BERN UNIVERSITY OF APPLIED SCIENCES

Today, many tasks call for interdisciplinary solutions. In order to better address these requirements, the Bern University of Applied Sciences (BFH) aims to concentrate and strengthen its competencies in specific areas based on established research groups. The BFH centres offer answers to current and future social and technological issues. They are unique in Switzerland due to their set-up and holistic approach.

For example, the BFH Centre for Technologies in Sports and Medicine combines the research and development activities of various institutions: two research institutes from the field of engineering and information technology collaborate with the Health Division and the Swiss Federal Institute of Sport. Thus, engineers can work together with medical doctors, health and physiology specialists, as well as sports coaches to achieve the common goal of sharing expertise with industrial partners and expediting innovation.

In addition to bringing together experts, linking research and education is an important concept of the BFH. Many of the lecturers are simultaneously engaged in research. And the latest discoveries and methods are incorporated and actively implemented in teaching - especially in the context of semester papers and projects. Thus, students often contribute to the development of marketable products, particularly in cooperation with business partners and spin-off companies.

This practice-oriented education prepares students both at bachelor's and master's levels to become outstandingly qualified specialists and executives in the industry. People who are already working can take their careers one step further with continuing education, for example, with the new program in Digital Health.

Medtech is an important branch of industry for Switzerland and has been able to grow steadily in recent years. The BFH is ready to further contribute to this positive development by providing the industry with well-trained professionals and close cooperation in the field of research and development. The Bern University of Applied Sciences is well connected as member of the Medical Cluster and the Competence Centre for Medical Technology – and a valuable partner in the region Mittelland, as well as throughout Switzerland and internationally.

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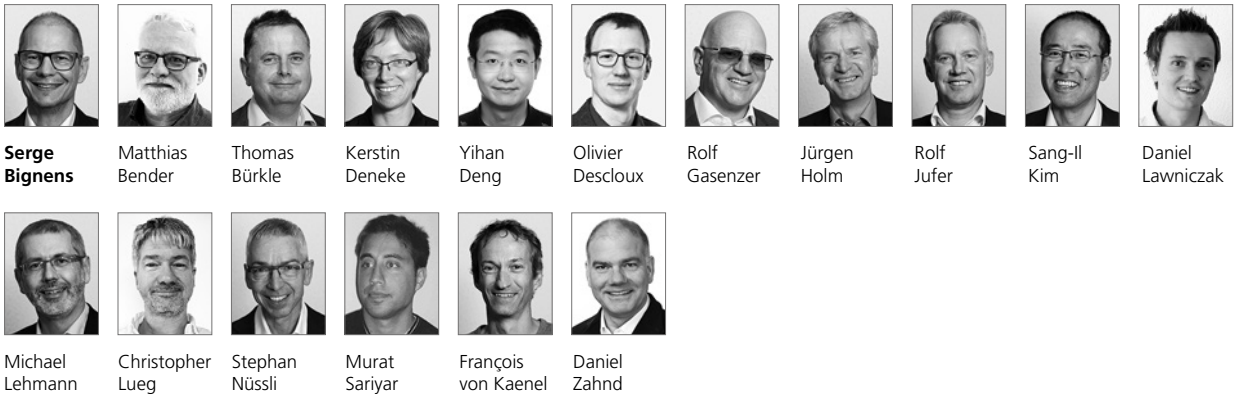


Serge Bignens | Matthias Bender | Thomas Bürkle | Kerstin Deneke | Yihan Deng | Olivier Descloux | Rolf Gasenzer | Jürgen Holm | Rolf Jufer | Sang-Il Kim | Daniel Lawniczak

Michael Lehmann | Christopher Lueg | Stephan Nüssli | Murat Sariyar | François von Kaenel | Daniel Zahnd

Research Profile

Knowledge Management

We focus on activities in the field of decision-making support (clinical decision support), expert systems and terminology, semantics, and ontologies closely associated with them for applications in the field of pharmaceutical treatment safety and data management, for example, clinical studies or e-learning. A sample project is the audit of the Tarmed accounting system for H+, the association of Swiss hospitals.

Evaluation of medical IT applications

We possess expertise in the evaluation of medical IT applications – for example, clinical IT systems, decision-support systems and active and assisted living (AAL) installations – as well as in the assessment of quality initiatives and e-health infrastructure. A sample project is the production of an evaluation handbook for the Swiss eHealth initiative.

E-Health and telemedicine

We run and support a wide range of initiatives in the field of e-health and telemedicine concerning the development of the Swiss electronic patient records system, mobile health, the set-up of integrated care processes, and telemedical applications. In this we analyse aspects of technical and semantic interoperability, the integration of AAL environments, the secondary use of data, and big data. An example of our activities in this area is the set-up of the national test environment for the Swiss electronic patient records system.

Patient-centred applications

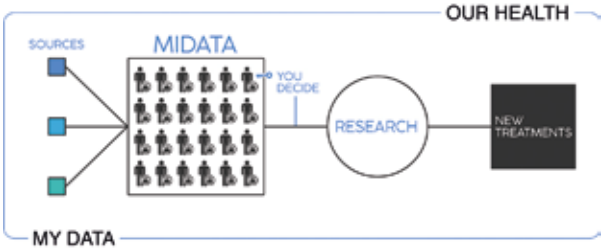
A key area of our research activities is patient-centred applications, such as personal mobile applications (apps), studies on patient empowerment and self-management, compliance support activities, and the integration of AAL with the service providers. We also focus on personalised medicine as an area of application. Informed patient privacy consent plays a significant role here. An example of application is the development of a pollen allergy app (Ally Science) for a major pollen study, supported by the citizen science approach, based on the MIDATA personal data and consent-management platform.

Information management and economic analysis of processes in the healthcare sector

Finally, another area we focus on is information management and the economic analysis of processes in the healthcare sector. We possess expertise and our own management tools in this environment for the analysis of treatment processes, the optimisation of treatment chains, the simulation of logistics processes, the design of clinical pathways, including pathway cost calculations, and the working procedures for electronic order communication (Computerised Physician Order Entry (CPOE)). One example is the "Hospital of the Future" project in cooperation with GS1.

MIDATA: Patient-centric Administration of Personal Health Data

MIDATA provides a new approach to the storage, management, and secondary use of personal health data. MIDATA places the emphasis on citizens as the owners of their data and thus transforms them from passive recipients of healthcare services to key players. Both healthy and ill citizens will be able to manage their own medical and non-medical health data themselves, thus obtaining maximum value added from this data. Organised as a not-for-profit association, MIDATA is controlled by the data owners themselves and ensures that society benefits from the gains made from the secondary use of data. This citizen-controlled added value from the data, which is currently still located in silos, forms the basis for personalised medicine and more effective and sustainable healthcare provision.



The MIDATA IT architecture has a modular structure and provides a FHIR API and semantic interoperability. It is based on cloud computing technology. The data

undergoes multiple encryptions and is stored with a leading Swiss cloud provider to guarantee the highest level of data security. Members can enter, manage, analyse, and visualise their data via a website and mobile apps, as well as granting healthcare providers and researchers access to particular data sets. Service providers and researchers access this shared data via their own dedicated portal.

Further services enable communication and the selection of appointments with healthcare providers. The possibilities presented by gamification and the creation of competitions between members will be introduced in the next version. MIDATA combines the attributes of an electronic patient records system and a personal data account with social networking tools and links to apps and applications of third-party providers.

Two pilot projects are currently in preparation. In the first project, the effectiveness of new treatments for chronically ill multiple sclerosis patients will be tested in a clinical study with the Department of Neurology at the University Hospital Zurich. The second project in collaboration with the University Hospital of Bern (Inselspital) focuses on after-care for obesity patients after bariatric surgery.

Project partners
- Federal Institute of Technology Zurich, Institute of Molecular Systems Biology
- University Hospital of Bern (Insel Group), Department of Visceral Surgery and Medicine, Obesity Centre
- University Hospital Zurich, Department of Neurology, Neuroimmunology and Multiple Sclerosis (NIMS)

Hospital of the Future Live

In the "Hospital of the Future" multi-stakeholder project, we focused on the extent to which the integration of treatment-relevant information flows can produce improvement potential at hospitals.

More than 20 organisations from the Swiss healthcare sector – including six hospitals, the IHE-Suisse and ehealthsuisse – came together for the workshops. They have thus far specifically identified over 50 future application scenarios with the focus: How can medical IT have a positive impact for people on the treatment pathway or the care network within five to seven years?

A typical treatment pathway (hip replacement) was selected from the perspective of a fictitious patient "Ms. Elisabeth Brönnimann," analysed in terms of efficiency, treatment quality, and patient safety and compared with an optimised pathway. Particular attention was often paid to the technical and cultural interfaces at the hospitals and along the outpatient/inpatient interface.

The work packages defined at the workshops were implemented as prototypes in I4MI's Living Lab. In particular, they focused on elements such as electronic patient records (EPD), the integration of mobile devices, and an active assisted living (AAL) apartment. The decisive factor was always how the situation looked from Ms Brönnimann's perspective, which means that user-centred design is a key element in the overall project.

Findings

Two current medical IT developments in the healthcare sector in particular – the setting-up of e-health communities and the advent of the digital transformation (Health 4.0, Internet of Things) – provide many opportunities for the effective, people-focused digitisation of the healthcare sector.

The combination of these technologies is likely to produce a major synergy effect. The challenges include:
- The implementation of regulatory provisions in the context of eHealth Suisse
- The increase in patient safety through an improved overview of the treatment processes, e.g. an improved medication process
- The traceability of medical products and pharmaceuticals
- The appropriate application of international standards
- The convergence of existing technologies, such as eHealth (networking), pHealth (personalised health data), mHealth (mobile health), and aHealth (automation) for a digitised society.

In the "Hospital of the Future" project, these conditions provided the framework for the focus on integral information flows along patient-oriented treatment paths, care networks, and the supply chains associated with them.

Project plan as an innovation process: (1) Multi-stakeholder workshops, where the work packages are defined, are held twice a year. These may be new packages or take work done in previous projects into more depth. (2) The work packages are incorporated into the following semester for the medical IT students in the form of internships, seminar projects, or bachelor theses. (3) The stakeholders support the students as experts according to their area of expertise and evaluate the results based on suitability for application. (4) Promising projects are implemented as prototypes in the Living Lab of the Medical IT Department and are integrated into the treatment process in their entirety (taking account of upstream and downstream processes and information flows). (5) The most promising developments are implemented as pilot projects with future users in collaboration with the stakeholders/project partners and (6) a business plan is drawn up and they are rolled out on the market in the event of a positive response.

Selected Publications

https://www.e-health-suisse.ch/gemeinschaften-umsetzung/epd-gemeinschaften.html

Widmer W., Schaffhuser K., Gesundheitswesen gestalten, careum Verlag, p. 110-134, 1st edition 2018

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Research Profile

The Institute for Human Centered Engineering HuCE combines its know-how acquired from research projects in various fields with engineering technologies in an interdisciplinary way to develop new products for industry and hospitals. The focus is on strong engineering technology core competences. Our practical problem-solving approach together with our clinical partnerships provides a basis for innovative products. The engineering core competences in our six research laboratories are:

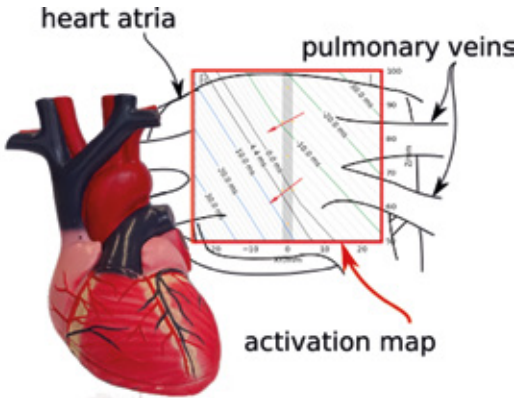
- Medical Instrumentation
- Electronic Implants
- Optical Instruments for Diagnosis
- Imaging in Medical Technology
- Optical Coherence Tomography
- Haptic Feedback Systems
- Sensors and Sensor Networks
- Signal Processing and Control
- Low-power Microelectronics
- High-speed Hardware Algorithms in Combination with Biomedical Engineering Applications

HuCE is currently involved in several SNF and more than a dozen Innosuisse/CTI-funded research projects, several medtec and industrial engineering projects, and has been the incubator for a few spin-off companies.

Research Area: Medical Diagnostic Devices in Electrophysiology

Semi-Invasive 3D Mapping System for Cardiac Arrhythmias Using Esophagus ECG Signals

Early detection of adverse arrhythmias is, in many cases, crucial to prevent more serious consequences. Whenever an arrhythmia is identified and an interventional therapy is indicated, the therapy planning so far usually relies on 12 lead ECG signals solely. Many common arrhythmias are localized in the heart's atria, exactly in that location that is insufficiently represented in common ECGs. Thus, our approach complements this standard ECG signals with ECG signals measured in the esophagus: The esophagus runs close to the hearts atria and, thus, provides a superior signal quality there. But we not only are interested in solely recording these signals, we use them to calculate the electrical activity on the atria surface in a three-dimensional manner, leading to a so-called activation mapping. The current research tightly links multiple disciplines: the catheter construction, signal acquisition technique, signal processing including high-speed hardware algorithm based on FPGAs and ASICs, and finally application software development, writing a diagnosis-supporting visualization tool. Overall, we aim at a bedside tool that provides clinicians with additional information and thus facilitates diagnosis in cardiology, or more specific, in rhythmology. This project is in close cooperation with the Department of Cardiology at Bern University Hospital and financed by SNF CR23I2_166030.

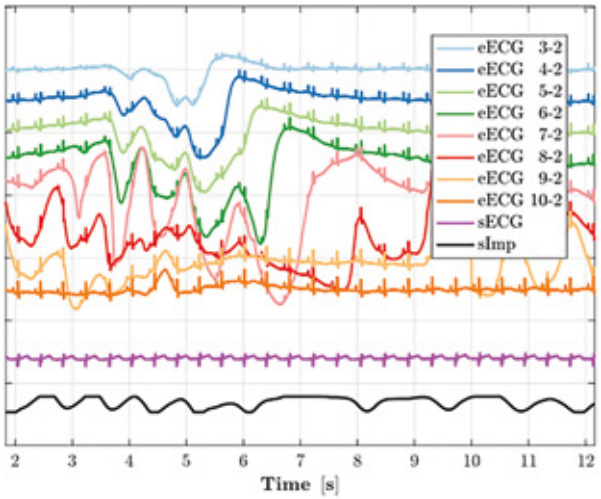


The figure shows an activation map of the left atrial posterior wall (red box), visualizing the electrical activity of the heart at each single beat. This map is the result of an algorithm performing a three-dimensional mapping based on the esophageal ECG measurements.

Neonatal Esophageal Observation (NEO) System for Improved Preterm Infant Care

Preterm infants, who account for more than 10% of all births worldwide, very often require cardiorespiratory monitoring on a neonatal intensive care unit (NICU) due to autonomic dysregulation. Surveillance of the heart rhythm and respiratory rate, however, is cumbersome since surface ECG and impedance registrations suffer from relevant motion artifacts. The resulting high number of false-positive alarms impedes care prioritization and optimal support of these neonates. Furthermore, accurate diagnostic tools that objectively assess and monitor precisely the level of maturation of neonates are lacking. Objective discharge from the NICU cannot be guaranteed.

To overcome the limitations of state-of-the-art technology, we aim to develop a novel monitoring system for preterm infants. The neonatal esophageal observation (NEO) system bases on esophageal signal recording, a technique that is widely known to provide high-quality electrocardiography and diaphragm electromyography. Based on recent technical advances in diagnostic catheter design and manufacturing, the NEO project proposes that vital signs and autonomic dysregulation may be monitored with a single esophageal catheter. With the initial support of the Swiss Heart Foundation and Bangerter-Rhyner-Foundation a first step towards the NEO system has been realized: the visualization of peristaltic waves in preterm infants by multichannel esophageal electrodes.



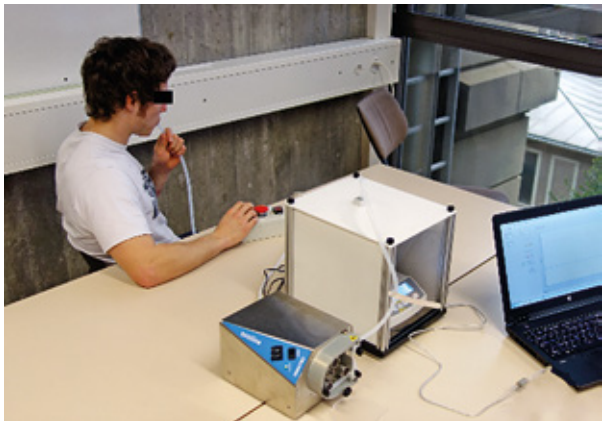
Multichannel esophageal signals recorded with a nasogastric feeding tube depicts peristaltic waves travelling from the most proximal (#2) to the most distal electrodes (#10).

Research Area: Therapy

Drinkometer

An effective treatment for morbid obese patients is the gastric bypass operation in which the size of the stomach is reduced and reconnected to bypass the first portion of

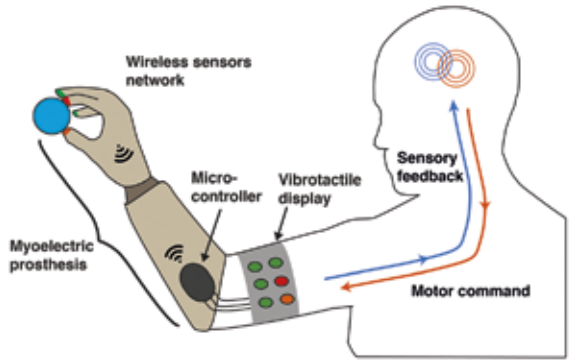
the small intestine. Studies suggest that the selection and intake of foods varying in fat content and glycemic index, as well as the pattern of ingestion within and across meals, changes for patients after such an operation. We developed a device («drinkometer ») that can measure detailed aspects of ingestion over time within a meal in humans. The drinkometer records the drinking speed with 1 kHz sampling and identifies individual sucks and bursts with their respective volumes, durations, and rates. A first study proves that our novel drinkometer can detect differences in drinking behavior dependent on different motivational states, thus, adds to the technological toolbox used to explore human ingestive behavior. The project is a collaboration with the UniSpital Zurich, which also financed it.



The Drinkometer device in use with a test-person.

WiseSkin – a Prosthesis with Sensor Skin

Amputation of a hand or limb is a catastrophic event affecting life quality. The WiseSkin project aimed at developing a prosthesis with a sensor skin that would allow for the feeling of pressure. The project was sponsored by NanoTera and SNSF, with three partners: CSEM, EPFL, and BFH. The WiseSkin concept is based on a sensor «skin». Wireless communication is used to transfer data to the actuators. Our work involved the investigation of a non-invasive sensory-substitution system using phantom maps, system design, as well as final integration and development of a functional prototype.



Concept of the WiseSkin demonstrator (source: LSBI-EPFL).

DrillMon - Nerve Detection while Drilling

To restore hearing in deaf patients, Cochlear implants are widely used. During implantation, when drilling, it is important to not harm delicate anatomical structures, in particular the facial nerve. Today, there are systems that allow determining distance to nerves. Some of these require removing the drill and inserting a stimulation electrode. We are developing an improved drilling system that integrates the stimulation electrode into the drill. This allows nerve detection without changing tools while the drill is spinning with up to 80'000 rpm. The project is financed by Innosuisse and involves the industrial partners Bien-Air Surgery SA (Le Noirmont) and inomed Medizintechnik GmbH (Emmendingen, Germany).

Drilling in a custom-made phantom with nerve monitoring.

Concept for a Low-Cost Hand Prosthesis for Children

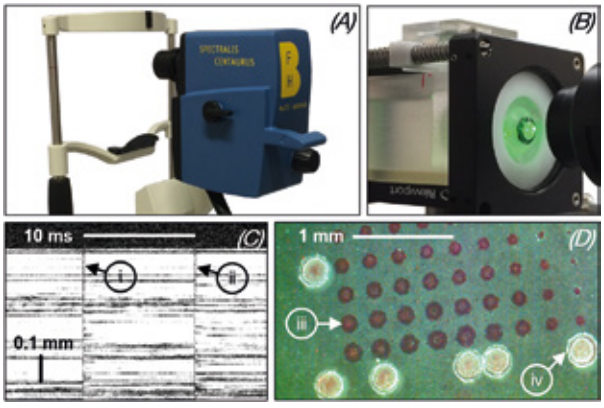
According to the World Health Organization, about 30 million people in Africa, Asia, and Latin America do not have access to adequate prostheses or orthotics. Commercial myoelectric prosthesis cost between 20’000 and 100’000 CHF. In developed countries, insurance companies usually limit contributions to prosthetic services to 500 to 3’000 CHF per year and 10’000 CHF to prosthetic devices during a person's lifetime. While a hand prosthesis may be a one-time investment for an adult, children and adolescents need to replace their prostheses often as they grow.

Realized prototype low-cost hand prosthesis. Size comparison between the hand of a 9-year-old child and the prosthesis. The prosthesis is controlled intuitively by reading EMG signals near the elbow.

In this project, a low-cost prosthesis for children and adolescents that is able to support daily activities was designed and built. To reduce costs, the expensive components of the prosthesis are reused as the child grows and the mechanical structure is 3D-printed. The estimated material costs are below 500 CHF for a prosthesis.
A functional prototype has been realized to prove the concepts behind the development. The prosthesis is intuitively controlled by an eight-electrodes EMG sensor placed on the forearm of the patient. Machine-learning based on a neural network acquires the sensor signal and recognizes the pattern. A controller then commands the six degrees of freedom of the prosthesis to achieve the desired hand configuration. Future work shall miniaturize the computation unit and power supply. Usability tests with patients will provide important end-user feedback. Finally, the device shall be further developed into a commercial product in developed countries and for humanitarian use in developing countries.

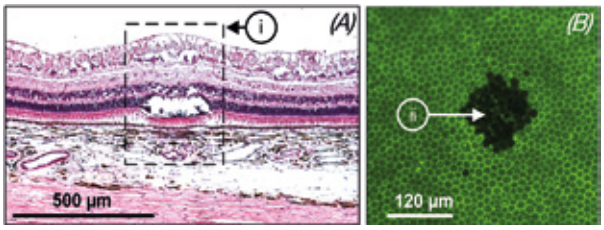
Optical Coherence Tomography Controlled Selective Retina Therapy for In-vivo Treatment

Conventional laser photocoagulation (LPC) is a common treatment method for retinal diseases that unfortunately leads to collateral damage of all retinal layers including healthy, non-regenerative photoreceptors. An alternative approach is selective retina therapy (SRT), in which finely dosed laser pulses in the sub-microsecond range cause selective cell death limited to the retinal pigment epithelium (RPE).
However, the complexity of radiant exposure control in variable absorbing tissue prevented wider uptake of the technology. Recent literature shows that optical coherence tomography (OCT) can provide reliable dosimetry control in parallel with SRT because RPE lesions can be predicted indirectly as a change of OCT signal strength in M-scans. In this project we investigated in OCT-controlled SRT in ex-vivo porcine test series and built the base for an upcoming human in vivo study.
For the experiments, the Spectralis Centaurus system was built, adapted, and tested for controlled treatment of excised porcine eyes. This device provides OCT in parallel to SRT and uses a dedicated laser manufactured for this project according to parameters that are mostly chosen in recent SRT studies.



(A) HuCE-optoLab Spectralis Centaurus system. (B) artificial eye used for porcine RPE explant measurements. (C) presents a M-scan with two so-called signal washouts showing a change of OCT signal strength (i,ii). (D) RPE sample evaluated under a fluorescence microscope with typical SRT (iii) and LPC marker lesion (iv).

To verify the laser's capability for SRT, experiments with different laser pulse durations in the microsecond range were carried out. Therefore, entire porcine eyes or porcine RPE explants were treated. Evaluation of the samples took place by using a live/dead staining kit (EthD-1, Calcein AM) and visualization by a fluorescence microscope and histological sections with hematoxylin and eosin (H&E) staining. Furthermore, the clinical potential of the system's OCT M-scans dosimetry was evaluated at the Medical Laser Center Lübeck.

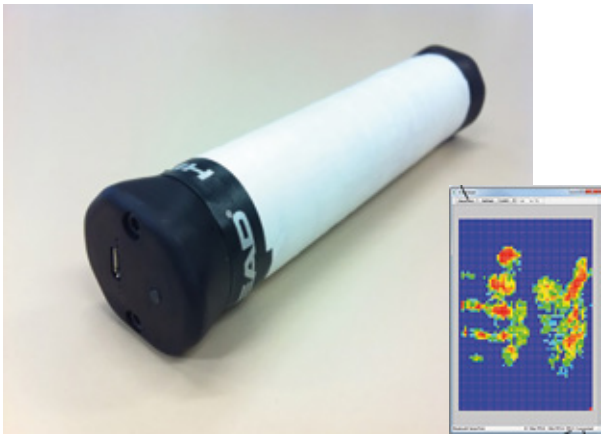


(A) histological sections with H&E stain of porcine retina at a LPC marker lesion (i). (B) RPE sample with rectangular SRT lesion (ii) evaluated under a fluorescence microscope.

Results: Histological sections with H&E stain showed LPC marker lesions but SRT lesions were not found. For the applied treatment parameters, changes of OCT signal strength in M-scans were observed when the Spectralis Centaurus system and the laser were able to create SRT lesions in porcine RPE. The novel Spectralis Centaurus system and the laser fulfill the requirements for OCT-controlled SRT. However, the sensitivity of the signal washout detection in OCT M-scans has to be improved. Regarding the experiments with different laser pulse durations, the results obtained correspond to the findings of similar studies. In general, OCT as real-time dosimetry has the potential to establish SRT as standard therapy for RPE-related retinal pathologies. A patient study at the University Hospital Bern (Augenklinik, Inselspital) is planned for 2019.

2D Hand Grip Sensor

A cylindrical sensor has been developed to accurately measure position and pressure of all fingers of a complete hand. Very detailed studies about the biomechanics of the hand are now possible. This hand grip sensor can be used for diagnostics as well as a control tool after a hand operation to measure the rehabilitation process. It provides a much more detailed picture about the biomechanical activity and of the hand and all fingers as the actual devices on the market. A high-resolution tactile sensor and a dedicated readout electronic has been developed allowing

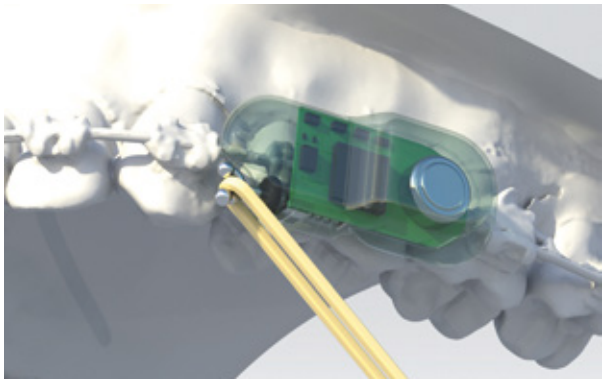


3000 pixels representing a hand imprint to be delivered in real time. This wireless device transmits data to a smartphone or another smart device for direct analysis. It can also be shared or stored. Data analysis algorithms have also been developed to facilitate the diagnosis. This project has been performed with EoSwiss Ldt. in Geneva. A patent application on this device has been submitted, and a clinical study is ongoing.

Research Area: Medical Monitoring

Monitoring system for the wearing time of orthodontic elastics

Fixed multi-bracket appliances are used to correct tooth and jaw misalignments. In most cases, intermaxillary elastics are worn between the upper and lower jaw to adjust the position of the jaws in relation to each other. The wearing time of these intermaxillary elastics determines the duration of treatment and the quality of the treatment results. Clinical studies have shown that patient compliance is improved by monitoring the wearing time. While micro-sensors are increasingly being used for removable appliances to monitor patient compliance, there is still no such possibility worldwide for fixed appliances. The project goal (Innosuisse/CTI with partner Universitäres Zentrum für Zahnmedizin Basel and Otmar Kronenberg AG) is to develop a miniaturized low-power monitoring system for measuring patient cooperation with fixed braces by measuring the wearing time of the intermaxillary elastics in a multi-bracket therapy. The orthodontist can visualize the wearing time of the elastics at the patients visits and thus gains better control over the cooperation of patients.



Design study to investigate patient comfort for direct measuring the presence of elastics and wear-out conditions as opposed to measurements via secondary parameters.

Hospital 4.0: Self-coordinating and distributed sensor network for patient monitoring in a hospital setting

Compliant Concept AG produces an under-the-mattress pressure sensor enabling pressure ulcer risk prevention and fall prevention for hospitalized patients. Nevertheless, configuration of alarms and measurement setup, tailored to the specific patient case, is a cumbersome task severely reducing the usability of the sensor. Our approach is to interface the sensor with a mobile monitoring device integrated into a sensor network framework enabling:

- Monitor and bed positioning;
- Patient recognition;
- Connection to the hospital's patient database for an auto-configuration of alarms and measurement setup;
- Nurse presence detection

Such an integrated monitoring setup enables an optimized smart care process and it makes it possible to extend the current sensor use to optimization of sleep patterns / medication, assessment, automated risk profile evaluation, and automated care process statistic reports. This project is financed by Innosuisse and conducted with the industrial partner Compliant Concept AG and the Inselspital in Bern.

Mobile Monitor and Pressure Sensor.

Selected Publications

Reto Andreas Wildhaber, Dominik Bruegger, Nour Salami, Hampus Malmberg, Josef Goette, Marcel Jacomet, Hildegard Tanner, Andreas Haeberlin, Hans-Andrea Loeliger, "Estimation of the Cardiac Field in the Esophagus Using a Multipolar Esophageal Catheter," IEEE Transaction on Biomedical Circuits and Systems, Aug. 4th, 2018

Reto A. Wildhaber, Nour Zalmai, Marcel Jacomet and Hans-Andrea Loeliger, "Windowed State-Space Filters for Signal Detection and Separation," IEEE Transactions on Signal Processing, July 15, 2018

Huaiqi Huang, Claudio Bruschini, Christian Antfolk, Christian Enz, Tao Li, Jörn Justiz, Volker M. Koch, "Automatic hand phantom map generation and detection using decomposition support vector machines," BioMedical Engineering OnLine, BioMed Eng OnLine, June 13, 2018

Thomas Niederhauser, Elena S. Hafner, Tarcisi Cantieni, Michelle Grämiger, Andreas Häberli, Dominik Obrist, Fiona Burkhard, Francesco Clavica, "Detection and qualification of overactive bladder activity in patients: Can we make it better and automatic?" Neurology and Urodynamics. 2018;37:823-831, February 2018

Rakesh Vasireddy, Corinne Roth, Johannes Mathis, Josef Goette, Marcel Jacomet, Andreas Vogt, "K-band Doppler radar for contact-less overnight sleep marker assessment: a pilot validation study," Journal of Clinical Monitoring and Computing, Springer, 11.09.2017

Ronchetti, T., Maloca, P., Jud, C., Meier, C., Orgül, S., Scholl, Jud,C., Hasler,P., Považay, B., Cattin, P. C., "Detecting early choroidal changes using piecewise rigid image registration and eye-shape adherent regularization," International Workshop Ophthalmic Medical Image Analysis (MICCAI OMIA), Springer, Lecture Notes in Computer Science book series (LNCS), 9. Sept. 2017

Huaiqi Huang, Tao Li, Claudio Bruschini, Christian Enz, Jörn Justiz, Christian Antfolk, Volker M. Koch, "Multi-modal Sensory Feedback System for Upper Limb Amputees," presented at 2017 New Generation of CAS (NGCAS), IEEE, September 6, 2017

Huaiqi Huang, Tao Li, Claudio Bruschini, Christian Enz, Jörn Justiz, Christian Antfolk, Volker M. Koch, "Multi-modality sensory feedback system for upper limb amputees," presented at the SSBE Annual Meeting in Winterthur, August 30, 2017

Daniel Kaufmann, Christian Burri, Patrik Arnold, Volker M. Koch, Christoph Meier, Boris Považay, Joern Justiz, "Dosimetry Control and Monitoring of Selective Retina Therapy using Optical Coherence Tomography," presented at OSA's 2017 European Conference on Biomedical Optics (ECBO), Published in SPIE Proceedings Vol. 10416, August 1, 2017

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