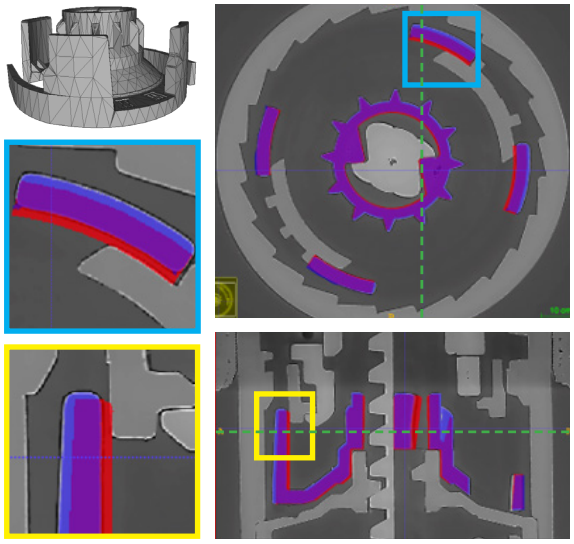
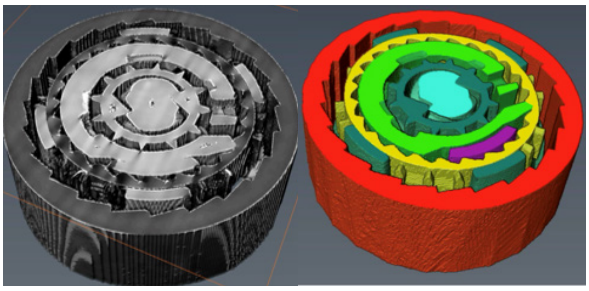
Tracking the location of components during operation

Novo Nordisk entered a collaboration with the 3D Imaging Centre at DTU through LINX, a project funded by the Innovation Foundation in Denmark. The goal of the project was to image an insulin injection pen during operation using X-ray Computed Tomography (CT) to visualise the movement of its internal components. To follow the fast movements of the components within the pen, it was necessary to scan continuously and acquire CT scans as fast as possible, so as to obtain a high temporal resolution. The time sequence of 3D scans depicts the central region of the pen in 53 individual 3D images. In this part of the project, we tracked the position of the internal components of the pen, found their speed of rotation and translation, and made a high-quality visualisation where the components were colour coded.



CAD model of a component to aid the tracking process (on the top left). 2D cross-sectional and longitudinal slices of the pen (on the right) showing the initial data in grey and the component from the CAD model after the coarse (red) and fine (blue) alignment. The two slices are perpendicular to each other and the green dashed lines indicate their relative position. Zoom images into the areas indicated by blue and yellow boxes (on the bottom left).



3D images of the pen cut at mid-height at a specific time point. Dynamic dataset during rotation of the internal components shown in grey shades (on the left). Note the artefacts that alter the intensities of the components which should be homogeneous. Static dataset after segmentation (on the right). Each component is shown in an individual colour.

Challenge

The 3D images obtained from the X-ray experiment contained noise and artefacts, which made visualisation challenging. To produce a high quality visualisation, we decided to give each component of the pen a unique colour. This requires a virtual extraction of the components for each individual time step. To solve this task, we incorporated prior knowledge about the geometry of the components, provided by Novo Nordisk as a CAD model.

Collaboration

This collaboration was part of the LINX project, in which researchers at leading Danish universities collaborate with scientists in industry to solve industry relevant problems using advanced neutron and X-ray techniques. Dedicated tools for image analysis were developed at the 3D Imaging Centre at DTU, while the X-ray experiment was carried out at the European Synchrotron Radiation Facility in Grenoble, France.

Results

The virtual extraction of the components was performed in 3 steps. First, the CAD model was aligned coarsely with a high quality static scan using manually annotated corresponding points. Second, a finer, automatic alignment, that also accounts for deformations, was performed to find the geometry of the produced components, which differ slightly from the design. Then, these geometries were used to find the position of each component while they move during the pen's operation. This was achieved using an automatic registration method which provides an optimal alignment by matching intensity values. Through this process we were also able to estimate the rotation and translation angles for every component at each time step. This information provides the speed of rotation and translation of the components during the operation of the pen.

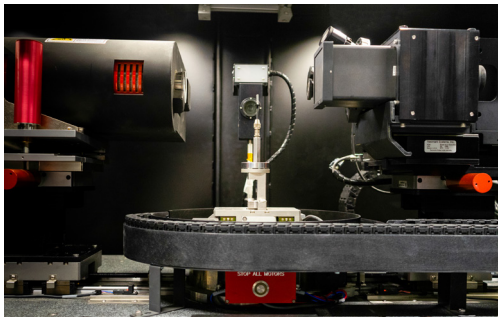
Perspectives

The process of tracking internal components using a priori knowledge about their geometry can be used to further understand the movements of internal components during operation, both for quality inspection, and also for testing new designs and production processes.

Imaging Industry Portal

The Imaging Industry Portal is a part of the 3D Imaging Centre at DTU and assists companies in using and implementing 3D Imaging in research, development and production. The portal offers research-based 3D Imaging services and provides companies with the latest equipment and the most advanced knowledge within 3D Imaging and data analysis. The Imaging Industry Portal works as a gateway to ESS and MAX IV, as well as other large scale facilities.

www.imaging.dtu.dk/Industry-Portal



DTU 3D Imaging Centre