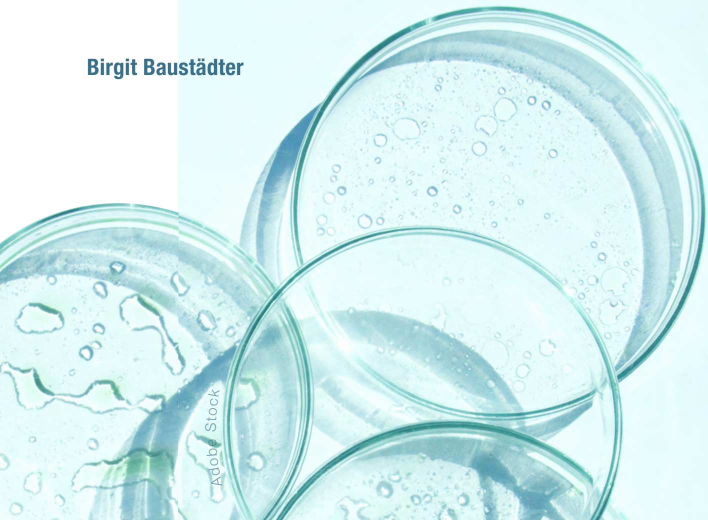

Lunghammer – TU Graz

Technology for Health

Diseases affect us all – in different forms and with different consequences. Medical advances supported by technical research have made diagnosis and therapy much more accurate, faster and more successful in recent years.

Birgit Baustädter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Focus areas such as biomedical engineering at TU Graz show the importance of this topic in research. Here, research is carried out on the fundamentals as well as on very practical diagnostic and therapeutic options. The topic of "people" is a multifaceted one and is treated in exactly the same way at TU Graz:

MEDICAL DEVICES

The Institute for Health Care Engineering and its European Testing Centre for Medical Devices offer testing of various medical devices. It is the only accredited testing centre in Europe the institute. Tests for certifications are carried out here. But of course we also develops, evaluates and validates point-of-care and sensor technologies. Research focuses on the analysis, modelling and simulation of biophysical, cell biological and tissue-specific processes as well as new technical approaches in diagnosis and therapy.

The Institute of Health Care Engineering, which is located right next door, is working on various aspects. One of these is a lab on a chip". The lab is a small chip, which is a microelectrode array. "We grow heart muscle cells on it," explains Christian Baumgartner, head of the institute. "This system enables non-invasive examinations of cardic activity." The electrodes are attached directly to the petri dish in which the heart muscle cells grow. They can then both stimulate the heart cells and measure data. Within a few days, the cultivated heart muscle cells form a dense cell layer and so-called pacemaker cells that send signals to their environment. In this way, the heart "beats" artificially in the Petri dish and researchers can simulate and analyse various disorders.

AORTIC DISSECTIONS

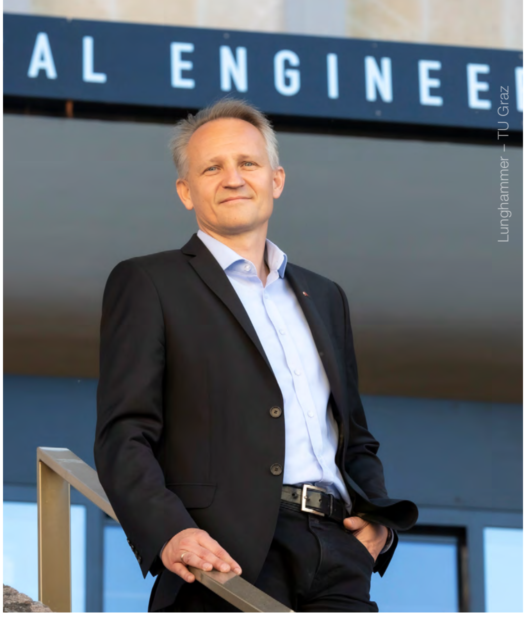
Gerhard A. Holzapfel (Institute of Biomechanics), Karin Ellermann (Institute of Mechanics) and their research team are investigating the "mechanics, modelling and simulation of aortic dissections" with funding from the TU Graz Lead Projects funding programme. This disease of our aorta results in a tear in the aorta. A start-up has already emerged from the lead project, which aims to significantly facilitate the diagnosis of aortic dissections using machine learning approaches.

Gerhard A. Holzapfel was awarded an ERC Synergy Grant worth 4.2 million euros by the European Research Council this month. In this six-year project will develop experimental and AI-based methods to analyse in detail for the first time the relationship between transcriptomics, microstructure and mechanical properties of soft biological tissue. The overarching aim is to develop an imaging method for the non-invasive investigation of tissue microstructure, which will improve the diagnosis and treatment of diastolic heart failure in everyday clinical practice. More details on page 10.

About the work in the lead project

THE GENOME

The Institute of Biomedical Informatics analyses the blueprint of our body – the human genome. In recent years, it have become the focus of medical research in order to make personalised



Lunghammer – TU Graz

Christian Baumgartner

medicine and individual therapies possible. The main focus is on the sections – genes – that code for proteins; however, these only make up two per cent of the human genome. The much larger part is made up of so-called non-coding sequences, which define whether and how strongly our genes are characterised. They therefore also have a central influence on embryonic development. Research at the Institute of Biomedical Informatics, where artificial intelligence and big data methods are used to study the human genome, is primarily focused on these sequences. Another field of research is the characterisation and optimisation of microorganism genomes, which are of great importance for the production of biotherapeutics. This is also being done in connection with the recently launched lead project "DigiBioTech".


Lunghammer – TU Graz

Gernot Müller-Putz

HUMAN LANGUAGE

At the Institute of Signal Processing and Speech Communication, Barbara Schuppler works with children and young people with different language impairments and helps them to participate better in everyday school life. She looks at human speech. She investigates how human dialogues work, how much interlocutors adapt to each other and how this behaviour can be modelled. She is primarily involved in basic research and generates important data for further research: "We have created Austria's largest database of spontaneous language dialogues. We can use this data to analyse the characteristics of spontaneous speech. For example, when the dialogue participants know when they can speak, how they signal agreement and how the pronunciation, intonation and rhythm of the language changes for example because of dementia." In this way, she is laying the foundations for improving speech recognition systems, which are used in medical assistance systems, among other things.

MOVING IT AGAIN

Depending on the location of a spinal cord injury, affected people have to cope with different restrictions in everyday life. Gernot Müller-Putz and his team at the Institute of Neural Engineering want to make life easier for these people and, in some cases, make communication possible in the first place.

Until now, research efforts have mainly specialised in non-invasive measurements of brain waves using an EEG cap. The EEG measures the electrical impulses emitted by the neurons in the brain, a computer decodes them and sends the understood commands to a robotic arm, a computer programme or an exoskeleton, for example. This enables test subjects to move external prostheses, use muscles that could no longer be controlled via the spinal cord, or “think” words on the computer screen. “Our biggest challenge is to assign the right potentials in the brain waves to the right movement,” explains Müller-Putz. But the test subjects first have to familiarise themselves with using the machine.

For a good two years now, the team has also been working on implantable systems and is involved in the development of a completely new type of chip that is implanted directly into the brain. “The main advantage is that the disturbing noise is reduced and the signals are much clearer than those from an EEG cap,” explains Müller-Putz. He wants to use the system to enable people with locked-in syndrome or people in a vegetative state to communicate in a new way.

Talk Science To Me
TU Graz-Podcast

Podcast interview with Gernot Müller-Putz

CYBATHLON

In the international student competition Cybathlon, teams of students compete against each other in various disciplines related to brain-computer interfaces. The students of the Mirage 91 team at TU Graz regularly take part, develop systems, train together with pilots and optimise their systems. In the competition itself, the pilots – people with spinal cord injuries – have to complete a computer game as quickly as possible via EEG measurement. The main challenge here is that the system has to function in a predetermined way at a predetermined time, explains Gernot Müller-Putz. But the mental state of pilots also has an impact: “These people are understandably excited in front of a large audience. Of course, this has a huge impact on the brain signals.”

Martin Uecker

IMPROVING MRI

Martin Uecker and his team at the Institute of Biomedical Imaging are investigating how images and measurements from magnetic resonance tomographs can be optimised. MRI examinations take a relatively long time due to their imaging method, but in contrast to computer tomography, for example, which delivers images much faster, they do not require ionised radiation. The length of the examination in a relatively narrow tube can be uncomfortable for some people, but it is necessary as many individual measurements are taken during an MRI examination, from which a very precise overall image is then compiled.

One way to improve these analyses is to use new numerical algorithms for image reconstruction. They can create accurate images from significantly less data – i.e. significantly fewer individual measurements. Some current approaches are based on machine learning and therefore require perfect MRI images for training. “However, perfect data is difficult to obtain,” explains Martin Uecker. “Especially from moving organs, such as the beating heart.” The institute is now researching ways to train the neural networks required for the algorithms from the data itself and without perfect images.

The institute is also involved in a wide range of activities to improve MRI examinations. For example, in the development of quantitative imaging biomarkers, such as those based on the Chemical Exchange Saturation Transfer (CEST) effect, or in low-field MRI.

A portable, small open-source MRI scanner

Christian Adams

MEDICATION

An important method of dealing with illness is to administer medication. TU Graz chemist Rolf Breinbauer and his team are involved in this area. They are developing active substances that reduce fatty acid levels in the blood. Among other things, fatty acid levels are partly responsible for type II diabetes, non-alcohol related fatty liver and some heart diseases. The enzyme ATGL (adipose triglyceride lipase), which releases fatty acids into the blood, is central to this process. Together with researchers from the University of Graz, Breinbauer is developing the active ingredient Atglistatin, which blocks the enzyme but does not interfere with any other processes in the body of an animal model.

RCPE

The competence centre RCPE (Research Center Pharmaceutical Engineering) located at TU Graz is developing new methods of drug production together with the closely interwoven Institute of Process and Particle Technology.

Link to RCPE

HEALTH AND NOISE

Christian Adams, on the other hand, specialises in ears at the Institute of Fundamentals and Theory in Electrical Engineering. More precisely, the perception of noise and its effects on our health and well-being. Noise can trigger illnesses. Holding an endowed professorship (from the ministry of climate action) for noise impact research, the researcher is in the process of setting up a competence centre for traffic noise and health, which will not only develop an intelligent noise map, but also carry out research on technical solutions that prevent noise in the first place. “The most important step is to control noise directly at the source. That has to be our first goal,” explains Adams. “In a second step, we have to prevent noise that cannot be stopped at source from spreading. For example, through noise protection measures that we either want to improve or develop from scratch.”

NEW PROJECTS

Contact persons and people involved in biomedical engineering research can be found on the website of the Field of Expertise Human & Biotechnology at TU Graz. ■

Human & Biotechnology at TU Graz

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