RESEARCH AND INNOVATION IN HEALTHCARE – AI AND CARDIOLOGY

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Agenda

✓ What is AI?

👍 The Good

☹ The Bad

☄ The Ugly

👥 Responsible AI

🩺 AI and Cardiology at Fraunhofer AICOS — Post-Cirurgical Risk Score Prediction
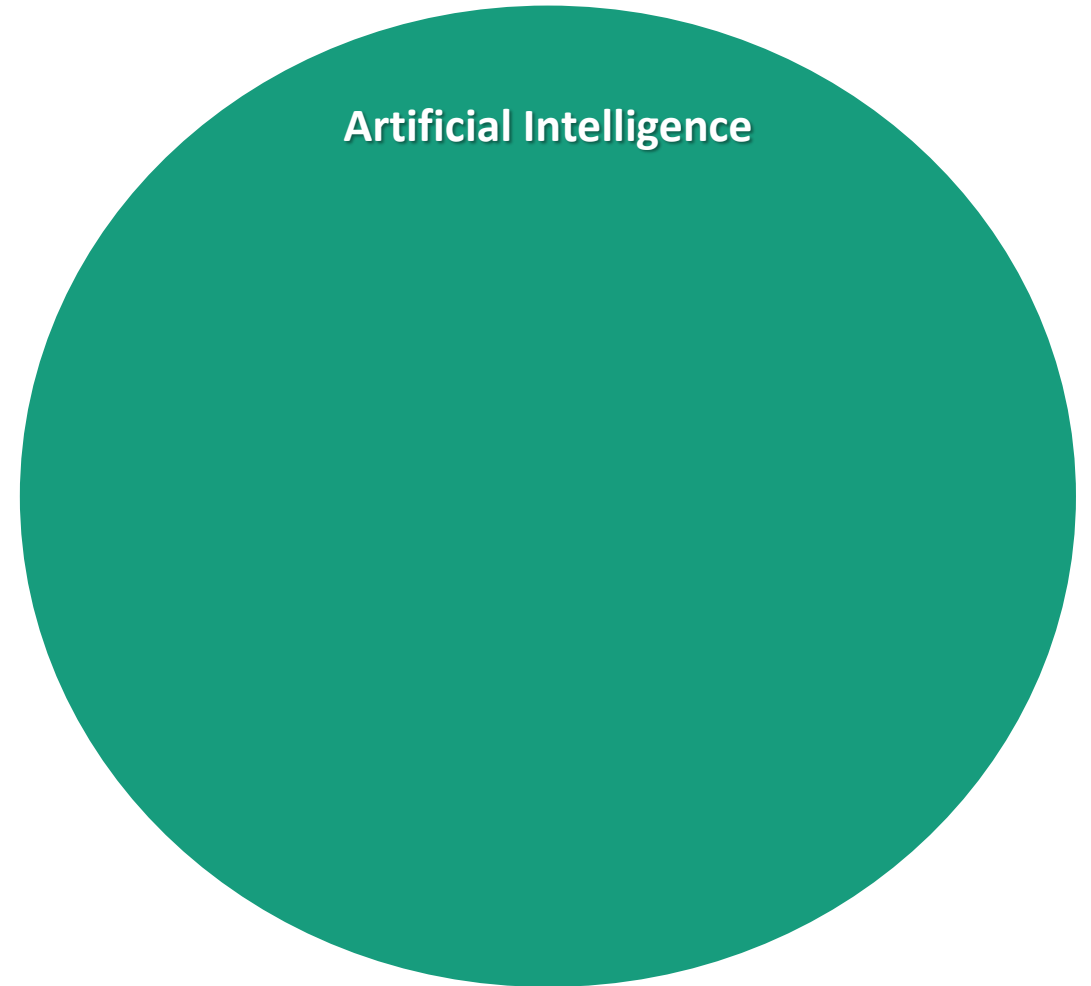
Explainable AI

⚙ Conclusions

What is AI?
Taxonomy

■ **Artificial Intelligence**

   ■ Computational programs capable of executing tasks associated to Natural Intelligence

      ■ Perception

      ■ Reasoning

      ■ Language

      ■ Etc.

Artificial Intelligence
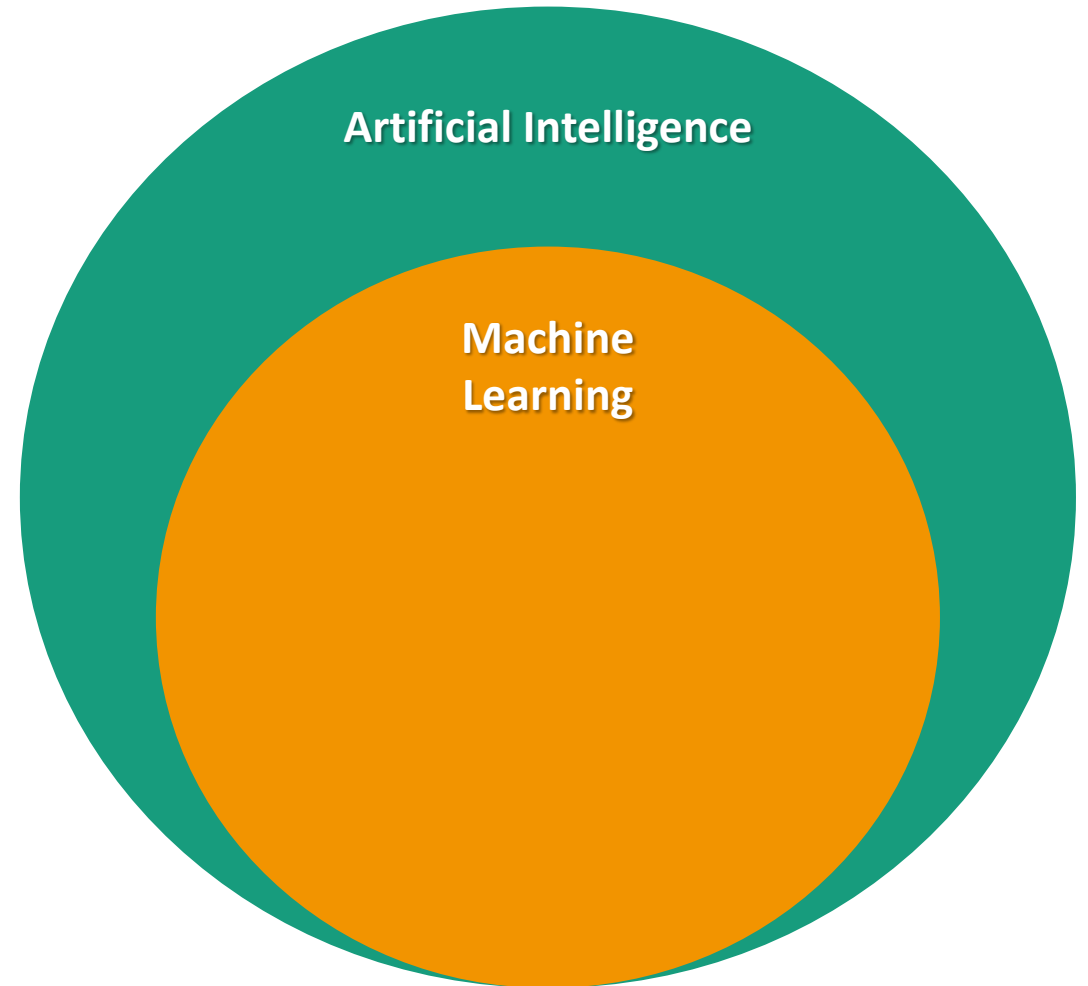
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What is AI?
Taxonomy

- **Machine Learning**

  - Subfield of AI where programs "learn" from data, without being explicitly programmed to perform a task

  - Learning can be

    - Supervised – with a "teacher"

    - Unsupervised – discovery

    - Reinforcement – the power of rewards

Artificial Intelligence

Machine Learning
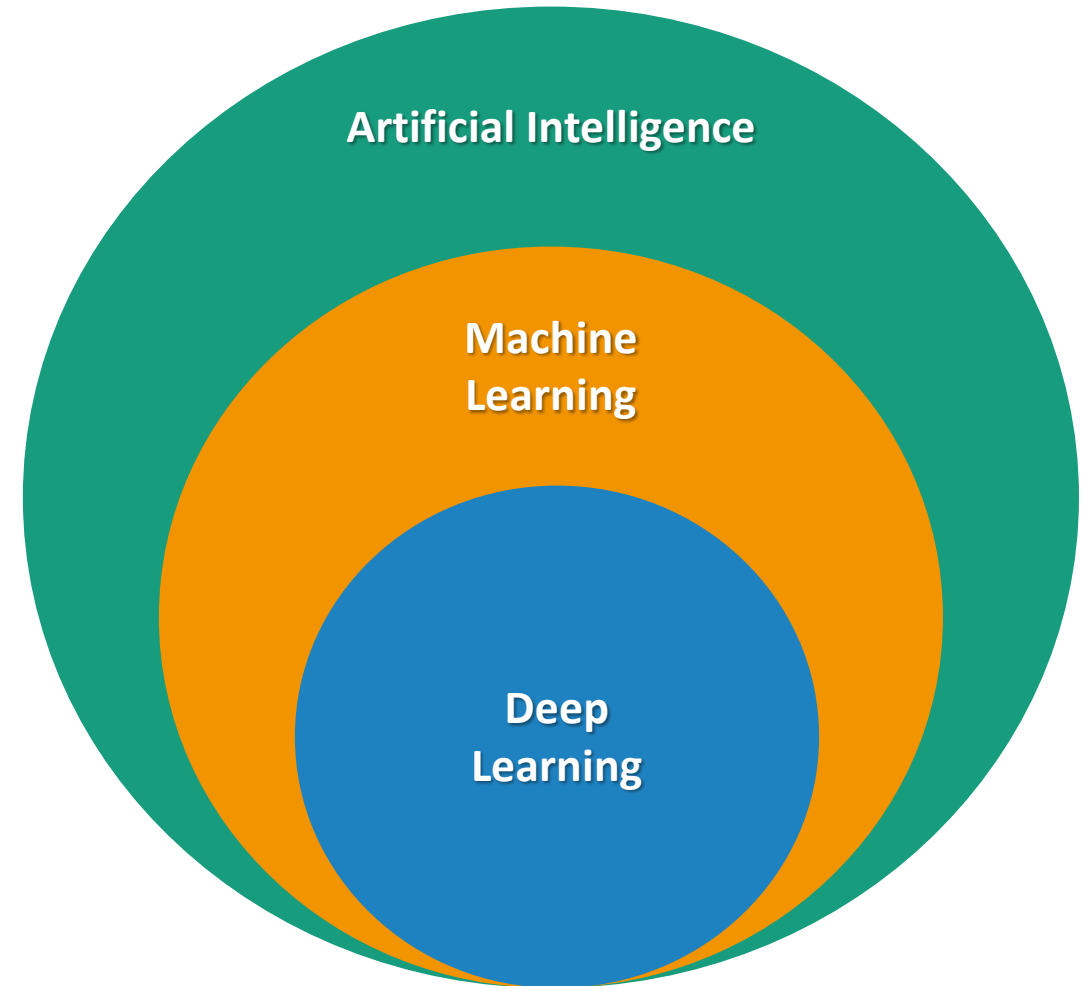
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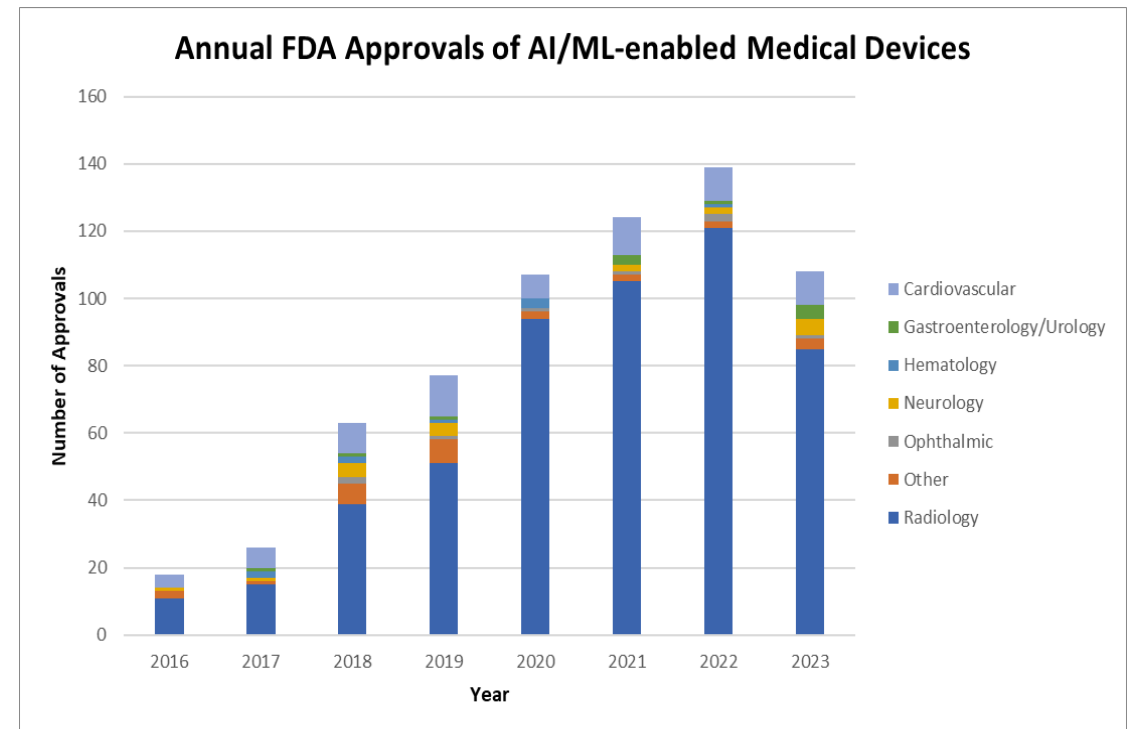
What is AI?
Taxonomy

■ **Deep Learning**

   ■ Subfield of Machine Learning

   ■ Neural Networks with multiple hidden layers to model complex tasks from huge amounts of data

   ■ Especially powerful in unstructured data
      ■ Image/Video
      ■ Language
      ■ Audio

Artificial Intelligence — Machine Learning — Deep Learning

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The Good

- AI-enabled Medical Devices growing

  - Radiology and Cardiovascular stand out

- Diagnostic Support

- Treatment recommendation

- Patient monitoring

- Reducing administrative burden

  - More time for patient care

- Drug Discovery

- Improved Health management, data-driven

Annual FDA Approvals of AI/ML-enabled Medical Devices

Legend:
- Cardiovascular
- Gastroenterology/Urology
- Hematology
- Neurology
- Ophthalmic
- Other
- Radiology

Data from https://www.fda.gov/medical-devices/software-medical-device-samd/artificial-intelligence-and-machine-learning-aiml-enabled-medical-devices

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The Good

AI Scours Documentation for Cancer Studies

The Fred Hutchinson Cancer Center in Seattle used NLP in Amazon Comprehend Medical to review mountains of unstructured clinical record data at scale to quickly match patients with clinical cancer studies. NLP helped physicians review about 10,000 medical charts per hour to find patients with the right inclusion criteria, removing the "heavy lifting," Kass-H...

Newly published research shows that deep learning model can predict the short-term risk of atrial fibrillation (AFib) based on 24-hour Holter recordings that show normal sinus rhythm

Abstract 13244: Real World Evaluation of an Artificial Intelligence Enabled Digital Stethoscope for Detecting Undiagnosed Valvular Heart Disease in Primary Care

Moshe A Rancier, Igor Israel, Vimalson Monickam, John Prince, Ben Verschoore and Caroline Currie

https://healthtechmagazine.net/article/2022/12/ai-healthcare-2023-ml-nlp-more-perfcon

https://www.philips.com/a-w/about/news/archive/standard/news/articles/2022/20220722-study-demonstrates-ai-may-soon-predict-occurrence-of-atrial-fibrillation.html

https://www.ahajournals.org/doi/10.1161/circ.148.suppl_1.13244

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The Bad

- The algorithms are non-deterministic and can make mistakes!

- Privacy regarding patient (and professionals') data

- Bias and inequalities propagated or even increased due to misrepresentative training data
  - Less effective or even denied treatments to minorities

- Challenges with integration in Health Systems
  - Access to data and its organization
  - Scaling complexity
  - Human-AI Interaction

The Bad

Google's medical AI was super accurate in a lab. Real life was a different story.
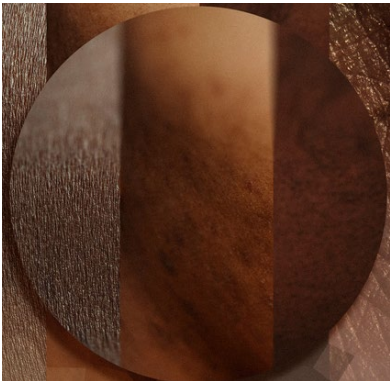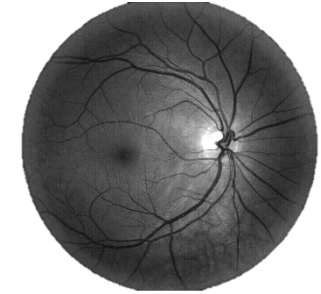
AI skin cancer diagnoses risk being less accurate for dark skin – study

Microsoft-owned AI company data breach affects 1.2 million patients

Noah Schwartz - Monday, September 25th, 2023

https://www.technologyreview.com/2020/04/27/1000658/google-medical-ai-accurate-lab-real-life-clinic-covid-diabetes-retina-disease/

https://www.theguardian.com/society/2021/nov/09/ai-skin-cancer-diagnoses-risk-being-less-accurate-for-dark-skin-study

https://www.beckershospitalreview.com/cybersecurity/microsoft-owned-ai-company-data-breach-affects-1-2-million-patients.html

The Ugly

- Who is accountable when the algorithm fails?
  - Programmers, the AI company, Health professionals, the Hospitals,… ?

- Regulation still in its infancy: EU AI Act

- Lack of transparency throughout the whole process
  - Data, Models, Experiments

- Trust is key, and depends on several factors
  - Mistrust can lead to the "Nirvana fallacy" – useful can be the enemy of perfection
  - Overconfidence can lead to loss of Autonomy and Control

Responsible AI
An analogy with Clinical Trials

Clinical Trials

- Distinct stages of development and testing
- Transparency

Populations   Side effects
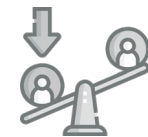
- Pharmacovigilance
- Continuous improvement process

Machine Learning

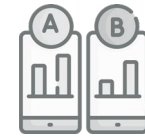- Distinct stages of development and testing
- Transparency

Data   Pipeline

Bias   Tests

- Model Monitoring
- Incremental learning or re-training

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Responsible AI
Center for Responsible AI – A Portuguese Initiative

Center for Responsible AI

- 10 Start-ups (2 "unicorns")

- 8 R&D Centers

- 1 Law Firm

- 5 Industry Leaders

- 21 Products

We believe in Fair, Explainable and Sustainable AI

Fair and transparent

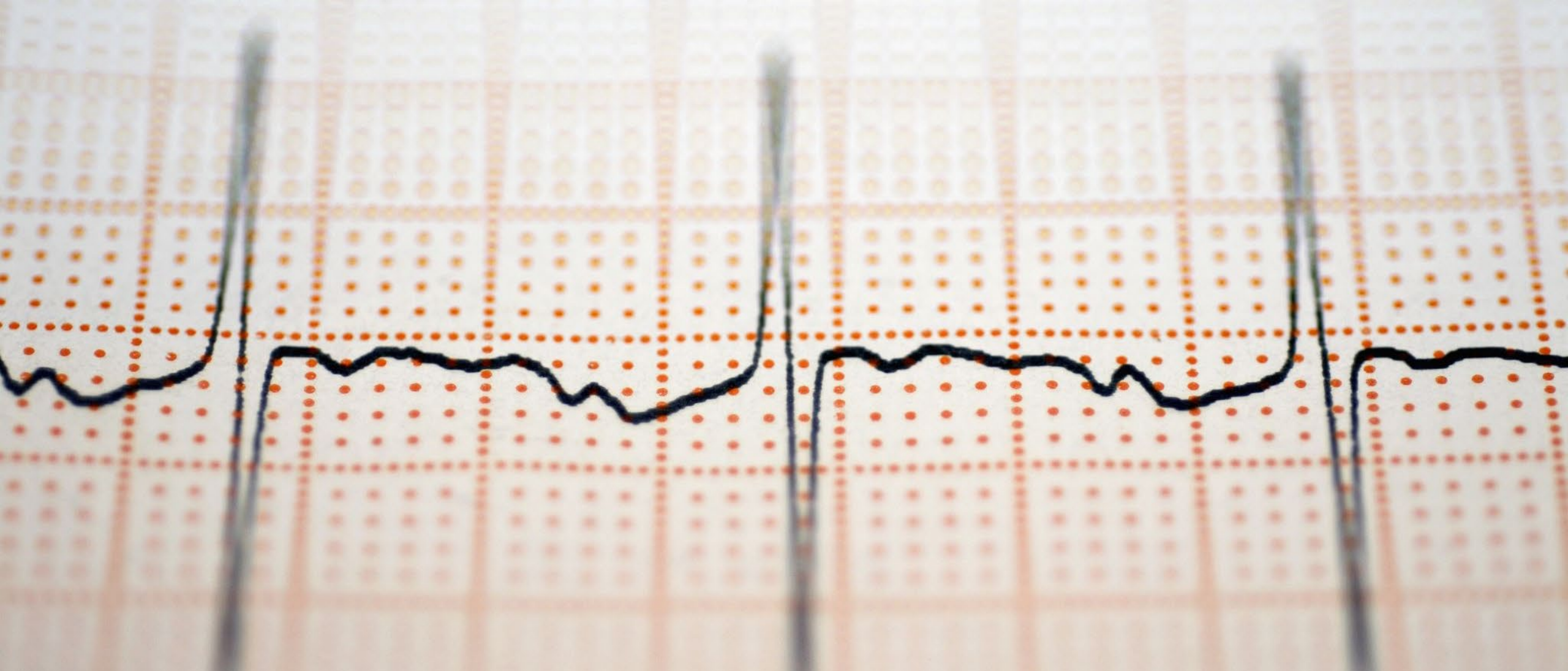We are committed to building AI products that help us build a more equal society.

Eco-friendly

Developing AI algorithms that need less computing power, and are more sustainable.
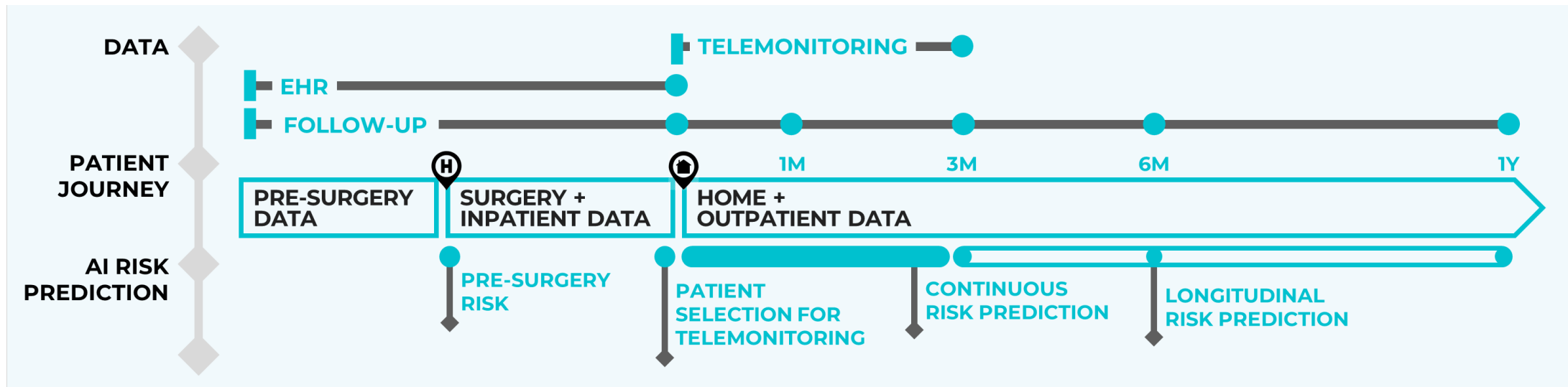
Trustworthy

AI will not replace humans - it's a tool that can make us better. We are working to make AI more explainable and trustworthy.
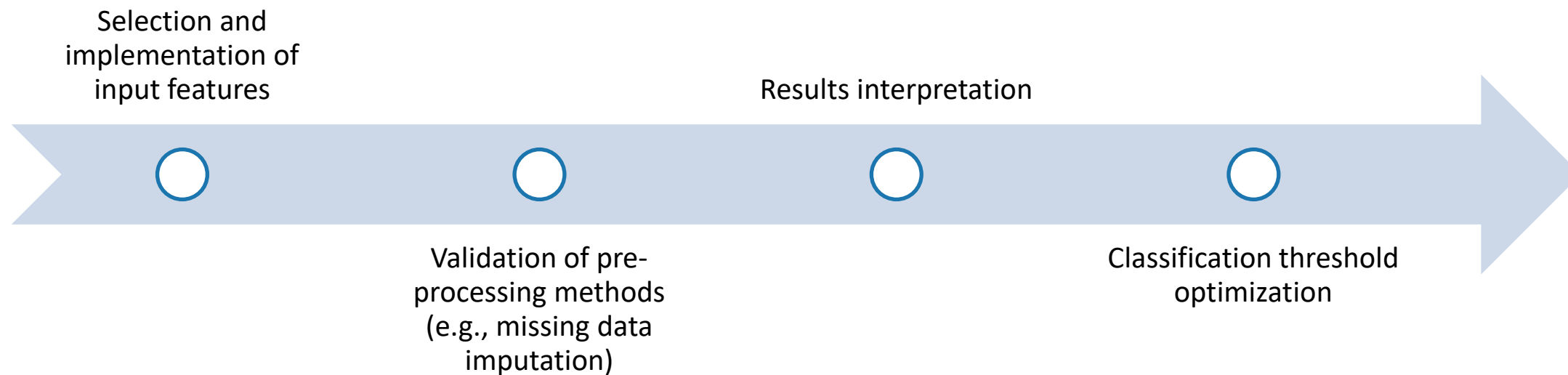
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AI AND CARDIOLOGY AT FRAUNHOFER AICOS

- Objective:
  1. Study the impact of telemonitoring patients after cardiothoracic surgery
  2. Predict the risk of complications (or death) for a patient after the surgery, to prioritize higher-risk patients to attribute the telemonitoring kits
     - Access to demographic data, time of stay in the different services, surgery-related data, etc.

- Iterative process involving Cardiology experts

Selection and implementation of input features

Results interpretation

Validation of pre-processing methods (e.g., missing data imputation)

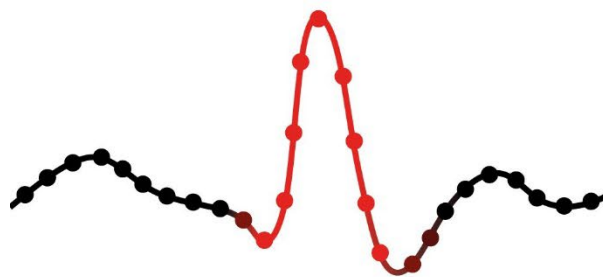Classification threshold optimization

Explainable AI (XAI)
Case Study with ECG

- Objective:

  1. Provide explanations with the model outputs, to support the final decision process
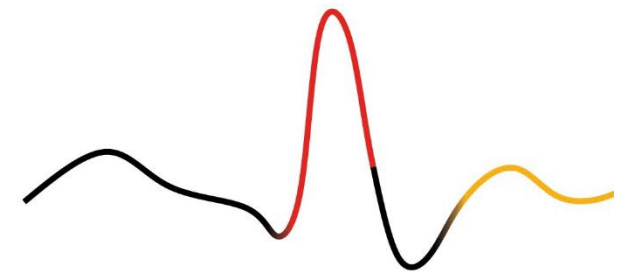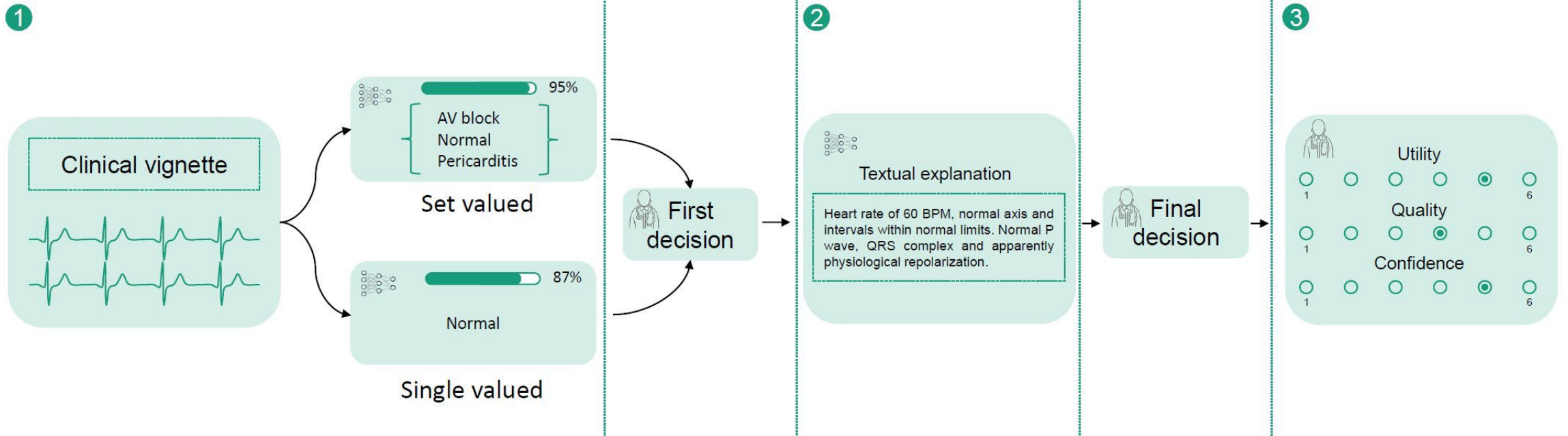
- Explanation taxonomy:
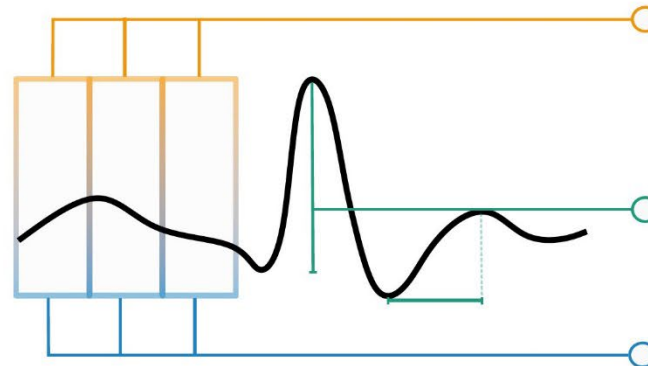
Neves, I, Folgado, D., Santos, S., Barandas, M., Campagner, A., Ronzio, L., Cabitza, F., Gamboa, H. (2021) *Interpretable Heartbeat Classification using Local Model-Agnostic Explanations on ECGs*, Computers in Biology and Medicine.

Explainable AI (XAI)
Clinician-AI Collaboration

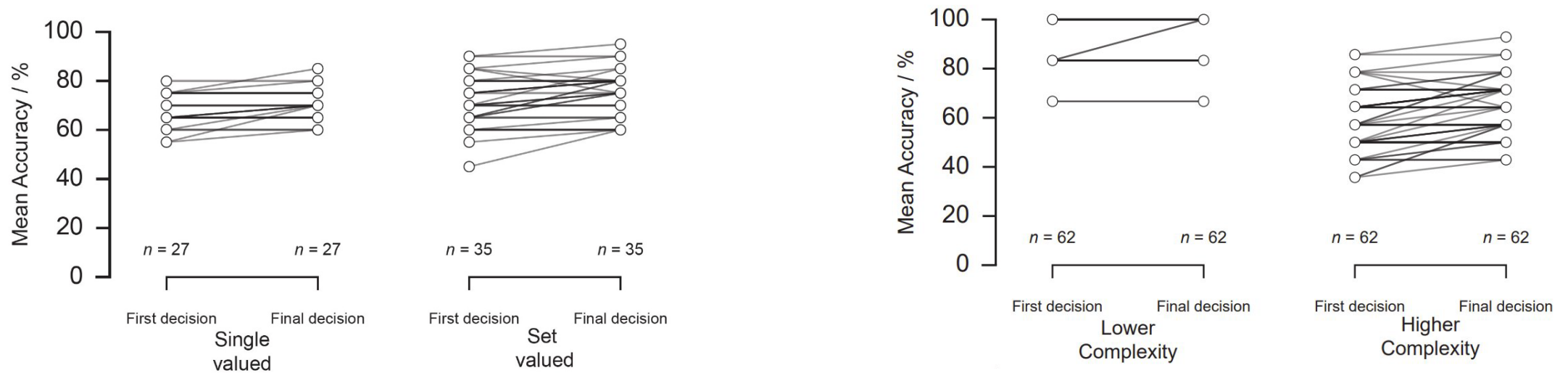62 cardiologists from several Portuguese healthcare institutions

Explainable AI (XAI)
Clinician-AI Collaboration

- Main conclusions:
  1. Textual explanations (by human experts in this case) significantly improved diagnostic accuracy
     - But only for more complex cases

Folgado, D., et al. Enhancing Decision-Making in ECG Analysis: A Comparative Study of Controllability Techniques in AI-Assisted Diagnostics. *IEEE Transactions on Systems, Man and Cybernetics: Systems.*

UNDER REVIEW

IA Explicável (XAI)
Colaboração Clínico-IA

- Main conclusions:

  2. Set-based predictions tend to outperform single-valued results

     - Especially in cases of higher complexity, and for less experienced professionals
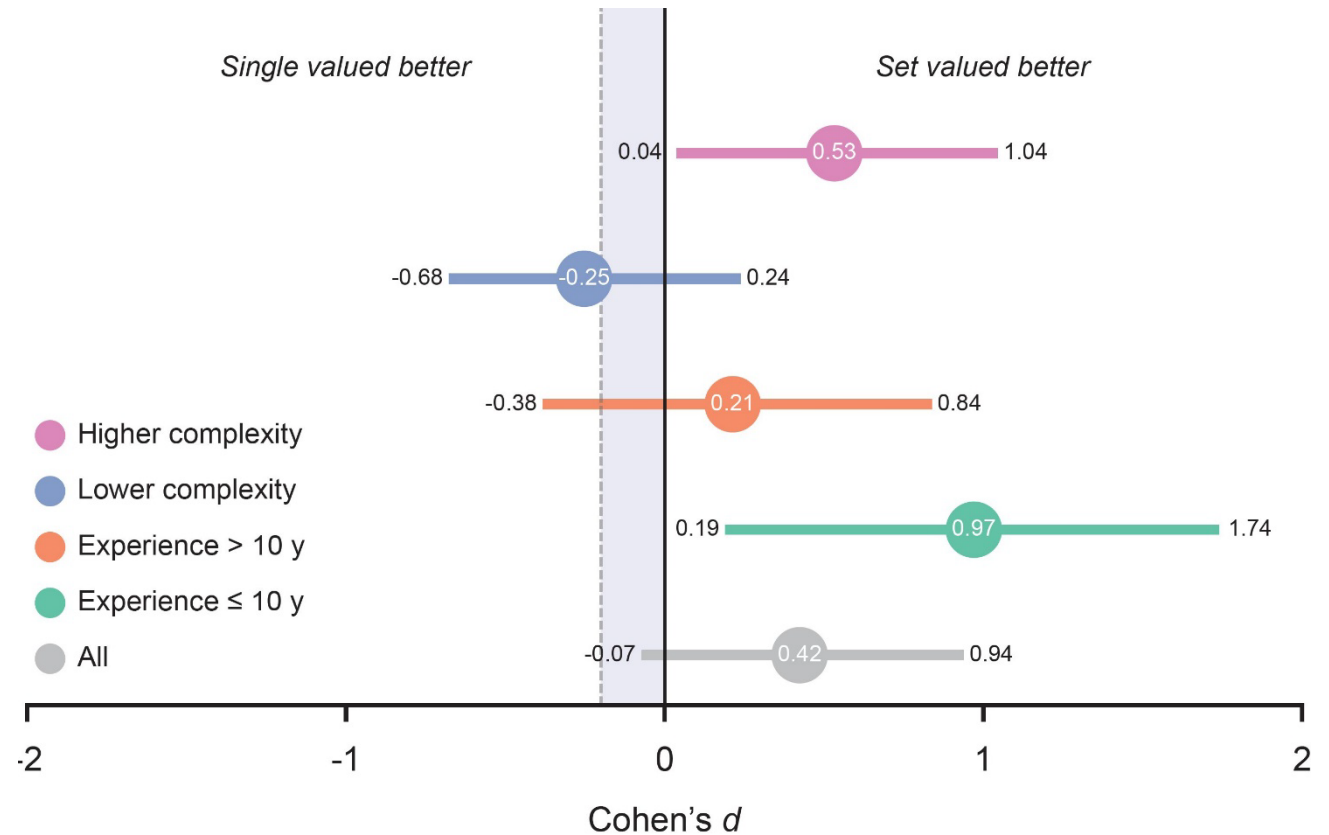

Folgado, D., et al. Enhancing Decision-Making in ECG Analysis: A Comparative Study of Controllability Techniques in AI-Assisted Diagnostics. *IEEE Transactions on Systems, Man and Cybernetics: Systems.*

UNDER REVIEW

Conclusions

- AI has incredible potential in Healthcare

  - Diagnosis, Treatment, and even freeing professionals towards patient-facing time

  - <u>It will not replace the experts</u>, but will change the operations, and augment human capabilities!

- However, there are significant risks to consider:

  - Privacy, bias, the need for robust validation, loss of autonomy, …

- Responsible AI is the way to go

  - Multidisciplinary collaboration: researchers, clinicians, regulators, AI producers

We're at the beginning of a true revolution, where AI is becoming indissociable from innovation in Healthcare, but its true potential depends on our collective commitment!

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Q&A
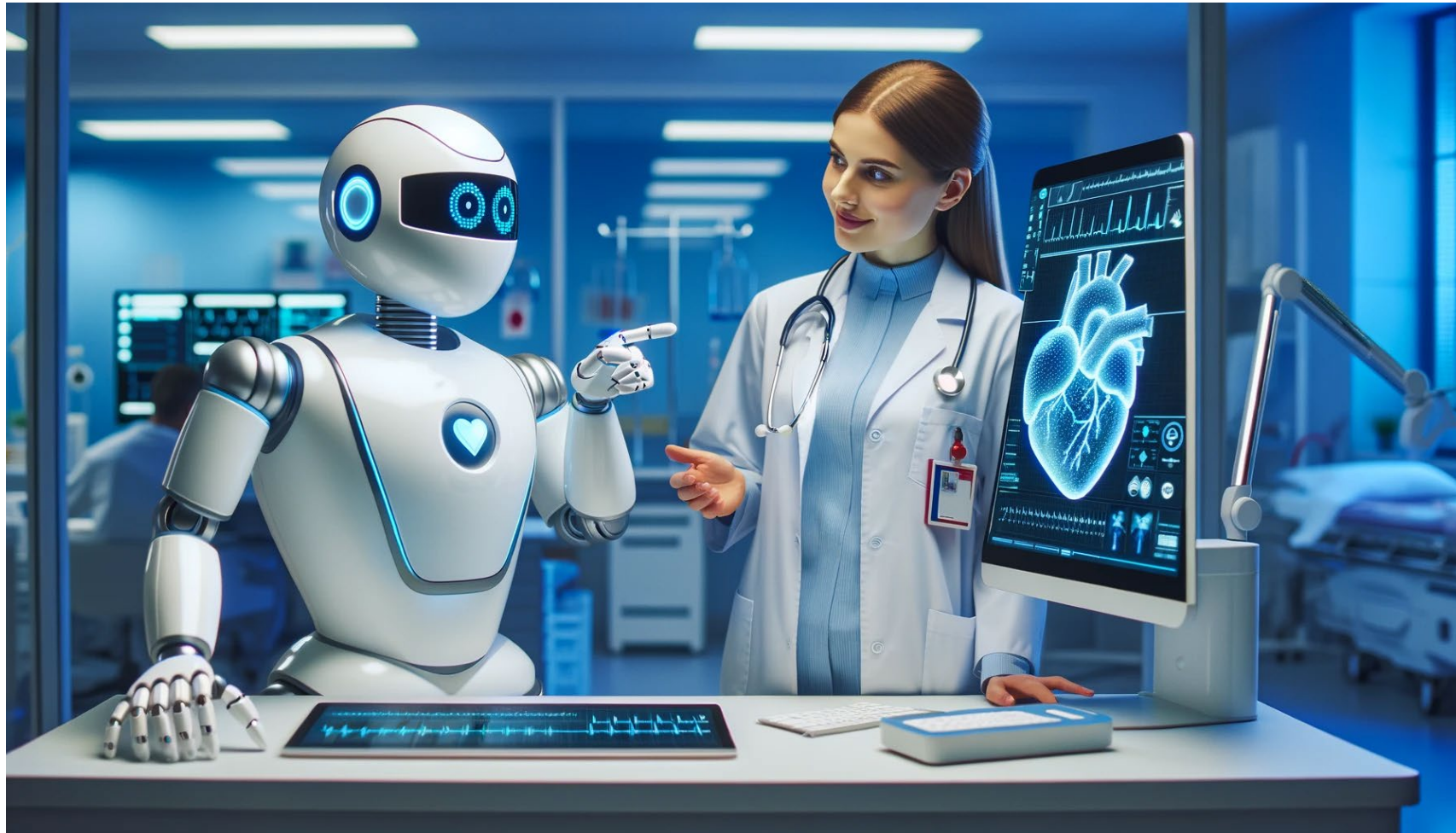
Contact me at: andre.carreiro@aicos.fraunhofer.pt