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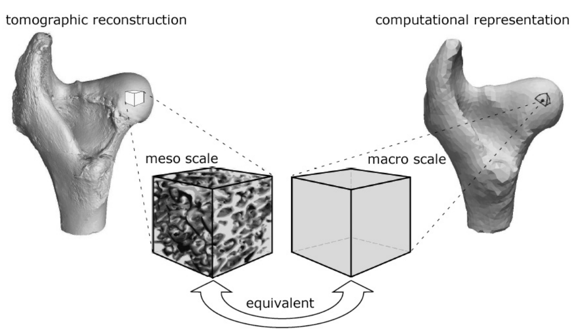
**The interview with the author of the PhD thesis:
„Computer simulation of the mechanical properties of bone tissue based on a biomechanical bone model using microtomographic measurements of animal bones"**

Your work is highly interdisciplinary. What was your path to this topic?

My interest in computer science and programming dates back to my high school days, but it was only during my university studies that I started focusing on engineering computer graphics, including methods of analyzing and visualizing data from 3D scanners and tomographic imaging. Through individual studies under the supervision of Dr. Jacek Tarasiuk and cooperation with Dr. Sebastian Wroński, I was able to personalize my academic path, which resulted in award-winning research projects and theses related to 3D data. This led me to join bone biomechanics research, including an internship at ENIM in Metz, France under the Erasmus program, where I conducted my master's research. In the case of interdisciplinary collaborations with other research centers, exchange of ideas and joint discussions are crucial for development and combining diverse expertise. Gaining knowledge and experience from this project, I continued research on modeling the microstructure and mechanical properties of bones as part of the faculty's PhD studies and research-teaching assistantship, taking advantage of research opportunities of LMiNT-AGH and the Cyfronet's infrastructure.

Your research has potential applications in medicine. Could you explain how the results might benefit patients?



Multiscale modeling of the femur based on the equivalence of computational representation and apparent properties through homogenization of tomographic imaging data

For the purposes of personalizing medical therapies, it is essential to expand the use of computer models that can predict the mechanical properties of bone based on precise, non-destructive measurements, so they can be adapted to be directly applied in clinical practice. The computational methodology developed in my work was created with the aim of predicting changes in the mechanical properties of bones that occur during remodeling under external loads. The obtained measurement data and computer models can serve as a valuable input for further specialized analysis. In particular, it may be important to adapt the methodology to data from modern high-resolution *in vivo* imaging of human bones, which allows for precise capture of the orthotropic microstructure of cancellous bone.

A patient imaged using traditional tomography, even if it were technically possible and precise, would be exposed to excessively high doses of X-ray radiation. To provide a better assessment of cancellous bone mechanics *in vivo*, research focuses on imaging devices and methods used to improve the precision of volume fraction measurement and to better account for bone anisotropy. Proper understanding of bone behavior under various loads also improves the design and construction of implants and endoprostheses. Another possible application for the defined modeling method is related to the multiscale analysis of bone remodeling in osteoporosis. With modern modeling approaches and computing clusters, it can be assumed that simulations in personalized medicine will become increasingly useful, cost-effective, and accessible. The development of models predicting bone mechanical properties based on non-destructive tomographic imaging, supported by *ex vivo* studies of prepared bones, may contribute to a deeper understanding of bone behavior and the processes occurring in the body, including implant integration.

How did the resources provided by Cyfronet support your computations?

Access to Cyfronet's resources was invaluable, both for test simulations using the Finite Element Method (FEM), including the selection of the size and type of computational meshes, and for final multiscale modeling, taking into account the micro and macro structure of the bone and other elements (muscles, tendons, cartilage, acetabulum). The larger the numerical problem, the greater the need to use computational clusters to significantly reduce simulation time and handle resource-intensive FEM meshes with numerous degrees of freedom, thanks to large shared memory and parallel computing. In my work I used Abaqus package for FEM simulations based on input data in the INP format. The unique capabilities of Abaqus package and the computational resources provided by Cyfronet ultimately allowed me to achieve all the goals of my doctoral thesis.

What limitations did you encounter during your research and how did you overcome them?

The main challenge was to obtain measurement data of the internal bone structure and to conduct demanding analyses and simulations. In the case of human bone samples, they are often affected by osteoporosis to a certain extent, because the bones usually come from endoprosthetic procedures in elderly individuals. The use of animal bones allowed access to diverse samples differing in terms of microstructure, but required development of advanced analysis based on many different computational tools. However, the effort put into the work enabled the development of an approach applicable to human bones. A digital registration method for femoral bone samples from micro-CT imaging was developed as an adaptation of the method based on local descriptors. The methodology was designed to rely mainly on standard file formats for easy pipeline processing and further analysis. For multiscale simulations, which are computationally intensive, I used the possibilities of advanced workstations and clusters, and commercial software thanks to faculty grants and research licenses.