Deep learning for automatic prediction of cardiovascular disease from CT volumes

**Background**

Cardiovascular disease is still a major contributor to mortality. In 2000, 39% of all deaths in the United States were attributable to cardiovascular disease (Nabel, 2003). Finding explanations and cures for cardiovascular disease are major drivers for the Swedish SCAPIS study (Bergström et al., 2015) (www.scapis.org). The extensive SCAPIS dataset (30,000 subjects) includes images of the thymus gland which is an important gland for the immune system that in many of us undergoes fat degeneration with increasing age. Even though thymus is visible in routine CT (computerized tomography) volumes, see Figure 1, limited interest has therefore been given to this gland in routine radiology in adults. Ongoing research in our group challenges this routine.

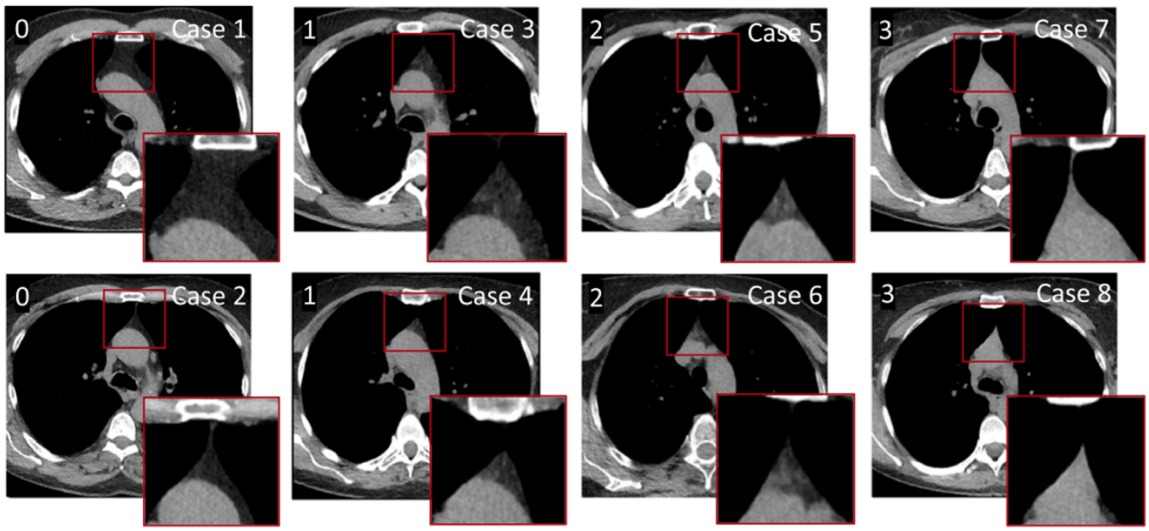



Figure 1. Representative CT images of each thymic score. 0 means no degradation and 3 means full degradation.

Using image data from the SCAPIS study, the thymus gland has been evaluated in CT volumes in 1,048 subjects 50–64 years of age. The majority (59 %) had a complete fatty degeneration of the thymus, that was correlated to an aged immune system, while 41 % had preserved thymus in different degrees (Sandstedt et al., 2023).

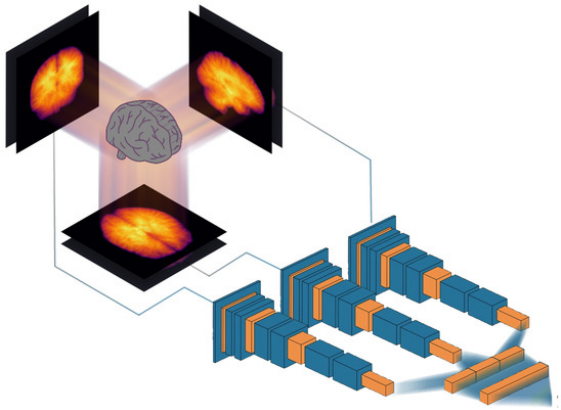
AI will be used in this master thesis to create a clinical tool to be able to automatically evaluate thymus size and morphology in a clinical radiology workflow. This tool could then be used for opportunistic screening in routinely performed CT (done for a multitude of reasons). Thymus morphology could then potentially be used as a new biomarker to automatically predict risk of cardiovascular disease and thereby initiate preventive measures. The main challenge here is to make this screening fully automatic.

CT volumes typically are of very high resolution, e.g. 512 x 512 x 512 voxels (3D pixels), and are therefore difficult to work with from a computational perspective (the complete SCAPIS dataset is about 42 TB in size). Training deep models, such as a 3D convolutional neural network (CNN), for predicting the degree of thymus degradation using such large volumes is therefore difficult.

**Objectives**

Implement and evaluate 3D CNNs using downsampled volumes, e.g. 256 x 256 x 256 or 128 x 128 x 128.

Implement and evaluate a 2D projection approach, which uses a few 2D projections from the large 3D volumes to make a prediction. Such an approach has previously been used for brain age prediction using 30,000 brain volumes (Jönemo et al., 2023).



Implement and evaluate an approach consisting of first locating the thymus gland in the large CT volume, using a 3D object detection network (Jaeger et al., 2020, Albuquerque et al., 2025) on down sampled volumes or using traditional medical image processing, to extract a much smaller volume covering the thymus (e.g. 64 x 64 x 64 voxels from the full resolution volume, like the red boxes in Figure 1). The object detection task can potentially also be performed using the 2D projections. The small full resolution volume can then be used for prediction of thymus degeneration using another 3D network.

**Data**

1048 CT volumes with grading of the thymus gland.

**Required background**

Machine learning, deep learning, Python programming

**Computing resources**
The student will have access to a computer with 4 graphics cards at CMIV.

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