aantal stappen en type activiteit. Hartritme is al een gevalideerde parameter. Bekend is dat de hoeveelheid postoperatieve dagelijkse stappen en fysieke activiteit van een patiënt tijdens ziekenhuisopname geassocieerd is respectievelijk het risico op heropname binnen 30 dagen na de operatie en de lengte van de ziekenhuisopname. Om deze informatie te implementeren in de perioperatieve zorg van hoog-risicopatiënten, moeten in kaart worden gebracht wat de betrouwbaarheid van verschillende sensoren is wat betreft het meten van vitale parameters, het aantal stappen en activiteit (en de gevoeligheid van vitale parameters voor activiteit). Daarom gaan we een validatiestudie doen bij gezonde vrijwilligers.

De studenten zullen telemonitoring devices valideren door het uitwerken van strategieën om looppatronen te simuleren, mee ontwikkelen van protocol en meetopstelling en uitvoeren van tests bij gezonde vrijwilligers. In dit project hebben studenten de mogelijkheid om zelf metingen uit te voeren en kennis te maken met de faciliteiten van het eHealth house (Techmed Centre, Universiteit Twente) en de nieuwste ontwikkelingen op het gebied van telemonitoring.

Supervisors:

dr.ir. M. Tabak, associate professor vakgroep Biomedische Signalen en Systemen, UTwente
dr. R.C.L. Schuurmann, post-doc multi-modality medical imaging group, UTwente
prof. dr. J.P.P.M. de Vries, vaatchirurg UMCG
M.E. Haveman, MSc, promovendus UMCG
Contact e-mail: m.e.haveman@umcg.nl

Project (BSS/RRD): Beyond step counting: applying novel data analysis techniques to longitudinal physical activity data

Contact person: Miriam Cabrita (Roessingh Research and Development)
Student assignment: BSc and MSc project assignment
Educational programme: Student in Biomedical Engineering (or similar) with strong interest in data analysis / signal processing

RRD is a pioneer in the field of coaching of physical activity in the prevention and management of chronic diseases. In the last 10 years we have performed more than 50 studies in which physical activity data was measured objectively with wearable sensors for periods ranging between 1 and 12 weeks. The target group varied from pediatric rehabilitation (e.g. children with cerebral palsy or asthma), to physical rehabilitation (e.g. COPD and chronic pain) or promotion of Active Ageing among older adults.

Most studies looking at physical activity patterns often compare two points in time, for example, the first and the last week of an intervention. Everything that happens in the between is unknown. In other words, we know the physical activity of the patient at the subject and at the end points, but we do not know what happened in the between. Did the patient have a fast recovery and reached a plateau soon after surgery? Were there periods of relapse? A second problem with this approach is that it does not allow for a look at the trajectory of each individual patient.

Conventional methods for physical activity analysis look at metrics of physical activity, such as total counts/steps at the end of day, or number of minutes in each activity intensity category. A new line of research, so called *compositional analysis of physical activity*, is now looking at physical activity as part of a pattern over 24-hour period, including: sleep time, sedentary time and light, moderate- or vigorous-intensity physical activity. The idea is that the relative amount of time spend in each category is compared, and not the absolute values.

Complexity analysis is another method gaining interest in the recent years. In complexity analysis, the changes of stages are investigated. In a practical example, one can look at how often the subject changes from sitting to standing position, or from sedentary to light active intensity.

Objective
The challenge within this assignment is to investigate how each one of the data analysis methods contribute to a better understanding of individual patterns of daily physical activity: (1) conventional analysis; (2) compositional analysis of 24-hours physical activity data; (3) complexity analysis.

Practicalities
- The dataset to be used in this assignment is already available (>50 participants over a period of 5-9 weeks). The student is not expected to perform data collection;
- The student will be integrated in a multidisciplinary team;
- It is the intention to work towards a scientific article to be published at the end of the research.

Contact
- If you are interested in the assignment or have any questions please contact Miriam Cabrita (m.cabrita@rrd.nl).

Supervised learning framework for real-time HD-EMG decomposition

Student assignment: BSS master assignment (28-32 weeks, 40-45 ECs)
Contact person: Dr. Utku S. Yavuz, Biomedical Signals and Systems research group,
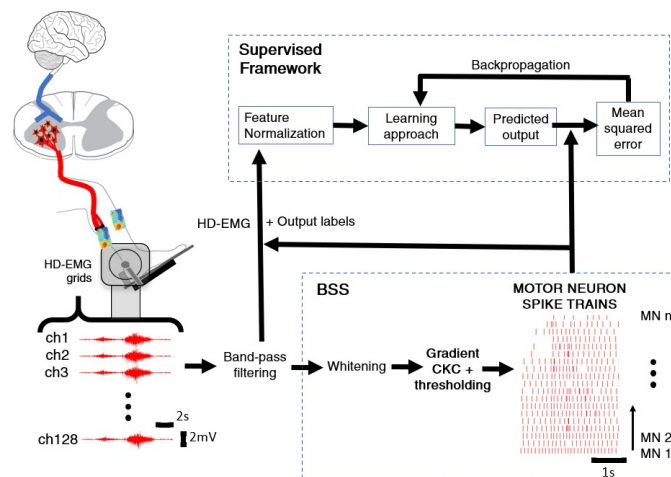s.u.yavuz@utwente.nl

Background: High-density surface EMG (HD-EMG) is a non-invasive technique to measure neural activity from multi-channel grids on the muscle. Blind source separation (BSS) techniques, such as Convolution Kernel Compensation (CKC), exploit the high resolution capability of HD-EMG to open a window into constituent motor neuron spike trains. However, although these techniques offer an accurate decomposition, they are often suboptimal in dynamic or noisy conditions, and most of them only work offline. For this assignment, we aim at developing a supervised learning framework to decompose HD-EMG signals, based on the output of CKC decomposition.

Goal: To develop a supervised decomposition technique to extract motor neuron spike trains from HD-EMG recordings.

Keywords: HD-EMG, motor unit, decomposition, BSS, deep learning, machine learning

Main Activities:
- Literature study on state-of-the-art techniques for HD-EMG decomposition.
- Developing a supervised decomposition framework using HD-EMG data and decomposed spike trains recorded from isometric plantar- and dorsi-flexion trials.
- Statistical analysis to compare several quality and efficiency metrics (accuracy,

computational time, rates of agreement, …) between the proposed supervised framework against CKC decomposition.

References:

K. Clarke *et al.*, "Deep Learning for Robust Decomposition of High-Density Surface EMG Signals," in *IEEE Transactions on Biomedical Engineering*, doi: 10.1109/TBME.2020.3006508.

C. Chen, Y. Yu, X. Sheng and X. Zhu, "Analysis of motor unit activities during multiple motor tasks by real-time EMG decomposition: perspective for myoelectric control," *2020 42nd Annual International Conference of the IEEE Engineering in Medicine & Biology Society (EMBC)*, Montreal, QC, Canada, 2020, pp. 4791-4794, doi: 10.1109/EMBC44109.2020.9176362