ImageHeadstart .eu

Breakthrough Computer Vision Applications in the Micro World: Consortium of Research Organizations for Industry 4.0

Interreg
EUROPEAN UNION
Austria-Czech Republic
European Regional Development Fund

The project ImageHeadstart addresses the challenges of digital imaging in the fields of microscopy and tomography. Research on digital imaging techniques such as light microscopy and X-ray tomography at the partner institutions has reached a stage from which many practical applications can unfold. The main goal of the project is to help companies in the Austria-Czech Republic cross-border region to translate this knowledge into new applications and technologies.

The ImageHeadstart consortium will (1) integrate regional companies into the region's research structure, (2) bring together research institutions and regional companies, and (3) support research development in optomechanics, imaging, software development, and Industry 4.0.

To this end, the consortium will (1) organize regular information workshops, (2) create a system to register for bilateral and multilateral consultations, and (3) publish a newsletter on the consortium's technical progress.

Jihočeská univerzita
v Českých Budějovicích
University of South Bohemia
in České Budějovice

ÚTAM AV ČR, v. v. i., Centrum excelence Telč

Donau-Universität Krems
Universität für Weiterbildung

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ImageHeadstart news no. 2

INTRODUCTORY MESSAGE

The year 2020 locked us down in our laboratories and workshops and broke all personal contacts. During this period, however, a lot of interesting ideas, proposals and technical solutions hatched up. For the basic overview, technological leaflets presenting engineered solutions for precise measurement based on optical and X-ray methods are available. But there are a lot of other particular innovative integrated tools and devices for acquisition, inspection, and quantification in broad spectrum of applications, not only to the image data. And the ImageHeadstart is about to bring these solutions to the innovative companies.

Dan Kytýř, Department of Biomechanics, Praha

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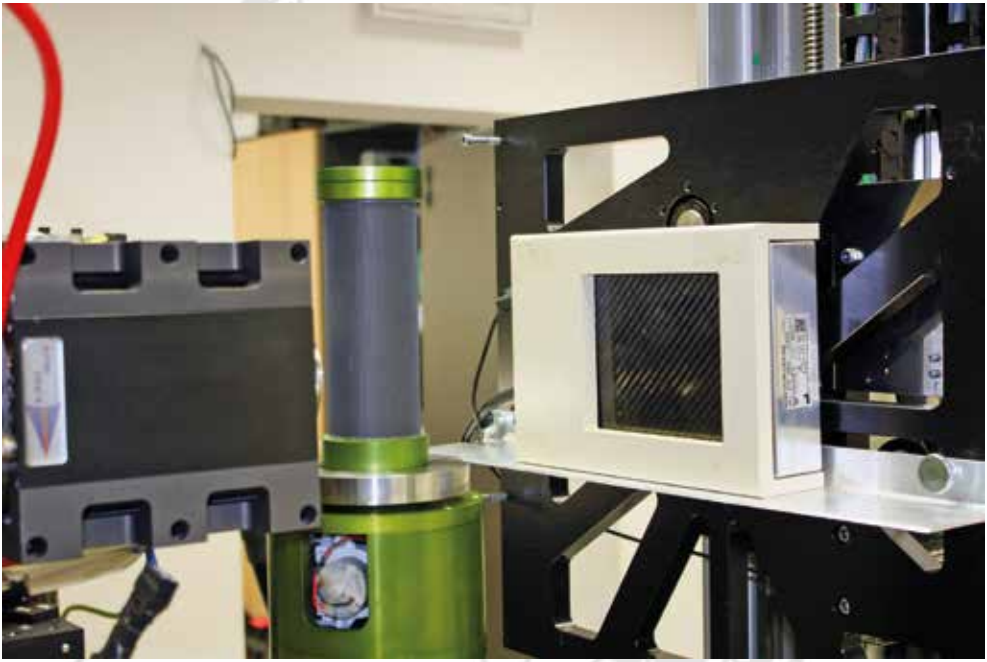
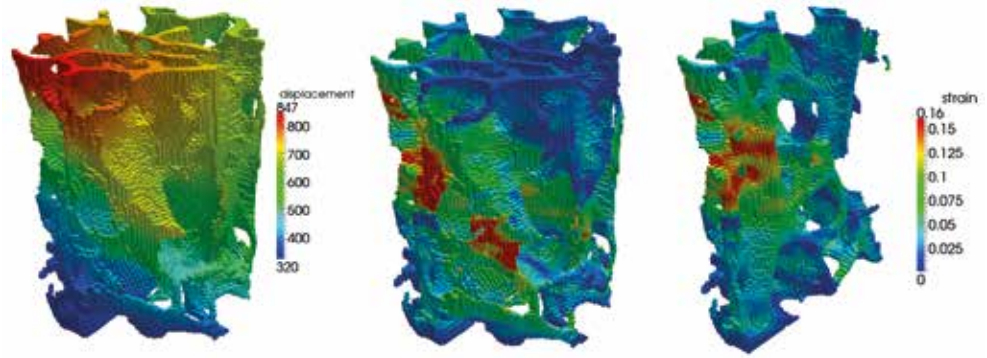
ON-THE-FLY 4D MICROTOMOGRAPHY OF BIOMATERIAL IN SIMULATED PHYSIOLOGICAL CONDITIONS

Demonstration of on-the-fly X-ray tomography for investigation of biological samples designed for bone tissue engineering applications. A tomography scanner together with micro-loading device were designed and engineered by the ITAM and employed for experimental evaluation of the cancellous bone deformation behaviour.

In bone tissue engineering, the proper description of deformation behaviour is one of the most important characteristics for assessment of biocompatibility and bone-integration characteristics of natural and artificial structures. We designed, instrumented and successfully tested an experimental method enabling the analysis of deformation behaviour and permeability of tissues and biomaterials under simulated physiological environment. Due to the continuous loading of samples in a controlled environment and the use of fast imaging, the method allows microstructural characterization of investigated materials with an accuracy of better than 10 μm at simulation of the effect of physiological and stress limits in the short and medium term.



Experimental set-up with the in-situ loading device mounted in the X-ray scanner.

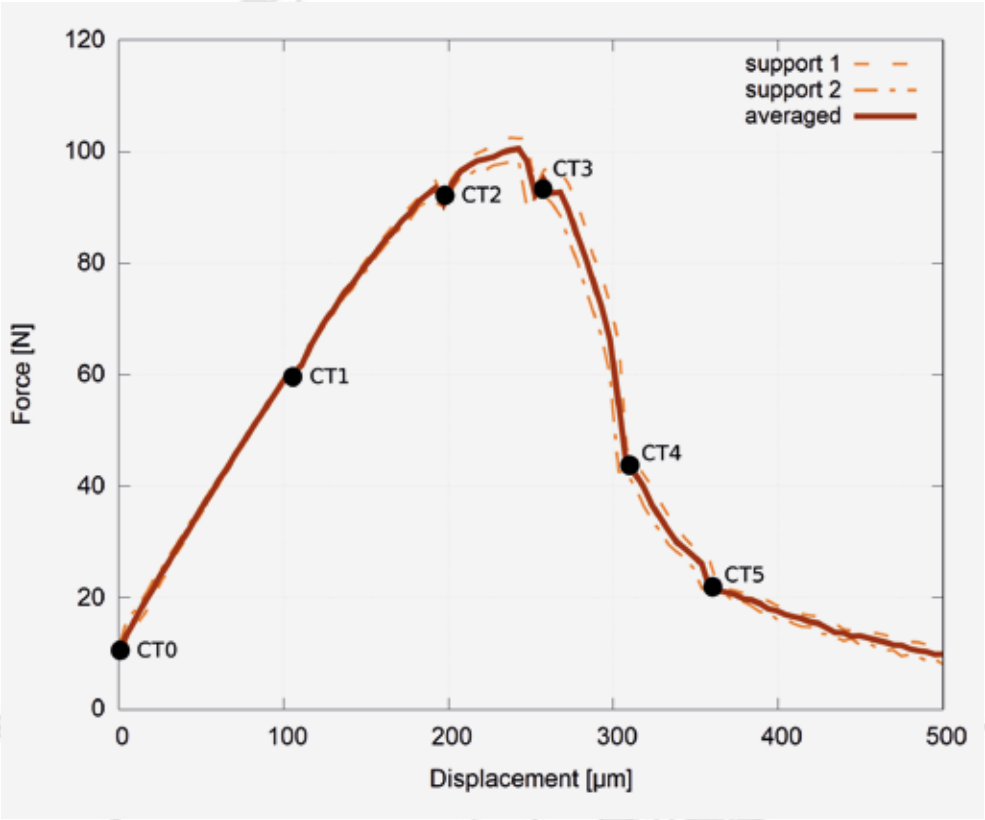


Displacement and strains full-field results obtained by the Digital Volume Correlation method.

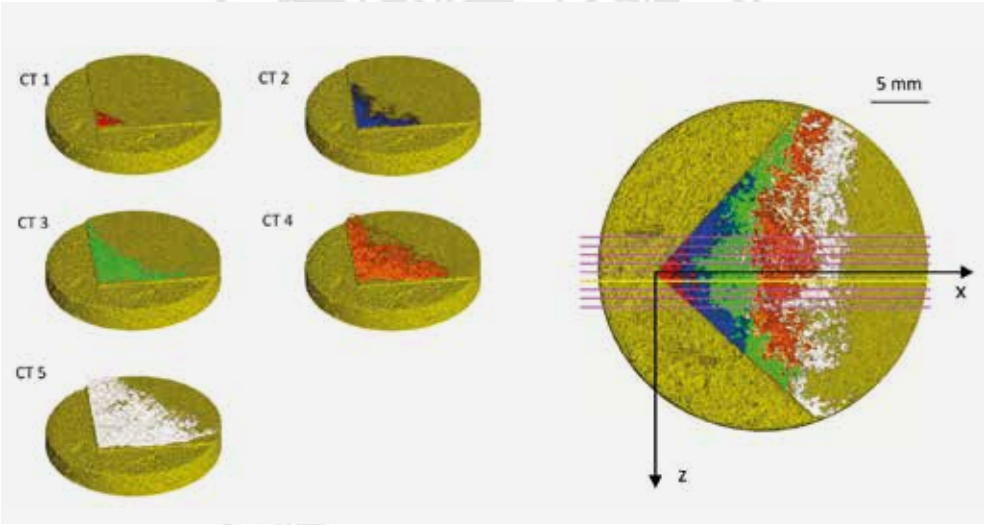
LOCAL FRACTURE TOUGHNESS TESTING OF SANDSTONE BASED ON X-RAY TOMOGRAPHIC RECONSTRUCTION

A unique testing protocol was designed for experimental investigation of damage propagation in quasi-brittle building materials using X-ray tomographic reconstruction.

The resistance of the material to failure is evaluatedted by fracture toughness, which is widely used for building materials. Since standard methods have been developed primarily for homogeneous and structureless materials, their use for rocks and concrete is debatable. Therefore, a new methodology for measuring the fracture toughness of quasi-brittle materials was developed, based on tomographic measurement of crack front opening. The data is recorded at several load levels, realized by a unique machine for four-point bending. For the sandstone sample, the crack front opening was about 5 μm. We measure this quantity in several places along the crack front and for several load levels. As a result, the newly developed method gives us a large number of results for a single sample, while the standard method would require a large set of samples for the same number of results.



Loading diagram including positions of the tomographic measurement.



Visualization of the identified microcracks in the selected regions after the cyclic loading.

Second project meeting in Wels (Austria)

On 29 June 2020, the project partners came together to present their ongoing research activities in the scope of the project ImageHeadstart. In total, nine participants of all four project partners participated in the meeting. Present were researchers from the University of South Bohemia (USB; consortium leader), the Institute of Theoretical and Applied Mechanics of

From left to right: **Jonathan Glinz** (FHOÖ), **Michal Vopálenský** (ITAM), **Jaroslaw Jacak** (FHOÖ), **Jiří Koleček** (DUK), **Sascha Senck** (FHOÖ), **Michael Fischer** (DUK), **Dalibor Štys** (USB; project leader), **Claudia Wittner** (FHOÖ) and **Markus Pasztorek** (DUK).

the Czech Academy of Sciences (ITAM), Danube University Krems (DUK), and University of Applied Sciences Upper Austria (FHOÖ).

The project meeting was the second in the year 2020 and provided an opportunity for all project partners to discuss relevant project goals and indicators that are relevant in the first year of the project that started in January of 2020.

Following the introduction and welcome notes of the project leader Prof. Dalibor Štys, the project partners presented their ongoing activities. The scientists from the Laboratory of experimental complex systems of the FFPW (USB) in Nové Hrady introduced their results on superlocalisation by common microscope and visualisation of true, uncrooked, results. The DUK Krems presented results in relation to the cytoarchitecture of mesenchymal stem cells including the visualization of stained cell cultures. Michal Vopálenský from the ITAM ASCR in Telč gave an overview of relevant aspects of employing computed tomography for precise mechanical measurements. The researcher representing the FHOÖ, Campus Linz (medical engineering) presented ongoing research in relation to 3D lithography and imaging in microfluidics while the researchers from the Research Group Computed Tomography (FH OÖ, Campus Wels) provided an overview of ongoing research in the field of non-destructive testing of composite materials using phase contrast and dark-field imaging.

Launch conference & information workshop in Nové Hrady (Czech Republic)

On 15th and 16th September 2020, the launch conference including company presentations took place in Nové Hrady. In total, circa 30 participants took part in this official event that featured an overview and scientific presentations from the involved institutions and connected industrial partners. The meeting took place in the lovely Nové Hrady Castle and Babak Minofar (Head of the Center) gave an overview of past and current activities at the Academic and University Center of Nové Hrady (ASCR). The ASCR regularly organizes symposia, conferences, workshops and a large number of courses, seminars, external meetings and educational events, such as the International Summer School of Molecular Biophysics and Systems Biology and FEBS (Federation of European Biochemical Societies) courses, the Visegrad Conference and EMBO courses.

After the introduction by the project leader Prof. Dalibor Štys (USB), the first session summarized the activities of the tomography section in the ImageHeadstart project. Firstly, Sascha Senck gave a broad overview of the projects´ X-ray tomographic activities including the research on phase and dark-field contrast at the FHOÖ (Campus Wels). The following talks were given by Michal Vopálenský and Dan Kytýř (ITAM) concerning their work on dimensional measurements and mechanical testing using custom designed in-situ loading stages. In the second session, microscopy specialists presented their ongoing work on microscopy, including superresolution optical microscopy (Jaroslaw Jaczak) and superlocalisation and pointwise spectral measurement (Dalibor Štys). After lunch, the workshop concluded with informative talks from Antonín Pošusta (Vrgineers Praha) about a high-resolution virtual reality headset for visualisation of

Launch conference & information workshop in Nové Hrady (Czech Republic)

scientific and engineering data and Kirill Lonhus (USB) about human and animal behaviour analysis and predictions.

The afternoon was reserved for networking activities between scientific and industrial partners and a live presentation of the virtual reality headset from Vrgineers Praha.

The ISM took place online between 23rd and 25th November 2020. The development of machine learning and artificial intelligence enables the automation of image processing tasks in the fields of microscopy and non-destructive testing, e.g., for the segmentation of image features. Compared to manual processing, time can be saved and, in many cases, better results can be achieved. In the ImageHeadstart project, a well-rehearsed Czech-Austrian consortium is trying to bring small and medium enterprises closer to the latest research in the field of digital image processing and to think about

practical applications in the respective companies. To get in close contact with companies in the cross-border region the project leader, Prof. Dalibor Štys (USB), organized a special session at the ISM introducing the consortium and its capabilities in two- and three-dimensional image processing.

This special session focused on the presentation of relevant examples from light microscopy (LM) and X-ray tomography (XCT) in the fields of material production and testing. XCT offers advanced possibilities in smart manufacturing process due to the combination of metrology and non-destructive testing. Additionally, the special session "Digital image information extraction for material quality control" that took place on 25th November showcased methods of superesolution/superlocalisation in quality control of nanoprinted structures, nanofibers and larger biocompatible nanostructured surfaces. The session was headed by Prof. Dalibor Štys (USB) featuring the following presentations by the respective project partners:

- **Michal Vopálenský** (ITAM): Advanced X-ray computed tomography methods for material characterization
- **Dan Kytýř** (ITAM): 4D μCT in experimental mechanics and material quality control
- **Sascha Senck** (FHOÖ): Defect extraction in carbon-fiber reinforced polymer composites using advanced microcomputed tomography

Company description
CADS https://www.cads.at/

The company *CADS* founded in 2006 focuses on creating intuitive software solutions for industry. To maintain their position as pioneer in innovation and technology, continuous investments in research and development are inevitable. Only by constantly developing their skills in technology and innovative spirit in all areas, development of new and efficient software solutions can be created to fit the exact customer's needs.

CADS.Medical provides visionary software solutions for medical engineering, e.g., in relation to surgical planning and virtual reality environments. CADS produces medical applications through many years of experience that are considered as technological pioneer work in the field. The software requirements

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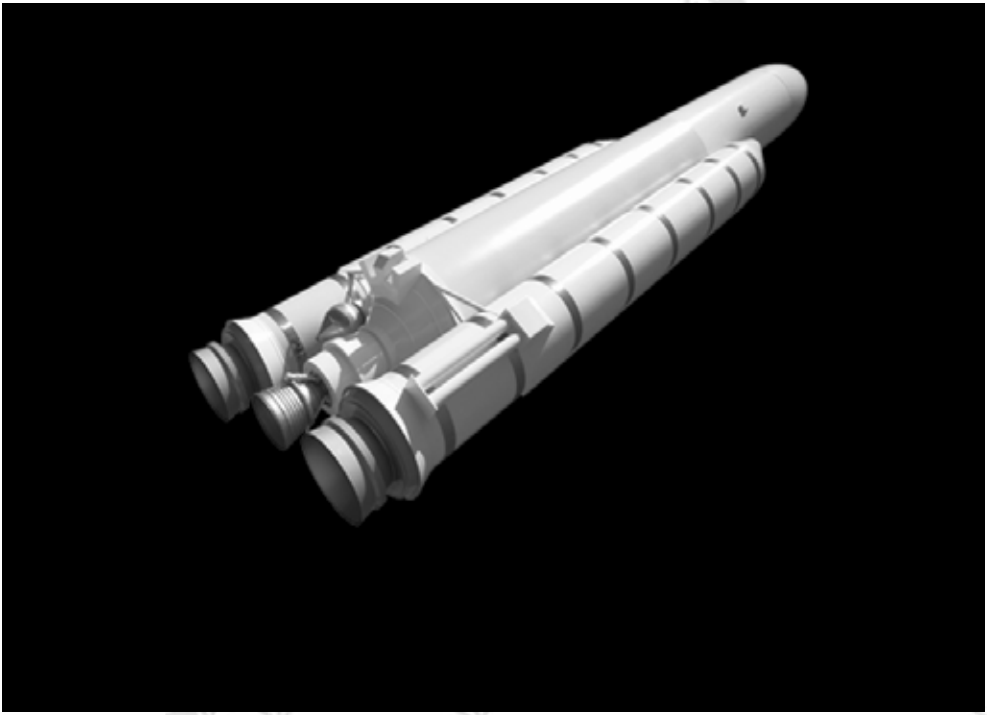

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in this field are considered particularly high. International partners therefore rely on the expertise on safety and connected systems as well as 3D visualizations in real-time.

Peak Technology is combining groundbreaking innovations in fibre composite lightweight structures with solid craftsmanship. This combination turns them into one of the world's most interesting high-tech manufacturers in the field of development and production of lightweight parts.

Working in close cooperation with their customers, *Peak Technology* is creating individual, flexible and highly innovative solutions that pass from initial prototypes to production readiness in record time. In intensive work processes the company is searching for the best solution and work on it with far-sightedness and greatest precision.

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PEAK Technologies greatest driving force is the will to do things better and ever more innovatively. For that reason they continuously optimize their methods and processes and invest a great deal of time and money in their best trained employees. For only these things guarantee maximum quality without compromises - from 3D design and simulation through manufacturing to our rigorous quality management.

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