The Premise for AI in Healthcare and how to bring it to the clinician

Steffen E Petersen, UK and Tim Leiner, USA

5/5/2022

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Disclosures

- **Steffen E Petersen:**
  - Consultancy, Circle Cardiovascular Imaging Inc., Calgary, Alberta, Canada
- **Tim Leiner:**
  - Founder, Quantib U
  - I have lectured for Philips, Bayer Healthcare, Guerbet

Part I

The Premise for AI in Healthcare…

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Message 1

Learn from AI innovations outside healthcare

Royal College of Physicians

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Medicinal Garden @ RCP

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PictureThis

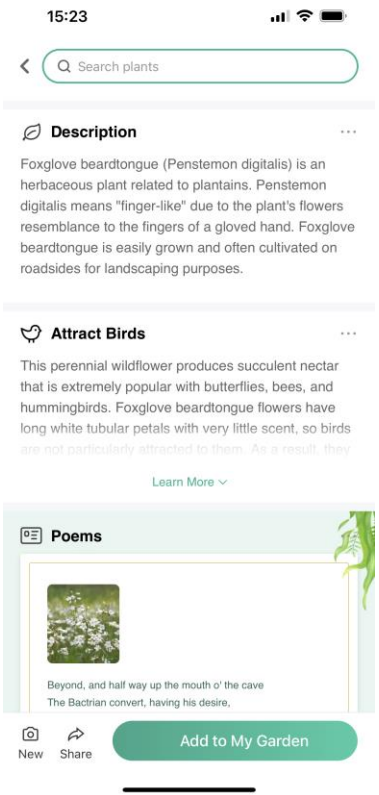

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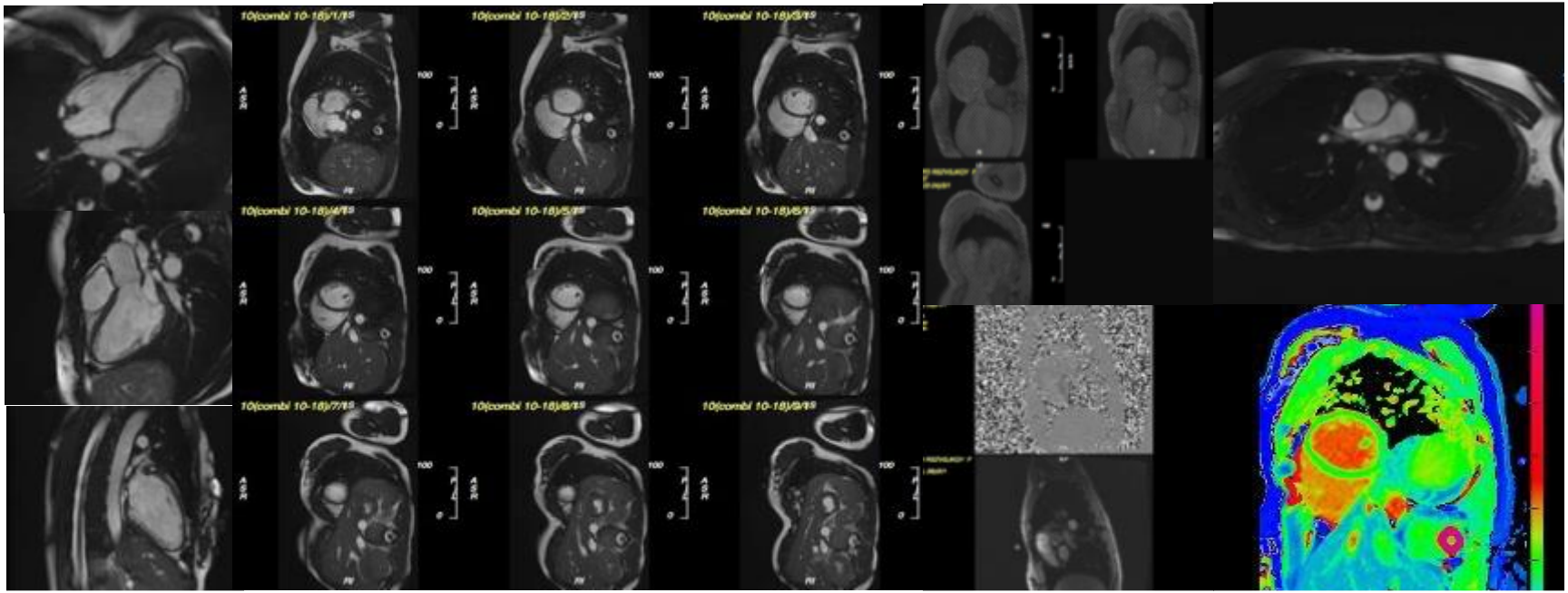
Image classification

Deep neural networks to classify sequence type and orientation



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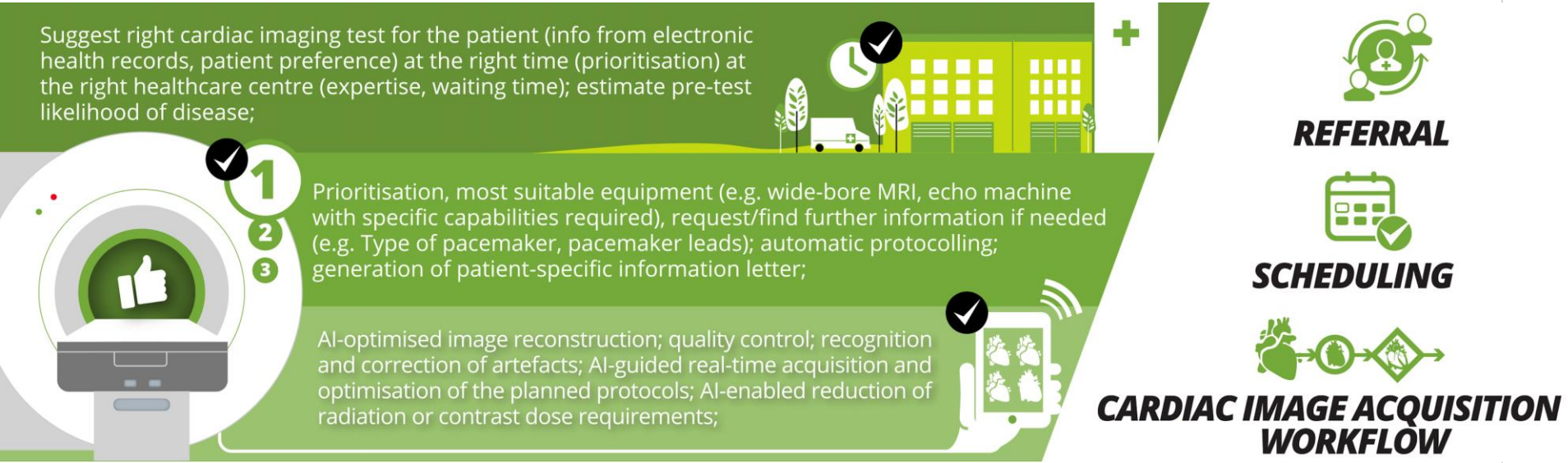
AI uses in cardiac imaging



Petersen, S. E., Abdulkareem, M., & Leiner, T. (2019). Artificial Intelligence Will Transform Cardiac Imaging-Opportunities and Challenges. Frontiers in cardiovascular medicine, 6, 133.

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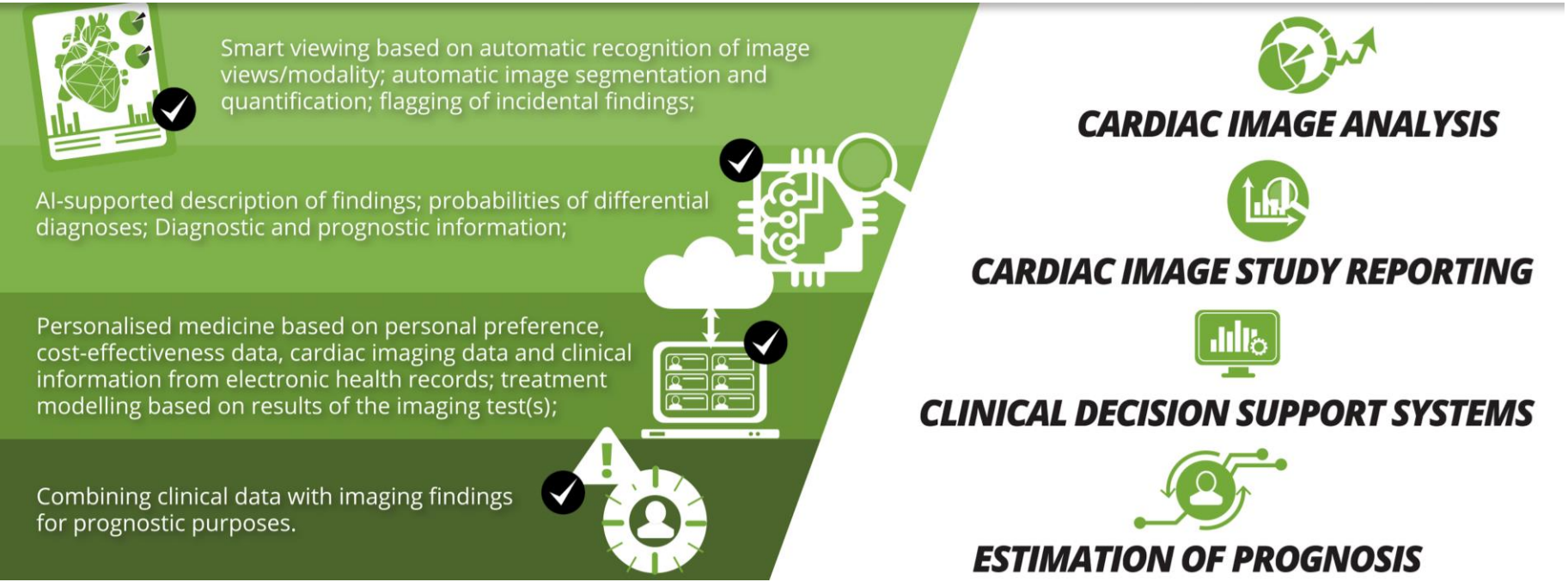
AI uses in cardiac imaging



Petersen, S. E., Abdulkareem, M., & Leiner, T. (2019). Artificial Intelligence Will Transform Cardiac Imaging-Opportunities and Challenges. Frontiers in cardiovascular medicine, 6, 133.

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Course programme

SCMR Society for Cardiovascular

EACVI European Association of Cardiovascular Imaging

Day 1 – Thursday 5 May

09:00-11:00 Registration

10:45-11:00 Welcome and Orientation to the Program – *Bernhard Gerber (Belgium) & Subha Raman (USA)*

11:00-11:30 Opening Plenary: The Premise for AI in Healthcare and how to bring it to the clinician – *Steffen Petersen (UK) & Tim Leiner (NL)*

11:30-13:45 Session I: Acquisition – *Chairpersons: Oscar Camara (Spain) & Katia Menacho (Peru)*

11:30-11:45 Fast CMR - clinical practice and unmet needs – *Subha Raman (USA)*

11:45-11:50 Q&A

11:50-12:05 AI for Faster CMR - Technique Talk I –*Rizwan Ahmad (USA)*

12:05-12:20 AI for Faster CMR - Technique Talk II – *Nicole Seiberlich (USA)*

12:20-12:35 AI for CMR across scanners, sites and populations – *Sotirios Tsaftaris (UK)*

12:35-12:45 First Top abstract: faster CMR acquisition (7'/3')

12:45-13:00 Panel discussion: where should we be going?

13:00-13:20 Industry show case by Circle Cardiovascular Imaging

13:25-13:45 Industry show case by Arterys

13:45-14:45 Lunch break / Exhibits & posters - CMR acquisition

14:45-17:00 Session II: Postprocessing – *Chairpersons: Bernhard Gerber (Belgium) & Sven Plein (UK)*

14:45-15:00 CMR Postprocessing - clinical practice and unmet needs – *Jeanette Schulz-Menger (Germany)*

15:00-15:05 Q&A

15:05-15:20 AI for CMR postprocessing - Technique Talk I – *Hui Xue (USA)*

15:20-15:35 AI for CMR Postprocessing - Technique Talk II – *Olivier Bernard (France)*

15:35-15:50 AI for CMR Postprocessing - Technique Talk III – *Qian Tao (Netherlands)*

15:50-16:00 Top abstract: CMR postprocessing (7'/3')

16:00-16:10 Panel discussion: where should we be going?

17:00-19:00 Social event

Day 2 - Friday 6 May

08:00-10:15 Session III: CMR Reporting – *Chairpersons: Jan Bogaert (Belgium) & Behzad Sharif (USA)*

08:00-08:15 CMR reporting - clinical practice and unmet needs – *James Moon (UK)*

08:15-08:20 Q&A

08:20-08:35 AI for CMR Reporting - Technique Talk I – *Nay Aung (UK)*

08:35-08:50 AI for CMR Reporting - Technique Talk II – *Karim Lekadir (Spain)*

08:50-09:05 AI for CMR Reporting - Technique Talk III – *Behzad Sharif (USA)*

09:05-09:15 Top abstract: CMR reporting (10'/5')

09:50-09:30 Panel discussion: where should we be going?

09:30-10:30 Coffee break / Exhibits & posters - CMR postprocessing and reporting

10:30-12:30 Session IV: Standardization – *Chairpersons: Michael Salerno (USA) & Eike Nagel (Germany)*

10:30-10:45 CMR Standardization - clinical practice and unmet needs – *Kathryn Keenan (USA)*

10:45-10:50 Q&A

10:50-11:05 AI for CMR Standardization - Technique Talk I – *Daniel Rueckert (UK)*

11:05-11:20 AI for CMR Standardization - Technique Talk II – *Martin Uecker (Germany)*

11:20-11:35 AI for CMR Standardization - Technique Talk III – *Declan O'Regan (UK)*

11:35-11:45 Second Top abstract: CMR standardization (7'/3')

11:45-12:30 Panel discussion: where should we be going?

12:30-13:30 Satellite Symposium by Circle Cardiovascular Imaging

13:30-14:15 Lunch break / Exhibits & posters

14:15-15:45 Session V: Discovery in Cardiomyopathies via AI in CMR – *Chairpersons: Nicole Seiberlich (USA) & Steffen Petersen (UK)*

14:15-14:30 Cardiomyopathies - clinical practice and unmet needs – *Robert Manka (Switzerland)*

14:30-14:35 Q&A

14:35-14:50 AI for Cardiomyopathy Discovery - Technique Talk I – *Vincente Grau (UK)*

14:50-15:05 AI for Cardiomyopathy Discovery - Technique Talk II – *Bharath Venkatesh (USA)*

15:05-15:20 AI for Cardiomyopathy Discovery - Technique Talk III – *Alistair Young (UK)*

15:20-15:30 Top abstract: Discovery via AI/CMR in cardiomyopathy (7'/3')

15:30-15:45 Panel discussion: where should we be going?

15:45-16:30 Coffee break / Exhibit & posters - Discovery via AI in CMR

16:30-17:50 Closing Plenary Session: Regulatory Considerations

16:30-16:40 Regulations on AI Research in Europe – *Fabien Hyafil (France)*

16:40-17:10 Regulations on AI Research in the Americas – *Nicholson Price (USA)*

17:10-17:30 Multinational AI Research: How to Engage Globally – *Claudia Prieto (UK)*

17:30-17:50 Roundtable Discussion and Summit Takeaways

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Focus issue: AI in CV imaging

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Message 2

Hype and hope of AI can change quickly

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ESC European Society of Cardiology

The ESC | Congresses & Events | Journals | Guidelines | Education | Research

European Society of Cardiology › Education › Courses › Organised

Courses

Organised

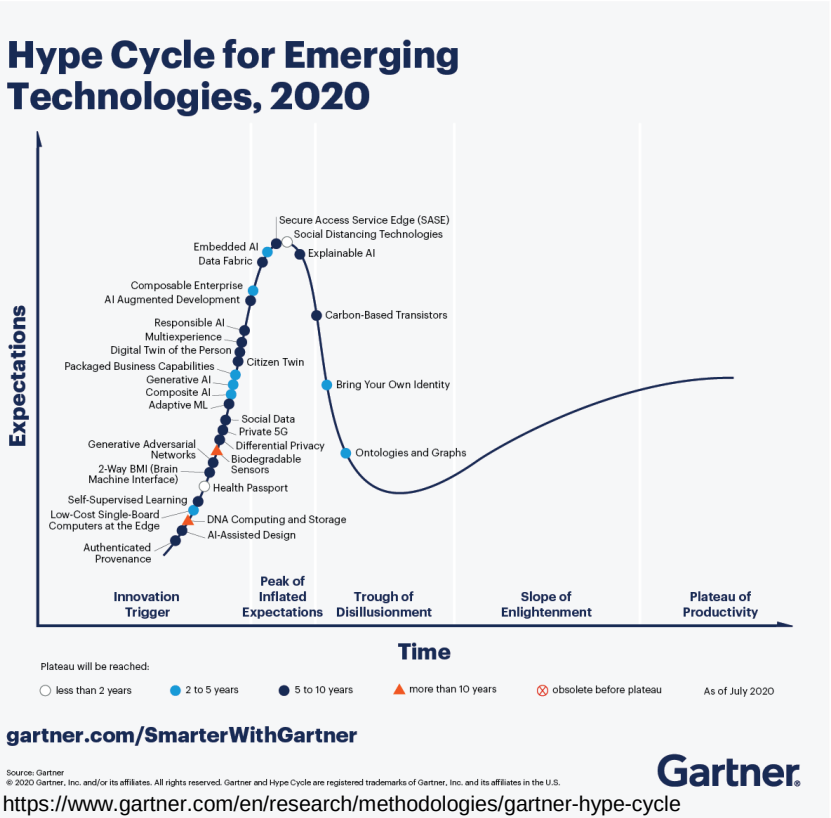
Resources

Artificial Intelligence in Cardiovascular Magnetic Resonance Imaging - A Joint Summit of the EACVI and SCMR

Thursday, 05 May - Friday, 06 May 2022 (2 Days), London - United Kingdom of Great Britain and Northern Ireland

Topic(s): *Cardiology; Imaging; Cardiac Magnetic Resonance;*

Gartner Hype Cycle



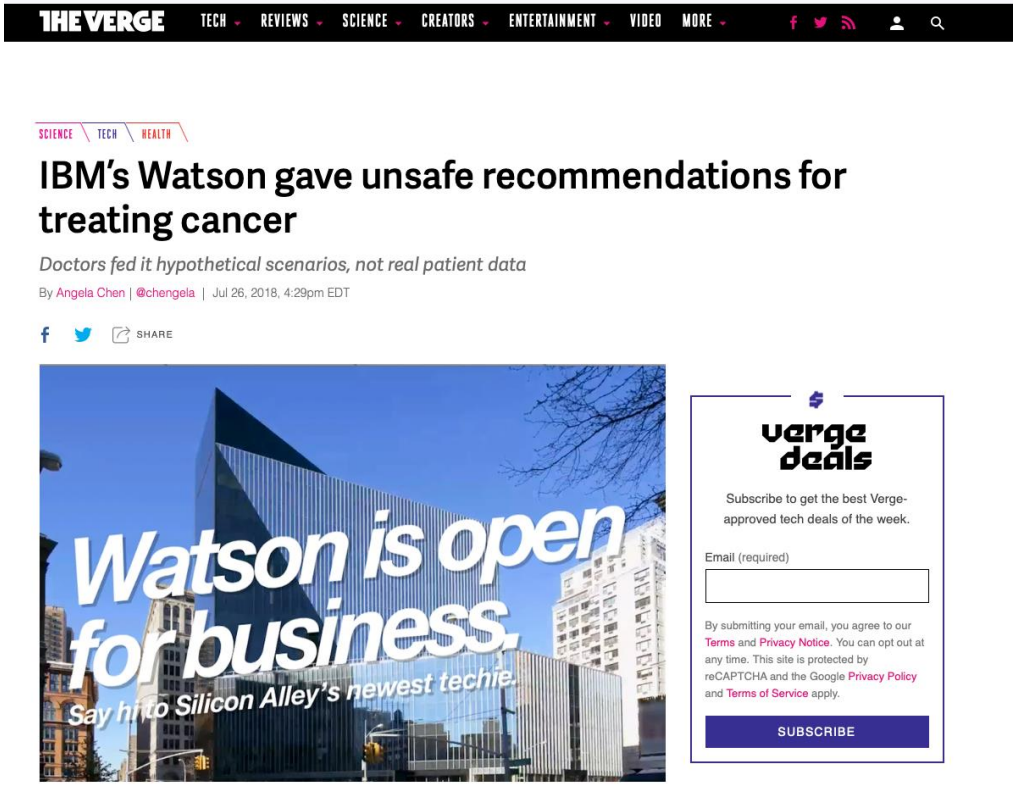
https://www.gartner.com/en/research/methodologies/gartner-hype-cycle

- The Hype Cycle for Emerging Technologies is a unique Hype Cycle that distills more than 1,700 unique technologies into a list of must-know technologies and trends. This year's list highlights five unique trends:
- Composite architectures
- Algorithmic trust
- Beyond silicon
- Formative artificial intelligence (AI)
- Digital me

https://www.gartner.com/smarterwithgartner/5-trends-drive-the-gartner-hype-cycle-for-emerging-technologies-2020

Hype and hope of AI can change quickly

Synthetic data vs real life data



THE VERGE TECH REVIEWS SCIENCE CREATORS ENTERTAINMENT VIDEO MORE

SCIENCE TECH HEALTH

IBM's Watson gave unsafe recommendations for treating cancer

Doctors fed it hypothetical scenarios, not real patient data

By Angela Chen | @chengela | Jul 26, 2018, 4:29pm EDT

SHARE

https://www.theverge.com/2018/7/26/17619382/ibms-watson-cancer-ai-healthcare-science

Hype and hope of AI can change quickly

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Message 3

AI in CMR requires multi-disciplinary interactions

AI and CMR summit

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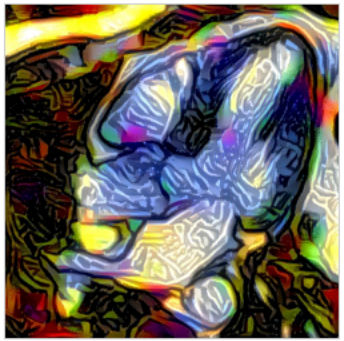
More about the summit



This summit will provide an overview of the current state of the art, recent progress, opportunities and future outlook of artificial intelligence in CMR. Recent developments will be illustrated by abstract sessions and industry showcases. We will all also cover current and future challenges, issues, as well as legal and regulatory issues of artificial intelligence in cardiovascular imaging. We hope to enhance interaction between scientists, clinicians and companies involved in AI research and applications and foster the further evolution of this exciting new technology.

Target audience

The audience for this event comprises cardiologists, radiologists and importantly, NEW audiences including computer scientists, commercial delegates, image analysis people (MICCAI members), ISMRM members, etc. There is a real opportunity to raise interest for both EACVI and SCMR from groups of people who normally may not attend our separate and joint conferences.

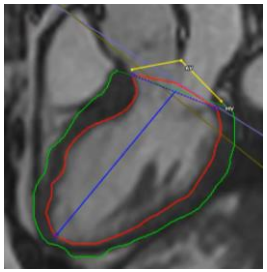
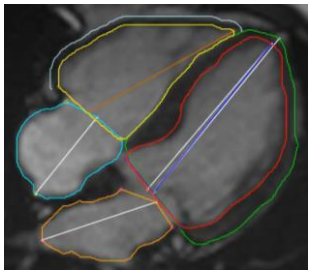
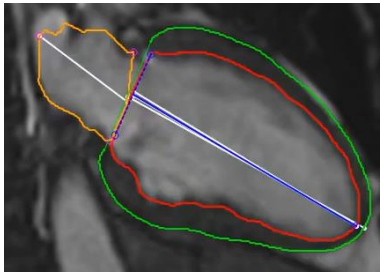
AI and CMR requires multi-disciplinary interactions

Team science

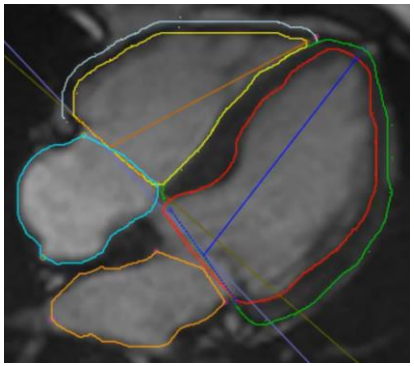
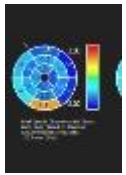
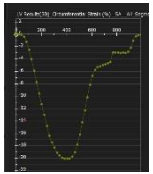
AI and CMR requires multi-disciplinary interactions

Lessons learnt from UK Biobank

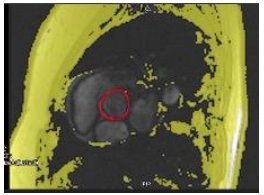
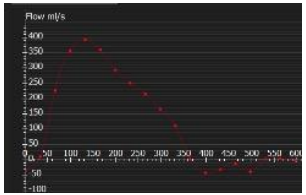
Long-axis segmentation

Tissue tracking

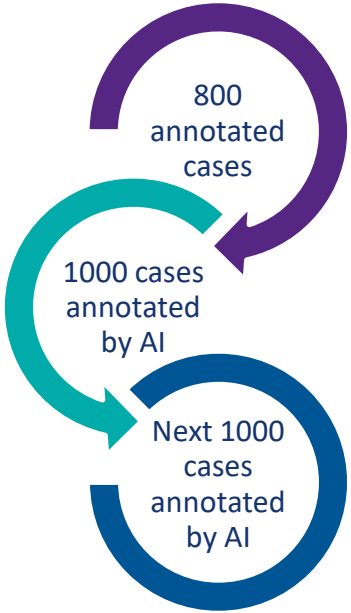




Aortic flow quantification

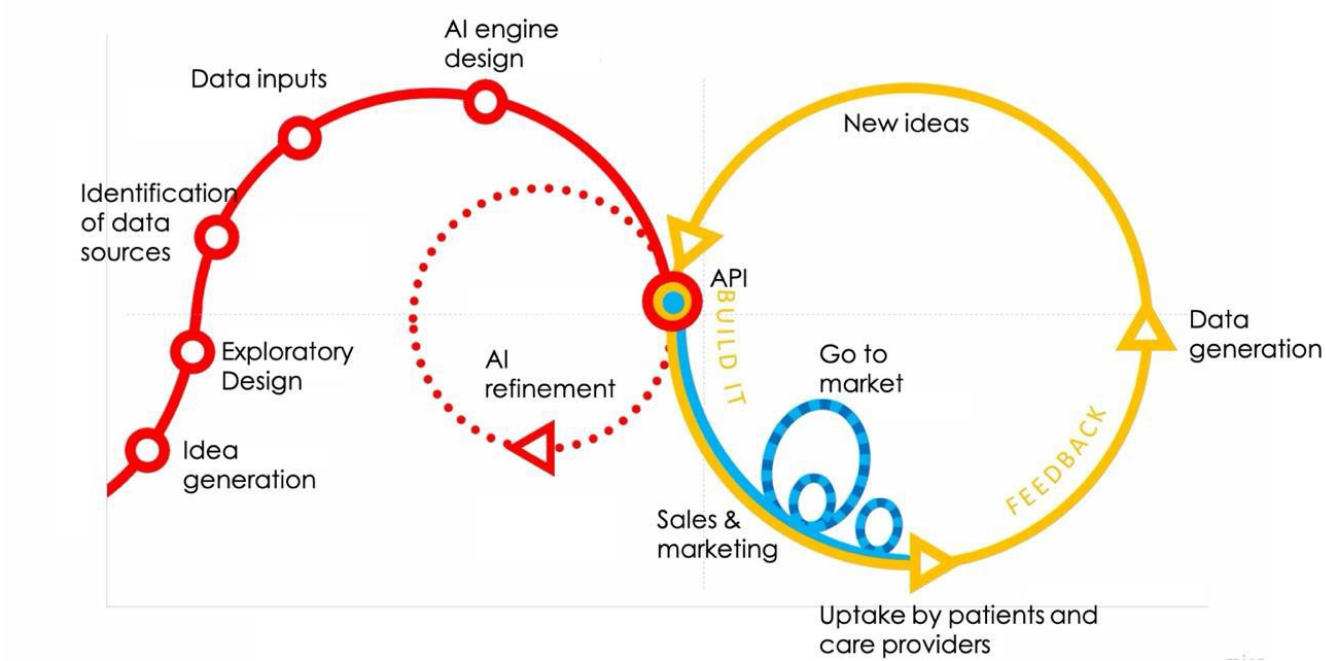
Initially we manually analysed 5,000 scans before deep learning

Now: Expert review and AI algorithm optimisation



AI and CMR requires multi-disciplinary interactions

AI development arc: complex & iterative



Source: Technolopolis Group, 2020 (based on the lean start-up by Eric Ries)
in https://ati.ec.europa.eu/reports/product-watch/artificial-intelligence-based-software-medical-device

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Message 4

Big Data for AI: we are not exploiting information enough yet

Dorchester Library @RCP

Big Data for AI: we are not exploiting information enough yet

Main hurdles

- **Healthcare data access and sharing**
  - Blockchain and Smart Contracts
  - Federated learning/secure multi-party computation
  - Synthetic data
  - Differential Privacy
- **Code sharing to enable transfer learning**
- **Underfunding of ground truth generation**
  - Expert annotations
  - Extracting relevant information at scale from electronic health records (e.g. NLP)
- **Clinical systems of data collection typically not designed with AI innovation in mind**

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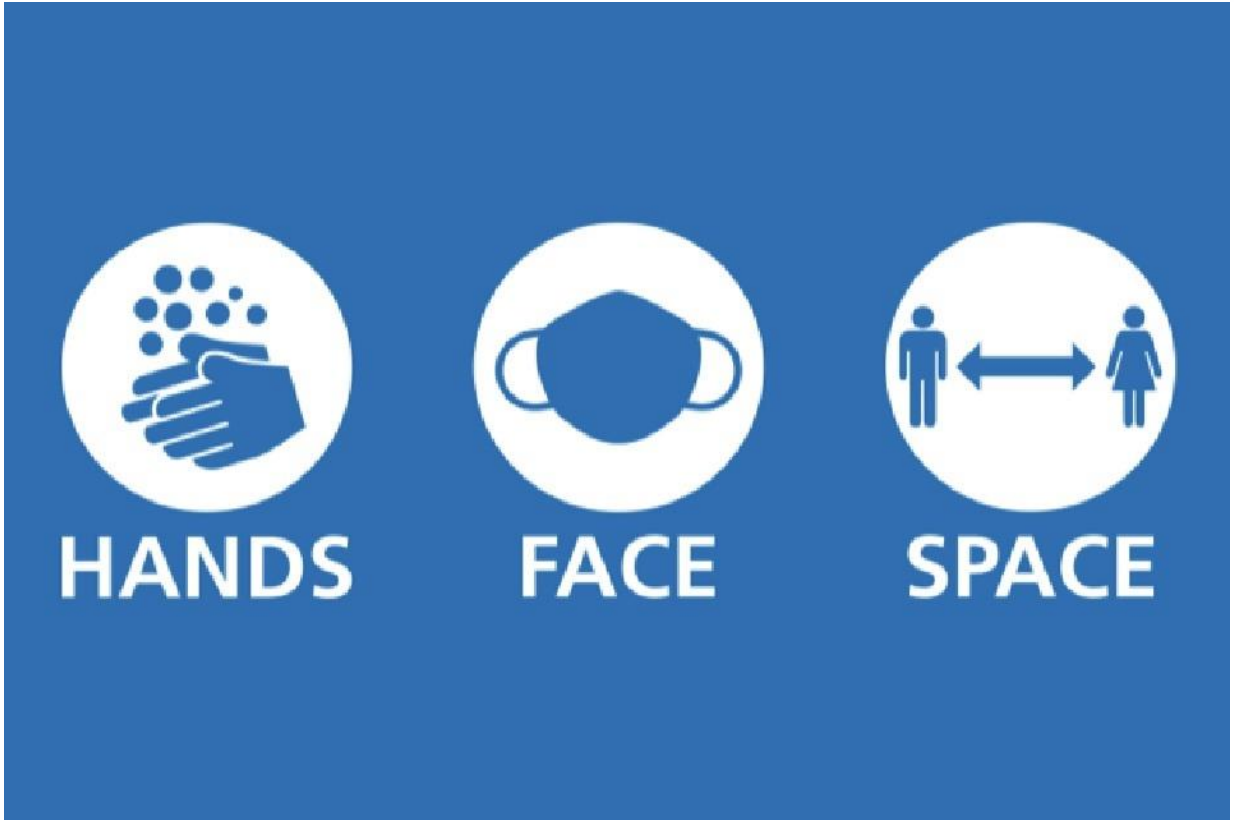
Message 5

Mind the complex and evolving landscape of ethics, governance and regulation

Evolving public health measures



Mind the complex and evolving landscape of ethics, governance and regulation

UK regulatory and governance landscape

- **MHRA – regulation and safety of AIaMD**
- **HRA – evidence-based research underpinning development & testing**
- **NICE – assessment of cost vs benefit and decision to deploy**
- **CQC – ensures adherence to AI best practice**
- **ICO – information governance (relates to DPA 2018 / UK GDPR)**

Mind the complex and evolving landscape of ethics, governance and regulation

EU ethics, governance for AI

- **EU Artificial Intelligence Act (2021)**
  - First law on AI by a major regulator
  - Categorises AI into risk (healthcare AI is risk)
  - Imposes transparency obligations; bans certain applications
  - Max administrative fine: greater of €30m or 6% annual worldwide revenue
- **Information governance - GDPR**
  - Data used for training and test data (and outputs such as synthetic data)
  - Covers all data processing (including systems such as federated learning)
  - Automatic decision making rules relevant to AI
  - Max administrative fine: greater of €20m or 4% annual worldwide revenue
- **GDPR considered a "gold standard" – AI framework may also occupy same position**

Mind the complex and evolving landscape of ethics, governance and regulation

Ethics by design

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European Commission

Ethics By Design and Ethics of Use Approaches for Artificial Intelligence

Version 1.0
25 November 2021

https://ec.europa.eu/info/funding-tenders/opportunities/docs/2021-2027/horizon/guidance/ethics-by-design-and-ethics-of-use-approaches-for-artificial-intelligence_he_en.pdf

Mind the complex and evolving landscape of ethics, governance and regulation

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Message 6

Let AI and Art inspire you

Portrait and fine art collection @RCP

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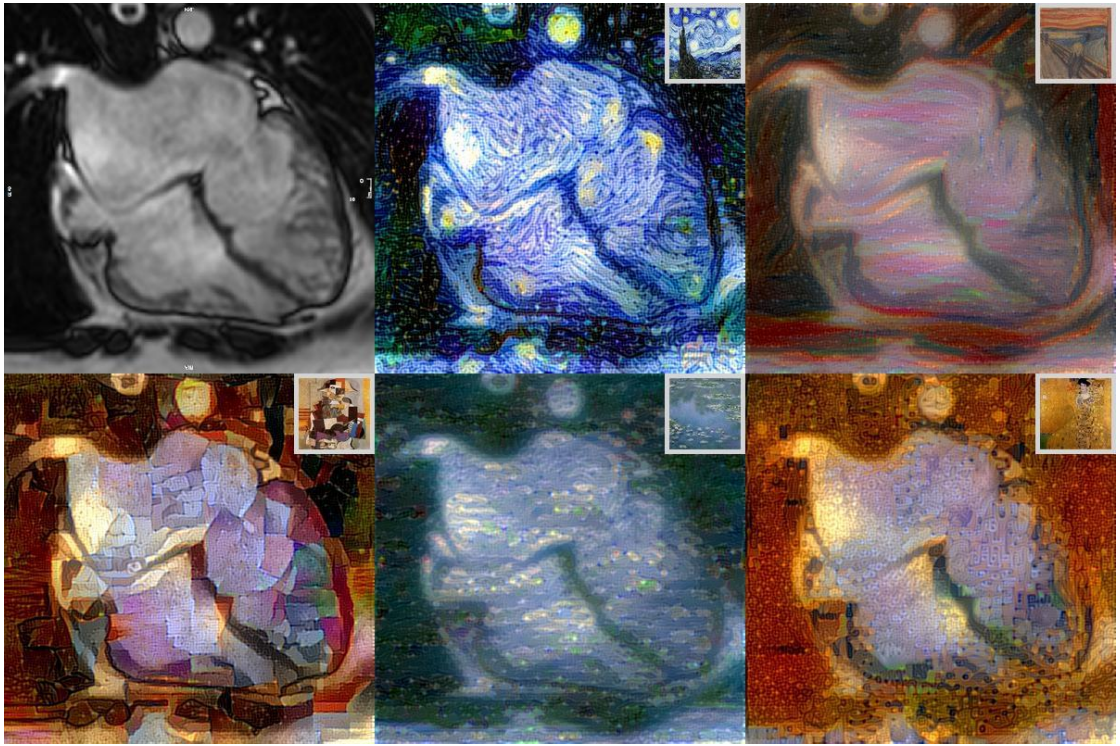
Neural style transfer



"AI finds beauty in a broken heart"
Winner of Life Sciences Image Award for Health and Technology theme
Credits: Dr Nay Aung

This technique extracts the stylistic characteristics of an artwork and applies them to the input image to generate a coalesced artistic image

Part II

How to bring AI to the clinic

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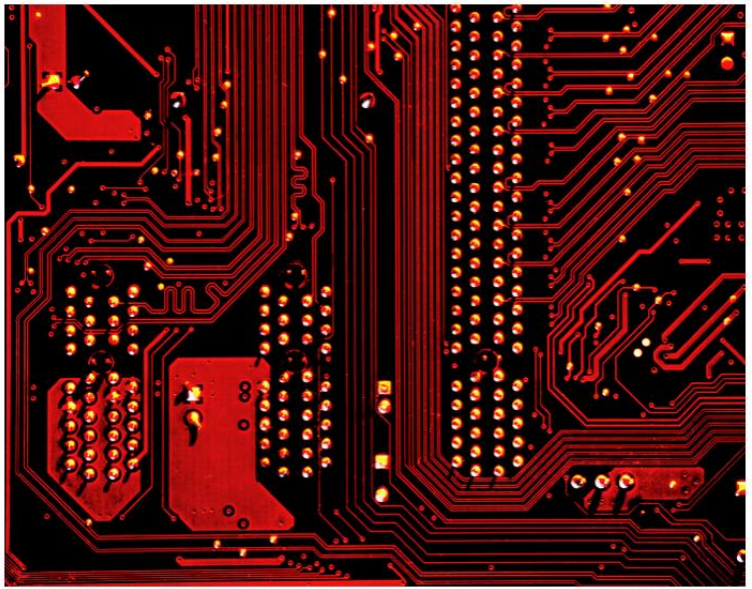
Main Point 1

Creating AI algorithms has been democratized

Anyone can create an algorithm today

- **There are tons of resources**
  - 2015: Google releases its AI engine Tensorflow
  - Coursera (Andrew Ng's course)
  - Udemy
  - SuperDataScience
  - Medium
  - ….

7 Best Courses to Learn Artificial Intelligence in 2022



https://medium.com/javarevisited/7-best-courses-to-learn-artificial-intelligence-in-2020-26d59d62f6fe

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Main Point 2

But……create something that solves a clinical need

Solve a problem with a MD team

- **Assemble a team of experts**
  - ML/AI experts, (Referring) Clinicians, End-users
- **Identify the clinical problem**
  - Entire imaging pipeline contains inefficiencies
- **Explicitly define what success looks like**
  - “I will save X time/money….”
  - “Diagnostic accuracy will increase by X%....”
  - “Radiation dose will decrease by X%.....”

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Main Point 3

Involve *all* stakeholders

Include patients

- **Patient engagement and adherence is ‘last mile problem’**
  - Non-compliance is huge issue in medicine
- **Involving patients results in better AI algorithms**
  - Key to create trust by addressing needs/concerns from patient perspective
    - E.g. safety / privacy / explainability / transparency
  - Asking permission ensures better source data and access to f/u data
  - Offers new opportunities to improve care

Davenport T & Kalakota R. Future Healthcare J 2019;6:94-98

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Main Point 4

Create a rigorous quality assurance process

Build a rigorous quality assurance system

- **Build algorithms as if you are a company**
  - Use ”Good machine Learning Practice[1]”
  - Document the building process carefully
  - Investigate and document modes of failure

Good Machine Learning Practice for Medical Device Development: Guiding Principles	
Multi-Disciplinary Expertise Is Leveraged Throughout the Total Product Life Cycle	Good Software Engineering and Security Practices Are Implemented
Clinical Study Participants and Data Sets Are Representative of the Intended Patient Population	Training Data Sets Are Independent of Test Sets
Selected Reference Datasets Are Based Upon Best Available Methods	Model Design Is Tailored to the Available Data and Reflects the Intended Use of the Device
Focus Is Placed on the Performance of the Human-AI Team	Testing Demonstrates Device Performance During Clinically Relevant Conditions
Users Are Provided Clear, Essential Information	Deployed Models Are Monitored for Performance and Re-training Risks are Managed

FDA U.S. FOOD & DRUG ADMINISTRATION

Health Canada Santé Canada

Medicines & Healthcare products Regulatory Agency

1) https://bit.ly/3LDuSlC

Build a rigorous quality assurance system

- **If you follow GMLP, you may use the algorithm clinically in YOUR institute**
  - FDA ‘Discretionary enforcement’
  - Not for commercial use / Not allowed to advertise
  - Training program needed

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Main Point 5

Think about a platform first

Think about a deployment platform

- **Lots of algorithms are coming**
  - You **cannot** rely on point solutions – you need a platform
- **Look at broad vendor neutral / vendor agnostic platforms**
  - Single vendor = risk of 'lock-in' & limited choice
  - Allows mix of commercial and research algorithms
  - Building your own platform is feasible for reasonable $$$
- **This is really a health system-wide IT issue**
  - Making the right choice now will allow to scale up quickly
  - Involve central IT

Leiner et al. Insights into Imaging 2021;12:11

Conclusions

Conclusions

- **Create a multidisciplinary team to solve meaningful problems**
  - Think your project through from the start to the end-user
  - Involve all stakeholders, including patients
- **Design your algorithm as if you are a company**
  - Use GMLP principles for guidance and you can actually use your algorithm
- **Think about a deployment platform**
  - Preferably vendor neutral / vendor agnostic

Want to learn more?

- **55 Chapters / 180 contributors**
- **600 pages**
- **Summary of the field**
  - Technical considerations
  - General approaches and applications
  - Cardiac applications
  - Thoracic applications
  - Ethics, Cybersecurity, Health economics
  - Commercialization and IP issues
  - ……..