University of Basel

Department of Biomedical Engineering

Department of Biomedical Engineering

Annual Report 2022

Guiding Principles

Our Vision
We contribute to a world where health care needs are met by innovative biomedical research and engineering solutions.

Our Mission
We translate basic science and engineering into medical knowledge and healthcare innovations.
We provide high-quality education and capacity building for academics, clinicians, and industrial partners.

Our Values
We adhere to the Code of Conduct of the University of Basel and promote an interdisciplinary culture of dialog, appreciation, respect, honesty, and tolerance.
We are committed to scientific integrity, reliability, transparency, and good scientific practice.
We value and foster enthusiasm and passion for science

Our Main Goals in Four Fields of Action
1. **Research, Problem Solving, Innovation & Translation:** The DBE provides practical innovative biomedical engineering solutions for clinical challenges and covers the whole translation process from bench to bedside by developing and validating clinical applications and supporting approval processes.

2. **Organization, Collaboration & Environment**: The DBE is a multidisciplinary network of research groups and clinicians and combines life sciences with complementary expertise. It is a research department that is embedded in the Medical Faculty, integrated in a clinical environment and part of an ecosystem of med-tech spin-offs, industry, and proximity to pharma and hospitals. In this constellation the DBE is a unique platform in Switzerland and the EU.

3. **Talents & Education:** The DBE's motivated faculty provides excellent education, capacity building, and integrates our interdisciplinary students directly into ongoing research activities.

4. **Finances & Structural Resources:** The DBE is secured by solid structural funding by the University, resp. the Medical Faculty covering the core facilities, research-IT, safety, and administration. To stabilize it in the future, at least one permanent University professorship in every research cluster will be needed. The DBE is an interesting partner for innovative research and able to secure substantial third-party funding exceeding the structural funding approximately three to four times.

The implementation of our mission relies on the support of our founding institutions:

University of Basel

Universitätsspital Basel

UKBB
kompetent & menschlich

Table of Contents

Authors if not mentioned otherwise: am: PD Dr. Andreas Müller; cg: Prof. Cristina Granziera; cp: Dr. Constanze Pfeiffer; dvs: Dr. Daniela Vavrecka-Sidler; god: Dr. Gabriela Oser; ps: Prof. Pablo Sinues; sf: Dr. Sara Freund; rw: Dr. Reinhard Wendler.

Preface

Three Buildings Reflect Our Success Story

Figure 1: Crane accident in Nobember 2009 at the old Frauenspital (picture: N. Fucario).

Figure 2: Gewerbestrasse 12-16 (picture: R. Wendler).

Figure 3: GRID in fall 2022 (picture: R. Wendler).

The DBE is comparatively young. But it has already moved twice. The three buildings perfectly reflect the history of the DBE, as I'd like to show you here.

Before the DBE was founded in 2015, the root projects including mine were located at the old Frauenspital. That building, inaugurated in 1896, was quite special, since it was already prone to demolishment when we moved in. Nobody took care of the building, and so we found holes in the floors, through which you could look down to the floor beneath. Our servers were placed in a room with broken windows. In the winter, pigeons loved the heat they emitted, and, as a thank you, left their droppings on our gear.

We were understandably quite happy when we could move to Allschwil in 2016. The so-called "Innovationszentrum Nordwestschweiz" was comparatively new, we had a lot of space – and it was proof that the University thought highly of us. Here, the DBE entered that phase of rapid growth in which it still finds itself. We were able to provide space even for an entire magnetic resonance tomograph and all it comes with. And it was just nice to not have holes in the floors and pigeon droppings on our servers.

After only three years it became clear that we would move again. This time, the building was yet to be built and we had the opportunity to plan our labs and workshops according to our needs. The architects Herzog & de Meuron are world famous and with the GRID they have designed the prime example of an innovation hub: A single, constantly repeating architectural element supports simple concrete floors and is thus practically infinitely flexible. Circumferential arcades, the park in the inner courtyard and the spatial proximity invite exchange, not only between the employees of each tenant, but also between the tenants themselves.

The architecture has already begun to positively change the DBE. While the different groups hardly came into contact with each other at Gewerbestrasse, at the GRID they meet daily along the hallway and in the Science Lounge, the new heart of the DBE.

Thus, the architectural history of the DBE reflects its steep rise to become one of the players at the Faculty of Medicine, at the University of Basel and in the Biomedical Engineering research landscape.

Philippe Cattin

The Move to the GRID – a Challenge Accompanied by Emotions

Our workshop ready to move (picture: R. Wendler).

Three years ago, we started to plan our new department at the so called "Grand réseau d'innovation et de développement" in short, the GRID. The prospect of a new, customized work environment excited us all, and enthusiastically we started to plan our future labs, workshops and teaching area. Personally I could hardly believe that we would ever go through the predicted "valley of despair", accompanying every change. For most of us this valley was the move itself. But now, after having re-installed our equipment, we can hardly believe how lucky we are to have this opportunity to work at our self-designed DBE@GRID.

The planning phase of our new labs and workshops was truly exciting and we see our new working environment as a great gift from the University or, respectively, the taxpayer, and as a recognition of our achievements and ambitions, indeed a "once in a lifetime opportunity".

Despite our joyful anticipation and even if well planned, the move itself and settling in was very exhausting: The number and variety of problems and tasks at hand was larger than expected and besides, our core businesses, research, teaching, and operations had to continue seamlessly. Additionally, during the first weeks at the GRID the beauty of our new space was hidden behind crumpled packing material, still full boxes and palettes.

As these lines are being written, spirits are high again. An additional and highly appreciated feature that helped to recover quickly is our science lounge. There we meet, discuss and inspire us mutually. In the science lounge we relax, have lunch and share a coffee or gather for a beer on "Thirstday", it is a meeting place that makes the DBE@GRID our own space. While working, we feel privileged to have these facilities which every research group could design according to its needs and with state-of-the-art installations. Moreover, the research consortium CADENCE has not only received a tailored research space, but additionally been granted an SNSF R'Equip grant, matched by the University of Basel, so that it can now equip its large laboratory with the most modern facilities. We have the best conditions for excellent research, let's do it!

Daniela Vavrecka-Sidler

DBE Moves without Major Catastrophy!

(rw) When the size of a move doubles, its complexity triples — and with it, the headaches. So, think of fifteen times your last move and you immediately see, that very early planning is the only remedy if you have to move a research department.

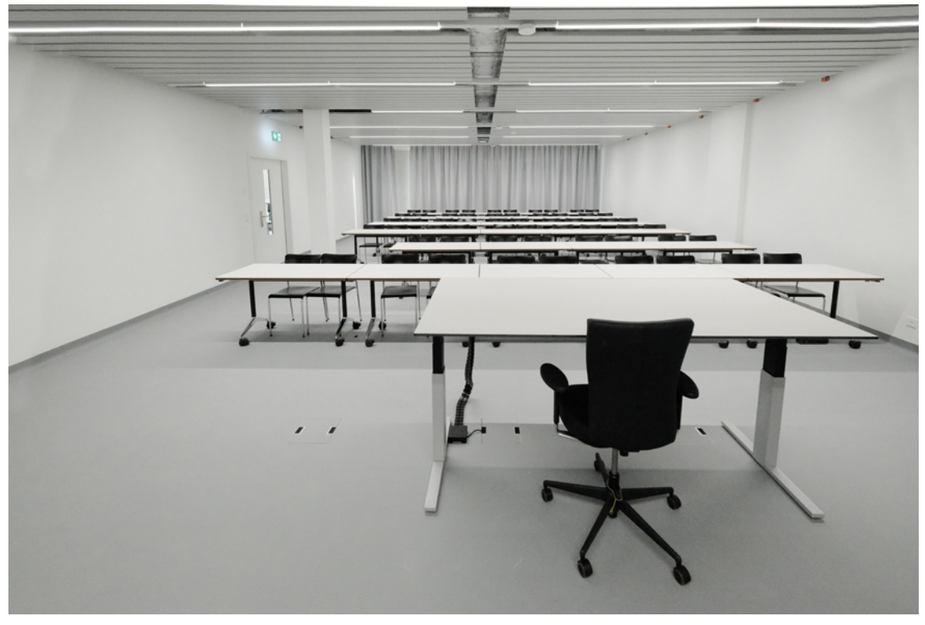
We started planning in 2019, three years before the move. The first step was: know thyself, as best as you possibly can. Who are we? How many researchers work here all the time, how many often, how many sometimes? How much space do we have? How much space do we need? What are the infrastructural requirements of the individual research projects, what are those of teaching, etc.?

The next step was to practice divination to answer questions like the following: How much space will we probably need in ten years? What could be the infrastructural constraints of research projects that do not even exist today? How many employees and students will we have in ten years? What kind of environment will they need in order to work optimally? And so on.

After we had answered these questions, it was time for negotiations. What is necessary, what is possible, what would be important, what would be desirable? How much space, how much money, how much support do we have? After many a winter moon of negotiations, we finally found solutions for all these questions.

The challenge is that a vibrant research institution like the DBE is constantly changing. New large projects suddenly appear, research questions evolve and call for new equipment, new cooperations and collaborations require new solutions, and researchers move to other universities taking their MRI tomograph with them. Planning and negotiations must keep pace with these new conditions so that the new building is not outdated from the start. This translates into a four-year marathon of meetings that have not ended to this day.

Nevertheless, the light at the end of the tunnel is becoming brighter, because we have moved in December 2022. The new rooms and the tailor-made labs shine, our Science Lounge has, as hoped, become the meeting point for all researchers, so that we can observe how new ideas, new collaborations and new friendships develop. As the new year progresses, the pressing problems will diminish and the benefits of the move become more apparent. Come and visit us and see for yourself where we are right now!

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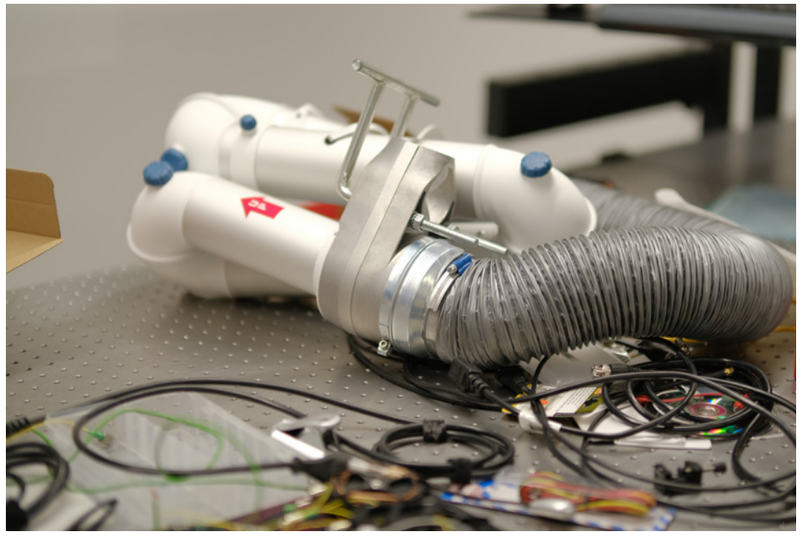

Highlights 2022

MIRACLE^{II} Launched

Figure 1: Press conference on occasion of the launch of the second funding phase on 5 September (picture: R. Wendler).

Figure 2: A new logo was designed that shows the letters as negative spaces and the colored elements as perfectly fitting implants that shape the miracle ((picture: R. Wendler).

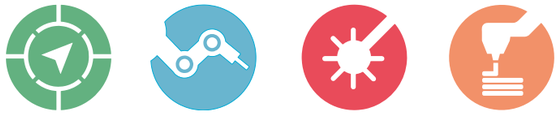

Figure 3: The old group icons were inverted in accordance with the new main logo (picture: R. Wendler).

(cp) With 12 million SFR additional funding generously provided by the Werner Siemens Foundation, MIRACLE has now become MIRACLE^{II}.

In July 2022, the MIRACLE^{II} project started at the DBE. During the first MIRACLE project phase, four research groups developed cutting-edge technologies to be used in future operating rooms aiming at cutting bones minimally invasively with lasers. The ambitious mission of MIRACLE^{II} is to develop a surgical robot hanging from the ceiling of an operating room, which smoothly collaborates with the surgeons, is able to cut bone with unseen precision in all kinds of shapes, and can place smart implants in a minimally invasive way. For the second project phase, the Werner Siemens Foundation is topping up their funding for the project, which has been running since 2015, by an additional 12 million SFR.

During a press conference that took place in September 2022, the four MIRACLE research group leaders informed the media representatives about the achievement of MIRACLE^{I} and the plans for MIRACLE^{II}, which resulted in various publications (see page 38).

Additional information about MIRACLE can be found in the new MIRACLE^{II} flyer or on the MIRACLE webpage.

Funding:
WSS
WERNER SIEMENS-STIFTUNG

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Medical Certification for Breath Test

Figure 1: Real-Time Exhalation Maneuvre into Mass Spectrometric Platform (picture: Sinueslab).

Figure 2: Sinueslab research group 2022 (picture: Sinueslab).

(ps) The DBI-EPIbreath® Test developed by the Deep Breath Intelligence Spin-Off of Prof. Pablo Sinues has received medical certification. The system supports healthcare providers to make faster and better decisions regarding epilepsy medication.

This major milestone provides a perfect example for the general idea of Pablo's Translational Medicine Breath Research group and the Sinueslab at the DBE and the University Children's Hospital Basel: Harvesting the biochemical information about our state of health emanated in every breath. Breath diagnostics offers many advantages over traditional diagnostic methods: it is absolutely not invasive, it is easy: a few exhalations are sufficient and the sample is taken, and it is fast: the evaluation of results are achieved in real time, no sample preparation is required.

The research spin-off Deep Breath Intelligence AG was founded in Nov 2018, (Rotkreuz, Switzerland) and employs 6 people. The Sinueslab is located at the University Children's Hospital Basel (UKBB), which gives its researchers the unique advantage of having direct access to well-characterized pediatric patients. They aim to improve the diagnosis of specific diseases, accurately phenotype complex pathophysiological processes and personalize therapy.

The mission of both groups is to explore exhaled Volatile Organic Compounds (VOCs) in detail and to conduct ample clinical studies to make this wealth of information fruitful for clinical applications.

More information:

DBI-EPIbreath®: www.dbi.ch
Sinueslab: www.sinueslab.ch
Translational Medicine Breath Research: https://dbe.unibas.ch/en/research/imaging-modelling-diagnosis/translational-medicine-breath-research/

Funding:
fondation BOTNAR
Swiss National Science Foundation

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Research Coordinator:
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References:
(1) Rapid Detection of Staphylococcus aureus and Streptococcus pneumoniae by Real-Time Analysis of Volatile Metabolites. Alejandro Gómez-Mejia, Arnold Kim, et. al. https://doi.org/10.1016/j.isci.2022.105080

(2) An Interoperability Framework for Multicentric Breath Metabolomic Studies. Gisler, Amanda, et.al., http://dx.doi.org/10.2139/ssrn.4076338

Good News for Children Suffering from Cleft Lip and Palate, Worldwide!

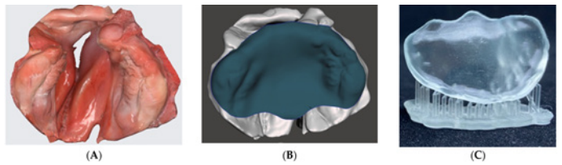

Figure 1: The digital workflow for the fabrication of a presurgical palatal plate. (A) Intraoral 3D digital image acquisition; (B) computer-aided plate design (CAD) modeling of presurgical orthopedic plate; (C) 3D printed plate (picture: FCA).

Figure 2: A patient with cleft in India receives a consultation on individualized 3D printed palatal plate (picture: FCA).

Figure 3: Surgical training session took place in Chile and Basel with the model we developed together with our collaborator (picture: FCA).

(am) The project "Burden-Reduced Cleft Care and Healing" supported by Botnar Research Centre for Child Health aims to improve accessibility of cleft care with enhanced quality and reduced burden for both healthcare provider and young patients around the world. Our national and international collaborations leverage advancements in use of artificial intelligence and 3D printing technology to facilitate the clinical workflow.

The care for patients born with cleft lip/palate begins at birth involving multi-disciplinary teams. We aim to promote pre-surgical palatal plate therapy from birth and concurrently refine and encourage subsequent one-step cleft surgery to reduce treatment burden while improving the outcome.

To increase accessibility, we develop a fully automated pipeline to compute digital plates based on input images and videos, which can be 3D printed locally. We have successfully integrated a digital workflow at the University Hospital Basel (1). Furthermore, with our collaborator at ETH Zürich, we develop a pipeline to automatically compute individualized plate to mitigate its need for specialized personnel. We have been able to test the pipeline in our hospital as well as at partner clinics in India.

We have published our one-step surgical technique combined with a palatal plate therapy to disseminate the approach towards treatment with less burden on the patients (2). A collaboration with our partner in Chile allowed us to develop a surgical trainer more accessible and affordable to overcome the difficulty of training young surgeons in this specialized field.

Funding:

BRC Botnar Research Centre for Child Health

propatient Forschungsstiftung Universitätsspital Basel

Centro Latinoamericano-Suizo Universität St.Gallen

Group Leaders:
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References:
(1) Zarean P, Zarean P, Thieringer FM, Mueller AA, Kressmann S, Erismann M, Sharma N, Benitez BK. A Point-of-Care Digital Work-flow for 3D Printed Passive Pre-surgical Orthopedic Plates in Cleft Care. Children. 2022; 9(8):1261.

(2) Benitez BK, Brudnicki A, Surowiec Z, Singh RK, Nalabothu P, Schumann D, Mueller AA, Continuous Circular Closure in Unilateral Cleft Lip and Plate Repair in One Surgery, Journal of Cranio-Maxillofacial Surgery, Volume 50, Issue1, 2022, 76-85.

Evaluated Group: Translational Imaging in Neurology (ThINk) Basel: New Biomarkers for Diagnosis, Prognosis & Treatment of MS

Figure 1: Prof. Cristina Granziera (picture: ThINk Basel).

Figure 2: ThiNk at work (picture: R. Wendler).

(cg) 2022 was a milestone year for the ThINk group headed by Prof. Cristina Granziera. They were able to identify new biomarkers that offer a very promising foundation for novel diagnostic and prognostic procedures for multiple sclerosis, which will foster the development of new therapies. They published a series of major papers, such as (1), (2), and (3). And Cristina, in addition, was awarded the prestigious Robert Bing Prize.

Cristina's group is in itself a bridge between the clinics and the bedside, as it consists of researchers, clinician scientists and clinicians with the common goal of paving the way for new imaging diagnostic, prognostic and monitoring tools for neurological diseases. This group and its large network of different partner institutions ensure that information, ideas, and solutions can circulate freely between all members. In this way, promising approaches are brought to light and technical solutions are made ready for application in clinical practice.

The results of ThINk are internationally recognized and validated in large longitudinal clinical studies. They already have a direct impact on the treatment and follow-up of patients with multiple sclerosis.

DBE's scientific advisory board evaluated ThINk by the end of August 2022. They found the group to be an invaluable asset for the DBE, the University and the Medical Faculty. They were impressed by Cristina's way of leading by example and by her ability to support her employees in their development. They recommended ensuring that the skills consolidated in ThINk can be permanently retained for the University and the University Hospital.

Funding:

Swiss National Science Foundation

Group Leader:
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References:
(1) Association of Brain Atrophy With Disease Progression Independent of Relapse Activity in Patients With Relapsing Multiple Sclerosis.
Cagol A, et al., JAMA Neurol. 2022

(2) Myelin and axon pathology in multiple sclerosis assessed by myelin water and multi-shell diffusion imaging.
Rahmanzadeh R et al., Brain 2022

(3) A New Advanced MRI Biomarker for Remyelinated Le-sions in Multiple Sclerosis. Rahmanzadeh R, et al., Ann Neurol. 2022.

Distinctions

Awards & Prizes

Figure 1: Neha Sharma receives the Dirk Schäfer Science Award 2022 (picture: T. Schürch).

Figure 2: Céline Vergne receives the Bronze Poster Award Award at the 8th DBE Research Day (picture: R. Wendler).

(sf) DBE researchers are increasingly successful in winning awards or being honored with committee nominations or other distinctions. This mirrors the excellent work of our teams as well as the increasing significance and recognition of biomedical engineering.

Awards

Dr. Manuela Eugster received a 30'000.– SFR scholarship award from the Zaeslin foundation to finance a four months research exchange at the Florida Institute for Human and Machine Cognition (ihmc) robotics group in Pensacola, Florida.

Rosa Visscher, PD Dr. Morgan Sangeux, Prof. Elke Viehweger and team, were awarded the first price for their preliminary results during the first Swiss Academy for Childhood Disability (SACD) Research Day. The price sponsored by the Anna Müller Grocholski Foundation has been awarded for the promising results of the team towards evaluation of developmental trajectories in gait variability.

Yukiko Tomooka received the first poster price by the conference of the German Society for Computer- and Robot-Assisted Surgery (CURAC), which took place in Karlsruhe, Germany.

Dr. Griffin Rogers, postdoc at BMC, won the Poster Award of the 2022 conference of the international society for optics and photonics SPIE.

Prof. Andreas Müller was awarded a prize for his talk "Digital Solutions for Burden-Reduced 3D Cleft Diagnosis and Presurgical Therapy" by Circle of Cleft Professional to recognize impactful research upon multi-disciplinary, team-based, and locally rooted cleft care in Low and Middle-Income Country.

Poster Awards presented at the 8th DBE Research Day

Gold Poster Award for **Lorin Fasel**, member of the BIROMED, for "Safer Robotic Endoscopes with Inspiration from the Human Finger".

Silver Poster Award for **Celine Berger**, researcher at Forensic Medicine and Imaging, for "Investigation of post mortem brain & forehead temperature relations".

Bronze Poster Award for **Céline Vergne**, active in Neurosurgery, for "Development and characterization of an electromagnetic tracking system: Application to deep brain stimulation surgery".

Prizes

Dr. Neha Sharma, member of the Swiss MAM research group, won this year's Dirk Schäfer Science Award of the Department of Surgery.

Prof. Bert Müller, head of the Biomaterials Science Center (BMC)**,** received the SPIE Biophotonics Technology Innovator Award. It recognizes extraordinary achievements in biophotonics technology development that show strong promise or potential impact in biology, medicine, and biomedical optics.

Prof. Cristina Granziera, head of the ThINk group, was awarded the Robert Bing Prize 2022 for her work on biomarkers for the diagnostics and monitoring of disorders such as multiple sclerosis and stroke.

Dr. Melanie Bauer, working at the research group Forensic Medicine and Imaging, received the PhD thesis award from the German Society of Forensic Medicine (DGRM).

Mahyar Joodaki, member of BMC, won the 2022 Master's Thesis Awards of the Medical Faculty of the University of Basel and additionally the prize for the best DBE Master's Thesis sponsored by the Zaeslin Teaching Grant for her work "Fabrication and Characterization of silk reinforced, micropatterned cellulose films for soft neural implants".

Dr. Claudia Lenz junior group leader of the research group Forensic Medicine and Imaging at the Institute of Forensic Medicine was recognized with the DBE's Best Lecture Award.

Figure 3: An older trophy symbolizes the prizes won by our members (picure: R. Wendler).

Honors & Nominations

From top to bottom: Profs. Müller, Rauter and Thieringer (picures: University of Basel and DBE).

Committee Nominations

Prof. Bert Müller was elected Vice President and Secretary of the Swiss Society for Biomedical Engineering. He will organize the 2023 SSBE Annual Meeting in Allschwil.

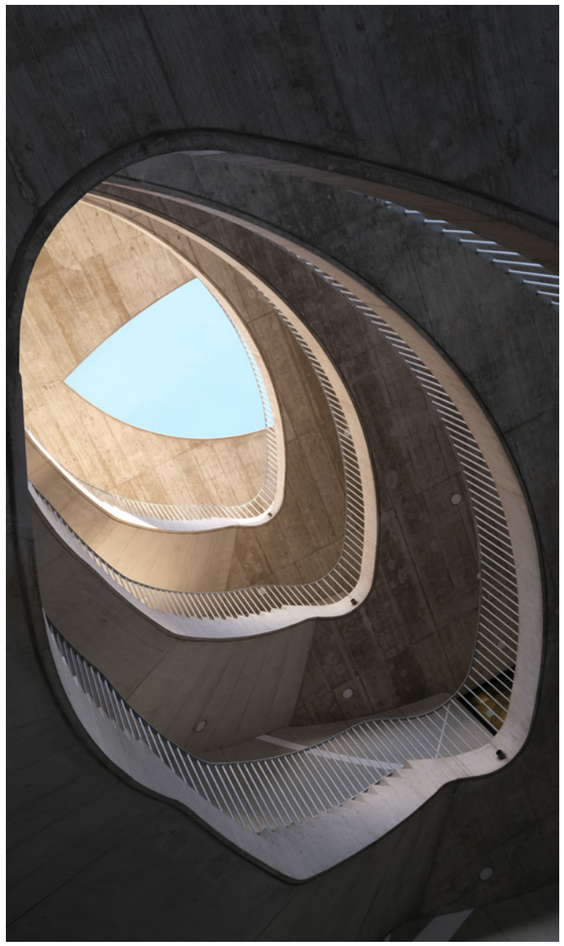
Prof. Georg Rauter became an invited member of the Strategic Commission for Information Supply & Information Technology. This commission is a newly founded institution of the University of Basel with the aim to actively shape the digital transformation in teaching, research and administration at our University.

Prof. Georg Rauter is co-PI and key person for topics in the field of medical robotics of the new NTN Innovation Booster Robotics, which aims to establish robotics as a core pillar of the Swiss economy and acts as a central hub for the Swiss robotics community, including key persons from industry, research and society.

Prof. Florian Thieringer has been elected as member of the Executive Board of the Mobility Goes Additive e.V. (MGA). MGA unites over 120 players from all areas of the market to jointly boost Additive Manufacturing with a user-driven focus.

Changes in Personnel & Organization

Promotions & Appointments



Sky is the limit (picture: R. Wendler).

Prof. Georg Rauter was appointed as Associate Professor for Surgical Robotics as of March 2022.

Prof. Pablo Sinues was promoted Associate Professor for Translational Medicine Breath Research at the University of Basel in February 2022. He has been administratively transferred from the University Children's Hospital of Basel (UKBB) to a structural position at the University, i.e. the DBE. Never the less he continues to have his working base at the UKBB, ensuring translational research, in addition he will have laboratories at the DBE in Allschwil.

Prof. Florian Thieringer was elected Professor of Oral and Maxillofacial Surgery (MKG Chirurgie) at the Faculty of Medicine and at the same time became the new Chief Physician for Oral and Maxillofacial Surgery at the University Hospital Basel.

Prof. Bert Müller was appointed Full Professor of the Medical Faculty at the University of Basel.

Prof. Marco Düring replaces Prof. Jens Würfel as head of the Quantitative Biomedical Imaging Group (qbig).

AMT Center Joining the University of Aberdeen

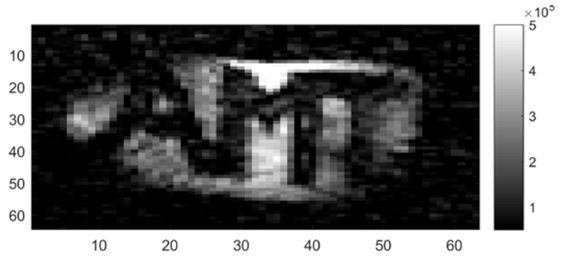


Figure 1: Ultra low-field MR scan (picture: N. Salameh/M. Sarracanie/AMT Center).

Figure 2: Some of the AMT team members (picture: N. Salameh/M. Sarracanie/AMT Center).

Prof. Najat Salameh and Prof. Mathieu Sarracanie, joint heads of the Center for Adaptable MRI Technology (AMT Center), were both appointed professors at the University of Aberdeen. The move will be completed in spring 2023.

Along with their visionary research, these pioneers of lower-field MR scanner development will move their giant old MR scanner with them, no doubt an irony of fate. However, it is an event of science-historical dimensions that the journey will take them to the University of Aberdeen, the place where the very first clinically usable MR scans were generated.

With the AMT Center, the DBE loses a formative authority, both internally and externally. The boldness of their goals, the serene professionalism and the cheerful collegiality of their group leaders and researchers matched exactly the self-image of our department. We will miss them.

However, the DBE is also proud to have contributed to the development of these research personalities as well as of low-field MRI technology. Nevertheless, our goal must be to ensure that outstanding researchers such as Najat Salameh and Mathieu Sarracanie retain their positions in our department in the future.

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Swiss National Science Foundation

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Prof. Mathieu Sarracanie
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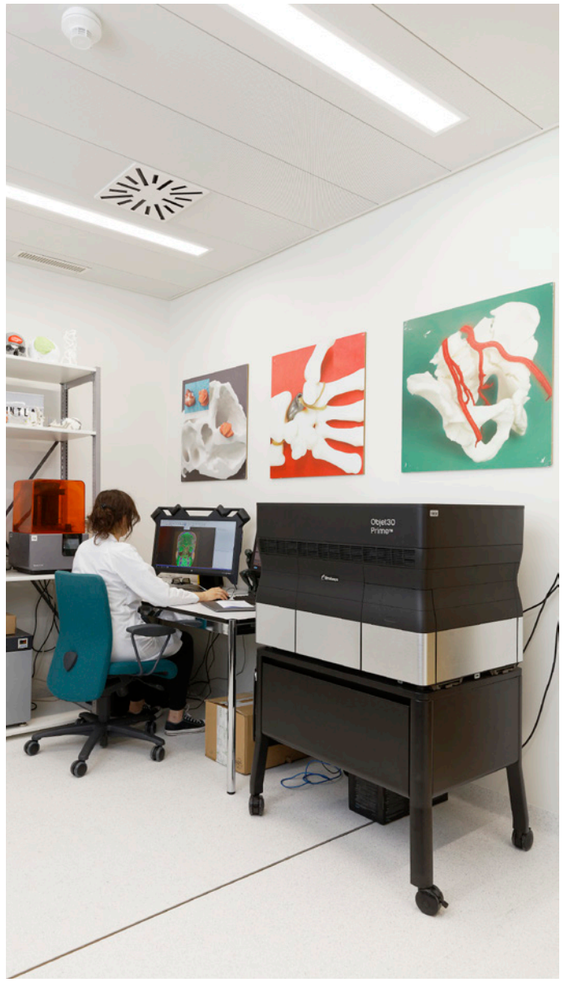
Core Facilities

The DBE's Core Facilities



3D-Print Lab Core Facility (picture: O. Lang, Werner Siemens Foundation).

(sf) The DBE's three Core Facilities were assessed by the Dean of the Medical Faculty at the beginning of 2022, based on the Faculty of Medicine's Development and Structure Plan 2022 – 2025. They met with approval and received basic staffing.

3D-Print Lab

This Core Facility intends to provide 3D printing technologies and services to support clinical practice and academic research. The core facility is equipped with state-of-the-art 3D printers under the scientific leadership of Prof. Dr. Florian Thieringer. Under the direction of its technical leader Dr. Neha Sharma, this facility seeks to offer technical support and services for its commercial orientation by employing a 3D printing technician, Andreas Roser, half funded by the Medical Faculty and half by third-party funding.

Micro- & Nanotomography (MiNa)

Following the successful SNF R'Equip application in 2021 and additional investment funds from the University, this Core Facility is expected to be equipped with two cutting-edge microtomographs by mid-2023. Both devices will have an isotropic spatial resolution of less than one micrometer and have the ability to measure in phase contrast mode. In order to be able to use these new devices and to organize user training and sample preparation, a small part-time position has been created for the data analyst Dr. Christine Tanner, who will support the technical director Dr. Georg Schulz.

Micro-Calorimetry

Dr. Olivier Braissant, scientific and technical leader of this Core Facility, is partly funded by the Merian-Iselin Foundation and the maintenance of the Core Facility is covered through industry contracts and user fees. With an additional part-time appointment financed by the Medical Faculty, Dr. Olivier Braissant becomes eligible to submit research project applications to the SNSF and other private foundations.

Management Framework for Core Facilities

SAB visit at the Core Facility MiNa in 2021 (picture: R. Wendler).

(dvs) The new structural support of the Core Facilities comes with an obligation to professionalize them and strategically align them with the needs of researchers at the Medical Faculty. The DBE executive board issued a guideline on how to organize the Core Facilities and created a specific commission for them.

The new commission is composed of the scientific and technical heads of the Core Facilities and is lead by the DBE's executive board member Prof. Raphael Guzman, who regularly reports to the board. The commission is in charge of the strategic, coordinated development and governance of all our Core Facilities.

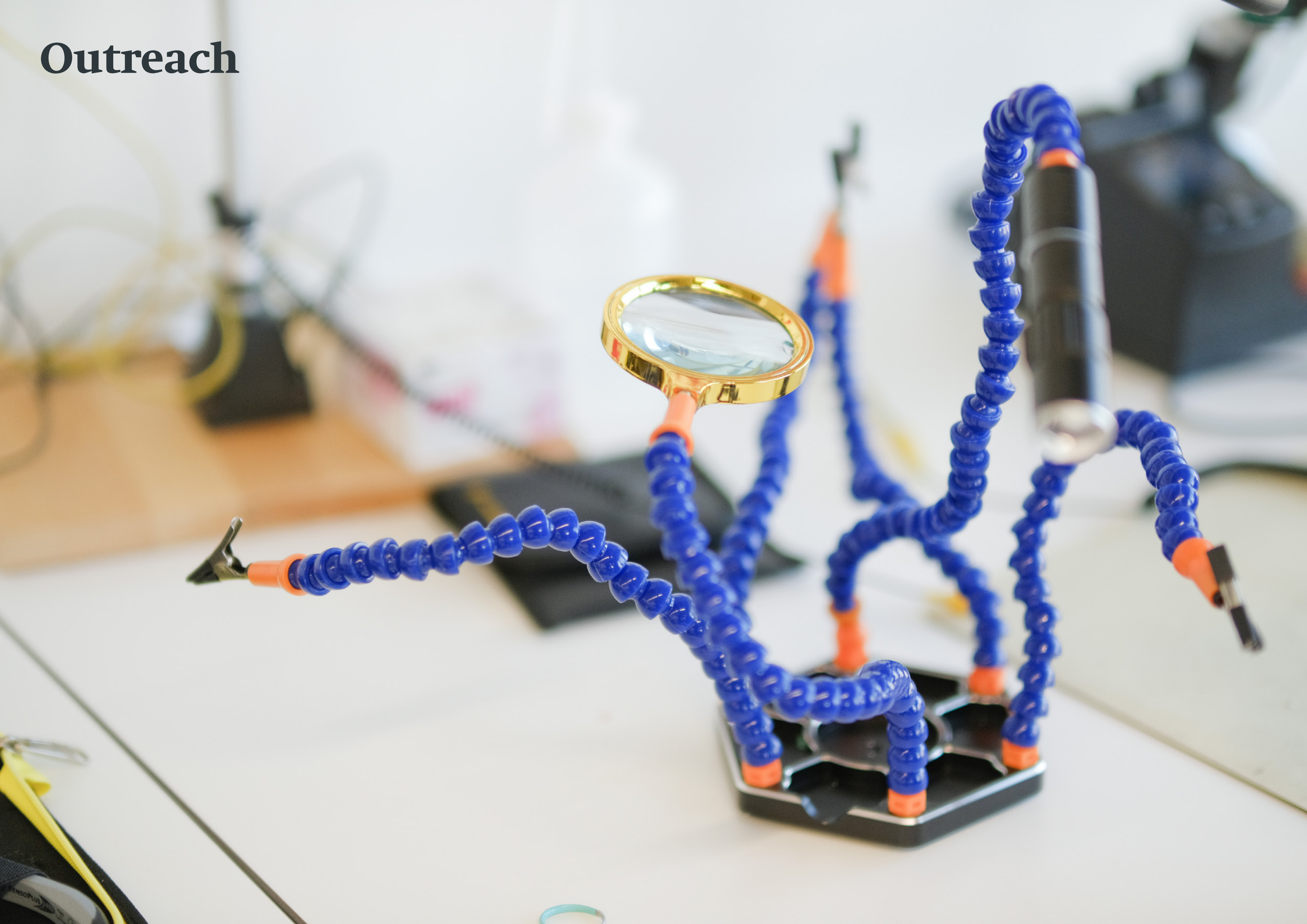
Each Core Facility is governed by a user board which elects its scientific leader. This board meets at least yearly and is responsible for the scientific development, defines user priorities, respective prices, means of advertisment and the budget.

All Core Facilities now have a technical leader with at least a part-time employment funded by the Medical Faculty. The missing part of the employment has to be covered by third-party funding or income from the operations of the Core Facility. All Core Facilities charge for their services because user fees have to cover at least the consumables, the maintenance and repair.

Apart from delivering services to the users, documentation of the equipment, its maintenance, training of users and accounting are tasks of the technical leader of a Core Facility, who is supervised by its scientific leader.

The purpose of a Core Facility is not only to deliver scientific services, but also to teach and to train possible users, to contribute to various networks and congresses and to discuss and initiate strategic developments and investments of and for the Core Facility.

Outreach



Events & Outreach Activities

Figure 1: 8th DBE Research Day (pictures: R. Wendler).

(sf) The DBE is involved in numerous communication activities not only for researchers but also for the general public.

The University's Master's Info Evening

The DBE participated in the Master's Info Evening organized by the University of Basel on March 17, 2022. During the virtual event, participants could visit several booths which included presentations of the master program and virtual lab tours but also a virtual room where they had the chance to meet former DBE master students. On this occasion, we also released a new video teaser wrapping up the main interests of the Master's program.

2nd DBE PhD Day

On April 29, the 2nd DBE PhD Day took place partly virtually and partly in person at the DBE. The successful event consisted of two units. The first, i.e. the academic part was open to the entire department and organized as a virtual conference on the online platform Gather Town. The second part was only open to PhD students, who met for a barbecue and a social game.

DBE Apéro

After having been canceled several times due to Covid, the DBE Apéro finally took place in person on May 18. This event was the occasion not only to bring the focus to current developments at the DBE but also to leave the stage to those PhD students who defended their PhD virtually in the past years. After listening to their speed talks, we celebrated together a last time at Gewerbestrasse 12-16.

Specto VR at the Museumsnacht

On Friday, May 20, between 6pm and 2am, the "Museumsnacht Basel" invited visitors to 27 museums and about 200 events. Among them was a presentation of the Specto VR system at the Institute of Anatomy in the Anatomical Museum Basel.

DBE Summer School

After two years impacted by Covid, the DBE Summer School 2022 was finally held in person again. 20 students from the PhD program in Biomedical Engineering as well as colleagues from Swiss TPH participated in this exciting event and immersed themselves in the topic of Big Data.

FCA at the 14th International Cleft Congress

At this congress, the FCA group, led by PD Dr. Andreas Müller, gave a workshop: "Learn the Full Digital Workflow: From Intraoral Scan to Point-of-Care 3D Design and Printing of Presurgical Orthopaedic Plates".

8th DBE Research Day

About 200 participants joined the 8th DBE Research Day on August 30. The event based on the motto "Translation through Collaboration" allowed the participants to attend eleven presentations, four translational science slam tandem talks bringing together junior and senior researchers, and as a novum to watch some short scientific films many of which have been produced by PhD students during the DBE winter school.

MIRACLE II Press Conference

The DBE organized a press conference for the launch of MIRACLE II. During this event, journalists got the chance to discover the work of our researchers via a guided tour through our laboratories.

The University's Bachelor Info Day

The DBE participated in the Bachelor Info Day organized at the Pharmazentrum by the University of Basel on November 18. There, potential future students had access to a booth presenting the Master's program of DBE.

Figure 2: MIRACLE II Press Conference (pictures: R. Wendler).

Media Coverage

Portrait of Ferda Canbaz (picture: Uni News, University of Basel).

(sf) Several media highlighted the innovative research conducted at the DBE.

BMC's research on the cover of "JMI"

The article "Three-dimensional analysis of aligner gaps and thickness distributions, using hard x-ray tomography with micrometer resolution" by Rémi Ammann et al. lead by Prof. Bert Müller featured on the cover of the Journal of Medical Imaging in June 2022.

Dr. Ferda Canbaz in "Die Zeit"

The newspaper "Die Zeit" published a short portrait of Dr. Ferda Canbaz titled"Die Laser-Lady".

Dr. Ferda Canbaz on "Uni News"

Uni News published an article on Dr. Ferda Canbaz, ad interim head of the laser lab of the MIRACLE^{II} project. This text focusing on her "burning passion for lasers" is part of a series that spotlights young researchers who contribute to the international reputation of the University of Basel.

MIRACLE^{II} in the "Basler Zeitung"

Basler Zeitung (BaZ) has dedicated a major article to the project, which is announced on the front page.

MIRACLE^{II} on air

German Südwestrundfunk (SWR) and Schweizer Radio und Fernsehen (SRF – 19:19) have both reported on the project.

MIRACLE^{II} on Telebasel

Telebasel reported on the project by focusing on 3D Printing. Prof. Florian Thieringer explained his part of the endeavor: 3D prints for diagnosis, education and patient-specific implants that really deserve their name.

Collaborations

Collaborating Institutions & Partners

Institute of Mother and Child

Kantonsspital Baselland

Kantonsspital Aarau

Kantonsspital Graubünden

KIT Karlsruher Institut für Technologie

KIDNEY CONTROL OF HOMEOSTASIS
SWISS NATIONAL CENTRE OF COMPETENCE IN RESEARCH

KUMOVIS

LÖWENSTEIN medical technology

materialise
innovators you can count on

MIAC
Medical Image Analysis Center

FACULTATIS MEDICINAE BASILIENSIS 1460

naturhistorisches museum archive des lebens

PAUL SCHERRER INSTITUT PSI

DEPARTMENT OF PHARMACEUTICAL SCIENCES

robotics Swiss National Centre of Competence in Research

REGEMAT 3D

REHA STIM MEDTEC

REHABILITATION ENGINEERING SCIENCE

SAVEETHA
INSTITUTE OF MEDICAL AND TECHNICAL SCIENCES
(Declared as Deemed to be University under Section 3 of UGC Act 1956)

SIEMENS Healthineers

SWISS LIGHT SOURCE SLS

SWITZERLAND INNOVATION PARK BASEL AREA

SOLEIL SYNCHROTRON

SNI SWISS NANOSCIENCE INSTITUTE
EINE INITIATIVE DER UNIVERSITÄT BASEL UND DES KANTONS AARGAU

SPENTYS
REINVENTING ORTHOPEDICS

Stanford MEDICINE

stratasys

swiss orthopaedics

SYNOVA

SmileTrain

stryker

UNIVERSITÄTS KLINIKUM FRANKFURT GOETHE-UNIVERSITÄT

Unil
UNIL | Université de Lausanne

UNIST
ULSAN NATIONAL INSTITUTE OF SCIENCE AND TECHNOLOGY

THE UNIVERSITY OF AUCKLAND
Te Whare Wānanga o Tāmaki Makaurau
NEW ZEALAND

1495 UNIVERSITY OF ABERDEEN

Universitätsspital Basel

1431 Université de Poitiers

EBERHARD KARLS UNIVERSITÄT TÜBINGEN

UNIVERSITY OF LEEDS

UNIVERSITY of OTAGO
Te Whare Wānanga o Otāgo
NEW ZEALAND

UNIVERSITÉ DE GENÈVE

UPPSALA UNIVERSITET

UNIVERSITY OF Massachusetts Amherst

université PARIS-SACLAY

UNI FREIBURG

UNIVERSITÄT BERN

Universitätsklinikum Erlangen

Université de Strasbourg

VNIVERSITAT DE VALÈNCIA

Universität Zürich[UZH]

THE UNIVERSITY of WISCONSIN MADISON

USZ Universitäts Spital Zürich

UZB Universitäres Zentrum für Zahnmedizin Basel
Zurich University of Applied Sciences

zhaw School of Engineering

ZEISS

Funding Through Grants & Foundations

Research Funding secured in 2022

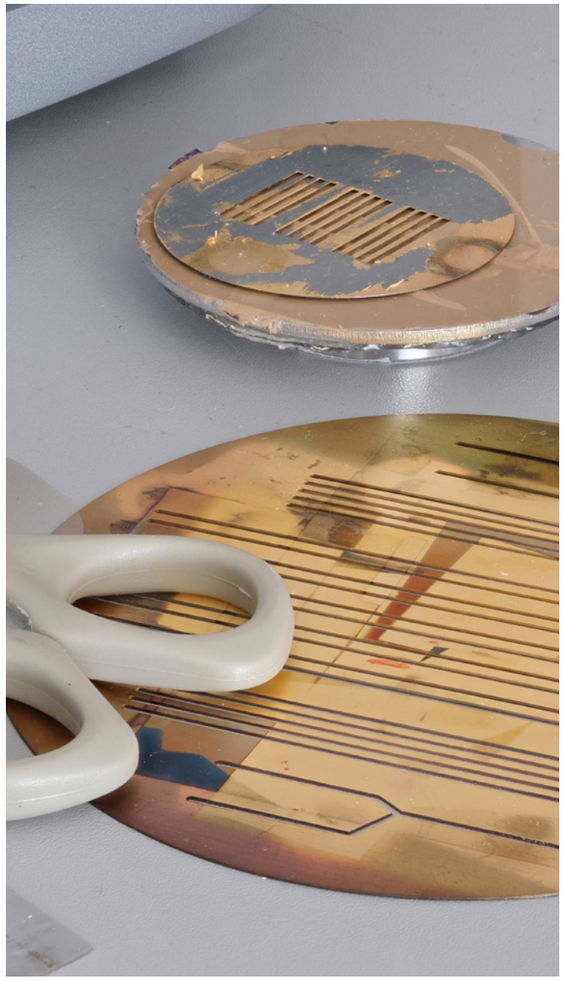


Figure 1: Microchip in the BMC Lab (picture: R. Wendler).

SFR	PI: Project title (funding source)
874 478.–	A. Mündermann, G. Rauter, E. Viehweger, M. Sangeux, C. Netzer: Clinical Biomechanics and Ergonomics Engineering (CADENCE) (SNSF R'Equip)
842 610.–	B. Müller et al.: Fluid Dynamics of the Central Nervous System: 3D Functional Anatomy & Pathophysiology in Mouse Models (DBE share of a 3 Mio SFR SNSF Sinergia)
313 627.–	M. Sangeux, E. Viehweger: Getting high level of evidence for surgical treatments from routine clinical data. A real-world testing of the SPHN infrastructure - EVIGAITCP (SPHN)
310 900.–	R. Sandkühler, Ph. Cattin et al.: ViALLIN MUsAcc: Visual Analysis of Long-Lasting Insecticidal Nets (DBE share of a 1 Mio. BRCCH Principal Investigator grant).
funding goes to UKBB	E. Delgado-Eckert et al.: Alex: Design, Development and Evaluation of a Digital Health Assistant for Paediatric Asthma (Principal Investigator Initiative (PII) of BRCCH)
188 250.–	Ch. Haas & A. Navarini: OCT-guided laser skin ablation system (Swiss Ass. Med. Sci. - MD-PhD-grant)
180 000.–	C. Granziera: Myelin streamline decomposition (MySD) in phase II RRMS SYNERGY and AFFINITY trials (Industry Collaboration)
173 170.–	C. Granziera: MSxplain (DBE share of a 450 kSFR grant of the Hasler Foundation for a collaboration with Lausanne University Hospital)
116 025.–	Ph. Cattin: Fluoroscopic Patient Referencing (Industry Collaboration)
100 000.–	N. Friederich: Funding for Education at DBE (Zaeslin Teaching Grant)
50 000.–	O. Braissant: Microcalorimetry Core Facility (Merian Iselin Stiftung)
49 955.–	G. Rauter: Human-Machine Interaction in Neurosurgery (SNSF NCCR Robotics)
42 000.–	A. Mündermann et al.: 3Dimensions and 3Destinations of Human Movement Studies (EUCOR)
29 000.–	G. Rauter & C. Niemeyer: SEEZER: The eye in hand grasper for precise semi-automated teleoperation in micro assembly tasks (NTN Innovation Booster Robotics)
15 000.–	G. Rauter et al.: Minimally-invasive bioprinter (NTN Innov. Booster HealthTech)
15 000.–	G. Rauter & W. Rauch: AI for individualized training task support in robot-assisted gait rehabilitation (Innosuisse)
3'300'015.–	**TOTAL SNSF and 3rd-party funding awarded in 2022**

Figure 2: Yukiko Tomooka working on her PhD project (picture: R. Wendler).

Funding Institutions

University of Basel

Innosuisse - Swiss Innovation Agency

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

WISSENSCHAFT. BEWEGEN
GEBERT RÜF STIFTUNG

Osteology Foundation

Berner Fachhochschule
Haute école spécialisée bernoise
Bern University of Applied Sciences

propatient
Forschungsstiftung
Universitätsspital Basel

sgms

AGA
Gesellschaft für Arthroskopie
und Gelenkchirurgie

WSS
WERNER SIEMENS-STIFTUNG

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Swiss Confederation

Federal Department of Economic Affairs,
Education and Research EAER
**State Secretariat for Education,
Research and Innovation SERI**

fondation BOTNAR

HMZ

AO
Research Institute Davos

FAG
**Freiwillige Akademische
Gesellschaft** Basel
seit 1835

VELUX STIFTUNG

swiss orthopaedics

Swiss National Science Foundation

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Eidgenössisches Departement des Innern EDI
Bundesamt für Gesundheit BAG

Jacobson-Goldschmidt Stiftung

BRC CH Botnar Research Centre for Child Health

Horizon 2020
European Union Funding
for Research & Innovation

NOVARTIS

MERIAN ISELIN
Klinik für Orthopädie und Chirurgie

suva

eurostars™

Deutsche
Arthrose-Hilfe e.V.
DAH

Education & Completed Student Theses

Education at the DBE: Master & PhD Program

Figure 1: Image of Pablo Sinues (Head of the Teaching Commission) and Mayhar Joodaki receiving the master's thesis prize 2022 of 1000 CHF, kindly sponsored by the Zäslin Teaching Grant (picture: R. Wendler).

Figure 2: Group image of the 20 participants of the summer school 2022 on the topic "Big Data" in June 2022 in Grafenhausen, Upper Black Forrest, Germany organized by Bert Müller and Najat Salameh (picture: G. Zihlmann).

(god) The DBE Master Program with 54 students and the PhD Program with 64 students are the two main educational pillars of the Department of Biomedical Engineering.

Master Program

In the past 5 years on average 22 students matriculated in our master program every year. 1/3 of the students have a Swiss bachelor degree, 1/3 come from other European countries and 1/3 from other continents. From 2018 to 2022, 43 students graduated from the Master Program with a master degree in Biomedical Engineering, on average after 4 semesters.

Every year during the DBE Research Day the best master's thesis is awarded. The winner of the master's thesis prize 2022 is Mayhar Joodaki from Prof. Bert Müller's Biomaterials Science Center (figure 1).

In 2022, four courses have been nominated for the course award, based on students' learning success and recommendation to peers. The course "Applied Methods in Forensic Imaging, Genetics and Toxicological Science" organized by Dr. Claudia Lenz received the course award.

PhD Program

Since the launch of the PhD Program in 2015, the PhD student numbers have been raising. In 2022, 10 students defended their PhD and 12 new PhD students started at our department.

In the spring semester, after a two-year hiatus, again a live summer school was organized. It took place in the Black Forrest (figure 2) and was on the topic "Big Data" with experts in supercomputing, machine learning, fairness, data engineering, ethics, and data science. Another highlight was the seminar series in the autumn semester on Biomechanics and Human Movement, co-organized by the UKBB, the USB and BiRoMed from Allschwil.

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Study & PhD Program Coordinator:
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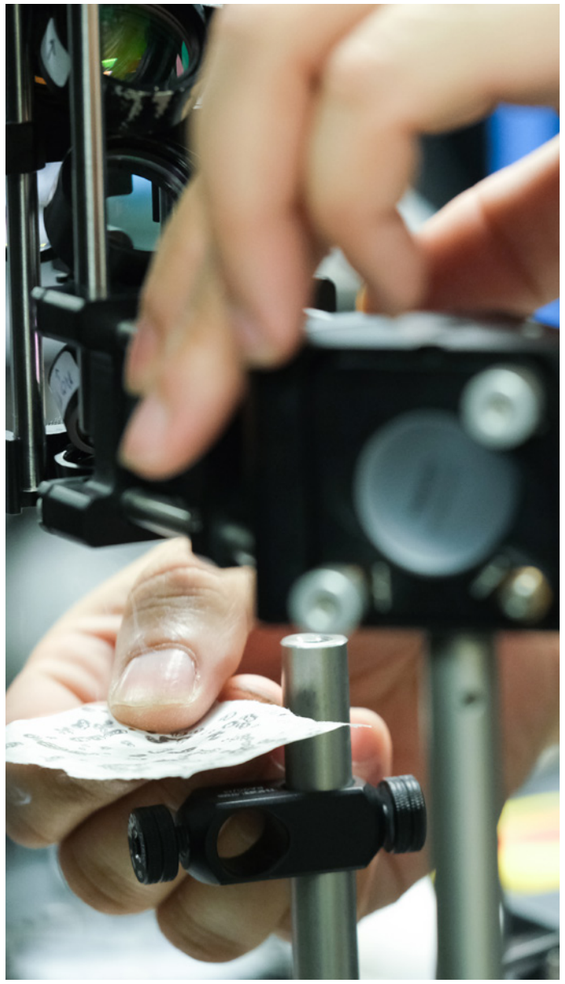
Completed PhD Theses



Working in BLOG's laser lab (picture: R. Wendler)

This year ten students completed their PhD thesis at the DBE:

Deep Learning in Clinical Dermatology

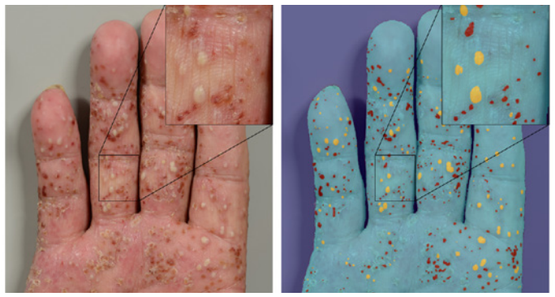


Figure 1: Quantification of pustular psoriasis lesions. Background is represented in violet, skin in blue, pustules in yellow and brown spots in red (picture: Universitätsspital Zürich, L. Amruthalingam).

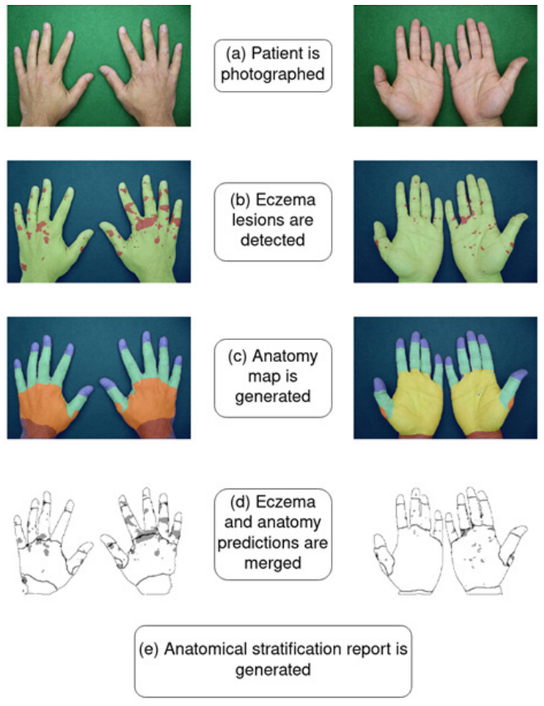


Figure 2: Hand eczema severity assessment (picture: L. Amruthalingam).

PhD Thesis by Ludovic Amruthalingam at the Digital Dermatology group.

The prevalence of skin diseases is high. A recent survey reported that half of the European population was afflicted with skin conditions. However, the resulting demand for dermatological care cannot be met satisfactorily because of a general shortage of dermatologists that will realistically not be filled by the healthcare sector. Alternative solutions should therefore be pursued to increase the capacities of the current healthcare workforce.

In this thesis (1) we developed different deep learning approaches to support various aspects of dermatologists' workflow. We proposed a method for the generation of anatomical maps from patient photographs (2) to assist dermatologists with lesion documentation and enable automated lesion stratification. Based on key features from lesion dermatological description, we developed an approach for the differential diagnosis of skin diseases. To enable objective severity assessment, we proposed a method for the precise quantification of palmoplantar pustular psoriasis lesions (3). Finally, we described an ongoing African teledermatology initiative aiming to provide semi-automatic triage of the six most prevalent local skin diseases.

Funding:

University of Basel

Helmut Fischer STIFTUNG fondation BOTNAR

Supervision:
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Prof. Marc Pouly
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References:
(1) L. Amruthalingam, "Deep Learning in Clinical Dermatology", PhD Thesis, University of Basel, 2022.

(2) L. Amruthalingam et al., "Improved Diagnosis by Automated Macro and Micro anatomical Region Mapping of Skin Photographs", Journal of the European Academy of Dermatology and Venereology, 2022.

(3) L. Amruthalingam et al., "Quantification of efflorescences in pustular psoriasis using deep learning", Healthcare Informatics Research, 2022.

Quantitative Analysis of Brain Edema Using Post Mortem Imaging

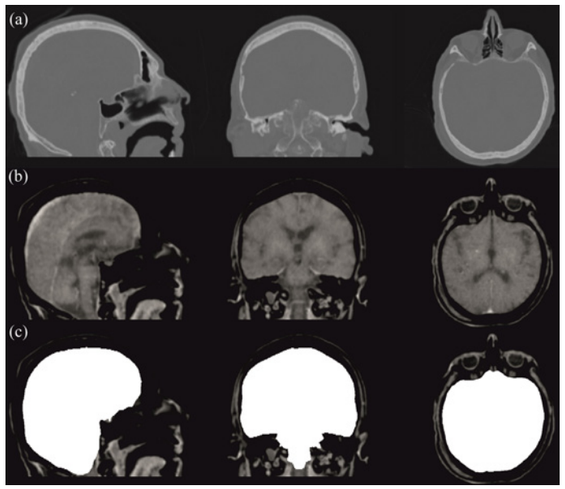

Figure 1: Example of image processing to calculate the intracranial volume for the computation of the NCW. Left: sagittal plane, middle: coronal plane, right: axial plane. (a) Original CT images. (b) Thresholded and smoothed images. (c) Segmentation of the intracranial volume (picture: M. Bauer).

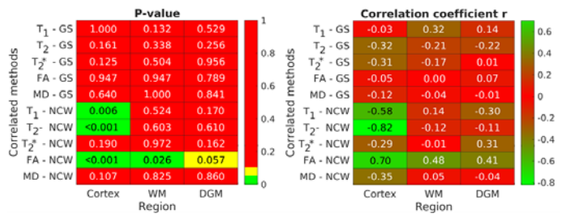

Figure 2: Heat maps of p-values and correlation coefficients r for correlations between GS (gold standard) and NCW, respectively, and the MRI parameters T1, T2, T2*, fractional anisotropy (FA) and mean diffusivity (MD) in the cortex, white matter (WM) and deep gray matter (DGM). Significant p-values are color-coded in green, not significant p-values in yellow (≤ 0.1) or red (> 0.1). The coloring for r starts with red at low correlations and becomes more green for higher correlations (picture: M. Bauer).

PhD Thesis by Melanie Bauer at the research group Forensic Medicine and Imaging of the Institute of Forensic Medicine of the University of Basel.

Brain edema is a common finding during forensic autopsies. The current gold standard in post mortem assessment of brain edema is the evaluation of the macroscopically visible signs by the forensic pathologists during autopsy. To facilitate their decision to rate a brain as edematous or non-edematous, a quantitative, objective and noninvasive evaluation method would be beneficial.

This PhD thesis contains six post mortem assessment methods for brain edema: the gold standard, a recently published mathematical model by Radojevic et al. (1), the normalized cerebral weight (NCW), histology, the wet-dry weight (WDW) and magnetic resonance imaging (MRI).

It was discovered that the mathematical model (1), the histology and the WDW method did not agree with the gold standard (2,3). The NCW has the disadvantage of being invasive (2). MRI proved to be a reliable assessment method for brain edema in deceased with the potential to replace the current gold standard, especially when determining the quantitative MRI parameters T2 and FA (4). Besides, the desired properties of non-invasiveness, objectiveness and quantitativeness are met by using MRI.

Funding:

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References:
(1) N Radojevic et al. J. Forensic Leg. Med., 45:21–28, 2017.

(2) M Bauer et al. FSI, 308:110164, 2020.

(3) M Bauer et al. FSI, 323:110808, 2021.

(4) Bauer et al. FSI, 337:111376, 2022.

Perfusion Culture Systems to Engineer 3D Biomimetic Bone Marrow Tissues

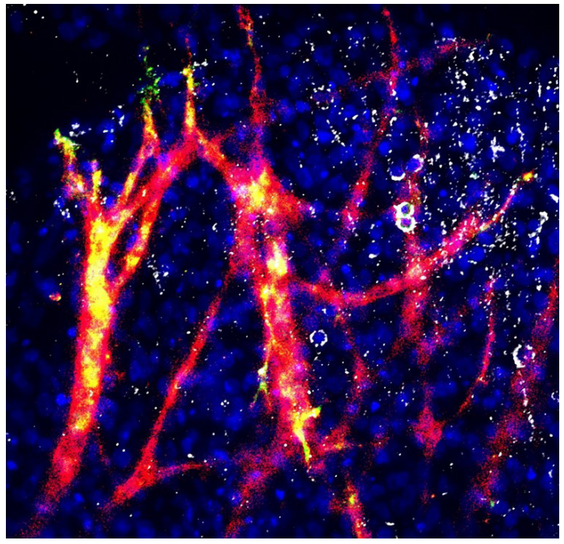

Figure 1: Whole-mount immunostaining labeling engineered blood vessels (red) with perivascular cells (green) and hematopoietic stem and progenitor cells (white). Cell nuclei are labeled in blue (picture: Technologies for Tissue Engineering Group).

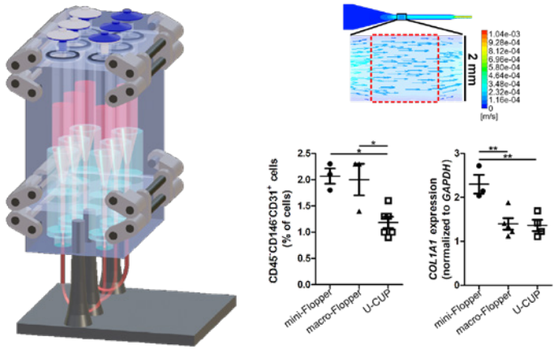

Figure 2: Miniaturized bioreactor models with optimized perfusion flow (Flopper) and complementary sizes that might be exploited to engineer homogeneous tissues and for drug testing assays with limited amount of biological material (picture: Technologies for Tissue Engineering group).

PhD Thesis by Gordian Born at the Technologies for Tissue Engineering group of the University of Basel.

Hematopoiesis is the process of blood production in the bone marrow (BM) tissue within the bones and is essential for every human. Most current in vitro systems to model human hematopoiesis fail to recapitulate the cellular diversity of native BM micro-environments or niches. The vascular component is a key part of native bone marrow that has been traditionally ignored when designing in vitro BM biomimetic niches.

In this thesis, firstly a novel fully humanized in vitro model with endothelial, perivascular and osteoblastic cells was engineered in a perfusion bioreactor system using human adipose tissue-derived stromal vascular (SVF) cells to generate the vascular component (figure 1). This vascularized bone marrow niche was able to significantly improve the preservation of undifferentiated cord blood hematopoietic stem and progenitor cells under physiological-like conditions (1).

Nevertheless, the macro-scale perfusion bioreactor system used to generate this vascularized osteoblastic tissue requires large amounts of cells/medium and applies a suboptimal flow to the tissue. For this reason, new flow-optimized macro- and mini-scale perfusion bioreactors were engineered in the context of this thesis. Computational fluid dynamic modeling confirmed the improved flow parameters in the new systems. Finally, we validated the functionality of these new bioreactors by engineering angiogenic niches (figure 2) (2).

Funding:

Swiss National Science Foundation

NCCR Molecular Systems Engineering

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Prof. Arnaud Scherberich
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References:
(1) Born, G. et al. (2021). Engineering of fully humanized and vascularized 3D bone marrow niches sustaining undifferentiated human cord blood hematopoietic stem and progenitor cells. Journal of tissue engineering, 12, 20417314211044855.

(2) Born, G. et al. (2022). Mini-and macroscale direct perfusion bioreactors with optimized flow for engineering 3D tissues. Biotechnology Journal, 2200405.

GAMER MRI : a Deep Dive in Multiple Sclerosis Pathology and Clinical Disability

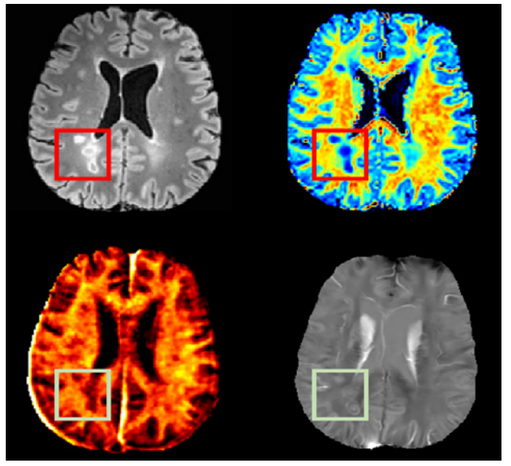

Figure 1: The white matter lesion representations of an exemplar MS patient on advanced qualitative and quantitative MRI. Upper row: FLAIR and Neurite Density Index (NDI) from NODDI. Lower row: Myelin Water Fraction (MWF) and Quantitative Susceptibility Mapping (QSM). Lesions are indicated by the green squares (picture: ThINk Basel).

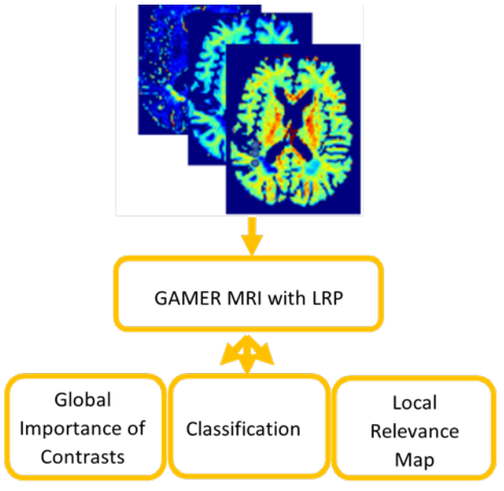

Figure 2: Overview of GAMER MRI in providing global importance and local relevance of the quantitative MRI (picture: ThINk Basel).

PhD Thesis by Po-Jui Lu at Translational Imaging in Neurology (ThINk) Basel group.

Multiple sclerosis (MS) is a chronic inflammatory disease of the central nervous system. Typical characteristics are multifocal inflammatory infiltration, demyelination, remyelination, and axonal loss. The advanced MRI (aMRI) sequences and the derived quantitative measures can provide surrogate measurements on these microstructural changes. The abundant information provided by aMRI is, however, partially redundant among them. There is a need to assess which aMRI or quantitative measures are important to a given task and explore the benefit of considering them jointly in studying MS axonal/myelin damage and repair.

We developed a novel deep learning method, Gated-Attention MEchanism Ranking of multi-contrast MRI in brain pathology (GAMER MRI), based on the convolutional neural network and gated attention mechanism. In the application of well-understood stroke-related and MS-related lesion classification, the method gave an attention weight-based importance of MR contrasts in line with clinical understanding [1]. Furthermore, we extended the method for highly intercorrelated diffusion MRI measures in the classification of MS lesion and perilesional tissue and the combination of the selected measures based on the importance more strongly correlated with the clinical measure of disability and the biological measure [2]. Last, we improved GAMER MRI and proposed a new Layer-wise Relevance Propagation (LRP) approach to identify important brain regions for assessing movement disability based on the combination of MRI and attention weight-based relevance maps

Along with these developments, we believe that GAMER-MRI can be a new means to jointly combine the abundant information in different kinds of MRI images for a more comprehensive analysis in the future.

Funding:

Swiss National Science Foundation

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Prof. Philippe Cattin
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References:
(1) Lu et al. GAMER MRI: Gated-Attention MEchanism Ranking of multi-contrast MRI in brain pathology. Neuroimaging: Clinical, 2021

(2) Lu et al. GAMER-MRI in Multiple Sclerosis identifies the diffusion-based micro-structural measures that are most sensitive to focal damage: a deep-learning based-analysis and clinico-biological validation, Frontiers in Neuroscience, 2021

Development of a Fiber-based Shape Sensor for Navigating Flexible Medical Tools

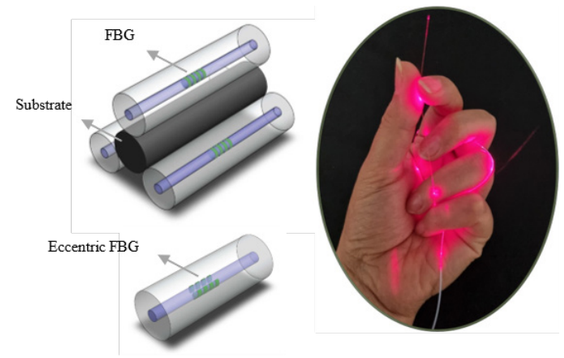

Figure 1: Shape sensing solutions based on multiple single-mode fibers with FBG arrays (top left) and eccentric FBGs (bottom left). The image on the right shows the 30 cm long fiber sensor with eccentric FBGs (picture: S. Manavi).

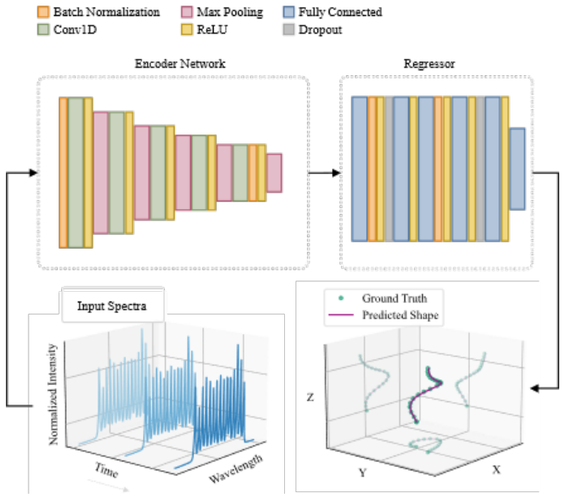

Figure 2: The architecture of the designed deep-learning model for the eccentric FBG shape sensor. The network receives the spectral scan of the sensor as the input and predicts the coordinates of 20 discrete points over the sensor's curve (picture: S. Manavi).

PhD Thesis by Samaneh Manavi at the Planning and Navigation group.

In minimally invasive surgical procedures, robots enhance manual dexterity and manipulability, especially in operations without adequate access to target anatomies. Continuum robots, in particular, can provide curvilinear and flexible access; however, their inherent deformable design makes it difficult to estimate their 3D shape accurately, which is why having a navigation system is of the essence during the operation.

This PhD project was conducted in the framework of the MIRACLE project (Minimally Invasive Robot-Assisted Computer-guided LaserosteotomE), which aims to develop a robotic endoscope for cutting bones with laser light. Within the scope of this thesis, two cost-effective fiber shape sensing solutions based on multiple single-mode fibers with fiber Bragg grating (FBG) arrays and eccentric FBGs were investigated for tracking the envisioned 30 cm long endoscope.

First, we presented the fabrication and calibration process of two shape-sensing prototypes based on multiple single-mode fibers with different substrate types (1). Then, we investigated the sensing mechanism of eccentric FBG and developed a deep-learning algorithm that directly predicts the sensor's shape from its signal and does not require any calibration or shape reconstruction steps (2). The eccentric FBG sensor, as the best-performing sensing mechanism among the investigated fiber shape sensors, achieved a tip accuracy of around 2 mm in complex shapes, competing with the state-of-the-art distributed fiber shape sensors that cost 30 times more (3).

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Analysis of Synthetic and Natural Cannabinoids in the Forensic Field Applying High–Resolution Mass Spectrometry

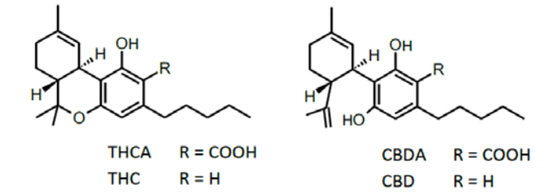

Figure 1: Chemical structures of THC and CBD (picture: drawn in ChemSketch, by M. C. Monti).

Figure 2: Cannabis flower sample analyzed for Study II (picture: M. C. Monti).

PhD Thesis by Manuela Carla Monti at the Institute of Forensic Medicine, University of Basel.

Multidimensional challenges arise in the field of forensic chemistry and toxicology from the ongoing emergence of synthetic cannabinoids (SCs) as well as the increasing legalization and medicalization of Cannabis sativa (C. sativa). This work addresses these challenges from different angles under the application of state-of-the-art mass spectrometry.

Study I investigated the in vitro metabolic fate of two SCs (1). As data on the metabolism of newly emerging SCs is typically scarce, in vitro metabolism studies are required for the identification of suitable screening targets.

Study II presents data gained on the phenomenon of low THC cannabis products adulterated with SCs. Since 2020, such products have been increasingly detected in Switzerland and various European countries. The drug user's unawareness about the presence of SCs combined with the typically higher potencies of SCs when compared to Δ9-tetrahydrocannabinol (THC) raised public health concerns. Cannabis samples and data on the drugs' effects obtained from three drug checking services were investigated (2).

Study III presents the development and validation of a comprehensive analytical method for the determination of major and minor cannabinoids in cannabis inflorescences. Minor cannabinoids are gaining interest for various applications, ranging from improved product characterization and differentiation of cannabis varieties to bioanalytical questions in the medico-legal field. The presented methods allowed for a refined representation of chemical differences, i.e., chemical fingerprints, between varieties, expanding traditionally applied classification systems based on THC and CBD alone (3).

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Quantitative Magnetic Resonance Imaging in Multiple Sclerosis: Neuropathology and Genetics Correlates

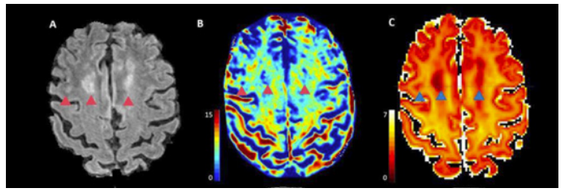

Figure 1: An exemplary conventional image (*D FLAIR) showing an MS lesion and of a myelin and an axon map as obtained with quantitative MRI (picture: ThINk).

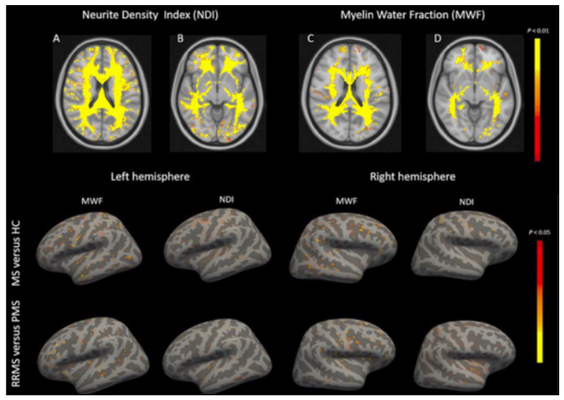

Figure 2: Normal appearing grey matter (botton two raws) but not normal appearing white matter (upper two raws, showed increased axon and myelin damage in progressive vs RRMS patients (picture:ThINk).

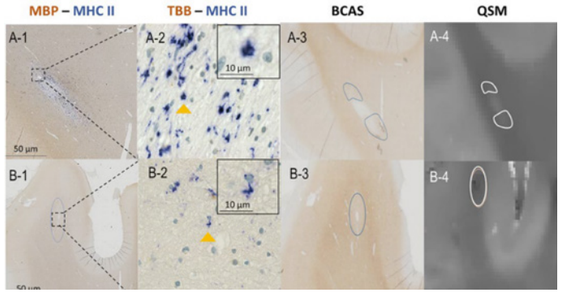

Figure 3: Remyelionation lesions in multiple sclerosis appear hypointense or isointense in quantitative susceptibility mapping (QSM) (picture:ThINk).

PhD Thesis by Reza Rahmanzadeh at the Translational Imaging in Neurology (ThINk) Basel group.

Multiple sclerosis (MS) is a chronic inflammatory demyelinating disease of the central nervous system characterized by multifocal inflammatory infiltrates, microglial activation, and degradation of oligodendrocytes, myelin, and axons. The imbalance between the damage to the myelin/axonal structure and axonal repair is considered to be one of the drivers of disability in MS patients.

In this doctoral work, we have studied in vivo in MS patients the complex interplay between axon and myelin damage in both lesion tissue and normal-appearing gray and white matter Figure 1 (1). And we have shown first that MS patients with progressive disease show increased axon and myelin damage in the normal-appearing cortex compared to relapsing-remitting patients, Figure 2 (1). We have also identified novel bio-markers of remyelination in quantitative susceptibility maps (QSM); specifically, we provided evidence that QSM hypo- and iso-intense lesions correspond to completely remyelinated plaques ("shadow" plaques), exploiting a dual approach based both on in vivo imaging and post mortem imaging-histopathology (figure 3), (2). Also, we have investigated the reproducibility of multiple myelin-sensitive MRI techniques in healthy controls and their sensitivity to focal and diffuse MS pathology in MS patients (3). Last, our work identified novel genetic loci that might be associated with myelin and axonal pathology in MS patients.

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References:
(1) Rahmanzadeh R. et al., Brain 2021.

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Prognoses on DNA-based Identification Success Rates of Altered Human Remains Using Capillary Electrophoresis & Sequencing Technologies

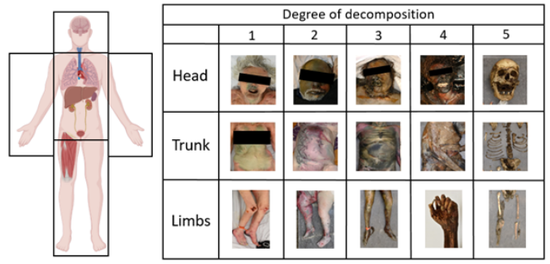

Figure 1: Excerpt of a scoring system for categorizing the decomposition progress The body was categorized into three anatomical regions and degrees from 0 (unaltered) to 5 (skeletonized). (graph: made with Biorender; pictures: Institute of Forensic Medicine, T. Rost).

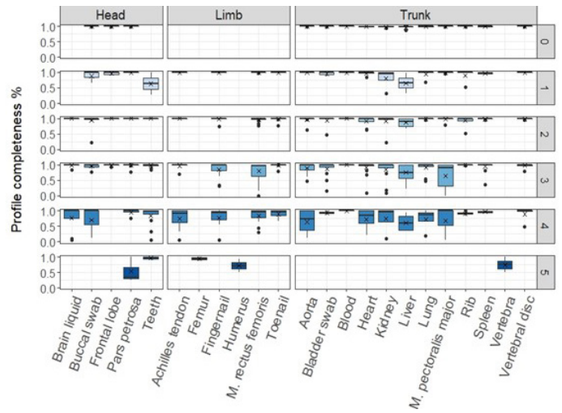

Figure 2: Profile completeness (%) of 22 STR markers separated according to the corpse's degrees of decomposition from 0 (unaltered) to 5 (skeletonized) and three anatomical regions (picture: Institute of Forensic Medicine).

PhD Thesis by Alina Senst at the Forensic Genetics group of the Institute of Forensic Medicine, University of Basel.

The DNA-based identification success of altered human remains relies on the condition of the tissue sample and the associated DNA quantity and quality (1). Due to tissue-specific differences in post mortem DNA stability, sampling the best-suited material is essential for successful identification (2).

Therefore, the thesis aimed to improve the genotyping success of Short Tandem Repeats (STRs) by presenting prognoses and recommendations for optimal tissue sampling according to the corpse condition.

In a systematic approach, the progress of alteration was assessed using a modified scoring system (figure 1). Thereafter, DNA yields, stability and profile completeness were investigated in 19 different tissue types from 102 deceased. Besides capillary electrophoresis (CE) methods, novel Next Generation Sequencing (NGS) technologies were validated and optimized to improve the sequencing of severely degraded and inhibited samples.

Regarding the profile completeness, blood samples revealed typing success rates of 100% for each degree of decomposition (figure 2). Notably, the more advanced NGS technology resulted in a significantly higher STR profile completeness compared to CE.

Overall, the novel established guidelines present optimal tissue types for each degree of degradation to improve the identification success of altered human remains at first attempt.

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Automatic Detection of Pathological Regions in Medical Images

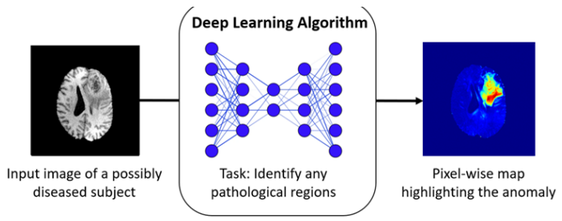

Figure 1: The goal is to develop deep learning algorithms that automatically identify anomalous changes in medical images. The generated anomaly maps lead the attention to the relevant parts of the anatomy (picture: J. Wolleb).

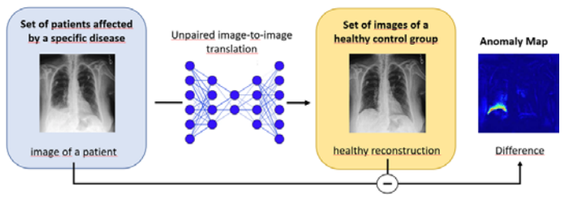

Figure 2: Workflow for weakly supervised anomaly detection using unpaired image-to-image translation between a set of patients and a healthy control group (picture: J. Wolleb).

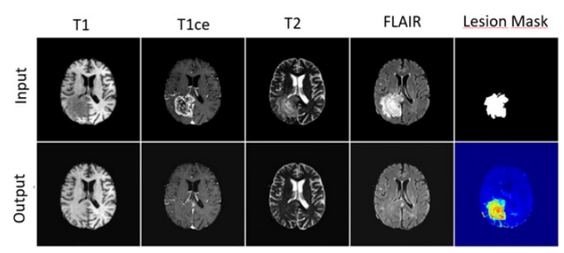

Figure 3: Results for our weakly supervised brain tumor detection algorithm on the BraTS2020 dataset. The difference map between input and output accurately highlights pathological changes (picture: J. Wolleb).

PhD Thesis by Julia Wolleb at the Center for medical Image Analysis & Navigation (CIAN).

Medical images are an essential tool in the daily clinical routine for detecting, diagnosing, and monitoring diseases. The fast progress of deep learning opened many new possibilities to automate the analysis of these images. In this thesis, the overall goal was to develop deep learning algorithms to find pathological regions in images of patients automatically.

In the first step, we present a fully supervised segmentation method based on denoising diffusion models (1). Due to the implicit ensemble characteristic, our method provides uncertainty maps that allow for the interpretability of the model's decisions.

Manual pixel-wise annotations face the problems that they are prone to human bias, hard to obtain, and often even unavailable. Weakly supervised methods in contrast avoid these issues by only relying on image-level annotations. We present two approaches based on generative models to generate pixel-wise anomaly maps using only image-level annotations, i.e., a generative adversarial network (2) and a denoising diffusion model (3). Furthermore, in an extension of the diffusion-based anomaly detection method, we present a flexible framework to solve various image-to-image translation tasks.

Finally, we focus on a problem frequently occurring when working with MR images from different hospitals: This multi-scanner setting introduces a bias between the datasets of different scanners, limiting the performance of deep learning models. We present a regularization strategy (4), improving the model's robustness and generalization quality.

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References:
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(2) J. Wolleb et al., DescarGAN : disease-specific anomaly detection with weak supervision. MICCAI 2020

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(4) J. Wolleb et al. Learn to ignore: Domain adaptation for multi-site MRI analysis. MICCAI 2022

Tools and Methods for Low-Field MR Imaging and Elastography

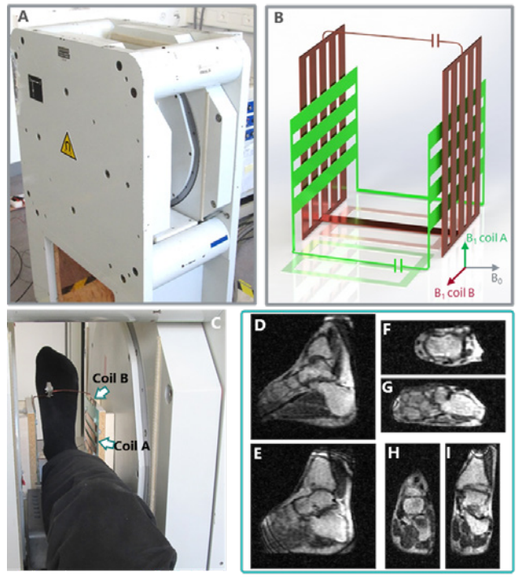

Figure 1: A) 0.1 T extremities MRI system. B) Open quadrature volume RF detector. C) foot positioning. D-I) slices from the same 3D bSSFP scan of an ankle, 7 min 54 s, resolution 0.8 x 0.8 x 1.1 mm3 (pictures: M. Yushchenko).

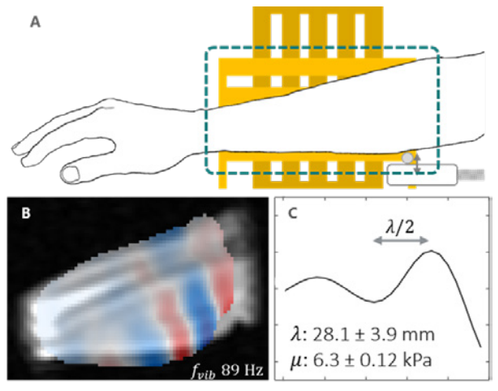

Figure 2: MR elastography experiment. A) forearm positioned inside a custom open detector. B) waves acquired within 1 min with a 0.1-T extremities scanner. C) shear stiffness of muscles estimated from the wavelength of the wave propagation (pictures: M. Yushchenko; drawing: A. Tioli).

PhD Thesis by Maksym Yushchenko at the Center for Adaptable MRI Technology (AMT Center).

Low-field magnetic resonance imaging (MRI) leverages rather low magnetic field strengths (< 0.2 T) compared to conventional clinical MR scanners that operate between 1.5 T and 3 T. This provides opportunities for small and mobile MR scanners, reducing both siting requirements and costs, which makes MRI possible in settings and applications currently out of reach due to limited access, exacerbated artifacts or reduced MR compatibility (1).

Low-field MRI is challenged by the low available signal; thus, many parts of the complex MRI system require optimization to obtain images with signal-to-noise ratio (SNR) sufficient for clinical applications within reasonable scan times.

In this PhD, efficient tools were developed for a compact 0.1 T MRI scanner for human extremities. These include high-performance detectors, such as an open quadrature volume RF coil for versatile imaging with simple positioning and access (figure 1). In addition, we investigated methods for MR elastography (MRE is a technique that quantifies the mechanical properties in the organs), including the assessment of validity criteria defined in calibrated phantoms (2), vibration hardware, open detectors and MRE sequences. With an innovative accelerated method, we were able to perform fast acquisitions (< 3 min) of waves for MR elastography in vivo in humans, for the first time at a field below 1.5 T3 (figure 2).

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(1) Sarracanie M, Salameh N, 2020. Low-Field MRI: How Low Can We Go? A Fresh View on an Old Debate. Front Phys.

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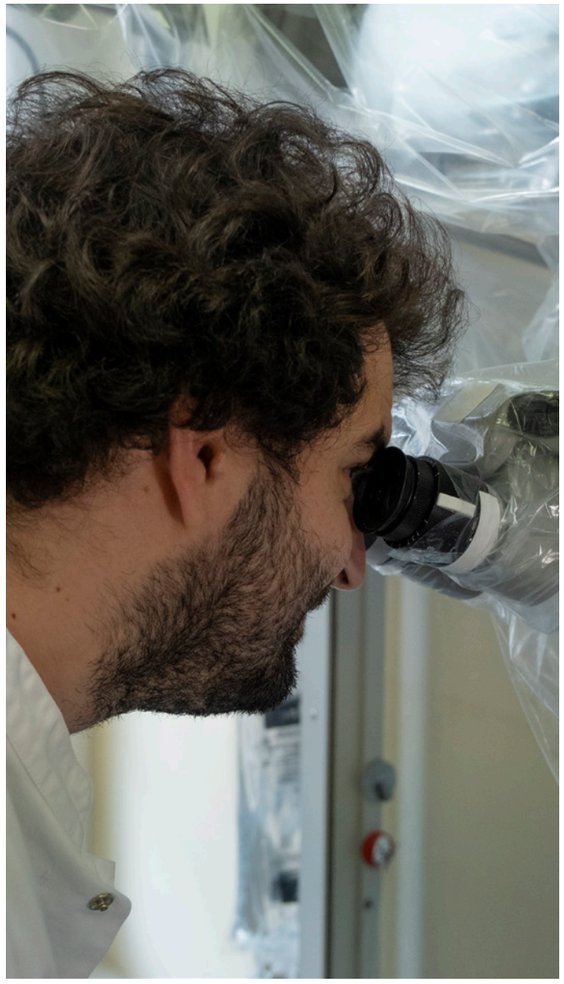
Completed Master's Thesis



Research project at the DBE (picture: R. Wendler).

In 2022, numerous Master's students were involved in DBE's research projects. They include:

Cell Damage Spreading in Manually and LASER Ablated Cartilage Samples

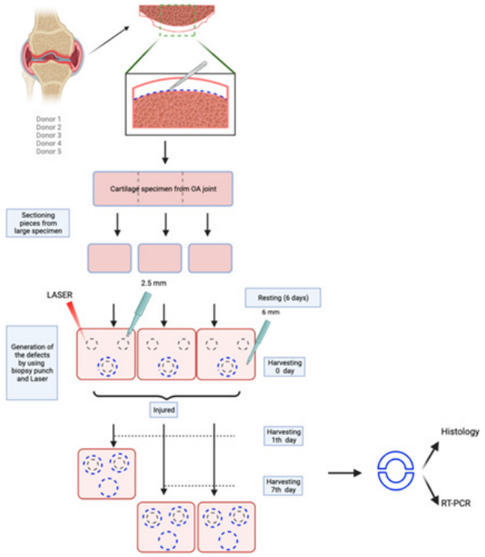


Figure 1: Experimental plan including taking cartilage samples from osteoarthritic patients, creating holes (with biopsy punch or Er:YAG LASER) and collecting samples at the cut edge for analyzes at different times (picture: A. Arslan, DBM).

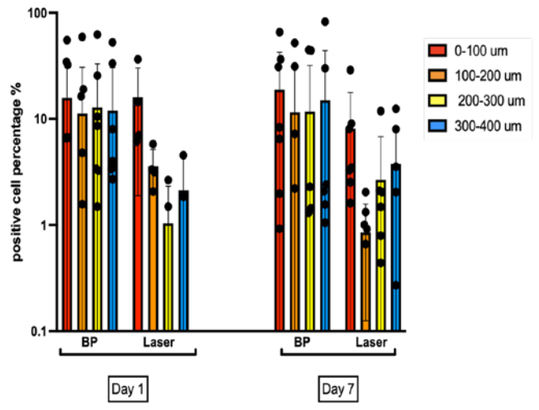


Figure 2: Quantification of MMP13 positive cells in laser and manually cut cartilage at different time points and at different distances from the wound edge (graph: A. Arslan, DBM).

Master's Thesis by Aybüke Arslan at Cartilage Engineering Lab (Department of Biomedicine, University of Basel).

A promising approach to treat cartilage injury is the implantation of engineered autologous cartilage (1). New methods to refresh the damaged cartilage are needed, considering that sharp tools cause serious damage of the chondrocytes at the wound edge (2), thus effecting an efficient integration of the graft to the surrounding native tissues. We investigated whether ablation of cartilage with laser would counteract the tendency of the damage to spread out from the cartilage defect over time.

Human cartilage samples were cut with a biopsy punch or with the (Er: YAG) LASER (3) (figure 1). Specimens collected at the wound edge were assayed to quantify Bone Morphogenetic Protein (BMP-2) and Metalloprotease (MMP)-13. Due to a large intra-donor variability, we could not find statistically significant differences in the mRNA expression of these markers among the groups. However, we observed a trend vs a reduction of the percentage of MMP13-positive cells in areas surrounding the laser ablated cartilage (figure 2).

Quantification of larger number of markers, in a larger number of joint specimens will be required to assess the benefits of laser in refreshing cartilage lesions.

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Advanced Three-Dimensional Visualization of Dynamic Muscle MRI

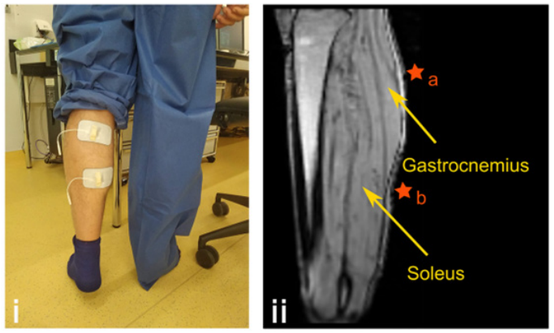

Figure 1: (i) Placement of the NMES electrodes prior to the scan. (ii) MR image of the lower leg indicating the Gastrocnemius and Soleus (picture: BAMM).

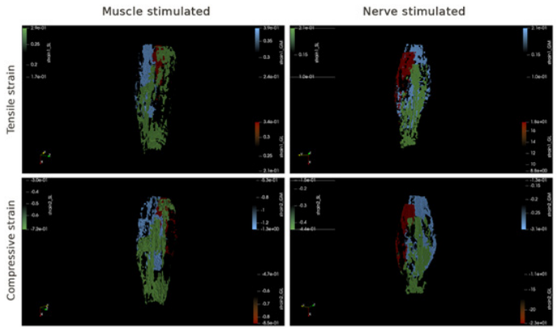

Figure 2: Compressive and tensile strain visualization during NMES via the muscle belly and nerve trunk (picture: E. Akporeha).

Master's Thesis by Efena Akporeha at the Basel Muscle MRI group (BAMM)

Muscle contractility can help understand the behavior of healthy and diseased muscles. Neuromuscular electrical stimulation (NMES) applied on superficial skeletal muscles evokes controlled muscle contractions (1) and can be combined with Magnetic resonance imaging (MRI) to get information about the magnitude and the location of the muscle response.

The purpose of this work was to create a semi-automatic pipeline for the 3D visualization of dynamic muscle datasets. A workflow was developed that takes strain values in a VTK file format as input and produces a 3D visualization in ParaView. In addition to the maximum strain, the temporal evolution of the strain was also visualized to better understand muscle contraction patterns. With this, it was possible to visualize calf muscle datasets and observe the inhomogeneity of contraction during NMES via stimulation of the muscle belly and vice versa for NMES via stimulation of the nerve trunk in agreement with (2).

This could offer additional information as a part of standard quantitative MRI protocol, by highlighting the differences in the pattern of deformation thereby providing better insights on how the muscles behave during NMES. Finally, it is a first step in the direction of a reproducible quantification procedure and it is an open source software upon which future researchers can further develop similar workflows.

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Reliability of Shoulder Muscle Strength During Abduction and Rotation with the Biodex Dynamometer in Healthy Subjects

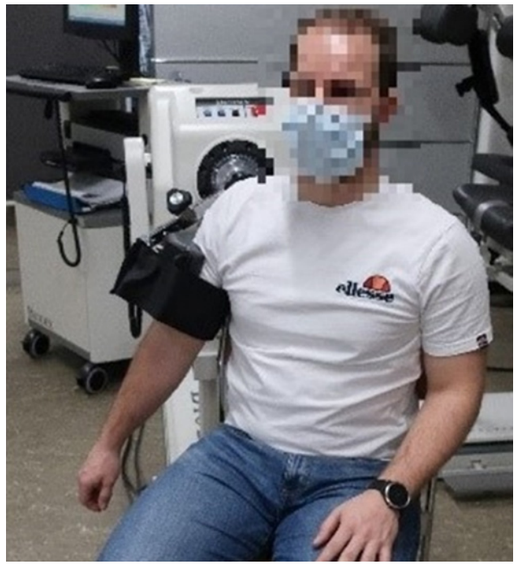

Figure 1: Biodex setup for shoulder abduction (picture: Functional Biomechanics Laboratory, USB).

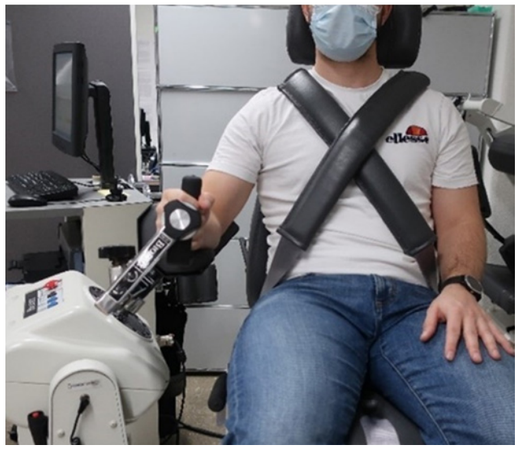

Figure 2: Biodex setup for shoulder external and internal rotation picture: Functional Biomechanics Laboratory, USB).

Master's Thesis by Patrik Born (Department of Biomedical Engineering, University of Basel; Department of Sport, Exercise and Health, University of Basel) at the Functional Biomechanics Laboratory (University Hospital Basel).

The Constant score (1) is a clinical questionnaire to assess the functionality of the shoulder. It also contains a strength assessment simply for abduction. The aim of this study was to evaluate the test-retest reliability of isometric shoulder muscle strength with the Biodex dynamometer and to establish their association with the strength assessment of the Constant score.

Isometric shoulder muscle strength was measured in two sessions for abduction at 10° and 30° abduction in the scapular plane, and for internal and external rotation in ten young healthy subjects. The Constant score was collected during the first session.

Muscle strength did not differ between tests ($P > 0.05$). Good to very good reliabilities were found for all repeated tests ($ICC > 0.7$). A moderate correlation of the strength parameter of the Constant score with all shoulder strength from the dynamometer was detected ($r > 0.5$).

Shoulder muscle strength for abduction and rotation are reproducible and correlate with the strength assessment of the Constant score. These strength tests can be further used to analyze the effects of different shoulder joint pathology on muscle strength.

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(1) Constant CR, Murley AHG. A clinical method of functional assessment of the shoulder. Clin. Orthop. Relat. Res. 1987;No. 214:160–164. doi:10.1097/00003086-198701000-00023

Fat Characterization at Increasing Temperature Using Low Field MRI (0.1T)

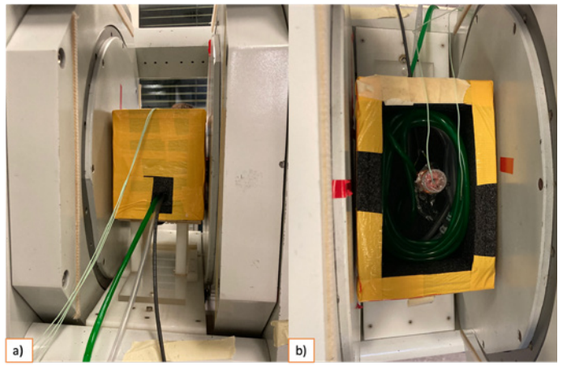

Figure 1: MR system with the insulation box. a) Set up of the ex-vivo porcine samples. b) Heating configuration inside the insulation box (picture: L. Corredor, AMT Center).

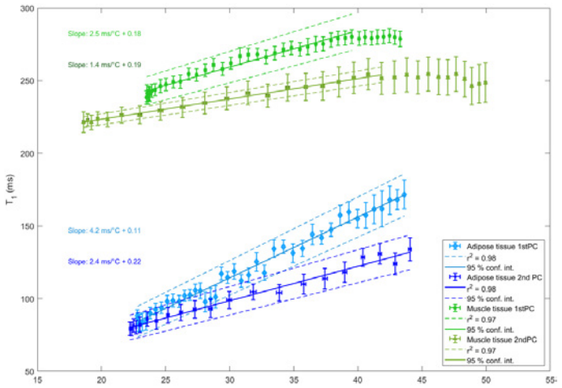

Figure 2: T_1 vs. temperature of ex-vivo porcine chops tissue. T_1 measurements for pork chop samples against the mean temperature recorded during the corresponding acquisition window. A linear fit was applied to all the samples. Blue indicates adipose tissue and green muscle tissue (picture: L. Corredor, AMT Center).

Master's Thesis by Luz Adriana Corredor Garcia at the Center for Adaptable MRI Technology (AMT Center).

MR temperature imaging (MRTI) allows to monitor temperature changes during thermal therapies such as thermal ablation or hyperthermia. These minimally invasive procedures reduce the risk of infections, accelerate recovery times, and allow to shorten hospital stays (1). Despite numerous advances in MRTI monitoring, a comprehensive method for adipose tissues has not been achieved and most research is performed at high fields, which does not allow for wider clinical adoption as the accessibility of these systems is low. Considering this, low-field MR may be relevant for the expansion of interventional procedures.

T_1 and T_2 based methods have recently gained interest for monitoring temperature changes in tissue with high fat content since one of the main limitations is that the T_1 contrast is lower at higher field strengths, so in this work these magnetic properties were studied as temperature markers in adipose tissues at 0.1T. To this end, a working temperature-varying setup was designed to have a minimal dissipation of heat capable of tracking the temperature variations induced into oil phantoms and porcine tissue samples. For T_1 measurements a saturation recovery (SR) sequence was used and for T_2 a CPMG sequence. A full investigation on the trade-off between data quality and time acquisition was carried out. We observed the T_1 and T_2 dependence on temperature in oil samples with high linearity in the temperature range of interest of 20°C to 43°C. Additionally, T_1 dependence on temperature was also evaluated in adipose and muscle tissue. Data acquisition was optimized and different fitting models for T_1 were investigated.

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References:
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Investigation of the Impact of Microbubbles on Visible Spectroscopy of Blood

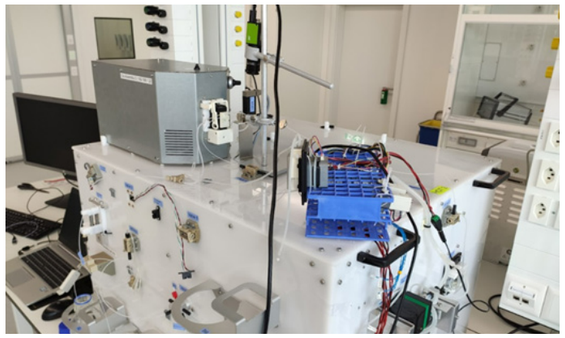

Figure 1: Overview of the set-up with the fluidic system and the oximetry module used for the measurement of the absorbance spectrum. (picture: J. Gómez, Roche).

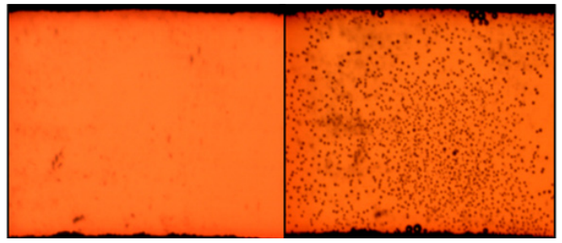

Figure 2: Comparison of the situation of the cuvette filled, on the left, with hemolyzed blood without air bubbles and, on the right, with microbubbles. (picture: J. Gómez, Roche).

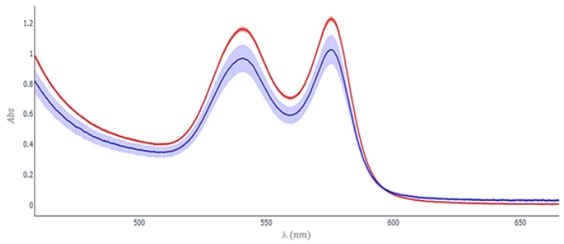

Figure 3: Measured spectra of absorbance from blood samples without bubbles (red) and samples with bubbles (blue). (picture: J. Gómez, Roche)

Master's Thesis by Juan de Dios Gómez Ventoso at Roche Diagnostics.

Hemoglobin is the major constituent of red blood cells responsible for oxygen transport across the organism. Abnormal values of hemoglobin may be an indicator of medical conditions, such as anemia.

The oximeter module of the Cobas b 123 POC system from Roche Diagnostics uses spectroscopy in the visible light range for the determination of the total hemoglobin concentration as well as the concentration of its derivatives. The blood sample is automatically filled into a cuvette with a fluidic system. During this process, air bubbles might be introduced accidentally due to small leaks in the fluidic system. These bubbles might negatively affect the analytical results since they can alter the optical properties of the sample.

This Master's thesis aimed to find characteristic finger-prints that the air bubbles might produce in the absorbance spectrum. To simulate the problem, air bubbles are intentionally introduced into the blood sample. The hemolysis unit of the oximeter module is used to reduce the size of the inserted air bubble. The acquired spectrum is compared to the spectrum of the sample without bubbles, as well as the concentration values of the derivatives. Statistical methods are used to determine the differences between both groups. Furthermore, image analysis is employed to analyze the density of bubbles in the cuvette in order to find a correlation between the volume occupied by air and the measurement results. Ultimately, a potential possible way of detecting air bubbles in the system based on a binary classifier is presented.

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Development and Characterization of Loaded Human Nucleus Pulposus Cells-On-Chip

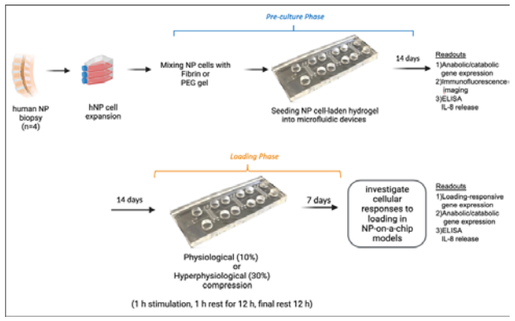

Figure 1: Experimental design in which a 3D NP matrix established in the hNPoC model after 14 days of preculture phase, and then subjected 10% or 30% compression for 7 days by electro-pneumatic system provided by BiomimiX© (picture: S.Erat, DBM).

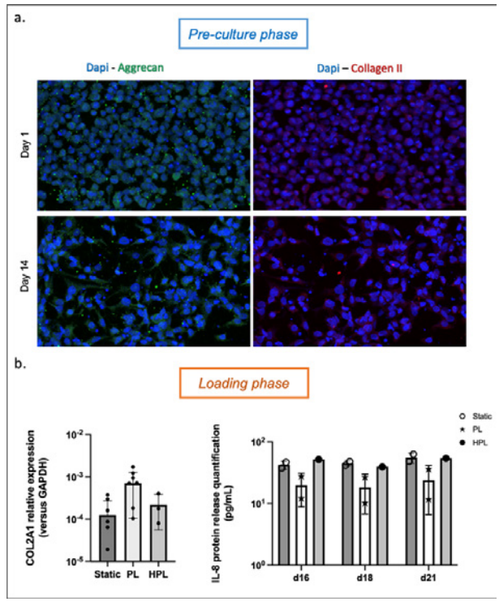

Figure 2: Immunofluorescence imaging of NP matrix constituents revealed; although aggrecan and collagen type-II deposition was more abundant on day 1, observed pericellular matrix indicated matrix remodelling after 14 days of maturation in the hNPoC model (a), slight upregulation in COL2A1 gene expression and decrease in IL-8 release in physiological (PL) compression group during loading phase (b) (imaging: A. Mainardi; picture: S.Erat, DBM).

Master's Thesis by Sila Erat at Cartilage Engineering Laboratory (Department of Biomedicine, University of Basel).

The intervertebral disc (IVD) is an avascular cartilage tissue that connects the vertebral bodies, functioning as a shock absorber. The progressive loss of IVD function causes rupture and/or loss in IVD content, and loss of mobility, which has been related to the degeneration of the soft inner core -nucleus pulposus (NP) tissue. Poor understanding of the mechanism of NP degeneration as well as how NP cells response to different magnitude of mechanical loading in physiological and pathological environment create an obstacle in the way of the development of disease-modifying therapies (1). Therefore, this project aims to establish a 3D lab-on-chip platform (hNPoC) to recapitulate NP phenotypes under physiological (10%) and hyperphysiological (30%) compression to investigate cellular responses under mechanical loading (figure 1).

In order to establish a 3D cell microconstruct after 14 days of culturing, the transglutaminase – catalysed (TG) PEG (2%) hydrogel was mixed with human NP cells and seeded in in hNPoC (2). Followed by confined compression for additional 7 days, physiological (10%) compression tended to upregulate COL2A1 gene expression and decrease pro-inflammatory cytokine IL-8 release (figure 2b), while hyper-physiological (30%) compression did not induce prominent changes compared to static control. Even though more donors are needed to acquire statistically significant data, physiological compression based hNPoC model has a potential to provide a beneficial environment for hNP cells (3).

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References:
(1) Adams, M.A., et al. Spine (Phila Pa 1976), 2006. 31(18): p. 2151-61.

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Alzheimer's Disease Classification: Ignoring the MR Scanner Bias for a Multi-Class Problem

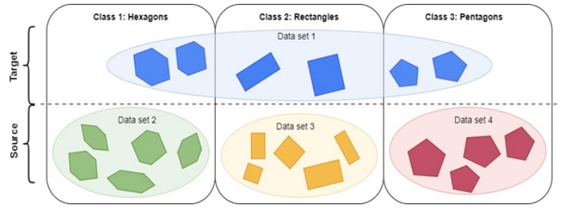

Figure 1: Quantity chart for the data sets in the source and target domain. Different shapes represent different classes and different colors represent different MR scanners (picture: T. Faludi).

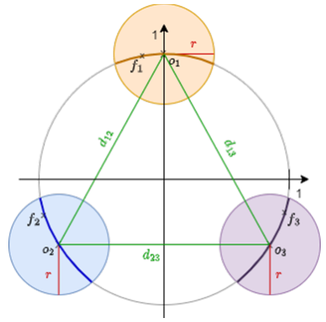

Figure 2: Schematic overview of the latent space in 2D. The latent vectors f_i of class i lie within a circle of radius r around o_i, whereas all ceter points o_i are sparated from each other. This is achieved with two additional loss functions of the classification network (picture: T. Faludi).

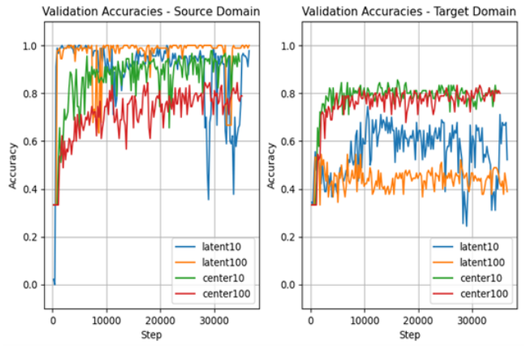

Figure 3: Validation accuracy of L2I latent10, L2I latent100, L2I center10, L2I center100 on the source and target domain. Only L2I center100 shows a consistent performance over images both from the source and the target domain (picture: T. Faludi).

Master's Thesis by Tamás Faludi at Center for Medical Image Analysis & Navigation (CIAN).

There is only a limited availability of large Magnetic Resonance (MR) image data sets, which makes combining different data sets unavoidable to train generalizable machine learning methods. However, using images from different MR scanners introduces a bias due to different acquisition settings, which limits the performances of deep learning models (1).

In previous work, a novel domain adaptation method called Learn to Ignore (L2I) was presented that learns to ignore the scanner-related features in MR images and focuses on the biological features relevant for a binary classification task (2). This was achieved by implementing additional constraints on the latent space of the classification network and thereby grouping the latent vectors of the same classes together, independently from their provenance.

In this work we adapt the L2I method to a three-class classification task between Alzheimer's disease patients, mild cognitive impairment patients and healthy subjects. We explore and analyze different modifications of the proposed method and find the L2I center100 variant, which shows a consistent performance across different scanners. Thereby, our method improves the robustness and generalization quality of the model.

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Robot-Assisted Laser-Ablation of Engineered Human Cartilage

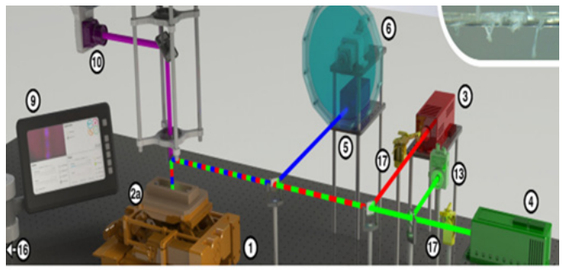

Figure 1: Setup of robotic stage with lasers (rendering: C. Duverney).

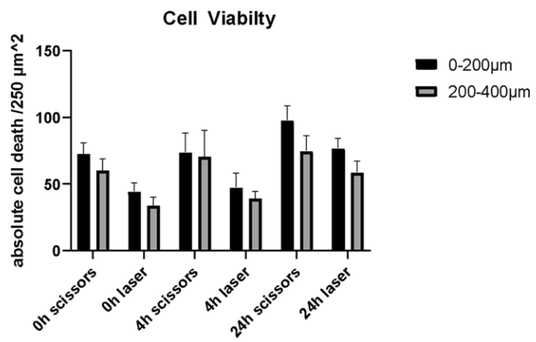

Figure 2: Cell viabilty results; comparison between two surgical methods. The first is a conventional method using surgical scissors, the second is laser ablation. Compared also in terms of time(after 0,4&24 hrs) and distance (black and grey) from the cutting edge (picture: BIROMED-Lab).

Master's Thesis by Roman Friedli at BIROMED-Lab.

The use of engineered human cartilage is an increasingly used and established method in invasive medicine. Since we are trying to make invasive medicine less invasive in the context of the MIRACLE (Minimally Invasive Robot-Assisted Computer-guided Laserosteotomy) project and to automate and robotically assist procedures as far as possible and sensible, it is a sensible procedure to combine the technology, which is in an upward trend, with the method that is trying to establish itself as the standard in operational medicine. The aim of the work was to determine the extent of cell damage from laser ablation, compared to mechanical preparation in engineered human cartilage to develop a user protocol that can be replicated at later time points. We also wanted to carry out the whole procedure robot-assisted and in a sterile environment, so that in a further step the minimally invasive manipulation of, in the beginning at least cartilage, can also be carried out in a simple, replicable, automated, and user-friendly way. This includes producing human engineered cartilage, laser ablating the generated samples, and making the whole ablation process as automated, safe, and sterile as possible.

We found that laser ablation has a better outcome in terms of cell viability than conventional methods (i.e. manipulating with biopsy punches and surgical scissors) and thus causes less apoptosis in the surrounding tissue in vitro.

Regarding the significance of the results, it is safe to say that the results can be statistically relied upon, all endpoints are statistically relevant and therefore important. However, since the process of producing the cartilage graft can be different, it would certainly have to be tested in a larger study in vivo on animal models in order also to observe the behaviour of cell viability in a period longer than three days.

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Compressed Sensing and Sub-Space Constrained Reconstruction in Cardiac MRI

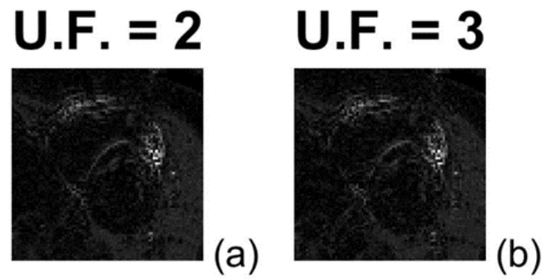

Figure 1: Pixel-wise subtraction of subspace constrained reconstructed images of different undersampling factors (U.F.) with the reference images (picture: A. Gkatziouras).

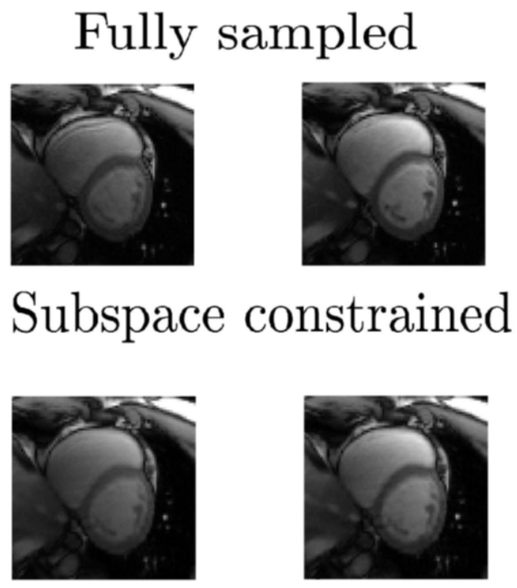

Figure 2: Comparison between fully sampled dataset reconstruction and subspace constrained reconstruction from the undersampled dataset with an undersampling factor of 3 (picture: A. Gkatziouras).

Master's Thesis by Andreas Gkatziouras at the Basel Muscle MR Imaging group (Radiological Physics, University Hospital Basel).

Quantitative imaging techniques are a main topic of ongoing research in Cardiac Magnetic Resonance Imaging (CMRI). Current challenges involve the speed up of acquisition as well as maintaining good accuracy. This work describes the comparison of sophisticated, state-of-the-art reconstruction methods of under-sampled inversion recovery balanced steady-state free precession data. The data consist of images of the heart in multiple phases of the cardiac cycle.

The reconstruction methods studied here are Compressed Sensing (1) and subspace constrained reconstruction (2). The mean squared errors between the reconstructed and the reference data are discussed.

The methods show promising results, while subspace constrained reconstruction also shows robustness to ascending undersampling factors.

Further improvements could be made with the addition of a gated signal acquisition to target purely the diastolic phase of the cardiac cycle and/or the addition of a registration step for motion correction and motion artefacts.

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References:
(1) M. Lustig, D. Donoho, and J. M. Pauly, "Sparse MRI: The applica-tion of compressed sensing for rapid MR imaging," Magnetic Resonance in Medicine: An Official Journal of the International Society for Mag-netic Resonance in Medicine, vol. 58, no. 6, pp. 1182–1195, 2007.

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Muscle Synergies During Single-Leg Hops 2 Years after Internal Brace-Augmented ACL Repair Compared to ACL Reconstruction & Healthy Controls

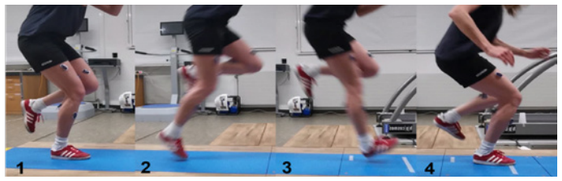

Figure 1: Performance of the single-leg hop in the measurement setting. Preparation (1), push-off (2), foot contact (3) and landing (4) (picture: A. Göbel).

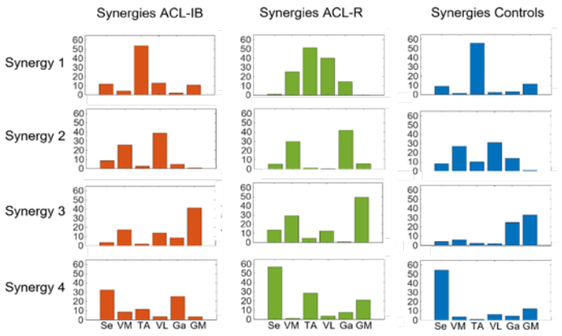

Figure 2: extracted muscle synergies for all three groups (picture: Functional Biomechanics Laboratory).

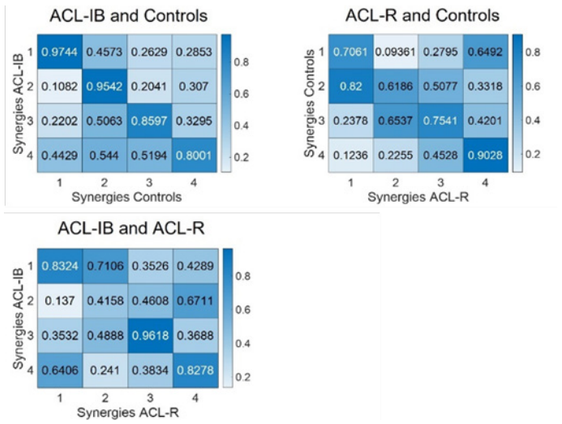

Figure 3: Heat map of muscle synergy comparison between groups (picture: Functional Biomechanics Laboratory).

Master's Thesis by Angela Göbel (Department of Biomedical Engineering, University of Basel; Institute of Sports and Sports Science, Karlsruhe Institute of Technology) at the Functional Biomechanics Laboratory (University Hospital Basel).

Rupture of the anterior cruciate ligament (ACL) results in altered signal transmission and neuromuscular function. To date, biomechanical and muscular studies after Internal-Brace-augmented ACL repair (ACL-IB) are lacking.

We compared muscle activity based on spatial muscle synergies during landing of forward single-leg hops (figure 1) between patients after ACL-IB, patients after ACL reconstruction (ACL-R) and healthy controls. For extraction of muscle synergies non-negative matrix factorization of the activity of vastus medialis (VM), vastus lateralis (VL), gastrocnemius (Ga), tibialis anterior (TA), semitendinosus (Se), and gluteus medius (GM) muscles was used. The number of synergies in a group were determined based on explained variance (VAF) ≥0.9. Cosine similarity (CS ≥0.8) was used for group comparison of identified synergies.

Analysis identified four synergies in all groups (figure 2). ACL-IB and controls were similar in four, ACL-R and controls in two, and ACL-IB and ACL-R in three synergies (figure 3).

Greater similarities in synergies between ACL-IB and controls than between ACL-R and controls indicate that preservation of the original ligament likely positively influences motion control and possibly minimizes development of abnormal motion patterns.

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(1) DiFelice, Gregory S.; van der List, Jelle P. (2016): Arthroscopic Primary Repair of Proximal Anterior Cruciate Ligament Tears. In: Arthroscopy techniques 5 (5), 1057-1061. DOI: 10.1016/j.eats.2016.05.009.

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The Impact of Perfusion Culture on hMSC Differentiation and Functional Maturation in a 3D-Bioprinted Bone Model

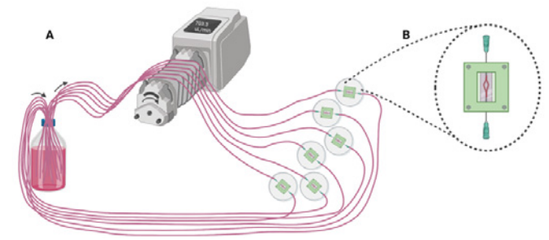

Figure 1: Recirculating Flow Loop. A) Overview of the flow loop set up with the multichannel pump, assembled microchips and osteogenic medium to perfusion in a glass schott bottle B) Adapted and assembled perfusion chambers (graphic: created with BioRender.com by N. Jucker).

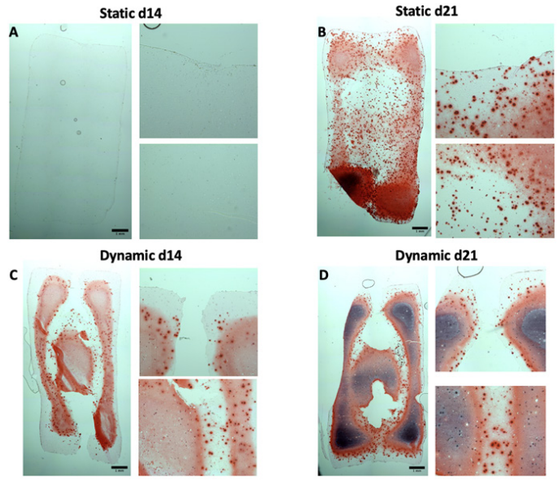

Figure 2: Alizarin red staining of static and dynamic cultures on day 14 and 21. Alizarin red staining of static 3D cell cultures on day 14 (A) and day 21 (B). In contrast, Alizarin red staining of dynamic 3D cultures on day 14 (C) and day 21 (D) show induced mineralization and indicate promoted differentiation of osteoblasts to osteocytes. Additionally, increased levels of osteocytic markers were observed over time by RT-qPCR. Scale bars = 1 mm (picture: N. Jucker).

Master's Thesis by Nicole Jucker at the Institute for Biomechanics, ETH Zürich.

Bone formation and remodeling are heavily dependent on spatiotemporal biochemical and biophysical cues, which enable bone cells to locally interact and self-organize. Osteoblasts and osteocytes are derived from mesenchymal stem cells (MSC) and their differentiation is tightly regulated by mechanical stimuli to ensure bone formation that suits the structural and dynamic support needed. If shear stress is applied to a bone, osteocytes are able to sense it and transduce these mechanical signals into biochemical signals to adapt bone mass and structure. This shape-function relation-ship is fundamental for bone homeostasis. Yet a truly functional in vitro bone model that contains the major bone cell types in a 3D bone-like environment and to which biomechanical forces can be applied has not been achieved.

Therefore, the aim of this thesis was to establish perfusable volumetric printed gelatin methacryloyl (GelMA) constructs in combination with adapted milifluidic perfusion chambers to investigate the effect of fluid shear stress (FFS) on human MSC differentiation and functional maturation.

Results revealed that lower GelMA concentrations lead to higher cell viability and increased cell differentiation. Further results did not reveal the expected significant increase in cell differentiation and maturation markers, but the dynamic cultures revealed a higher content of mineralization. Overall, the present achievement of establishing dynamic volumetric printed 3D bone cultures with enzyme and gene expression analysis to track bone formation holds great promise for future applications in regenerative bone medicine.

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Effect of Age and Lumbar Spinal Stenosis on Static and Dynamic Sagittal Spinal Balance: Single Center Observational Pilot Study

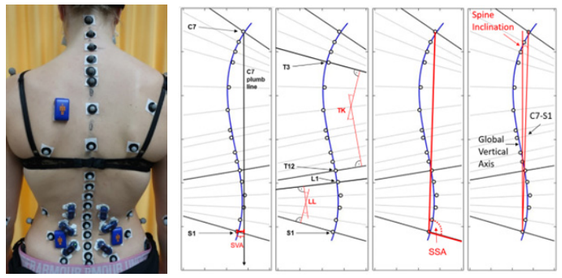

Figure 1: Spine Markers, Fitted Spinal Curve and Calculation of Marker-based Sagittal Spinal Balance Parameters (picture: D. Koch).

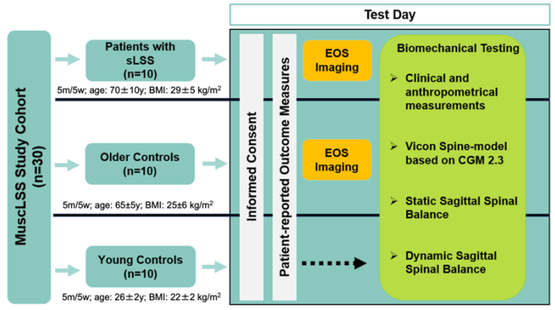

Figure 2: Study Flow Diagram (picture: D. Koch).

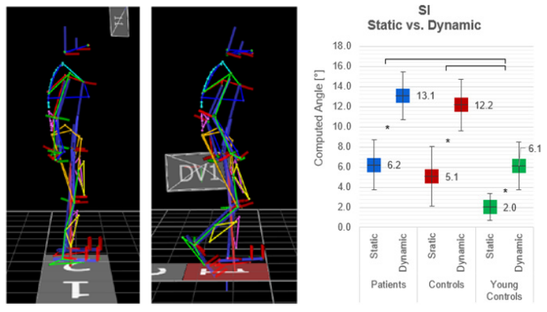

Figure 3: Left: Static vs. Dynamic condition. Right: Spine Inclination – Group comparison / Static vs. Dynamic (picture: D. Koch).

Master's Thesis by David Koch (Department of Sport, Exercise and Health, University of Basel) at the Functional Biomechanics Laboratory (University Hospital Basel).

Lumbar spinal stenosis (LSS) – the most common reason for spinal surgery in patients >65 years (1) – is characterized by a narrowing of the lumbar spinal canal. Symptom intensity in patients with symptomatic LSS (sLSS) is associated with body posture and activity (2), indicating functional influence of spinal alignment. Patients are often clinically observed bending forward during walking in an attempt to decompress the spinal canal.

A pilot study was conducted aiming to investigate sagittal spinal balance (SSB) in patients with sLSS, older controls and young controls during standing and walking using motion capture. To create a spinal curve from the coordinates of retroreflective markers, a cubic polynomial was fitted to the marker coordinates (3).

We observed significant differences in SSB between groups and conditions. Spine inclination was significantly greater in patients ($p<0.001$) and older controls ($p=0.02$) than in young controls. No differences in SSB were found between patients and older controls.

Comparison of activities resulted in significantly higher values for spine inclination during walking compared to standing across all groups (all $p<0.001$). Data showed that the differences between the static and dynamic condition were significantly higher in patients with sLSS ($p=0.021$) and older controls ($p=0.013$) than in young controls.

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References:
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Implementation in an R-package of the Lung Function Fluctuations Based Clustering Algorithm

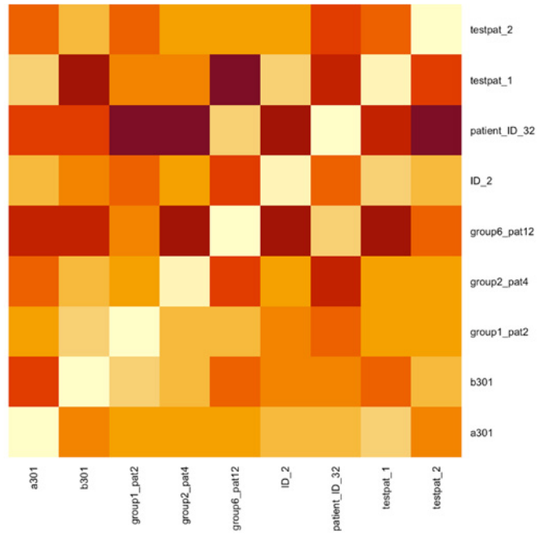

Figure 1: Visualized heat map of an Earth Mover's Distance square matrix for the parameter peak expiatory flow (PEF) (picture:UKBB).

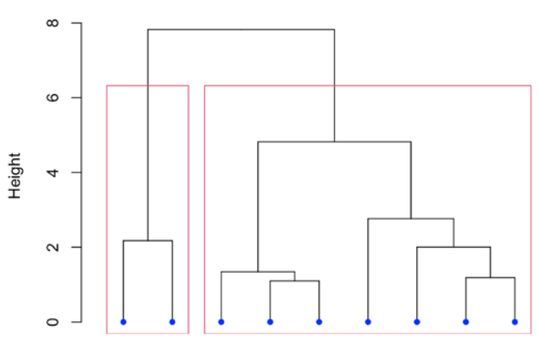

Figure 2: Graphical illustration as a dendrogram utilizing Ward's Minimum Variance Method to identify heterogeneous groups in asthmatic populations based on physiological parameters' Earth Mover's Distance (picture: UKBB).

Master's Thesis by Maximilian Köhler (Department of Biomedical Engineering, University of Basel) at the Computational Physiology and Biostatistics Research Group, Basel Children's Hospital (UKBB).

Patients' time series data only encompass a limited time interval measured which only represents a fraction of the whole treatment period. Nevertheless, machine learning may be used to develop longterm patient management programs (1).

In this thesis an R package that provides efficient access to the development and evaluation of unsupervised time series data models for asthma pheno- and endotype categorization via unsupervised clustering models was developed (2).

The novelty of the methods is that it views the fluctuation of physiological time series data over time. Data check-up, processing and Earth mover's distance (EMD) calculation are applied before doing Fluctuation Based Clustering (FBC) (2). The process includes three alternative approaches: An examination using extended data analysis, cluster stability after random data removal and an approach of doing FBC analysis based on the CRAN package clValid, developed by Brock et al. It calculates and ranks cluster validation measures (3).

Development version of the package (GitHub Repository): https://github.com/MrMaximumMax/FBCanalysis

The package was also submitted to Bioconductor.

Funding:

UKBB kompetent & menschlich

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References:
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Effect of Load Carriage on Joint Kinematics, Vertical Ground Reaction Force and Muscle Activity: Treadmill Versus Overground Walking

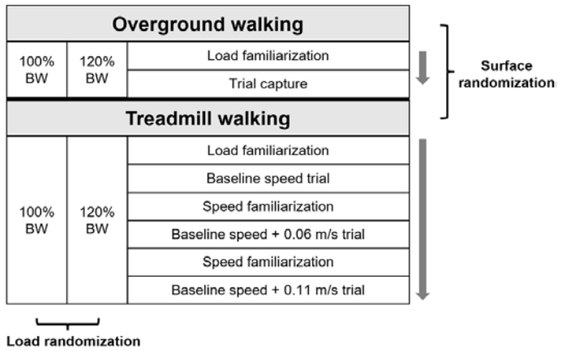

Figure 1: Visualization of the walking trials. BW – bodyweight (figure: M. Künzler).

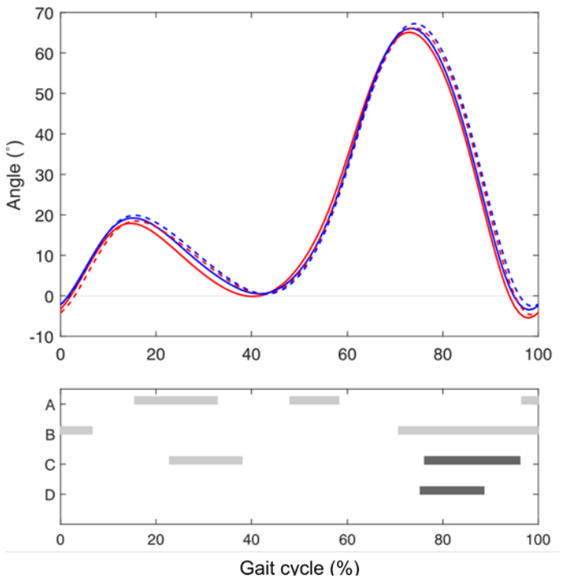

Figure 2: Mean joint angle for the knee in sagittal plane for 100%BW (red) and 120%BW (blue) overground (solid line) and treadmill (dashed line) walking. Grey bars indicate time periods with significant differences ($p<0.05$) for each paired t-test comparison. Differences >3° are colored dark grey. A: 120%BW vs. 100%BW overground walking; B: 120%BW vs. 100%BW treadmill walking; C: 100%BW treadmill vs. 100%BW overground walking; D: 120%BW treadmill vs. 120%BW overground walking (figure: M. Künzler).

Master's Thesis by Marina Künzler (Department of Biomedical Engineering, University of Basel) at the Functional Biomechanics Laboratory (University Hospital Basel).

Previous studies have investigated the effect of either different load or different surface conditions (overground, treadmill) on biomechanics (1), and studies combining these two aspects are lacking (2).

The purpose of this study was to determine the magnitude of difference in spatiotemporal parameters, lower extremity joint kinematics, vertical ground reaction forces (vGRF) and muscle activity between normal bodyweight (100%BW) and 20% increased bodyweight (120%BW) during overground and treadmill walking. Ten healthy young adults walked overground at self-selected speed and on an instrumented treadmill. Spatiotemporal parameters, 3-dimensional lower extremity kinematics, vGRF and muscle activity were measured and compared between conditions.

Stance phase was longer for 120%BW than for 100%BW for both overground and treadmill walking. Further, the stance phase was longer and cadence higher in treadmill than overground walking for both load conditions. Joint kinematics were comparable for all load by surface combinations, except of greater knee flexion angles for treadmill than for overground walking (diff$_{100\%BW}$, 5.2°; diff$_{120\%BW}$, 4.8°). vGRF was higher for 120%BW compared to 100%BW on both surfaces ($p<0.001$).

Treadmill walking can be used to simulate overground walking and loads of 20%BW added symmetrically to the trunk have no relevant influence on spatiotemporal parameters, joint kinematics, and muscle activity.

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References:
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BIAN: Multilayer Micro-Fluidic-Based Tissue-Mimicking Phantom for Optical Devices

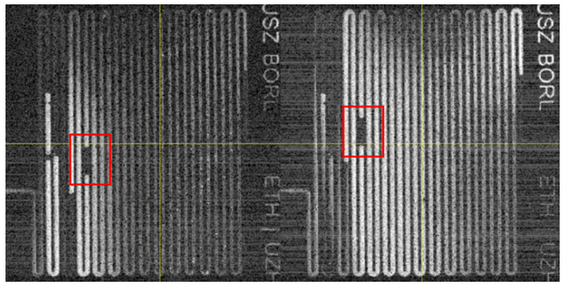
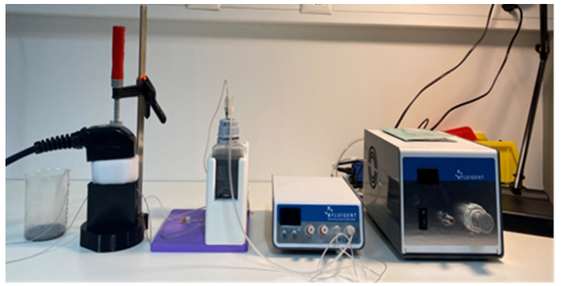


Figure 1: The picture of the microfluidic chip (2) while the water flowing inside was obtained by Optical Coherence Tomography (picture: T.Li, BLOG and BORL).



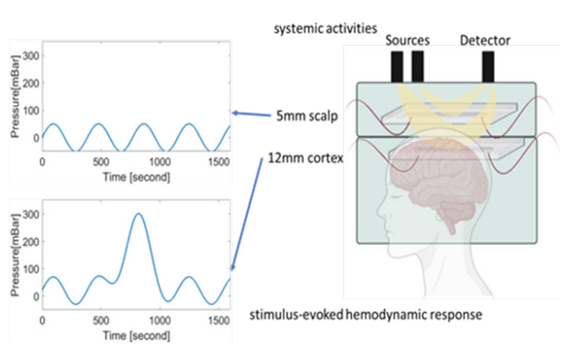


Figure 2: The photo of the setup of the phantom system (up). The diagram of the two-layer phantom system that can simulate systemic activities in the superficial layer and brain activation in the deeper layer (down) (picture: T.Li, BLOG and BORL).

Master's Thesis by Tong Li at Biomedical Optics Research Laboratory (BORL, Department of Neonatology, University and University Hospital of Zurich) and Biomedical Laser and Optics Group (BLOG, Department of Biomedical Engineering, University of Basel).

An imaging phantom is specially designed to evaluate, analyse, or tune the performance of imaging devices. However, there is a lack of dynamic phantoms which have anatomical structures (1) as well as the capability of simulating physiological dynamics.

The project aims to design, fabricate, and characterize a complex dynamic microfluidic-based phantom with a controllable contrast agent flowing inside the phantom to simulate physiological dynamics for validation and standardization of optical instruments.

This phantom system included silicone, PDMS microfluidic chips as well as a control system (a pump and a pressure controller). The size of microfluidic channels and flow velocity while water flowed inside were characterized by an optical coherence tomography (OCT) system. Two chips were embedded in the silicone at the depth of 5mm and 12mm to simulate the scalp and cortex layer of the brain. Firstly, the periodic pressure perfused the blood-like liquid in the chip at two depths, and the optical properties and light intensity were measured by the Near-infrared spectroscopy (NIRS) probes. Then the periodic pressure was applied to perfuse the blood-mimicking liquid to the chip at the superficial layer. An activation wave was added to the periodic wave and was applied to perfuse the blood-like liquid to the chip at the deep layer. This phantom system was successfully tested and validated by NIRS and has the potential to validate other optical methods and devices.

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References:
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3D Printed Patient-Specific Meshes Made of Poly (L-lactide-co-D, L-lactide) and β-TCP for Guided Bone Regeneration

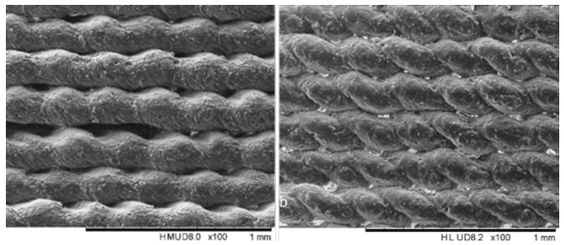
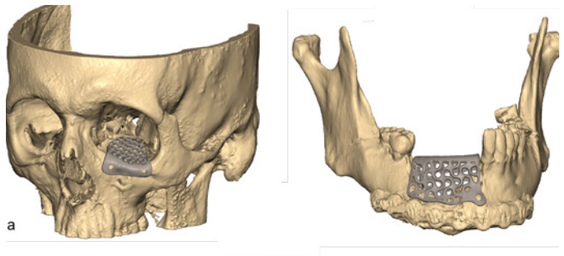


Figure 1: Scanning electron micrograph of the surface of a 3D-printed object with the old and new parameters. a) surface with the old parameters (1); b) surface with the new parameters (picture: a) C. Frei; b) D. Mory).



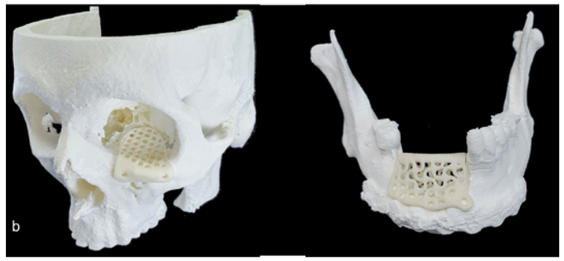


Figure 2: The design and fabrication of patient-specific meshes. a) the design of the patient-specific meshes for the orbital and mandibular area; b) the final result of the printed patient-specific meshes for the orbital and mandibular area (picture: D. Mory).

Master's Thesis by Dominik Mory at Medical Additive Manufacturing Research group.

The available meshes for guided bone regeneration are often made of metal and have to be removed by a second surgery after successful bone healing. With bioresorbable materials, such as polymers, a second surgery to remove the implant can be avoided. By combining bioresorbable materials with 3D printing technology, patient-specific meshes for the maxillofacial area can be produced.

Arburg Plastic Freeforming (APF) is an innovative 3D printing technology that is finding its way into the medical field. In the APF technology, the 3D printed part consists of countless small droplets that bond together.

Since the APF technology is an open system, almost all process parameters can be varied, which leads to a high level of flexibility in the output. The various changeable parameters have a direct influence on the mechanical properties and the quality of the printed parts. (2, 3)

In this thesis, the print quality could be increased by optimizing different parameters (figure 1). In addition, the new parameters were found to improve the flexural mod-ulus and strength for vertically and horizontally printed samples.

Within the scope of this work, patient-specific meshes were designed and produced with the newly found parameters. It was possible to produce meshes for the orbital and mandibular area with good quality and accuracy of fit on the Arburg Freeformer (figure 2).

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(1) C. Frei, Bachelor-Thesis,University of Applied Sciences and Arts Northwestern Switzerland, 2021.

(2) L. Hentschel et al. Polymers, vol. 12, no. 11,doi:10.3390/polym12112677, 2020

(3) E. Moritzer et al. 30th Annual International Solid Freeform Fabrication Symposium, pp. 705-714, 2019

Generation and Characterization of a New Screening Platform for Deorphanization of G-Protein Coupled Receptors

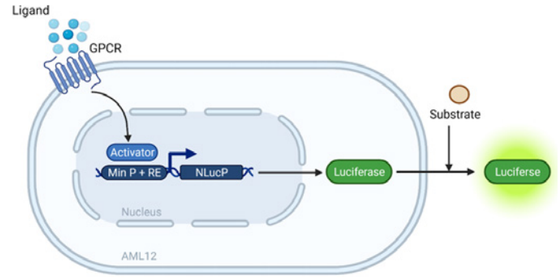

Figure 1: Stable reporter cell lines to find ligand for orphan GPCRs (picture: P. Nagar, DBSSE-ETH).

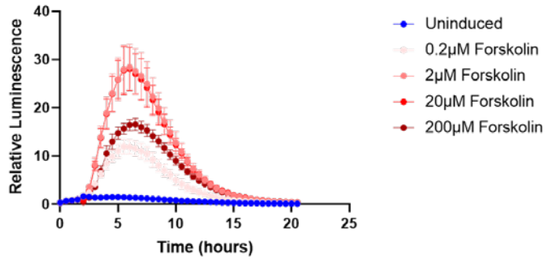

Figure 2: AML12 live cell, nonlytic reporter gene assay result with CRE response element (picture: P. Nagar, DBSSE-ETH).

Master's Thesis by Pragya Nagar at Laboratory for Systems Physiology (D-BSSE, ETH Zürich).

G protein-coupled receptors (GPCRs) are crucial for many physiological functions and important targets for therapeutic strategies. With still approximately 140 druggable orphan GPCRs this field is at the forefront of the drug discovery process. In my thesis stable reporter cell lines were designed that allow for simultaneous and parallel interrogation of the entire druggable GPCRome. Distal approach with four Response Element triggering cellular readouts for G-protein mediated signaling and proximal approach via β-Arrestin-recruitment. All vectors cloned contain novel configuration of Nano Luciferase with destabilizing sequence, hPEST and were stably integrated into modified AML12 (alpha mouse liver 12) cells via site-specific recombinase technology called Cre-Lox recombination.

Live cell, continuous luminescence assay of these Reporter lines with positive controls indicated a sensitive and stable system. This system can hence be applied to pair orphan GPCRs with their potential ligands found in either tissue extracts or synthetic compound libraries. Given the consistency, reduced inter-experimental variability and simplicity of setting up multiple runs this platform can be robotized and applied as high throughput homogenous screening assay.

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Automatic Curvature Analysis of the Left Atrium from Cardiac Magnetic Resonance Imaging

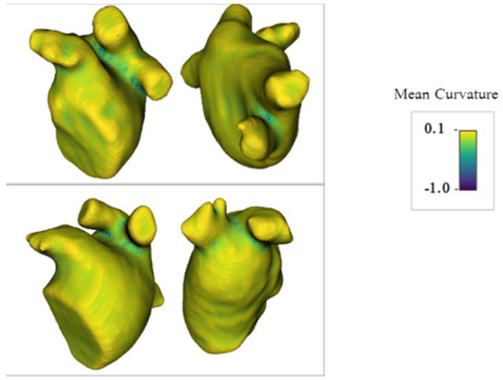

Figure 1: 3D view of the reconstructed LA and PVs for two subjects. Color corresponds to the computed curvature (picture: S. Pla Alemany).

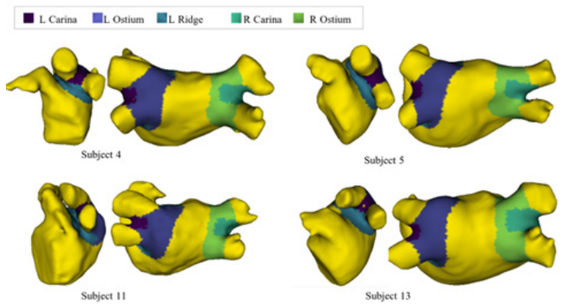

Figure 2: 3D View of the LA and PV of 4 subjects. Each color represents a region of interest, where the curvature was studied to determine the correlation with atrial fibrillation (picture: S. Pla Alemany).

Master's Thesis by Sofia Pla Alemany at the Center of Medical Imaging and Navigation (CIAN).

This study aims to develop an automatic, consistent framework to acquire curvature features of the left atrium (LA) and pulmonary veins (PVs). We train an autoencoder (AE) network to segment the LA and PVs from preprocedural cardiac MRI scans. Then an automatic pipeline, based on image registration, aims to reconstruct their 3D surface and locate certain regions of interest (ROIs) to study the correlation between atrial fibrillation recurrence (AFR) and curvature values. Automatic segmentation of the LA and PVs was achieved successfully. Promising results on localising and extracting curvature values of the ROIs were also achieved with the proposed workflow. Further developments are required to improve the results obtained for subjects with shape anomalies and to automatically detect error locations without visual inspection. Finally, due to the lack of a large data set available for a deep statistical analysis, no strong correlations were found between the extracted features and AFR.

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Evaluating Void Imperfections in Injection Molding Containers

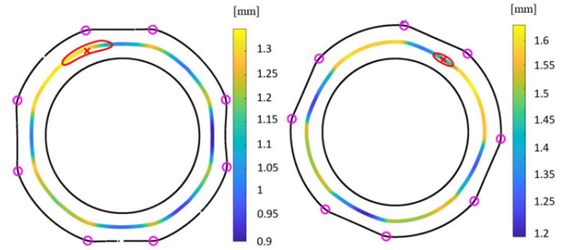

Figure 1: Diameter boundary shown on center line with red contours of void and black contours of two containers. The colour bar from yellow, green, and blue represents the diameter of the container boundary from the largest to the smallest value, respectively. Corners on containers wall are marked by magenta circles. (from left to right) (picture: C. Tanner, BMC).

Figure 2: Set up of the fixtures created to perform the compression test with the Zwick Roell testing machine (picture: J. Sanjaume, regulated company).

Master's Thesis by Judit Sanjaume Figueras at the Biomaterials Science Center (BMC).

For patient treatments, not only life-saving implants and drugs are needed, but their suitable packaging has to be guaranteed. PETG is one of the most widely used polymers in the packaging (1), which is often processed by injection molding. Even though the injection molding process has many advantages, voids in the container walls can be created.

This study was carried out on two container sizes. Size, morphology, and location of the voids was determined in 3D using computational analysis of micro computed tomography data (2). Potential morphological changes of the voids due to mechanical load, temperature changes, and sterilisation treatment were investigated. Results of compression tests on containers with voids and without voids before and after treatment, and subsequent relevant environmental changes were compared.

Voids were frequently found nearby corners. Smaller voids were almost spherical, whereas larger voids had the shape of an ellipsoid. Their size tends to increase as the result of the treatments mentioned. Results from the compression tests for containers with and without voids showed hardly difference. It was concluded that injection-molded PETG containers with voids up to 0.94 mm3 can be used without risk in terms of integrity or functionality.

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References:
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Enhancement of Human Adipose Stem Cells' Chondrogenic Differentiation Potential by Modulating TGFβ Receptor Ratio

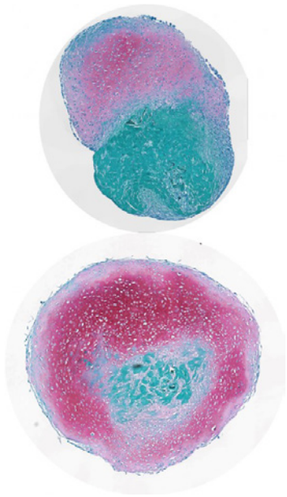

Figure 1: Brightfield images of SafraninO stained scaffolds. The upper one was preconditioned using Standard condition and the lower one with added TGFβ3. The later one shows higher chondrogenic differentiation (picture: J. Sigrist).

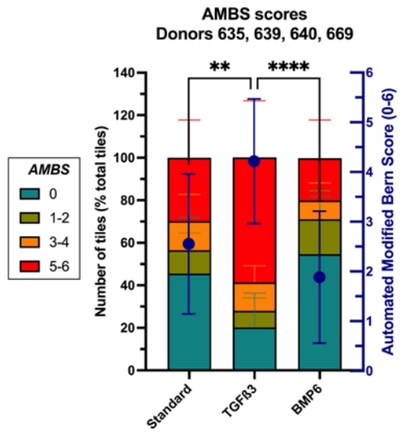

Figure 2: AMBS scores for four donors grouped according to their preconditioning. Each bar represents one condition and the percentual distribution of the AMBS scores achieved by the tiles. In dark blue the average and SD are shown. Using a One-way ANOVA multiple comparison test ($p < 0.05$) a significant difference between the average AMBS scores between the TGFβ3 and the BMP6 condition as well as between TGFβ3 and Standard was shown (picture: J. Sigrist).

Master's Thesis by Joana Sigrist at the BORE group (Department of Biomedicine, University of Basel).

A major challenge for the use of human adipose stromal/stem cells (hASCs) in bone regeneration is the inherent donor variation in their chondrogenic differentiation potential (1). Studies with human bone marrow mesenchymal stromal/stem cells (hBMSCs) have confirmed that the ratio of TGFβ-RI/ TGFβ-RII at the time of cell recovery from the tissue culture plastic reliably predicts chondrogenic potential. This study assesses if the regulation of these receptors showed similar effects in hASCs and can be used to for the prediction and enhancement of chondrogenic differentiation.

ASC-P0 were preconditioned using three different media: Standard, TGFβ3 or BMP6 supplemented, followed by differentiation in media with TGFβ3 and BMP6. The level of expression in genes important for chondrogenesis were measured after preconditioning and at one week of differentiation and the TGFβ-RI/II ratio was calculated. An increase in the TGFβ-RI/II ratio was shown for TGFβ3 preconditioning. Automated Modified Bern Scoring (AMBS) assessing the chondrogenic differentiation revealed two different donor profiles. Either the chondrogenic differentiation was increasing when preconditioning with TGFβ3 or the score stayed at the same level when they already showed good differentiation with a standard preconditioning. However, no correlation between the receptor ratio and AMBS score was found. In contrast, we found that the chondrogenic potential correlates with the GAG concentration in the supernatant. By measuring the gene expression level after one week for both, differentiation with and without BMP6, we showed a set of genes which was regulated by BMP signaling. Namely, BMP-R1b showed downregulation and the three genes Sox9, COL2A1 and ACAN showed upregulation.

This result can be used as starting point to further understand the importance of BMP6 on chondrogenic differentiation in ASCs.

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Optimized Hand & Wrist Radiofrequency Detectors for Low-field MRI

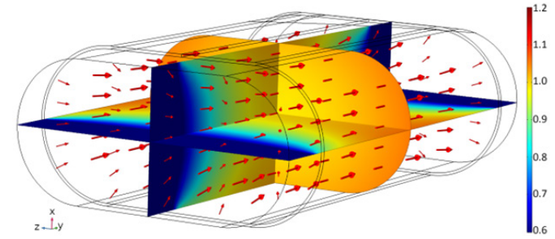

Figure 1: FEM simulation of the magnetic field B1. The magnetic field orientation is found to be pointing longitudinally along the coil's main axis (red arrows). Colorscale is normalized to the central value of the coil. A large central volume with good homogeneity in the B1-field is observed, with a strong decrease in B1-amplitude towards the openings of the coil (picture: M. Spreiter, AMT Center).

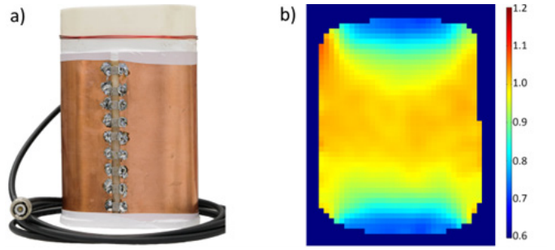

Figure 2: a) The final STS coil optimized for use in hand & wrist imaging in a 0.1 T MRI system. b) Central slice of an experimentally acquired map of the coil's transmit field B1 (picture: M. Spreiter, AMT Center).

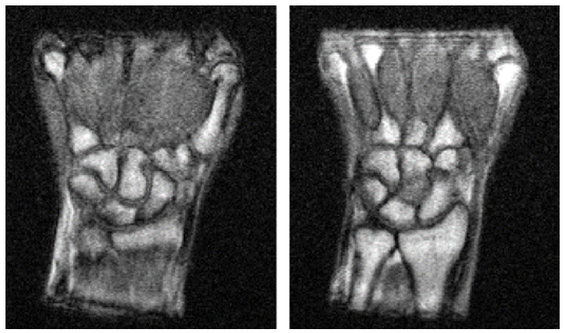

Figure 3: Two slices of a gradient echo 3D image of a healthy volunteer's hand and wrist, acquired with the final STS coil. The slices were cropped to the region of interest, no further image processing has been applied.
Acquisition parameters: 512x159x11, 0.8x0.8x6.0mm3, TE/TR=20/120ms, NA=3, 75% Sampling. Total acqu. time: 7min 52s (picture: M. Spreiter, AMT Center).

Funding:

AMTCENTER
FOR ADAPTABLE MRI TECHNOLOGY

Swiss National Science Foundation

Master's Thesis by Mauro Spreiter at the Center for Adaptable MRI Technology (AMT Center).

Low-field (LF) MRI offers alternatives to diversify today's use of MR technology with enhanced access. By developing systems dedicated to a certain application, the financial burden of MRI systems can be lowered and patient comfort improved. In order to overcome the inherent signal-to-noise ratio (SNR) penalty of LF-MRI, development of optimized hardware components is prime to deliver performance compatible with clinical standards.

In this thesis, an optimized radio-frequency (rf) coil for application in hand & wrist imaging at 0.1 T was developed. Different coil geometries were simulated by finite-element method (FEM), fabricated and characterized. A standardized protocol was established, allowing to compare performance of the fabricated coils to each other and to a benchmark coil.

For the final, proposed rf-coil, a close-fitting single-turn solenoid (STS) with oval cross section was developed that offers improved filling factor. FEM simulations of this geometry (figure 1) showed a highly homogeneous, high amplitude, magnetic field B1, that is promising for use as transceiver coil in the desired application. The coil was fabricated using a 350 µm thick copper plate mounted on a 3D-printed support structure (figure 2a). B1-field maps acquired experimentally (figure 2b) appear to be in good agreement with simulations. High signal intensity paired with low noise figure was further observed in spectroscopic and imaging experiments. In-vivo hand & wrist images of healthy volunteers (figure 3) confirmed the excellent performance of the proposed coil, allowing for 3D images to be acquired with 800 x 800 µm2 in-plane resolution with sufficient SNR in clinically acceptable acquisition times in a compact 0.1 T MRI system.

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Development & Evaluation of a Virtual Simulation Environment for a Visuo-Haptic User Console

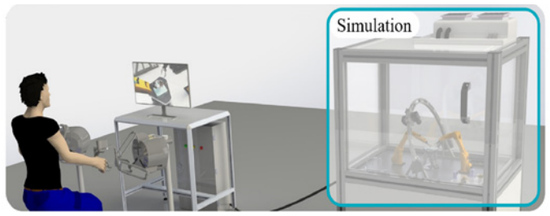

Figure 1: Representation of the future intended teleoperated micro-assembly station (picture: C. Duverney).

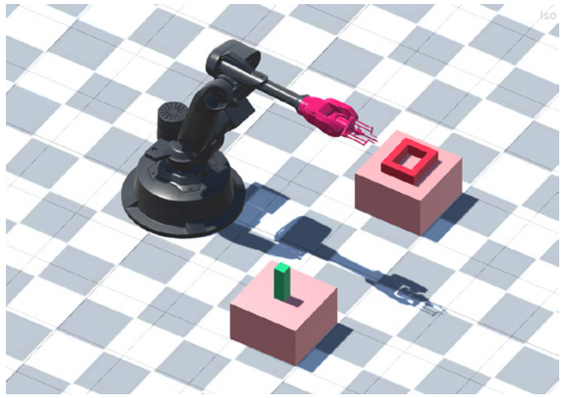

Figure 2: A picture from the final virtual scene (picture: M. Yorulmaz).

Master's Thesis by Mahmut Yorulmaz at BIROMED-Lab.

There is a trend towards miniaturization and automation in several domains. One of those is the MIRACLE project, which aims at developing robotic endoscopic devices for minimally invasive surgery. Here, to develop prototypes, components with dimensions in the millimeter and even micrometer range need to be assembled. Human-controlled, teleoperated robotic micro-assembly stations are a way to tackle this challenge. Still in the lab, we don't have a physical system. To see potential improvement in the system, simulation can be used.

This thesis aimed to see how the joint speed parameters affect the user experiences. We had a 3-DOF robotic arm and we controlled it via a haptic device. We have simulated this robotic arm in a virtual scene and teleoperated it via a physical haptic device. We had collisions and gravity in the scene. At the end of the thesis to see the result, we conducted an evaluation study on 11 people. 5 for the pilot study, 6 for the main study. We had 3 joint speed parameters configuration. The slowest configurations showed better performance on-task time and accuracy. That was an unexpected result.

Funding:

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Automated Detection of Cardiac & Neurological Causes of Death in Post Mortem CT data

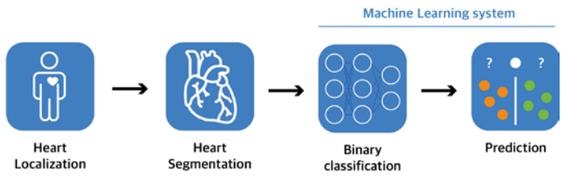

Figure 1: Cardiac pathology detection pipeline. The first step of the pipeline is to define the region of interest (ROI) of the heart. The second step is the semi-automatic segmentation with seed growing within the 3D slicer software. The third and last step consist of the predicting the binary classification into the pathological or healthy category with different machine and deep learning algorithms (picture: A. Zirn).

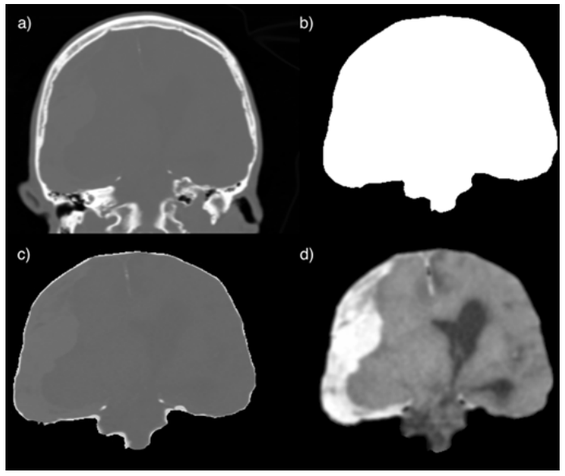

Figure 2: Cerebral segmentation process. The segmentation process consisted of 3D CT datasets. a) Original CT image in the coronal plane, b) 2D view of the created binary mask with the FSL library, c) segmented CT image in the coronal plane, d) contrast enhanced CT image in the coronal plane (picture: A. Zirn).

Master's Thesis by Andrea Zirn at the research group Forensic Medicine and Imaging of the Institute of Forensic Medicine, University of Basel.

During the last years, the detection of different causes of death based on post mortem imaging findings became more and more relevant. Especially post mortem computed tomography (PMCT) as a non-invasive, relatively cheap and fast technique is progressively used as an important imaging tool for supporting autopsies. Additionally, previous works showed that deep learning applications have yielded robust results for medical imaging interpretation. In this work, we propose and implement two pipelines to identify cerebral and cardiac causes of death on three-dimensional PMCT data.

For this study, we retrospectively selected 129 PMCT cases from the database of the Institute of Forensic Medicine Basel. This data contained 13 cases with cerebral hemorrhage, 24 cases with cardiac infarction, eight cases with cardiac pump failure, seven cases with left-sided cardiac failure, five cases with right-sided cardiac failure, three cases with cardiac tamponade and 69 consecutive healthy cases. Based on these datasets, six machine learning classifiers (k-nearest neighbors, Gaussian naive Bayes, logistic regression, decision tree, linear discriminant analysis and support vector machine) were executed and two different artificial neural networks (CNN, DenseNet) were trained. For the machine learning algorithms, CNN and DenseNet, 80% of the data was randomly selected for training and 20% for validation purposes. The best performing classification networks for cranial hemorrhage were Gaussian naive Bayes, CNN and DenseNet with an accuracy of 90.91%. This thesis further shows that deep learning algorithms show promising results for the automated classification in the area of right-sided cardiac failure, where both deep learning algorithms achieved an accuracy of 85.71%. Additionally, DenseNet was able to obtain an accuracy of 90.91% for the classification of cardiac infarction.

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Publications

Milestone Publications

On the way to the top. (picture: R. Wendler)

A wide research spectrum, heterogeneous but equally important studies: in this section we report some of our milestone publications of the year 2022 in order to give an insight into the DBE's research.

Dr. Alessandro Cagol, Prof. Cristina Granziera and the research group ThINk are in the driving seat of a study published in the highly prestigious JAMA Neurology Journal. Its title is "Association of Brain Atrophy with Disease-Progression Independent of Relapse Activity in Patients with Relapsing Multiple Sclerosis". read

Dr. Griffin Rodgers and Prof. Bert Müller have provided compelling evidence that virtual histology based on X-ray imaging can overcome the most critical limitations of the classical cellular resolution histopathological analysis approach, such as the alteration of living tissues. read

Dr. Claudia Lenz, her research group and her collaborator Ass.-Prof. Christoph Birkl from Innsbruck have published a method together to optimally suppress the cerebrospinal fluid signal in FLAIR (fluid attenuated inversion recovery) magnetic resonance imaging for varying brain temperatures in post mortem subjects. read

Dr. Amanda Gisler and the rest of the Sinues group pave the way towards robust, large-scale clinical studies in their iScience paper entitled "An interoperability framework for multicentric breath metabolomic studies". read

Dr. Olivier Braissant, Dr. Astasov-Frauenhoffer and Dr. Tino Töpper have published a paper providing convincing evidence that cellulose based biocompatible materials used to fabricate clear dental aligners could be loaded with essential oils thus making such material antimicrobial. The decrease in biofilm formation on these aligners greatly decreases the risk of further caries during therapy. read

Selected Publications 2022

***Peer-reviewed publications (106), where first author or last author is at DBE, impact factor >2.**

Abbasi H; Guzman R; Cattin P.C; Zam A (2022): 'All-fiber-optic LIBS system for tissue differentiation: A prospect for endoscopic smart laser osteotomy'; Optics and Lasers in Engineering.

Amruthalingam L; Gottfrois P; Gonzalez Jimenez A; Gökduman B; Kunz M; Koller T; DERMANATOMY Consortium; Pouly M; Navarini AA (2022): 'Improved diagnosis by automated macro- and micro-anatomical region mapping of skin photographs'; Journal of the European Academy of Dermatology and Venereology : JEADV.

Ayde R; Senft T; Salameh N; Sarracanie M (2022): 'Deep learning for fast low-field MRI acquisitions'; Scientific Reports.

Bachmann M; Enodien B; Frey DM; Taha-Mehlitz S; Taha A (2022): 'The Development of Healthcare Jobs in the COVID-Pandemic – A New Economic Market'; Frontiers in public health.

Bauer M; Berger C; Gerlach K; Scheurer E; Lenz C (2022): 'Post mortem evaluation of brain edema using quantitative MRI'; Forensic science international.

Benitez B.K; Brudnicki A; Surowiec Z; Singh R.K; Nalabothu P; Schumann D; Mueller A.A (2022): 'Continuous circular closure in unilateral cleft lip and plate repair in one surgery'; Journal of Cranio-Maxillofacial Surgery.

Benitez BK; Brudnicki A; Surowiec Z; Wieprzowski Ł; Rasadurai A; Nalabothu P; Lill Y; Mueller AA (2022): 'Digital impressions from newborns to preschoolers with cleft lip and palate: A two-centers experience'; Journal of plastic, reconstructive & aesthetic surgery : JPRAS.

Berger C; Bauer M; Wittig H; Scheurer E; Lenz C (2022): 'Post mortem brain temperature and its influence on quantitative MRI of the brain'; Magma (New York, N.Y.).

Berger C; Birkl C; Bauer M; Scheurer E; Lenz C (2022): 'Technical note: Quantitative optimization of the FLAIR sequence in post mortem magnetic resonance imaging'; Forensic science international.

Bieri O; Pusterla O; Bauman G (2022): 'Free-breathing half-radial dual-echo balanced steady-state free precession thoracic imaging with wobbling Archimedean spiral pole trajectories'; Zeitschrift fur Medizinische Physik.

Bjerklund Johansen TE; Kulchavenya E; Lentz GM; Livermore DM; Nickel JC; Zhanel G; Bonkat G (2022): 'Fosfomycin Trometamol for the Prevention of Infectious Complications After Prostate Biopsy: A Consensus Statement by an International Multidisciplinary Group'; European urology focus.

Bless N; Keller N; Steinitz A; Klein T; Rikli D (2022): 'Analysis of the subcapital two-part humerus fracture by fluoroscopy: objective criteria for classification and decision making'; Archives of orthopaedic and trauma surgery.

Blume C; Schoch SF; Vienneau D; Röösli M; Kohler M; Moeller A; Kurth S; Usemann J (2022): 'Association of transportation noise with sleep during the first year of life: A longitudinal study'; Environmental research.

Bosticardo S; Schiavi S; Schaedelin S; Lu PJ; Barakovic M; Weigel M; Kappos L; Kuhle J; Daducci A; Granziera C (2022): 'Microstructure-Weighted Connectomics in Multiple Sclerosis'; Brain connectivity.

Bravo D; Braissant O (2022): 'Cadmium-tolerant bacteria: current trends and applications in agriculture'; Letters in applied microbiology.

Brégère C; Schwendele B; Radanovic B; Guzman R (2022): 'Microglia and Stem-Cell Mediated Neuroprotection after Neonatal Hypoxia-Ischemia'; Stem cell reviews and reports.

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Brehm A; Tsogkas I; Ospel JM; Appenzeller-Herzog C; Aoki J; Kimura K; Pfaff JAR; Möhlenbruch MA; Requena M; Ribo MJ; Sarraj A; Spiotta AM; Sporns P; Psychogios MN (2022): 'Direct to angiography suite approaches for the triage of suspected acute stroke patients: a systematic review and meta-analysis'; Therapeutic advances in neurological disorders.

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Cheng C; Chaaban M; Born G; Martin I; Li Q; Schaefer DJ; Jaquiery C; Scherberich A (2022): 'Repair of a Rat Mandibular Bone Defect by Hypertrophic Cartilage Grafts Engineered From Human Fractionated Adipose Tissue'; Frontiers in bioengineering and biotechnology.

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