Prediction of Patient-level Outcomes:
Acute Kidney Injury in Cardiac Surgery Patients

Frederic Schneider

Intermediate Presentation

Trends in Bioinformatics, Winter 2017/18

Agenda

1. Motivation and problem statement

2. Methods and tools

3. Challenges

4. Outlook

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Acute kidney injury in heart patients

- Heart and kidney are interconnected

- Pathways:
    - Salt and water retention
    - vasoconstriction

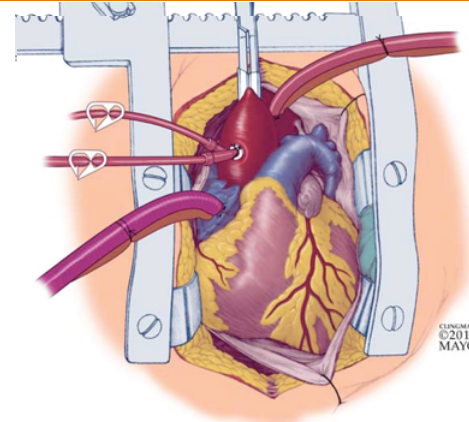➡ Injury or stress on either organ can cause dysfunction of the other
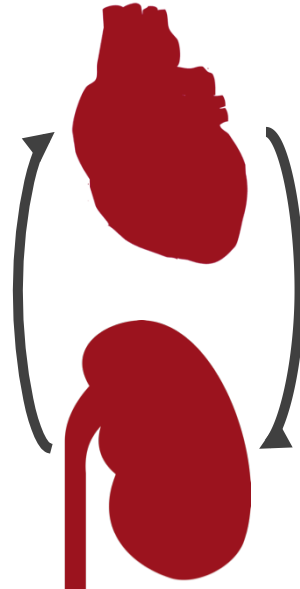
- Pathways:
    - Hormonal factors
    - Increased venous pressure
    - Decreased perfusion, i.e. filtered blood
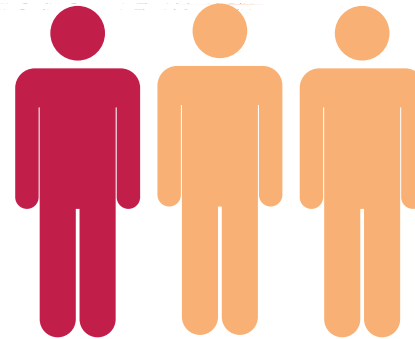
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Acute kidney injury in heart patients
Cardiopulmonary bypass and incidence

- Up to 30 % of patients undergoing cardiac surgery develop AKI [1]

- Associated with substantial morbidity and mortality independent of cardiac disease

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Top left: https://upload.wikimedia.org/wikipedia/commons/thumb/c/c3/Coronary_artery_bypass_surgery_Image_657C-PH.jpg/1200px-Coronary_artery_bypass_surgery_Image_657C-PH.jpg, top right: Greason, K.L., Sundt Ill T.,M., Cardiac surgery in the adult (4th ed.), Chapter 21, retrieved from: http://accesssurgery.mhmedical.com/data/books/cohn4/cohn4_c021f005.png

Acute kidney injury in heart patients
Previous work

- Previous work focuses on detection of AKI onset
- Monitoring vitals and blood test results during ICU stay after surgery
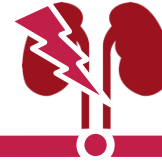
- Goal of this seminar work: Identifying patients who are at risk for AKI before surgery
- Analyzing patient records, laboratory values, patient data leading up to surgical intervention

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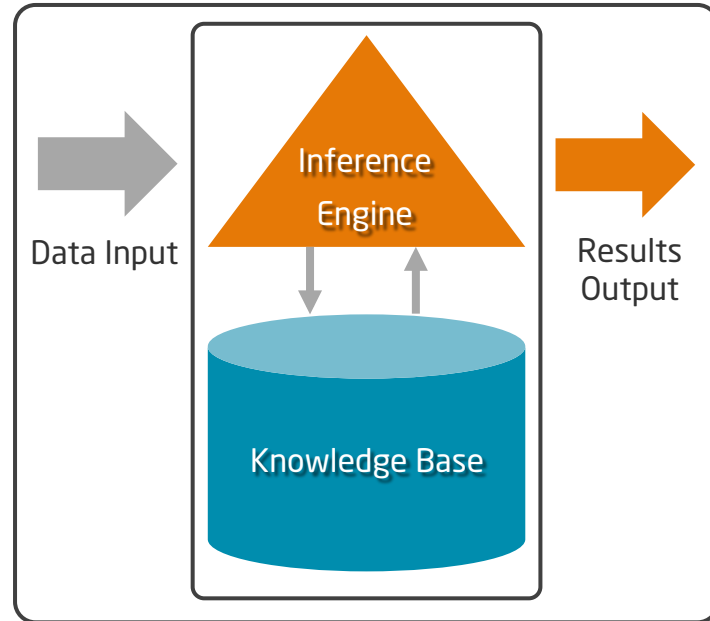TiB Winter 2017/18

Chart **5**

Goal:
A clinical prediction model for post-operative AKI

- Prediction of AKI before surgery
- Based on historical patient data
- Relevant outputs:
  - Risk for AKI
  - AKI stage
  - Confidence of classification
  - Need for renal replacement therapy
- ➡ Applicable in a clinical environment for decision support
  - How do you gain trust?
  - Does the result have an explanation?
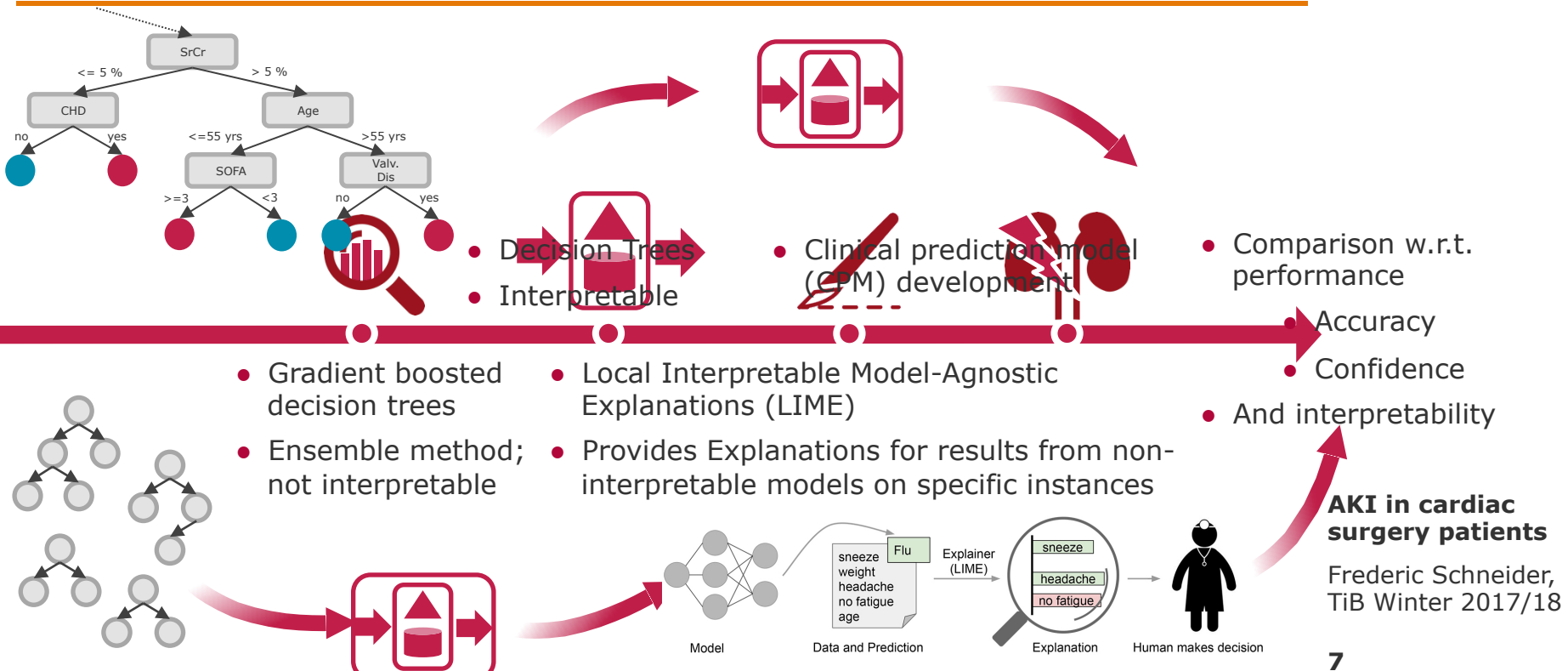
Data Input

Inference Engine

Results Output

Knowledge Base

Architecture components of CDSS (Kola, n.d.)

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Berner, E. (2009). Clinical decision support systems: state of the art. AHRQ Publication, (9) Retrieved from https://healthit.ahrq.gov/sites/default/files/docs/page/09-0069-EF_1.pdf

Methods and Tools
Interpretable and non-interpretable prediction models

- Decision Trees
- Interpretable

- Clinical prediction model (CPM) development

- Comparison w.r.t. performance
  - Accuracy
  - Confidence
- And interpretability

- Gradient boosted decision trees
- Ensemble method; not interpretable

- Local Interpretable Model-Agnostic Explanations (LIME)
- Provides Explanations for results from non-interpretable models on specific instances

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sneeze
weight
headache
no fatigue
age

Flu

Explainer (LIME)

sneeze
headache
no fatigue

Model

Data and Prediction

Explanation

Human makes decision

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Explaining predictions to a human decision maker. Source: Marco Tulio Ribeiro, https://www.oreilly.com/learning/introduction-to-local-interpretable-model-agnostic-explanations-lime

Challenges

- Missing values and heterogeneity of medical data

- Feature extraction with regard to the temporal context of laboratory values, events, etc.

- Explaining the non-explainable prediction model
  - Critical for acceptance into practice in the clinical domain
  - Necessitates special tooling, e.g. **LIME**

Outlook

- Identified input and output attributes for CPM

- Data preparation and pipeline

- Preliminary model evaluation

- LIME: Explaining the non-interpretable model

- Assess the trade-off of interpretability and model performance

- Preparation:
  - Decided on prediction models for CPM
  - Available data
  - Talked with domain experts

- Fine-tuning of CPM

- Application-ready implementation

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