Deep learning - orthopedic surgeons new best friend

- Based on the Master's thesis: *Automated 3D Bone Segmentation using Deep Learning in Scoliosis*

Filip Winzell
Andreas Bennström

The development of deep learning and AI is on its way to become an essential part of modern medicine. Recent studies have shown the potential of combining modern biomedical imaging techniques with AI to revolutionize today's diagnostic and therapeutic procedures. In this thesis, the possibility of using deep learning for diagnostics in scoliosis was studied, with promising results.

Scoliosis is a condition where the patients spine is crooked and rotated in a three-dimensional way. It can be very painful and make it difficult to move. It is a quite common condition, affecting almost 10% of all children in Sweden to some degree. Severe scoliosis is rare, but in these cases surgery might be needed to straighten the spine. Such surgeries are complicated procedures that need extensive planning. To visualize the structure of the spine, x-ray images of the patient are used. CT-scans yield volumetric x-ray images that can depict the body in layer by layer. One scan often consists of more than 500 layers. However, a full upper-body CT-scan contains a lot more than just the spine. Therefore it could be very beneficial to use some computational tool to segment the spine structure from the CT-scans. The three-dimensional structure could be visualized in a graphical interface or even used in three-dimensional printing to print a physical replica of the patient's spine for the surgeon to use in the treatment planning. This can be performed manually, by an expert, who outlines the structure of the spine, image by image, which is very time-consuming. Developing an automatic algorithm for segmentation of the spine could both save time and reduce possible human errors. In this master thesis, we have developed an automatic method for the segmentation of the spine or other bone structures. The automatic method is based on deep learning.

In short, deep learning is a method where inspiration is taken from nature and a large number of artificial neurons or nerve cells are connected into a network with many layers, hence the name deep. Different algorithms are used to train a computer to solve certain tasks. Essentially, during training, a large amount of examples where the desired output is known, is presented to the network. By adjusting the strength of connections between the neurons the computer can gradually get a result that is closer and closer to the desired output. Hence, it learns to perform the task correctly.

Our method can perform a segmentation of a spine in a couple of minutes. This is much faster than doing a manual segmentation. When testing the method on two spines suffering from scoliosis, it performed very well. An example of such a spine is showed in Figure 1. Since the method worked well with spine segmentation, it was also further developed into general bone segmentation. The results from the more advanced model showed that it is possible to segment even more types of bones, such as pelvises and shoulders.

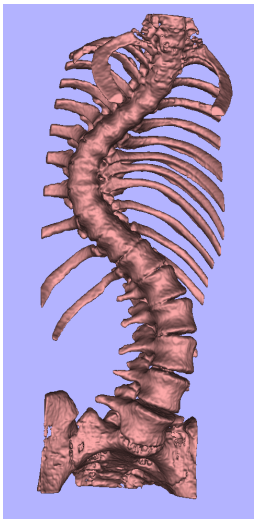

Fig. 1. Example of an automated segmented spine with scoliosis

The results from this project indicate that our automatic model can be used to outline spines, along with other types bones. This can be a valuable tool for orthopedic surgeons working with diseases effecting the structure of the bones, such as scoliosis.