@LIU 2022

PROGRAM, INFORMATION AND ABSTRACTS

LINKÖPING UNIVERSITY

INDEX

A GUIDE TO BME@LiU 2022

In this compendium you will find the program for BME@LiU 2022 – a conference that focuses on Biomedical Engineering at Linköping University. You will also find the information you need to navigate this year's conference. Welcome!

WHEN

The conference starts April 28, at 8 am and will continue until 6 pm. However there is also a dinner for those who have signed up for it. For more information, go to the webpage (link here).

WHERE

This year's conference is a hybrid with both on Campus activity and online streams for those who can't participate on site. You will find information on lecture halls and zoom links in the schedule further down in this compendium.

HOW DO I GET TO CAMPUS US?

If you travel by train you can take the local bus 2, 4, 16, 17 or 18. If you travel by car, choose " LiU Campus Universitetssjukhuset" in your GPS. There are outdoor and indoor parking lots for visitors. For more details, see map on the next page.

SCHEDULE

You find the schedule further down in this document. You will also find abstracts, more detailed information on every talk, and posters.

LUNCH AND SNACKS

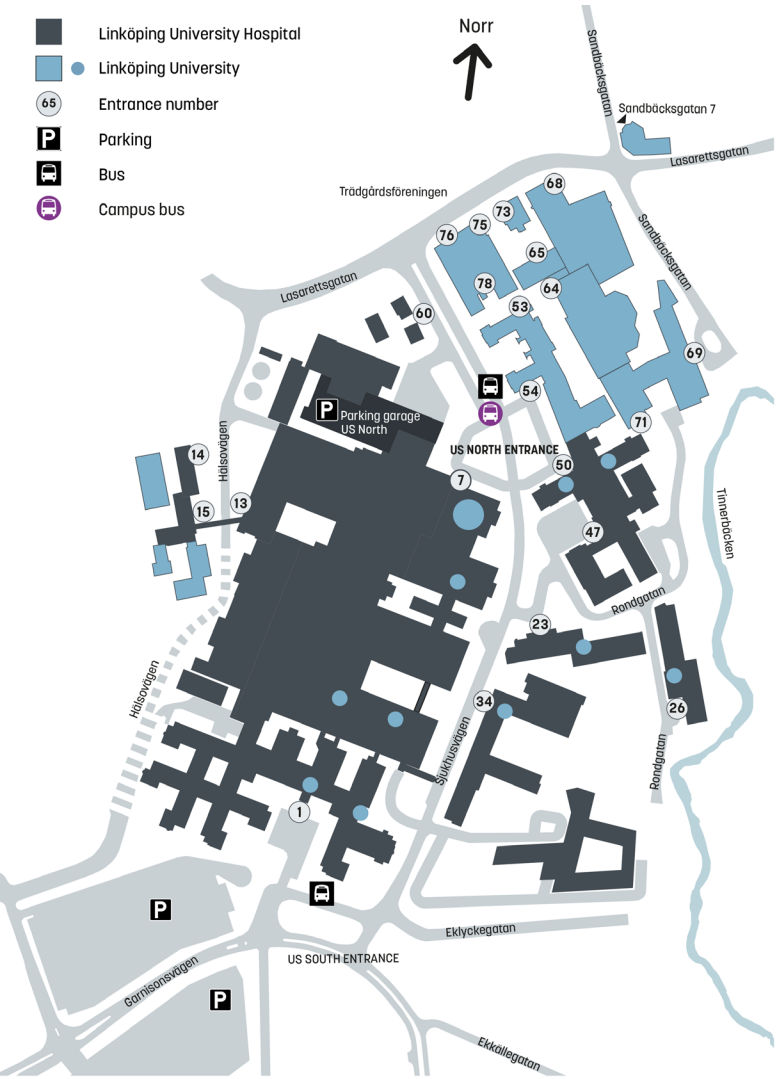
All that have registered will get a lighter lunch consisting of a sandwich. We will provide gluten free and veg/vegan sandwiches based on an estimation of the need. For other dietary needs email us. There will also be coffee and some fika during the breaks. If you would like to buy a bigger lunch there are several alternatives on campus and nearby.

WHO DO I CONTACT?

If you have any questions you are welcome to contact the committee through: bme.at.liu@imt.liu.se.

This documet was last updated April 19, with reservations for late additions and changes in the program.

MAP OF CAMPUS US



Linköpings universitet, www.liu.se Region Östergötland, www.regionostergotland.se LiU 2021-03-23

Lecture Halls

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Hugo Theorellsalen, Granit	7
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LiU Innovation	Sandbäcksgatan 7
Barnafrid - national knowledge centre	Sandbäcksgatan 7

Student union

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Restaurants and cafés

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	Entrance
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Entrance	65	Floor 9
Entrance	68	Floor 8
Entrance	71	Floor 8
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Entrance	76, 78	Floor 9 and 10

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Program – Day at a glance

Welcome and first two keynotes

08.00 **Introduction** (zoom link, click here)
Tomas Strömberg, Head of Department, Professor
Department of Biomedical Engineering, Linköping University.
Location: Berzelius lecture hall

08.05 Welcome and overview of the program
Gunnar Cedersund, Senior Lecturer
Department of Biomedical Engineering, Linköping University.
Location: Berzelius lecture hall

08.10 Biomedical Engineering at Linköping University – a strategic perspective
Matts Karlsson, Deputy Vice-chancellor for research, Professor
Department of Management and Engineering,
Linköping University.
Location: Berzelius lecture hall

08.30 **Keynote – industry perspective**
Torbjörn Kronander, CEO Sectra.
Location: Berzelius lecture hall

09.00 **Keynote – scientific perspective**
Gerhard Andersson, Professor
Department of Behavioural Sciences and Learning,
Linköping University.
Location: Berzelius lecture hall

09.30 Coffee break + Arenas

Three parallel sessions: from data, to analysis, and presentation

10.00 **Data, Biosensors, and Actuators**
Location: Eken
Session chair: Daniel Aili

10.00 **Data analysis: Modelling, AI, Imaging, and Bioinformatics**
Location: Berzelius lecture hall
Session chair: Gunnar Cedersund

10.00 **Clinical Implementation, eHealth, and Health Economics**
Location: Linden
Session chair: Aseel Berglund

Lunch + Arenas

12.00 Poster session and Arenas
Have a bite and visit our arena; on site or online

Four parallel sessions: medical applications

13.30 **Circulation and Metabolism (CircM)**
Location: Belladonna
Session chair: Tino Ebbers

13.30 **Inflammation (MIIC) and Wound healing**
Location: Eken
Session chair: Daniel Simon

13.30 **Neuro**
Location: Berzelius lecture hall
Session chair: David Engblom

13.30 **Cancer**
Location: Linden
Session chair: Gunnar Cedersund

15.30 Coffee break + Arenas

Final plenary sessions: Keynotes and mingling + Lecture-performance

16.00 **Keynote – science perspective**
Jessica C. Ramella-Roman, Associate Professor
Medical Photonics Laboratory, Department of Biomedical Engineering, Florida International University, USA.

16.30 **Keynote – industry perspective**
Lena Miranda, CEO Linköping Science Park.

17.00 Mingling and Lecture-performance
Gunnar Cedersund (IMT) on piano, and Julia Bengtsson, ballet dancer (New York)

18.30 Dinner
At Hotell Ekoxen. More information will follow.

End of the day

Zoom links

BERZELIUS
Zoom link:
click here

EKEN
Zoom link:
Click here
Meeting ID: 690 2737 3781
Passcode: 272738

LINDEN
Zoom link:
click here
Meeting ID: 644 0576 1795
Passcode: 528490

BELLADONNA
Zoom link:
Click here
Meeting ID: 655 2400 5071
Passcode: 795233

LINKÖPING UNIVERSITY

Morning sessions

Data, Biosensors, and Actuators

Session chair: Daniel Aili Location: Eken

10.00 **Measurement of skin microcirculation for cardio vascular risk stratification in clinical practice – cross-sectional data from the SCAPIS Linköping cohort**
Carl Johan Östgren and Hanna Jonasson

10.36 **Soft microrobots that create their own bone: a tool for tissue engineering?**
Edwin Jager

10.54 **Short break**

11.06 **A Fiber Optical Sensor System for In-situ Detection of Biomolecules**
Erik Martinsson, ArgusEye AB

11.24 **Advancing peripheral nerve interfaces**
Mary J Donahue

11.42 **Organic Bioelectronics: Bridging the signaling gap between biology and technology**
Daniel Simon

Data analysis: Modelling, AI, Imaging, and Bioinformatics

Session chair: Gunnar Cedersund Location: Berzelius lecture hall

10.00 **Mathematical modelling of Covid-19**
Fredrik Gustafsson

10.18 **Machine learning to improve diagnostic accuracy of rare events in Orthopedics**
Anders Eklund and Jörg Schilcher

10.54 **Short break**

11.06 **Data-driven Precision Medicine and Diagnostics**
Wen Zhong

11.24 **Topological Method for activity pattern analysis in task-based fMRI data**
Farhan Rasheed

11.42 **Novel diffusion MRI for noninvasive imaging**
Evren Özarslan

Clinical Implementation, eHealth, and Health Economics

Session chair: Aseel Berglund Location: Linden

10.00 **VisualNeuro: A Hypothesis Formation Application for Multi-Variate Cohort Study Data**
Ingrid Hotz, Susanna Walter and Daniel Jönsson

10.36 **Development of a mobile exergame for patients with heart failure to increase physical activity**
Aseel Berglund and Erik Berglund

10.54 **Short break**

11.06 **Design for transformation towards person-centered care**
Stefan Holmlid and Tomas Edman

11.42 **The Effect of Internet-Delivered Cognitive Behavioral Therapy Versus Psychoeducation Only on Psychological Distress in Patients With Noncardiac Chest Pain: Randomized Controlled Trial**
Ghassan Mourad

Afternoon sessions

Circulation and Metabolism (CircM)
Session chair: Tino Ebbers Location: Belladonna

13.30 **4D-flow MRI for assessments of the cardiovascular system: methodological developments and clinical applications**
Tino Ebbers and Carl Johan Carlhäll

14.06 **Physiologically based digital twins predict meal responses before and after long-term fasting**
Oscar Arrestam

14.24 **Short break**

14.36 **Affected microcirculation and vascular hemodynamics in vascular inflammatory diseases**
Christina Svensson and Tomas Strömberg

15.12 **The impact of body composition on cardiometabolic diseases: from research to clinic and commercialization**
Magnus Borga

Inflammation (MIIC) and Wound healing
Session chair: Daniel Simon Location: Eken

13.30 **HEALiX: Antimicrobial peptides for treatment of infected wounds**
Johan PE Junker

13.48 **A model for skin response due to noxious heating using a spatial frequency domain imaging system with compact eye camera**
Nandan Das

14.06 **Line scanner for tomographic blood flow measurements**
Johannes Johansson

14.24 **Short break**

14.36 **Combining in vitro and in vivo systems biology for robust biomarker discovery in multiple sclerosis**
Jan Ernerudh and Mika Gustafsson

15.12 **Multifunctional Nanocellulose Composite Wound Dressings**
Olof Eskilsson and Elisa Zattarin

Neuro
Session chair: David Engblom Location: Berzelius lecture hall

13.30 **Treating nerve damage with strechable neural cuff electrodes**
Simon Farnebo and Klas Tybrandt

14.06 **Self-organization of spinal circuitry through learning**
Jonas Enander

14.24 **Short break**

14.36 **Integrative systems biology for the brain: from ion channels to neurovascular coupling**
Fredrik Elinder and Nicolas Sundqvist

15.12 **Real-time optical guidance in frameless brain tumor biopsies**
Elisabeth Klint and Johan Richter

Cancer
Session chair: Gunnar Cedersund Location: Linden

13.30 **Unraveling the genetics of sex-bias in human disease**
Colm Nestor and Björn Gylemo

14.06 **Dynamic biofunctionalization and modulation of hydrogels by peptide-folding mediated interactions and bioorthogonal crosslinking for 4D bioprinting**
Sajjad Naeimipour

14.24 **Short break**

14.36 **Classification of thyroid diseases in optical coherence tomography images using deep learning**
Iulian Emil Tampu

15.12 **Mimicking a 3D environment resembling normal breast tissue with high density mediates a more aggressive phenotype of estrogen positive breast cancer cells**
Fatemeh Rasti Boroojeni and Annelie Abrahamsson

Abstracts

On the following pages you will find abstracts for talks, posters and the digital arena. If you are viewing a digital copy of this document you can easily jump between pages by clicking on the name of the abstract you would like to read and then back again via the link in the lower right hand corner of every page.
The colour on the page shows what category the abstract belongs to.

Data, Biosensors and Actuators

Data analysis: Modelling, AI, Imaging, and Bioinformatics

Clinical Implementation, eHealth, and Health Economics

Circulation and Metabolism (CircM)

Affected microcirculation and vascular hemodynamics in vascular inflammatory diseases

The capillary refill test in acutely ill children – intra observer reliability and inter observer agreement

Insights of hemodynamic changes in hypertension and T2D through non-invasive cardiovascular modeling

Inflammation (MIIC) and Wound healing

HEALiX: Antimicrobial peptides for treatment of infected wounds

A model for skin response due to noxious heating using a spatial frequency domain imaging system with compact eye camera

Line scanner for tomographic blood flow measurements

Monitoring Multiple Sclerosis Progression and Response to Treatment with OECT-based Biosensors

Enhanced thin layer detection with spatial frequency domain imaging using multiple spatial frequencies ranges

Neuro

Self-organization of spinal circuitry through learning

Real-time optical guidance in frameless brain tumor biopsies

Long-term recordings of cerebral microcirculation during neurointensive care

Multidimensional Diffusion MRI with Confined Subdomains

The future of multi-level models of the brain

Cancer

Dynamic biofunctionalization and modulation of hydrogels by peptide-folding mediated interactions and bioorthogonal crosslinking for 4D bioprinting

Classification of thyroid diseases in optical coherence tomography images using deep learning

Mimicking a 3D environment resembling normal breast tissue with high density mediates a more aggressive phenotype of estrogen positive breast cancer cells

Arena: unique resources and expertise from LiU

Department of Biomedical Engineering (IMT)

Forum Östergötland

Forum Scientium - Cultivating curiosity and community between Life Science, Medicine and Engineering

Advanced Tissue Simulating Optical Phantoms – a LiU Resource

SUND

Room:
Eken

Zoom link:
click here
Meeting ID: 690 2737 3781
Passcode:
272738

Keywords:
Microcirculation, Cardiovascular disease, Risk factors

Measurement of skin microcirculation for cardiovascular risk stratification in clinical practice – cross-sectional data from the SCAPIS Linköping cohort

Hanna Jonasson, Sara Bergstrand, Ingemar Fredriksson, Marcus Larsson, Carl Johan Östgren, Tomas Strömberg

In the last decade, the potential of assessing microvascular function has become evident in research on the pathophysiology of cardiovascular disease and cardiovascular risk stratification. The skin microcirculation has the advantage of being easily accessible and can potentially be considered as a mirror of overall systemic vascular dysfunction in terms of underlying mechanisms and endothelium-dependent vasodilation response. The measurements of skin microcirculatory reactivity were performed in Linköping as an ancillary study to the Swedish CArdioPulmonary bioImage Study (SCAPIS). Microcirculatory reactivity was assessed using a 5-minute arterial occlusion-release protocol. Quantitative skin microcirculatory data were collected continuously with a multimodal optical instrument (PeriFlux 6000 EPOS, Perimed AB) using a fiberoptic probe placed on the lower right arm. We investigated the associations between skin microcirculatory function and established cardiovascular risk factors. Among microcirculatory parameters, peak skin microcirculatory oxygen saturation after occlusion release had the strongest relationship to the cardiovascular risk factors and was associated with virtually all established cardiovascular risk factors. We are now planning to follow up microcirculatory reactivity in the SCAPIS cohort and follow up the clinical outcome data on myocardial infarction and stroke of the study participants.

Room:
Eken

Zoom link:
click here
Meeting ID: 690 2737 3781
Passcode:
272738

Keywords:
Biomaterials, Biosensors, Novel instrumentation

Soft microrobots that create their own bone: a tool for tissue engineering?

Edwin Jager

Inspired by the fontanelle structure and function of the newborn skull, in which a soft tissue turns into a solid load-bearing structure, we hereby present the fabrication, optimization, and characterization of soft biohybrid variable stiffness actuators for soft robotics. These actuators can morph in various shapes and change their properties from soft to rigid. We developed soft bilayer actuators by combining the electromechanically active polymer polypyrrole with compliant alginate gels that were functionalized with cell-derived plasma membrane nanofragments (PMNFs) that mineralize within 2 days. This results in the mineralization in the gel layer accomplishing the soft to stiff change by growing their own bone. The mineralized actuator showed an evident frozen state compared to the movement before mineralization. In addition, patterned devices were developed that showed programmed directional and fixated morphing. Finally, these variable stiffness devices could wrap around, adhere, and integrate onto bone tissue due the PMNF-induced mineralization in and on the gel layer. The developed biohybrid variable stiffness actuators could be used in soft (micro-)robotics and as potential tools for bone repair or bone tissue engineering.

Room:
Eken

Zoom link:
click here
Meeting ID: 690 2737 3781
Passcode:
272738

Keywords:
Biomaterials, Biosensors, Novel instrumentation

Advancing peripheral nerve interfaces

Mary J. Donahue

The informational density and relative accessibility of the peripheral nervous system make it an attractive site for therapeutic intervention. Although electrode-based electrophysiological interfaces for peripheral nerves have been under development for over half a century, achieving spatial specificity and minimally invasive devices remains challenging. The value in tackling this challenge lies in the possibility to treat disorders such as, for example, chronic pain, overactive bladder, depression, and epilepsy1. We aim to improve peripheral nerve interfaces through the use of wired flexible electrode arrays to optimize reduced invasiveness stimulation methods. Our first approach includes the use of the conformal arrays to intelligently design wireless optoelectronic devices for vagus nerve stimulation. Another technique utilizes similar technology to provide scannable electrode grids for focal stimulation from the surface of the skin using a method called temporal interference2,3. The material systems utilized are non-toxic and allow for intimate interaction with the nerve where implantable devices are of interest as well as conformal skin contact for surface arrays. The advancement of these methods not only contributes to the understanding of signaling pathways and disease treatment through peripheral nerve stimulation, but also holds clinical translation potential.

Room:
Eken

Zoom link:
click here
Meeting ID: 690 2737 3781
Passcode:
272738

Keywords:
Biomaterials, Biosensors, Novel instrumentation

A Fiber Optical Sensor System for In-situ Detection of Biomolecules

Erik Martinsson, ArgusEye AB

ArgusEye AB develops innovative sensor systems for real-time monitoring of biological systems and processes. The sensor technology is based on extensive academic research conducted at Linköping University and combines nanoplasmonic sensing with a fiber optical read-out. This enables a flexible sensor design that basically shrinks a benchtop biosensor to the tip of an optical fiber. Specificity towards various analytes of interest can be obtained by adding a versatile surface chemistry that supports immobilization of different ligands or receptors. Application areas for this sensor technology includes, in-line monitoring and control of bioprocessing, water quality monitoring, and in-situ detection for diagnostic purposes.

Room:
Berzelius

Zoom link:
click here

Keywords:
fMRI, topological feature vector, Merge tree, Morse matching

Topological Method for activity pattern analysis in task-based fMRI data

Farhan Rasheed, Daniel Jonsson, Emma Nilsson, Talha Bin Masood, Ingrid Hotz

We present a method for detecting patterns in time-varying functional magnetic resonance imaging (fMRI) based on topological analysis. The oxygenated blood flow measured by fMRI is widely used as an indicator for brain activity. The signal is prone to noise from various sources. Random brain activity, physiological noise, and noise from the scanner can reach a strength comparable to the signal itself. Thus, extracting

the underlying signal is a challenging process typically approached by applying statistical methods. The goal of this study is to investigate possibilities to recover information from the signal using topological feature vectors directly based on the raw signal without any medical pre-knowledge. The goal is to recover, the temporal development of brain activations, connectivity between these activations, and their relation to these cognitive tasks.

Data-driven Precision Medicine and Diagnostics

Wen Zhong, Anders Gummesson, Abdellah Tebani, Hanna Danielsson, Linn Fagerberg, Göran Bergström, Mathias Uhlen

Room:
Berzelius

Zoom link:
click here

Keywords:
Multi-omics; Precision medicine; Data-driven

One of the most important fields of biotechnology is the need to stratify patients to allow individualized treatment and monitoring of therapeutic interventions. This field called precision medicine has been dominated by genomics platforms, led by the rapid development in "next-generation sequencing". However, there is a need to move towards new omics tools to take the next step in precision medicine. In the Swedish SCAPIS SciLifeLab Wellness Profiling (S3WP) program, we have studied the longitudinal effects of lifestyle variation in 101 healthy individuals based on personalized expression profiles including genome, plasma proteome, plasma metabolome, blood cell composition, auto-antibody reactivity profiles, and gut microbiota for two years. The first step was to establish the normal variation in the multiple omics profiles of healthy individuals. Then, more disease cohorts, including type 2 diabetes, cardiovascular disease, non-alcoholic fatty liver disease, and preterm infants, were studied to show proof-of-principle for omics-profiling of specific diseases.

Affected microcirculation and vascular hemodynamics in vascular inflammatory diseases

Svensson Christina, Eriksson Per, Jonasson Hanna, Strömberg Tomas, Sjöwall Christopher, Zachrisson Helene

Room:
Belladonna

Zoom link:
click here
Meeting ID: 655 2400 5071
Passcode:
795233

Keywords:
Vessel inflammatory disease, Microcirculation, Ultrasound

Takayasu arteritis (TAK) is a rare inflammatory disease affecting aorta and its major branches. Ultrasound (US) can detect inflammatory features in the arterial wall, but less is known about skin microcirculation and vascular hemodynamics. The aim was to study if assessment of these variables could add valuable information regarding vascular affection in TAK. Systemic lupus erythematosus (SLE) is a multi-organ autoimmune inflammatory disease primarily affecting young females. Patients with SLE have an increased risk of cardiovascular disease (CVD) with accelerated atherosclerosis and higher mortality rates compared to the general population. We will present results of microcirculation measurements in forearm skin after induced ischemia in TAK and SLE and compare the results to those from healthy controls.

HEALiX: Antimicrobial peptides for treatment of infected wounds

Ivana Rinklake, Kristina Hanna, Emanuel Wiman, Hazem Khalaf, Robert Selegård, Torbjörn Bengtsson, Daniel Aili, Jonathan Rakar, Johan PE Junker

Room:
Eken

Zoom link:
click here
Meeting ID: 690 2737 3781
Passcode:
272738

Keywords:
Wound healing, Infection, Antimicrobial peptides

Infected non-healing wounds causes large suffering for patients and an enormous burden to the healthcare system. In the EU, 25-40% of hospital beds are occupied by patients with wounds, and more than half of the resources in the outpatient setting are spent on wound treatment. The alarming problems with antimicrobial resistance prevent effective infection control, and more than 70 % of bacteria found in wounds are resistant to at least one antibiotic. Antimicrobial peptides (AMPs) represent a promising alternative to antibiotics, without risking resistance development. The HEALiX consortium brings together wound care experts and academic researchers to develop a new generation of antibacterial wound dressings, relying on functionalization of bacterial nanocellulose with the antimicrobial peptide (AMP) Plantaricin NC8 (PLNC8). The AMPs have further been modified to increase stability in the wound microenvironment, while maintaining low toxicity and high bactericidal capacity. The safety and efficacy of the AMPs in fighting wound infection has been tested using human cell cultures in vitro as well as infected porcine wounds in vivo. We have shown complete eradication of Staphylococcus infection within days following topical administration of the modified version of PLNC8. Future studies will evaluate efficacy against other clinically relevant pathogens, including antimicrobial resistant strains, as well as synergistic effects of co-administration with antibiotics. Moreover, functionalization strategies of cellulose wound dressings will be evaluated.

A model for skin response due to noxious heating using a spatial frequency domain imaging system with compact eye camera

Nandan Das, Saad Nagi, Keiichiro Kagawa, Jun Tanida, Rolf B Saager

Room:
Eken

Zoom link:
click here
Meeting ID: 690 2737 3781
Passcode:
272738

Keywords:
Noxious heating, Inflammation, tissue chromophores, Vessels dilation, Extra vascular water, Spatial frequency domain imaging, Scattering, Absorption.

Detection of tissue hemoglobin (tHb), tissue water (tH20), vessel dilation can be critically important as these indicate early signs of physiological changes like inflammation, edema. Tissue inflammation is a complex biological response against harmful pathogens, damaged cells or noxious heating, and can be a good indicator of possible diseases. To monitor tHb and tH20 together, we need to know dynamics of absorption and scattering properties in visible and near infrared (NIR) light simultaneously. To achieve this, we have developed a compact, spatial frequency domain imaging (SFDI) system around a custom, nine wavelength, compound-eye camera, spanning 450-1000nm. In addition to the characterization and validation of this device, we performed a preliminary in-vivo investigation to evaluate the imager's ability to characterize dermal response under a noxious heating protocol. Initial results indicate that there is a significant change in tissue scattering and absorption properties due to noxious heating. Through physiological modeling of absorption and scattering dynamics, we found that noxious heating induced changes in tissue water contents, hemoglobin, and tissue morphology which can be interpreted as vascular dilation, inflammation, edema, and extra blood circulation etc. Observed similarity between trends of tissue water dynamics from NIR wavelengths with tissue morphological (scattering) changes

in visible region additionally indicate a new possibility to detect tissue water contents (inflammation, edema) by tracking tissue morphology with visible light only.

Room:
Eken

Zoom link:
click here
Meeting ID: 690 2737 3781
Passcode:
272738

Keywords: Biomedical Optics, Laser Speckles, Microvascular Blood Perfusion, Burn Wounds, Tomography

Line scanner for tomographic blood flow measurements

Johannes Johansson and Rolf Saager

Partial thickness burn wounds are very painful injuries that may or may not heal on their own depending on burn depth and area in the dermis of the skin. Quick assessment of the burn depth is important to quickly perform surgery of the wound if needed. Unlike superficial or deep burn wounds, partial thickness wounds are difficult to determine an early prognosis for. Laser speckle imaging (LSI) of skin blood flow can be helpful in finding severe coagulation zones with impaired blood flow but is a too superficial measurement technique to properly reach the full depth of adult dermis and cannot resolve the flow in depth, so only indirect estimates of burn depth are possible. Diffuse correlation spectroscopy (DCS) uses varying source-detector separations to allow differentiation of flow depths but requires time-consuming 2D scanning to form an image of the burn area. We here propose a hybrid approach of DCS and LSI called speckle contrast Diffuse Correlation Tomography (scDCT) with a novel approach of using a laser line as a source. This will allow for fast 1D scanning to perform 3D tomographic imaging, making quantitative estimates of the depth and area of the coagulation zone from burn wounds. Proof-of-concept tests on a flow phantom are presented, showing ability to differentiate flows at different depths.

Room:
Berzelius

Zoom link:
click here

Keywords:
Spinal development, Neuron model, Primary afferents

Self-organization of spinal circuitry through learning

Jonas M.D. Enander, Gerald E. Loeb, Henrik Jörntell

Control of the musculoskeletal systems depends on integration of voluntary commands and somatosensory feedback in the complex neural circuits of the spinal cord. It has been suggested that the observed spinal connectivity patterns may be controlled by the specific transcriptional neuron types that have been observed among spinal neurons. We ask instead if the details of these connectivity patterns could arise as a consequence of Hebbian adaptation during early development. We constructed an anatomically simplified model plant system with realistic muscles and sensors and connected it to a recurrent neuronal network consisting of both excitatory and inhibitory neurons endowed with Hebbian learning rules. We configured it with spontaneously active beta motoneurons innervating both extrafusal and intrafusal muscle fibers. The beta motoneurons were driven to mimic the spontaneous twitches and waves of muscle activation that have been observed during embryogenesis. We discovered that a simple, Hebbian rule for synaptic plasticity could account for the development of the selective monosynaptic projections of spindle primary afferents to homonymous motoneurons, the first components of the system to appear during fetal development. Subsequently, we simulated the learning of connectivity patterns of spinal interneurons. Here, we consistently found diverse and stable patterns of activity and connectivity. We also found that such learning led to an increased degree of cooperativity between interneurons when performing larger limb movements on which it had not been trained. Thus, Hebbian learning could give rise to rich sets of spinal interneuronal connectivity patterns that reflect the mechanical properties of the plant.

Room:
Berzelius

Zoom link:
click here

Keywords: Neurosurgery, Optical navigation, fluorescence, laser Doppler, MRI

Real-time optical guidance in frameless brain tumor biopsies

Elisabeth Klint1, Johan Richter1,2, Karin Wårdell1

Background

Brain tumor biopsies are performed to conclude diagnosis and tailor treatment. Secondary outcomes of the procedure include inconclusive results (5-7%)[1,2] and hemorrhage (5%)[2], where risks increase with repetitive needle insertions and prolonged surgery.

A previously developed optical probe system for frame-based biopsies[3] provides real-time feedback on tissue characteristics, in difference to the standard biopsy procedure, which relies on preoperative images and calculated virtual parameters. The aim was to adapt the optical probe system for frameless biopsies.

Methods

The two-laser probe system was adapted to the outer cannulas of frameless biopsy needles. The cannulas were modified with an aperture at the tip to allow for forward-looking measurements of tissue fluorescence, perfusion, and light intensity. The probe was fitted into a modified cannula and measurements were made along planned trajectories in nine patients (written informed consent EPM-2020-01404). When fluorescence peaks were registered at or in the vicinity of the target, the probe was replaced by the inner cannula, samples were taken according to clinical protocol and sent for histopathological analysis.

Results

Real-time feedback of tissue fluorescence, perfusion and light intensity was obtained in 103 locations. In eight patients, tissue fluorescence was found (33 locations) and pathology results confirmed tumor after 30-60 minutes. In one patient, no fluorescence peak was detected. Slightly increased perfusion was detected in four locations. Post-operative imaging showed no hemorrhage or blood vessel lesions.

References

[1] Kesserwan MA, et al, Surg Neurol Int. 2021.
[2] Livermore LJ, et al, Br J Neurosurg. 2014.
[3] Richter JC0, et al, Operative Neurosurgery, 2021.

Room:
Linden

Zoom link:
click here
Meeting ID: 644 0576 1795
Passcode:
528490

Keywords: 4D Bioprinting , 3D cell culture, Hydrogel, Tissue model

Dynamic biofunctionalization and modulation of hydrogels by peptide-folding mediated interactions and bioorthogonal crosslinking for 4D bioprinting

Sajjad Naeimipour, Robert Selegård, Daniel Aili

Culturing cells in 3D needs a supporting material that can resemble the properties of natural extra cellular matrix (ECM). However, studying the interactions between cells and their environment is only possible if different properties of the matrix can be tuned independently according to the aims of the experiment. Here we presented a tuneable and modular biomaterial for generating cell- and tissue models and constructs for drug development, tissue engineering, and fundamental studies of cell-matrix interactions. The hyaluronan/poly (ethylene glycol) based hydrogel system combines robust and tuneable covalent biorthogonal cross-linking strategy with peptide-folding mediated interactions to enable dynamic modulation of hydrogel properties. Peptide dimerization enabled dynamic modulation of both cross-linking density and hydrogel functionality, before, during and after gelation. A toolbox of functionalized peptides with different functionalities were developed, which allowed for altering cell adhesion and enhancing retention of biofunctional enzymes. This feature was demonstrated by triggering enzyme-mediated biomineralization of the bioprinted structures. This flexible strategy for controlling and changing hydrogel properties can facilitate development of 4D bioprinting techniques and studying cell matrix interactions.

Room:
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Keywords:
OCT, Deep learning, Thyroid

Classification of thyroid diseases in optical coherence tomography images using deep learning

Iulian Emil Tampu

Optical coherence tomography (OCT) has potential for visualizing tissue microstructure with micrometer resolution in both 2D and 3D. To boost its adoption, image analysis methods are needed to process OCT images that otherwise can be difficult to interpret. Convolutional neural networks (CNNs) have been applied successfully in a variety of medical imaging tasks but their implementation on OCT data is yet not fully investigated. In this work we investigate practices for deep learning-based OCT image classification with application on thyroid diseases.

Room:
Linden

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Meeting ID: 644 0576 1795
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528490

Keywords:
Breast cancer, MCF7, 3D cell culture, Hydrogel, Monocyte

Mimicking a 3D environment resembling normal breast tissue with high density mediates a more aggressive phenotype of estrogen positive breast cancer cells

Fatemeh Rasti Boroojeni, Annelie Abrahamsson, Robert Selegård, Daniel Aili, Charlotta Dabrosin

In the western world, breast cancer is the most common cancer in women with increasing incidences. Women having dense breasts tissue have an increased risk of developing cancer compared to women with non-dense tissue. The link between density and increased cancer risk is not fully understood but stiffness and intercellular crosstalk are crucial factors for identifying preventive measures for these patients.
Here we present an in vitro model resembling high and low breast tissue densities in normal breast by using semi-synthetic hyaluronic acid-based hydrogel comprised by crosslinked- hydrophilic-polymeric network. Using multi-armed-polyethylene-glycol-based crosslinkers, we engineered hydrogels to control spheroid formation of estrogen positive breast cancer cell-line MCF-7 human primary monocytes in 3D- microenvironment with different stiffness.

Vinculin, integrin-1 and matrix metalloproteinases (MMPs) are important for cell-adhesions, matrix-regulation and are upregulated in invasive tumors. We explored if different densities mediated expression of these proteins. Immunofluorescence staining of hydrogel-sections for vinculin and integrin-1 showed a significant increase in high density hydrogels (1500 Pa) in MCF-7 and co-cultures with monocytes compared to low density (900 Pa). In collected culture medium significant increase of MMP9 in MCF-7 and in co-cultures in high density, MMP1 showed a significant increase in high density in the co-cultures whereas MCF-7 alone showed no significant difference. Integrin-1, MMP9 and MMP1 all increased significantly in high density co-cultures compared to MCF-7 only.

Here we show that a 3D environment resembling normal breast tissue with high density mediates a more aggressive phenotype of estrogen positive MCF-7 and in presence of monocytes.

Keywords:
Wound infection.
Antimicrobial.
Sensing.

Multifunctional Nanocellulose Composite Wound Dressings

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Wound infections are often hard to eradicate and delay healing, which contributes to wound chronification. The healing time of chronic wounds protracts from the normal 6 weeks up to several months or even years. Early-stage detection and treatment of wound infections is thus of key importance for managing this highly overlooked issue and facilitate healing.

Herein we present a novel wound dressing material which combines bacterial nanocellulose (BC), with mesoporous silica nanoparticles (MSN), capable of augmented loading of molecular sensing components and antimicrobial compounds for wound status monitoring and eradication of infection, respectively. Three main applications are targeted: (a) passive and (b) triggered release of antimicrobial agents, (c) immobilization of sensing molecules.

MSNs are physiosorbed in the BC network by self-assembly, and the bioactive components are loaded in the MSN pores. Capping of the MSN pores is performed in (b) and (c), where the molecules used for capping can be (b) protease degradable or (c) inert. Produced via a robust and highly controllable process, this composite material displays a dramatic increase in specific surface area, from 88 m2/g of native BC up to 469 m2/g after MSN functionalization, granting an enhanced loading capacity. Addition of MSNs has minimum impact on the physical properties of BC, and the dressings retains good conformability to the wound bed, adequate moisture retention and transmission, and transparency. Thanks to a scalable production process that is independent on dressing size and geometry, this technique paves the way for the creation of a new class of highly performing multifunctional wound dressings.

Keywords:
Bio-optics, SFDI,Melanoma, Breslow Thickness, Cellular morphology

A classification framework for melanoma cancer screening using depth-resolved light scattering

Motasam Majedy, Nandan Das, Rolf Saager

Melanoma is one of the deadliest forms of skin cancer that arises from the uncontrolled proliferation of melanocytes. Although treatable when detected early, delayed diagnosis can lead to disease progression and high mortality. Screening for early-stage melanoma in clinical settings is quite challenging, as many benign pigmented lesions exhibit similar superficial characteristics. As a result, 80-99% of suspected lesions are revealed to be benign after biopsy and histology. Therefore, novel methods that can predict the need for invasive biopsies and/or risk for malignancy are needed. We employ Spatial frequency domain imaging (SFDI), a technique that uses a modulated spatial frequency projection to quantify absorption and scattering properties of tissue across both visible and near infrared ranges. As the penetration depth of light increases as wavelengths get longer, the isolation of lesion specific scattering properties can provide two novel measures currently inaccessible in clinical screening: 1) a non-invasive means to determine lesion depth (I.e. Breslow Thickness) and 2) an indirect, lesion-specific assessment of cellular morphology. To test these hypotheses, we have generated solid phantoms that replicate the dimensions and optical properties of pigmented lesions and dermis in skin. The method could substantially improve the efficacy of melanoma screening in a clinical setting. Such applications would be of great benefit in aiding diagnosis and improving treatment options for patients.

Keywords:
Gold nanowires, Stretchable electronics, Nanowire synthesis

Synthesis of gold nanowires for stretchable electronics

Laura Seufert, Samuel Lienemann, Ulrika Linderhed, Klas Tybrandt

Electrical stimulation in direct proximity to neural tissue is investigated to treat neurological disorders like Parkinson's disease and epilepsy. One major challenge for neural interfaces is the huge mechanical mismatch between the electronics and the tissue. This can be addressed by developing soft and stretchable devices. High performance stretchable conductors can be made from nanowires (NWs) embedded in elastomers like polydimethylsiloxane (PDMS). Silver nanowires (AgNWs) are commercially available in controlled dimensions and have been widely used for stretchable conductors. For biomedical applications, however, AuNWs are needed, and to date there exists no robust method of synthesizing large amounts of high aspect ratio AuNWs. In this work we present a novel synthesis of high aspect ratio AuNWs with smooth surface structure. The process allows for selective control of the diameter of the nanowires and gives the possibility to determine the ideal dimensions for application in stretchable electronics.

Keywords: Cerebral Blood Flow (CBF); Secondary brain injury; Magnetic Resonance Imaging (MRI); Arterial Spin Labeling (ASL);

Repeated ASL Measurements as a Method for Detection of Altered Cerebral Blood Flow in Patients in the Neurointensive Care Unit

Sofie Tapper, Sandra Wyss, and Karin Wårdell

Patients in the Neurointensive Care Unit (NICU) who have suffered from severe brain damage need to be monitored carefully to prevent secondary brain injury. A reduced cerebral blood flow (CBF) can indicate that secondary brain injury may occur, which makes early detection of this state crucial for the patient to start appropriate preventive treatment in time. At the Department of Neurosurgery, Linköping University Hospital, a unique setup is available with an MRI scanner located in the NICU. However, most used MR-based perfusion techniques require a contrast agent, which is not recommended for daily repeated measurements due to patient risks. Arterial Spin Labeling (ASL) is a subtraction-based MRI technique not requiring any contrast agent and instead relies on magnetically labelling of arterial blood water. Therefore, the current aim of this project is to implement an ASL-based workflow for detecting altered CBF in the NICU patient. Data was acquired from two healthy volunteers using a 3 T MR system (Skyra, Siemens) with the imaging protocol consisting of structural imaging (T1, T2), pulsed ASL, and Proton density (PD) imaging. Post-processing steps mainly built upon FMRIB Software Library in combination with own implementations are currently being evaluated. PD images are used for scaling to obtain quantitative perfusion maps in absolute units, which are essential for enabling day-to-day comparison. At a later stage, we are also aiming to combine this methodology with MR flow measurements in the larger arteries entering the brain and local microcirculation recording with laser Doppler flowmetry, and thus investigate CBF from a macro- to a micro perspective.

Keywords: Diffusion magnetic resonance exchange acquisition; Magnetic Resonance Imaging (MRI); Arterial Spin Labeling (ASL);

MRI based measurement of diffusion and water exchange

Alfredo Ordinola, Deneb Boito, Evren Özarslan

Diffusion magnetic resonance imaging (dMRI) has been successfully employed for determining tissue structure and organization at a microscopical level through the motion of water molecules. Complex processes, such as exchange, have also been modeled using diffusion magnetic resonance data. One of the models proposed to describe this process is the filter exchange framework, which introduces an "apparent exchange rate" to describe the microscopic exchange process. However, this estimation model presents limitations which require further theoretical and experimental analyses and developments. Therefore, the main focus of this study is to experimentally explore the possibility of using a benchtop MR scanner to estimate water exchange in cell suspensions. To this end, a double diffusion encoding sequence was implemented in-house. Our results are comparable to previously reported studies within the limitations of the benchtop scanner and employed model. This suggests that diffusion measurements, more specifically water exchange acquisitions, can be performed and further theoretical and experimental developments can be made using this type of scanner.

Efficient 3D deep learning using 2D projections

Johan Jönemo, Robin Kämpe, Anders Eklund

Keywords: Deep learning, Neuroimaging, Image processing

In medical imaging, the data is typically 3D and training 3D convolutional neural networks (CNNs) for classification or regression is a very time-consuming task. To give an example, the UK biobank dataset (Littlejohns et al., 2020) contains 3D MRI (magnetic resonance imaging) brain volumes of 256 x 256 x 256 voxels from 100,000 subjects. To train (multi-channel) 3D CNNs to classify subjects as normal or diseased, or to predict features such as age or other biological metrics, using the UK biobank data is extremely computationally demanding. Recent work has demonstrated that instead training 2D CNNs on 2D projections of 3D volumes can lead to reasonably good accuracy. Using 2D CNNs has many advantages, such as much faster training, much lower GPU memory usage, and the possibility to use CNNs pre-trained on ImageNet (there are very few pre-trained 3D CNNs). To investigate if the projection approach can be applied to brain volumes, we applied 2D CNNs to intensity projections of some 40,000 brain volumes from UK biobank. The task was to predict the age of each person, and the network achieved a mean absolute error of about 3 years. The performance is currently a bit lower compared to previously reported results for 3D CNNs, but completing a training epoch using 30,000 training subjects can be done in about 40 seconds using a single graphics card (this would probably take at least 1-2 hours using a 3D CNN).

Prediction of Behavior and Cognition by an AI-based approach

Taher Hansen, Morteza Esmaeili, Alireza Salami

Keywords: Artificial Intelligence, Individual behavior prediction, Resting-state fMRI, Functional connectivity

Introduction

Functional MRI enables the identification of several resting-state networks, constituting the brain's functional architecture. This functional architecture alters in different conditions, suggesting that functional connectivity measures may serve as a sensitive biomarker. This study aims to develop artificial intelligence (AI) platform to predict individual behavior, such as episodic memory (EM) score, from individual functional connectivity profiles.

Method

We present resting-state functional connectivity acquired from 180 healthy subjects. This study was approved by the Regional Ethical board and the local Radiation Safety Committee. Functional data were obtained during the rest-state conditions. We prepared functional architecture maps of 273x273 connectivity nodes using an established pre-processing pipeline. Using cross-correlation analysis and pre-defined p-value thresholds, we aimed to eliminate the contribution of other covariances (e.g.,age) in correlation connectivity maps. We modified the internal loops inside the DenseNet-121, resulting in a less dense model named semi-DenseNet.

Results

The semi-DenseNet model predicted the EM score range based on connectivity map features with a mean cross-validated accuracy of >96% on the testing dataset. Saliency heatmaps demonstrated significant contributions from subcortical nodes, par-

ticularly along the hippocampus axis. Furthermore, the between-network connectivity of the default mode to the subcortical network significantly contributed to the predictive model.

Conclusion
Our AI-predict model showed that regions within the subcortical areas, including the hippocampus, and their interactions with the cortical default mode network, contributed to predicting individual differences in EM. This is in line with several previous studies showing that interactions between the default mode network regions have implications for memory function.

Digital twin predicting diet response before and after long-term fasting

Oscar Arrestam, Christian Simonsson, Mattias Ekstedt, Peter Lundberg, Peter Gennemark, Gunnar Cedersund

Keywords:
Diet response; Systems biology; Protein metabolism; Health optimization

Today, there is great interest in diets proposing new combinations of macronutrient compositions and fasting schedules. Unfortunately, there is little consensus regarding the impact of these different diets, since available studies measure different sets of variables in different populations, thus only providing partial, non-connected insights. We lack an approach for integrating all such partial insights into a useful and interconnected big picture. Herein, we present such an integrating tool. The tool uses a novel mathematical model that describes mechanisms regulating diet-response and fasting metabolic fluxes, both for organ-organ crosstalk, and inside the liver. The tool can mechanistically explain and integrate data from several clinical studies, and correctly predict new independent data, including data from a new study. Using this model, we can predict non-measured variables, e.g. hepatic glycogen and gluconeogenesis, in response to fasting and different diets. Furthermore, we exemplify how such metabolic responses can be successfully adapted to a specific individual's sex, weight, height, as well as to the individual's historical data of metabolite dynamics. This thus enables an offline digital twin technology.

Development of a compact SFDS system for quantitative assessment of skin in clinical settings

Sumaya MO, Rolf Saager

Keywords:
Optics, Depth, Skin, Clinics, Non-invasive

Over the years, several non-invasive optics-based methods have been developed to assist in diagnosing various skin conditions and diseases. One of these methods is spatial frequency domain spectroscopy (SFDS) which uses light transport models to quantify the optical properties (absorption and reduced scattering coefficients) of biological tissues. SFDS uses a broadband source to illuminate the region of interest by subjecting it to a light pattern which will penetrate the skin and allow photons to interact with the tissue. This enables detection of reflected light over a wide range of depth which allows the SFDS system to collect data from a broad-spectrum conveying

the optical properties of deeper tissues. Currently existing SFDS systems are difficult to use in clinical settings due to size, bulkiness, and rigidity. To solve that problem, we present our compact SFDS system which consists of two units that project and detect, respectively. The main objective of this is to build a device that is flexible and can be used in clinical settings.

Evaluation of brain tumor radiosurgery treatment plans using fMRI-derived functional organs at risk

David Abramian, Ida Blystad, Anders Eklund

Keywords:
Gamma Knife, Radiosurgery, Brain tumors, Functional MRI

Stereotactic radiosurgery (SRS) provides a non-invasive alternative to resection for the excision of small brain tumors. However, due to its use of ionizing radiation to destroy the target tissue, patients can experience complications after treatment, including functional deficits. To minimize the risk of complications arising, sensitive brain regions can be specified as organs at risk (OARs) in the treatment planning phase, with the dose distribution being tailored to spare these regions. These OARs typically include anatomical landmarks such as the optic nerves and brainstem, but to date no attempt at avoiding eloquent brain regions by providing functional OARs (fOARs) has been reported.

In this work we used open MRI data from 5 brain tumor patients to investigate the effects of including fOARs in the dose optimization process for Gamma Knife SRS, as carried out by the automated dose optimization algorithm available in the associated GammaPlan software. fOARs were obtained by performing activation mapping of functional MRI data, including motor and language tasks. We present the effects of the inclusion of such fOARs on planning time, treatment time, treatment metrics, and dose received by the various fOARs.

TBA

Karin Hedin, Roland Nilsson, Gunnar Cedersund, Nina Grankvist, Cecilia Jönsson, Nicolas Sundqvist, Daniel Rancho, Kyumi Byun

Keywords:
NAFLD, Digital twin, Liver (ex vivo)

NAFLD is one of the leading causes of chronic liver disease worldwide. It is defined as macrovesicular steatosis in > 5 % of hepatocytes, in the absence of a secondary cause. If untreated, NAFLD can progress into fibrosis and inflammation of the liver, and ultimately develop into liver cirrhosis, which requires the organ to be transplanted. It is well known that the metabolic activity of the liver is altered in patients with NAFLD. The objective of this study is to investigate how metabolic fluxes are altered in patients with NAFLD by the use of live liver tissue, cultivated in C13 traced culture media coupled to advanced computational models. Hopefully, this will shed some light to the metabolic enigma that is NAFLD.

Keywords:
Microcirculation, Reflectance spectroscopy, Capillary refill test

The capillary refill test in acutely ill children – intra observer reliability and inter observer agreement

Frida Meyer

The microcirculation is altered in acute illness and blood loss, but there is a limited understanding of how it corresponds to clinical features. In emergency clinical settings, simple bedside tests for assessing the patients' circulatory status are sought for, especially when assessing pediatric patients. One of the few tests available is the capillary refill test. The skin of the patient, often on the sternum, is pressed down by the examiners' index finger for 5 seconds, and when the pressure is removed the number of seconds it takes for the blanching of the skin to disappear, is counted. If the time it takes for the skin to resume its original color is 2 seconds or more there is a general perception that the patient is circulatory compromised. In this study, the aim was to explore observer related causes of error. Staff from a pediatric emergency department observed videos of capillary refill tests from pediatric patients and asked to estimate the capillary refill time. Some videos were shown twice. The capillary refill time was quantified using video reflectance spectroscopy (TiVi) and software (WheelsBridge). The observers' estimations of capillary refill time showed poor reproducibility, even by the same observers, and differed from the quantified capillary refill time. Further research, both exploring microcirculatory characteristics, and on how clinical staff perceive microcirculatory tests, is needed.

Keywords:
Cardiovascular, Diabetes, Hypertension, Modelling, MRI

Insights of hemodynamic changes in hypertension and T2D through non-invasive cardiovascular modeling

Kajsa Tunedal, Belén Casas, Carl-Johan Carlhäll, Federica Viola, Tino Ebbers & Gunnar Cedersund

Today, 22% of all persons worldwide have high blood pressure (hypertension), and it is twice as common in patients with type 2 diabetes (T2D). Uncontrolled hypertension is a risk factor for cardiovascular diseases such as coronary artery disease, heart failure, and renal failure. The basic causes of hypertension, such as hemodynamic changes due to increased blood volume and aortic and vascular stiffness, are known. Nonetheless, hypertension treatment is today based on a trial- and error approach where several anti-hypertensive drugs are tested. There is a need for a deeper understanding of the changes in hemodynamics during hypertension and T2D. Detailed hemodynamic data can be acquired with non-invasive measurements such as 3D imaging of blood flow over time, four-dimensional magnetic resonance imaging (4D Flow MRI). However, 4D Flow MRI cannot measure blood pressure or elastance of the heart and aorta. In this study, we combine 4D flow data with a cardiovascular model to extract information that otherwise is hard to measure non-invasively. For 38 T2D patients and 43 controls, we used patient-specific data to create personalized models of the individual hemodynamics. Finally, the models were used to predict changes in model-derived biomarkers in disease progression from healthy to hypertensive T2D patients and in potential treatments. Preliminary results show changes in atrial and ventricular relaxation in both hypertension and T2D. The study can bring new insights into the hemodynamic mechanisms behind hypertension in patients with or without T2D and may provide a new clinical tool for the assessment of personalized hemodynamics.

Keywords:
Multiple sclerosis, Biomarker, Organic electrochemical transistors

Monitoring Multiple Sclerosis Progression and Response to Treatment with OECT-based Biosensors

Sara Hojjati, Jan Ernerudh (and possibly Bernhard Burtscher, Daniel Simon)

The main goal of this PhD project is to manufacture organic electrochemical transistor (OECT) based biosensors for detection of multiple sclerosis (MS) protein biomarkers in cerebrospinal fluid (CSF) samples. OECT biosensors are highly sensitive, specific, and biocompatible devices that can detect trace amount of target molecules in fluid samples. Initially, proteomics and bioinformatics methods are applied on different MS cohorts to find most relevant cytokines and chemokines in CSF that could be of prognostic value. Afterwards, a semiconductor is manufactured and characterized from multiple aspects to measure transconductance, signal amplification, etc. this will be followed by biofunctionalization of the manufactured device with recognition elements such as aptamers or antibodies which facilitate the specific quantification of small amount of proteins in fluids. For sensing, electrochemical methods such as cyclic voltammetry, impedance spectroscopy etc., are being used. This project is ongoing and preliminary results have been obtained.

Keywords:
Spectral imaging, Wound healing, Depth resolved, Tissue-simulating phantoms

Enhanced thin layer detection with spatial frequency domain imaging using multiple spatial frequencies ranges

Luigi Belcastro, Hanna Jonasson, Tomas Strömberg, Ahmed Elserafy, Rolf B. Saager

Spatial frequency domain imaging (SFDI) is a spectral imaging technique that uses patterns of light to quantitatively measure optical properties non-invasively over a wide field of view. Currently, the light propagation models used in SFDI assume a semi-infinite homogeneous medium. Biological tissue, however, is composed by several layers with different properties. Many biological applications would benefit greatly from the ability to discriminate between thin layers of tissue.
We propose a new technique that makes use of the difference in penetration depth of structured illumination, depending on the spatial frequency of the patterns to separate the measurements of the underlying tissue from a superficial thin layer and estimate its thickness. The technique has been tested on layered silicone phantoms of known optical properties and thickness. SFDI data has been acquired at 11 spatial frequencies with an imaging system and optical properties were reconstructed from 8 partially overlapping sets of spatial frequencies. These sets of data give us information about different volumes of tissue, which were used as a base for our algorithm.
The technique has been used to assess the efficacy of stem cells-based therapies for wound regeneration. Burn wounds have been created on human tissue ex-vivo. Stem cells have been applied on the wound and cultured for ten days. An SFDI data set was acquired and processed at several spatial frequency ranges. The dataset was then used to estimate the thickness of the new growth of epithelial cells and results were compared with histology results from biopsies.

Keywords:
Laser Doppler flowmetry (LDF), Brain microcirculation, Subarachnoid haemorrhage (SAH), Neurointensive care unit (NICU)

Long-term recordings of cerebral microcirculation during neurointensive care

Stina Mauritzon, Fredrik Ginstman, Oscar Åneman, Jan Hillman, Peter Zsigmond, Karin Wårdell

Introduction

Subarachnoid haemorrhage (SAH) patients are monitored in the neurointensive care unit (NICU) to avoid further brain damage such as ischaemia or infarction. Current multimodal approaches mostly include snapshot measurements of the cerebral blood flow, whereas continuous monitoring techniques such as laser Doppler flowmetry (LDF) could add useful information about the immediate physiological state. Therefore, a LDF system for brain microcirculation monitoring was adapted (1) with the aim to detect signal patterns indicating pathophysiological events, such as vasospasm, at an early stage.

Method

A two-channel optical probe for LDF monitoring (PF5000, Perimed, Sweden) of brain perfusion and total light intensity was designed. The system was adapted for use during all aspects of the neurointensive care, including MR scans and possible additional surgeries. After obtaining informed consent (EPM 2018/322-31, 2021-03527), data acquisition was done on two patients 4-6 hours per day using LabVIEW (National Instruments Inc., USA) and notes of clinical events were taken during each session. Data analysis included trend curves, peak-to-peak and time-frequency analysis using wavelets.

Result and conclusion

The system provided stable signals throughout the 10 days of neurointensive care, which included endovascular surgery for vasospasm. The resulting data showed slowly changing trends, dynamic rapid changes and vasomotion. Unwanted movement artefacts could be identified through time-frequency analysis, which offers the possibility to study the microvascular blood flow response to treatment and common pathophysiological events after SAH without artefact interference. Next steps include more measurements, further analysis of signal patterns and correlation with other monitored NICU parameters and MR scans.

References

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Keywords:
Diffusion, Confinement, Microstructure, Restricted, Tensor, Distribution

Multidimensional Diffusion MRI with Confined Subdomains

Deneb Boito, Cem Yolcu, Evren Özarslan

Diffusion Magnetic Resonance Imaging (dMRI) is an imaging technique sensitive to the structural properties of complex media at the microscopic scale. This is achieved by sensitizing the MR signal to the random motion of water molecules. Information recovered via dMRI has been used to characterize, for example, disease-induced alterations in brain tissue. Conventional acquisition schemes produce data where the effects of different factors on the motion of water molecules cannot be disentangled, thus limiting the interpretability of the results. Recent developments in encoding schemes have been suggested as a means for adding specificity to the recovered information, allowing a more complete description of the medium. This is typically achieved by representing the medium as a collection of non-exchanging compartments, each of which exhibits unrestricted diffusion. This resulted in a series of methods collectively referred to as multidimensional diffusion MRI. In this work we propose to represent the medium using a model that takes confinement of each compartment into consideration, thus providing a diffusion time-dependence closer to that of restricted diffusion. First, we demonstrate that this confinement tensor model captures features of both free and restricted diffusion in data simulated using a clinically feasible acquisition scheme for different pore geometries. Then, we incorporate this model into one of the multidimensional dMRI methods, and attempt to estimate the distribution of confinement tensors on a healthy human brain dataset.

Keywords:
Brain, Electrophysiology, Mathematical modelling, Neuroscience

The future of multi-level models of the brain

Henrik Podéus, Nicolas Sundqvist, Malin Silverå Ejneby, Gunnar Cedersund

In the pursuit of a full model description of the brain, we will expand and integrate the available models of the brain. With a vast collaboration network we will integrate, i) electrophysiological knowledge, ii) include a description of how the neurons are geometrically arranged and the electrical signalling that occurs in a vast network, iii) detailed intracellular knowledge of how ion channels are activated in the neurons, iv) include an intracellular logic of neuronal facilitation and depression, v) knowledge of the intracellular processes resulting in secretion of vasoactive substance controlling the response of local blood flow in the brain. By integrating these aspects into a model, we aim to have a model that can, not only accurately describe the geometrical position of the neurons in the brain, but also includes logic of the behaviour of a single neuron. With these intracellular descriptions included in the full model, we hope that this can be used as a basis to study and predict different diseases, such as if the facilitation of neurons can cause epilepsy, and how Alzheimer's disease affects the signalling patterns between neurons populations. Conditions like stroke could also be explored by introducing a vascular description of the blood vessels in the brain. This would allow the blood supply and oxygenation of the extracellular tissue to be included, closing the loop between electrophysiology and hemodynamics. This would also bring value for imaging techniques such as functional magnetic resonance imaging (fMRI).

Department of Biomedical Engineering (IMT)

In close collaboration with the medical technology industry and medical clinics we work to meet the needs in healthcare. Since 1972, we have been a national center for research and graduate and undergraduate education in medical technology.

We strive towards being a catalyst for sustainability in future medical systems and innovations – an arena for leading international researchers and teachers where new knowledge is created and dispersed.

Our research and education centers around biomedical optics, ultrasound and bio-acoustics, modeling and simulation of physiological processes, neuro-technology, knowledge-based decision support systems as well as signal and image processing methods.

Forum Östergötland

Forum Östergötland is a support function for clinical and translational research at Linköping University and Region Östergötland. We are a part of the regional node Forum Southeast in the national collaboration Clinical Studies Sweden.
Forum Östergötland provides scientific, regulatory and statistic counselling support at the start or underway of a clinical research project. We provide help with statistical analyses such as power calculations, study design and data management. We can provide help with setting up e-CRF (electronic data collection tool) for a clinical study. We can help scientist with creating study protocol, informed consent form and all the essential documents required to make a combined application for a clinical investigation of medical device to the Swedish Medical Products Agency (Swedish MPA) (involving the ethics part). Forum Östergötland can provide help with randomization and monitoring of clinical studies and within Forum Östergötland there is a clinical trial facility with research nurses.

All clinical investigations regarding medical devices which follows MDR, have to be submitted to the MPA as of 2021. A clinical investigation is a systematic investigation involving one or more human subjects, undertaken to assess the safety or performance of a device according to the EU Regulation 2017/745 on medical devices (MDR).

Forum Scientium - Cultivating curiosity and community between Life Science, Medicine and Engineering

Forum currently comprises 65 doctoral students and postdocs, representing five departments, from both the medical and technical faculties, across LiU's three main campuses. As an interdisciplinary graduate research school in its 25th year, it has been our legacy to provide graduate students and postdocs with exceptional opportunities to reach beyond the bounds of their specific disciplines and continues toward this aim under the new management of Rozalyn Simon and Caroline Brommesson. By providing leadership training, professional presentation and communication skills, specialized courses in project management, grant writing, and even national and international study visits, Forum provides students with the tools and experience to extend their networks, enhance their qualifications, and recognize potential careers including those outside of academia.

As new interfaces are continuously being established at LiU (e.g., in medicine, humanities, bioethics, sustainability, and environmental sciences) Forum's vision is to expand the diversity of perspectives at the interface of technology and medicine through the invitation of PhDs and postdocs within these new related fields. Forum will also continue efforts to recruit industrial and clinical PhD students to enhance the expertise represented in our interdisciplinary network. With the addition of large national initiatives such as Wallenberg AI Autonomous Systems and Software Program (WASP), and Analytic Imaging Diagnostics Arena in AI (AIDA), Wallenberg Initiative Materials Science for Sustainability (WISE), and Data-Driven Life Science (DDLS), Forum aims to connect to existing and upcoming national graduate research schools by providing a package of leadership and project management courses, interdisciplinary seminar series, workshops, conferences, and most importantly a local network and meeting place.

Advanced Tissue Simulating Optical Phantoms – a LiU Resource

This resource enables a fundamental shift in early medical device development that replaces animal use to evaluate instrument performance and accuracy with physical proxies that are constructed specifically to mimic human tissue over a range of pathological states while also covering normal biological variances (such as skin pigmentation, diet, age, etc.). Here, not only can these proxies, otherwise known as "tissue simulating phantoms," remove the need for animal experiments and all of its associated costs and oversight, but it can also evaluate the optical device's sensitivity to other known sources of biological variance and thereby provide constructive feedback on the device design and performance. Lastly, these proposed phantoms are inert, stable over time, and independently traceable. These can also provide a Gold Standard to evaluate the device performance not just in its developmental stage, but again when it is seeking clearance for medical use.

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