AI in Medical Imaging

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AI in medical imaging

- Imaging is a cornerstone of modern medicine
- Number of acquired images is exponentially increasing
- Acquired images are larger and more detailed

- Shortage of experts → Increasing workload

- Artificial intelligence can automate image interpretation and alleviate the problem!

Basics of AI

Computer Analysis of Medical Images

- Rule-based analysis (1970-)
  - Decision making of an expert was translated into algorithm (Modelling)

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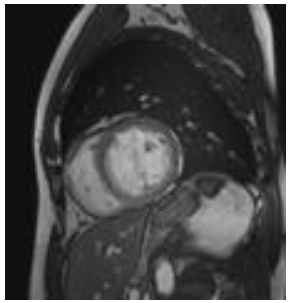
  - Algorithms were trained by examples
  - Among them are **statistical classifiers**

Machine learning

Input



Intensity value
Texture filters
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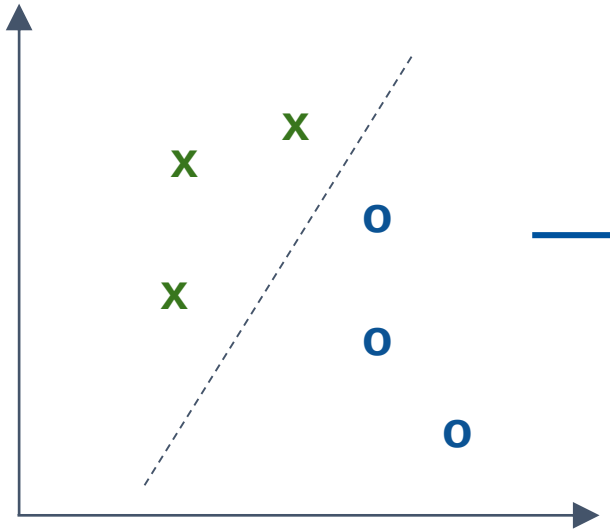

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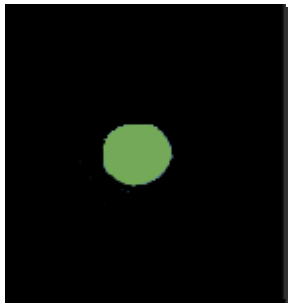

Why is this not trivial?

But then…

Computer Analysis of Medical Images

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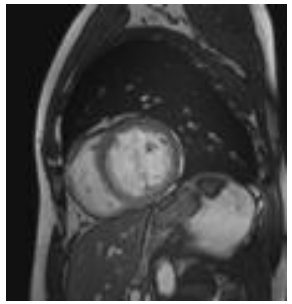
- Deep learning systems (1980 -)
  - Algorithm learns directly from the data
  - Based on neural networks
  - Applied to medical images since 1995; Became popular 2012

LitjensG. et al. Med Image Anal. 2017;42:60-88
Fukushima K. Biol. Cybern 1980;36(4):193-202.
LeCun Y. et al. In Proceedings of the IEEE; 1998;86(11):2278 - 2324

Machine learning

Input



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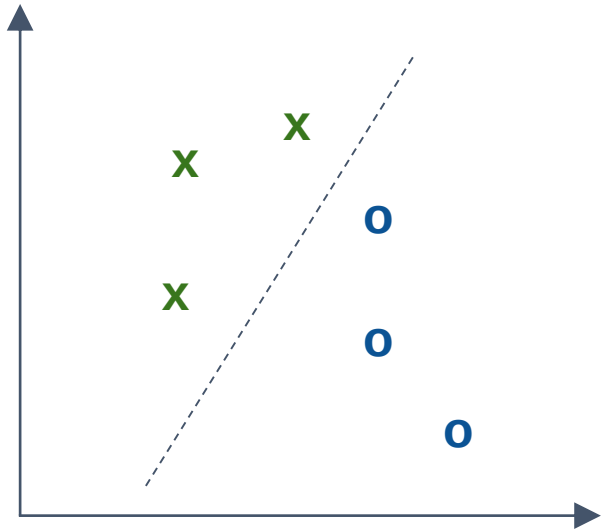

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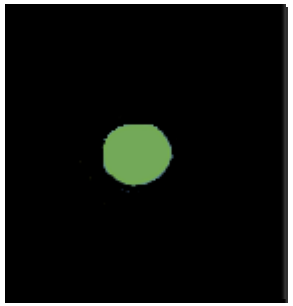
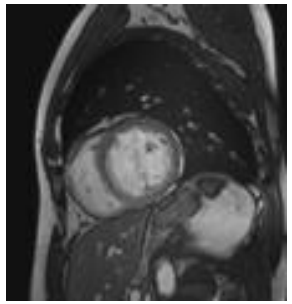


Machine learning

Input



Intensity value
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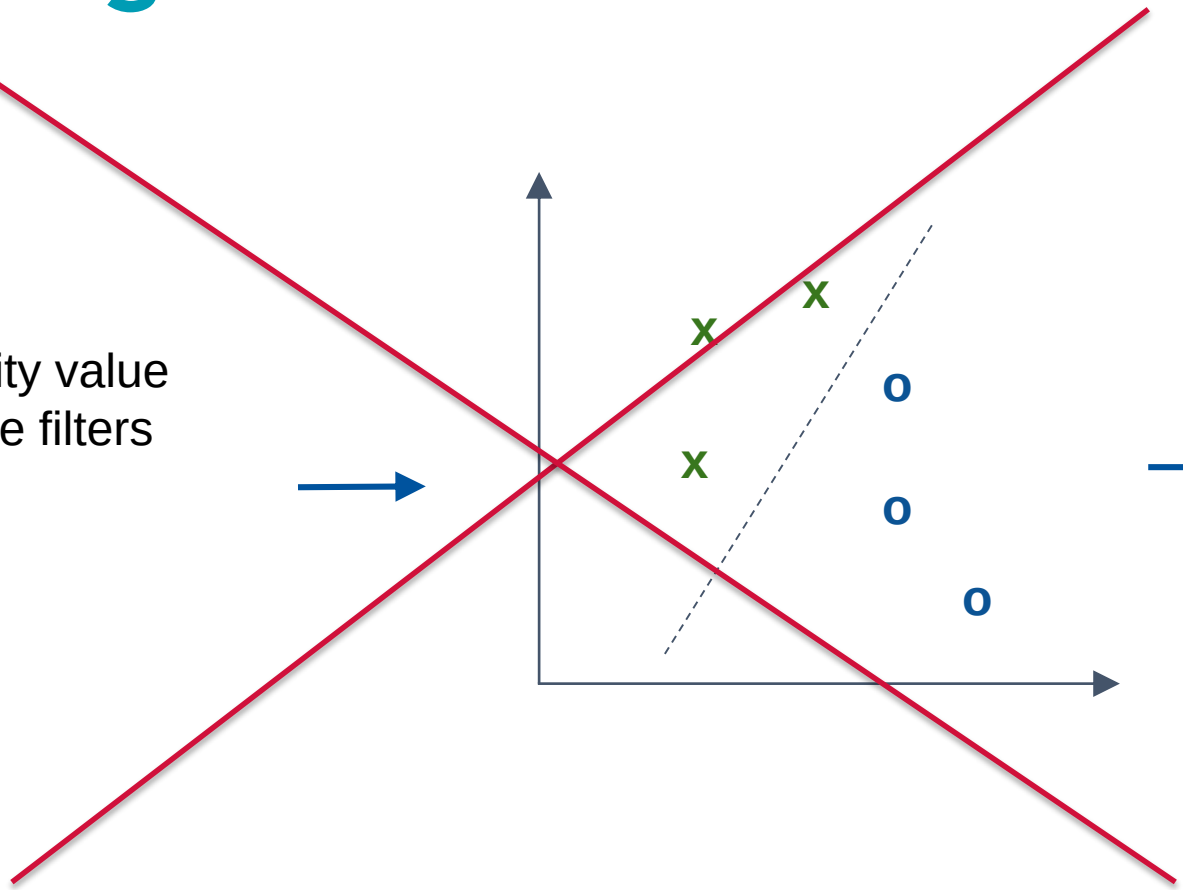

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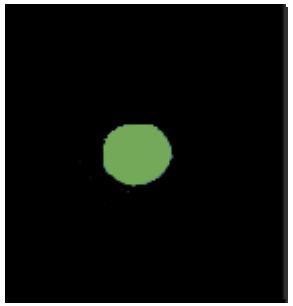
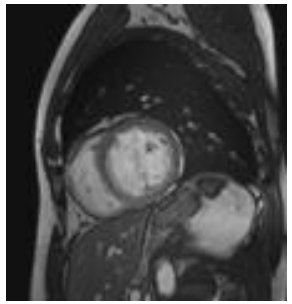
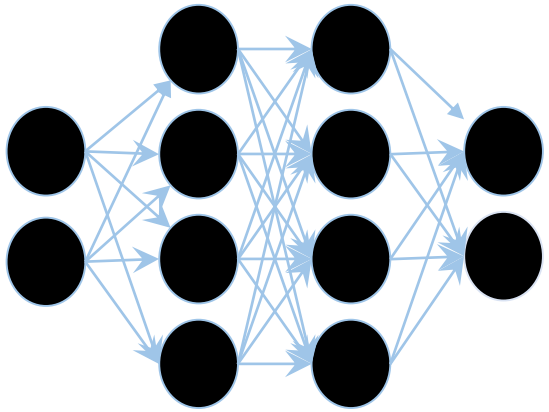


Deep learning

Input



Deep learning



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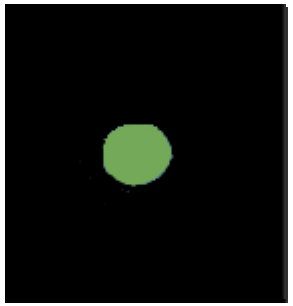
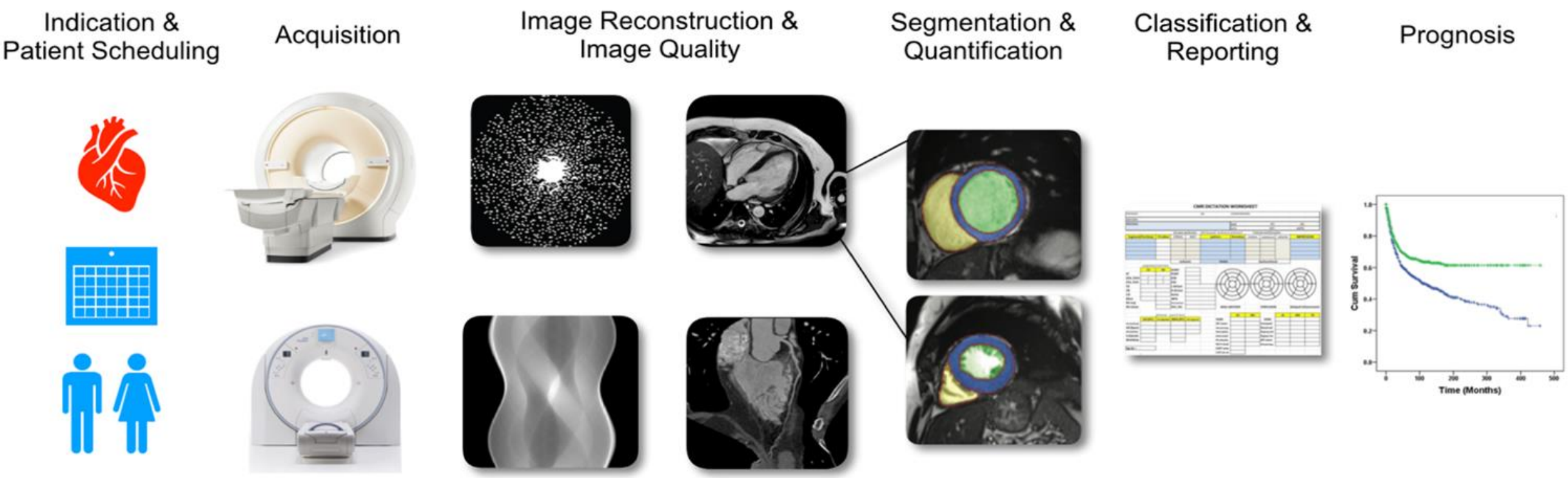


Medical Imaging



AI can impact all these steps

Figure courtesy Tim Leiner

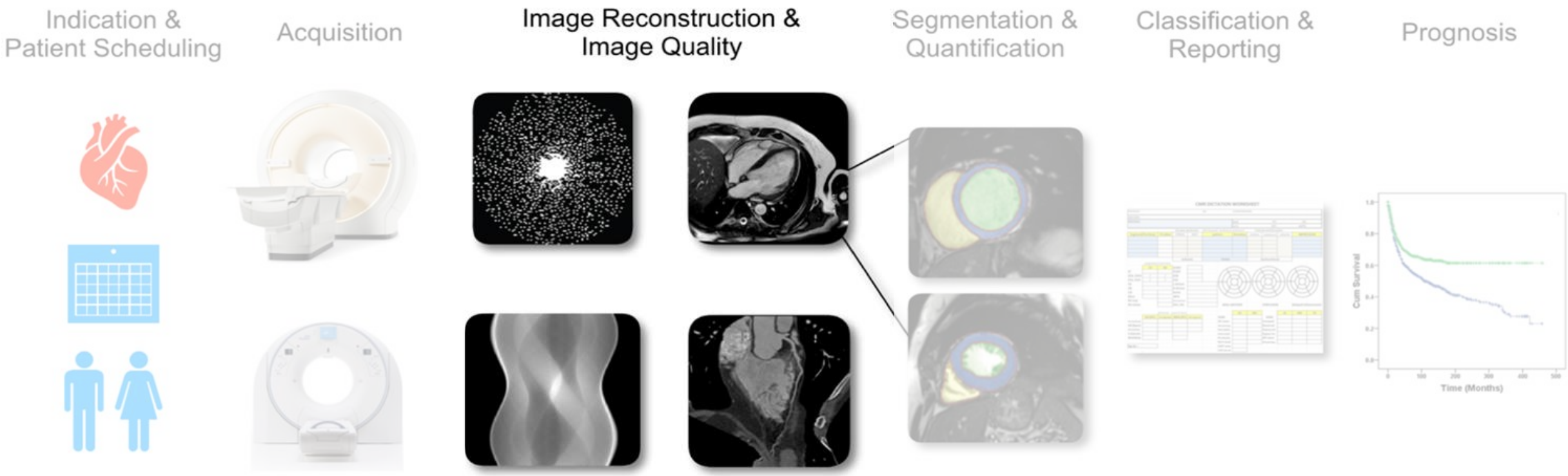


Image reconstruction

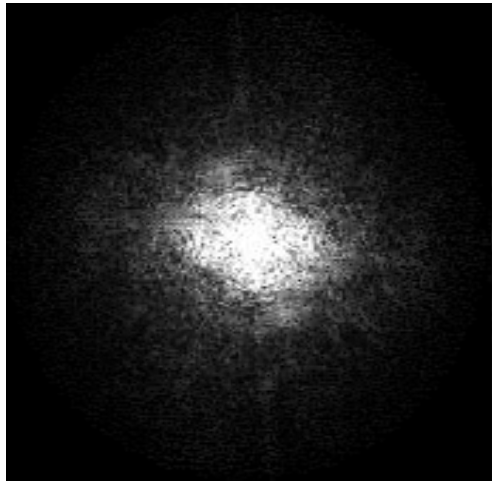
Figure courtesy Tim Leiner

Image acquisition & reconstruction

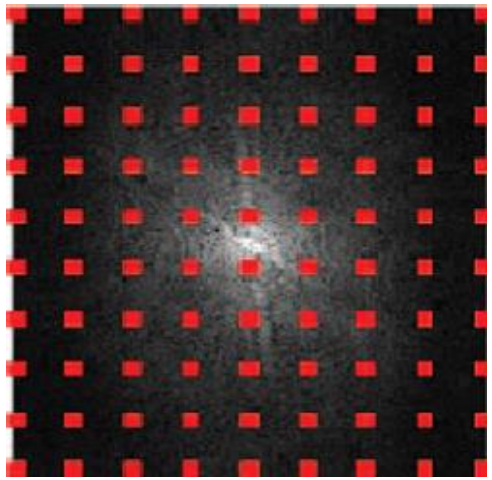
AI can be used to

- Accelerate image acquisition
- Improve image quality
- Omit (unnecessary) acquisition through image synthesis

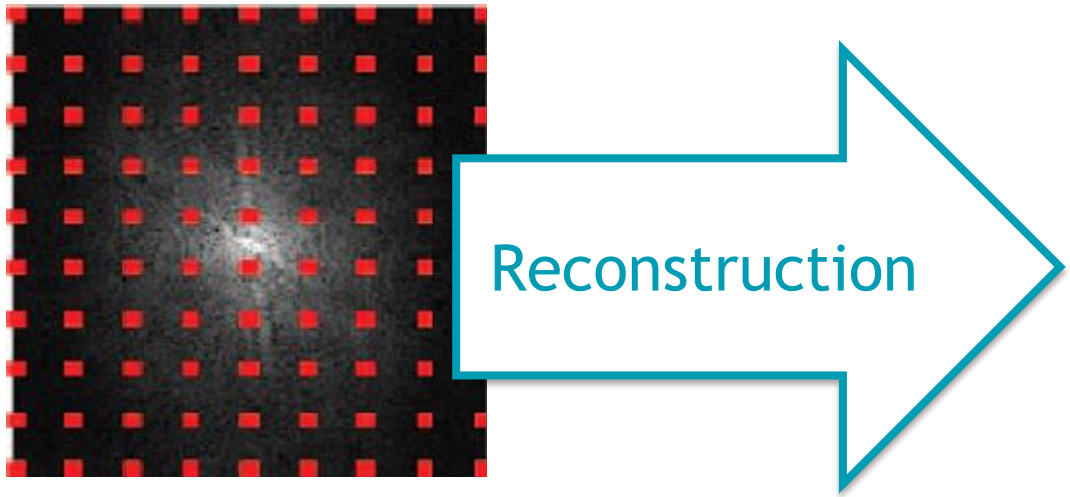
Accelerating MR reconstruction



Accelerating MR reconstruction



Accelerating MR reconstruction



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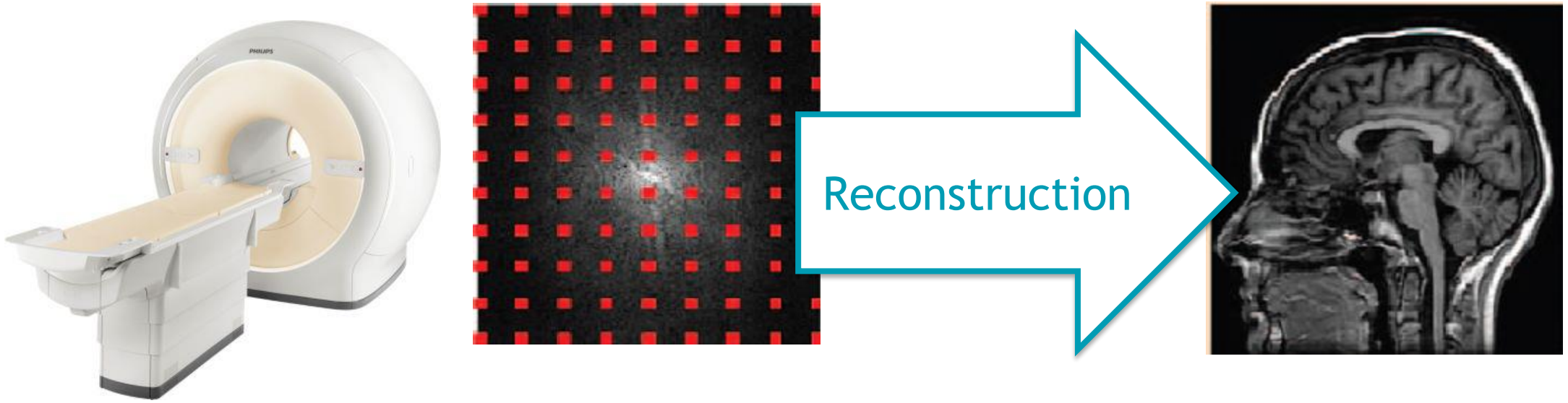
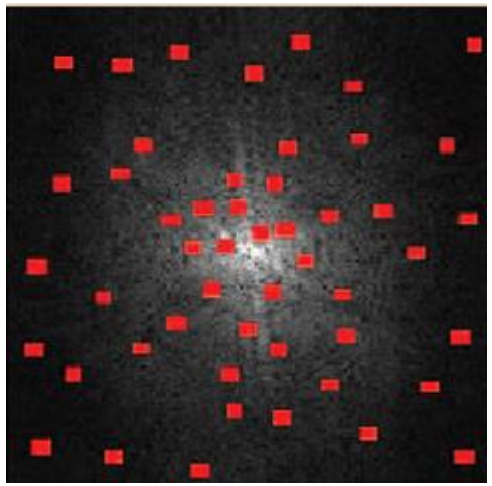
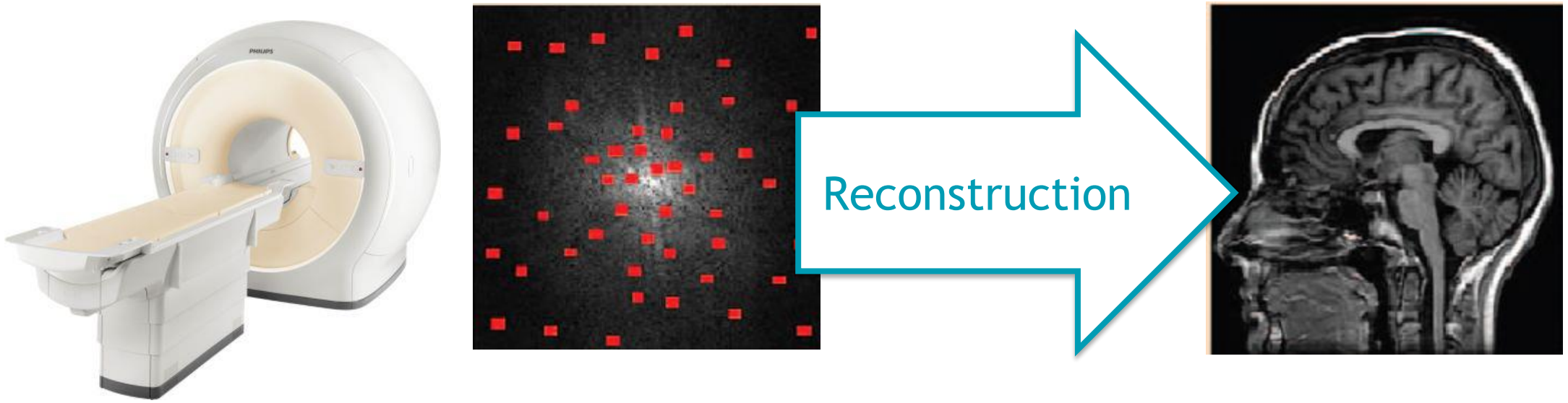


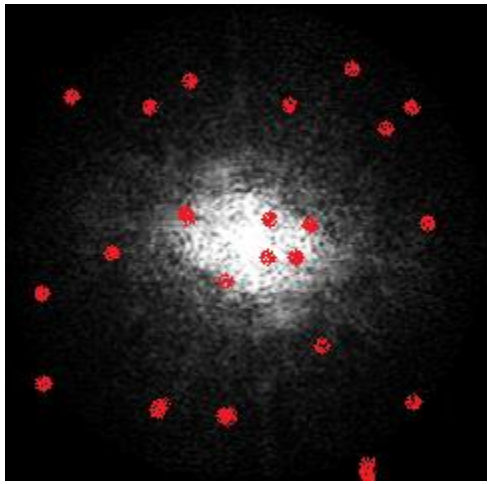
Accelerating MR reconstruction



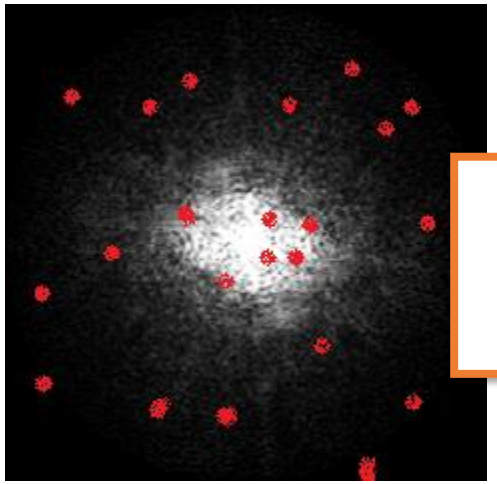
Accelerating MR reconstruction



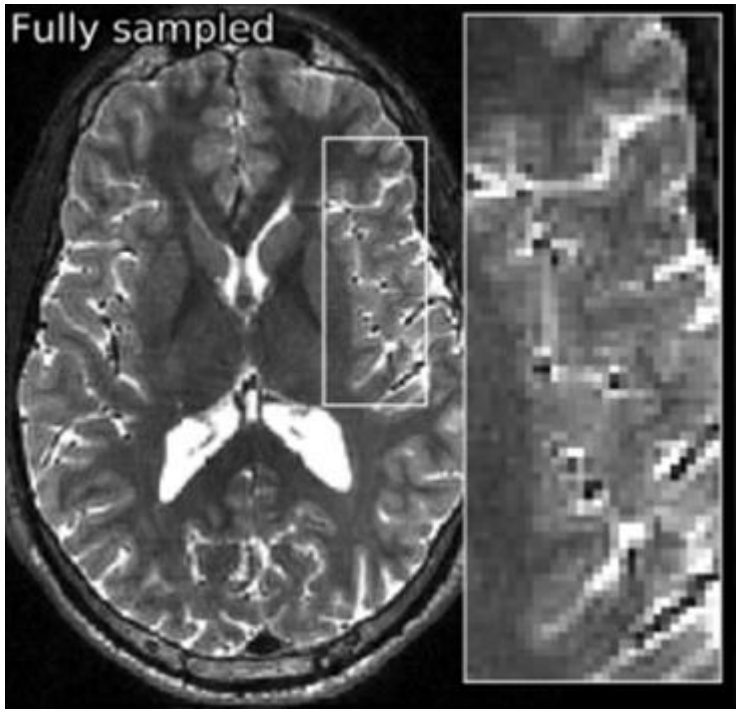
Accelerating MR reconstruction

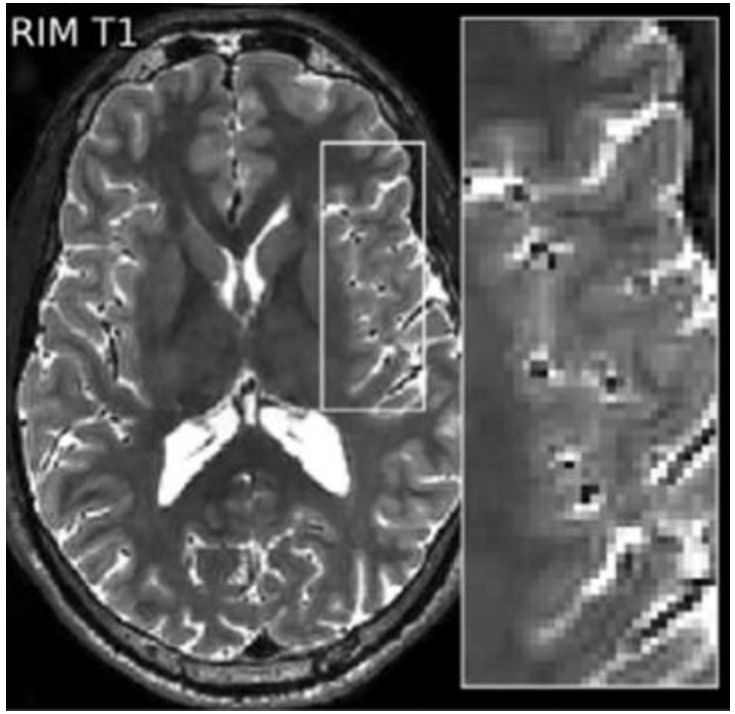


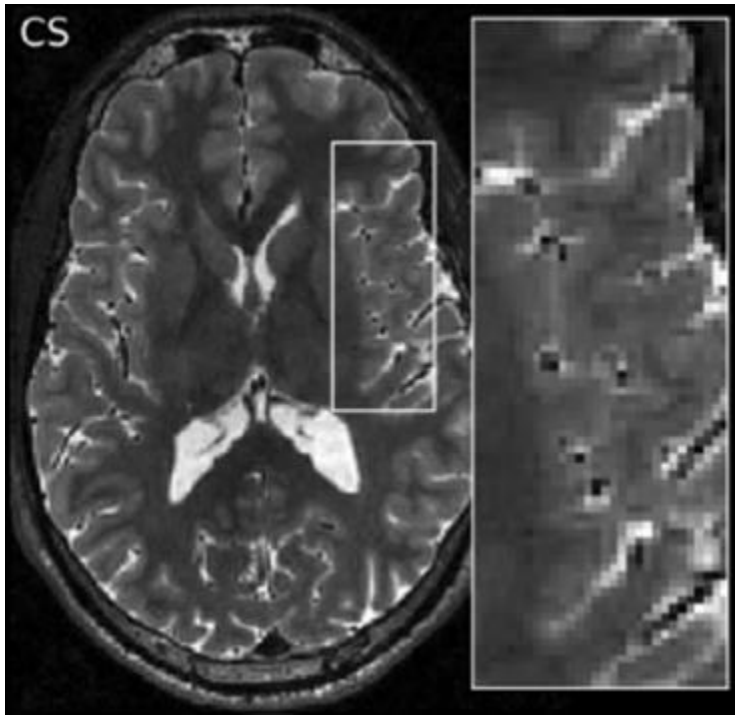
Accelerating MR reconstruction



Deep Learning







Prospectively undersampled 3D-TSE (12x)

Lønning K et al, Med Image Anal. 2019 Apr;53:64-78; Illustration courtesy of Matthan Caan, Amsterdam UMC

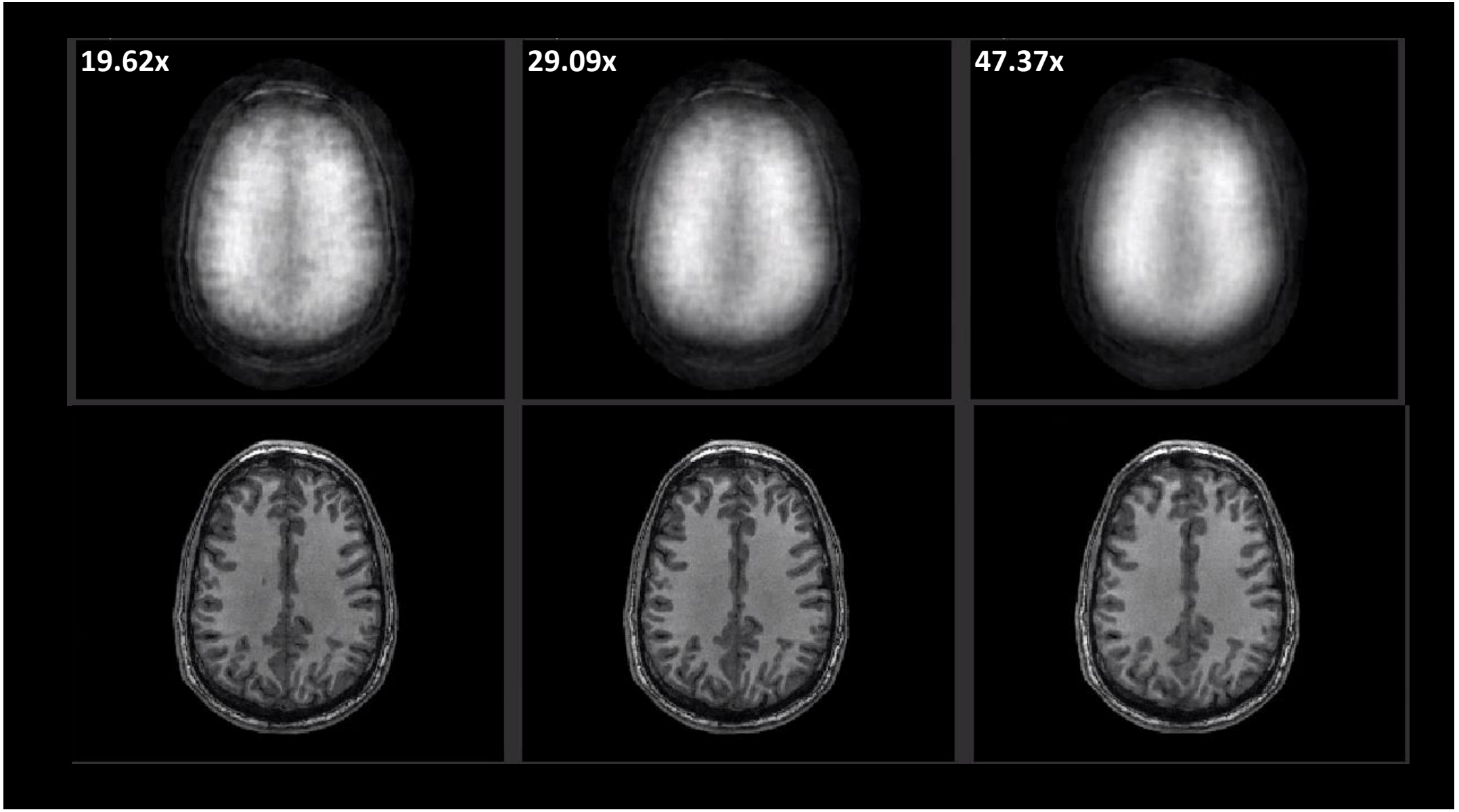
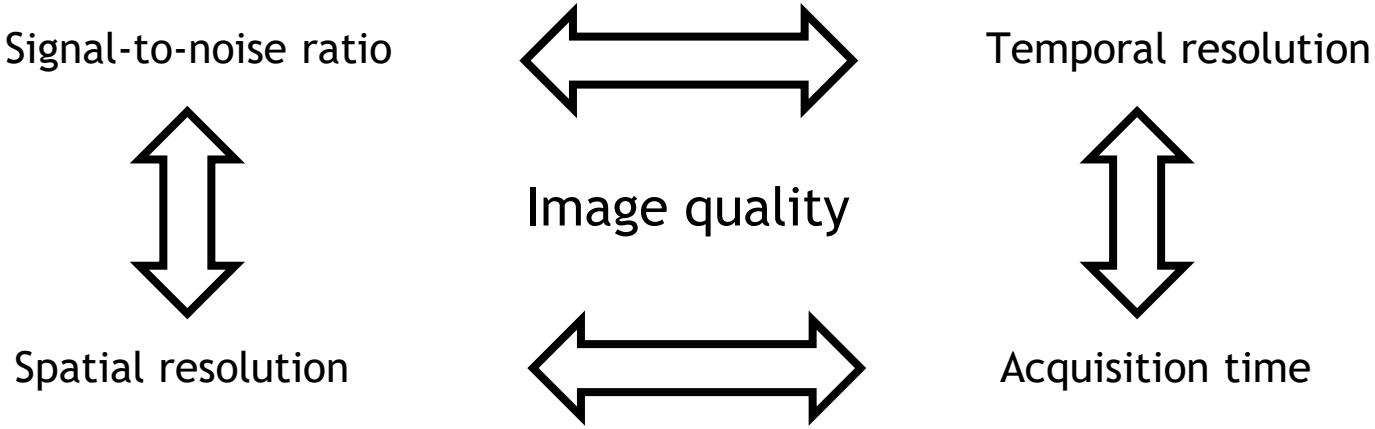


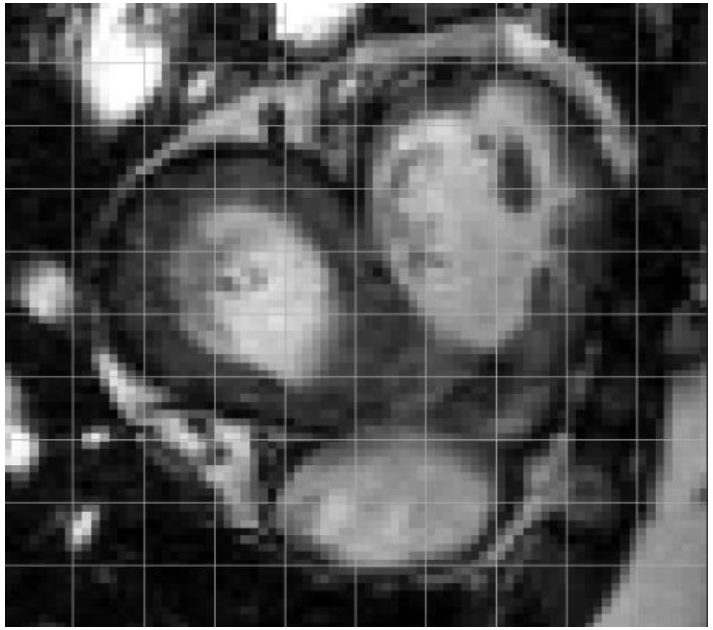
Figure courtesy D. Karkalousos, Amsterdam UMC

MRI resolution

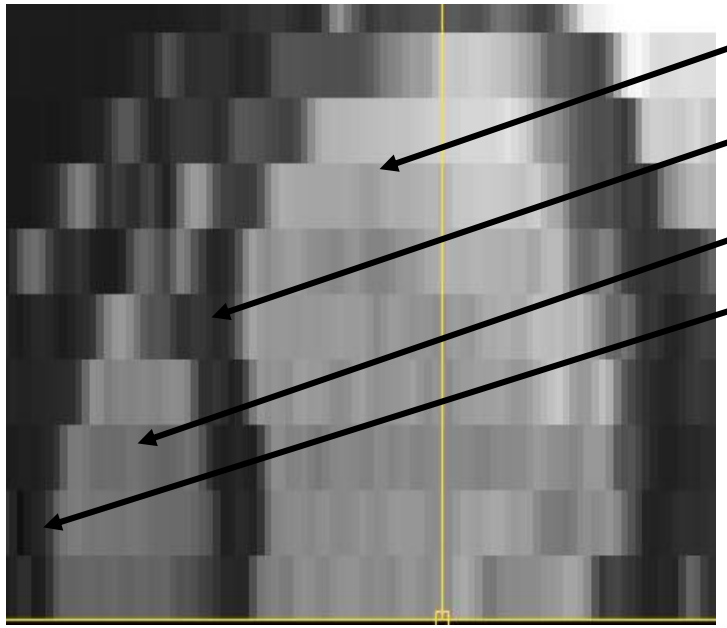
High spatial resolution of medical imaging is considered a key quality component for accurate disease diagnosis and prognosis



Cardiac MRI: Image resolution



In-plane

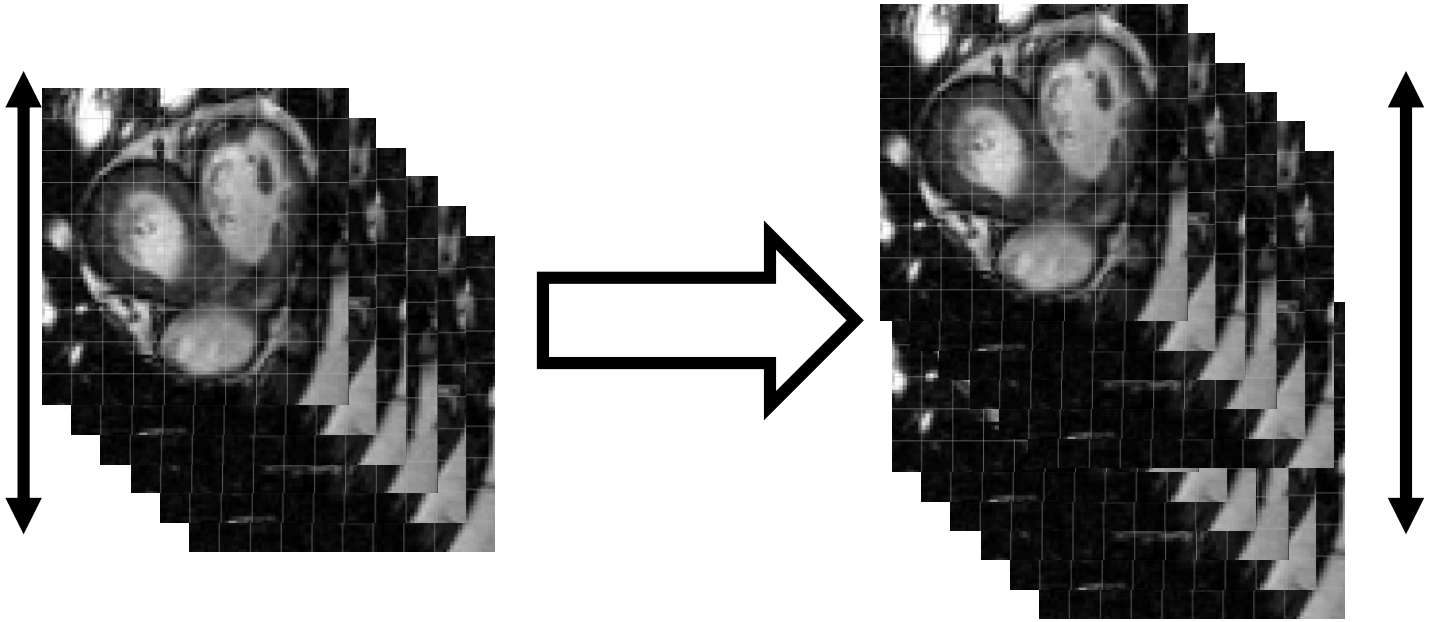


Through-plane

J Sander et al Med Image Anal. 2022 May;78:102393.

Image resolution

Low-resolution through-plane

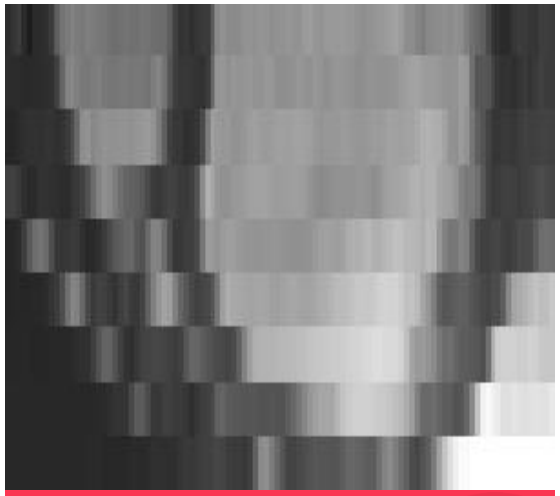


High-resolution through-plane

Super-Resolution methods

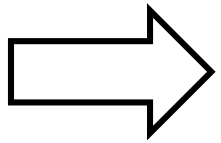
J Sander et al Med Image Anal. 2022 May;78:102393.

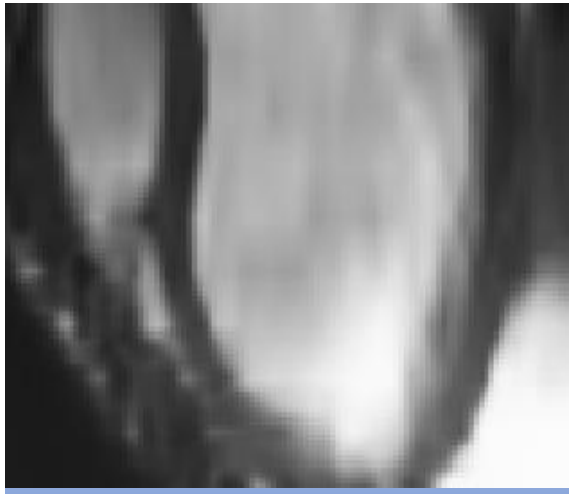
Super-resolution



Original

Low through-plane resolution



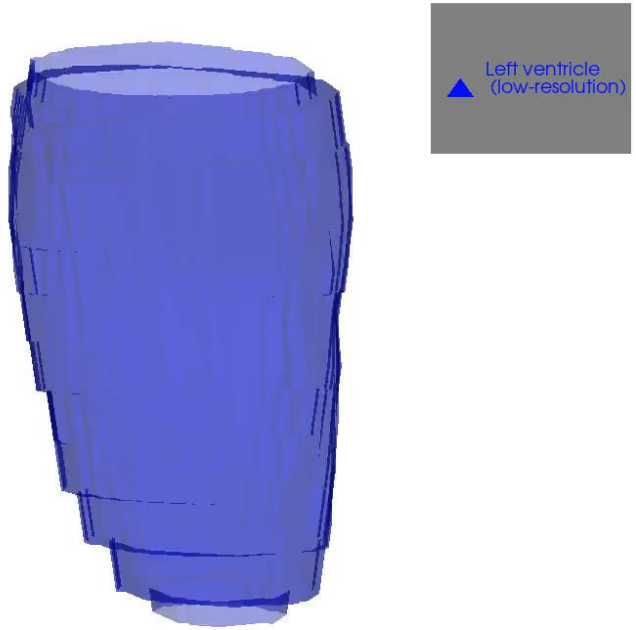


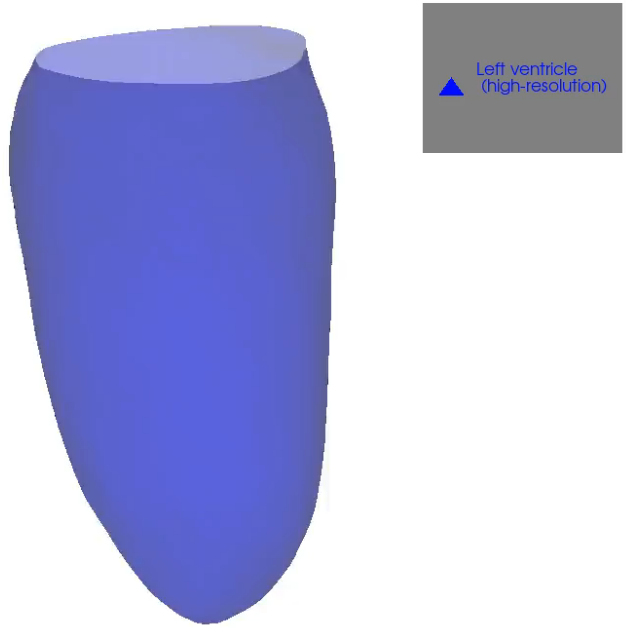
Super-resolved

High through-plane resolution

J Sander et al Med Image Anal. 2022 May;78:102393.

Super-resolution





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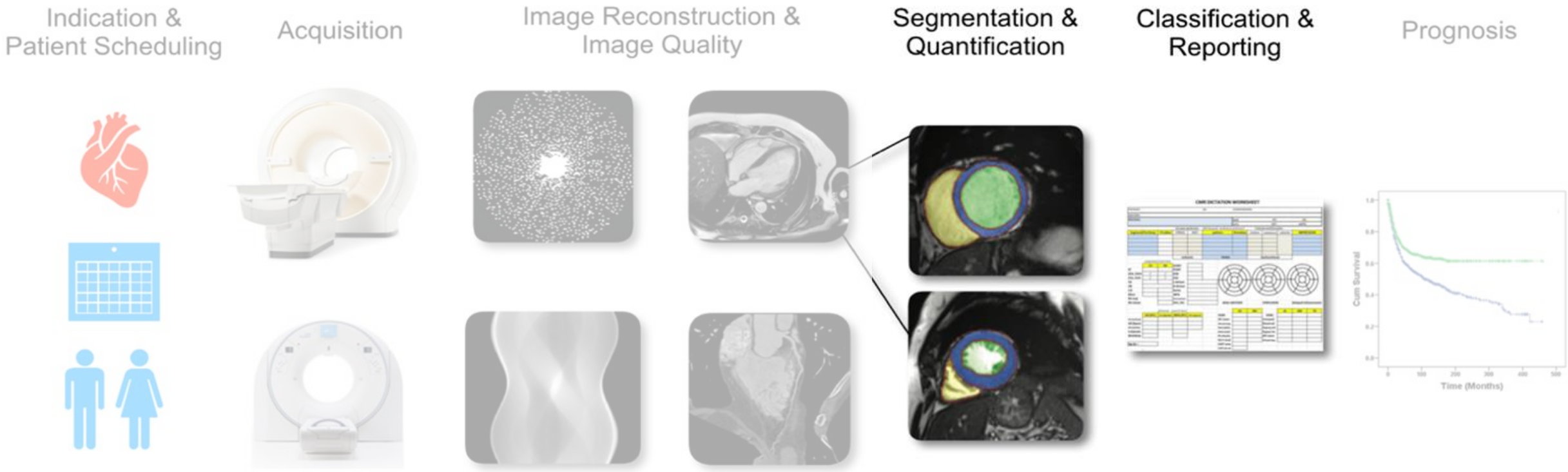


Image analysis

Figure courtesy Tim Leiner

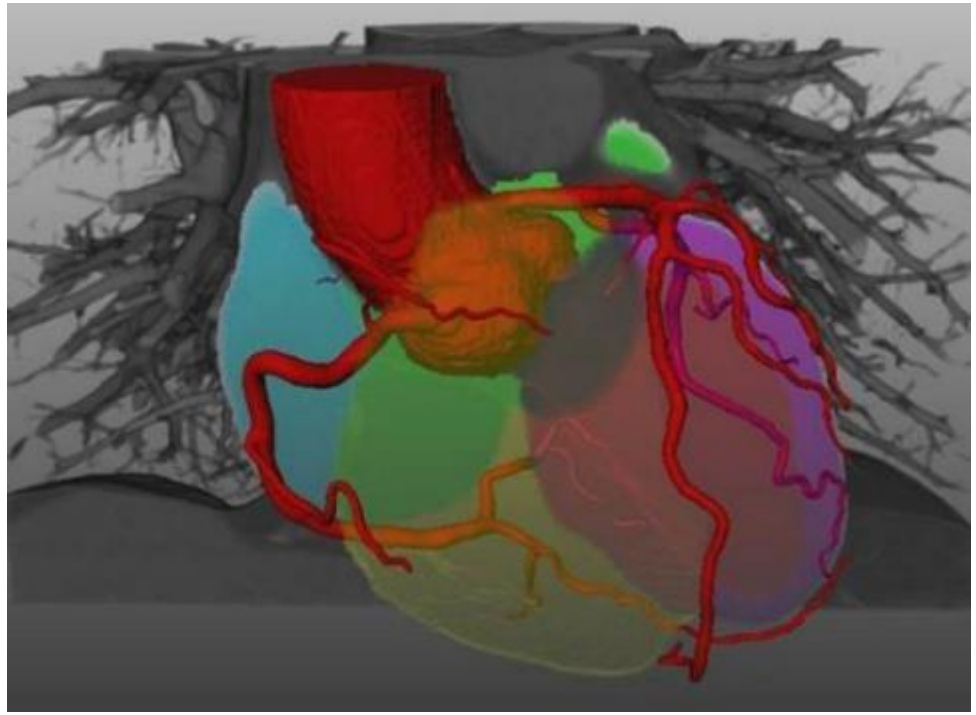
Image analysis

- Detection and segmentation are used to
  - Quantify image (bio)markers for diagnosis and prediction
  - Time-consuming, cumbersome, and prone to intra- and interobserver variability

- AI can be used to automate to automate the process
  - For routinely performed analysis tasks
  - To allow research

Coronary artery analysis in CTA

- Coronary artery analysis
  - Atherosclerotic plaque is predictor of heart infarction
  - Some plaques need treatment
- Morphology analysis and function
  - Analysis of cardiac chambers and large arteries indicates presence of range of pathologies
  - Cardiac function important diagnostic and prognostic indicator



Coronary artery analysis in CTA

To automatically extract and label coronary arteries to facilitate further analysis of the arteries

Coronary artery analysis in CTA

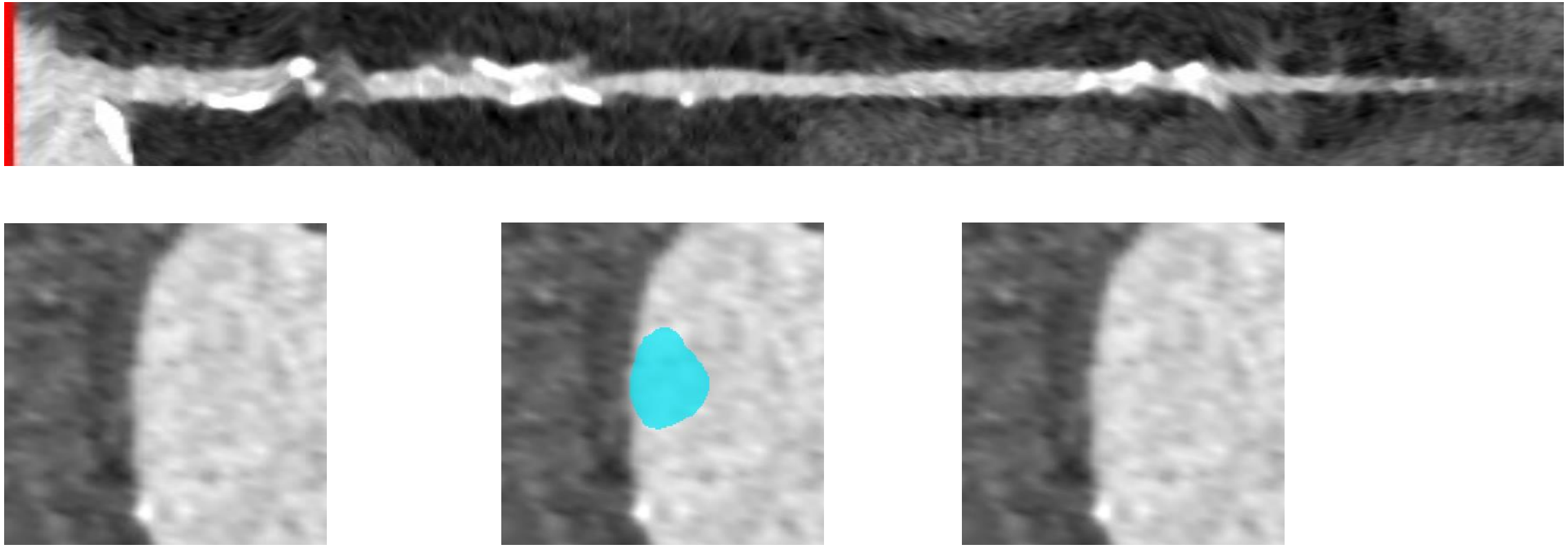
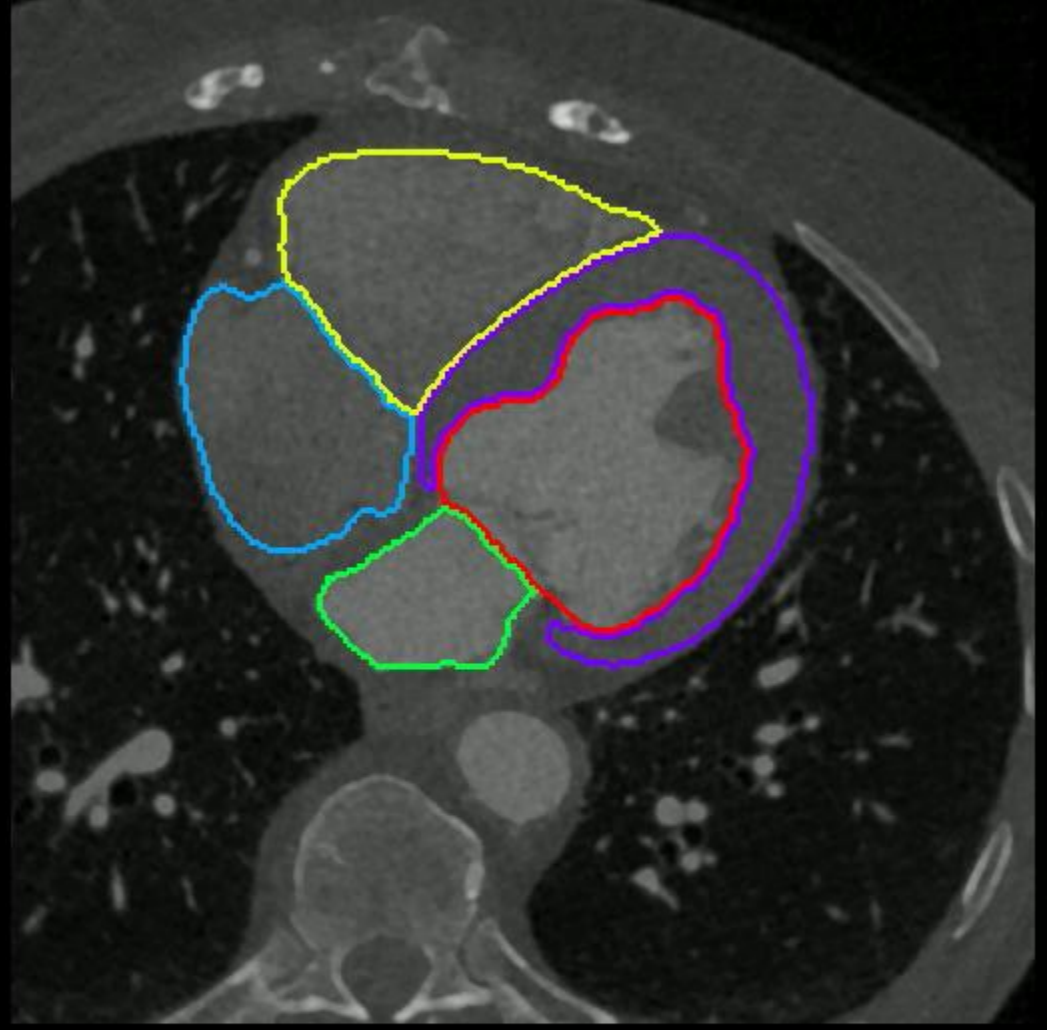
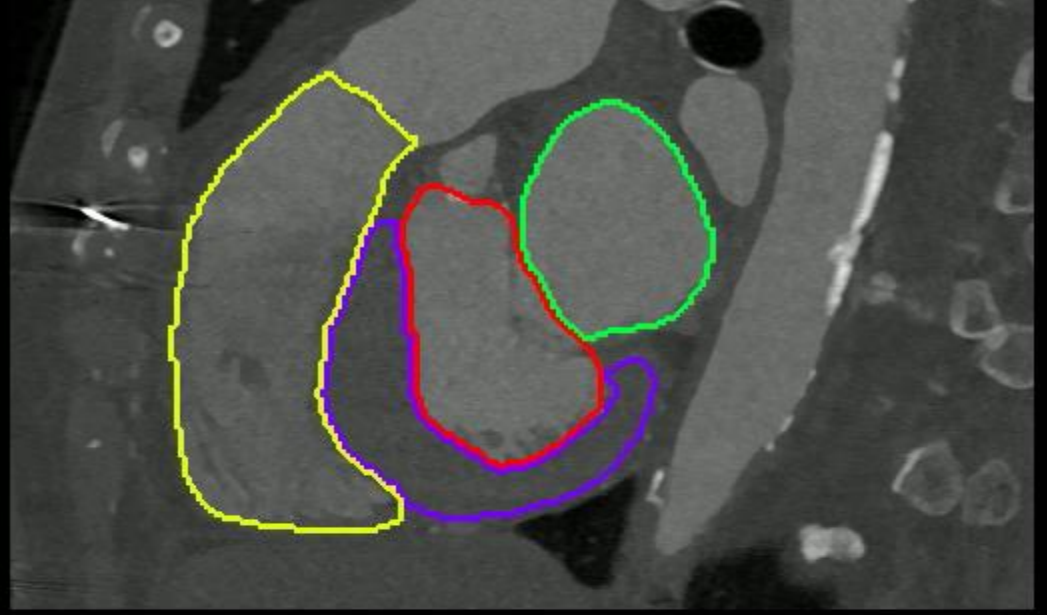
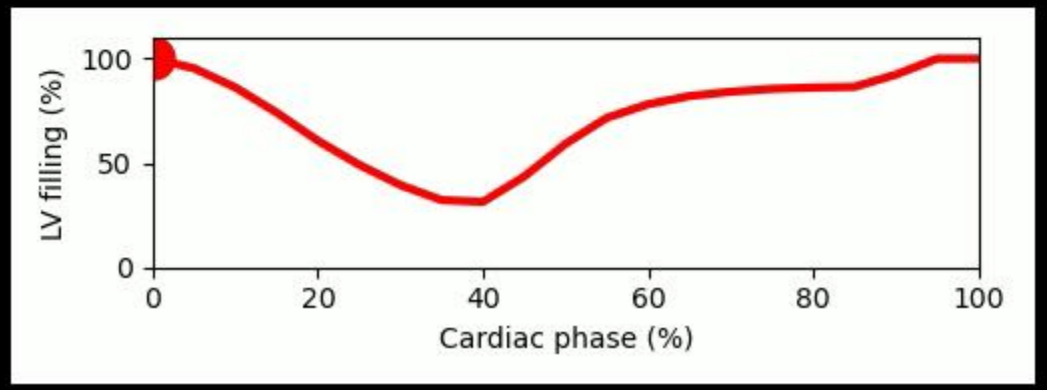
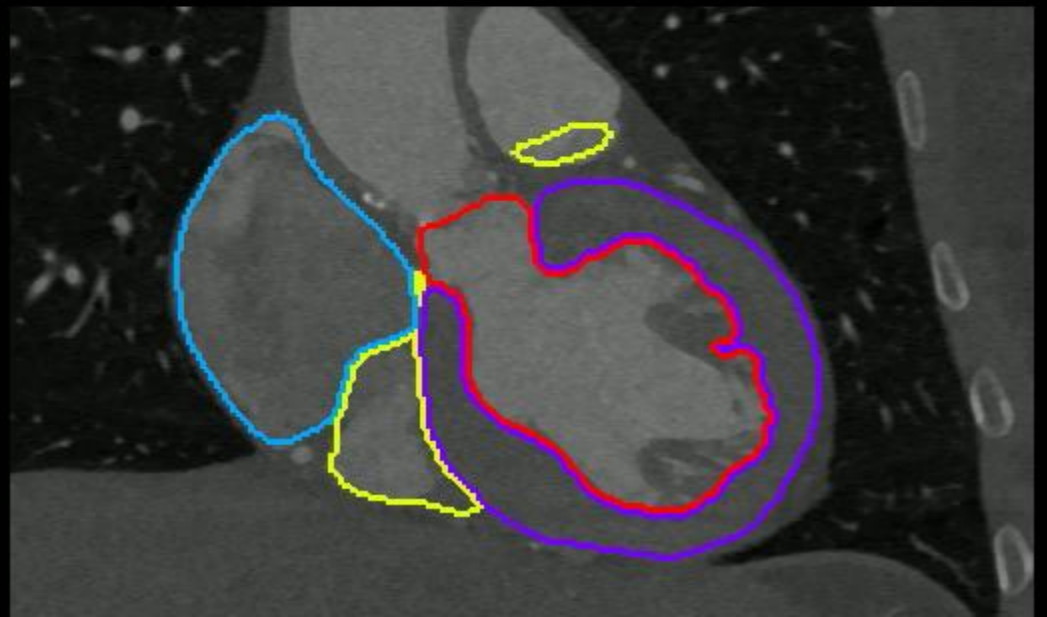


Figure courtesy R. van Herten, Amsterdam UMC






LV filling (%)
100
50
0
0
20
40
60
80
100
Cardiac phase (%)



Implementation

Research Article | Hot Topics

Machine Learning Will Change Medicine

Michael Forsting

Journal of Nuclear Medicine March 2017, 58 (3) 357-358; DOI:

JAMA | Original Investigation | INNOVATIONS IN HEALTH CARE DELIVERY

Development and Validation of a Deep Learning Algorithm for Detection of Diabetic Retinopathy in Retinal Fundus Photographs

Varun Gulshan, PhD; Lily Peng, MD, PhD; Marc Coram, PhD; Martin C. Stumpe, PhD; Derek Wu, BS; Arunachalam Narayanaswamy, PhD;
r, MS; Tom Madams, MEng; Jorge Cuadros, OD, PhD; Ramasamy Kim, OD, DNB;
lessica L. Mega, MD, MPH; Dale R. Webster, PhD

JAMA | Original Investigation

Diagnostic Assessment of Deep Learning Algo for Detection of Lymph Node Metastases in Women With Breast Cancer

Babak Ehteshami Bejnordi, MS; Mitko Veta, PhD; Paul Johannes van Diest, MD, PhD; Bram van Ginneken, PhD;
Nico Karssemeijer, PhD; Geert Litjens, PhD; Jeroen A. W. M. van der Laak, PhD; and the CAMELYON16 Consortiu

Article

International evaluation of an AI system for breast cancer screening

https://doi.org/10.1038/s41586-019-1799-6

Received: 27 July 2019

Accepted: 5 November 2019

Published online: 1 January 2020

Scott Mayer McKinney[1,14*], Marcin Sieniek[1,14], Varun Godbole[1,14], Jonathan Godwin[2,14], Natasha Antropova[2], Hutan Ashrafian[3,4], Trevor Back[2], Mary Chesus[2], Greg S. Corrado[1], Ara Darzi[3,4,5], Mozziyar Etemadi[6], Florencia Garcia-Vicente[6], Fiona J. Gilbert[7], Mark Halling-Brown[8], Demis Hassabis[2], Sunny Jansen[9], Alan Karthikesalingam[10], Christopher J. Kelly[10], Dominic King[10], Joseph R. Ledsam[2], David Melnick[6], Hormuz Mostofi[1], Lily Peng[1], Joshua Jay Reicher[11], Bernardino Romera-Paredes[2], Richard Sidebottom[12,13], Mustafa Suleyman[2], Daniel Tse[1*], Kenneth C. Young[8], Jeffrey De Fauw[2,15] & Shravya Shetty[1,15*]

AI

Concerns over "exaggerated" study claims of AI outperforming doctors

News • Experts express doubts

AI outperforming doctors: hype, exaggeration or fact?

Many studies claiming that artificial intelligence (AI) is as good as (or better than) human experts at interpreting medical images are of poor quality and are arguably exaggerated, posing a risk for the safety of [illegible]ons of patients' warn researchers in The BMJ.

Resistance to Medical Artificial Intelligence

Get access >

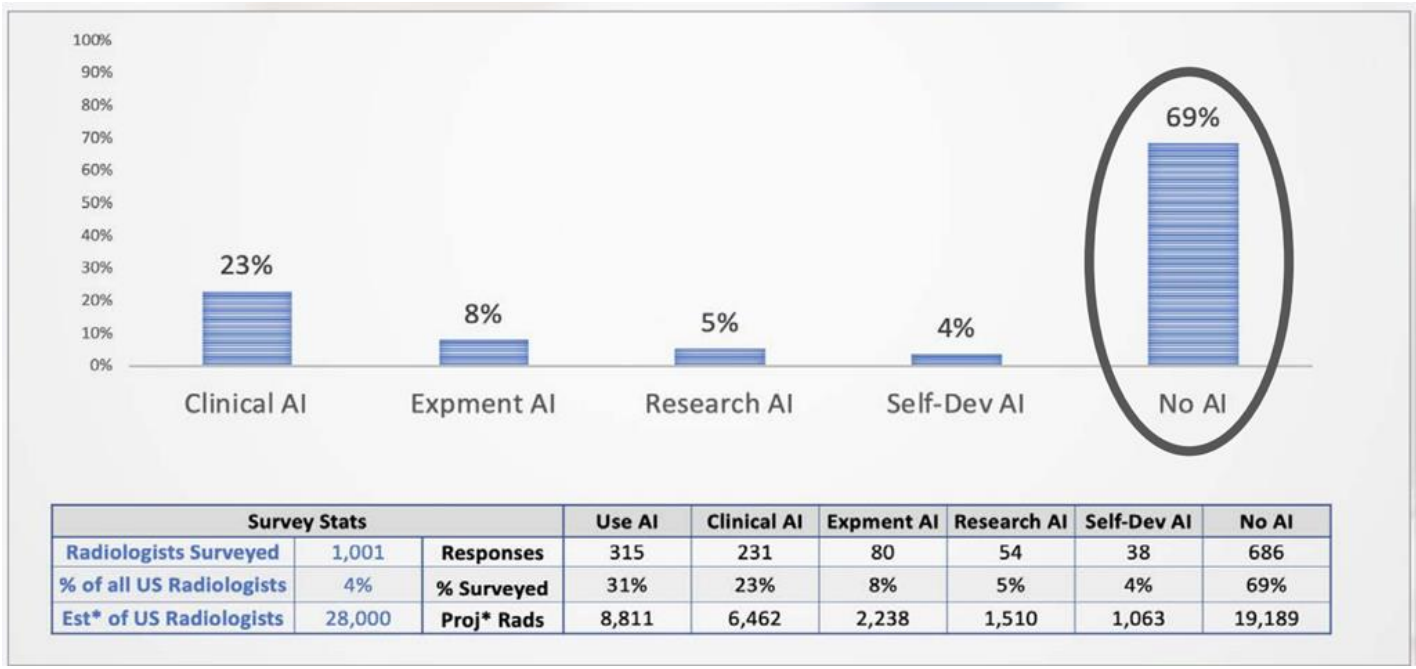
Chiara Longoni, Andrea Bonezzi, Carey K Morewedge

Journal of Consumer Research, Volume 46, Issue 4, December 2019, Pages 629–650, https://doi.org/10.1093/jcr/ucz013

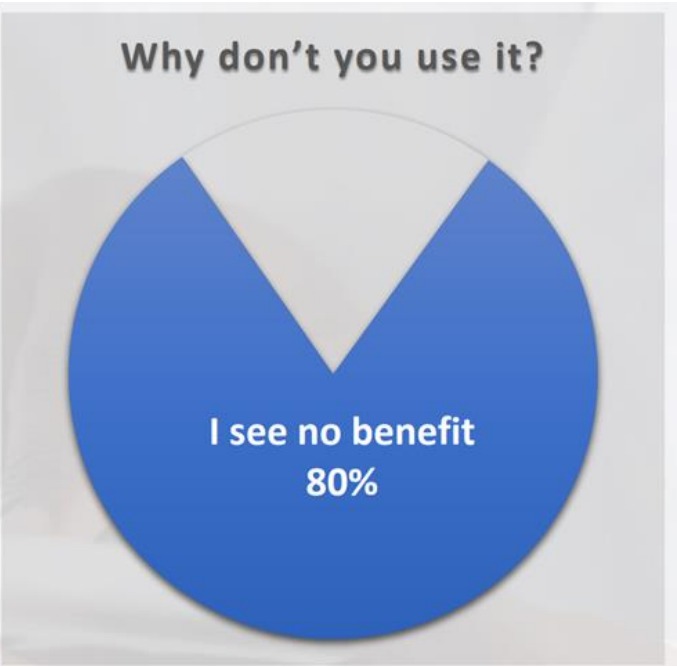
Published: 03 May 2019

https://www.bmj.com/company/newsroom/concerns-over-exaggerated-study-claims-of-ai-outperforming-doctors/
https://healthcare-in-europe.com/en/news/ai-outperforming-doctors-hype-exaggeration-or-fact.html

AI in healthcare

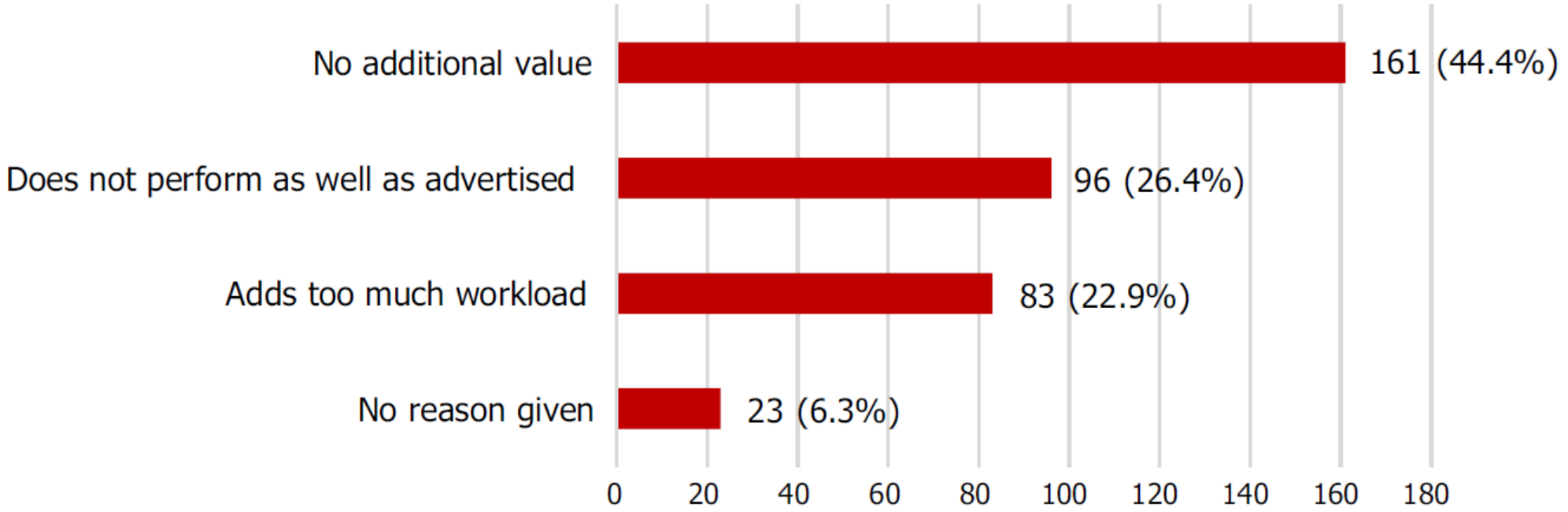


Survey Stats			Use AI	Clinical AI	Expment AI	Research AI	Self-Dev AI	No AI
Radiologists Surveyed	1,001	Responses	315	231	80	54	38	686
% of all US Radiologists	4%	% Surveyed	31%	23%	8%	5%	4%	69%
Est* of US Radiologists	28,000	Proj* Rads	8,811	6,462	2,238	1,510	1,063	19,189



American College of Radiology DSI Survey 2021

European Society of Radiology: Survey



Reasons on not intending to acquire a certified AI-based algorithm for their clinical practice (53% participants)

Reality check

- Ample research results demonstrating potential of AI in medical imaging
- Clinical use/application still in infancy
- Research and real-world settings differ
- Artificial intelligence thrives with large data sets
- Current datasets are often restricted → may lead to biases

Summary

AI methods

- Can analyze a wide range of imaging modalities and anatomical structures
- Have the potential to be applied to all analysis steps in the workflow
- Have potential to improve healthcare and make it affordable and humane

AI implementation

- Requires attention regarding societal, legal and ethical questions

Thank you!

qurAI

i.isgum@amsterdamumc.nl

https://qurAI.amsterdam

More about qurAI