

Machine Intelligence in Clinical Imaging

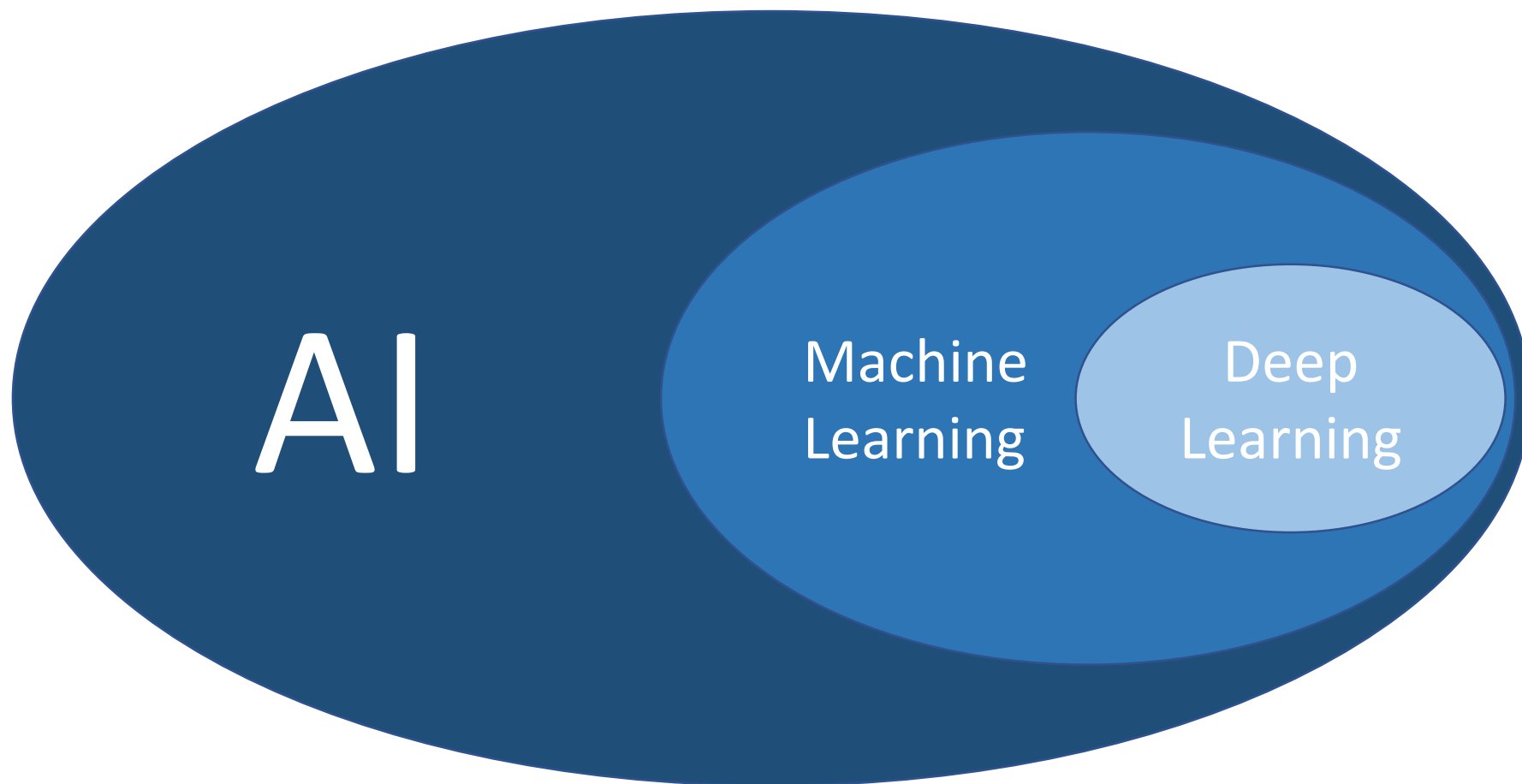
Ben Glocker

Senior Lecturer, Department of Computing, Imperial College London

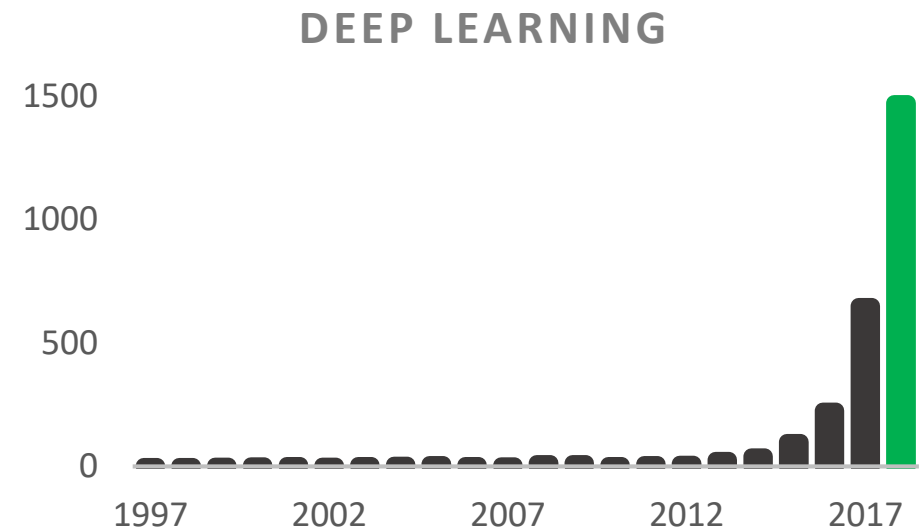
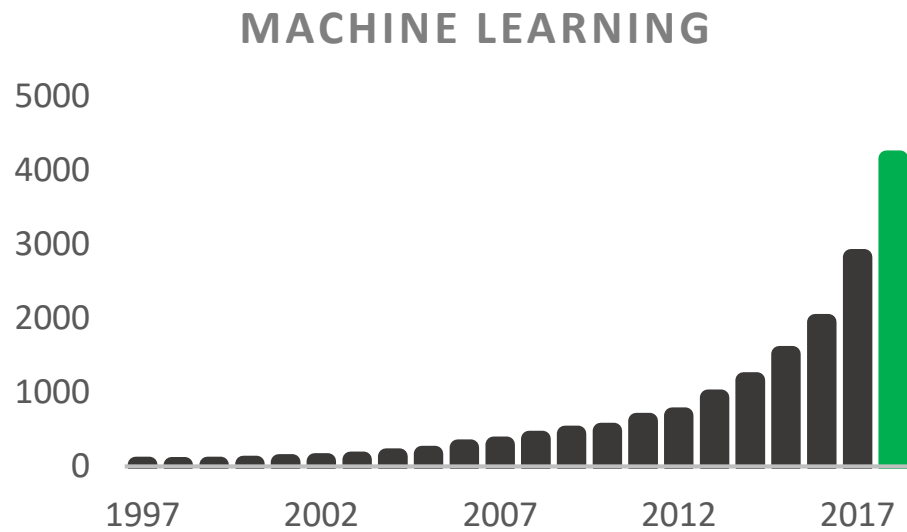
Adviser – Medical Image Analysis, HeartFlow Inc.

Scientific Adviser, Kheiron Medical Technologies Ltd.

Artificial Intelligence

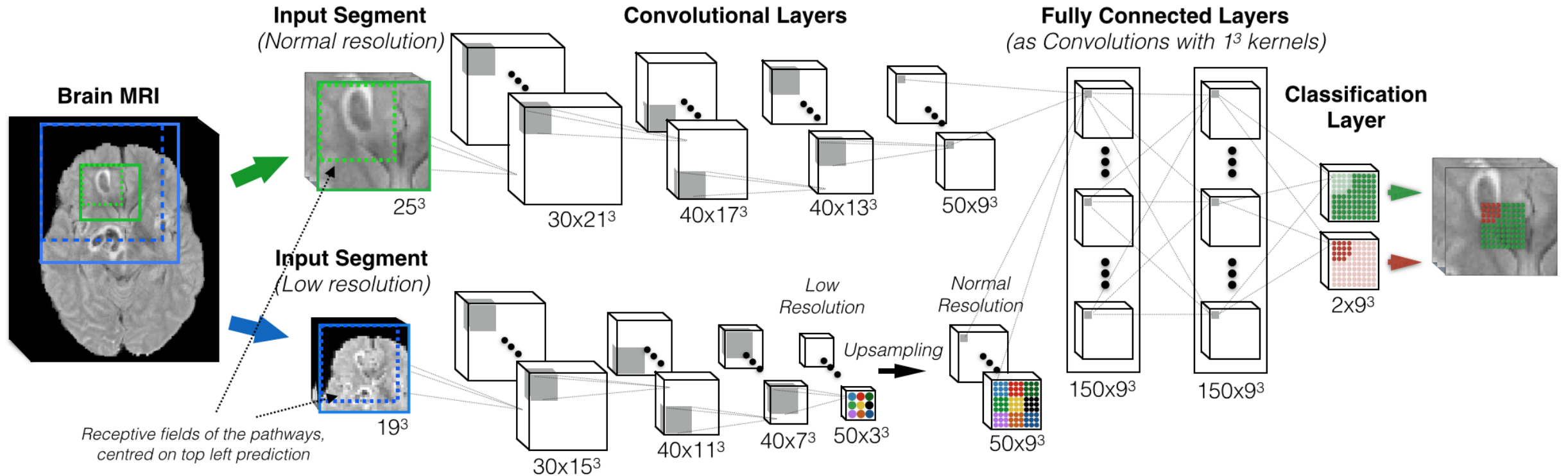


The Rise of Deep Learning

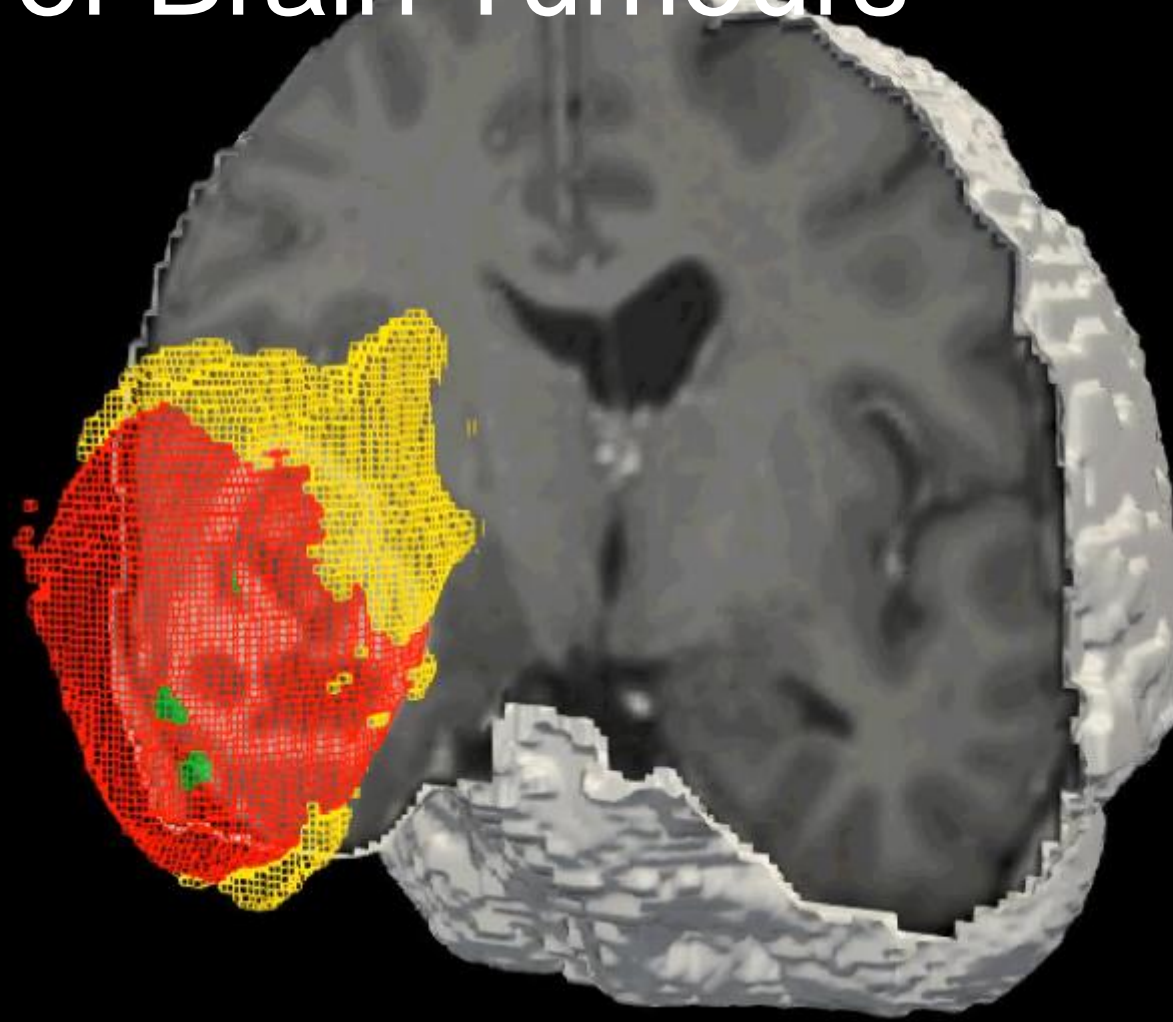


Number of publications on PubMed containing these terms in title or abstract, queried 01/11/2018

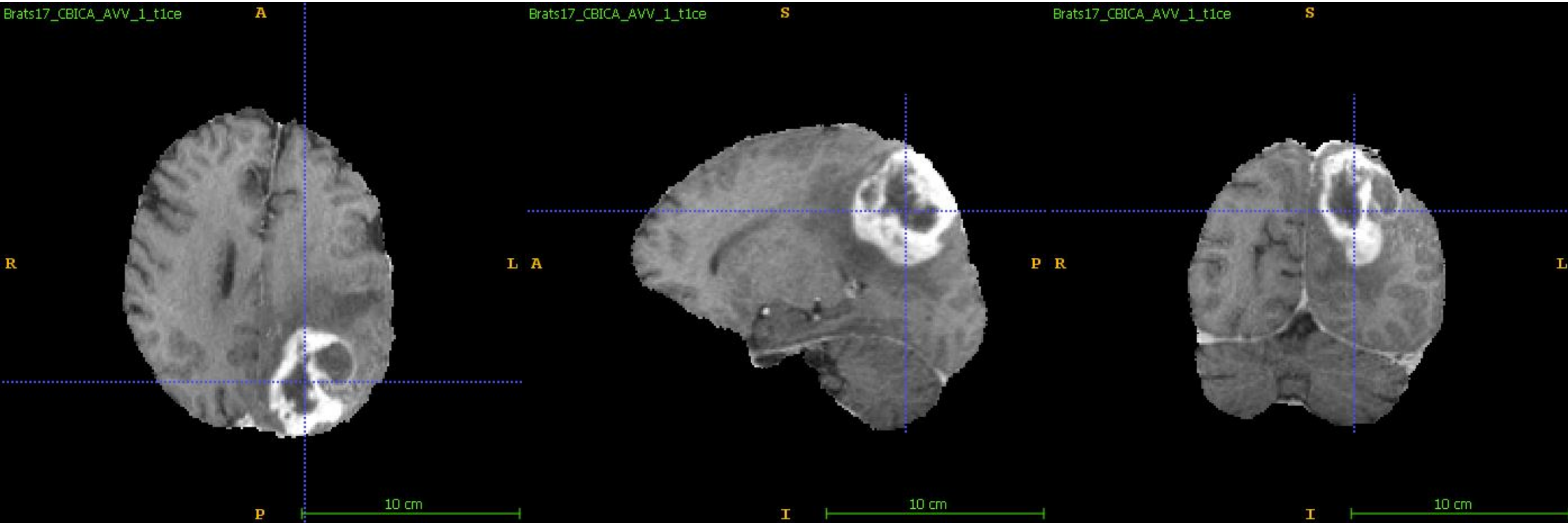
DeepMedic



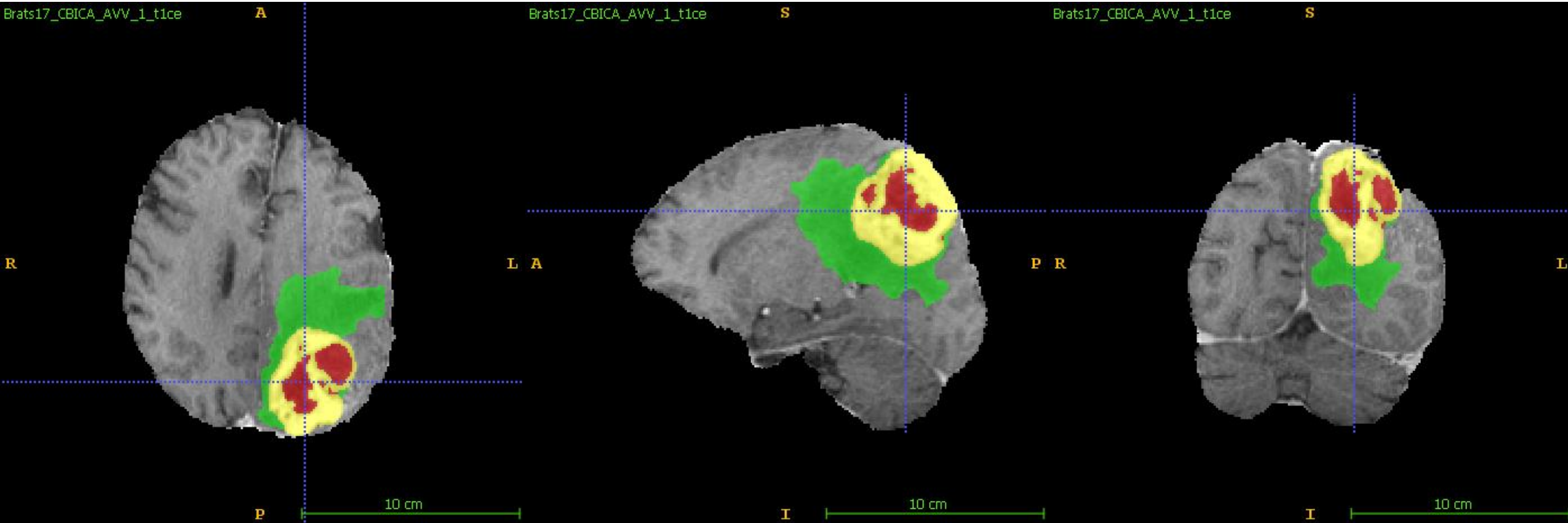
Analysis of Brain Tumours



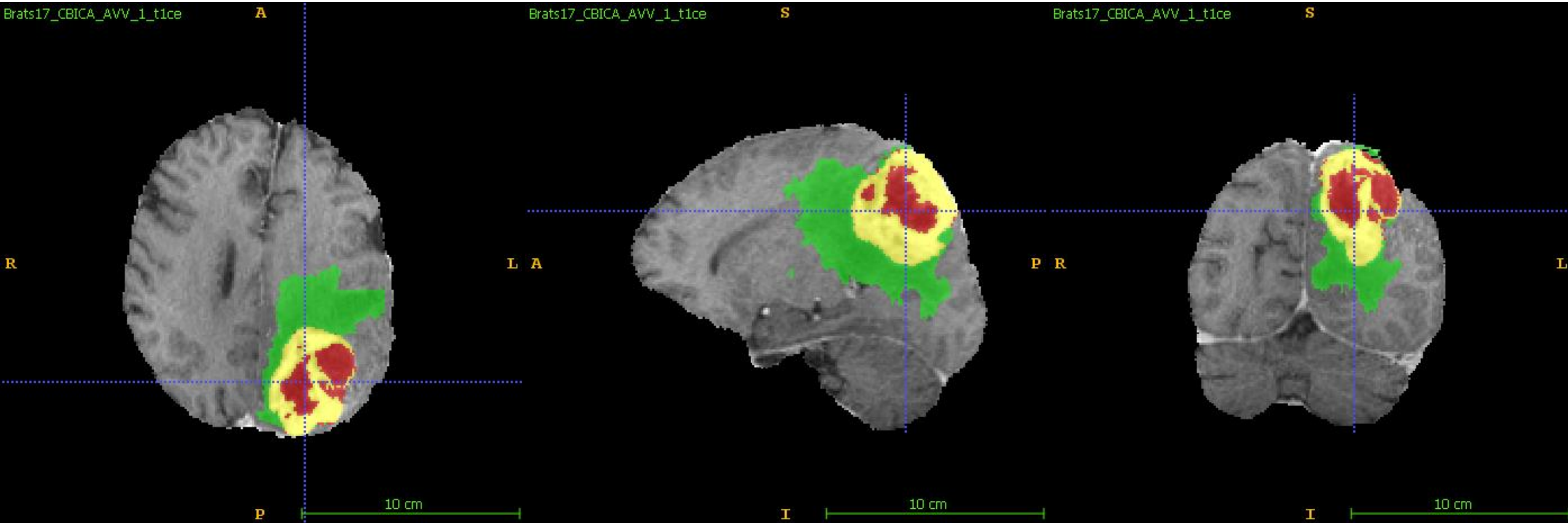
Analysis of Brain Tumours



Analysis of Brain Tumours



Analysis of Brain Tumours

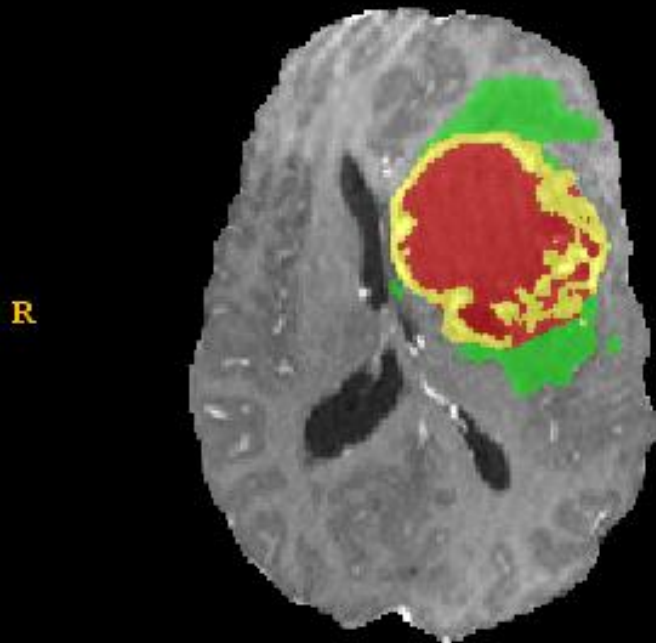


Analysis of Brain Tumours

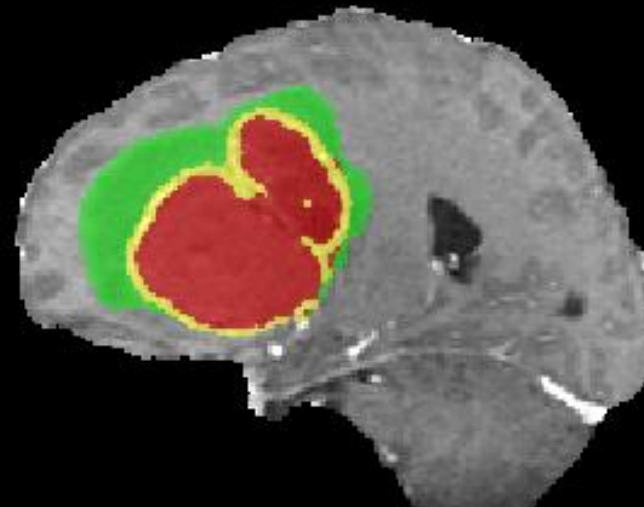
Brats17_CBICA_AXO_1_t1ce **A**

Brats17_CBICA_AXO_1_t1ce **S**

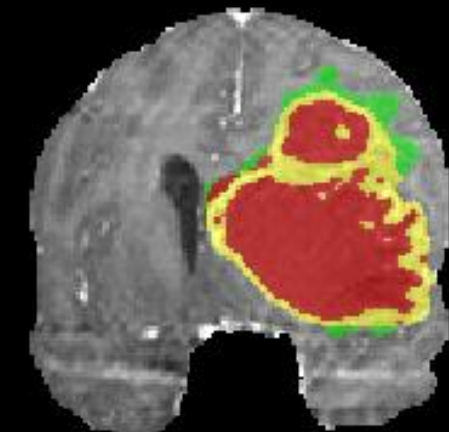
Brats17_CBICA_AXO_1_t1ce **S**



L A



P R



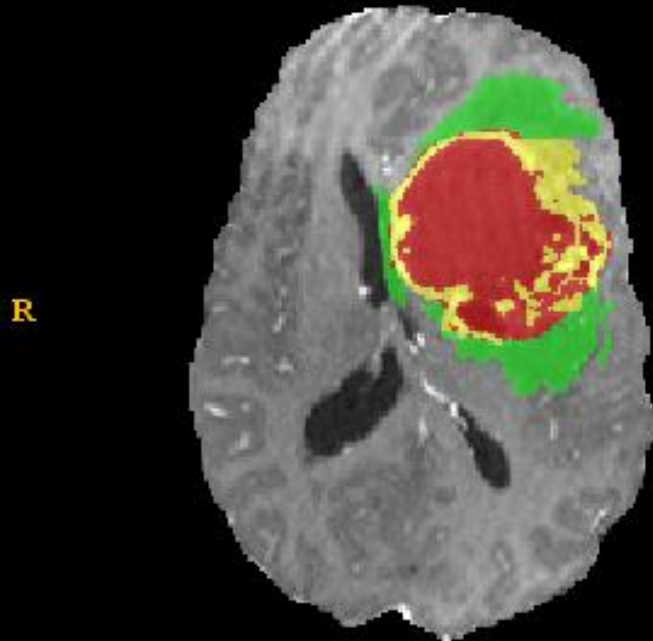
I L

Analysis of Brain Tumours

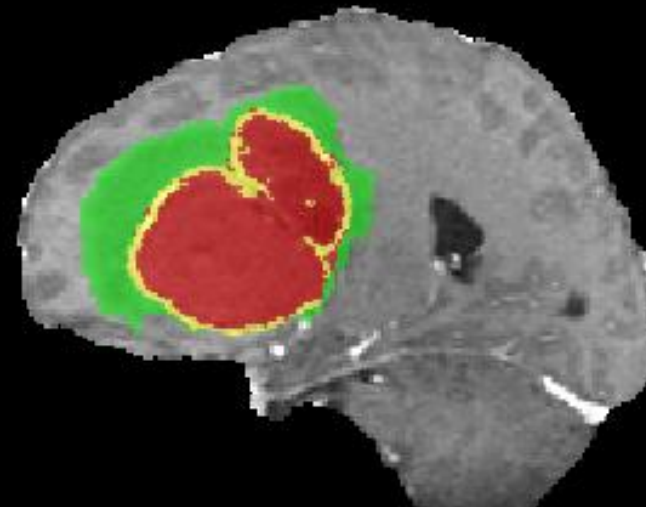
Brats17_CBICA_AXO_1_t1ce **A**

Brats17_CBICA_AXO_1_t1ce **S**

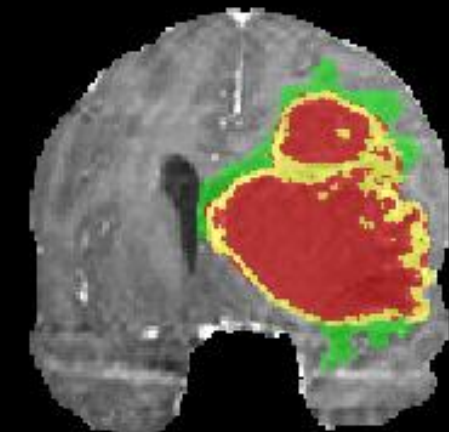
Brats17_CBICA_AXO_1_t1ce **S**



L A



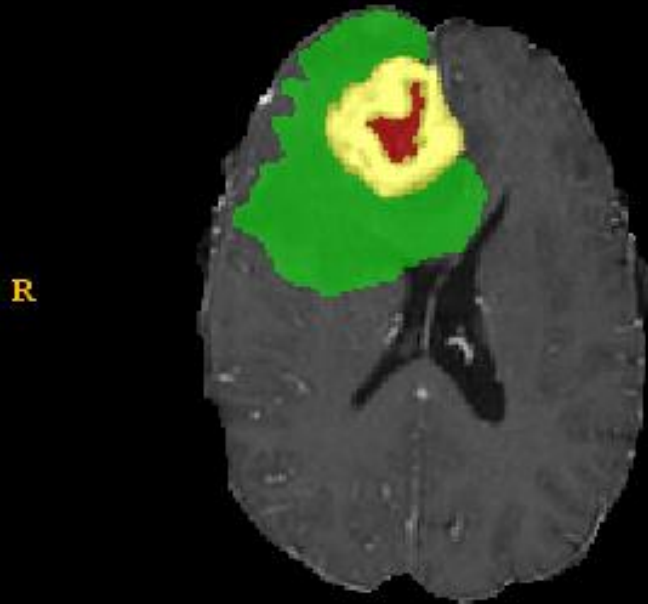
P R



I

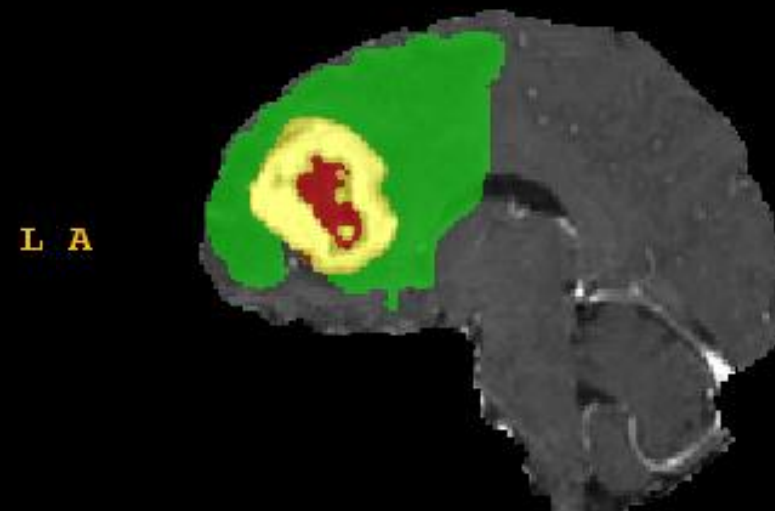
Analysis of Brain Tumours

Brats17_TCIA_199_1_t1ce **A**



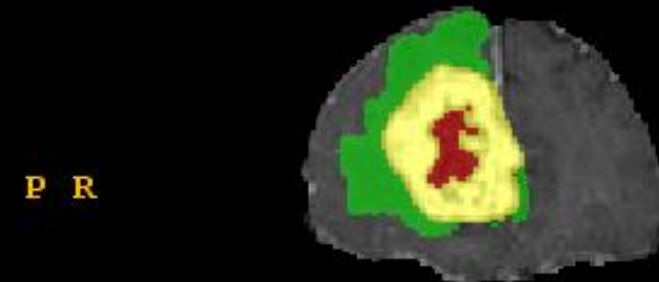
P | 10 cm

Brats17_TCIA_199_1_t1ce **S**



I | 10 cm

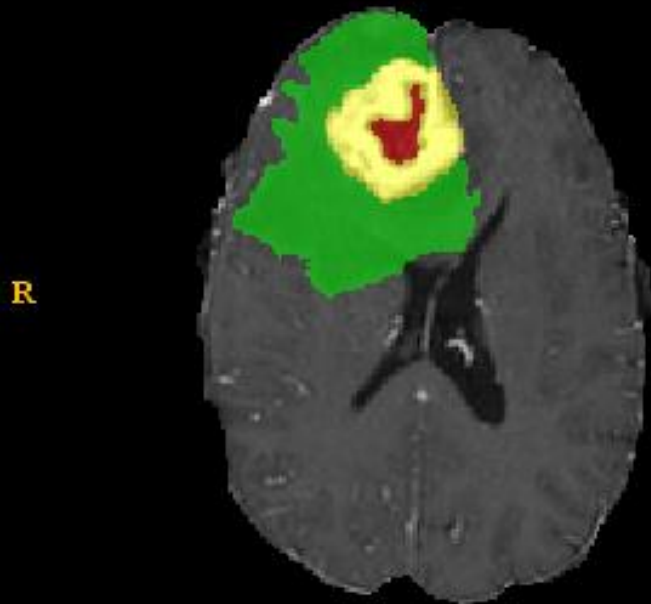
Brats17_TCIA_199_1_t1ce **S**



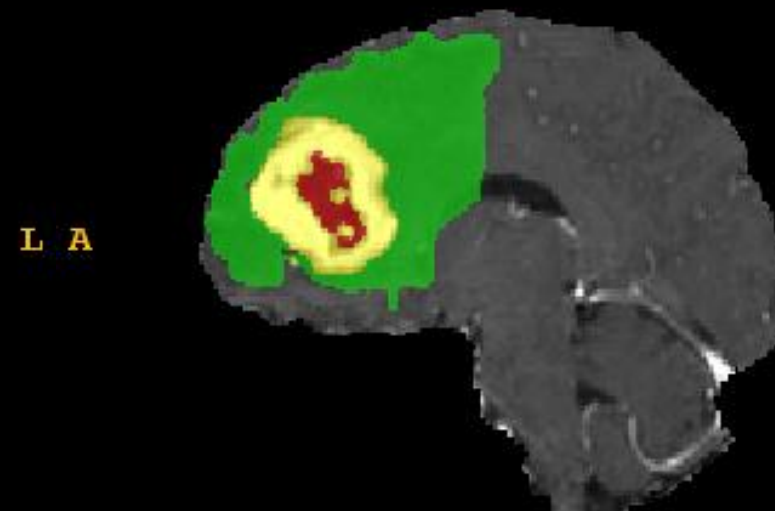
I | 10 cm

Analysis of Brain Tumours

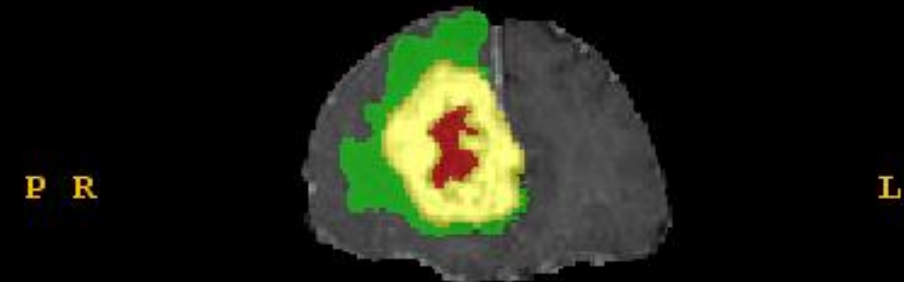
Brats17_TCIA_199_1_t1ce **A**



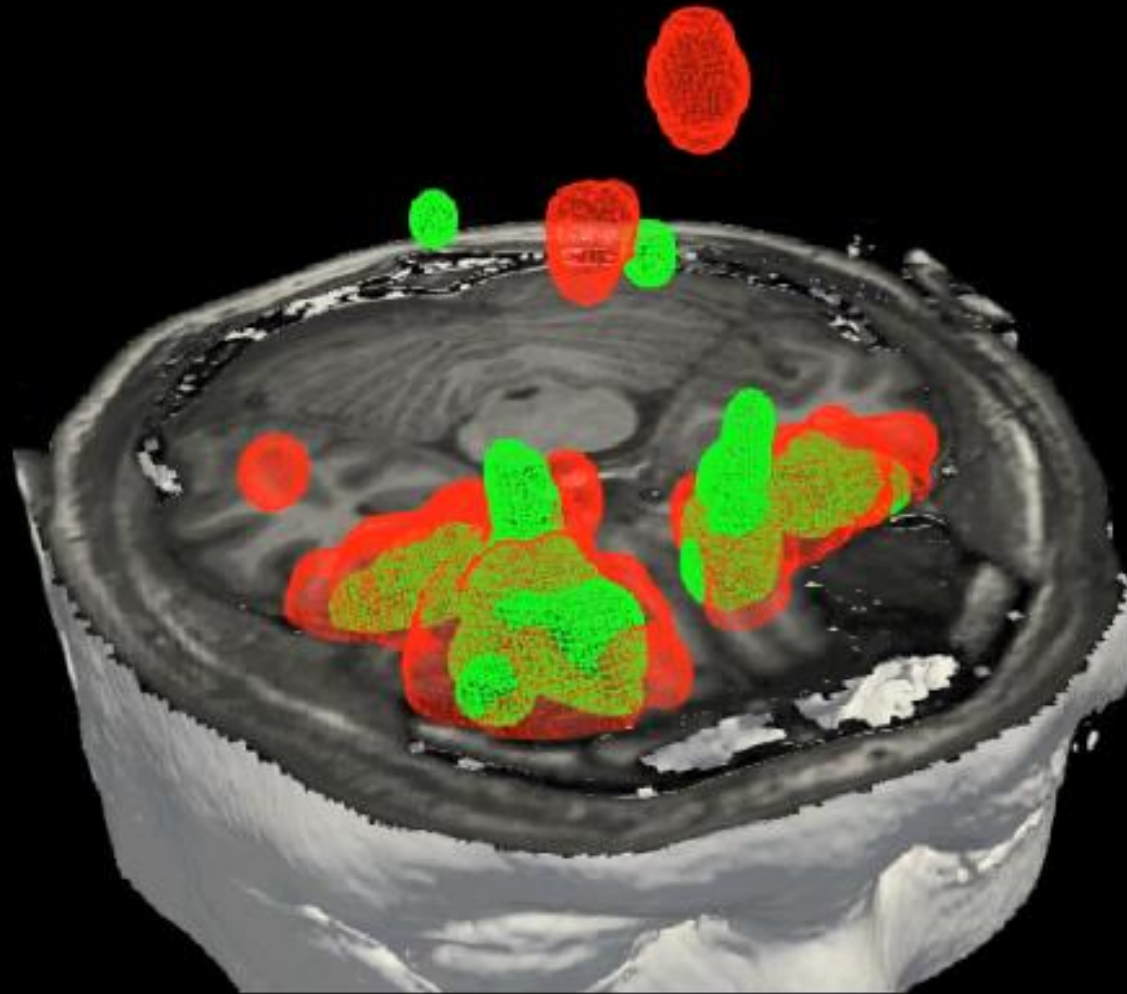
Brats17_TCIA_199_1_t1ce **S**



Brats17_TCIA_199_1_t1ce **S**

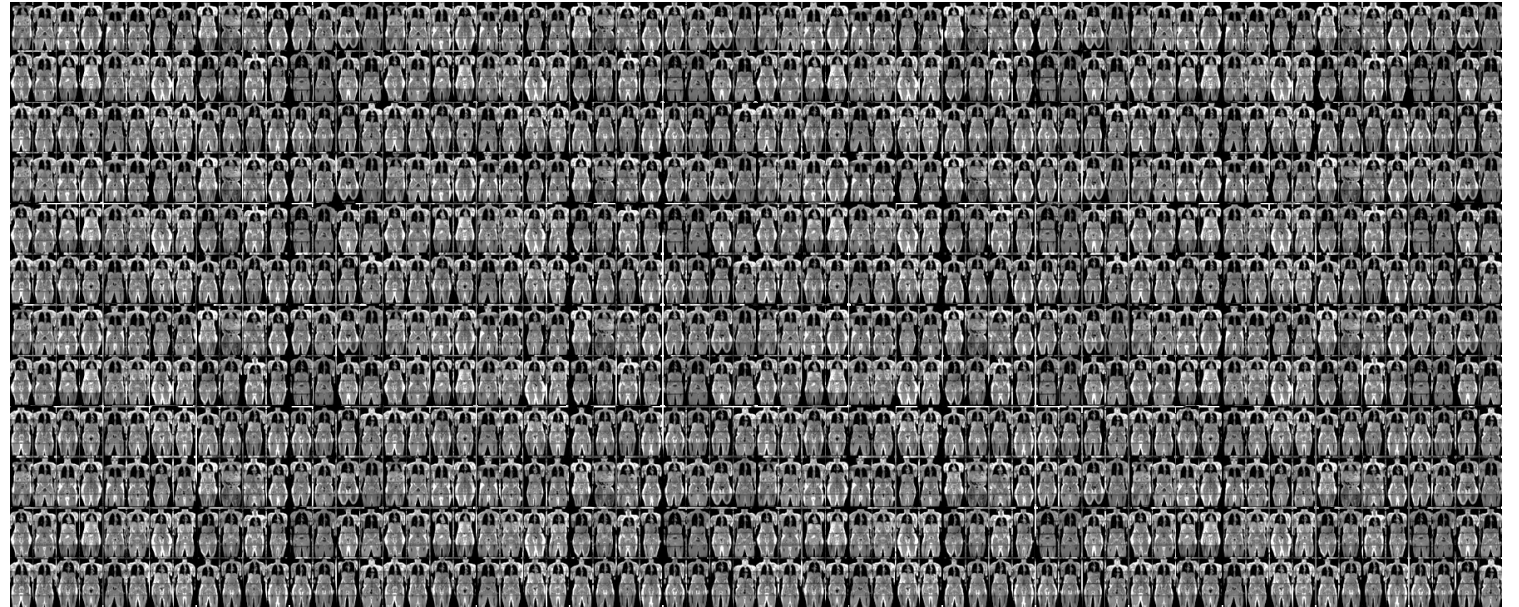


Acute versus chronic

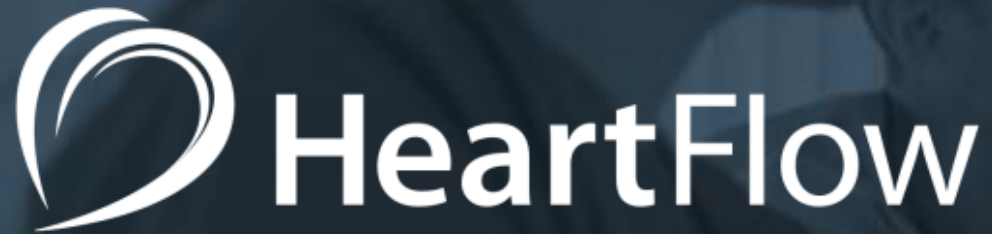


Many more applications...

- computer-aided diagnosis
- disease classification
- outcome prediction
- disease progression
- decision-support
- population health
- ...

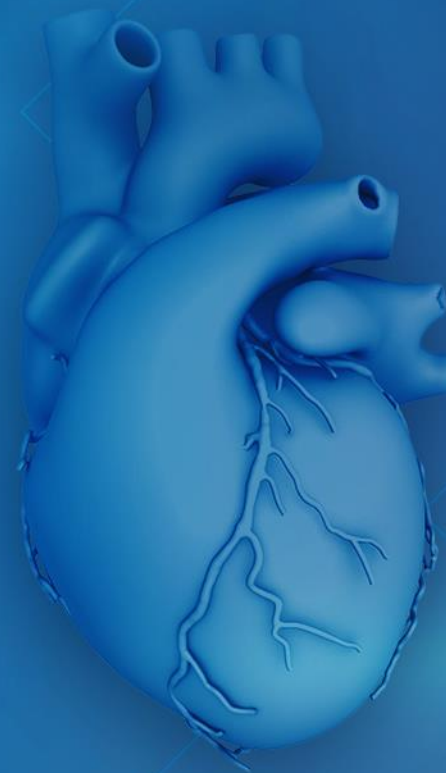


Deep Learning has arrived in clinical practice

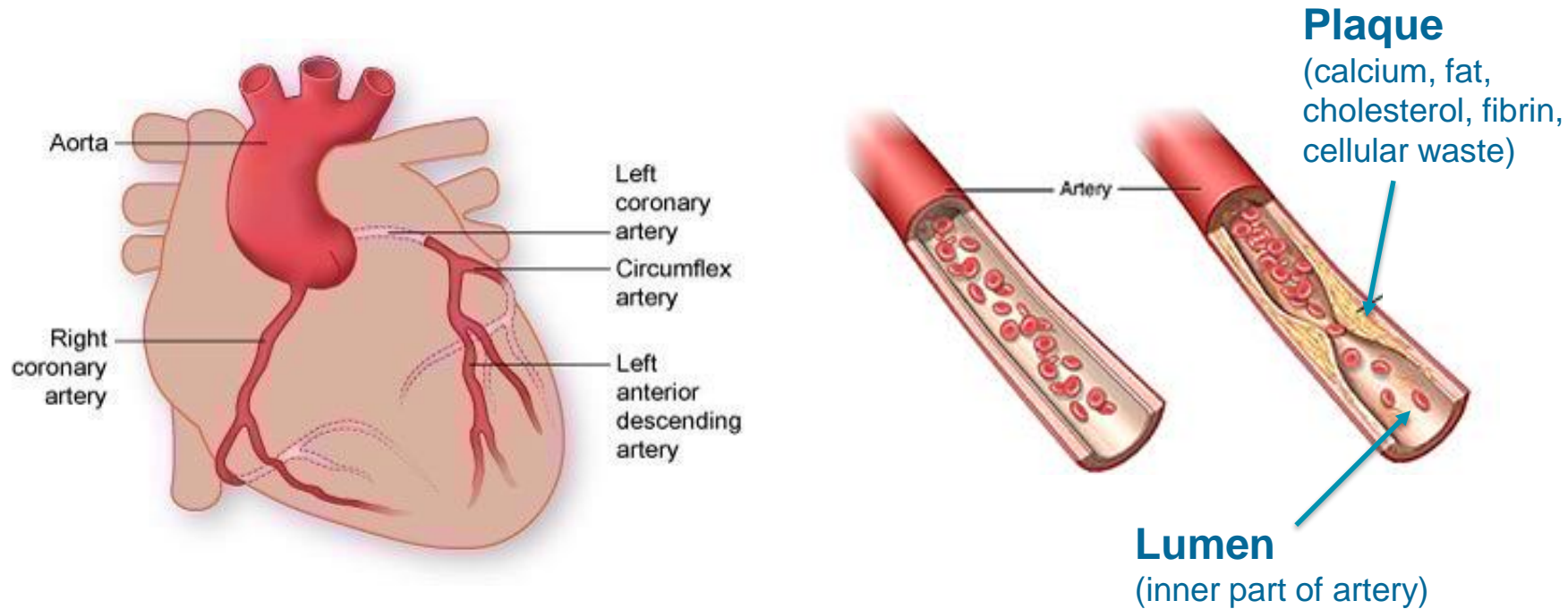




Personalizing Cardiac Care




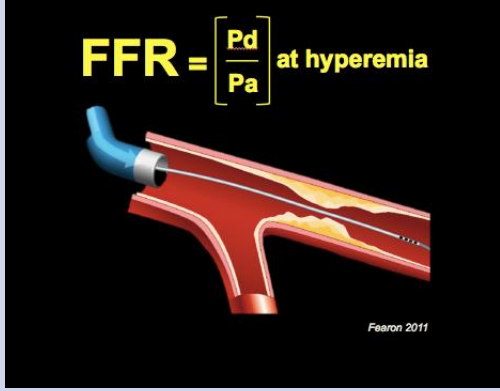

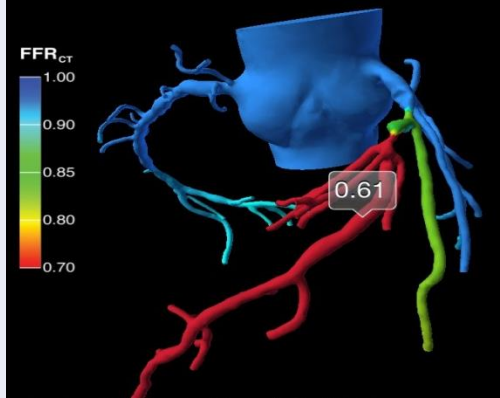
Coronary Artery Disease (CAD)



Plaque in the artery walls can **obstruct** the blood flow to the heart.

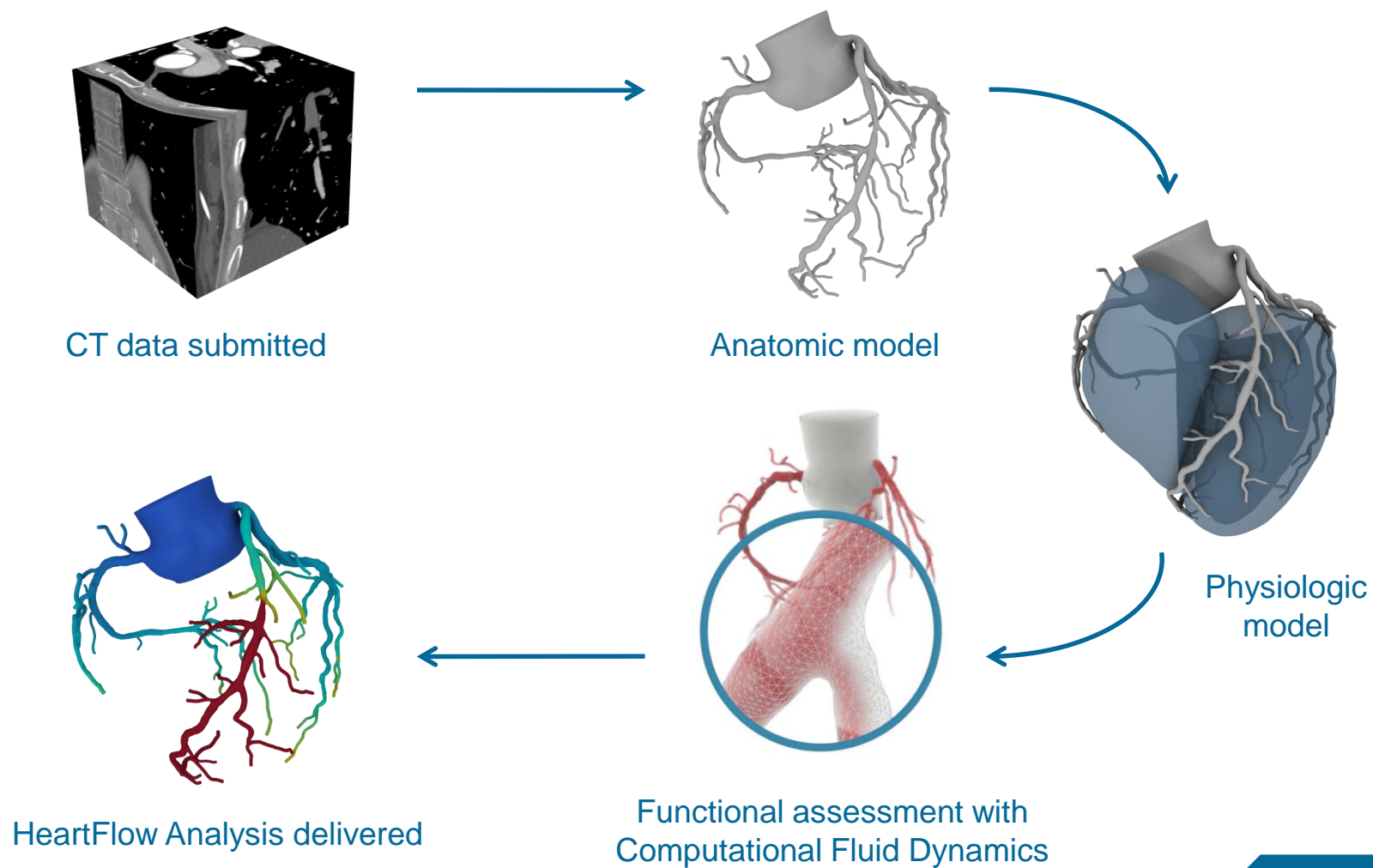


How do we find the **right treatment** for **patients** with symptoms of **CAD**?

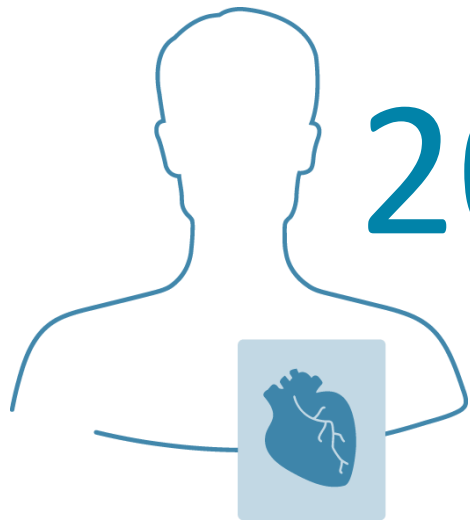
	<u>ANATOMY</u> <i>Identify obstructive CAD</i>	<u>FUNCTION</u> <i>Identify lesion-specific ischemia that may benefit from PCI</i>
<i>Invasive</i>		$FFR = \frac{Pd}{Pa} \text{ at hyperemia}$ 
<i>Noninvasive</i>		

➔ FFR_{CT}

The HeartFlow Analysis



HeartFlow is now part of clinical practice around the world

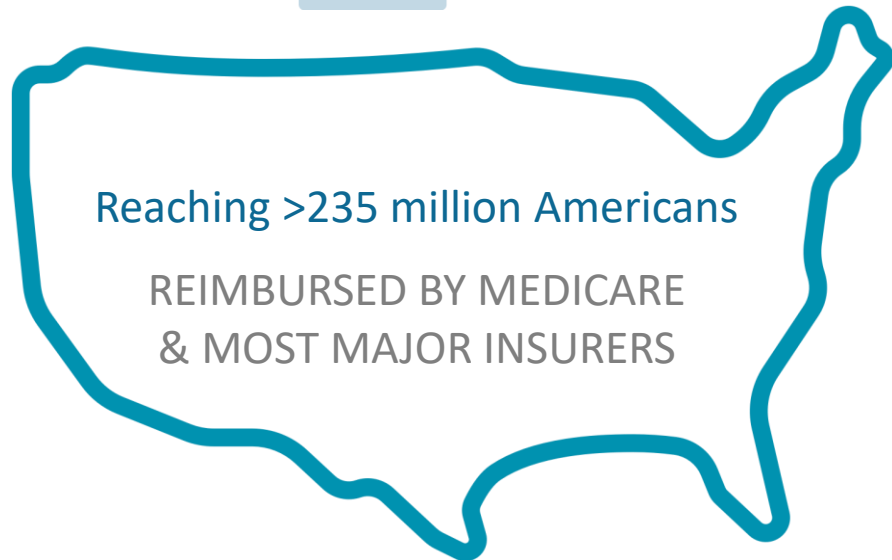


20K

HeartFlow FFR_{CT} Analyses
completed to date



< 5 Hours
median turnaround time

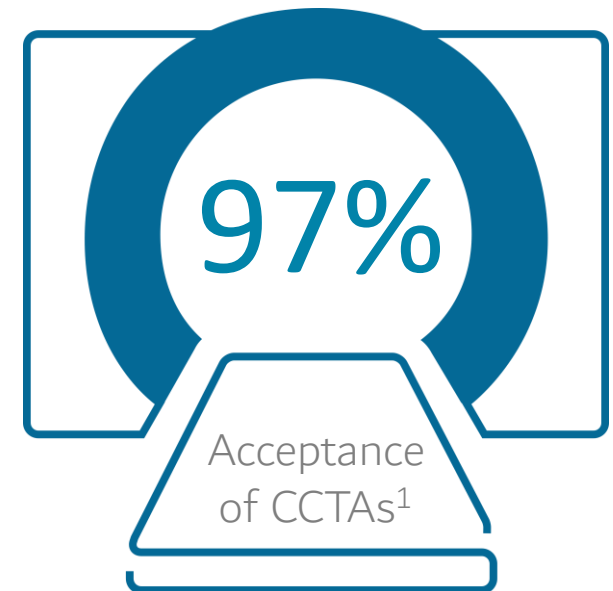


Reaching >235 million Americans

REIMBURSED BY MEDICARE
& MOST MAJOR INSURERS



Cleared for use in the
US, EU, Canada, and
Japan

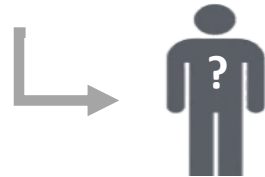


Enabling a CTA-FFR_{CT} Pathway

NICE Clinical Guideline
on cCTA
November 2016

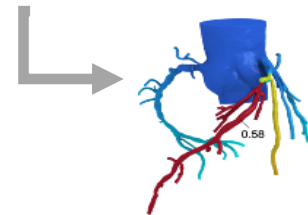


Coronary CTA as a frontline test for patients with chest pain



Results of CTA may indicate coronary artery disease (CAD) of **uncertain functional significance**

NICE Medical Technologies Guidance
on FFR_{CT}
February 2017



HeartFlow FFR_{CT} Analysis:

- **proven functional information** to aid in diagnosing ischemia
- **better diagnostic performance**
- **cost saving compared with all functional imaging tests**

NHS Innovation Technology Payment
April 2018

The ITP program is a new NHS program to fund emerging technologies

- HeartFlow was **1 of 4 technologies selected from > 270 applications**
- Funding provides for full adoption for 1 year across leading NHS sites

HeartFlow Announces Collaborative Research Agreement with Imperial College London

Joint research in medical imaging and deep learning to help improve treatment planning for patients with heart disease

March 07, 2018 09:00 AM Eastern Standard Time

REDWOOD CITY, Calif.--(BUSINESS WIRE)--HeartFlow, Inc. today announced that it has entered into a collaborative research agreement with Imperial College London. The collaboration will enable experts from HeartFlow and Imperial to work side-by-side on joint projects in the areas of medical imaging and deep learning. The company's non-invasive HeartFlow® FFRct Analysis leverages deep learning to create a personalized 3D model of the heart to help clinicians diagnose and treat coronary artery disease (CAD).

“We are delighted to collaborate with the team at Imperial, who are globally recognized leaders in applying deep learning techniques to medical imaging”

 Tweet this

“We are delighted to collaborate with the team at Imperial, who are globally recognized leaders in applying deep learning techniques to medical imaging,” said John H. Stevens, M.D., president and chief executive officer, HeartFlow. “I have no doubt that the combined expertise of the HeartFlow and Imperial teams will help accelerate turning cutting-edge science into ground-breaking products that can positively impact how patients with suspected heart disease are diagnosed and managed.”

The collaboration between HeartFlow and Imperial will be led by Dr. Ben Glocker and Professor Daniel Rueckert and will involve co-locating a HeartFlow team at Imperial's Biomedical Image Analysis (BioMedIA) group. The company also will fund additional research roles at the lab. The team will follow a joint project roadmap, initially focused on developing algorithms for extracting models of the coronaries from 4D computed tomography (CT) datasets, aligning images across modalities, and improving the precision of image acquisition and reconstruction.



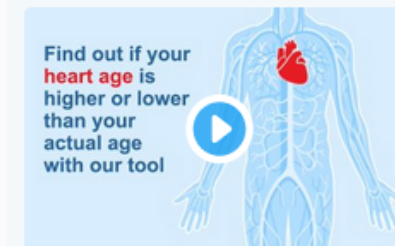
HEARTFLOW, INC.

Tweets by @HeartFlow

 HeartFlow Retweeted

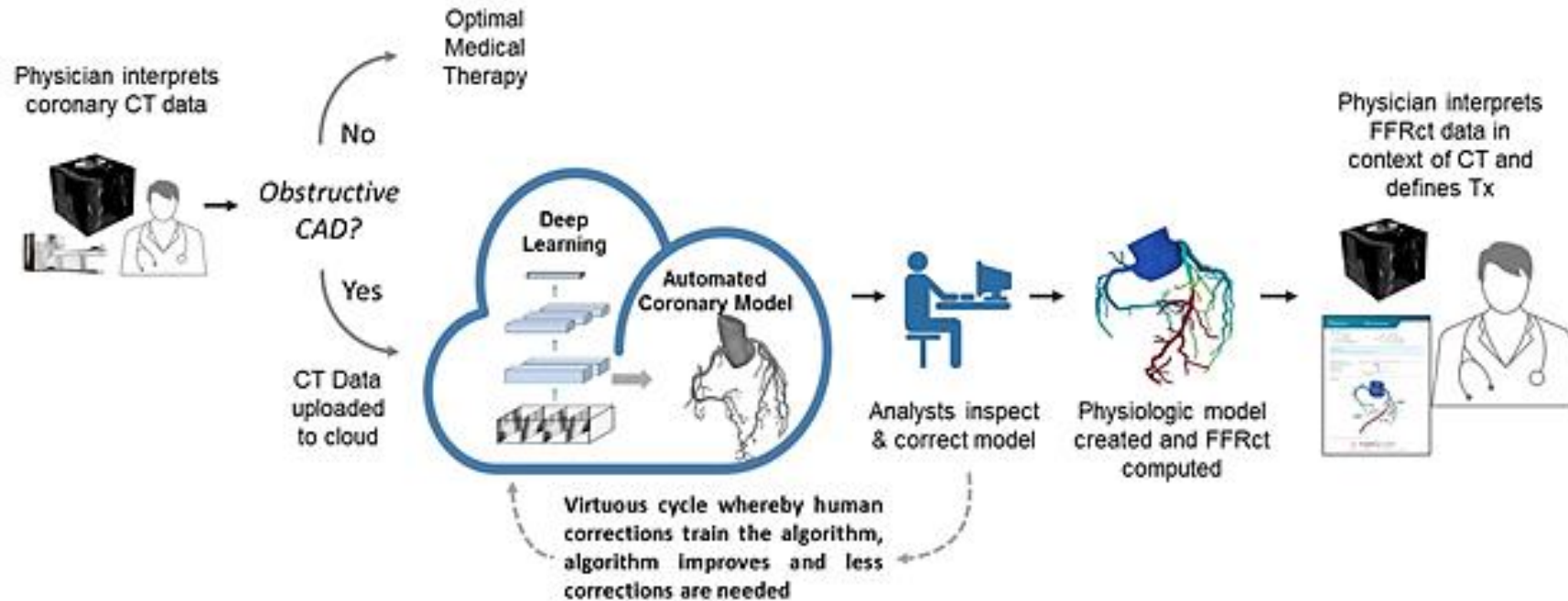
 NHS 
@NHSuk

The heart age tool will tell you your heart age and give practical advice to improve your heart health: ow.ly/7jyw30fRcN9



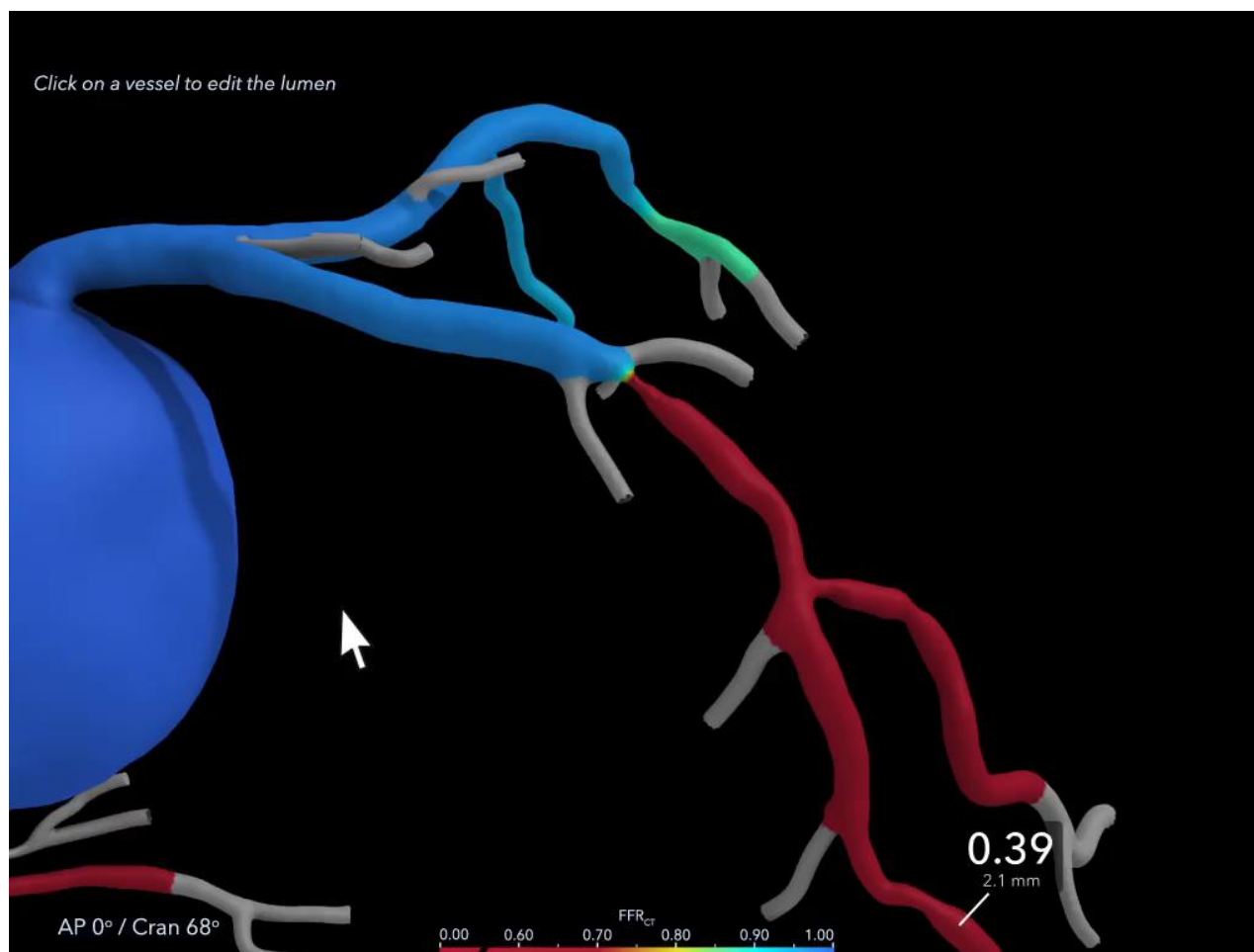
Sep 6, 2018

Automation via Deep Learning



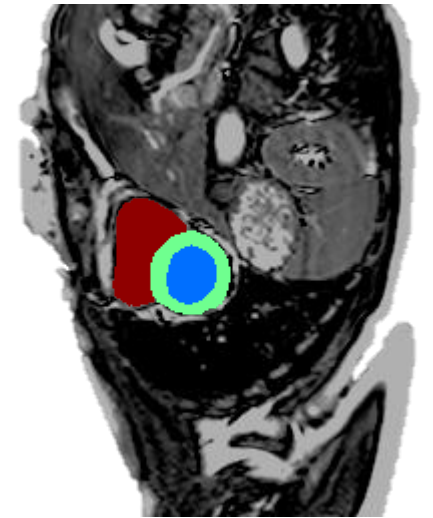
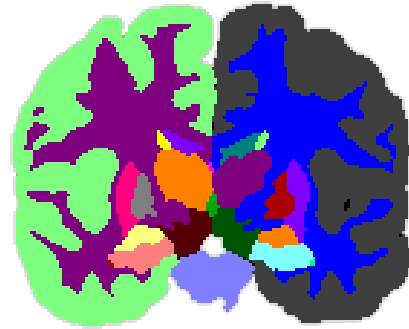
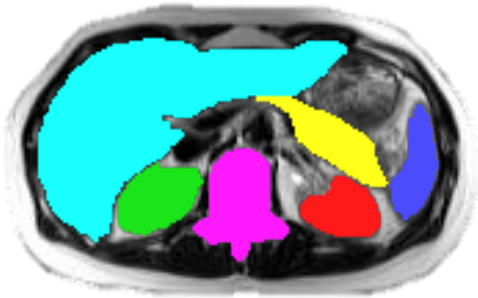
Large quantities of **rigorously annotated data**

Future HeartFlow Product Feature

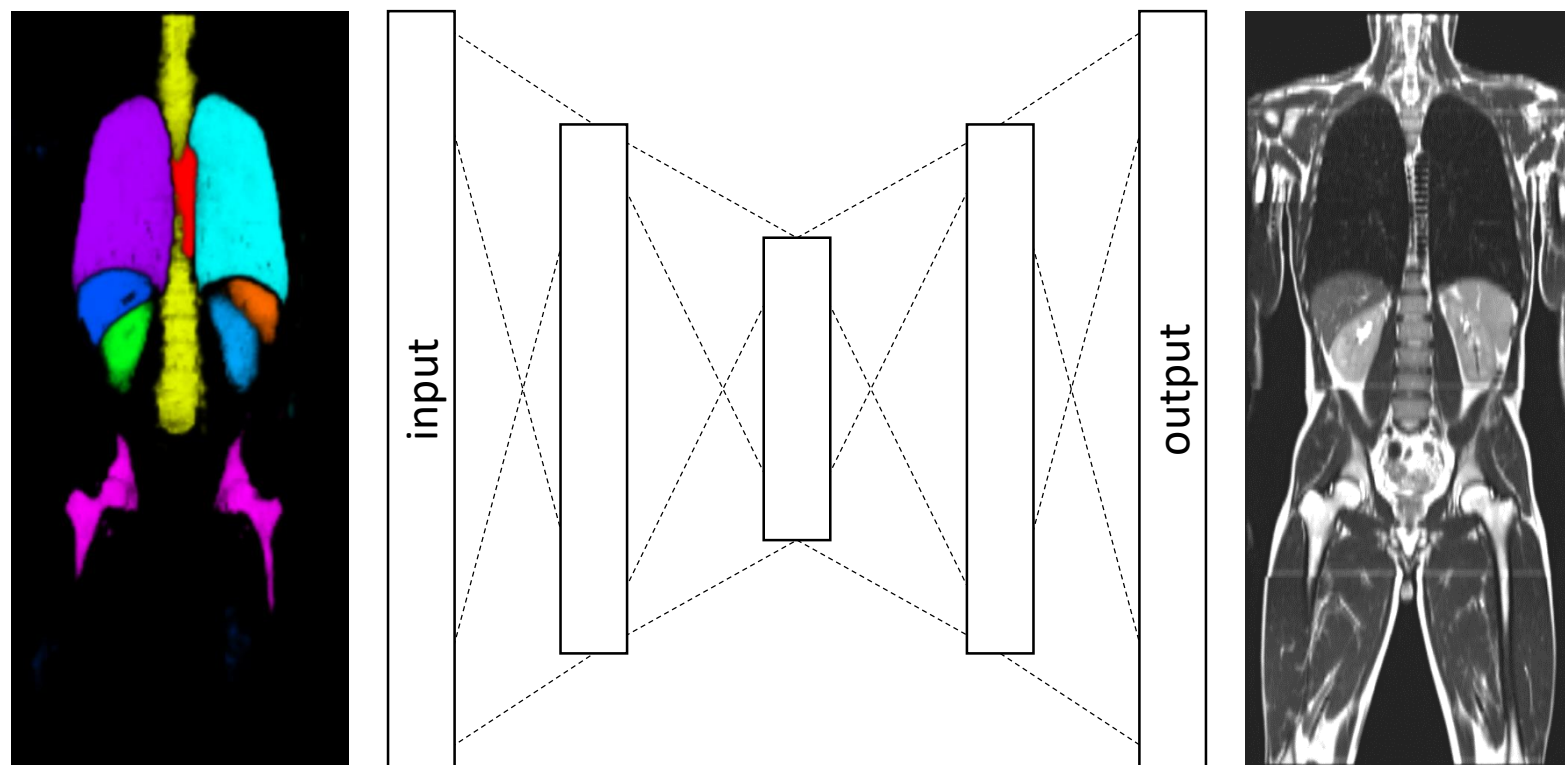


Virtual
Intervention
Planner

Beyond Human Level Performance



Beyond Human Level Performance



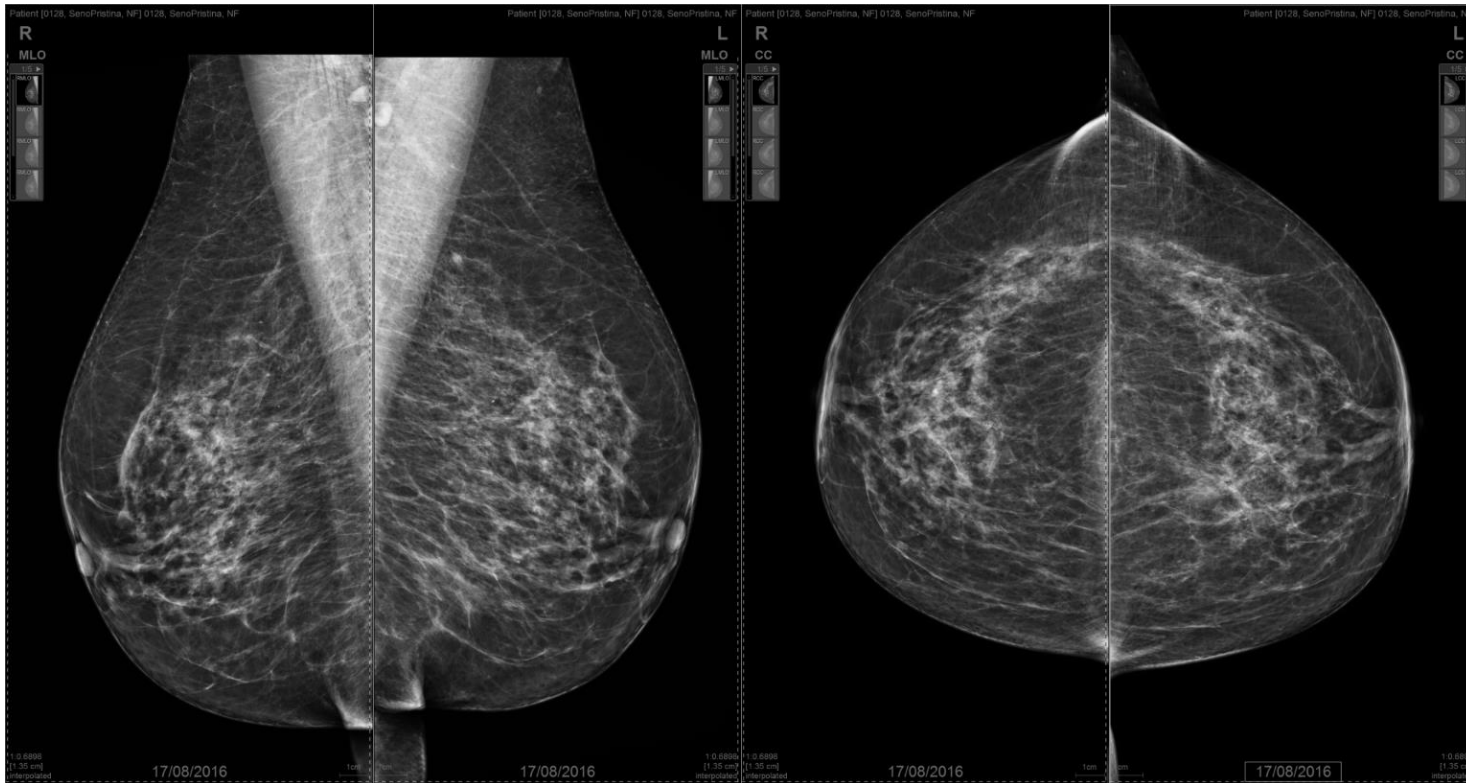
Can we synthesise **ground truth**?

The background features a complex, glowing blue network of interconnected nodes and lines, resembling a molecular structure or a data network, set against a dark blue gradient. The nodes are small dots, and the lines are thin, creating a sense of depth and connectivity.

High-Resolution Mammogram Synthesis using Progressive Generative Adversarial Networks

Dimitrios Korkinof





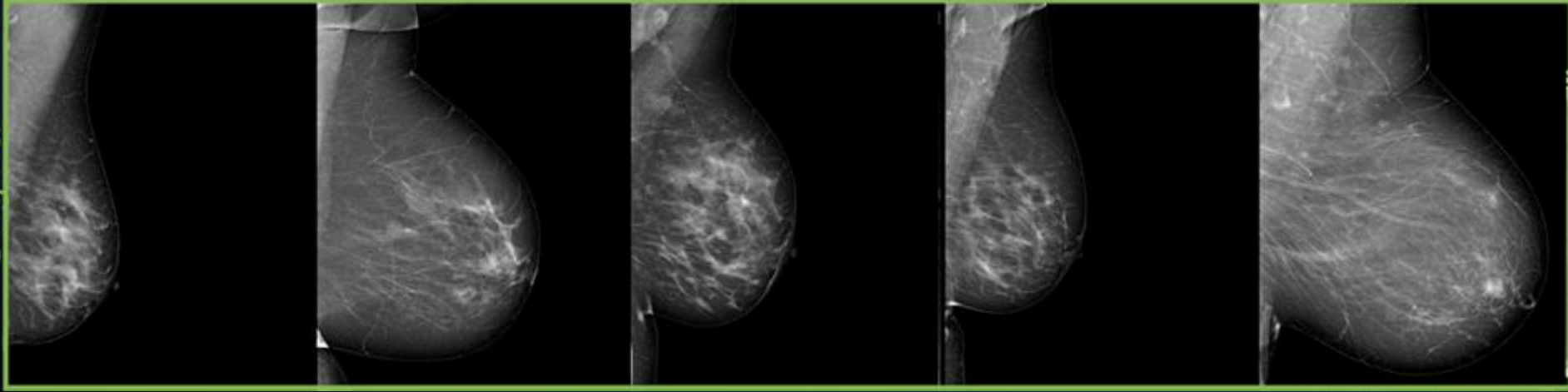
CE

Kheiron builds clinically meaningful, practical oncology solutions for radiologists
using advanced machine learning
to improve breast cancer detection in mammograms

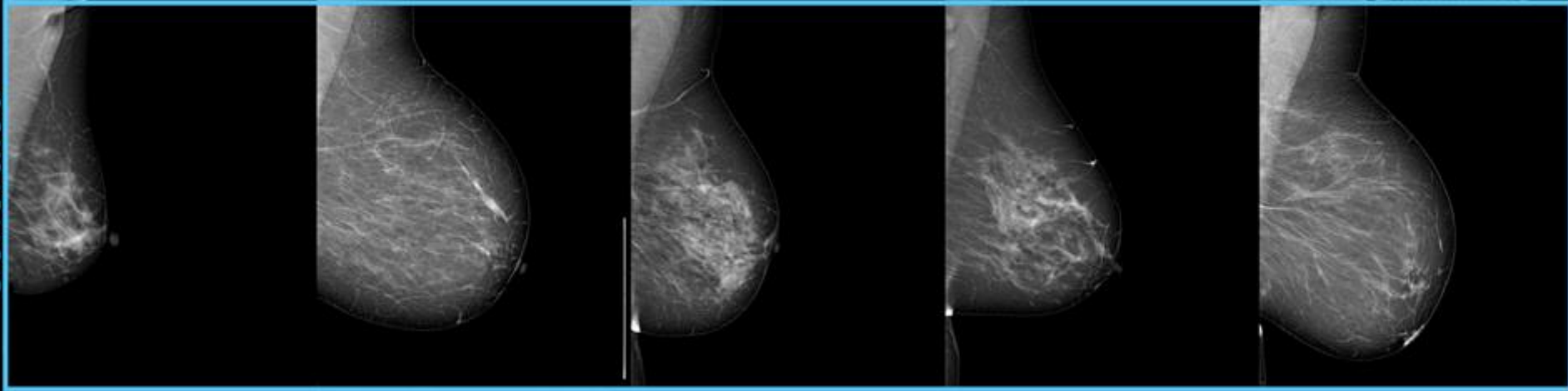
One image is computer generated the other image is real



Original



Generated



Deep Learning has come to stay

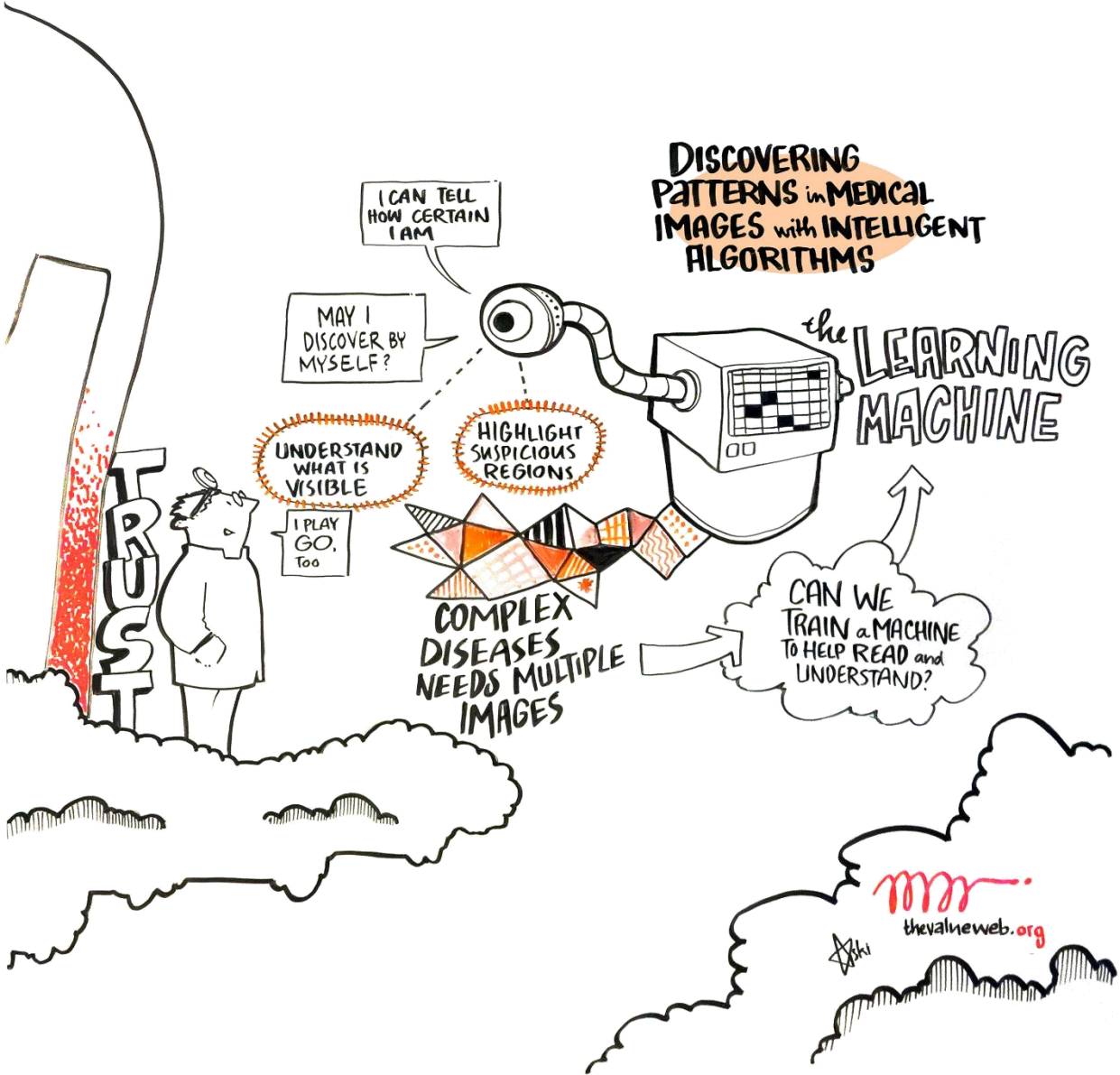
Today

Human-level performance is improving clinical practice by solving difficult tasks **more efficiently** and **more objectively**

Tomorrow

AI will **transform every part of clinical imaging** from diagnosis to treatment, therapy and intervention

Thank you for listening!





International Conference on Medical Imaging with Deep Learning

London, 8 – 10 July 2019



Full papers: 13 Dec 2018
Notification: 28 Feb 2019

Abstracts: April 2019
Notification: May 2019

<https://2019.midl.io>

Conference Chairs
Tom Vercauteren
Ben Glocker
M. Jorge Cardoso

Program Chairs
Gozde Unal
Ender Konukoglu
Ipek Oguz