The Artificial Intelligence Motion (AIM) study
Segmentation of cervical spine vertebrae in cinematographic recordings.

Department of Neurosurgery, Maastricht University Medical Center +
Drs. Esther van Santbrink (MD, PhD candidate): esther.van.santbrink@mumc.nl
Drs. Valérie Schuermans (MD, PhD candidate): valérie.schuermans@mumc.nl
Dr. Toon Boselie (MD, PhD, Neurosurgeon): toon.boselie@mumc.nl

Background information
The term 'physiological motion of the spine' is commonly used, although there is no proper definition of normal cervical spine motion. Most likely because analyzing motion of the cervical spine remains a challenge. We are interested in researching the relation of motion patterns in the cervical spine and the development of pathologies. Moreover, we want to investigate the influence of specific surgeries to the cervical spine. In a previous study by our group, motion patterns in radiographic recordings of flexion and extension movements were investigated (1). Contours of the occiput (C0) and cervical vertebrae (C1-C7) were manually drawn and corrected, which is very labor-intensive (±30h per recording). Another drawback is that it can only be done by trained and experienced individuals.

Previous project
In a previous collaboration with the technical university of Eindhoven an artificial intelligence (AI) algorithm was developed to automatically segment the cervical vertebrae (2). The U-net model with 5 layers was trained for 6 epochs on 2709 frames, with a validation after each epoch on 964 frames. Visual outcomes and performance metrics, such as Intersection over Union (IoU) and Dice, suggest moderate to good performance across vertebrae. An example of the contour predictions of the model compared to the ground truth (manually annotated contours) can be seen in Figure 1.
The current model shows promising results in efficient segmentation of C0 to C7 in healthy participants pre-operative patients with cervical degenerative disc disease. We aim to clinically validate the model and to analyze motion patterns in patients with anatomical variants or implants, to understand the relationship between cervical spine motion quality, development of pathology, surgery and pathology. Moreover, we want to develop an interface for the model to be applicable in the daily clinic.

Student task description
The students tasks will include three objectives:

1. To improve the accuracy of the current model
2. Training and testing a new model with manually annotated recordings of patients with anatomical variants or implants in-situ.
3. To develop a user-friendly interface to upload and analyze the recordings and detect motion patterns.

This can be executed in the form of a short-term external internship, or a longer thesis graduation project. The execution of the internship is flexible and can be both on location and digital. You will be able to work alongside other researchers in a workspace in the Maastricht UMC+ hospital.

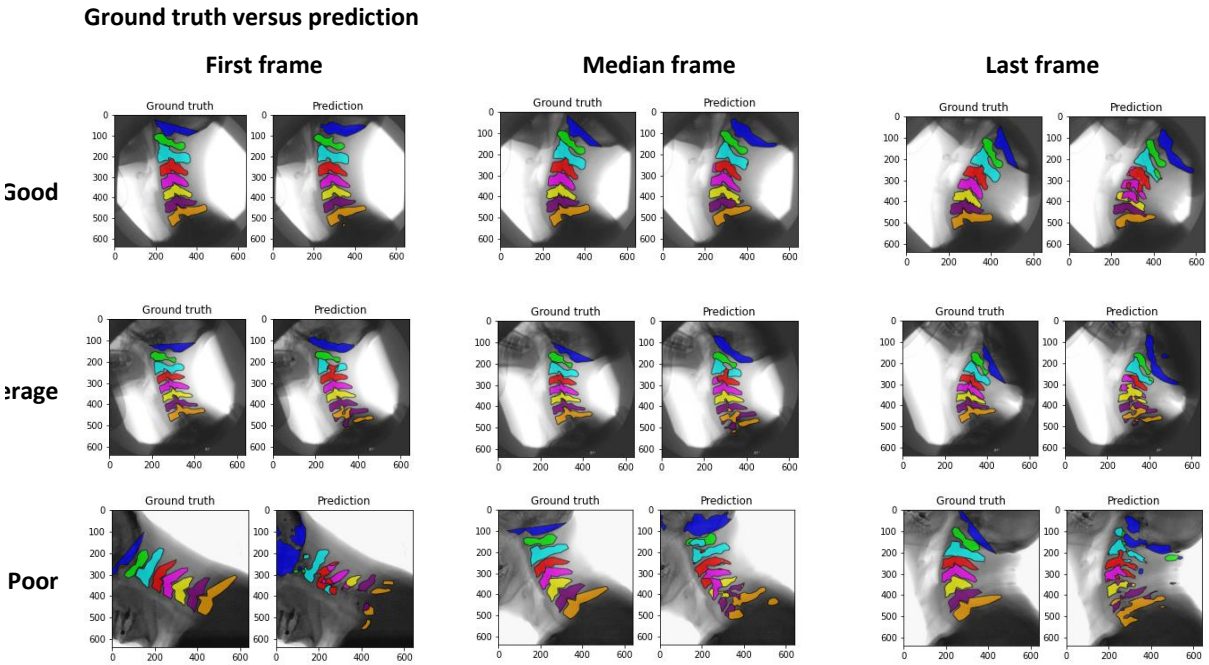

Figure 1: Visual comparison of cervical contours C0 to C7, manually annotated and considered as ground truth, in comparison to the predicted contours of the vertebrae by the model. The X and Y axes represent a coordinate system. The first, median, and last frames of a recording are shown. Three example recordings were selected from the dataset and are displayed to demonstrate good, average, and poor matches between the ground truth and predicted contours.

Literature

1. Boselie TFM, van Santbrink H, de Bie RA, van Mameren H. Pilot Study of Sequence of Segmental Contributions in the Lower Cervical Spine During Active Extension and Flexion: Healthy Controls Versus Cervical Degenerative Disc Disease Patients. Spine (Phila Pa 1976). 2017;42(11):E642-E7.

2. Schuermans V.N.E., Van Santbrink E., Cerfonteijn E.E.J., Van Santbrink H., Boselie A.F.M. The Artificial Intelligence Motion study (AIM): AI-assisted image recognition of cervical spine motion. 2024 [unpublished]

Interested in this project? Then contact prof. Marcel Breeuwer, email m.breeuwer@tue.nl