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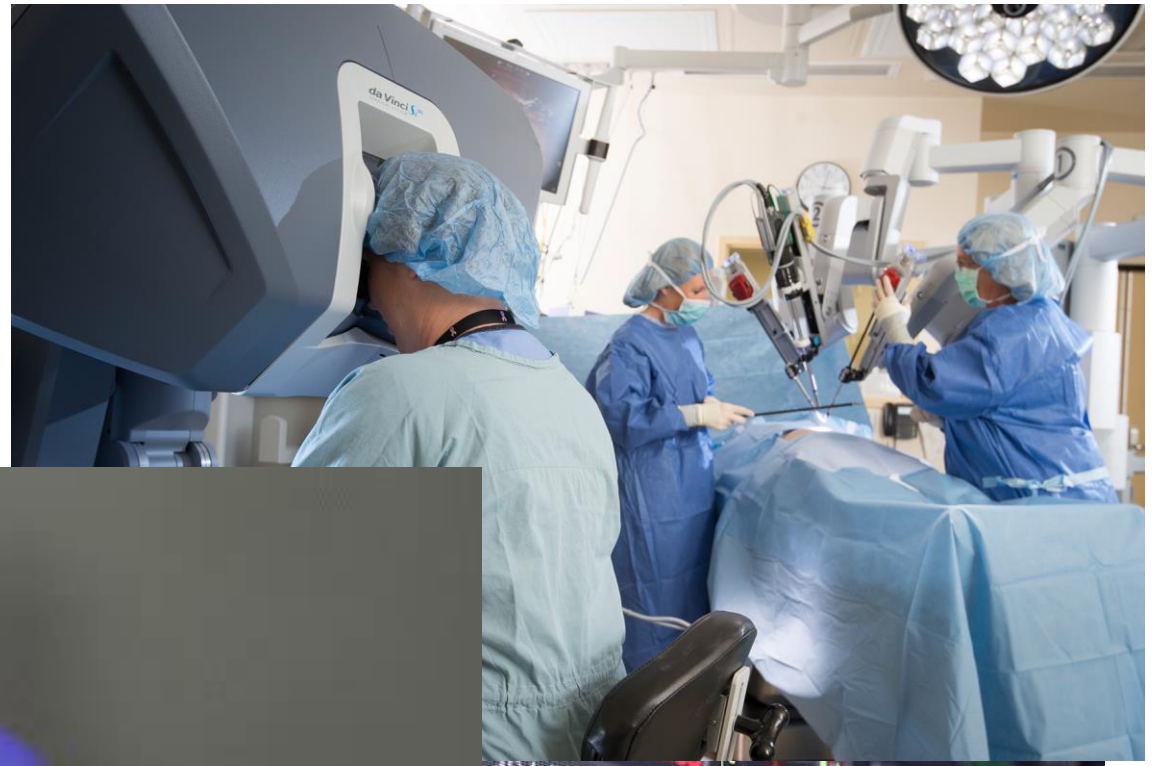
AI and Healthcare

Ahmed Serag, Ph.D.
Senior Scientist and Research Lead
22/10/2019

innovation you


smart
On my way


da Vinci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imgflip.com


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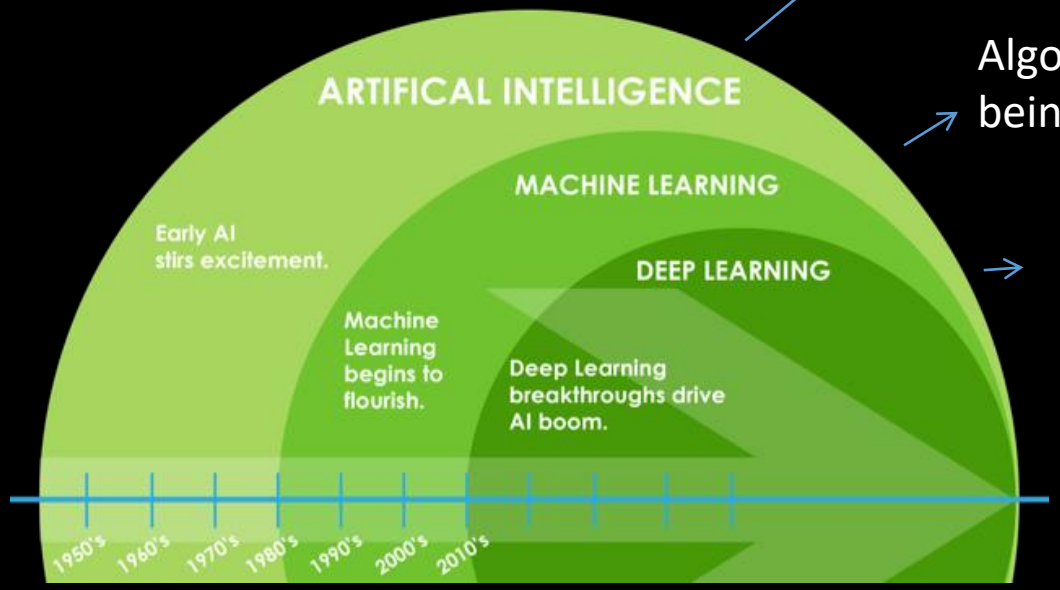
Agenda

- What’s AI?
- What’s AI potential impact for businesses?
- How AI can change healthcare?
- Medical data types
- Challenges in medical image analysis
- AI applications in radiology and pathology
- Challenges ahead
- Conclusions

“A.I. is one of the most important things humanity is working on. It’s more profound than, I don’t know, electricity or fire.”

Sundar Pichai

GOOGLE CEO, ON ARTIFICIAL INTELLIGENCE

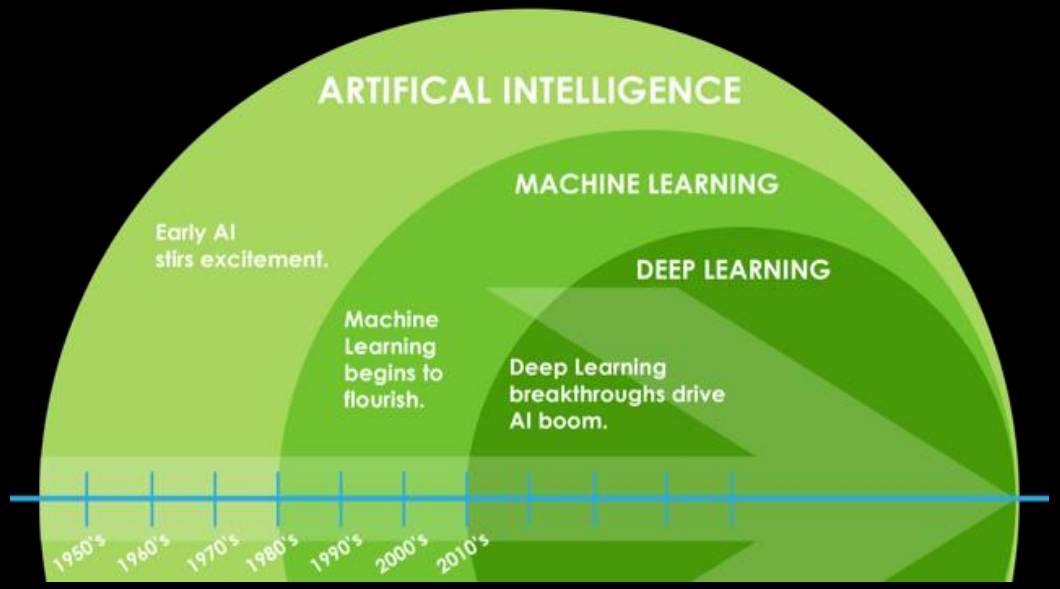


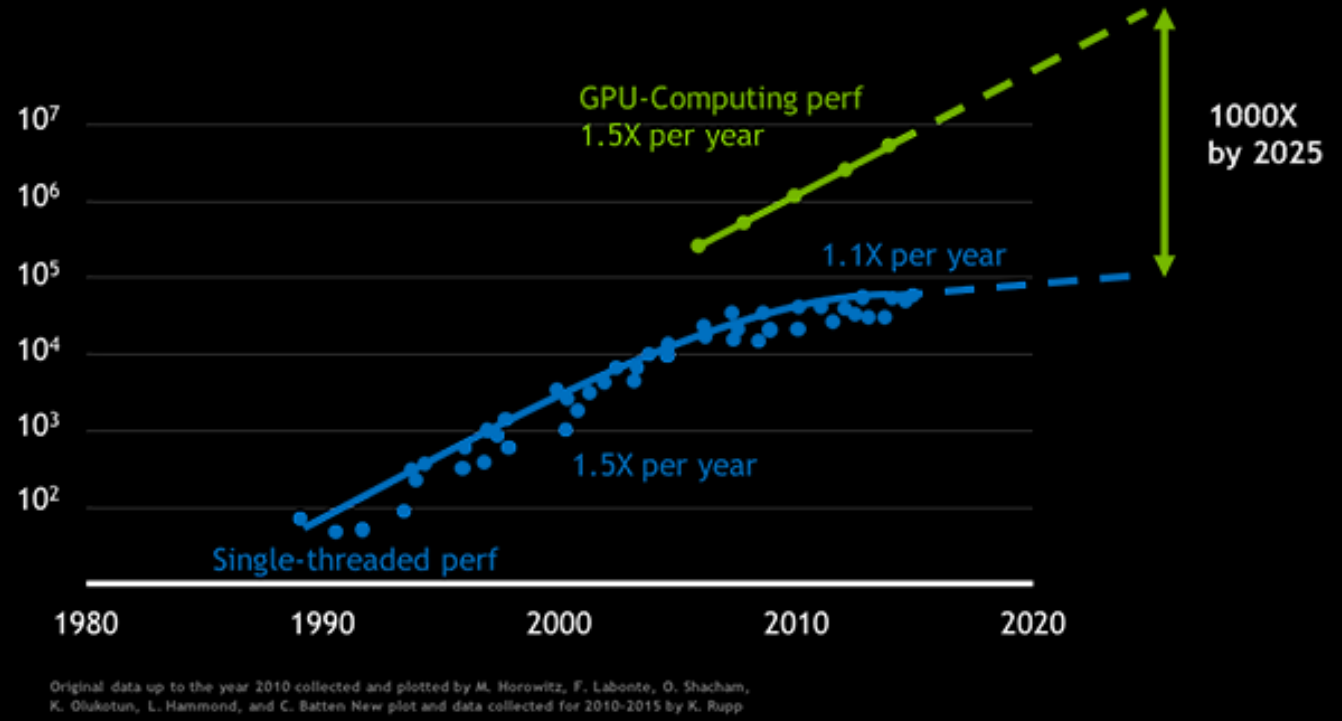
Any techniques that enable machines to solve a task in a way like humans do

Algorithms that allow machines to learn from examples without being explicitly programmed

A subset of ML techniques which uses deep artificial neural networks to build a hierarchy of data representations

RISE OF GPU COMPUTING





Source: nvidia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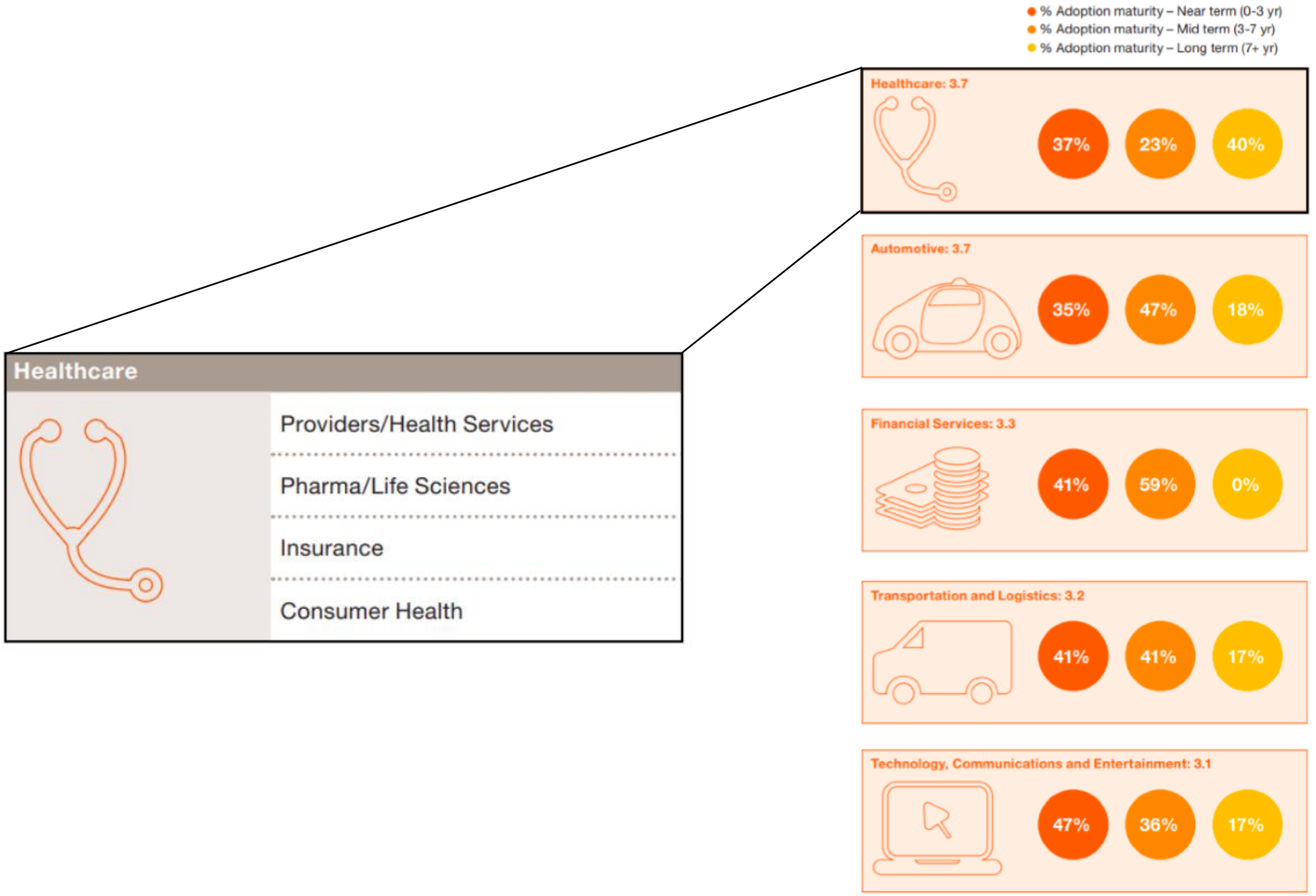

% Adoption maturity – Near term (0-3 yr)
% Adoption maturity – Mid term (3-7 yr)
% Adoption maturity – Long term (7+ yr)
Healthcare
Providers/Health Services
Pharma/Life Sciences
Insurance
Consumer Health
Healthcare: 3.7
37%
23%
40%
Automotive: 3.7
35%
47%
18%
Financial Services: 3.3
41%
59%
0%
Transportation and Logistics: 3.2
41%
41%
17%
Technology, Communications and Entertainment: 3.1
47%
36%
17%

Source: PwC

10 AI Applications That Could Change Health Care

APPLICATION	POTENTIAL ANNUAL VALUE BY 2026	KEY DRIVERS FOR ADOPTION
Robot-assisted surgery	$40B	Technological advances in robotic solutions for more types of surgery
Virtual nursing assistants	20	Increasing pressure caused by medical labor shortage
Administrative workflow	18	Easier integration with existing technology infrastructure
Fraud detection	17	Need to address increasingly complex service and payment fraud attempts
Dosage error reduction	16	Prevalence of medical errors, which leads to tangible penalties
Connected machines	14	Proliferation of connected machines/devices
Clinical trial participation	13	Patent cliff; plethora of data; outcomes-driven approach
Preliminary diagnosis	5	Interoperability/data architecture to enhance accuracy
Automated image diagnosis	3	Storage capacity; greater trust in AI technology
Cybersecurity	2	Increase in breaches; pressure to protect health data

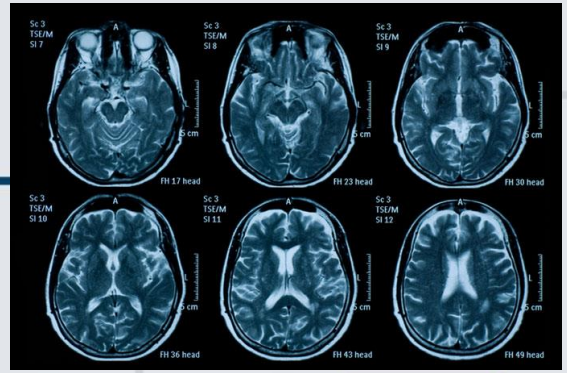
SOURCE ACCENTURE

Narrative, textual data

Signals

Medical Data

Numerical measurements



Images

Medical Records & Signals

Search UK edition
The Guardian

Hospital develops AI to identify patients likely to skip appointments

Exclusive: London's UCLH creates tool predicting 90% of no-shows – potentially saving NHS millions

▲ Even an imprecise indication of which patients will attend could save hospitals vast sums of money and help cut waiting times. Photograph: Hannah Mckay

A leading hospital has developed artificial intelligence to predict which patients are most likely to miss appointments.

University College Hospital in London created an algorithm using records from 22,000 appointments for MRI scans, allowing it to identify 90% of those patients who would turn out to be no-shows.

AI predicts hospital readmission rates from clinical notes

KYLE WIGGERS @KYLE_L_WIGGERS APRIL 11, 2019 9:28 AM

Image Credit: iStock / Steve Debenport

Electronic health records store valuable information about hospital patients, but they're often sparse and unstructured, making them difficult for potentially labor- and time-saving AI systems to parse. Fortunately, researchers at New York University and Princeton have developed a framework that evaluates clinical notes (i.e., descriptions of symptoms, reasons for diagnoses, and radiology results) and autonomously assigns a risk score indicating whether patients will be readmitted within 30 days.

Mobile phone app 'helps doctors detect acute kidney injury'

Thursday 1 August 2019

BBC News reports: "A mobile phone app has speeded up the detection of a potentially fatal kidney condition in hospital patients."

While it is relatively unknown, acute kidney injury puts a considerable strain on NHS resources (estimated at £1 billion in England) and is responsible for around 100,000 deaths per year in the UK.

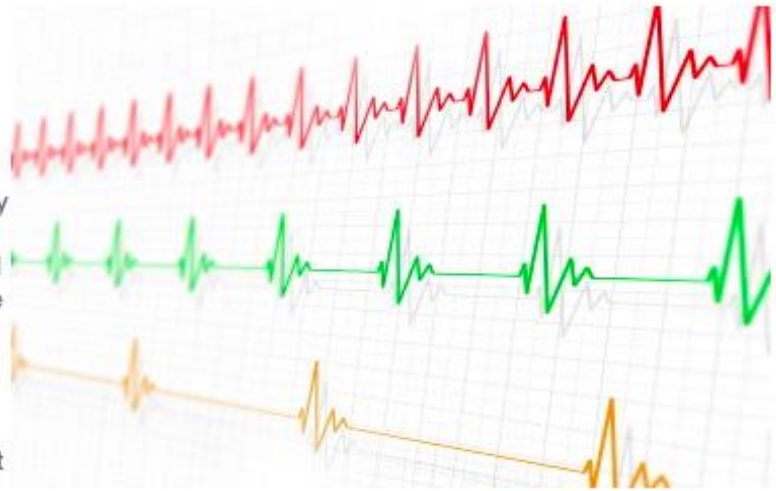
The app, called Streams, is a secure mobile device that brings together important medical information, like patients' blood test results, in one place.

It brings together data and test results from a range of IT systems used by the hospital and alerts medical teams if acute kidney injury has been confirmed.

AI neural network detects heart failure from a single heartbeat

30 September 2019

Researchers developed a neural network that identifies congestive heart failure with 100% accuracy through analysis of just one raw electrocardiogram heartbeat.



Congestive heart failure (CHF) is a chronic progressive condition that affects the pumping power of the heart muscles. Associated with high prevalence, significant mortality rates and sustained healthcare costs, clinical practitioners and health systems urgently require efficient detection processes.

Dr Sebastiano Massaro, Associate Professor of Organisational Neuroscience at the University of Surrey, has worked with colleagues Mihaela Porumb and Dr Leandro Pecchia at the University of Warwick and Ernesto Iadanza at the University of Florence, to tackle these important concerns by using Convolutional Neural Networks (CNN) – hierarchical neural networks highly effective in recognising patterns and structures in data.

Published in Biomedical Signal Processing and Control Journal, their research drastically improves existing CHF detection methods typically focused on heart rate variability that, whilst effective, are time-consuming and prone to errors. Conversely, their new model uses a combination of advanced signal processing and machine learning tools on raw ECG signals, delivering 100% accuracy.

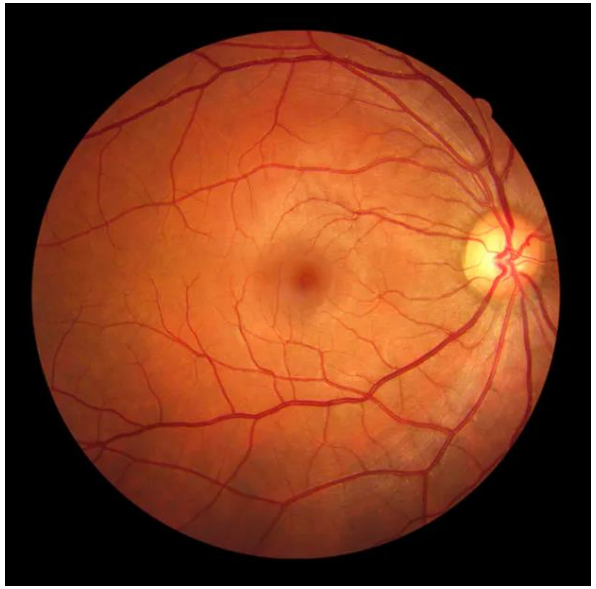
Dr Massaro said: "We trained and tested the CNN model on large publicly available ECG datasets featuring subjects with CHF as well as healthy, non-arrhythmic hearts. Our model delivered 100% accuracy: by checking just one heartbeat we are able detect whether or not a person has heart failure. Our model is also one of the first known to be able to identify the ECG' s morphological features specifically associated to the severity of the condition."

Medical Image Analysis

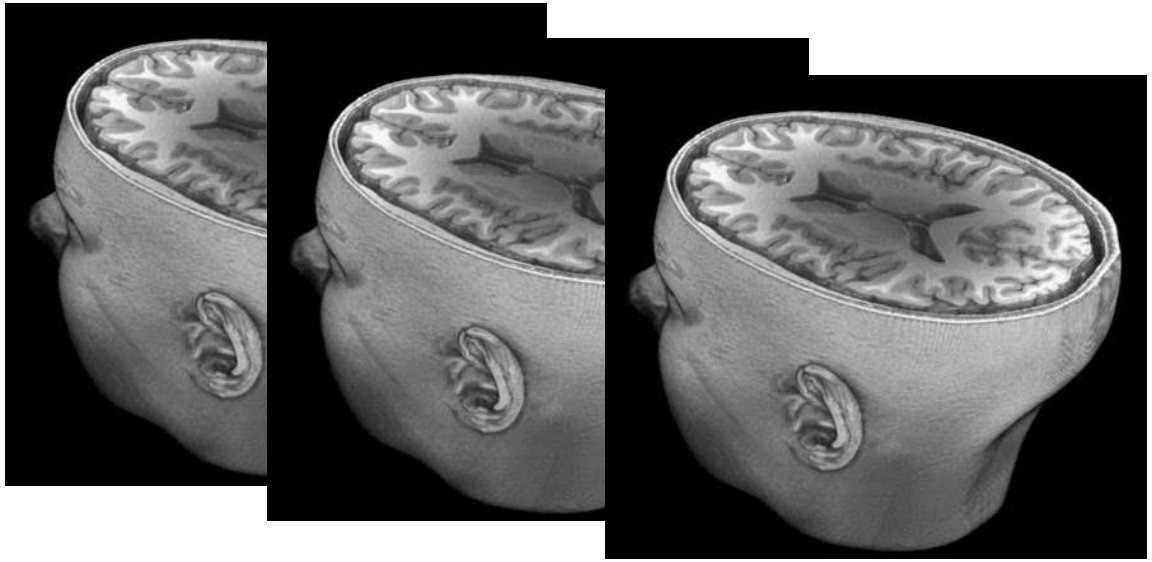
Grayscale Image (2D)

Grayscale Image (3D)

High-resolution
Color Image (2D)

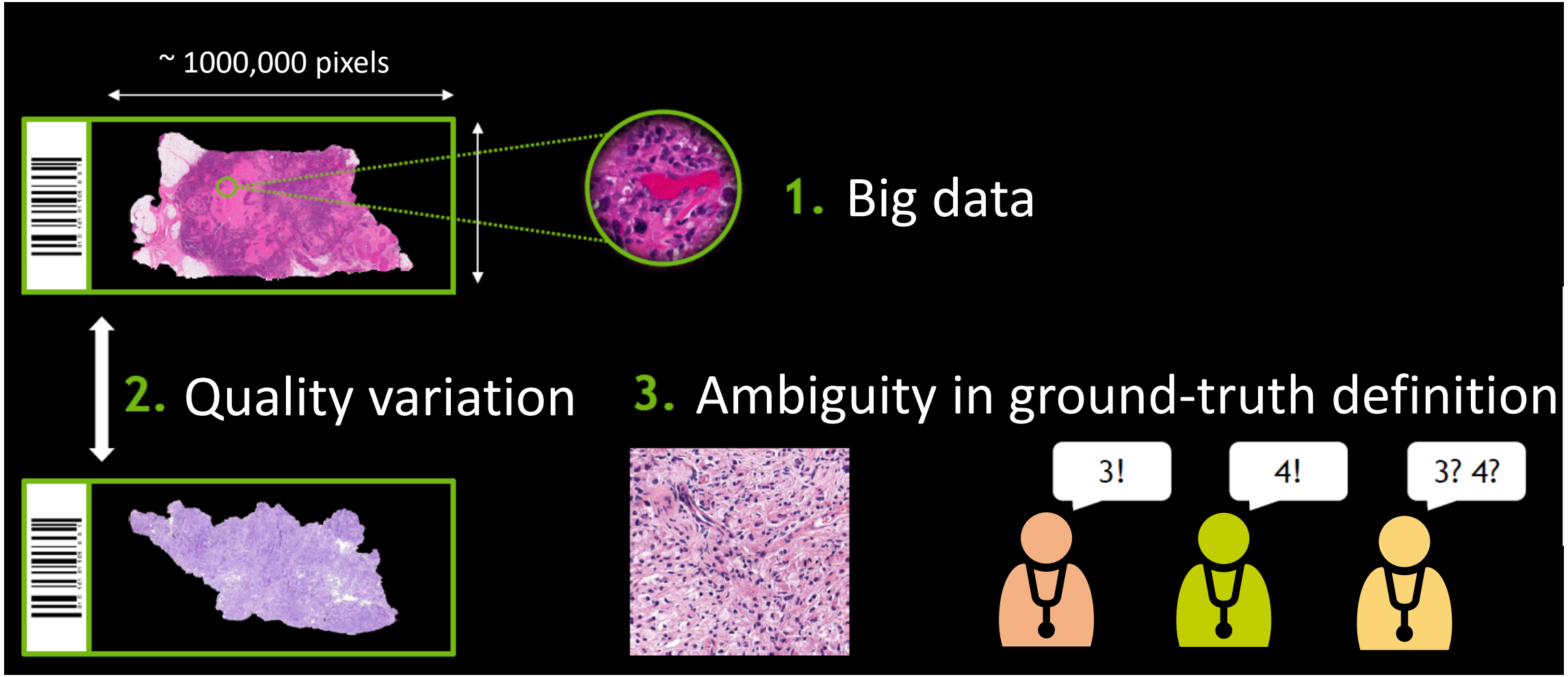


Color Image (2D)

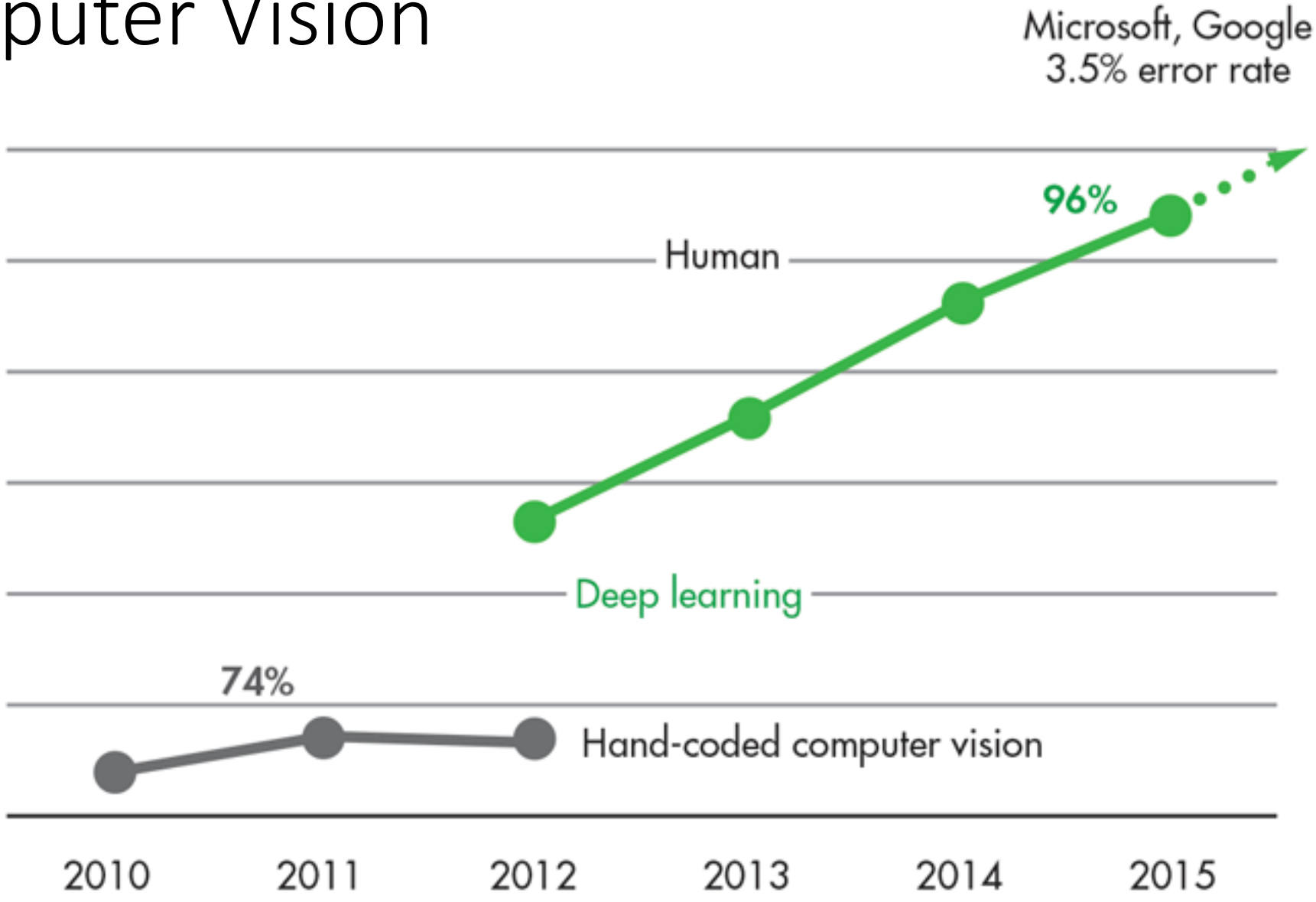


Grayscale Image (4D)

Challenges in Image Analysis



Computer Vision



DeepMind's AI can detect over 50 eye diseases as accurately as a doctor

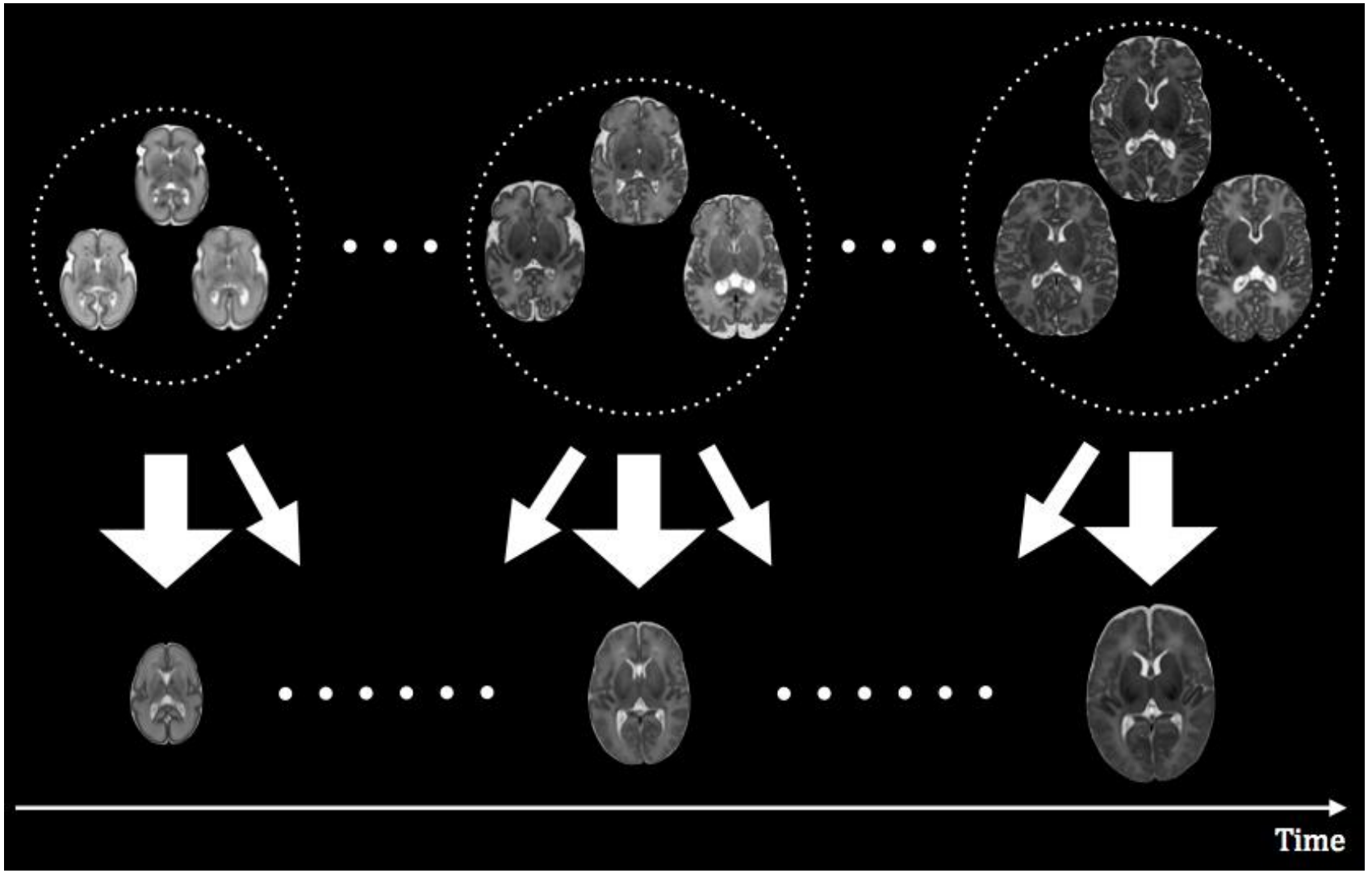
The system analyzes 3D scans of the retina and could help speed up diagnoses in hospitals

By James Vincent | Aug 13, 2018, 11:01am EDT

SHARE

Radiology

“Normal” Models

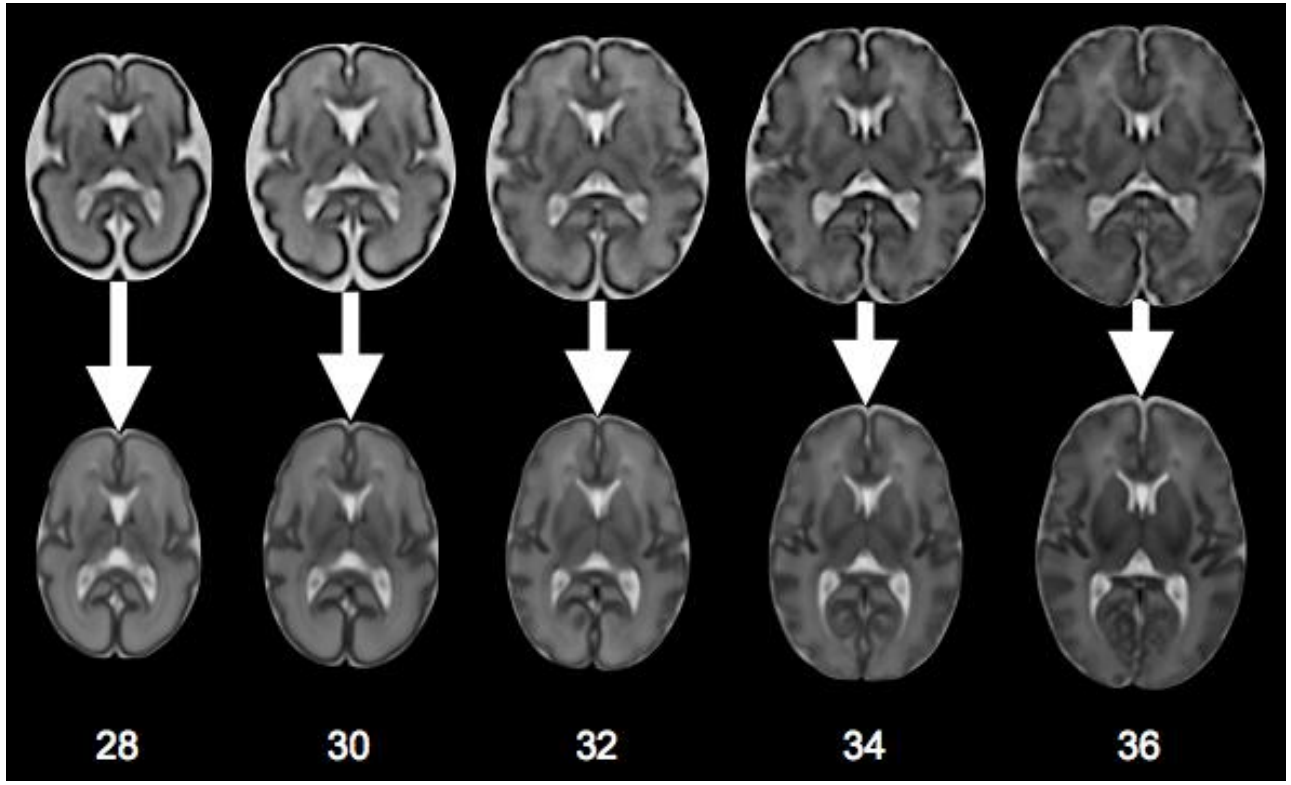


Serag, 2012

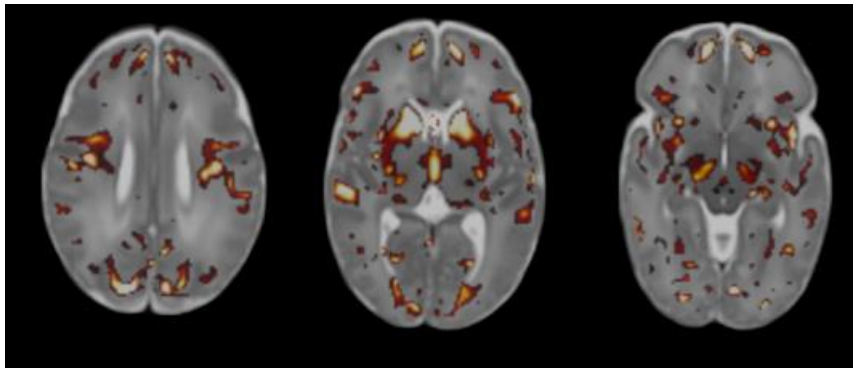
Detection of variations

Fetal Brain
"Model"

Preterm
Neonatal
Brain

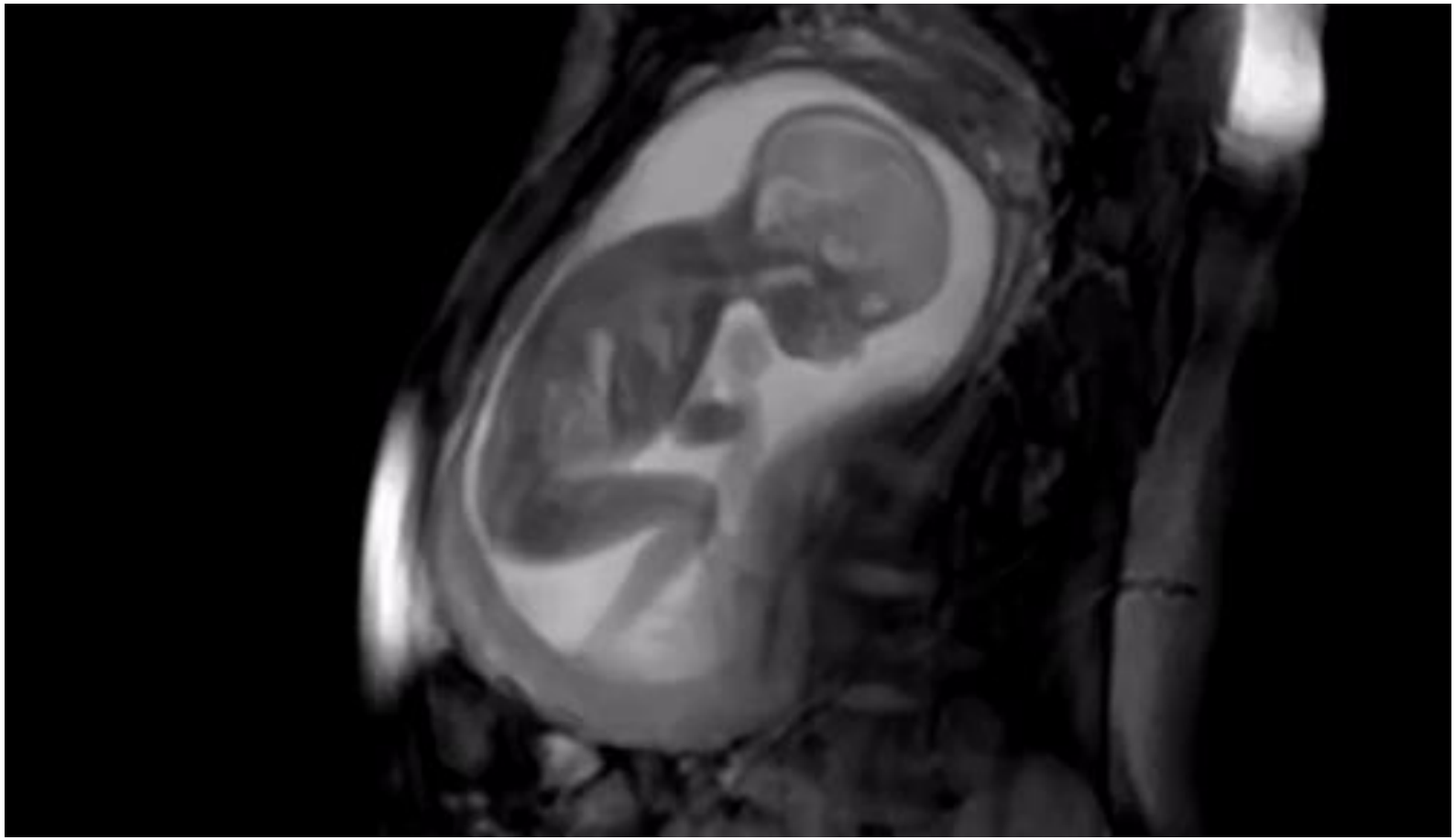


Variations from model



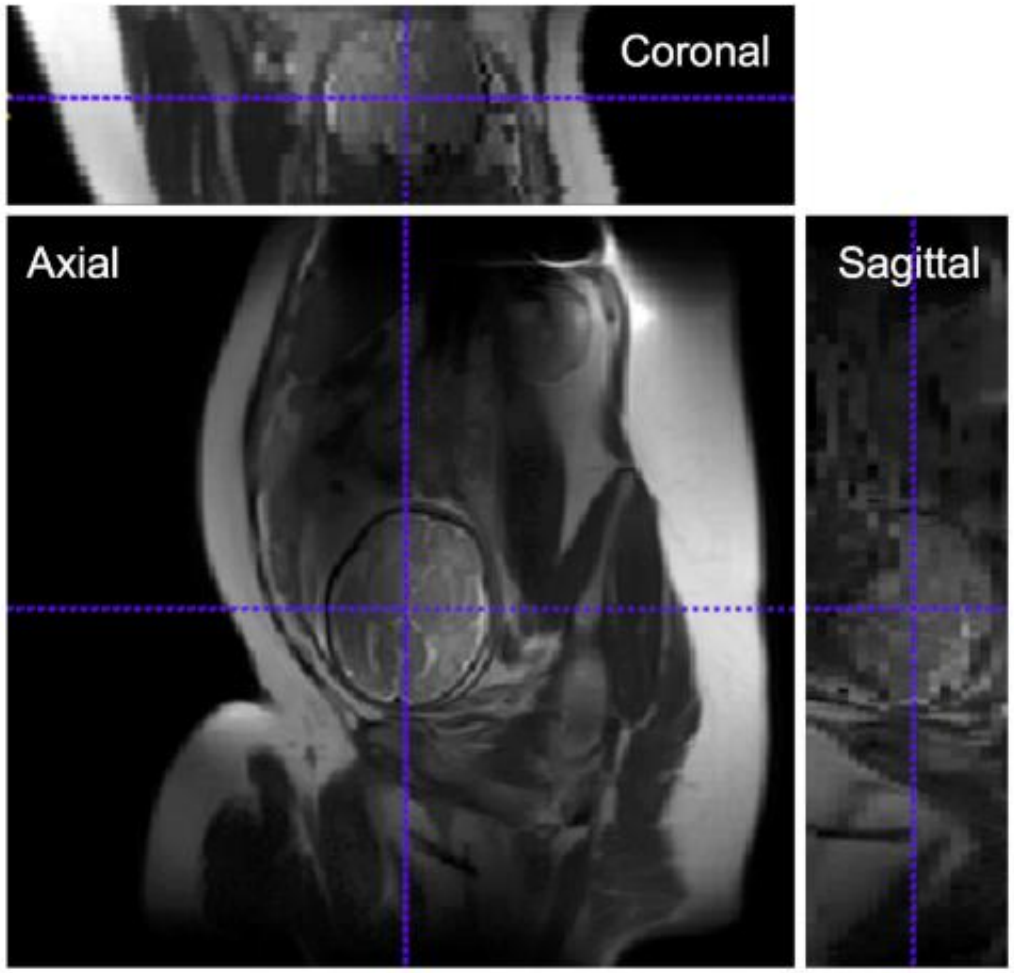
Serag, 2012

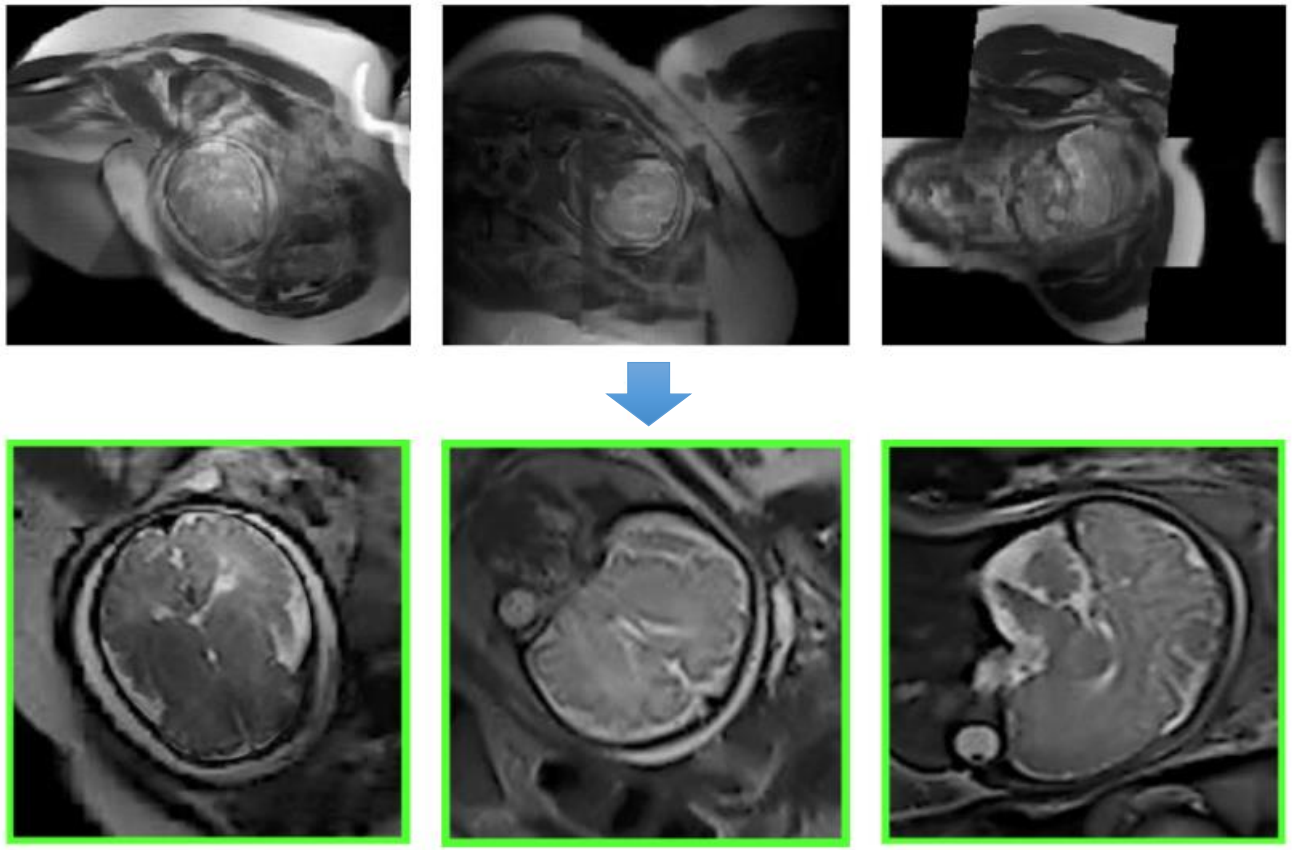
Motion correction



Source: youtu.be

Motion correction





Serag, 2016

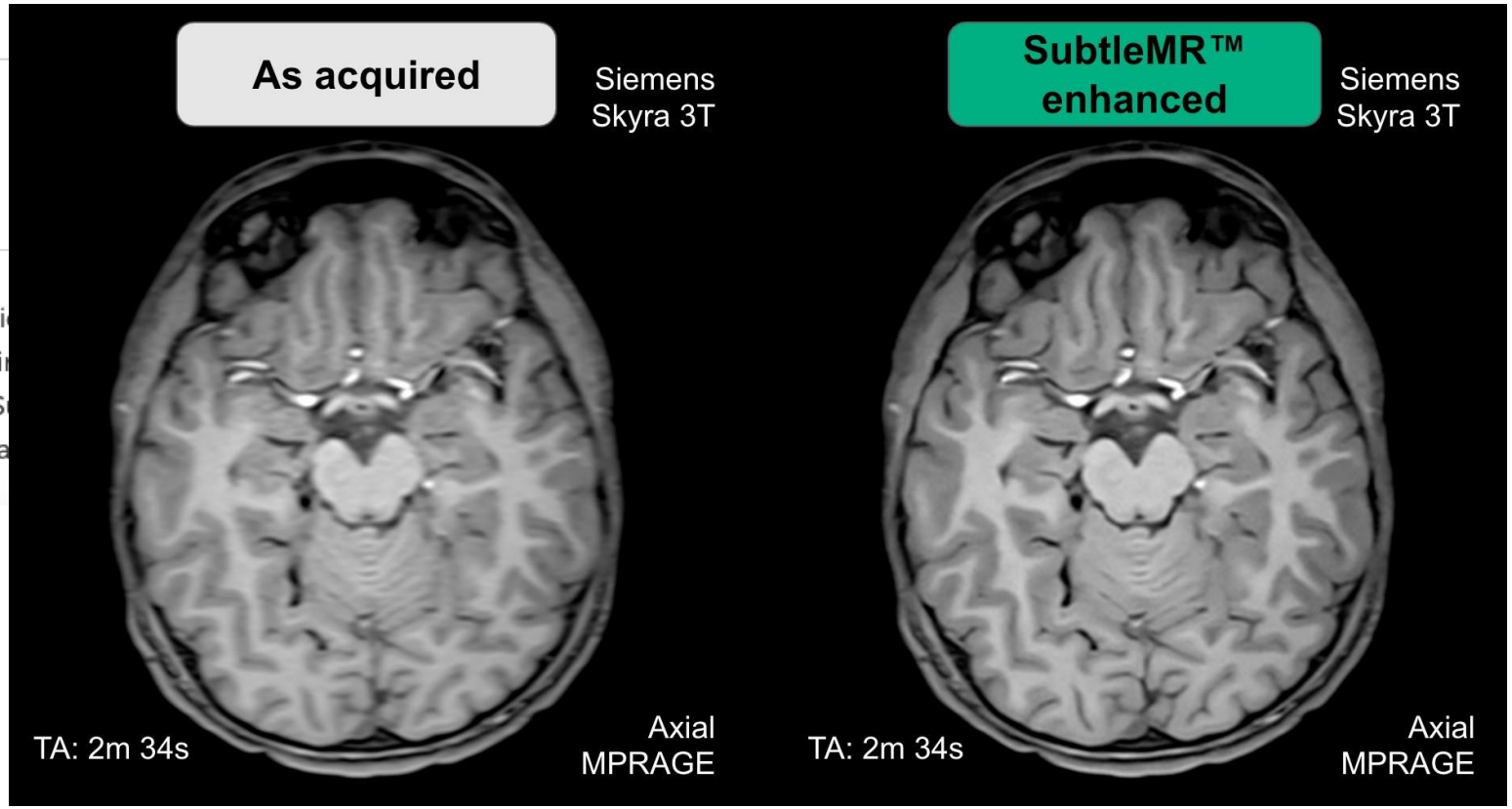
Subtle Medical Receives FDA 510(k) Clearance for AI-Powered SubtleMR™

SUBTLE MEDICAL

First AI Product Cleared for MRI Image Enhancement

NEWS PROVIDED BY
Subtle Medical, Inc. →
Oct 15, 2019, 08:12 ET

MENLO PARK, Calif., Oct. 15, 2019 /PRNewswire/ -- Subtle Medi
improving the quality, efficiency, and accessibility of medical i
Food and Drug Administration (FDA) to market SubtleMR™. S
denoising and resolution enhancement to improve image qua



Pathology

Health

Pathologists shortage 'delaying cancer diagnosis'

By Emma Forde
5 live Investigates

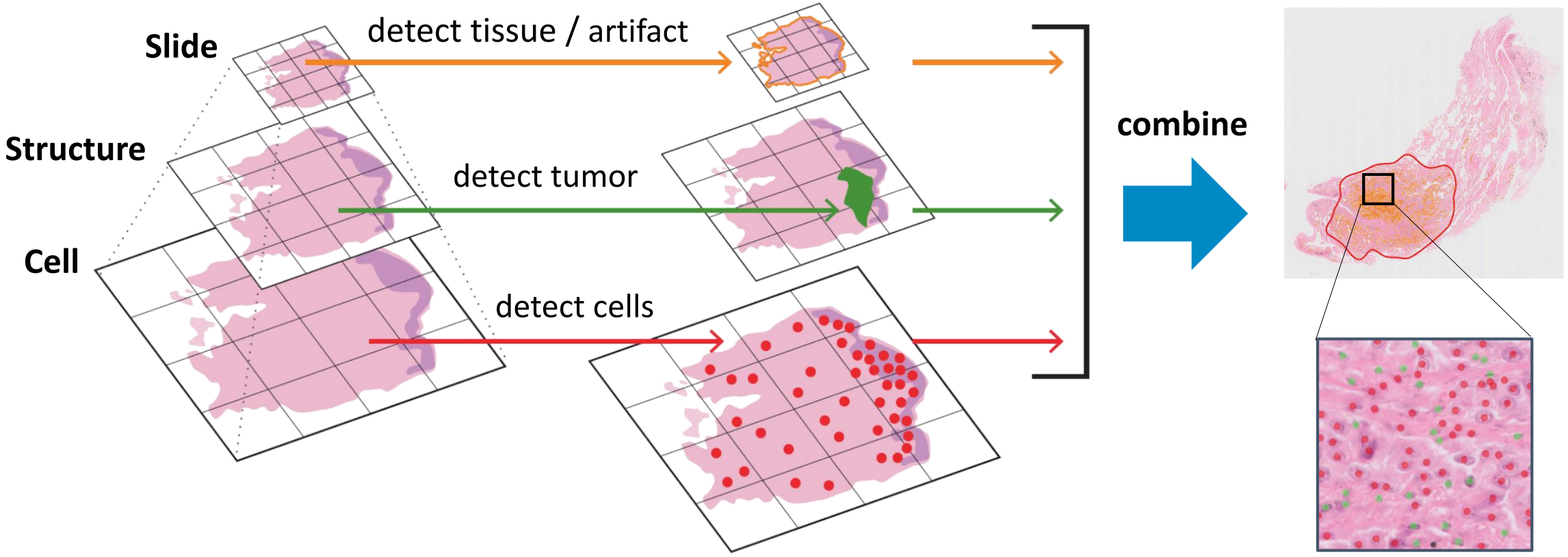
16 September 2018

Patients are facing delays in diagnosis because of severe shortages among pathology staff, according to a report seen by the BBC.

Digital pathology

Dr. Afschin Soleiman, Medical Director of the Pathology Institute at Tirol Kliniken in Innsbruck in Austria

Cancer detection system



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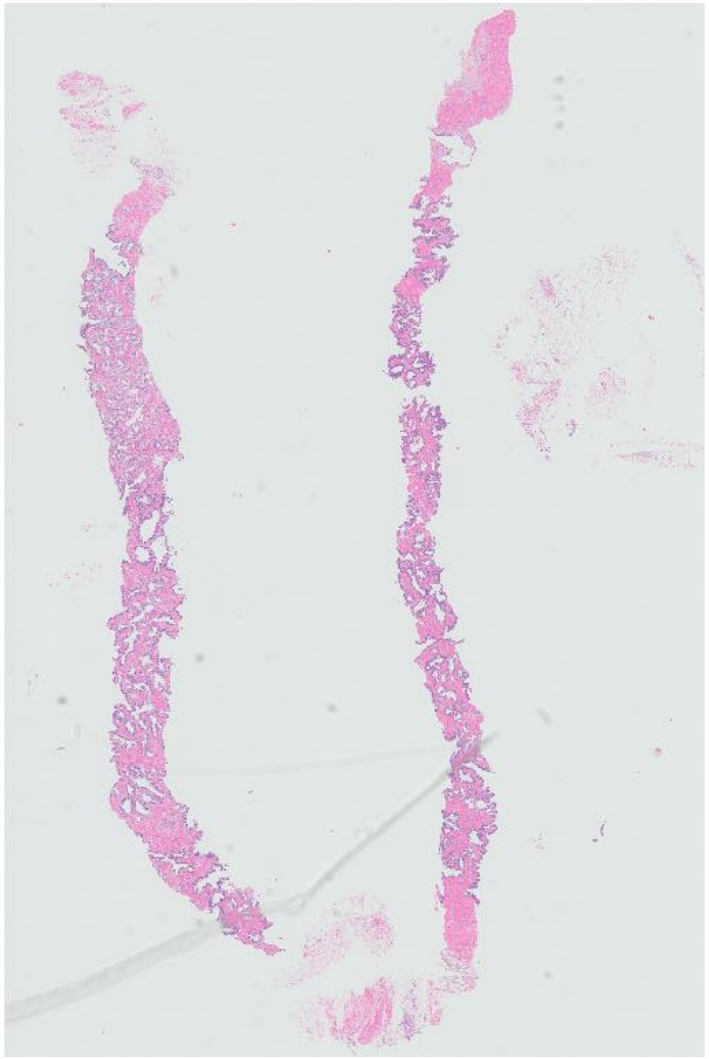
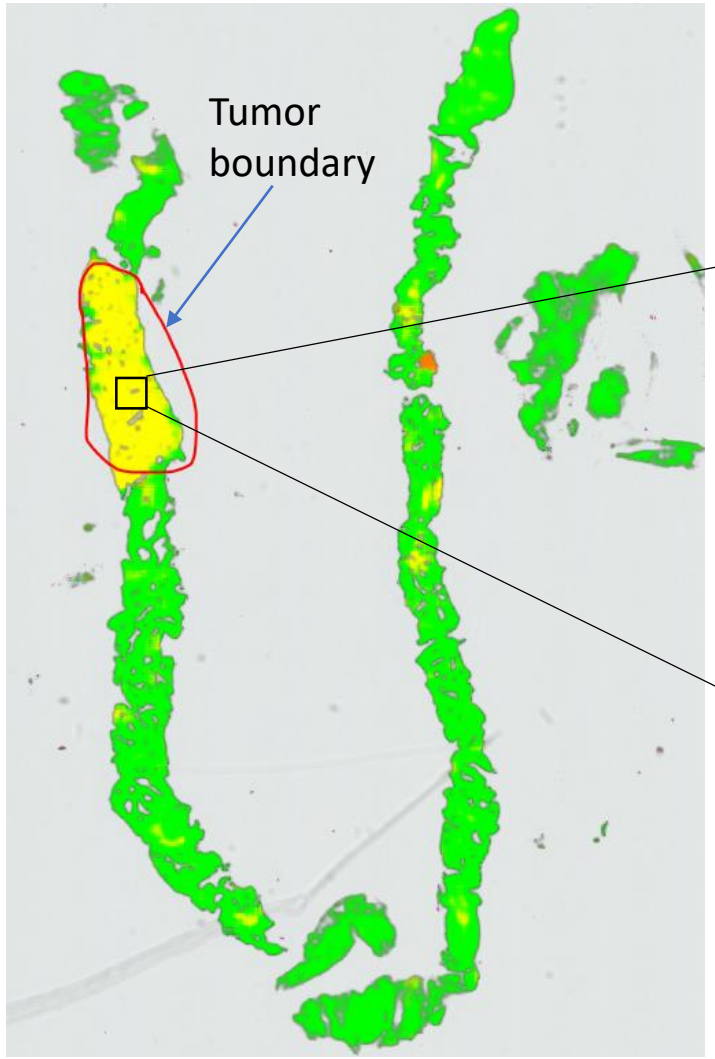
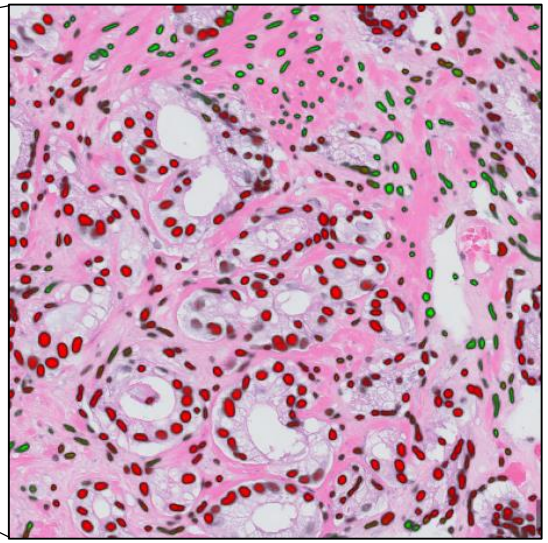
Example – Prostate Cancer







Gleason 3

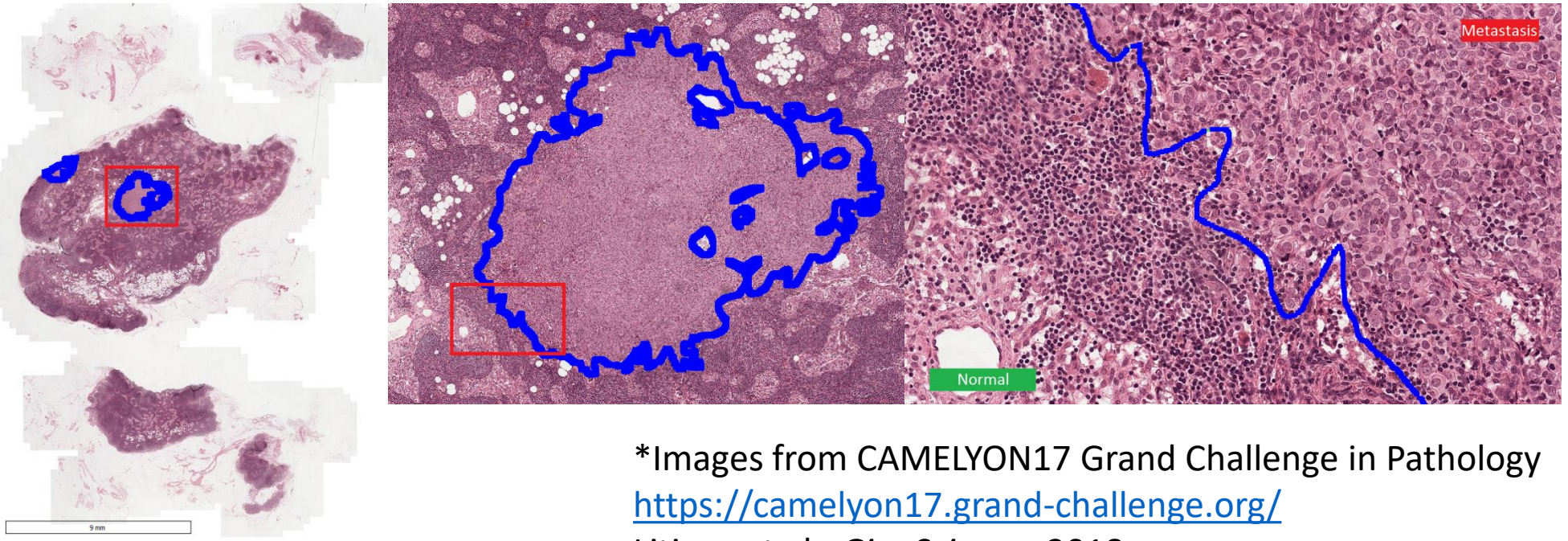
Gleason 4

Gleason 5

Non-Tumor

Deep learning and Data

Obtaining expert labels for training deep learning models is difficult, time-consuming, tedious, and costly.

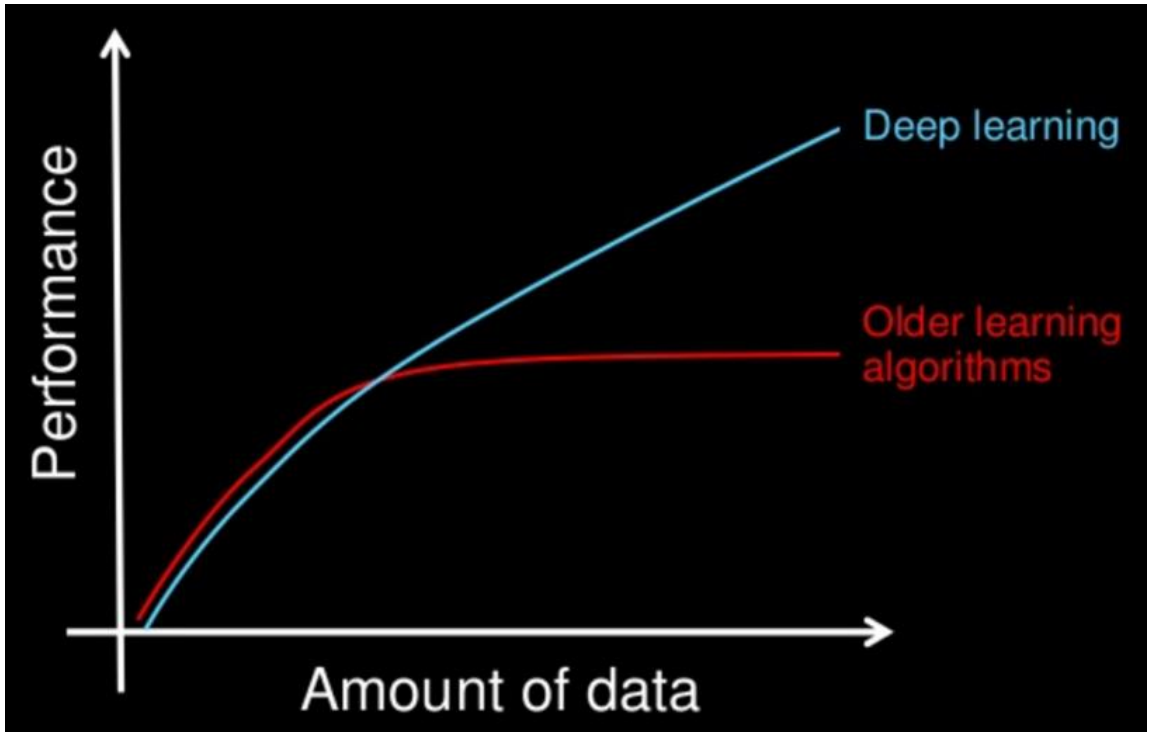


*Images from CAMELYON17 Grand Challenge in Pathology
https://camelyon17.grand-challenge.org/
Litjens et al., *GigaScience*, 2018

Deep learning and Data

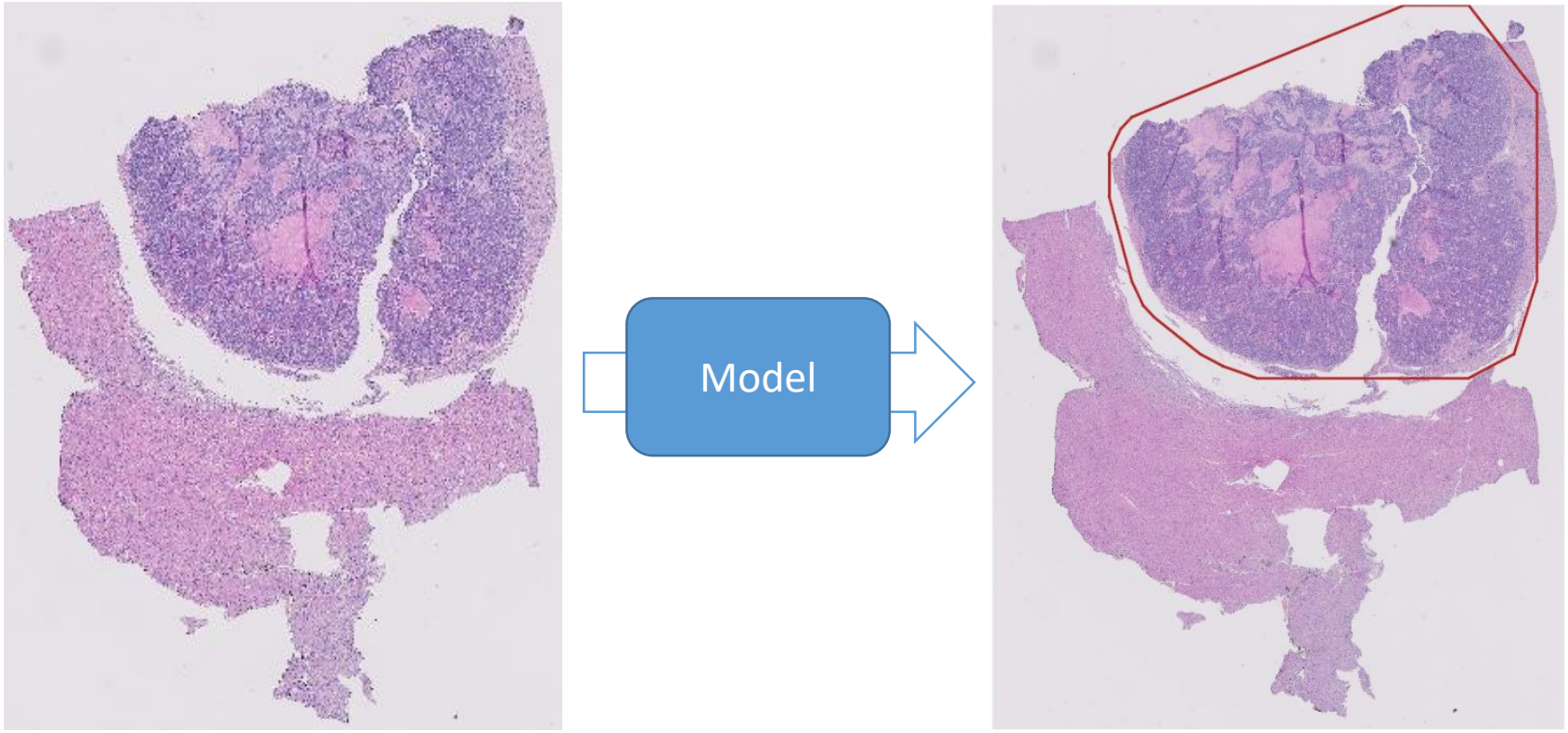
"The analogy to deep learning is that the rocket engine is the deep learning models and the fuel is the huge amounts of data we can feed to these algorithms."

– Andrew Ng (source: Wired)

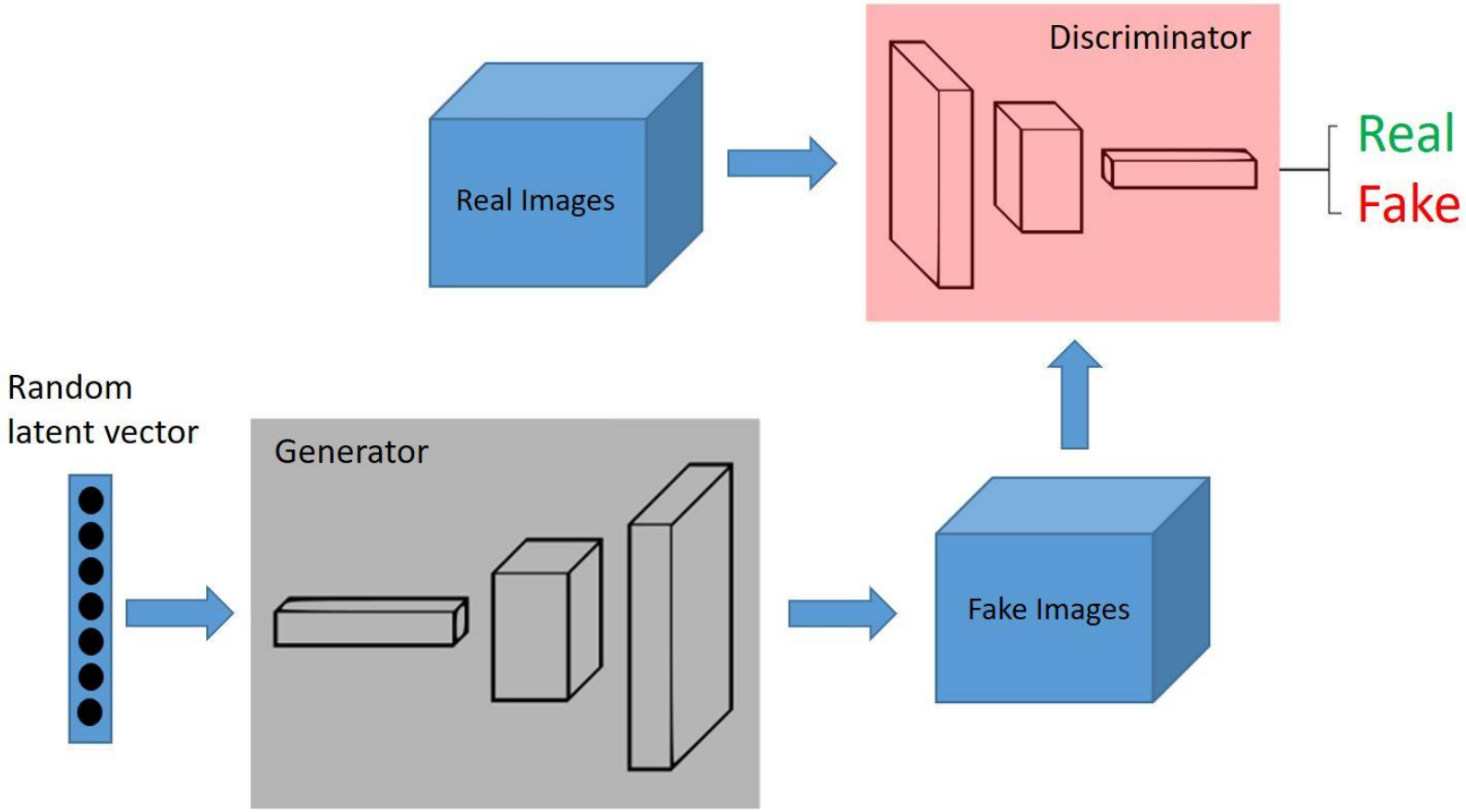


* Slide by *Andrew Ng*, all rights reserved.

Unsupervised learning



Generative Adversarial Networks (GANs)



Goodfellow et al., NIPS, 2014

Applications

Image generation

Impressive text to image results

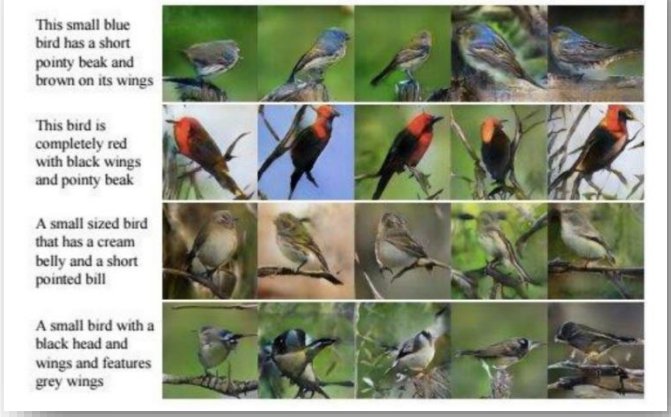
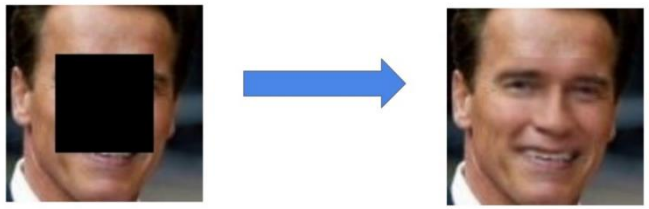


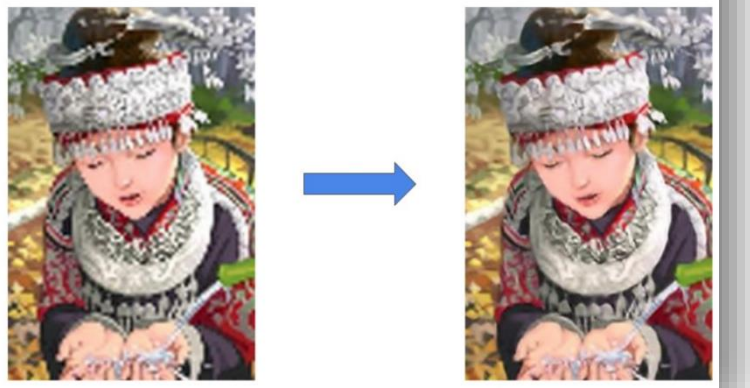
Image inpainting



Input to GAN

GAN generated output

Image super resolution using SRGANs



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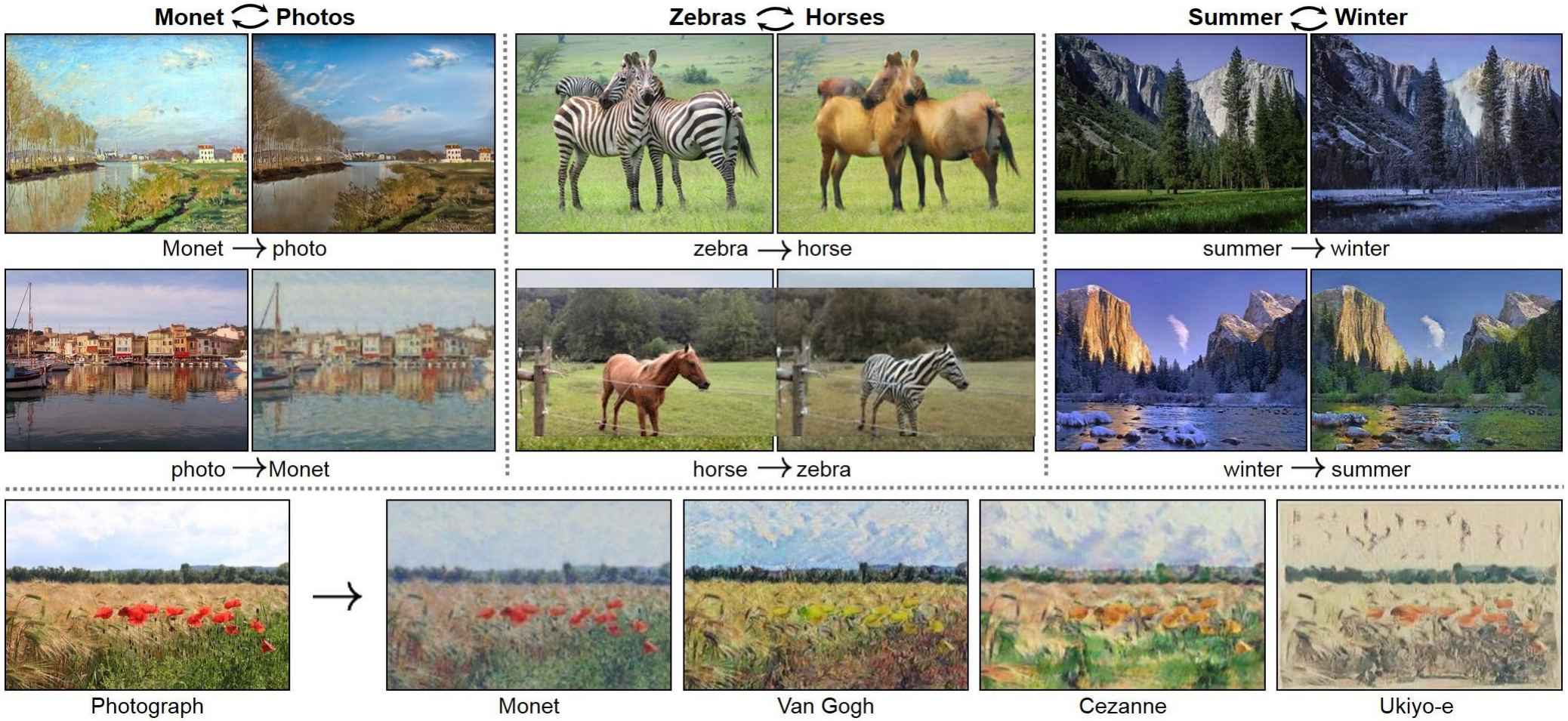
More applications …



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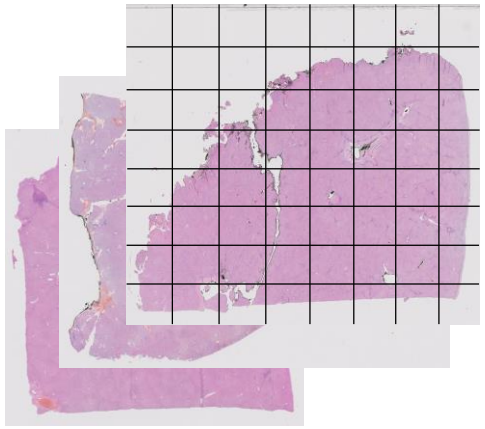
Anomaly Detection using GANs

Training



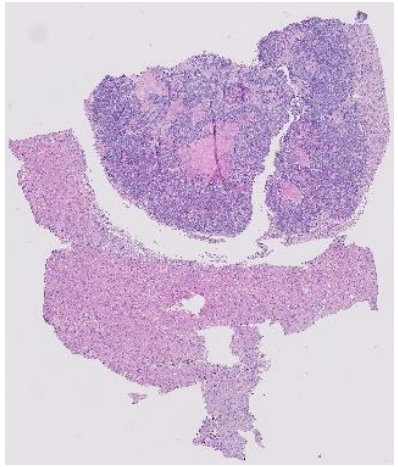
Normal/Healthy Data
'Unannotated'

GAN Model

Generator

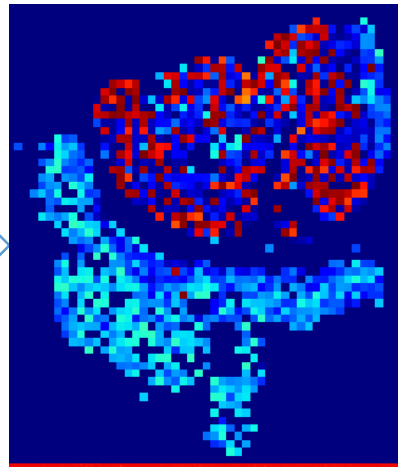
Discriminator

Identifying anomalies



Test Data

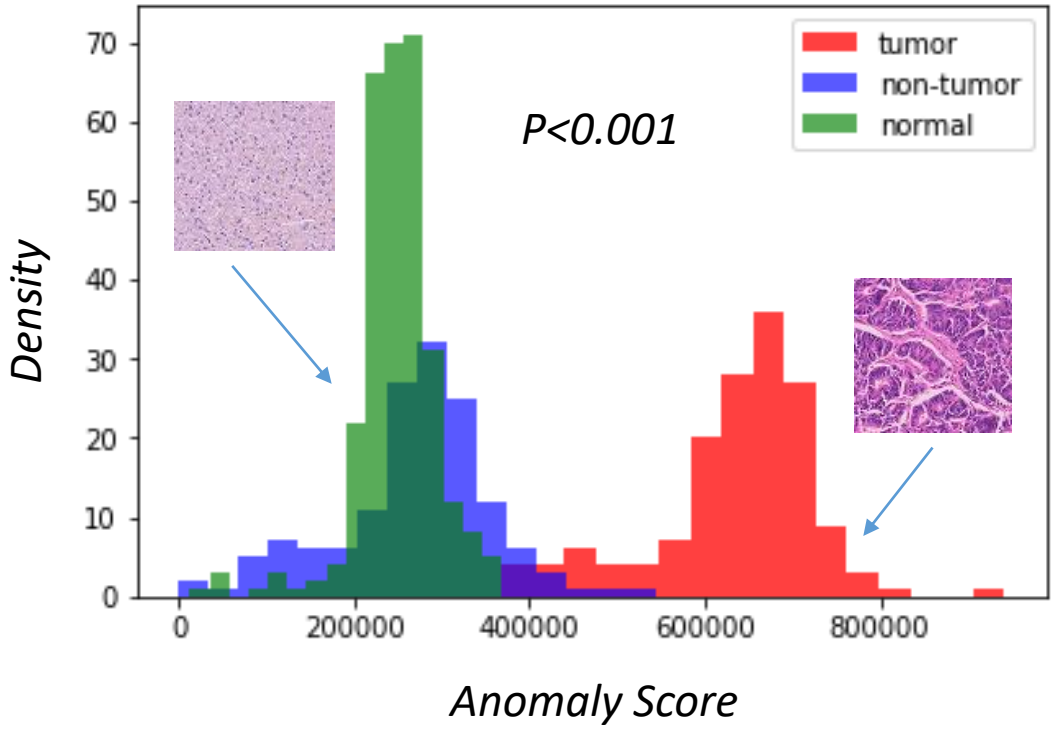
Model

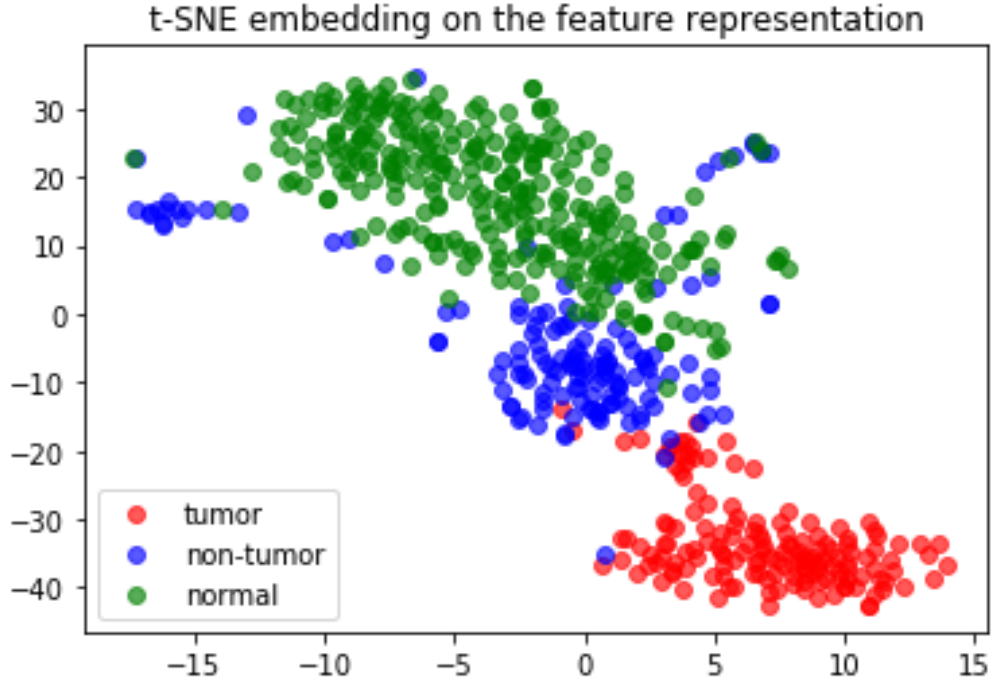


Anomalies

Serag et al., 2019

Distribution of anomaly scores





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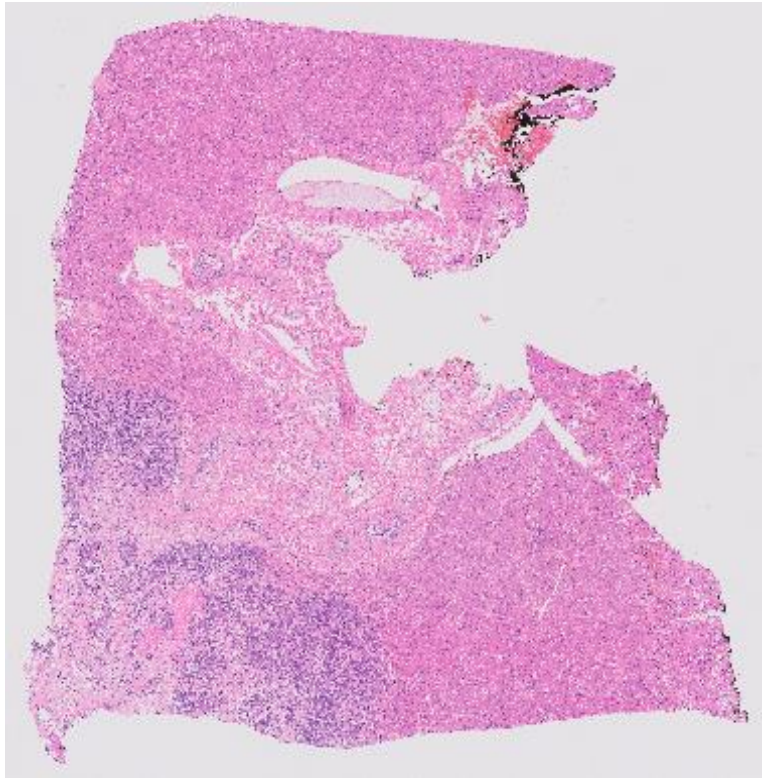
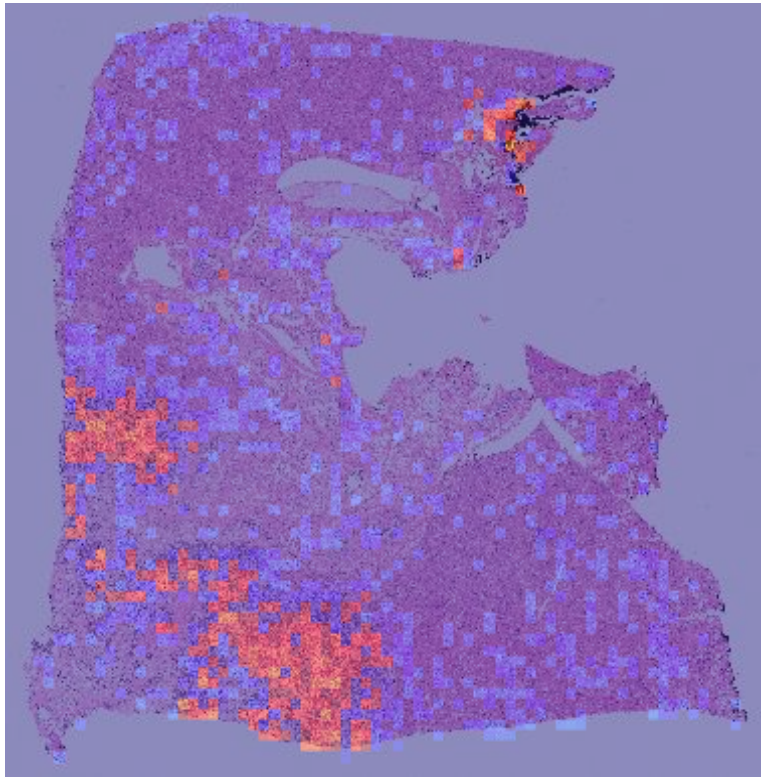
Whole slide processing



Slide



Slide with overlaid anomaly heat map

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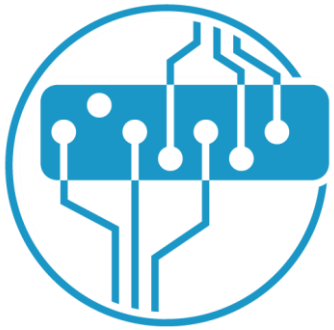
Challenges Ahead

Doctors not to fear AI
Doctors understand AI

Patients to trust AI

Ethics
Privacy
FDA Approval



Scalability of models (more data, acceptable runtime)
Easy ways to train models

Precision Diagnostics
(radiology, pathology, genomics)

Conclusions

- AI is getting increasingly sophisticated at doing what humans do, but more efficiently, more quickly and at a lower cost.
- The potential for AI in healthcare is vast. Ultimate benefits are improved health and lives saved.
- It would be necessary to address concerns over the privacy and protection of sensitive health data.
- The complexity of human biology and the need for further technological development also mean than some of the more advanced applications may take time to reach their potential and gain acceptance from patients, healthcare providers and regulators.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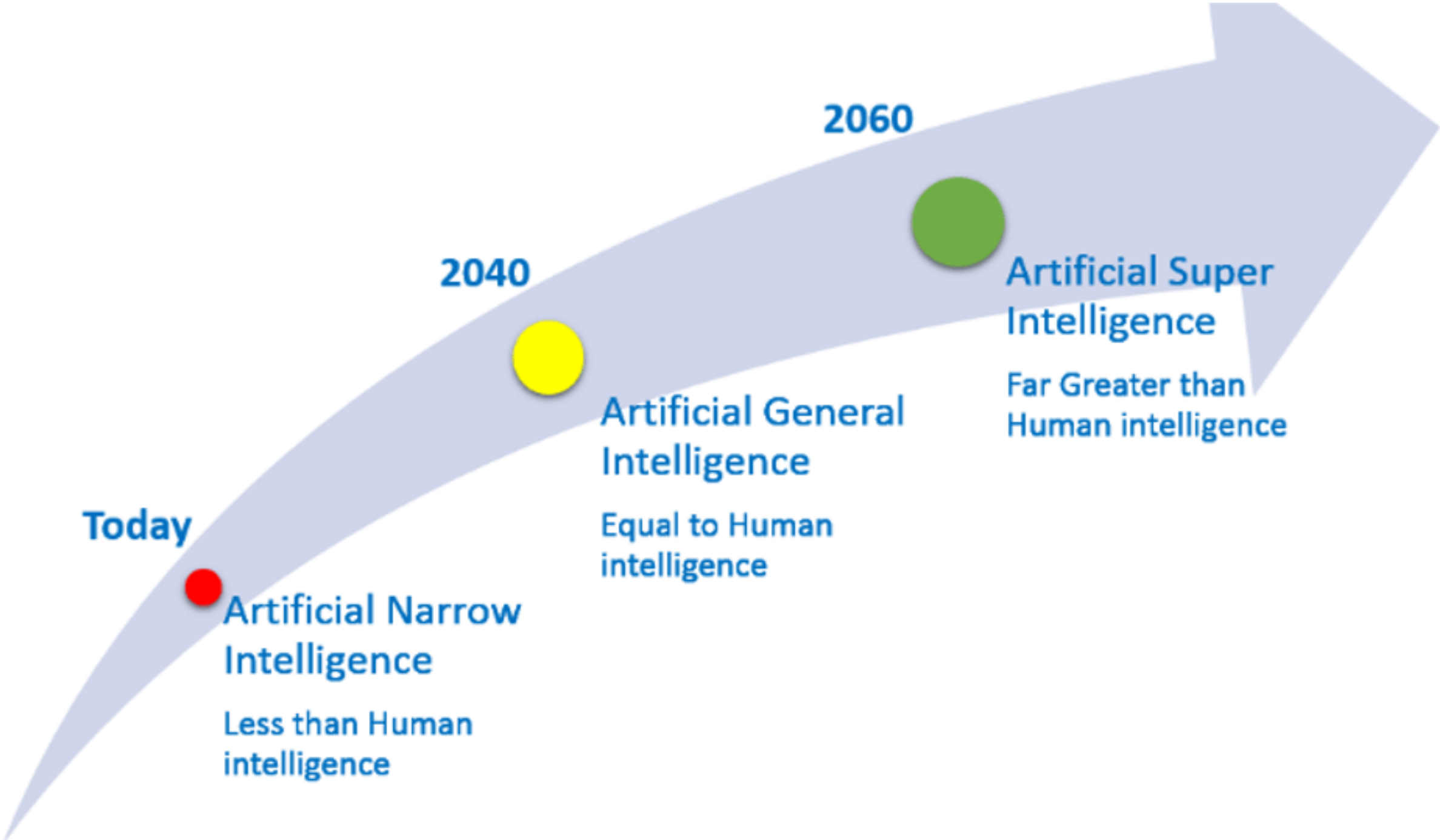
2060
2040
Artificial Super Intelligence
Far Greater than Human intelligence
Artificial General Intelligence
Equal to Human intelligence
Today
Artificial Narrow Intelligence
Less than Human intelligence