

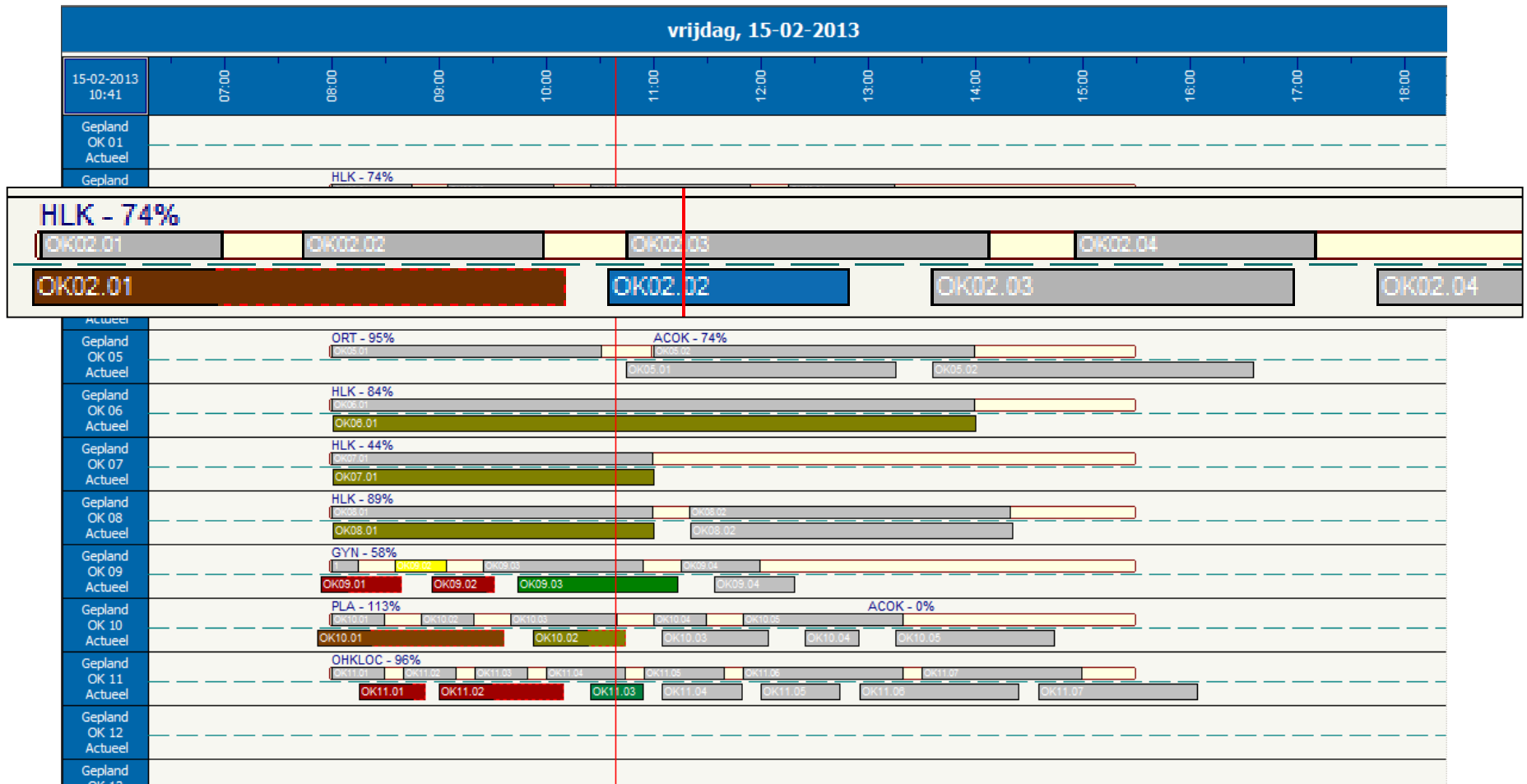
Learning Systems

Computer assisted process management in the OR

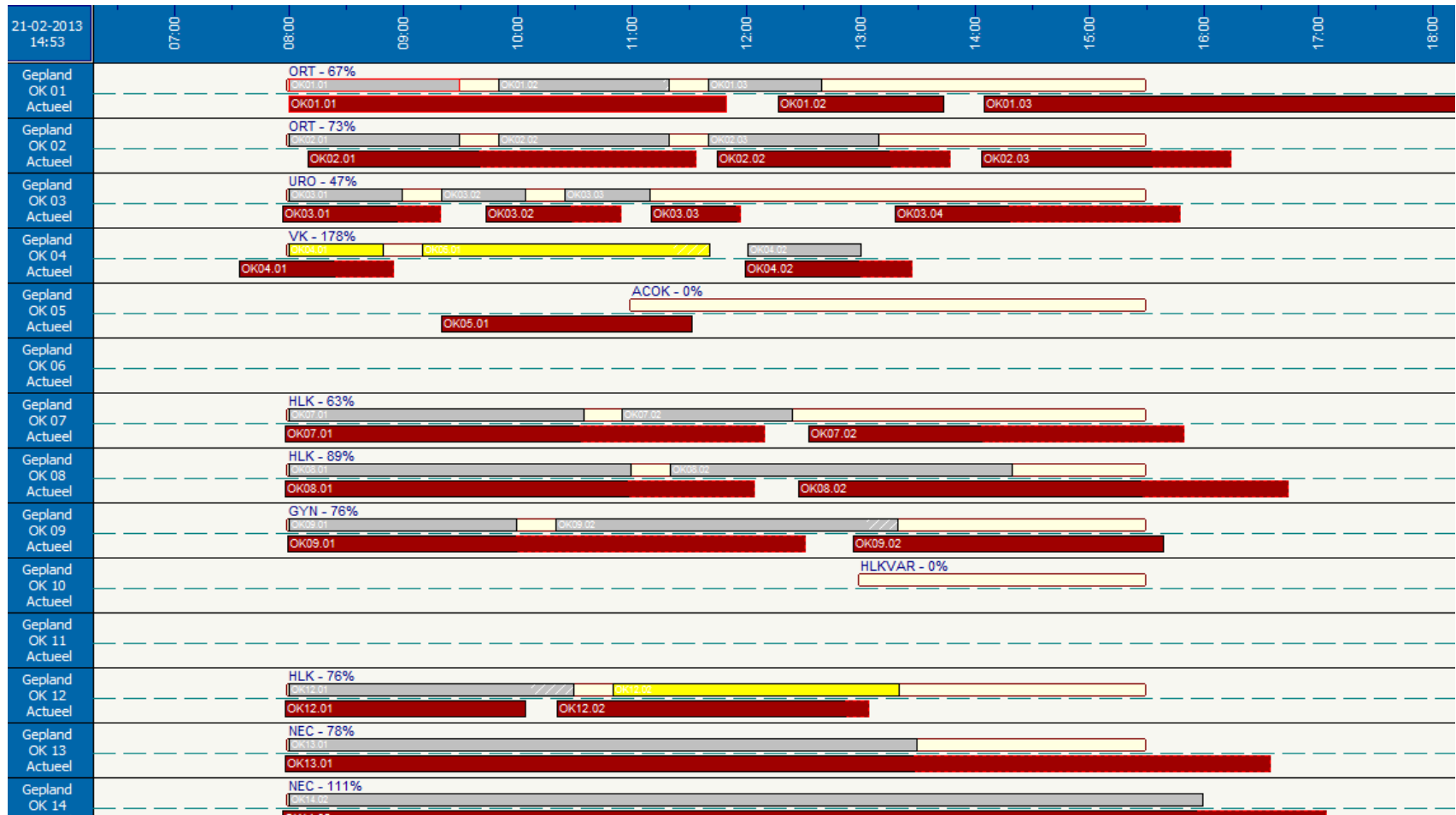
John van den Dobbelsteen
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Delft University of Technology



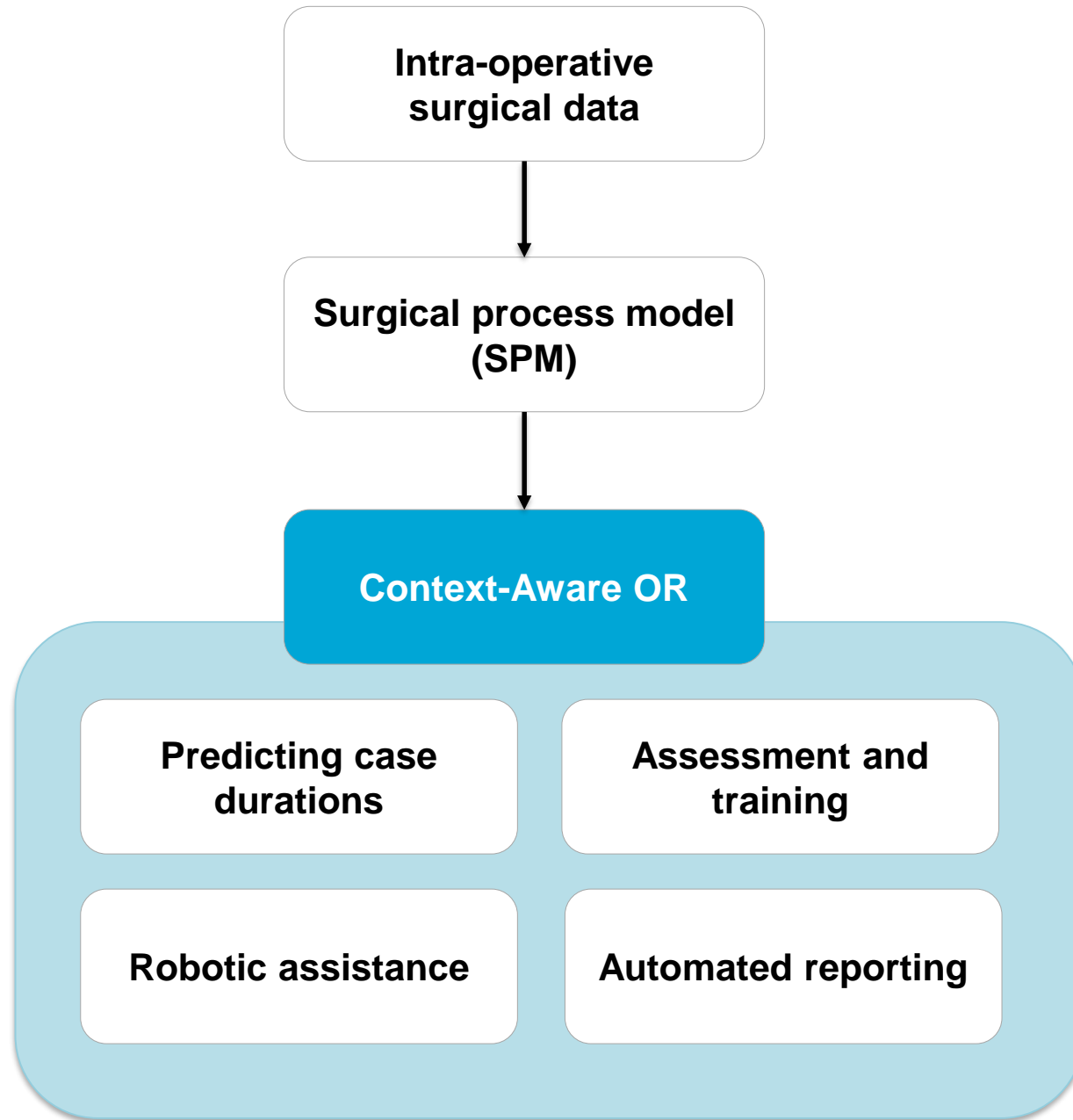
Planning of OR time and resources



Planning of OR time and resources



Goal



Surgical Process Model (SPM)

Low level (sensor) information

Intra-operative data:

- Video and audio
- Instrument use
- Equipment use

Challenges:

- Manual annotation
- Small number of cases

Surgical Phases

Higher level descriptions:

- Protocols
- Sub tasks
- Surgical steps

- Natural language
- Assumptions like order

Phase recognition model

Approaches:

- Classification
- Regression
- State-space models

- Model validation
- Performance metrics

A clinical case

- Recordings of laparoscopic hysterectomy (n=40)
- Challenge: significant duration with high variance (122 ± 28 min S.D.)



Image: <http://bronovo.nl>

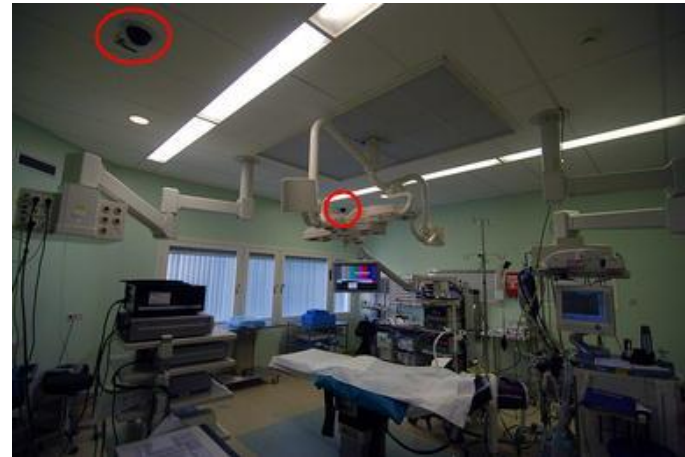
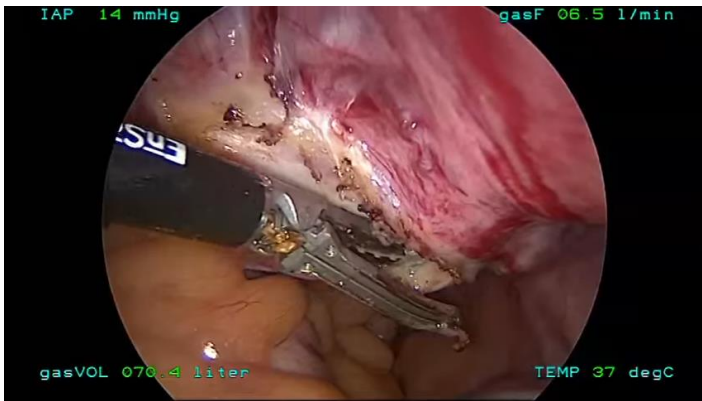
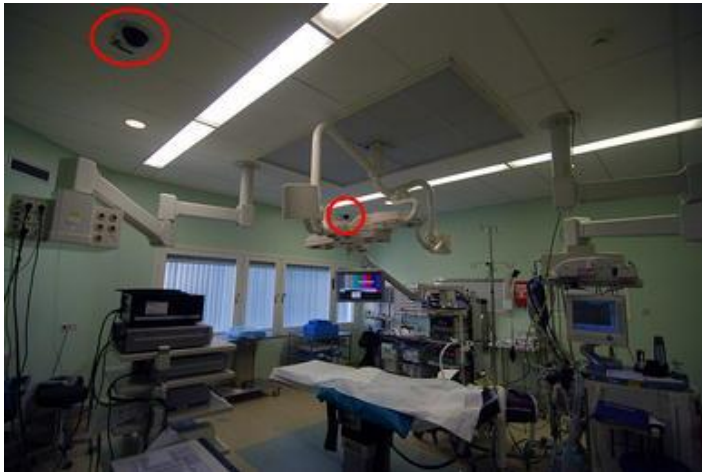


Image from [9]

[9] Blikkendaal et al., 2017

Surgical data



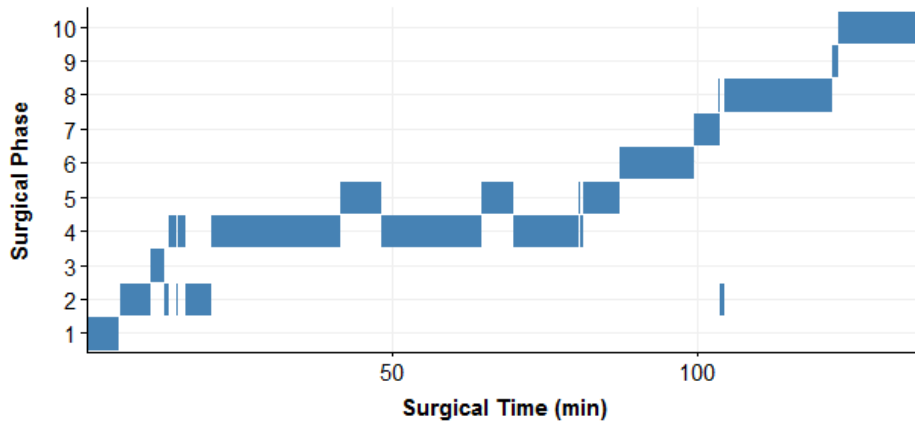
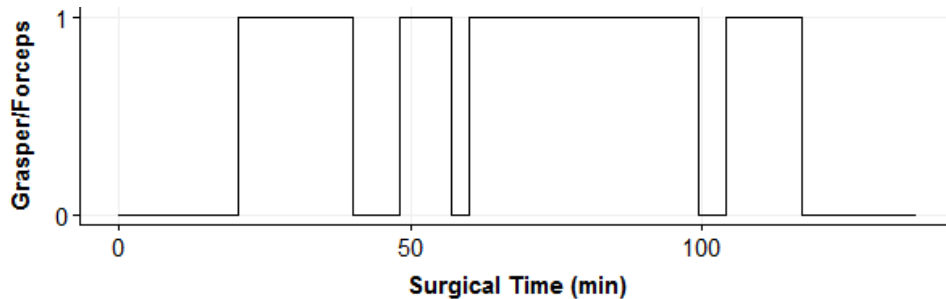
Instruments (12 binary signals)

1. Grasper / forceps
2. Bipolar coagulation
3. Ultrasound coagulation
4. Probe
5. ...

Phases (1 categorical signal)

1. Create CO2 pneumoperitoneum
2. Insert access ports
3. Preparation operative area
4. Expose uterine arteries
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Surgical data



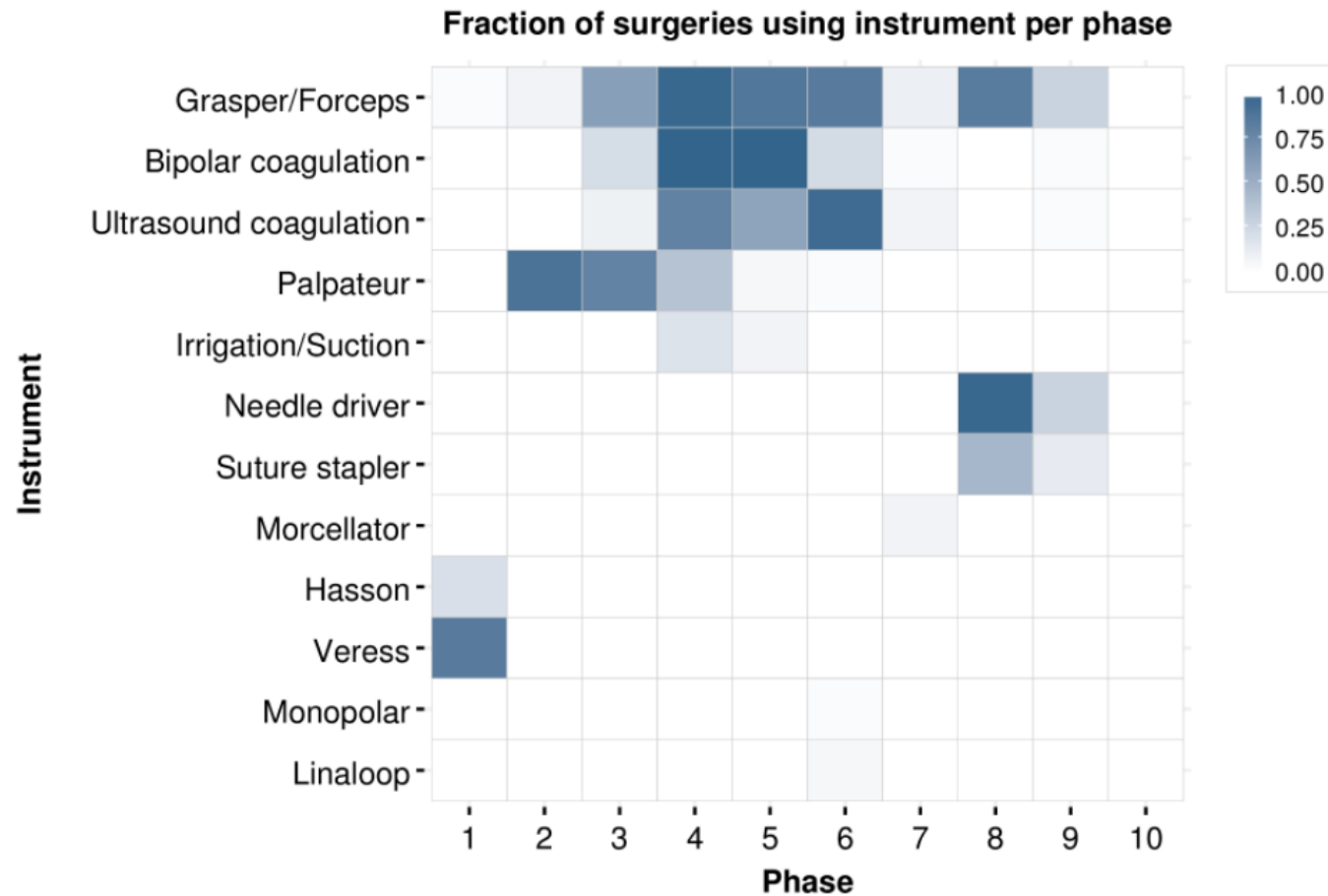
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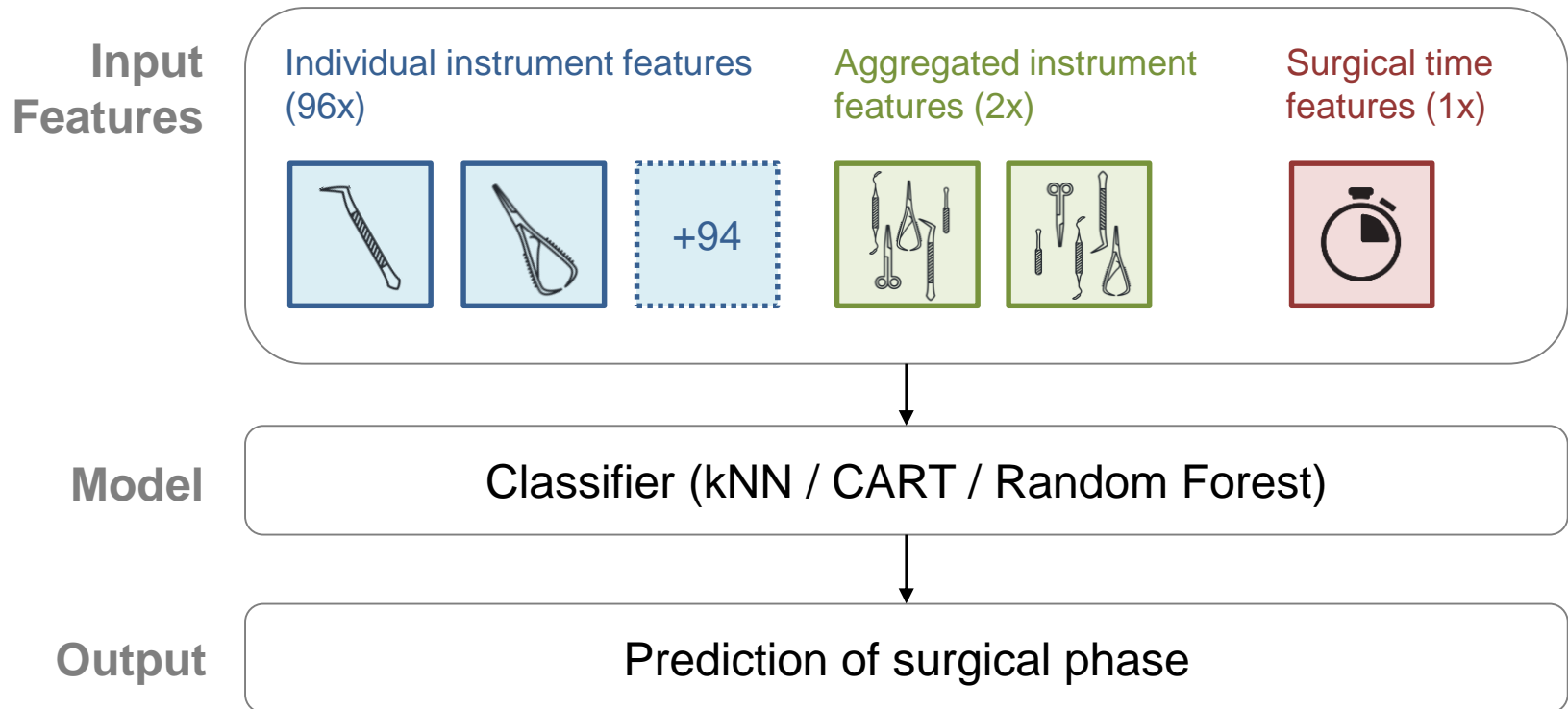
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Patterns in instrument use

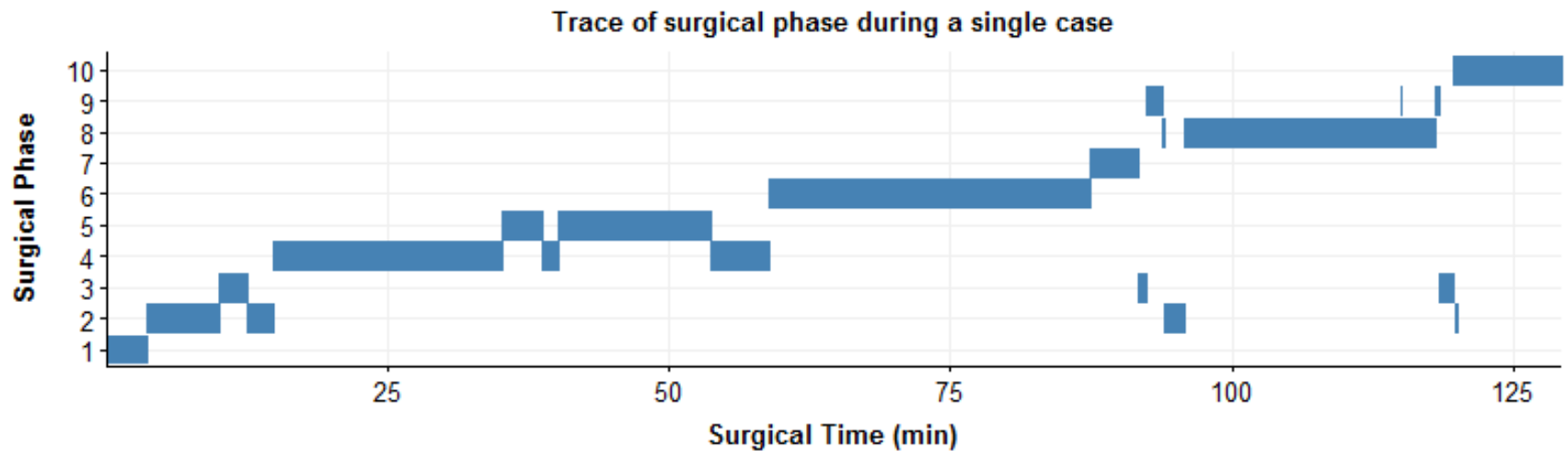


Classification of surgical phases



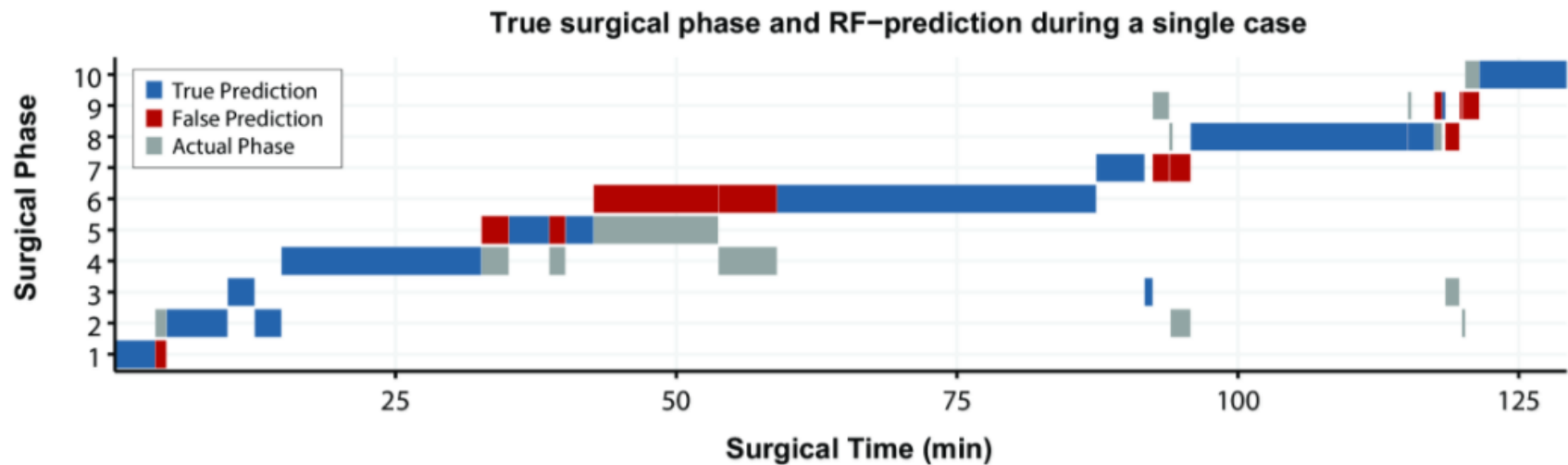
Model performance

- Phase transition in single surgical case



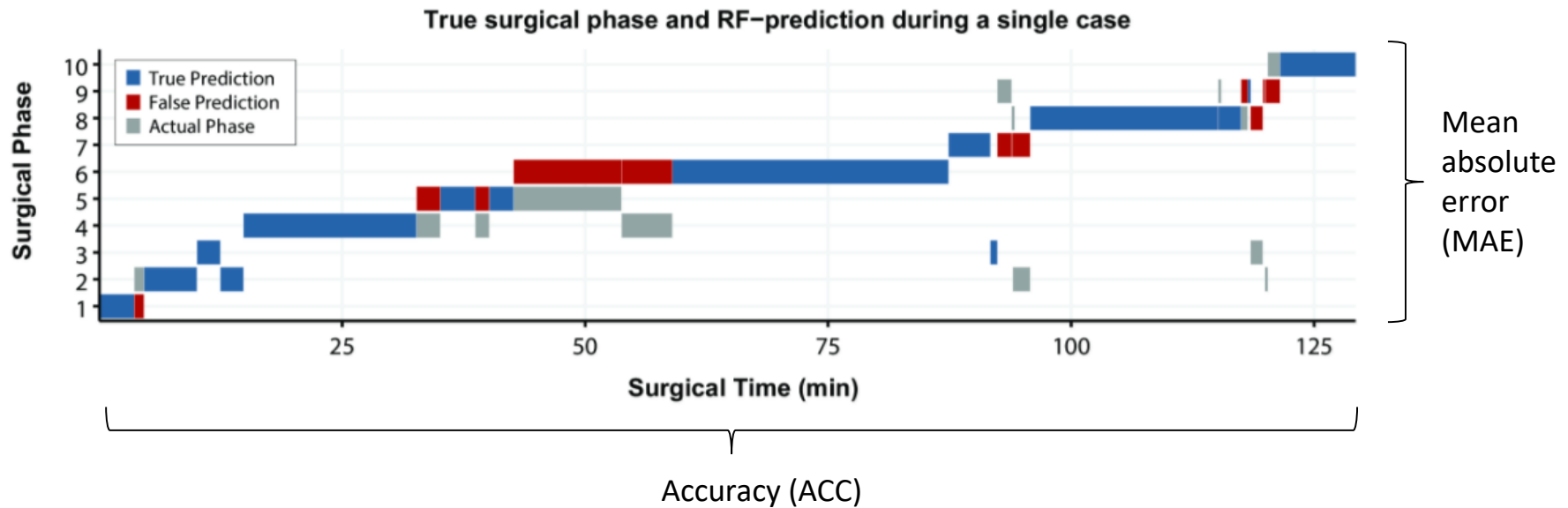
Model performance

- Application of model to single surgical case



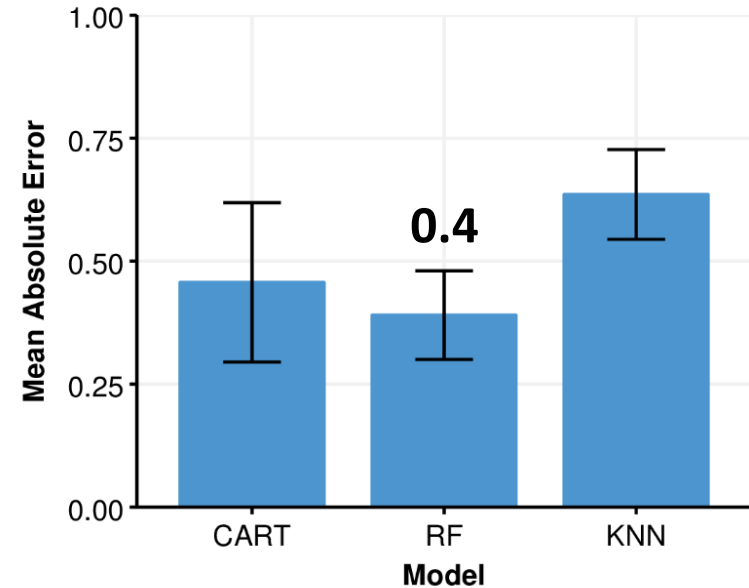
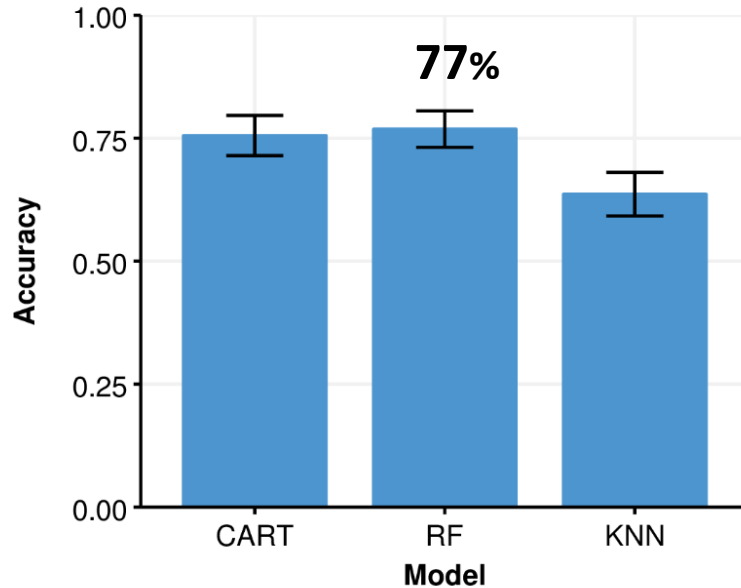
Model performance

- Optimization using 10-fold cross-validation:
 - Accuracy (ACC)
 - Mean Absolute Error (MAE)



Model performance

Comparison of optimized models



Note that:

- Performance strongly differs per phase (0%-91% accuracy)
- Feature analysis highlights 4 out of 12 tracked instruments.

Towards a Context-Aware OR

Summary

- Data acquisition needs
 - Annotation vs. sensors
 - Formal descriptions
- Model development needs:
 - Granularity and formalization level
 - Scalability, generalization to other procedures
 - Interpretability (non 'black-box')