German Research Center for Artificial Intelligence

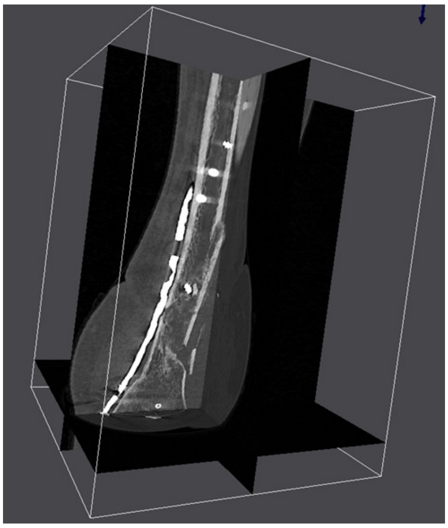
IIP-EXTREM

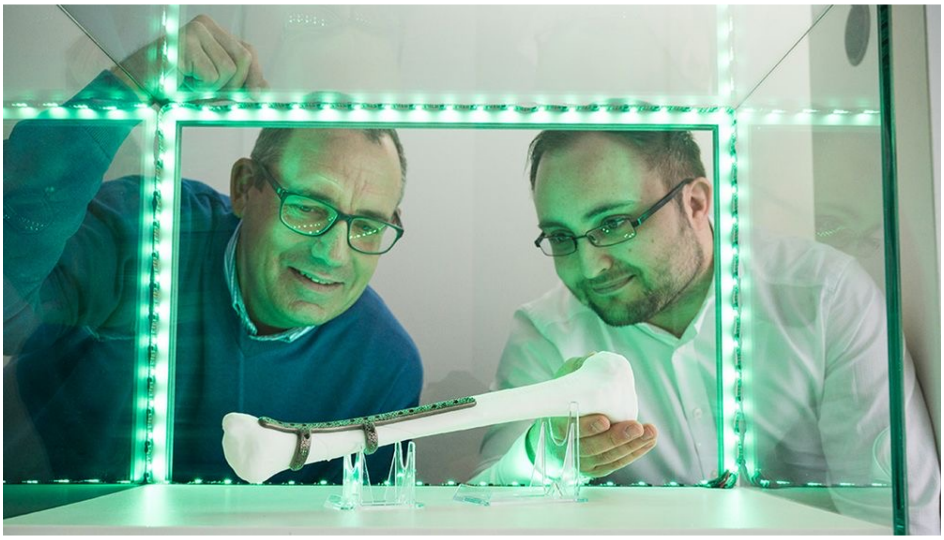
Individualized Implants and Prosthetics for the lower Extremities

The project IIP-EXTREM (Individualized Implants and Prosthetics for Treatment of the Lower Extremities) started on June 1st 2016 with the primary goal of improving the treatment of tibia fractures. State of the art techniques in the areas of 3D-imaging, segmentation, mechanical simulation and laser sintering are combined to facilitate a workflow that ultimately produces an individualized implant for a given patient.

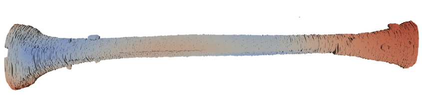
We remedy this by utilizing Deep Learning technology. After training on several thousand images, a neural network is able to classify materials on CT images almost in an instant, thus greatly improving speed and reliability of the image segmentation.

Taking the then segmented tomograms, a 3D volume mesh data is constructed in Unreal Engine, using the Marching Cubes algorithm. Image data and grayscale values are combined to assign material properties to mesh cells. The resulting model can then be further handled virtually or exported to commonly used 3D object formats, such as stereolithography (STL), which is supported by most CAD software packages.





Routinely performed computer tomography (CT) yields image data sets that can be used for 3D reconstruction. As as distinction between different materials (cortical bone, cancellous bone, implant metal, soft tissue) is required, the image data needs to be segmented. Since a single CT scan requires pixel-accurate identification of materials over several hundred images, this results in a lengthy and laborious process of manual classification by highly qualified personell.



Picking up the 3D model generated in the previous step, a Finite Element Method Simulation is performed, calculating the influence of pressure on the bone-implant structure in terms of stress and strain. While most solutions utilize generic approaches on CPU clusters, this project deploys a specialized FEM approach using Nvidia CUDA that allows for being run on special purpose hardware.

Equipped with 3D Models and corresponding FEM simulation results, medical professionals will be able to plan and visualize the individual treatment of a patient, making surgical intervention less invasive and more effective at the same time.

Furthermore, the workflow allows for implants that are tailored to the patient and can be optimized in an iterative approach. This is enabled by a semi-automatic process embedded in a computer assisted surgery (CAS) environment. The custom implant can then be manufactured via selective laser melting or high speed cutting milling machines.

To validate simulation results, the whole process was tested on real-life human legs acquired by body donation. Using a custom build testing facility, we induced specific fractures in a controlled setting to the donated leg and applied the process developed, recreating everything from imaging to implant manufacturing.

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