Critical Applications of AI in Industry, Healthcare and Other Sectors

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07.April.2025

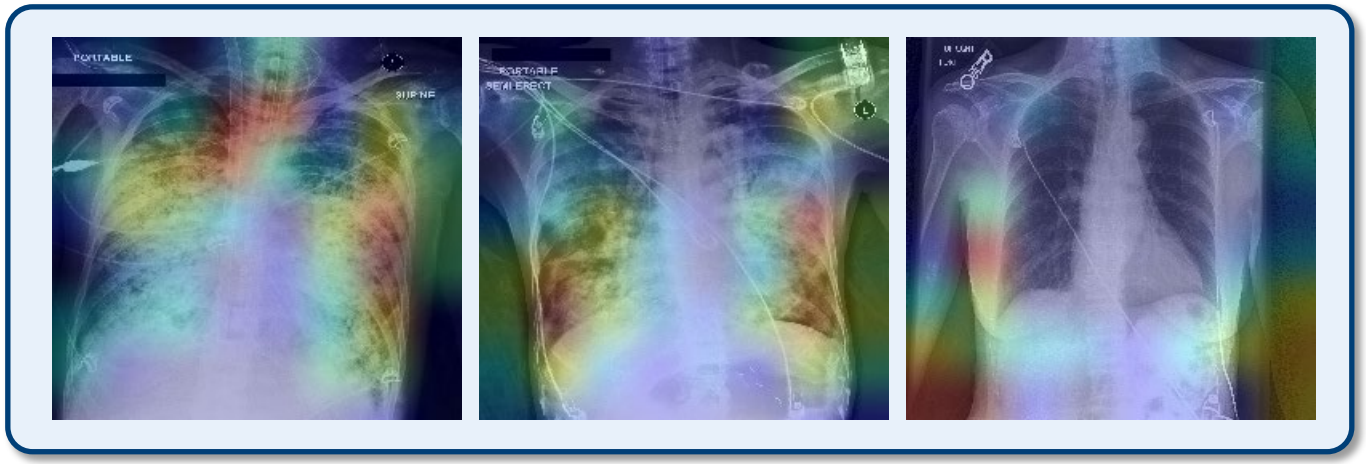
Challenges for AI applications in intensive care medicine

Informatik 11
Embedded Software

RWTH AACHEN UNIVERSITY

AI Methods in Medical Applications

- Natural language processing of medical reports
- Image processing



- Speech enabled automation
- Utilization of high-resolution data-streams in intensive care medicine

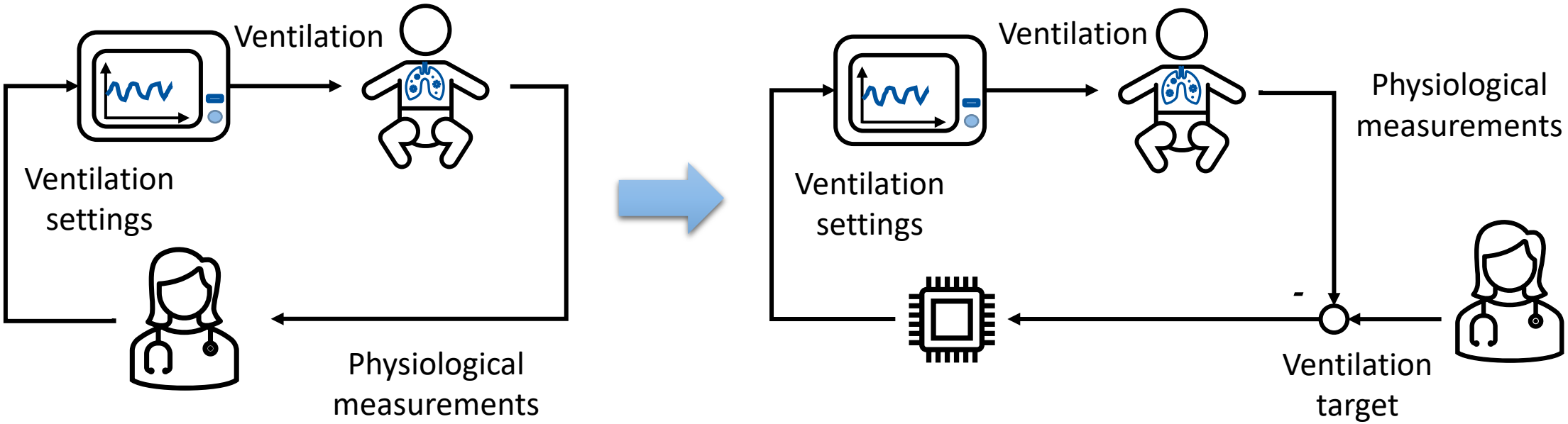
Use-Cases: Mechanical ventilation

- Why do patients need mechanical ventilation?
  - Lung injuries
  - Immaturity (neonates)
  - Surgical procedures (anaesthesia)

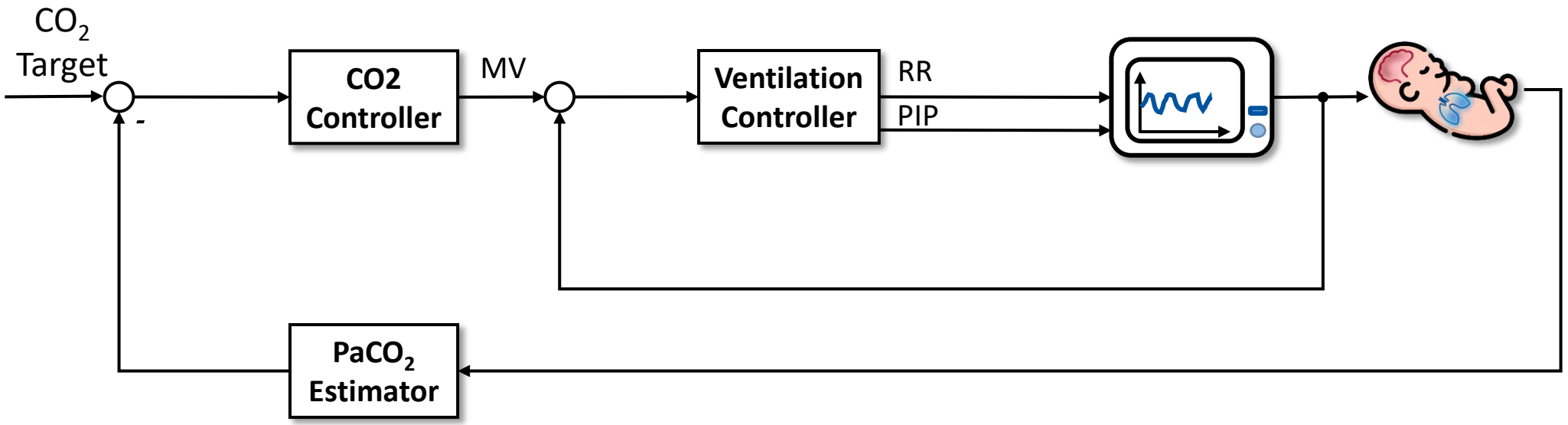
- Goal
  - Supply organs / body with oxygen
  - Eliminate carbon dioxide (CO_2)
  - Allow lungs to recover / develop
  - Wean from need for mechanical ventilation

Closed-Loop Ventilation

- Main goal: keeping O_2 and CO_2 in physiological range

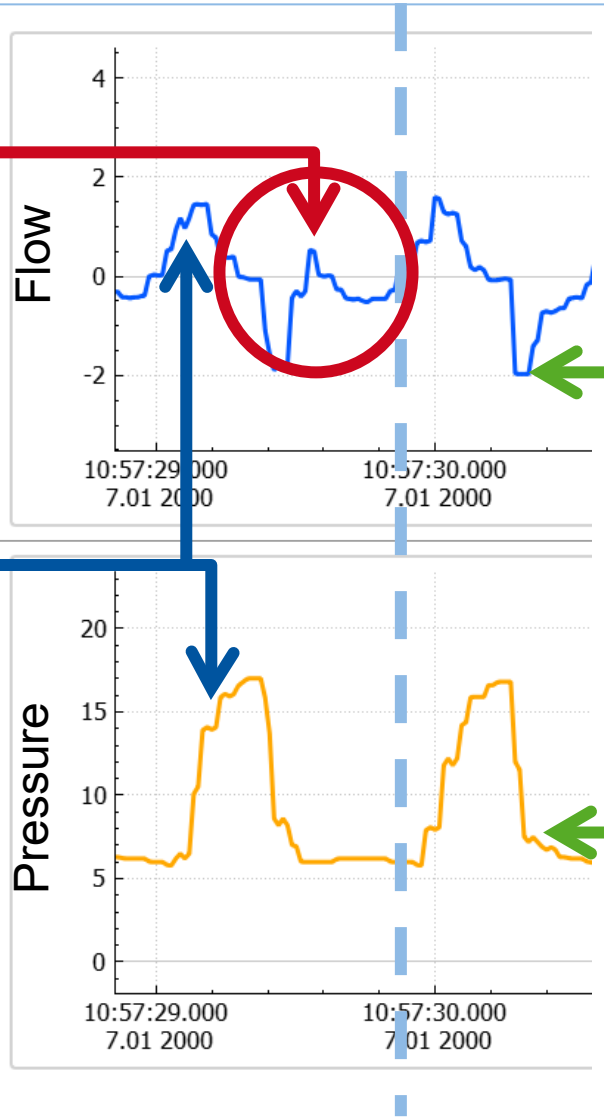


Next generation of machine ventilation control



Classification of breath-types

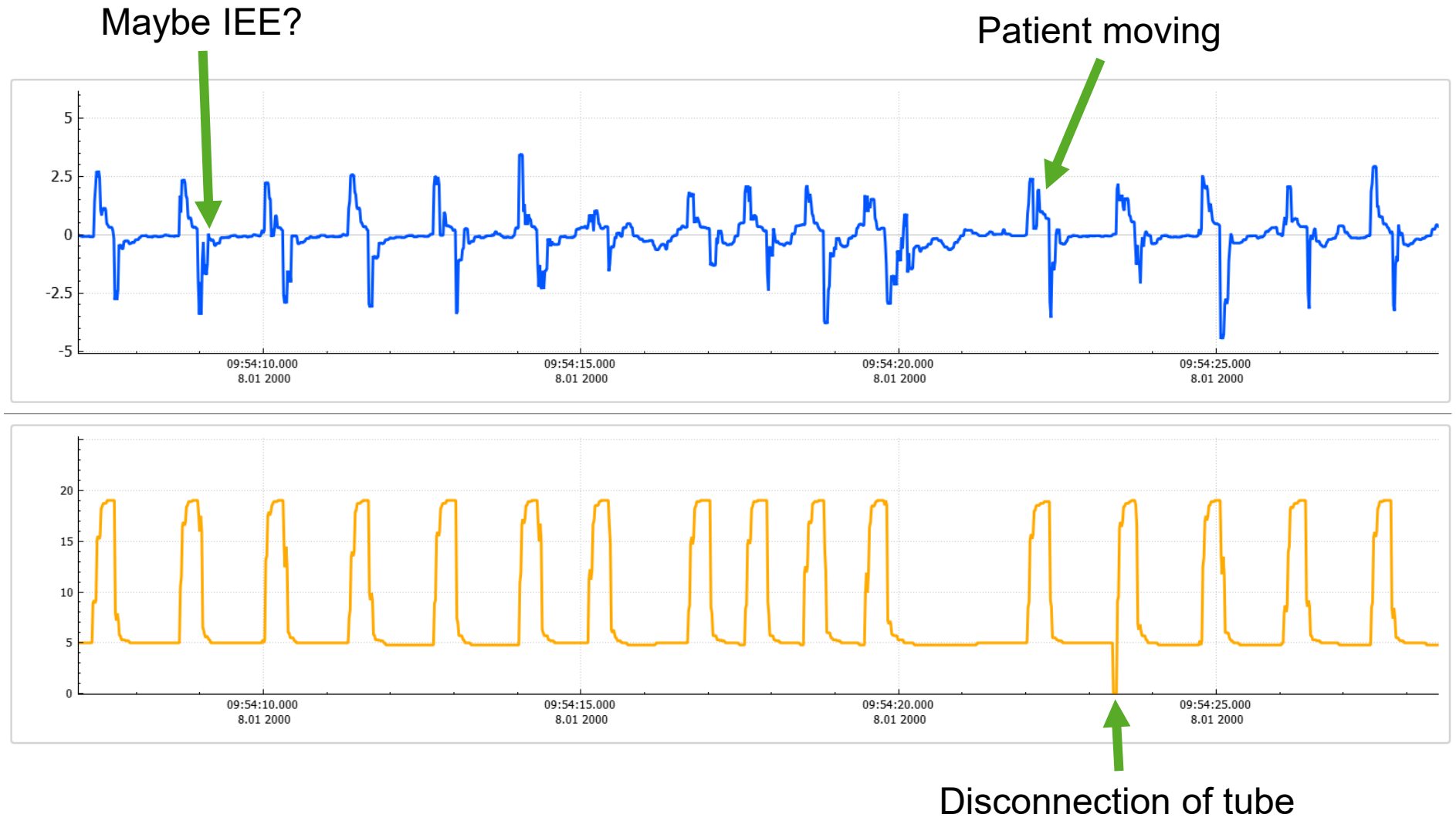
Ineffective effort during expiration (IEE)



Inspiration

Expiration

Patient-Ventilator Asynchrony



Challenges

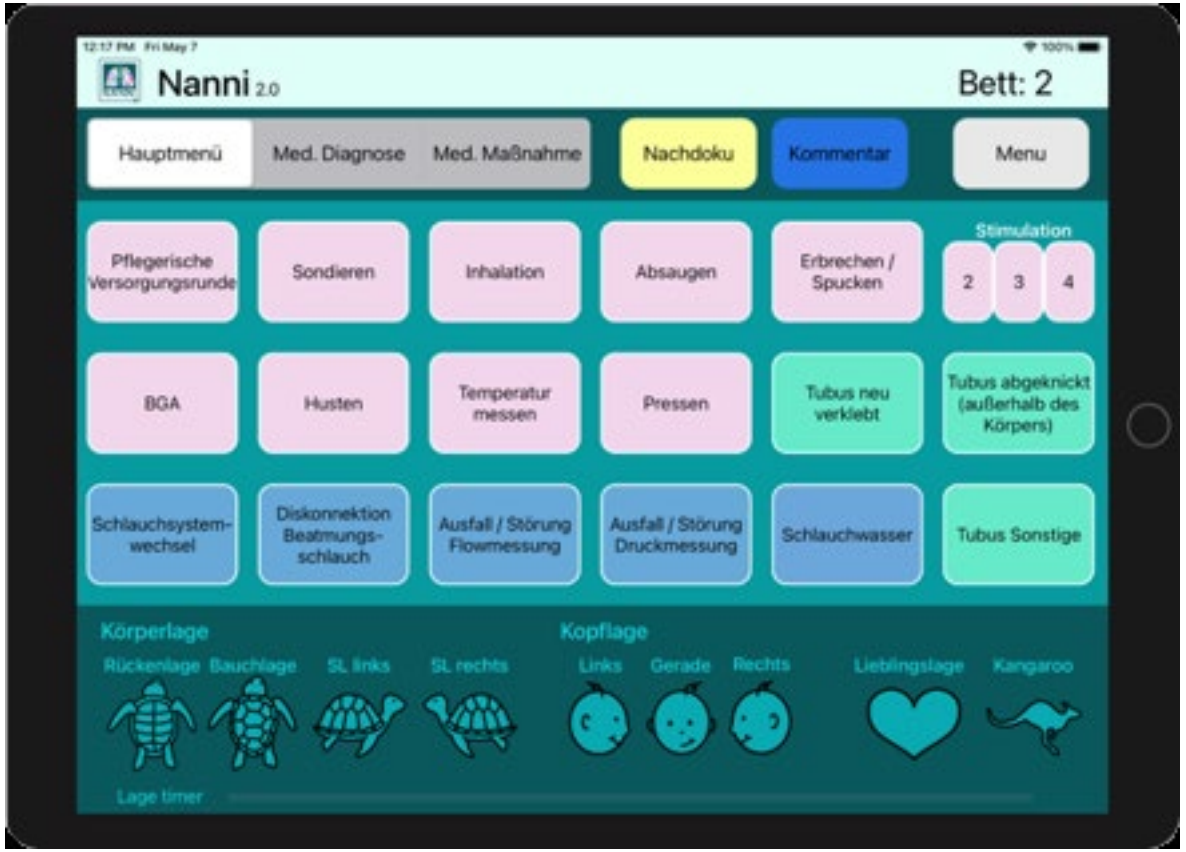
- Data protection regulations
- Annotations
- Data quality
- Data quantity
- Debugging / back-box characteristics of methods
- Approval as medical product
- EU AI Act

Data Protection

- EU guardrail: General Data Protection Regulation
  - GDPR recognises *data concerning health* as a special category of data
- Anonymization
  - Time-series-data useless without timestamps
- Pseudonymization / Coding
- Informed consent of patients (and parents?)
  - “Sometimes” data usage via research option possible
- Additionally Institutional Review Board / ethics committee approval

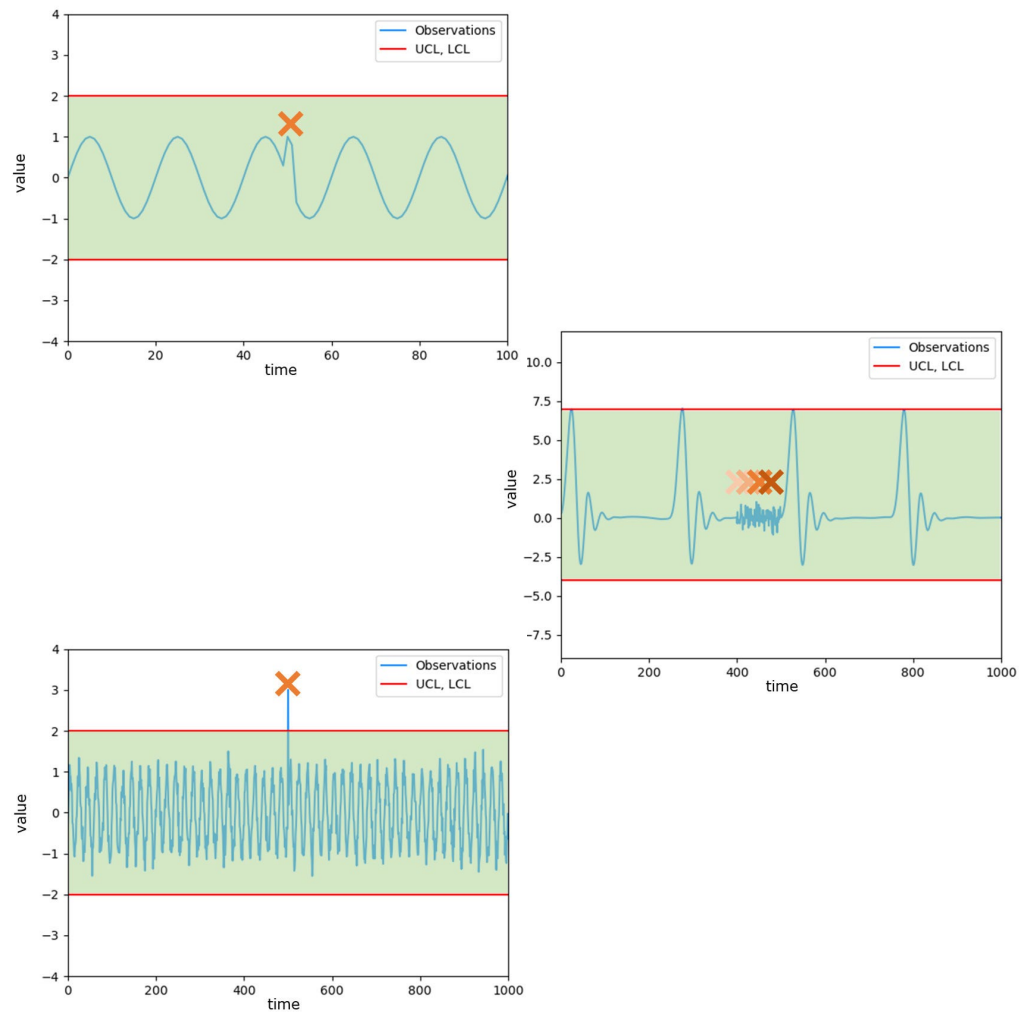
Annotation of Data

- Annotations needed for many ML algorithms
- Online annotation
  - Lack of time during daily routine
  - Chance to have a “look-see”
- Post-hoc annotation
  - Missing detail knowledge
- Variance in different annotators



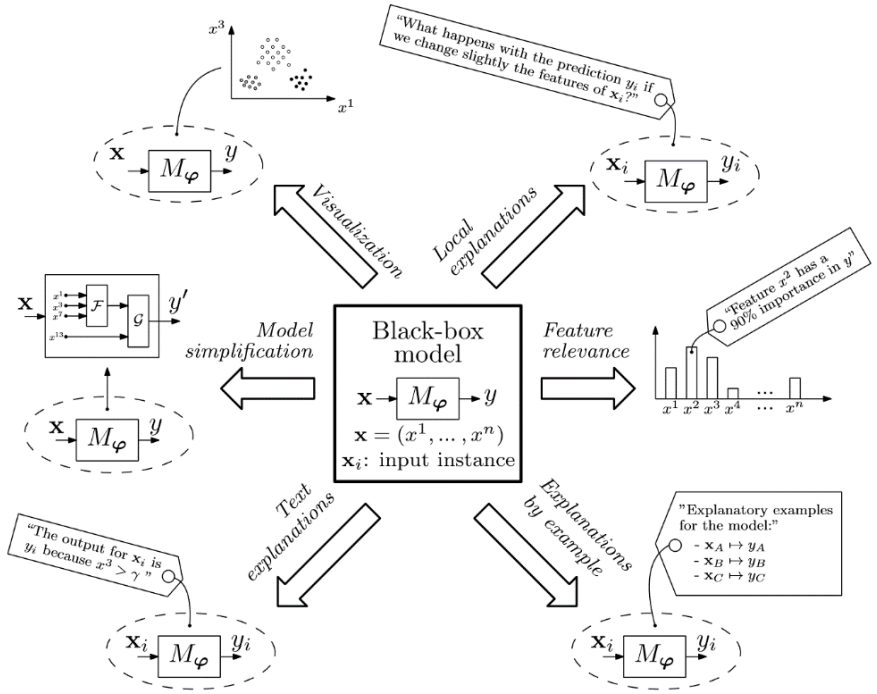
Data quality and quantity

- Anomalies in Data
  - Sensor Errors
  - Wear-out of sensors
  - By-effects of treatment or caregiving
- Synchronicity of different measurements
- Need to also include rare events
- Resolution of Data
- Desire for multicentric studies
  - Legal issues of exchanging data
  - Comparability of data
    - Standard Operating Procedures
    - Classification of illnesses e.g. ICD-Codes



Need for explainability and interpretability

- EU AI Act demands *transparency & human oversight*
- Use-Cases
  - Debugging of algorithms
  - Approval of medical product
  - Plausibilize decision support recommendations
  - Education of e.g. medical students
- Intrinsic explainable methods
  - Rule-based approaches
  - Ascribe nodes within net to specific property
- Add-on explainability
  - Additional Algorithms



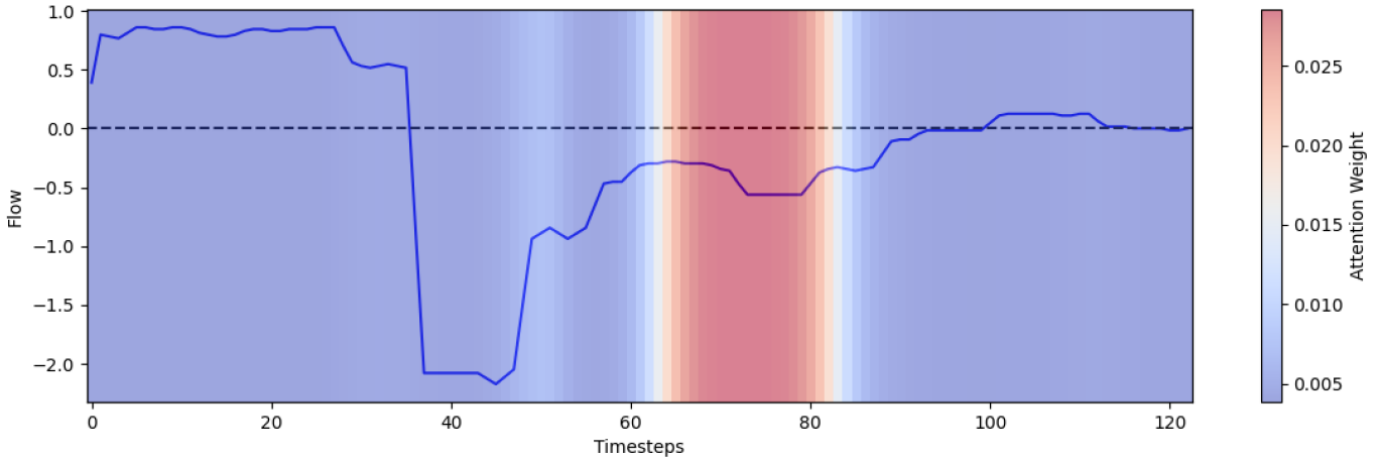
Examples for Concepts for xAI[1]

[12] Arrieta et al., "Explainable Artificial Intelligence (XAI): Concepts, Taxonomies, Opportunities and Challenges toward Responsible AI" (2019)

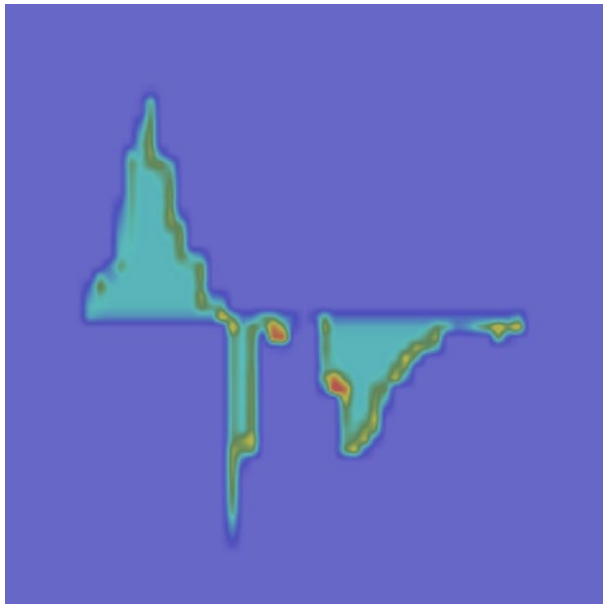
Explainable AI

- Opening the black box of neural networks
- Highlight important sequences

IEE detection RNN



IEE detection CNN



Consequences

- Ethical discussions need to be carried out
  - Blue-prints / pathways to enable data exchange for research
    - European Health Data Space
    - European Open Science Cloud
  - More Detailed confines for allowed actions
    - Reducing discussions with Institutional Review Boards
- Define different classes of explainability / interpretability for AI methods
- Allow for the usage of AI in Physiological Closed-Loop Control Applications
  - Displace Clinician-in-the-loop as safeguarding