HeartFlow®

Imperial College London

Development of Neural Network Models for Automated Cardiac Image Analysis: From Research to Clinical Software

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April 16th, 2019
Deep Learning for Medical Imaging School, Lyon

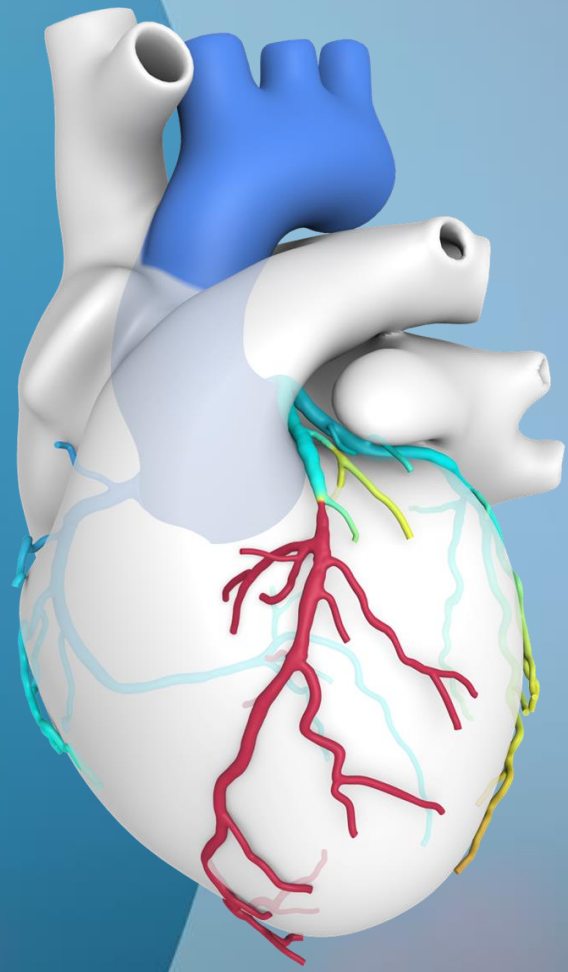
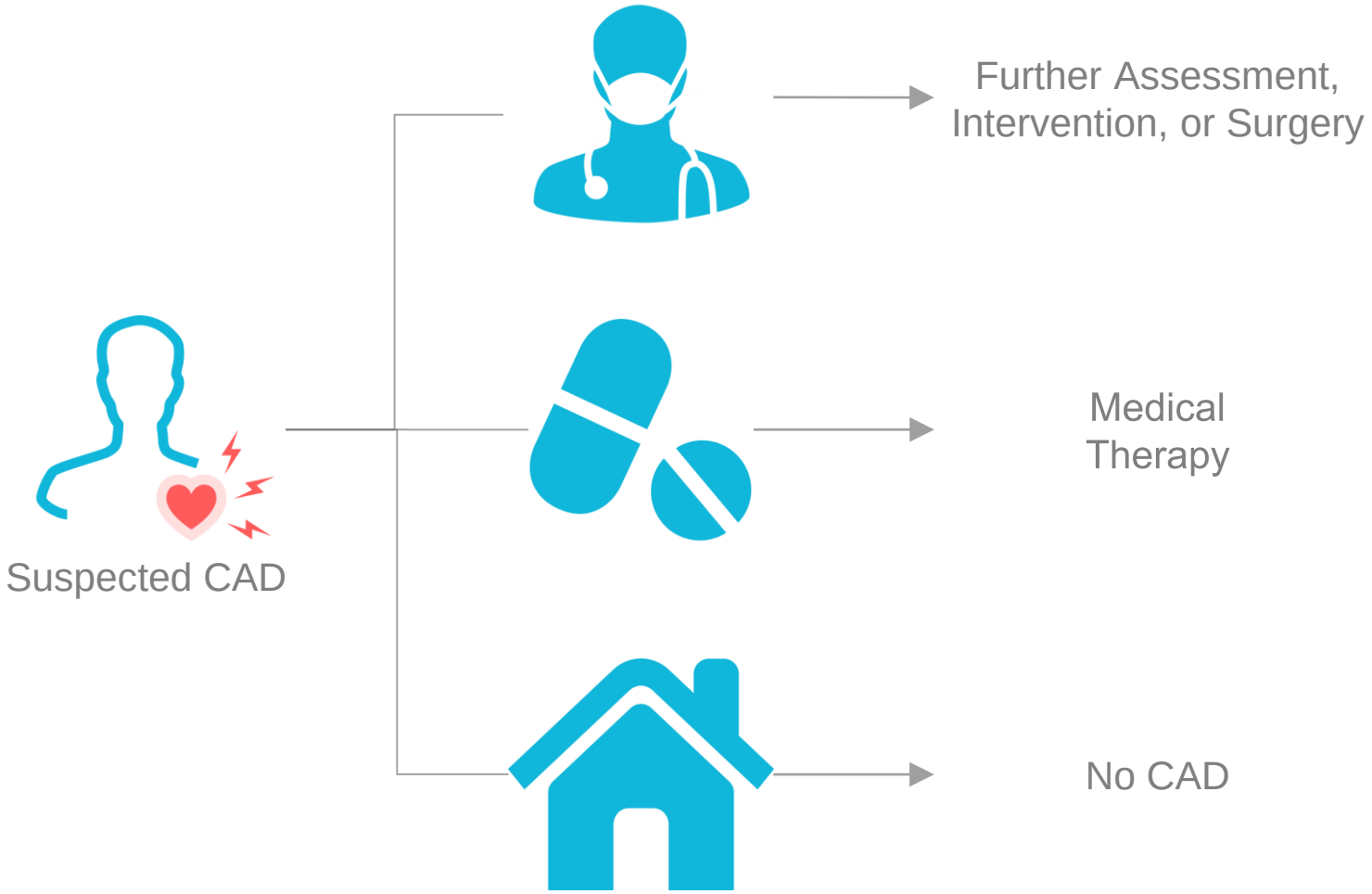


Image not representative of actual product

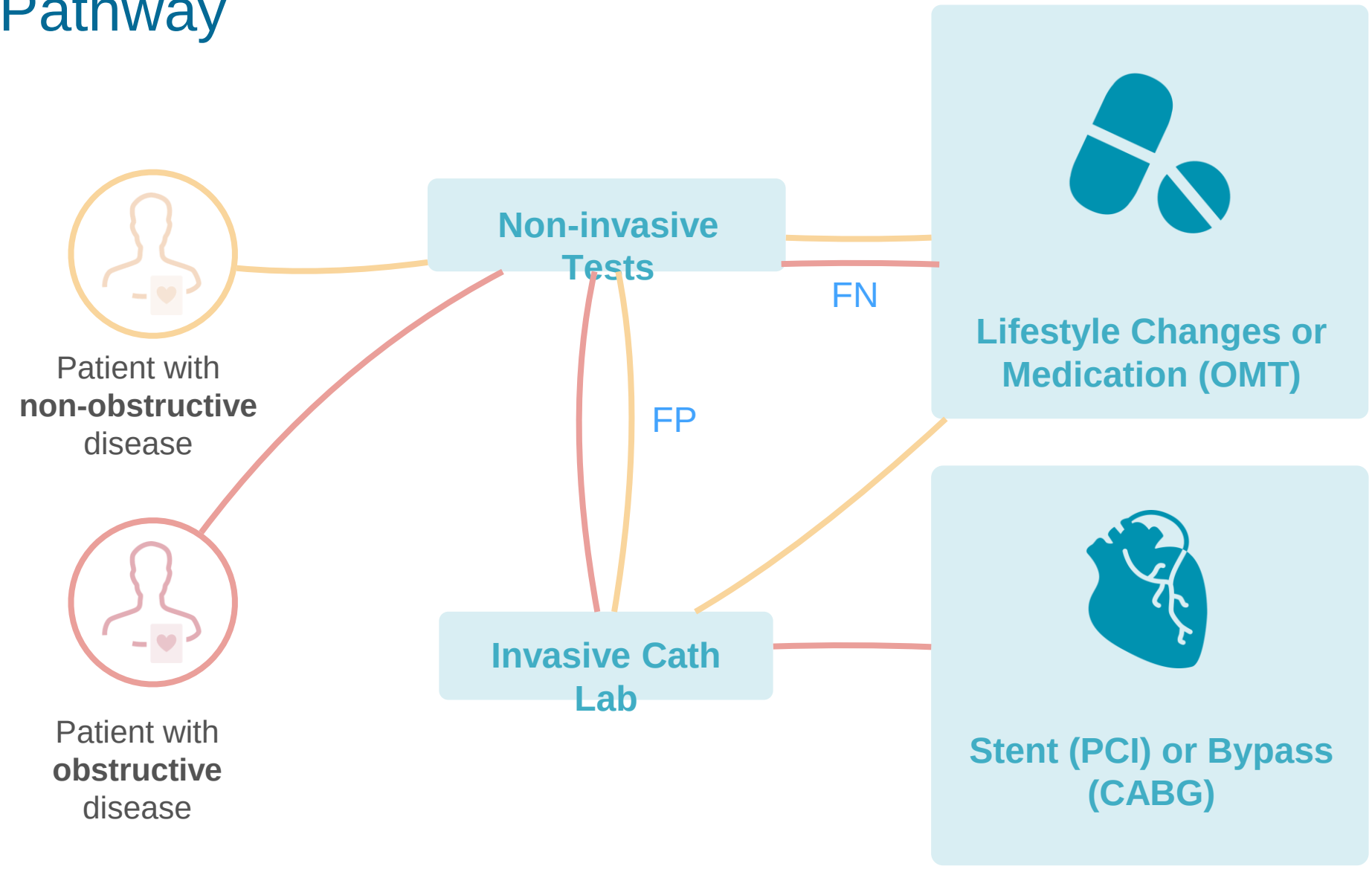
Agenda

Building Clinical Solutions
(HeartFlow Inc.)

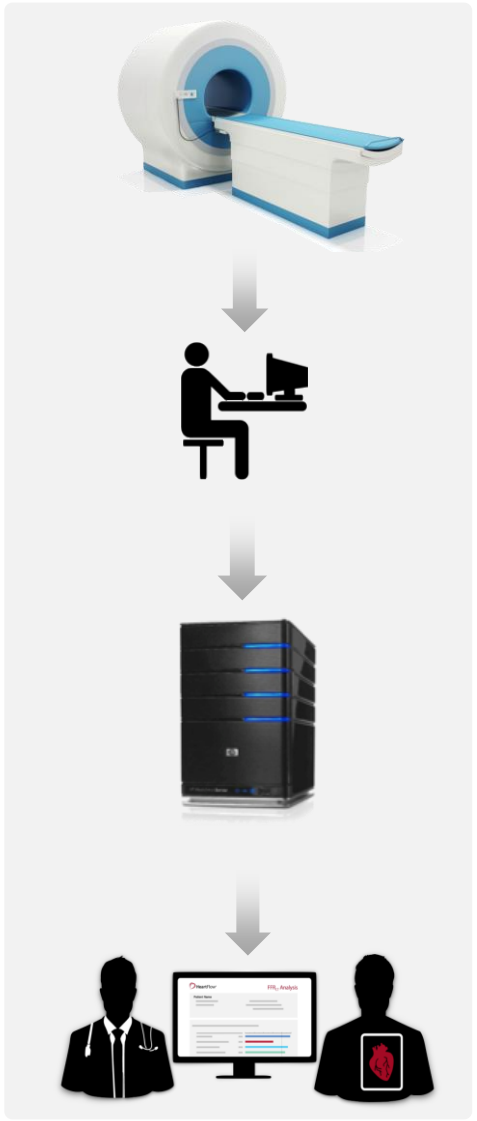
Coronary Artery Disease (CAD)



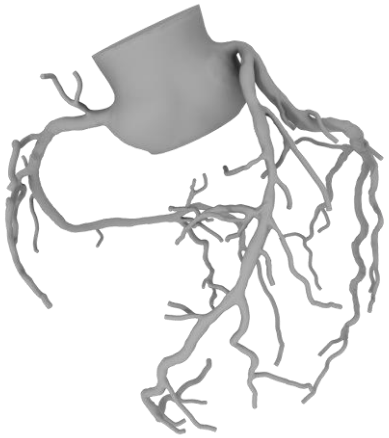
Clinical Pathway



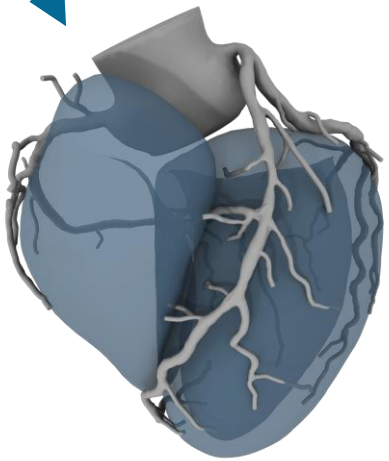
Overview of HeartFlow Analysis



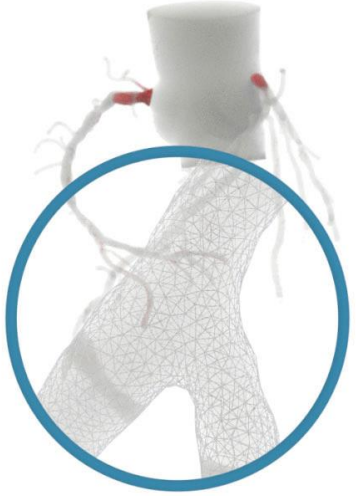
CT data submitted



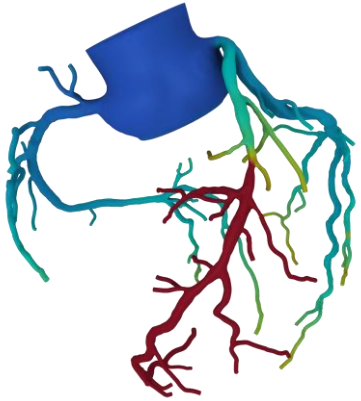
Anatomic model



Physiologic model

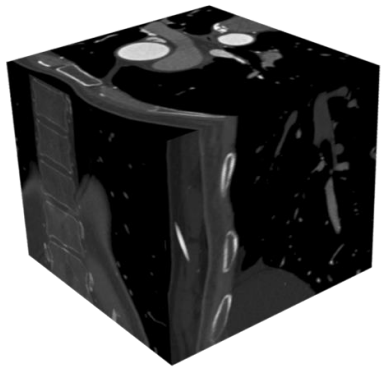


Functional assessment with CFD

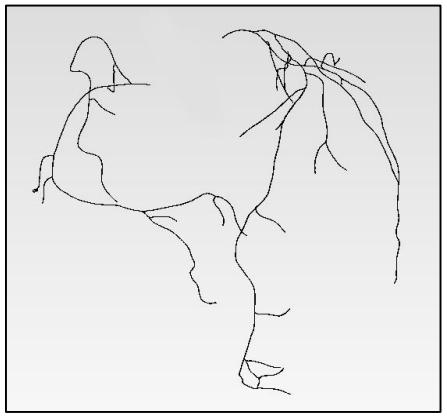


HeartFlow Analysis delivered

HeartFlow FFR-CT Analysis

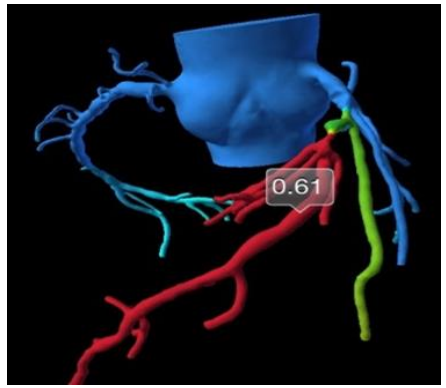


Input CTA Image



Coronary Tree Centerlines

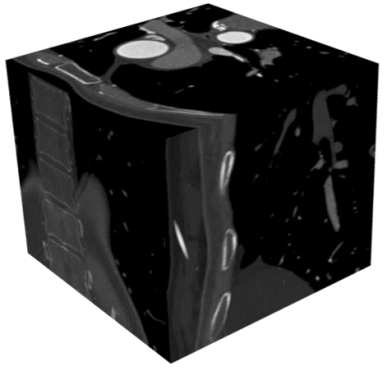
Lumen Geometry



Functional Assessment CFD

Machine Learning based solutions / The results are manually inspected by trained clinical analysts

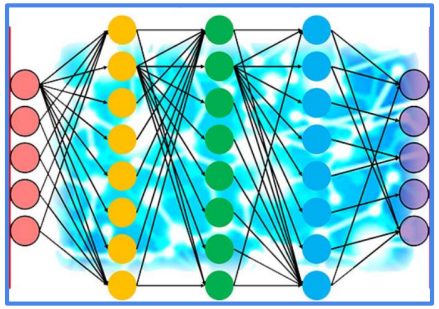
CTA Image Data to Centerline Extraction



Input 3D-CTA
Query Image

Prediction with the learnt model

$(\Theta_{l_1}, \Theta_{l_2}, \Theta_{l_3}, \ldots)$



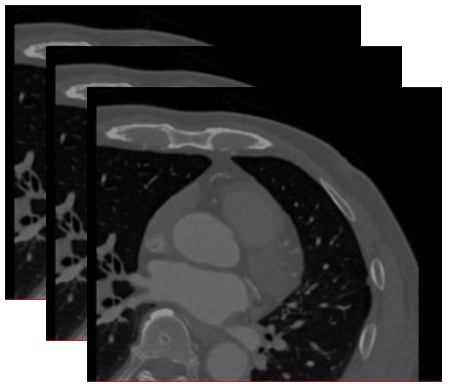
Fuzzy Vessel Segmentation

Tree Extraction Algorithm

Candidate Tree

Image Analysis Framework used in Production Environment

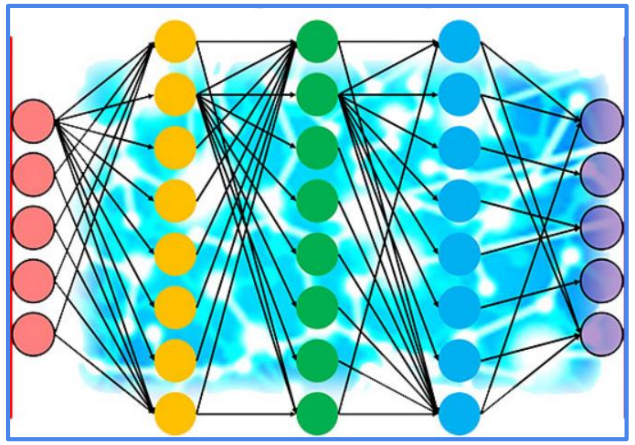
Training of the Neural Network Model



Input 3D-CTA Images

Lumen Annotations

4000+ Pairs of Image and Manually Labeled Training Data

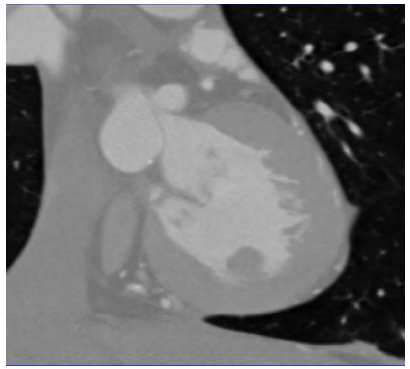


Neural Network Model Training

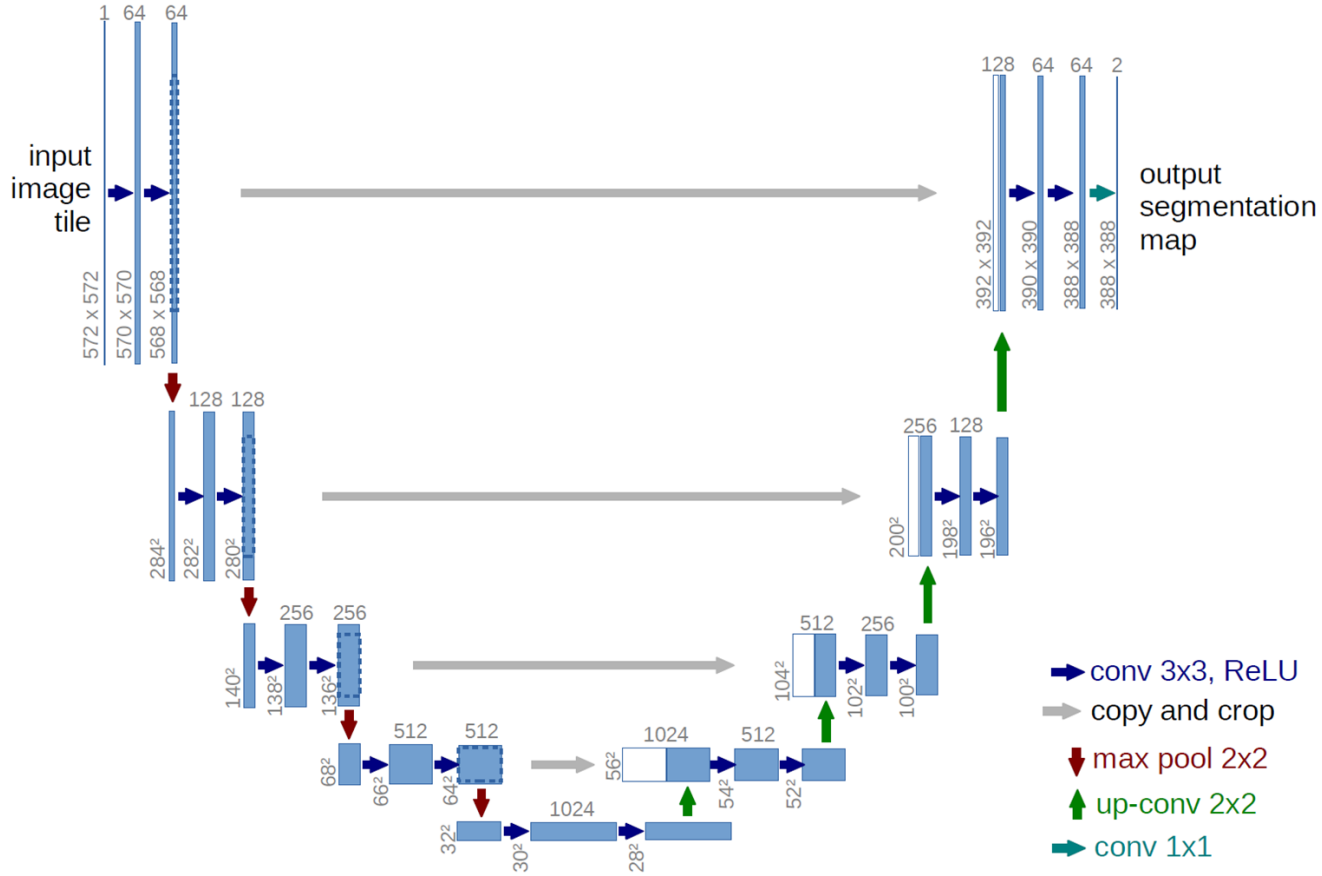
$$(\Theta_{l_1}, \Theta_{l_2}, \Theta_{l_3}, \ldots)$$

Learnt Model Parameters

3D U-Net Model for Vessel Segmentation



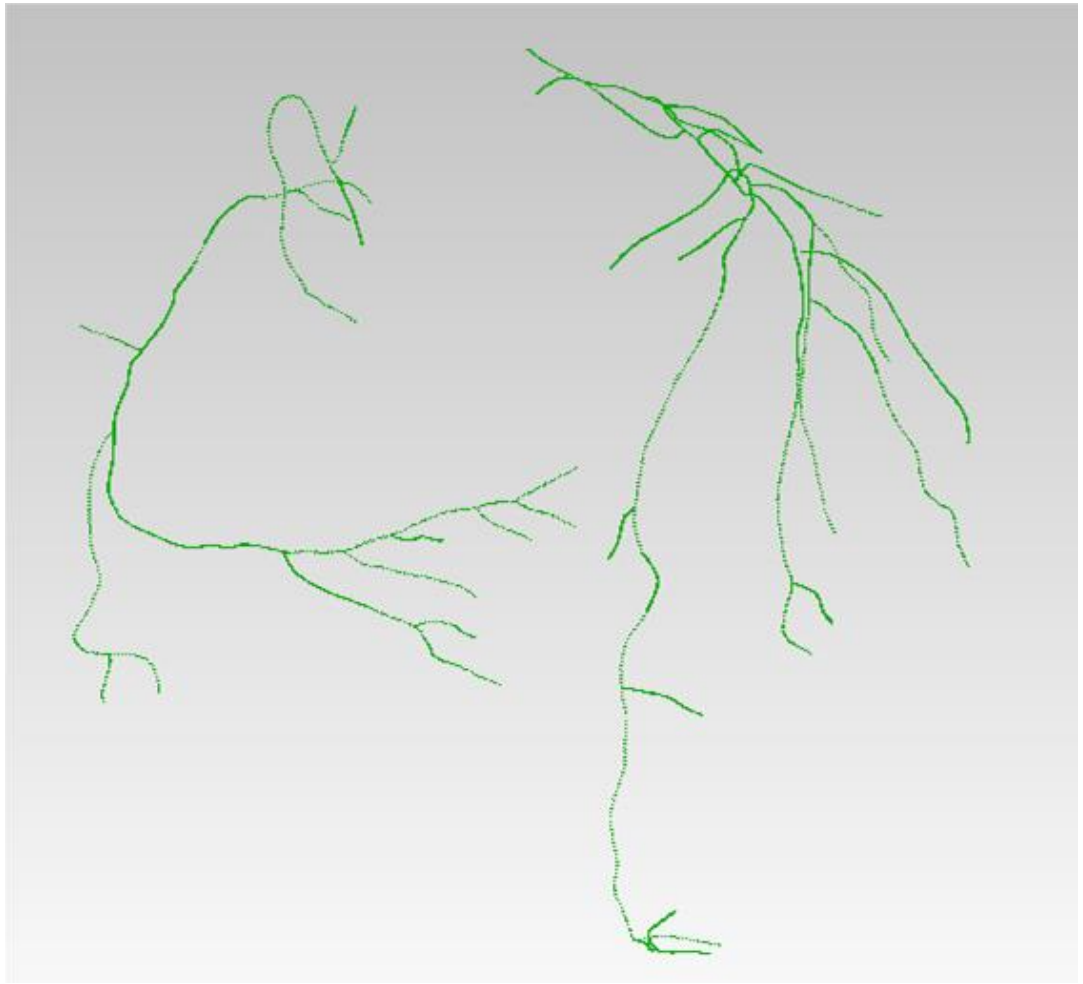
Input 3D CTA Image



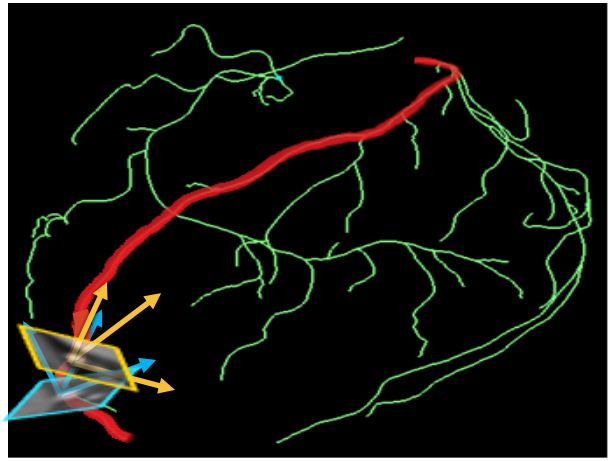
Output 3D Vessel Segmentation

Rendering of Vessel Voxel Classifier Output

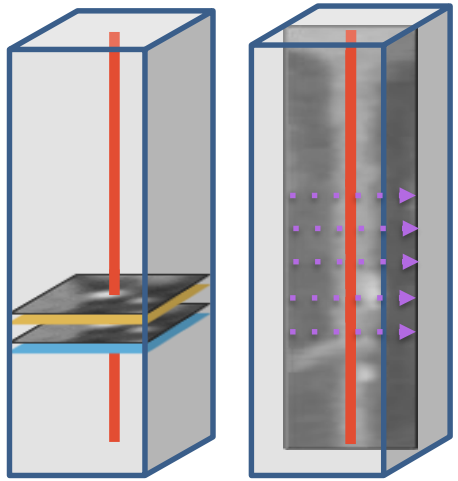
Extracted Vessel Tree Centerlines



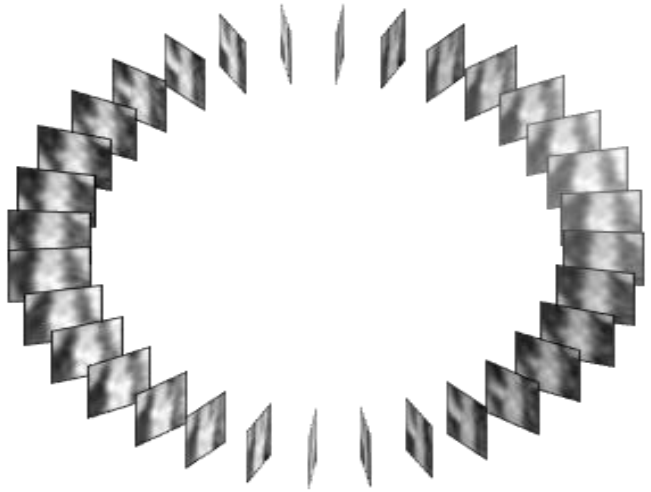
DeepLumen Algorithm - Lumen Segmentation



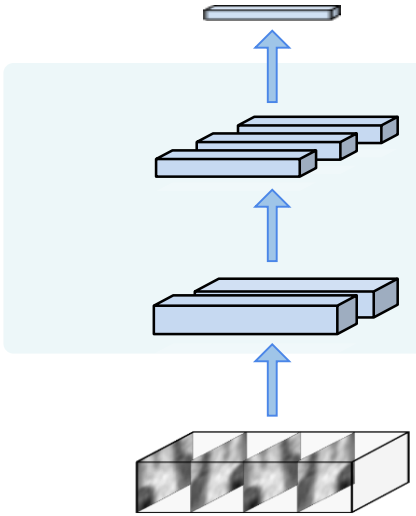
Vessel paths



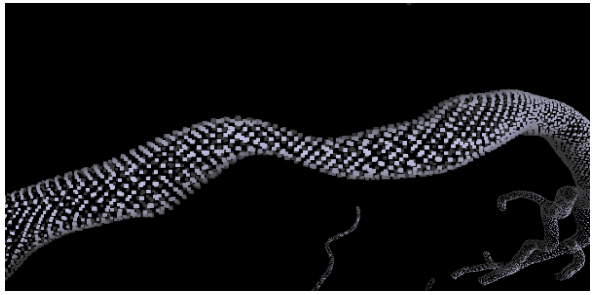
Cross sectional image patches



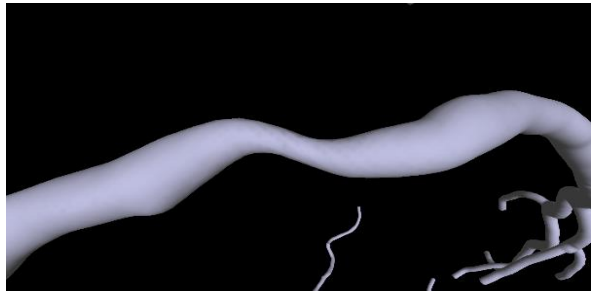
3D cylindrical ring system



Deep learning neural network



Point cloud on surface



Lumen surface reconstruction

[Petersen et al. NIPS 2017]

Summary

Application Areas of Machine Learning

- Automated Segmentation of Target Anatomical Structures
- Automated Image Quality Assessment and Control
- Inverse problems – Image Reconstruction

Advantages

- Automation of quantitative image analysis task might be possible.
- Reproducible results at each run.
- It can potentially reach the performance of an average reader (for some tasks).

Challenges

- Large number of medical images and annotations are required.
- Sensitivity and generalisation issues (may require inspection of results).

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Thank you. Questions?