Amsterdam UMC
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LINC

The use of AI to predict AAA growth rate

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University of Twente
Netherlands

70TH ESCVS CONGRESS
& 7TH IMAD MEETING
20 I 23 JUNE 2022

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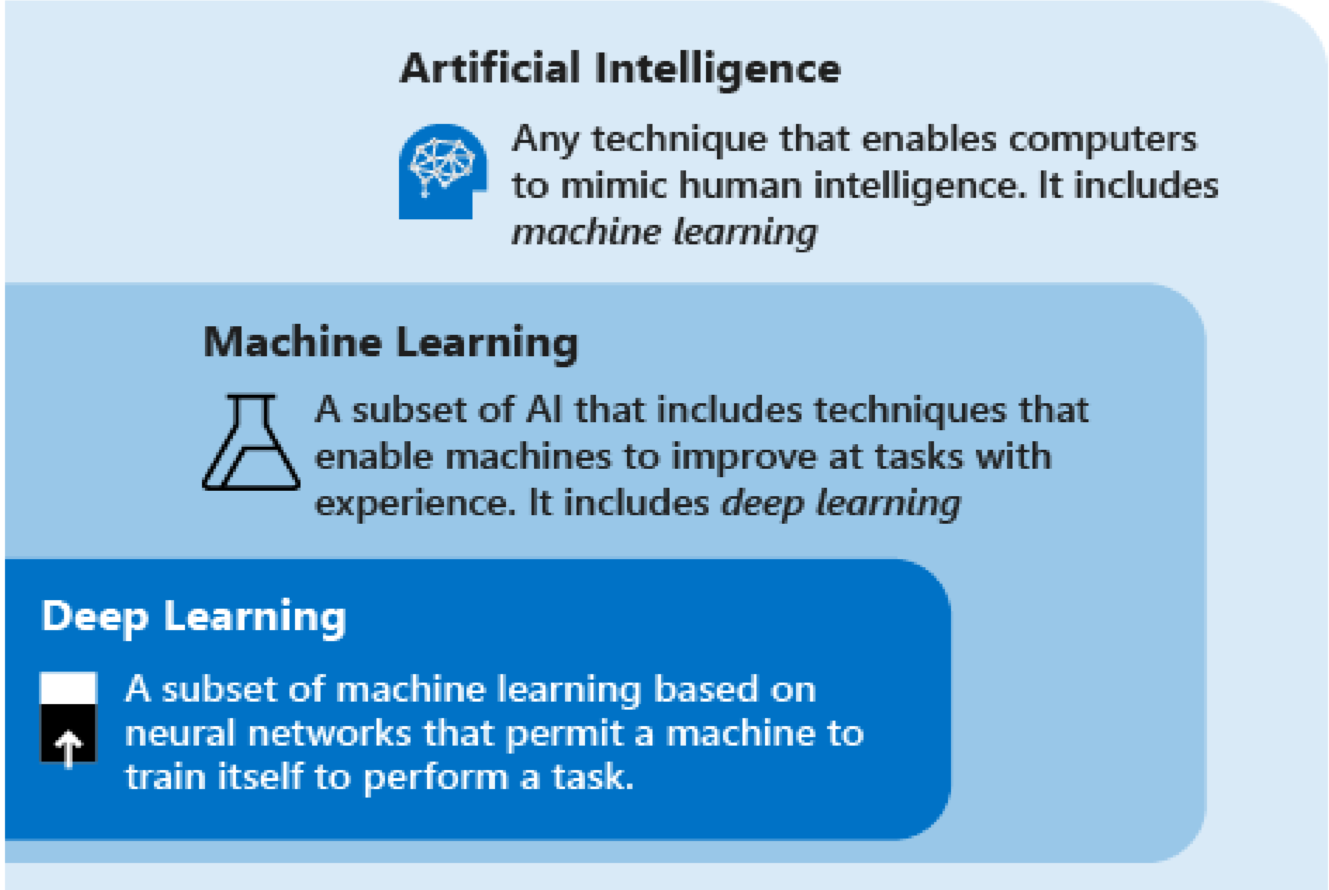
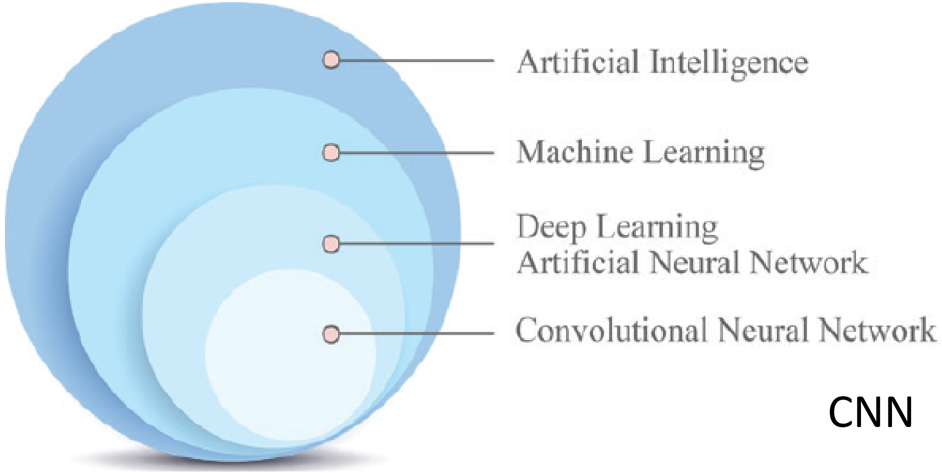
Disclosures

- Research grants:
  - Philips Medical
  - Medtronic (unrestricted)
  - ZonMw

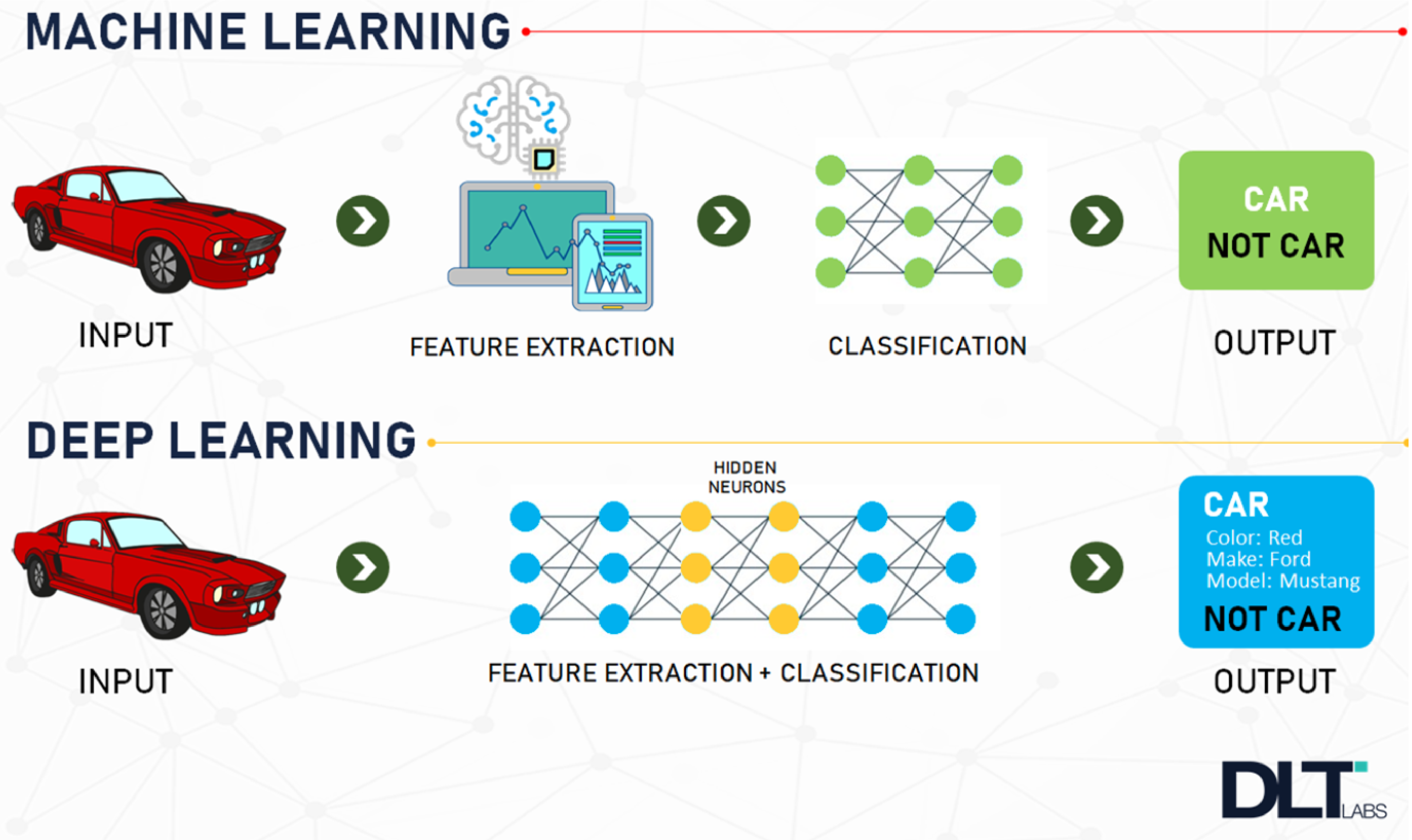




CNN

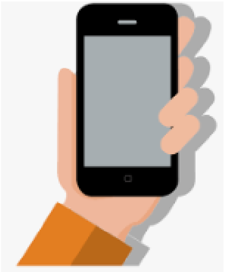
Soffer S et al, Radiology 2019

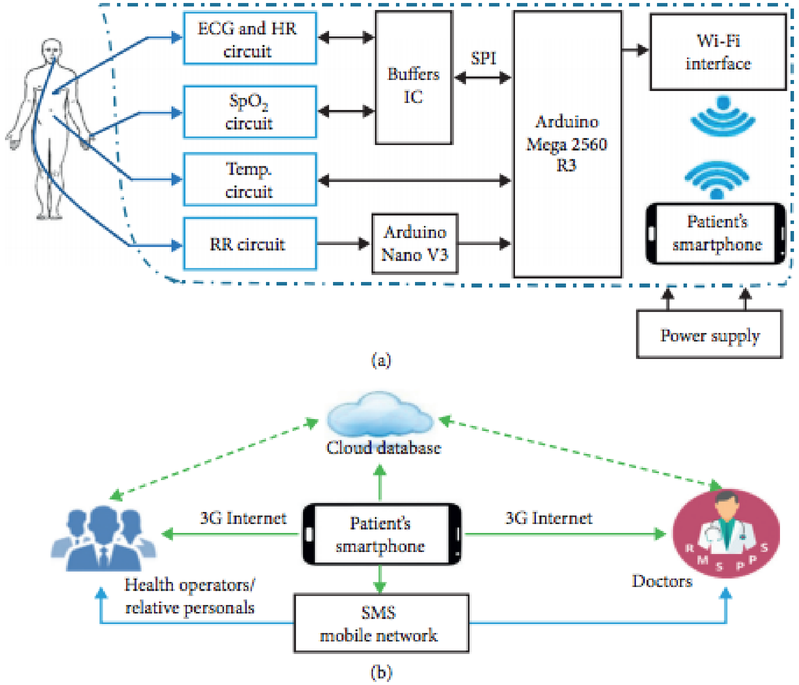
https://docs.microsoft.com/en-us/azure/machine-learning/service/concept-deep-learning-vs-machine-learning

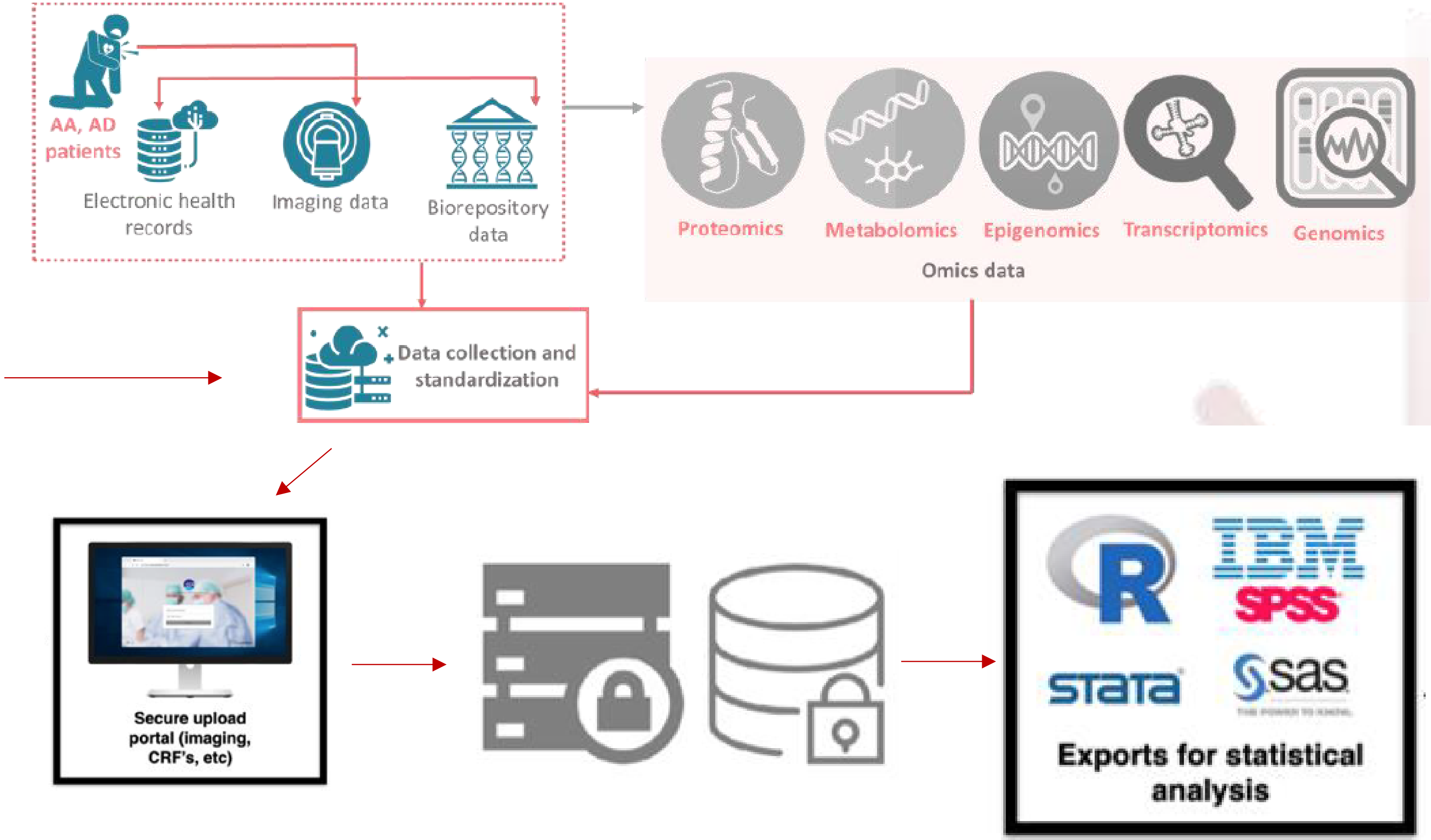

MACHINE LEARNING
INPUT
FEATURE EXTRACTION
CLASSIFICATION
CAR
NOT CAR
OUTPUT
DEEP LEARNING
INPUT
HIDDEN
NEURONS
FEATURE EXTRACTION + CLASSIFICATION
CAR
Color: Red
Make: Ford
Model: Mustang
NOT CAR
OUTPUT
DLT LABS

Data collection in vascular surgery

Telemonitoring







Al-Naggar NQ, et al. J Healthc Eng. 2019
Image owned by AI-plan

The power of big data

- Amount of stored medical data has increased tremendously
- Exponential growth of computing power
- Unable to analyze all medical data efficiently

↓

Leverage artificial intelligence techniques

Echocardiography
A Journal of Cardiovascular Ultrasound and Allied Techniques

ORIGINAL INVESTIGATION

Statistical and machine learning methodology for abdominal aortic aneurysm prediction from ultrasound screenings

JVS Journal of Vascular Surgery SVS Society for Vascular Surgery

REVIEW ARTICLE | VOLUME 72, ISSUE 1, P321-333.E1, JULY 01, 2020

Artificial intelligence in abdominal aortic aneurysm

Juliette Raffort, MD, PhD • Cédric Adam, PhD • Marion Carrier, PhD • ... Réda Hassen-Khodja, MD, PhD • Nabil Chakfé, MD, PhD • Fabien Lareyre, MD, PhD • Show all authors

Published: February 21, 2020 • DOI: https://doi.org/10.1016/j.jvs.2019.12.026 • Check for updates

ORIGINAL RESEARCH

Applied Machine Learning for the Prediction of Growth of Abdominal Aortic Aneurysm in Humans

R. Lee [a,*,†], D. Jarchi [b,†], R. Perera [c], A. Jones [a], I. Cassimjee [a], A. Handa [a,‡], D.A. Clifton [c,‡], on behalf of the Oxford Abdominal Aortic Aneurysm Study and the Oxford Regional Vascular Service

[a] Nuffield Department of Surgical Sciences, University of Oxford, Oxford, UK
[b] Department of Engineering Science, University of Oxford, Oxford, UK
[c] Nuffield Department of Primary Care Health, University of Oxford, Oxford, UK

Prediction of abdominal aortic aneurysm growth by artificial intelligence taking into account clinical, biologic, morphologic, and biomechanical variables

Nikolaos Kontopodis, Michail Klontzas, Konstantinos Tzirakis, Stavros Charalambous, Kostas Marias, Dimitrios Tsetis, Apostolos Karantanas, Christos V Ioannou   Show less

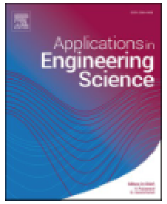
First Published June 10, 2022 | Research Article | Check for updates

Applications in Engineering Science 10 (2022) 100104

Contents lists available at ScienceDirect

Applications in Engineering Science

journal homepage: www.sciencedirect.com/journal/applications-in-engineering-science

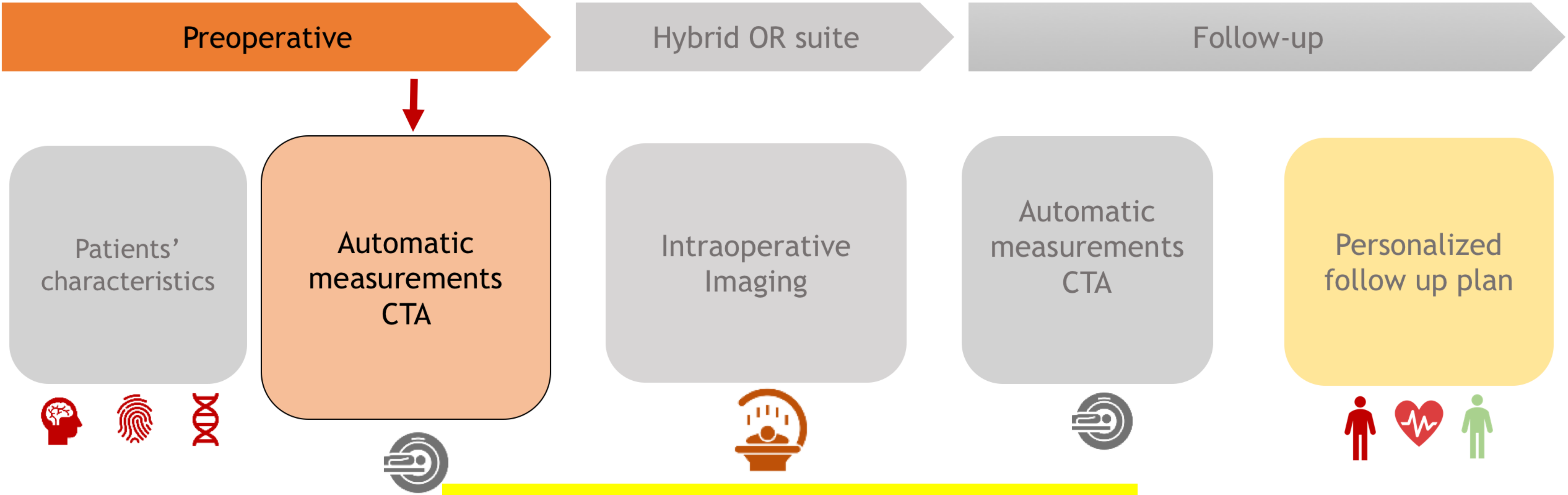


Check for updates

Artificial intelligence framework to predict wall stress in abdominal aortic aneurysm

Timothy K. Chung [a], Nathan L. Liang [d,e], David A. Vorp [a,b,c,d,f,g,h,*]

AI-based workflow of AAA from research team in Amsterdam UMC

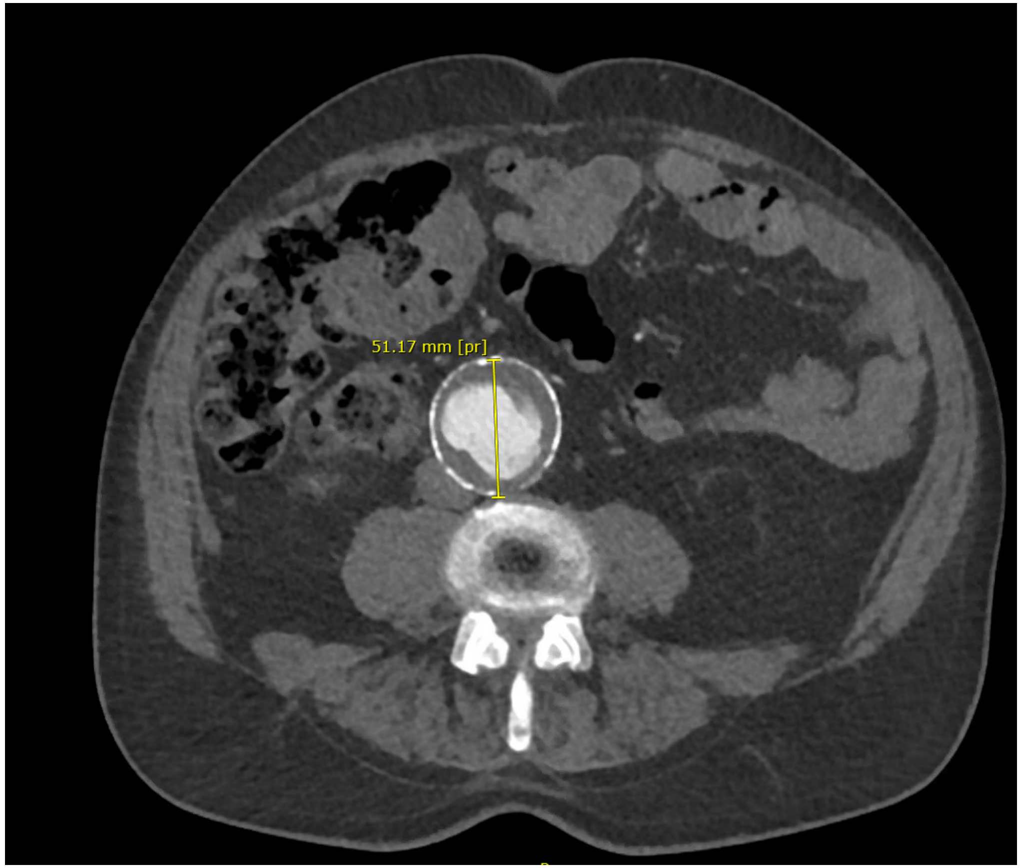


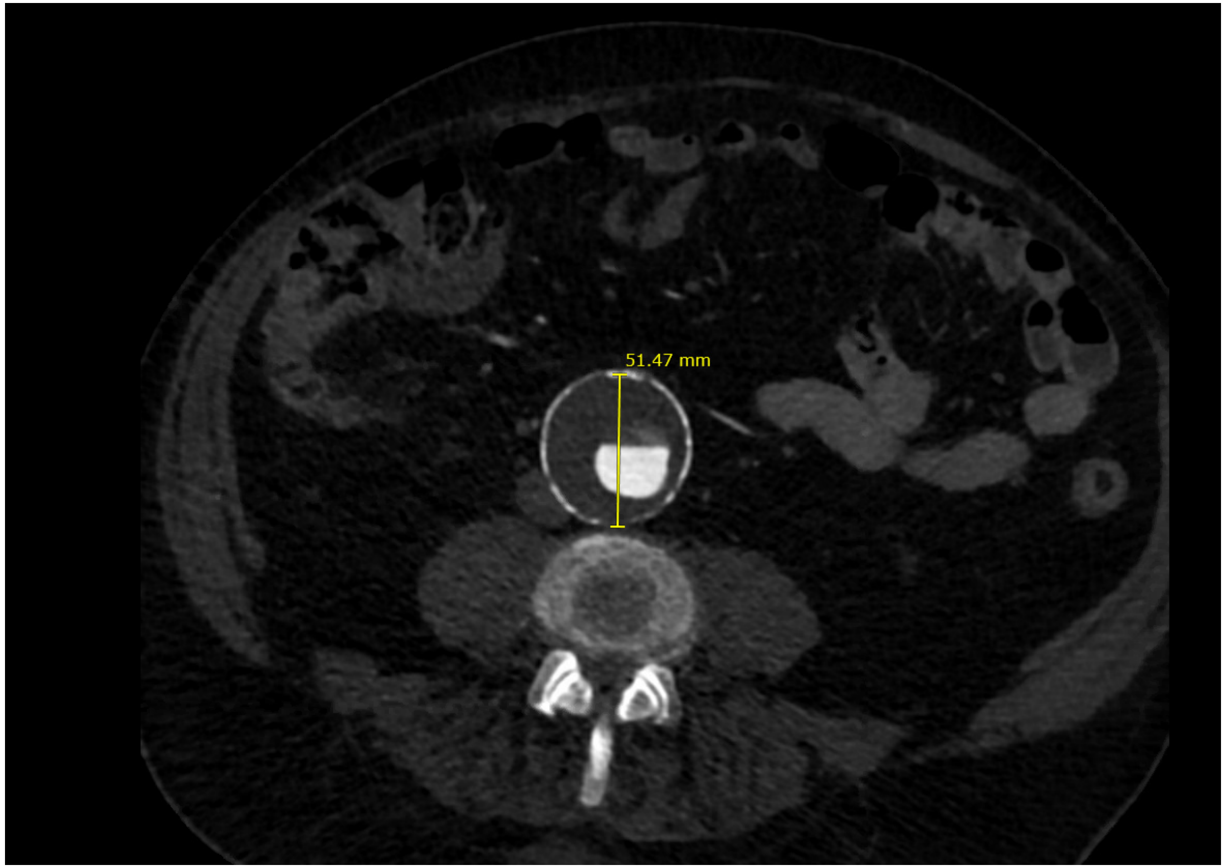
- Workflow
- Research purposes → growth or rupture predictions

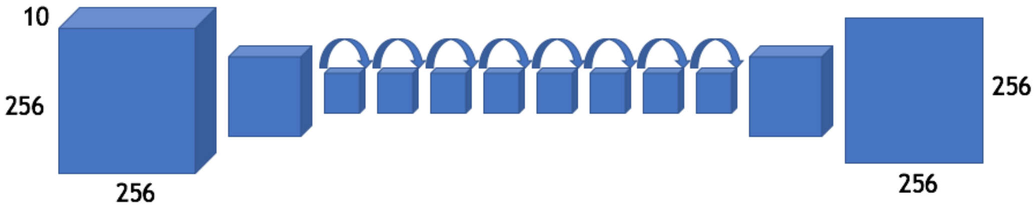
Practical example: why did a 51 mm AAA rupture?

2017

2019

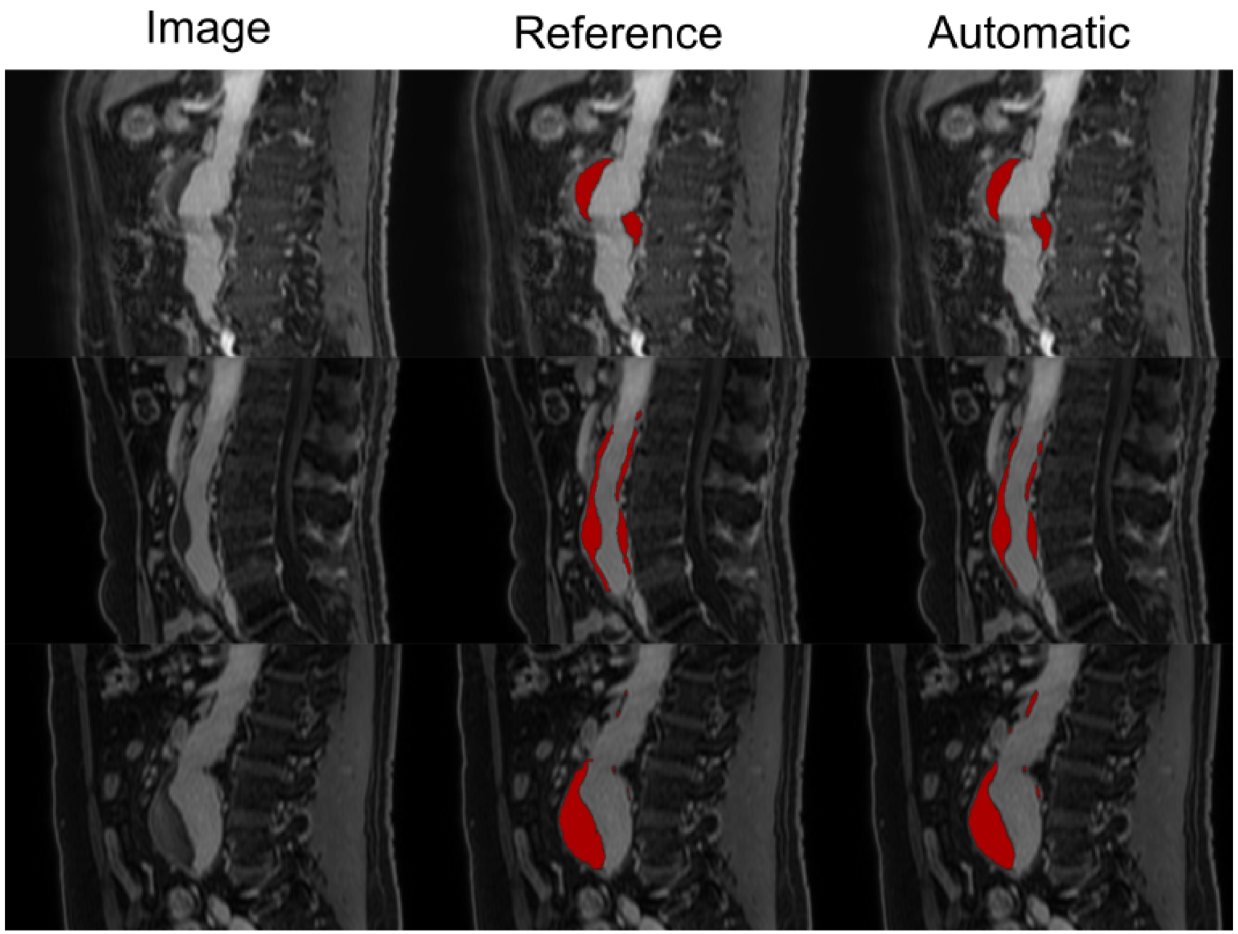






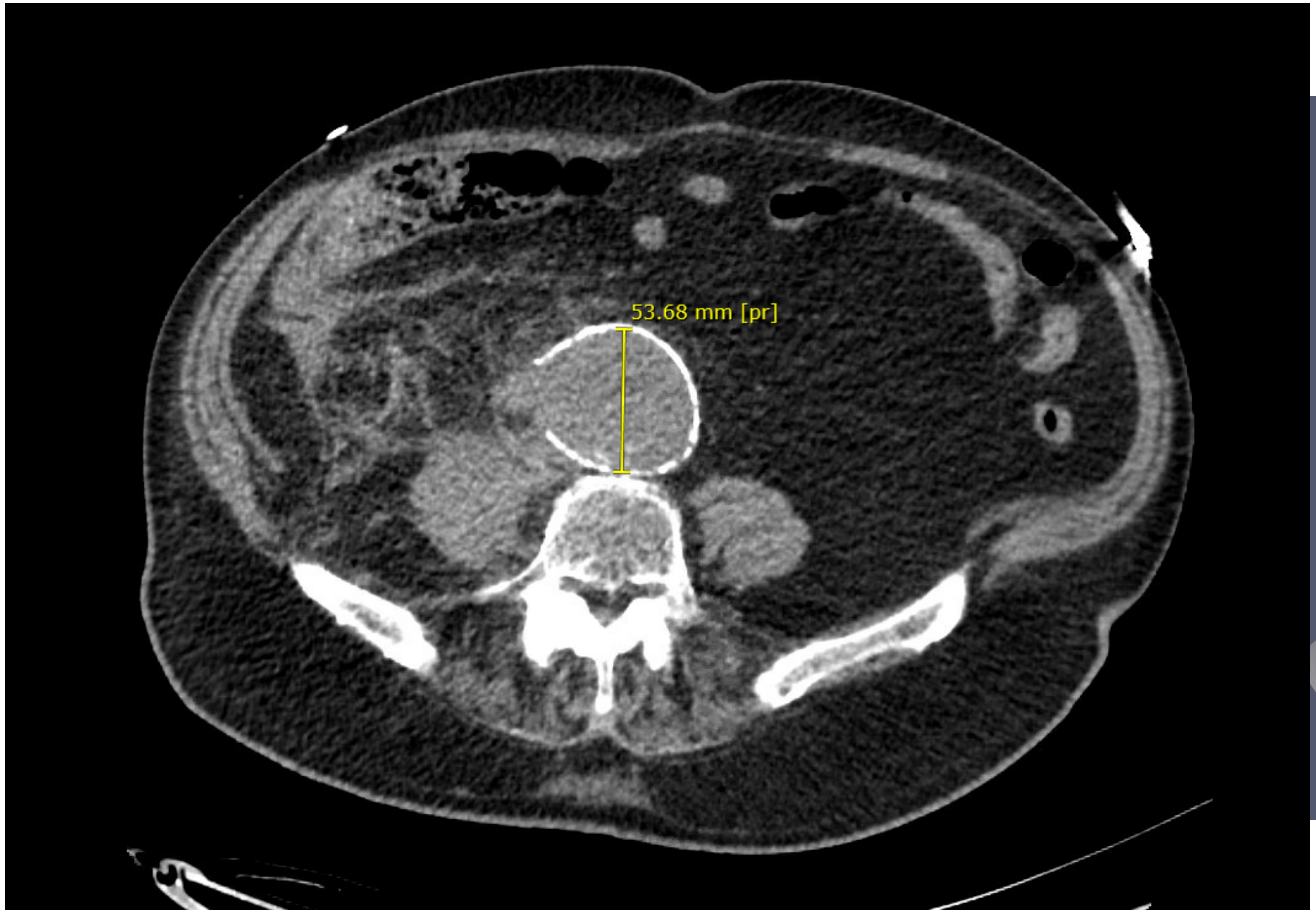
AAA thrombus segmentation

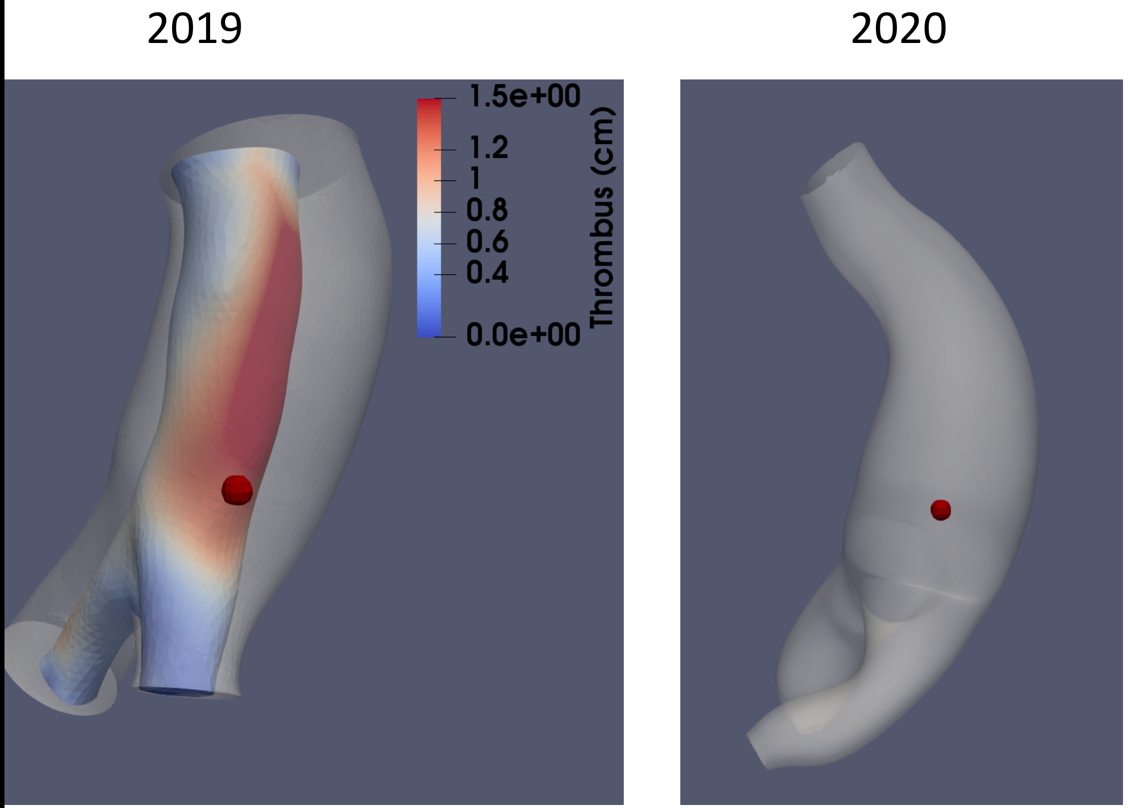
- Pilot study: 20 pts
- Four-channel Dixon MR images
  - Water
  - Fat
  - In-phase
  - Out-phase
- Manual annotations of thrombus
- 3D fully convolutional network
  - Four-channel input
  - Residual blocks



Kak Khee Yeung, Jelmer Wolterink, Data Amsterdam UMC

Automatic analysis of thrombus





Data Amsterdam UMC

OBJECTIVE:

Automatic acquisition of patient-specific biomarkers indicative for aneurysm rupture risk

- Geometric features, hemodynamics

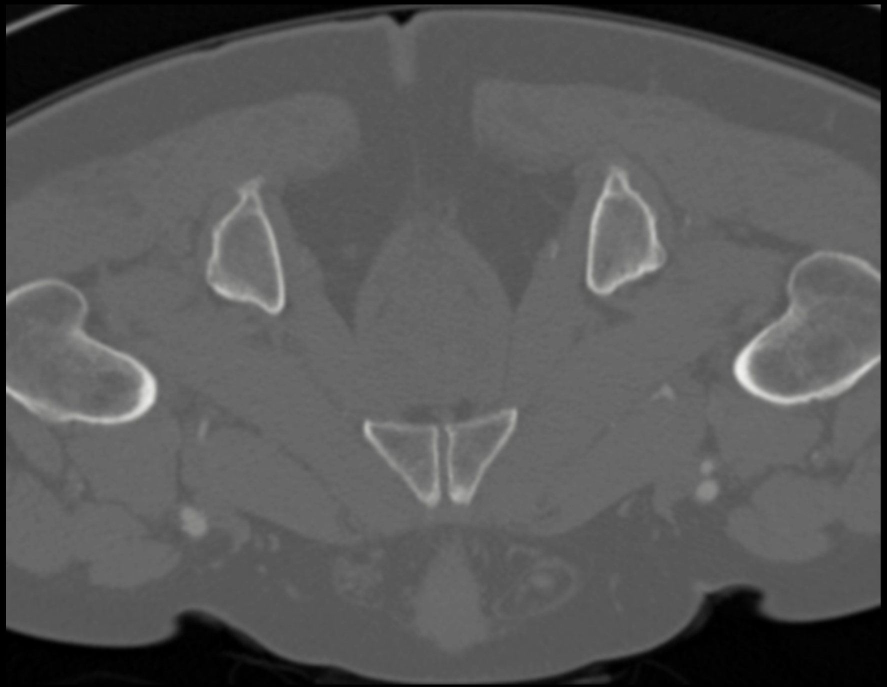
  → Personalized 3D vascular model

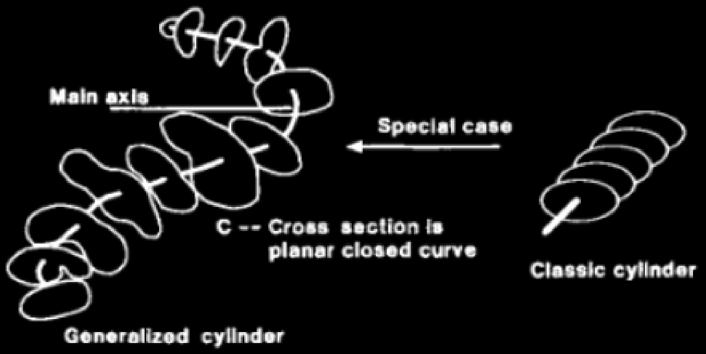
OBTAINING A 3D VASCULAR MODEL • CHALLENGES

- Small structures
- Anatomic variations
- Smooth boundaries for CFD simulation

→ Conventional voxel masks unsuitable

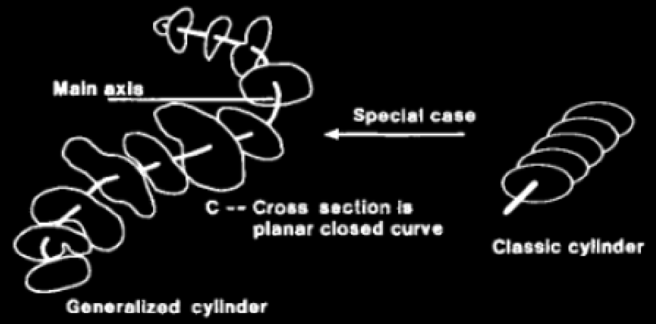
- Model vessels as generalized cylinders

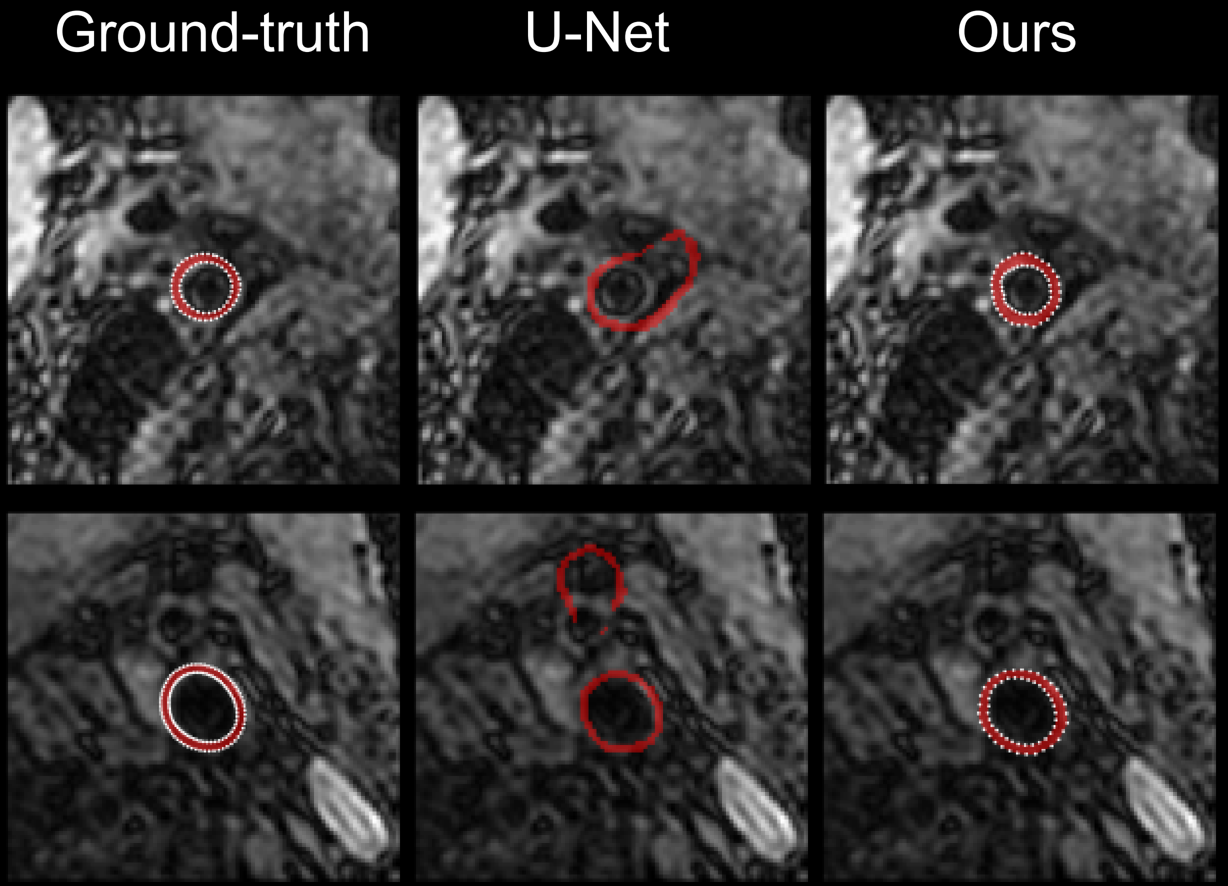




VESSEL SEGMENTATION

- Voxel classification
- Vessels as generalized cylinders[1]





[1] Shani & Ballard, 1984, *Computer Vision, Graphics and Image Processing*, **27**(2), pp. 129-156

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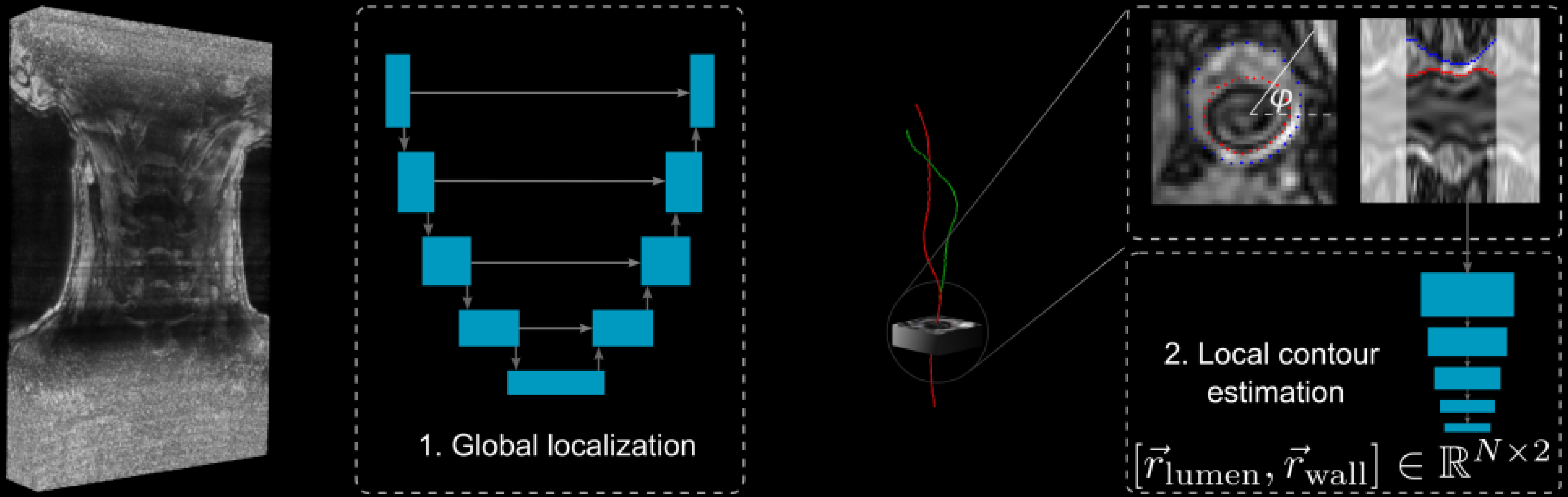
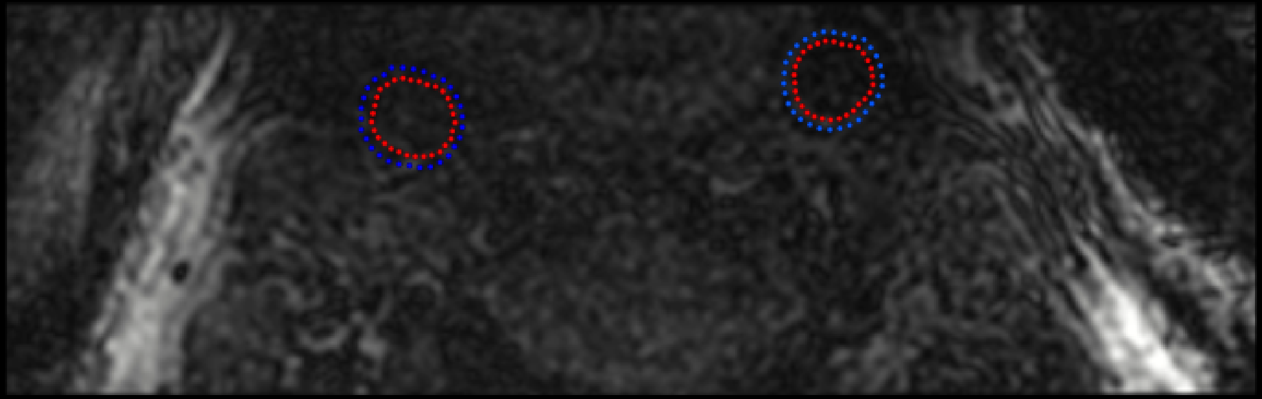
AUTOMATIC SEGMENTATION CAROTID ARTERY VESSEL WALL
⊨ TOP RESULT IN PUBLIC CHALLENGE!





Extend this method to aortofemoral tree

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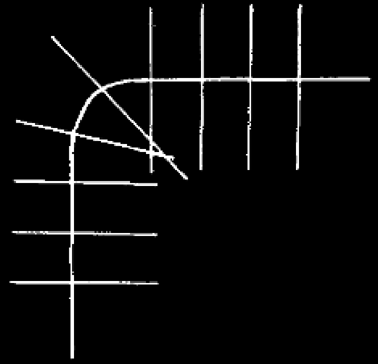
[1] Alblas, Brune, Wolterink, 2022, *SPIE Medical Imaging,* **12032,** pp. 237-244

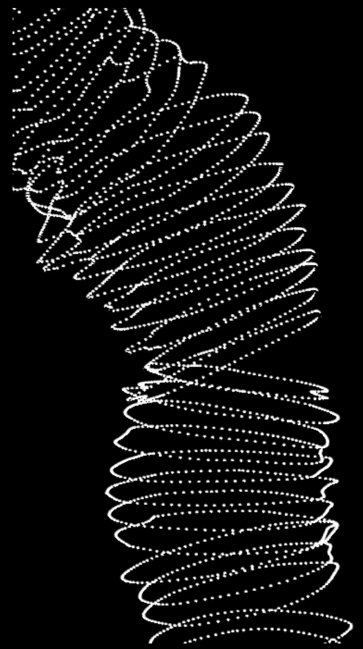
FROM CONTOURS TO 3D VASCULAR MODEL



Two main challenges:

1. Bifurcations
2. Self-intersections due to tortuosity

Represent the vessel contours as a point cloud instead



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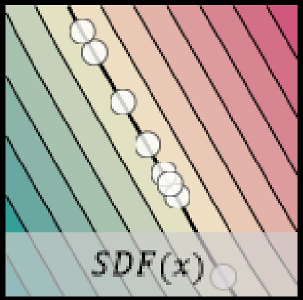
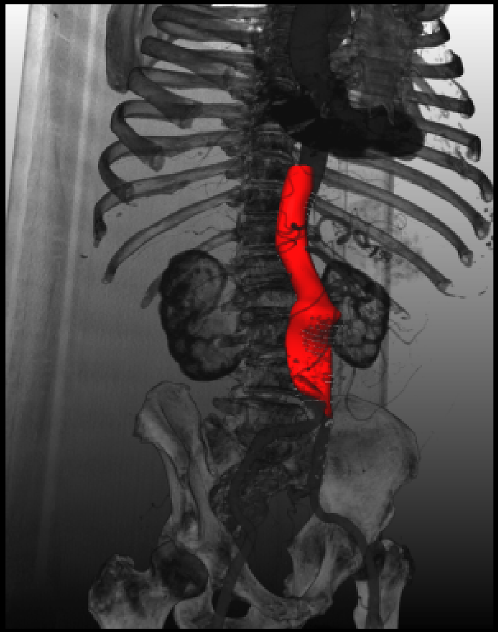
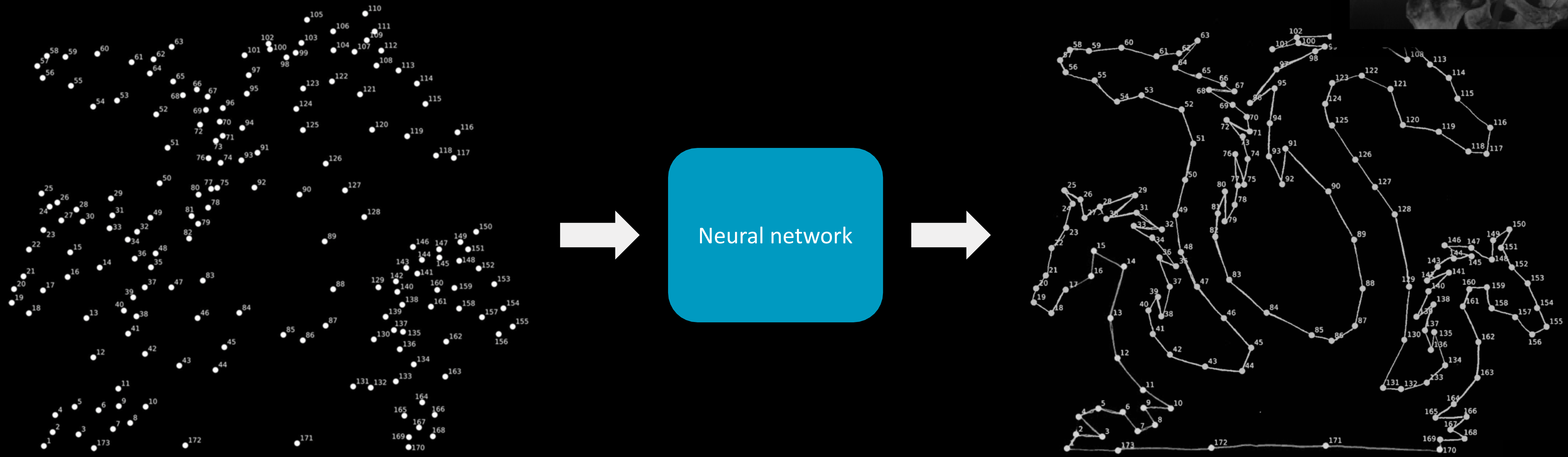
"CONNECT THE DOTS"





- Represent surface by signed distance function[1]
- Embed SDF in neural network[2]

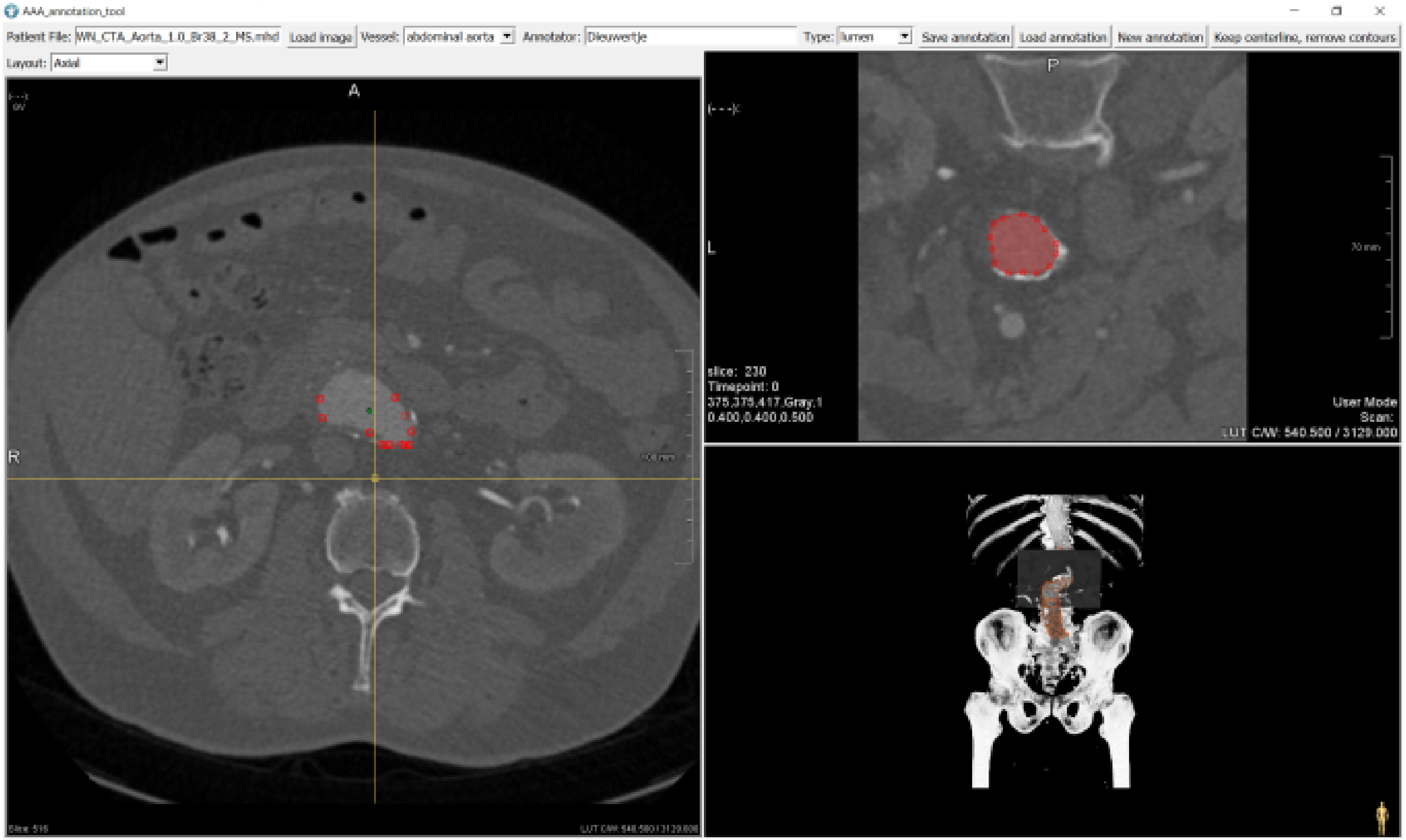


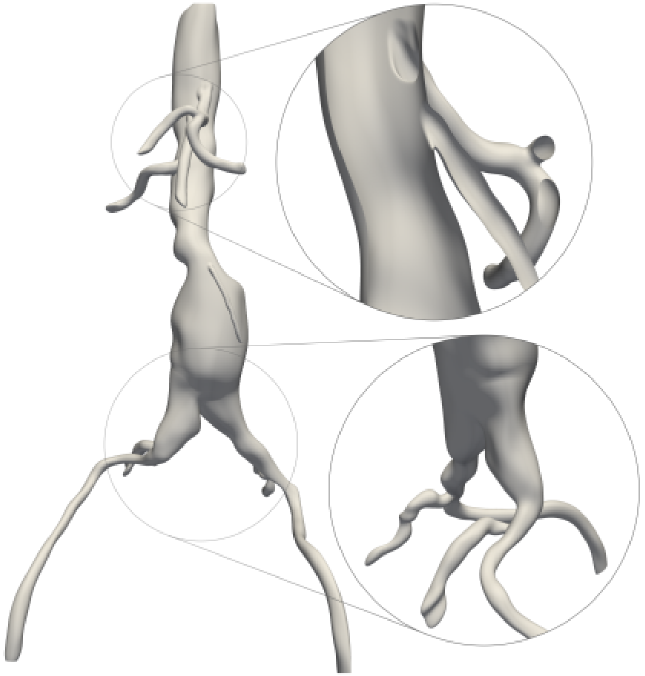
[1] Osher, Sethian, 1988, *Journal of Computational Physics,* **79(1),** pp. 12-49

[2] Gropp et al., 2020, *ICML,* pp. 3789-3799

This method is feasible for obtaining 3D vascular models of the CTA data from Amsterdam UMC.

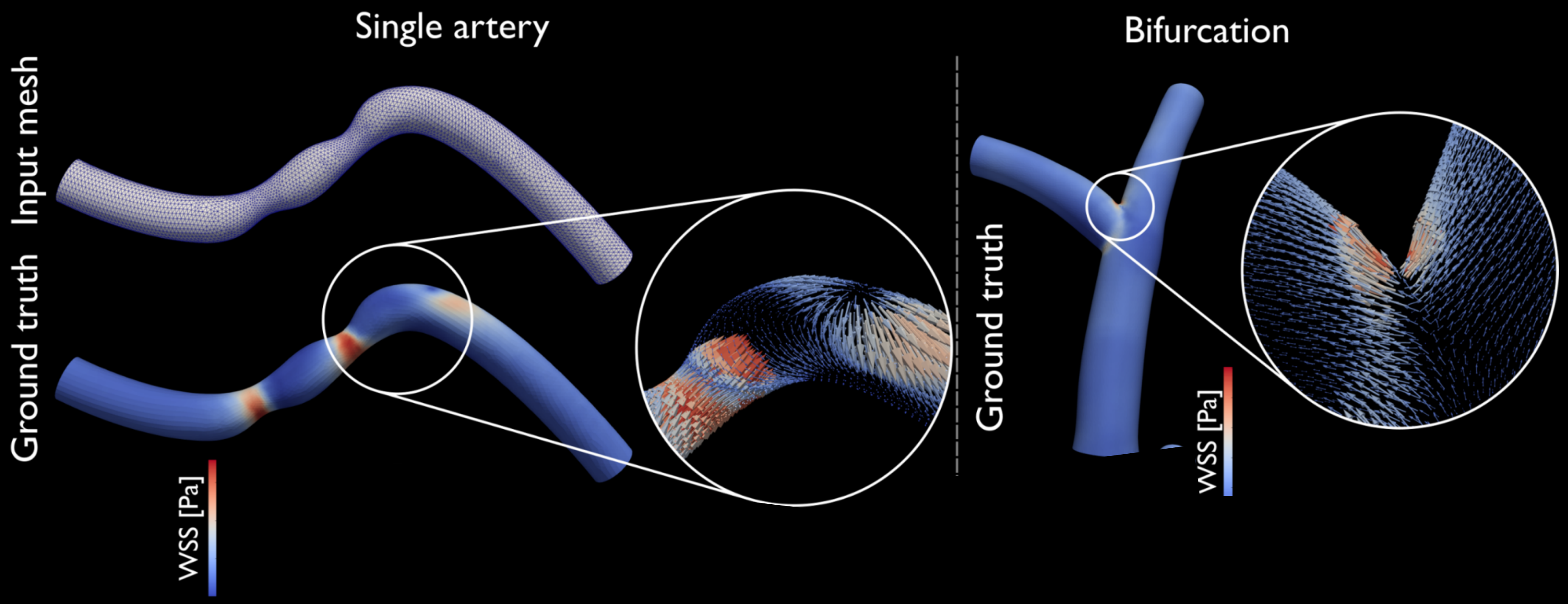
- Use INR to fit SDF to a pointcloud[2]:

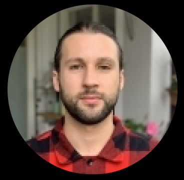




+ CFD simulation, thrombus segmentation
→ Increase understanding of AAA

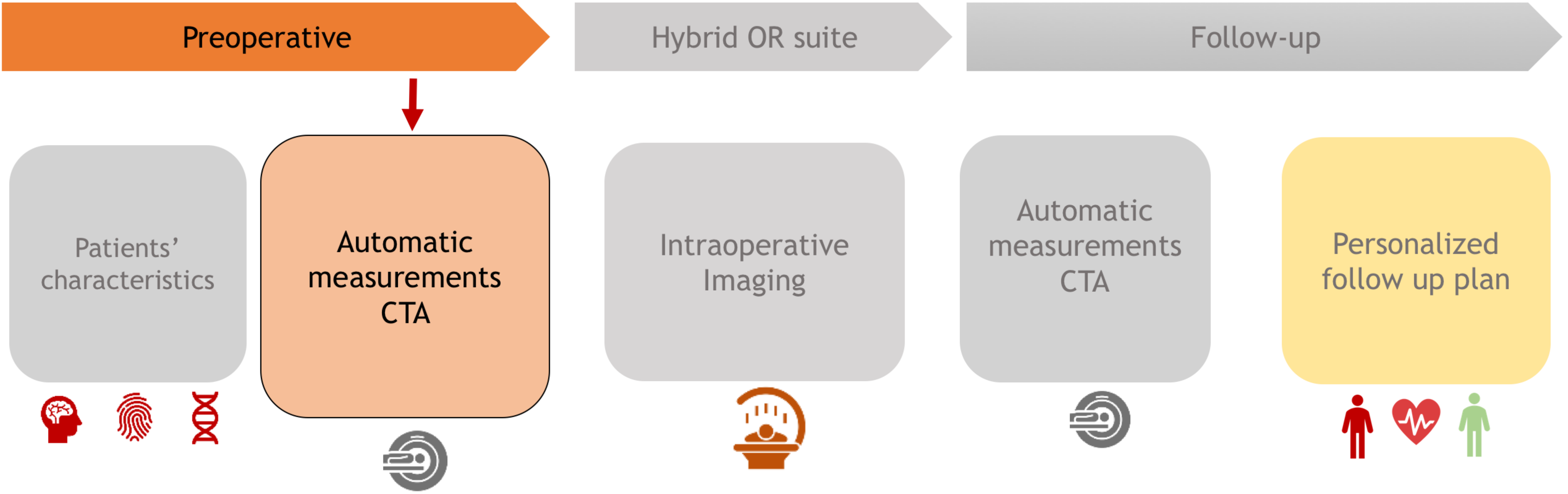
HEMODYNAMIC ANALYSIS





Suk et al., 2021, Statistical Atlases and Computational Modeling of the Heart, pp. 93-102

AI can be implemented in all phases in vascular treatment



Advanced intraoperative visualization

Preoperative → Hybrid OR suite → Follow-up

Patients' characteristics

Automatic measurements CTA

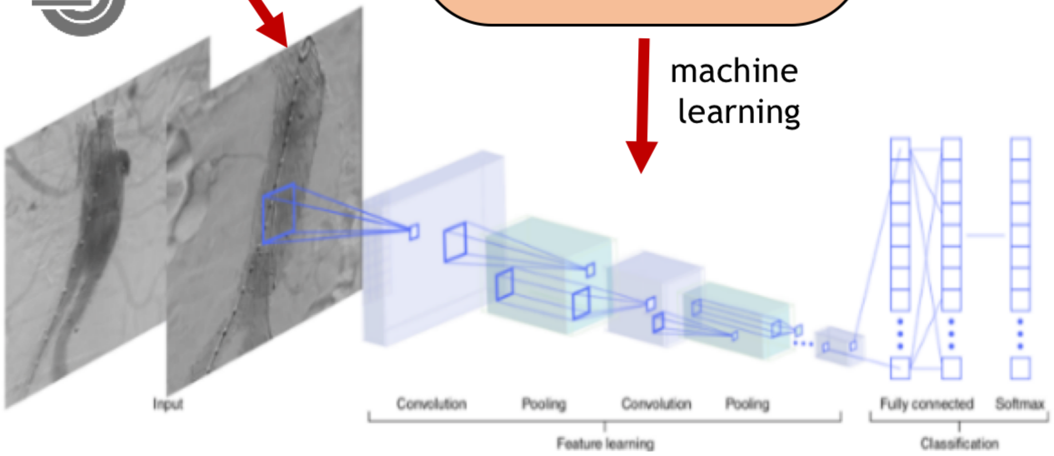
Intraoperative Imaging

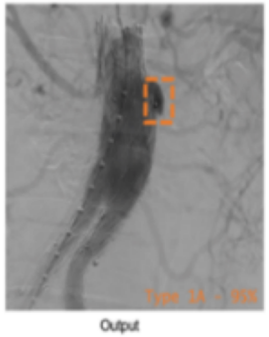
Automatic measurements CTA

Personalized follow up plan

n=1000 patients

machine learning





Automatic visualization of Endoleaks
Stefan Smorenburg
Tuesday 9.00 session

AI Team

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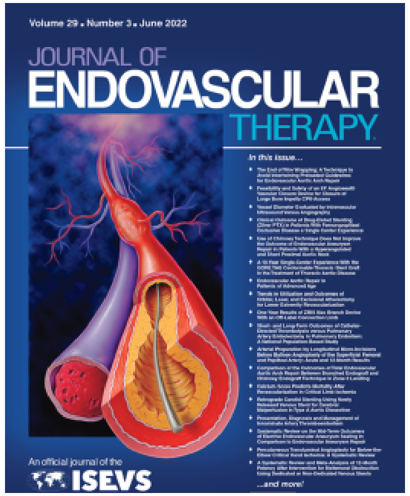

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