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Project: Domain Decomposition for Machine Learning Based Medical Imaging

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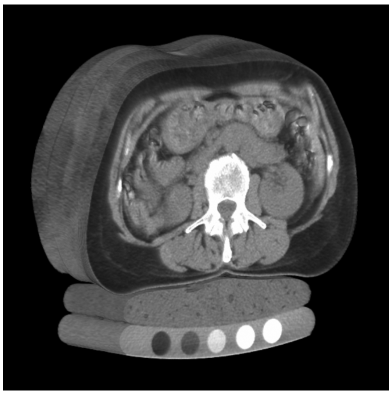
September 30, 2022

1 Project Description

Modern medical imaging tools, such as magnetic resonance imaging (MRI) or computed tomography (CT) scans, combined with machine learning have the potential to provide unprecedented diagnostic capabilities providing near real time "in office" results. Typical machine learning techniques used for image processing are deep learning models, in particular, deep convolutional neural networks (CNNs); cf. [2]. Despite their superior efficiency compared with classical dense neural networks, computational costs can easily overwhelm modern GPU platforms during training and inference, especially for 3D images. This limits the practical applicability of this approach.

This project proposes to look at domain decomposition methods to allow efficient utilization of multiple GPU platforms for training. Classically, domain decomposition methods [3, 4] are numerical methods for solving partial different equations. Instead of solving a large problem on the whole computational domain, the domain is decomposed into parts, so-called subdomains, and local problem on the subdomains are solved. In order to obtain a global solution on the whole computational domain, the subdomain problems have to be coupled; this can be performed using various strategies, for instance, using overlapping subdomains, transmission conditions, and/or adding small global problem (a.k.a. coarse problem).



A computerized tomography voxel image highlighting a vertebrae. Image Link

With the respect to the application to 3D image processing via machine learning (for instance using a U-Net architecture [1]), a domain decomposition strategy would allow the decomposition of 3D voxel images into smaller 3D images where diagnostic predictions can be made locally on a single GPU. These predictions are then stitched together mathematically to account for global patterns imparted by both the medical imaging tools and the global nature of the biological system (the human body). Given the various relevant applications for the envisioned techniques, there is a high potential for scientific and societal impact of this project.

We anticipate that this work will requires innovation not only in the development of machine learning algorithms but also in their implementation within machine learning software libraries. Therefore, both a solid understanding of machine learning models, especially neural networks, as well as good programming skills are important requirements for a candidate for this project.

Contact

If you are interested in this project and/or have further questions, please contact Alexander Heinlein, a.heinlein@tudelft.nl.

References

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