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Application of Artificial Intelligence in Predictive Maintenance

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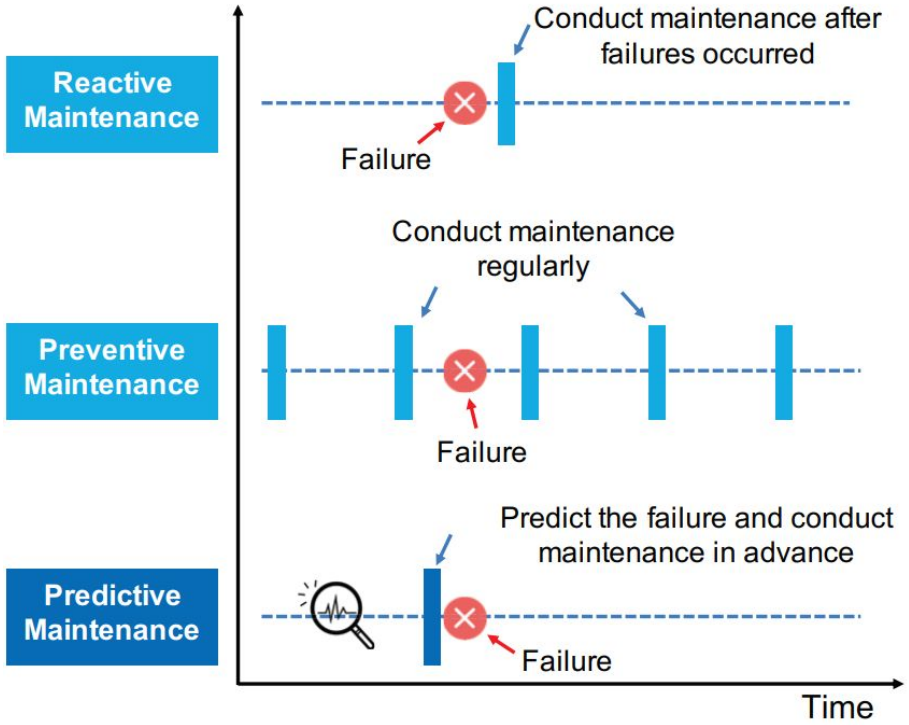
Motivation I



Why PdM?

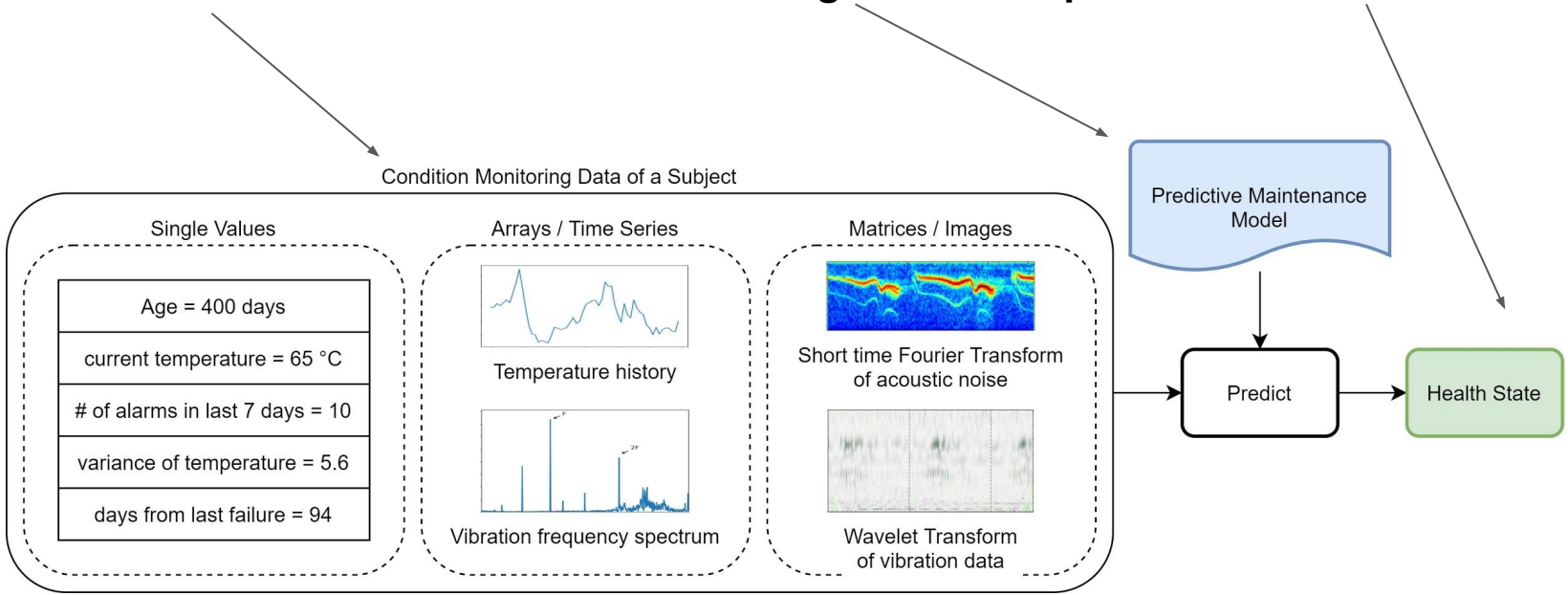
- Reduce costs
- Avoid downtime

Why AI in PdM?

- Automate subject's condition assessment

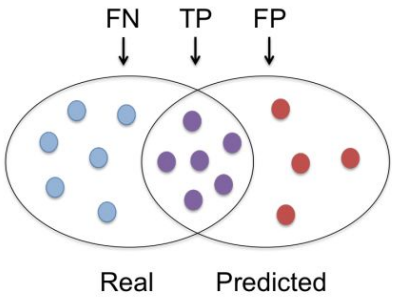
Motivation II

Use **historical data** to build a **machine learning model** that **predicts condition** of a subject**.**

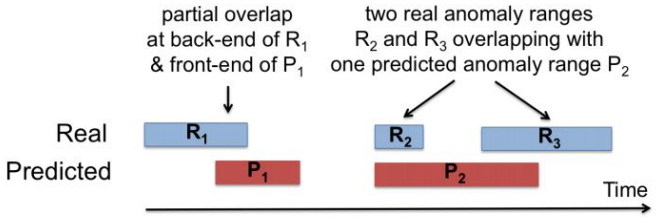


Challenges of AI in PdM

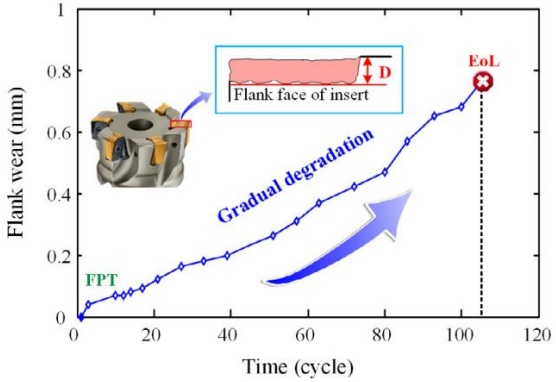
1. **operational profiles** of subjects can differ
2. different **type of data** is available
   - run-to-failure vs healthy/faulty
3. non-trivial **evaluation**

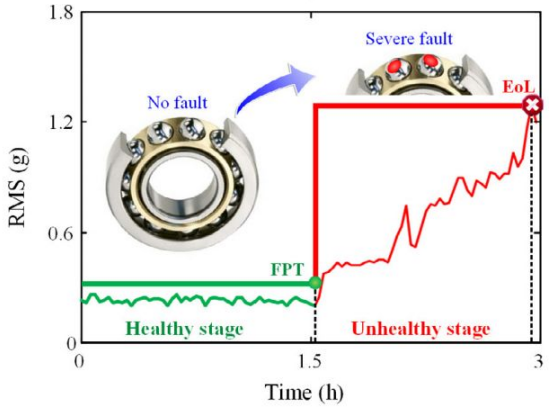


(a) Precision = 0.6, Recall = 0.5



(b) Precision = ?, Recall = ?





Goals of the Thesis

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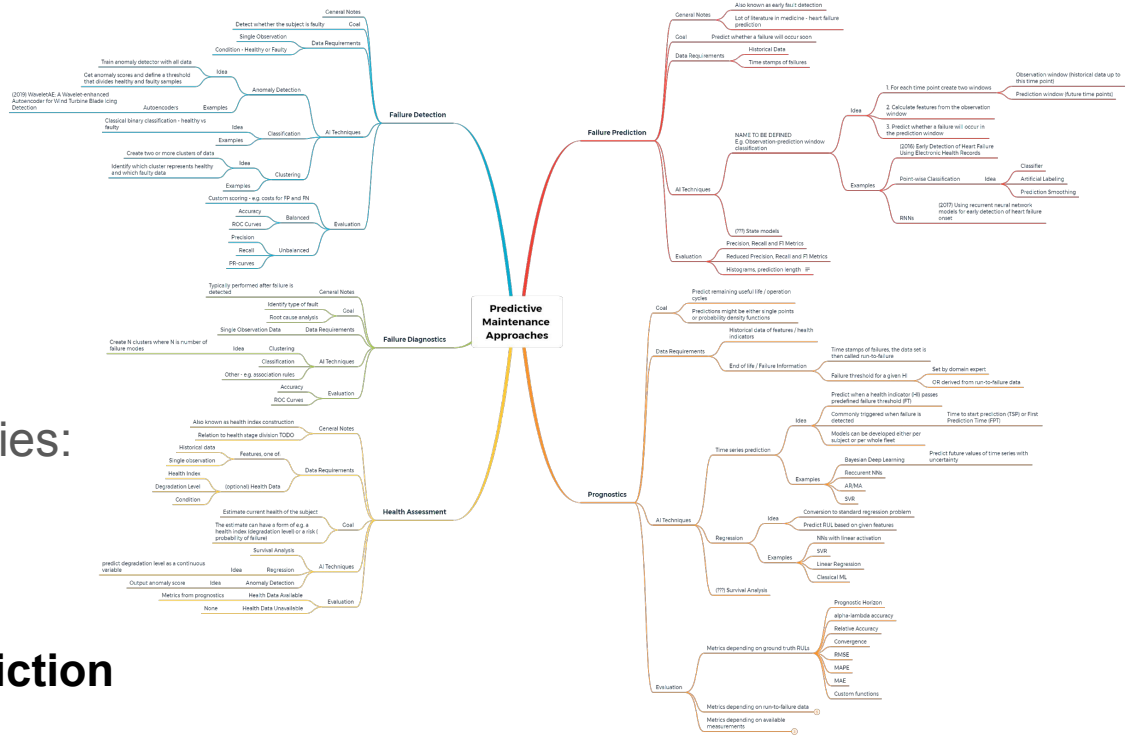
1. **Review approaches** to predictive maintenance
   - AI modeling techniques
   - Evaluation metrics
2. **Conduct experiments** on real-world publicly available data sets
   - Demonstrate the approaches
   - Compare their evaluation metrics

Literature review

- Over 50 related articles
- No consent in terminology
- Multiple approaches using the same modeling techniques and vice versa

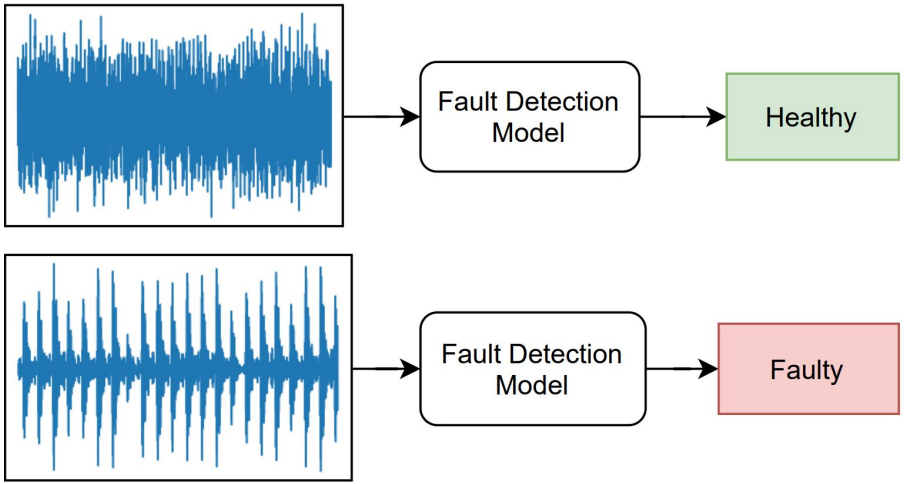
Unified into three main categories:

A) Fault detection
B) Failure prediction
C) Remaining useful life prediction



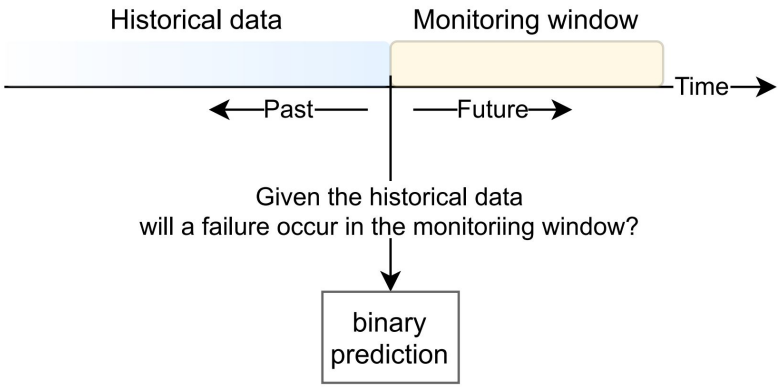
A) Fault Detection

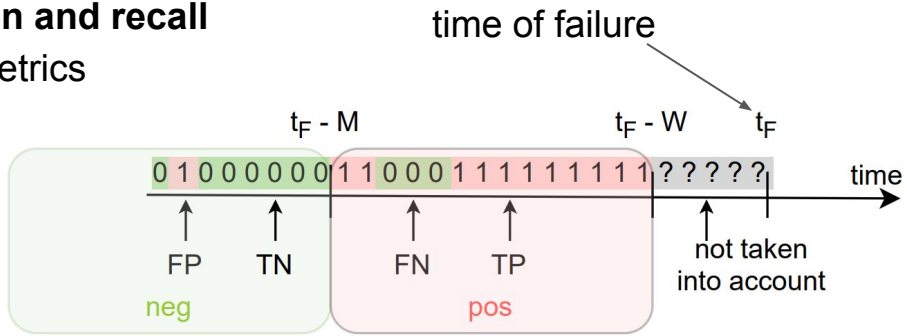
- Question
  - **Is the subject malfunctioning?**
- Data
  - healthy/faulty samples
- Modeling
  - **binary classification**
  - **anomaly detection**
- Evaluation
  - precision and recall
  - AUROC, AUPR(G)



B) Failure Prediction

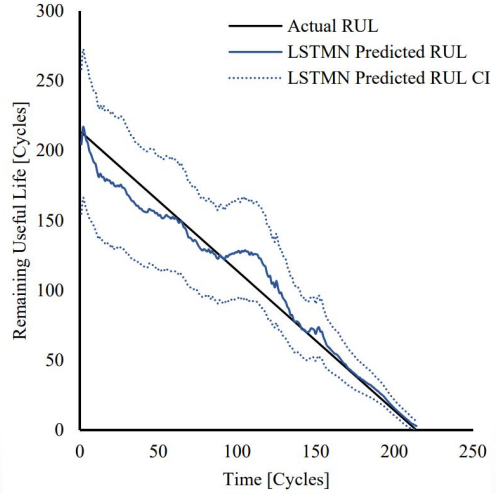
- Question
  - **Will the subject fail soon?**
- Data
  - run-to-failure
- Modeling
  - classification with artificial labeling
- Evaluation
  - **modified precision and recall**
  - proposal of new metrics

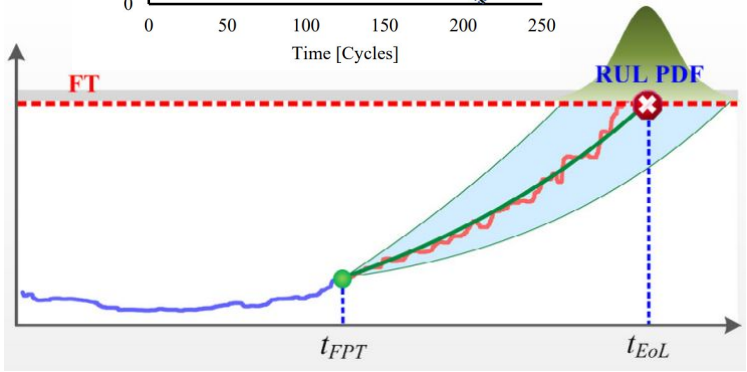




C) Remaining useful life prediction

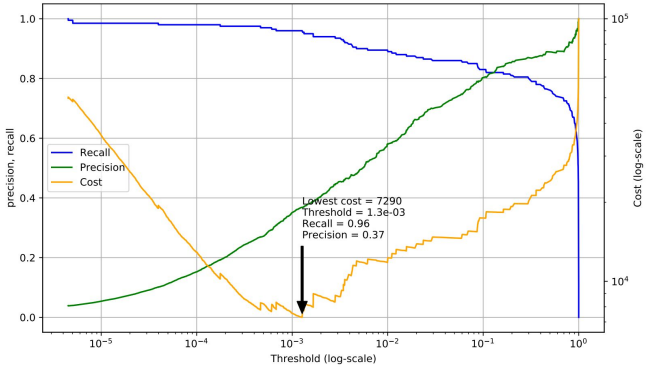
- Question
  - **How much time is left until a failure?**
- Data
  - run-to-failure
  - health index with failure threshold
- Modeling
  - regression
  - time series prediction
- Evaluation
  - MAE, RMSE, MAPE
  - **metrics relative to RUL**

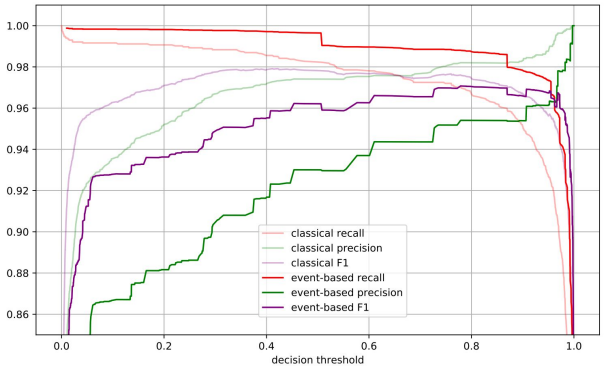


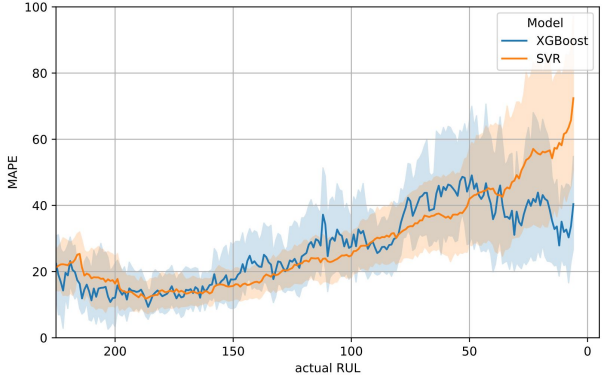


Experiments

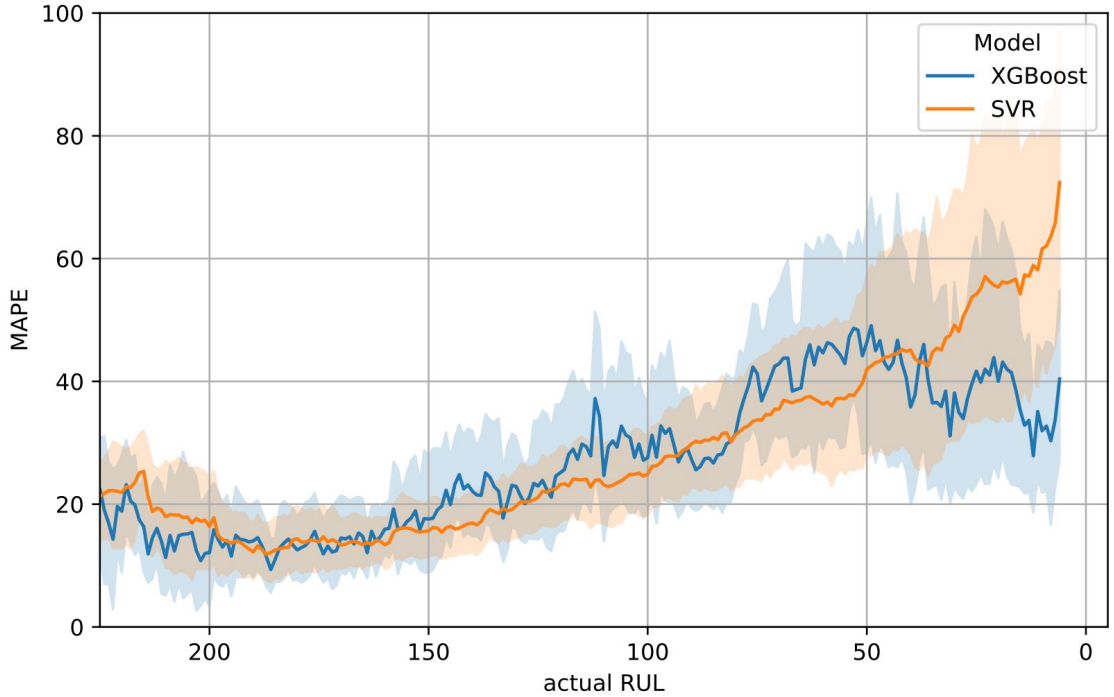
- Suitable dataset for every approach
  - real-world publicly available
- **Demonstration of the approaches**
- **Comparison of evaluation metrics**
  - ranking of multiple models
  - decision threshold selection / RUL prediction







Experiments: Example



Conclusion

- Reviewed tens of articles about AI in PdM
- **Identified three main approaches**
  - AI modeling techniques
  - evaluation metrics, proposal of new metrics for failure prediction
- Experiments
  - demonstration on real-world publicly available datasets
  - comparison of evaluation metrics
- **Future research**
  - analyze behaviour of the metrics with respect to
    - their parameters (e.g. existence vs overlap)
    - more datasets (when available)
    - different families of ML algorithms

Reviewer's Questions

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1. Q: Existují i další dostupné datasety, nebo jste v experimentech využil všechny, které jste našel?

2. Q: Nechystáte se práci publikovat?

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Discussion