eSAAM 2023
on Cloud to Edge Continuum

VTT

Feature Estimation for Punching Tool Wear at the Edge

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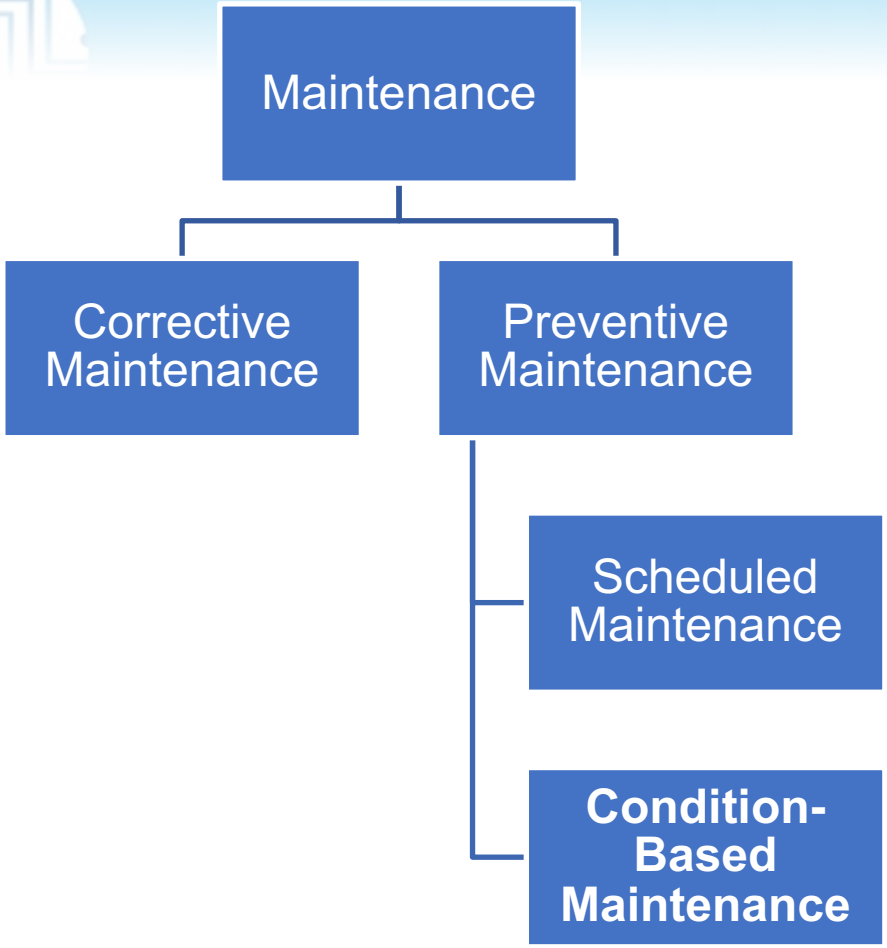
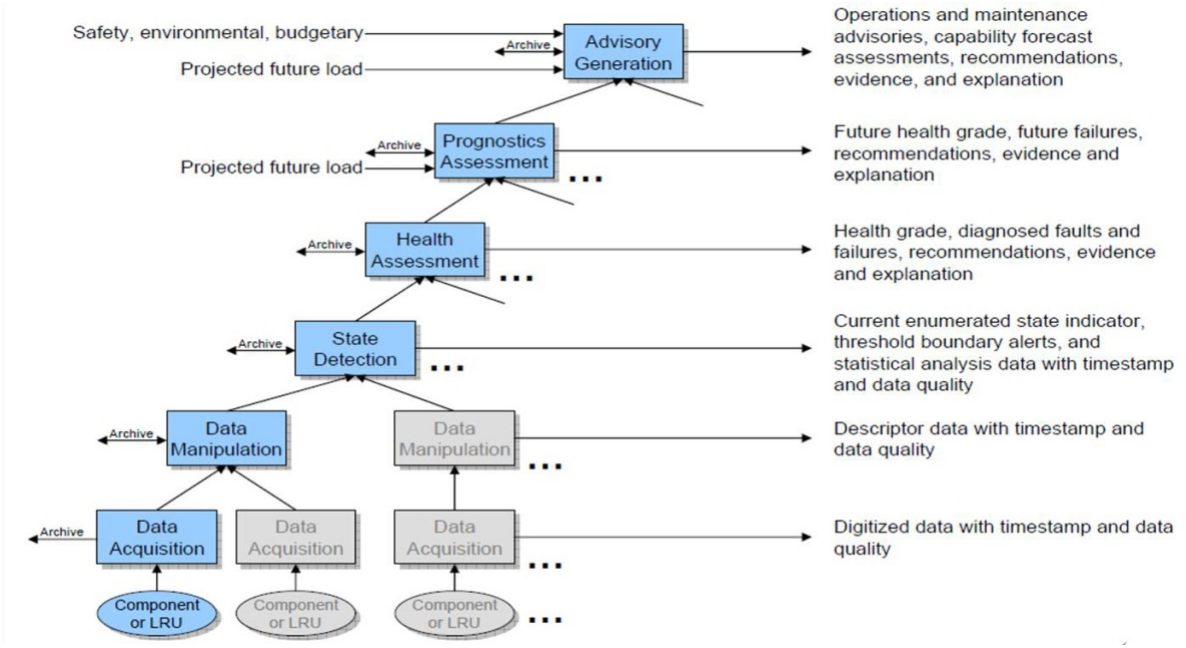
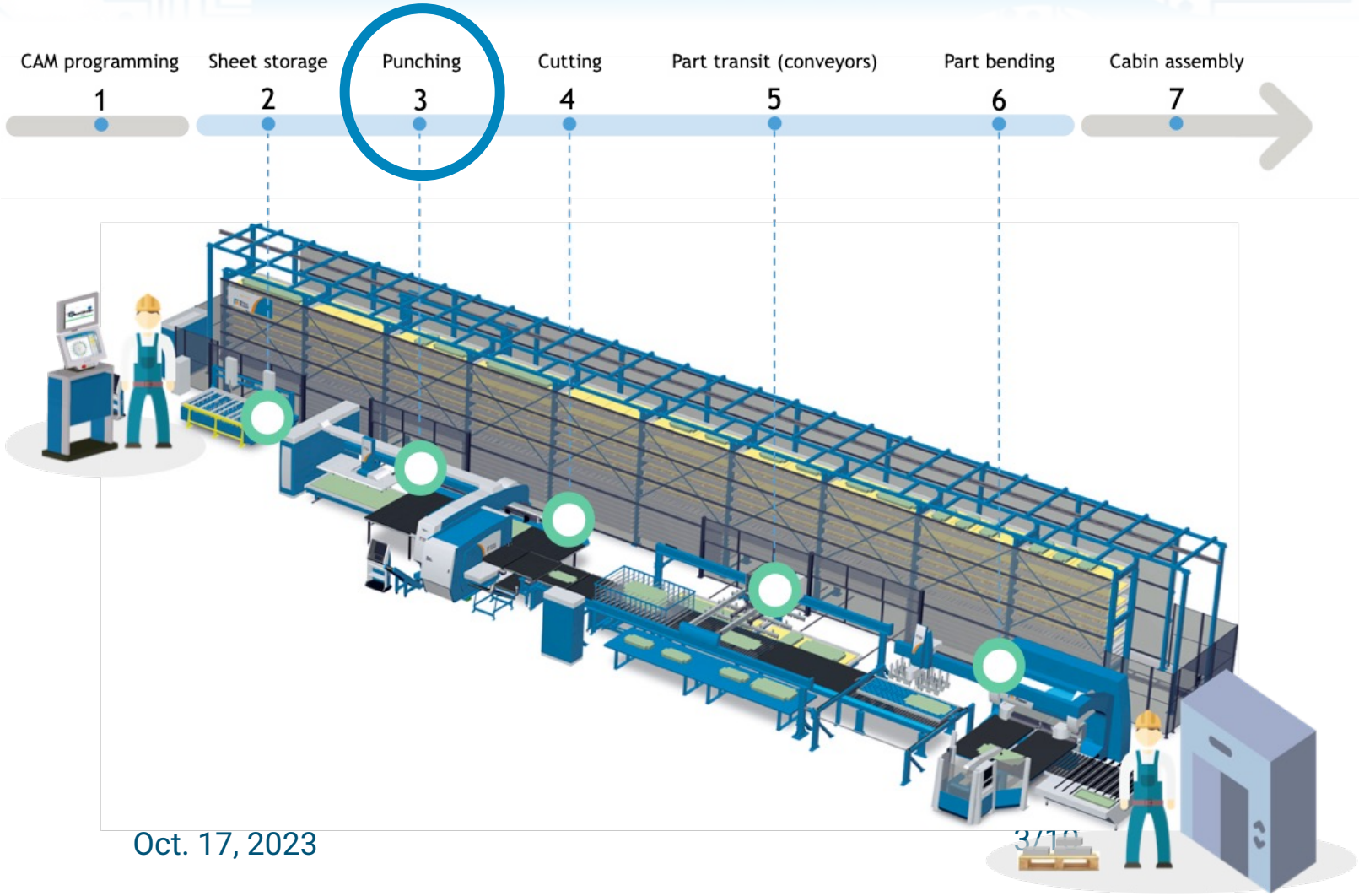
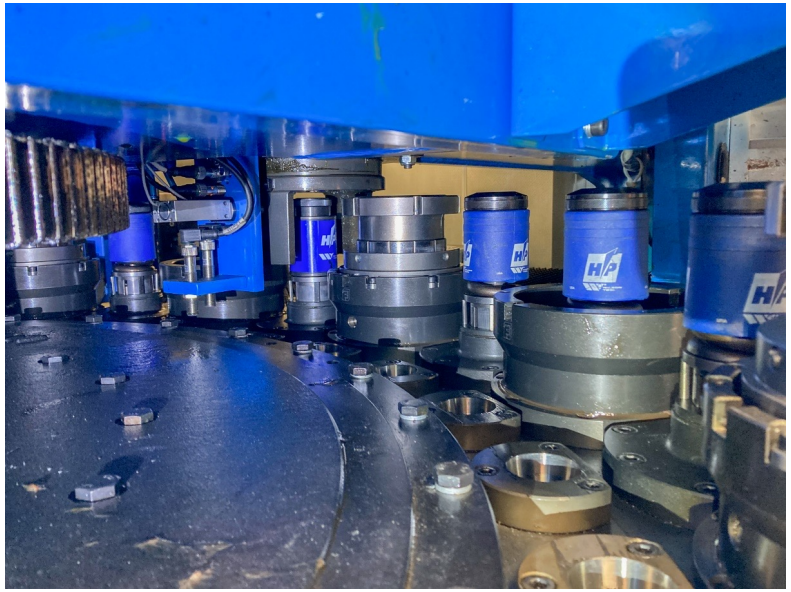
Condition-Based Maintenance





Punching holes



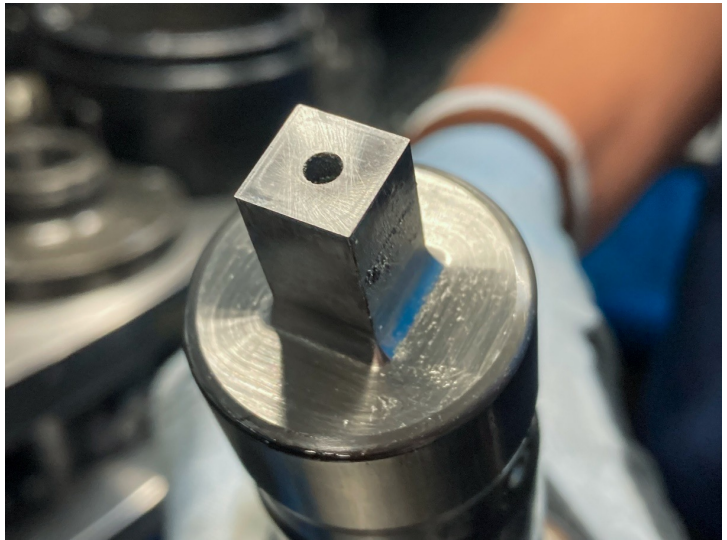


Wear monitoring

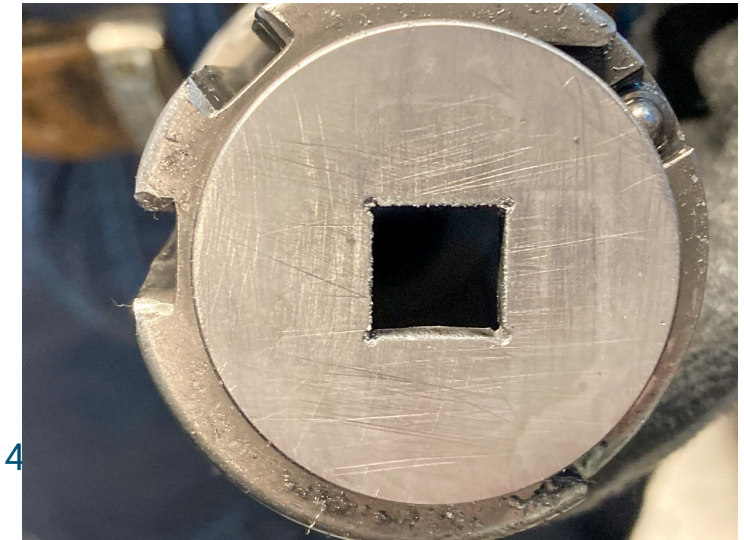
- **Input:**
  - 2 vibration acceleration signals
  - 20 kHz sample rate, plenty of data
- **Output**
  - Reading of tool condition

Edge processing

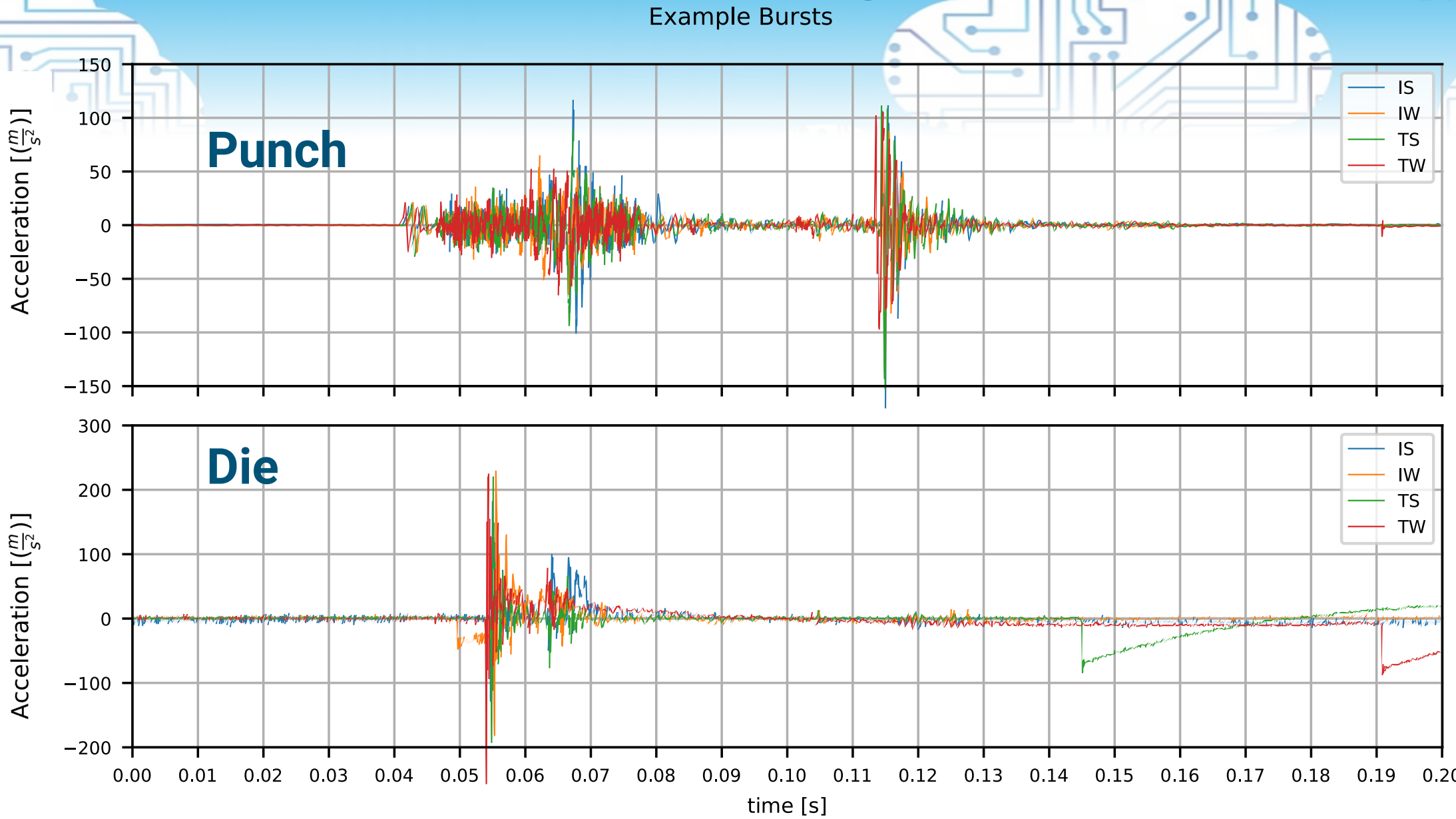
Punch



Die



Example vibration signatures



Legend:

I/T = steel **I**nox/**T**erninox

S/W = the state of the punch tool **S**harp/**W**orn

Data processing

- **Both accuracy and computation speed are needed**

- **Feature extraction**
  - Time Series Feature Extraction Library (TSFEL)
    - Ca. 400 statistical features, both time and frequency domain
    - Literature reference in similar applications
  - MiniRocket
    - Ca. 10 000 features based on convolutions with predetermined kernels

- **Classification**
  - Logistic regression

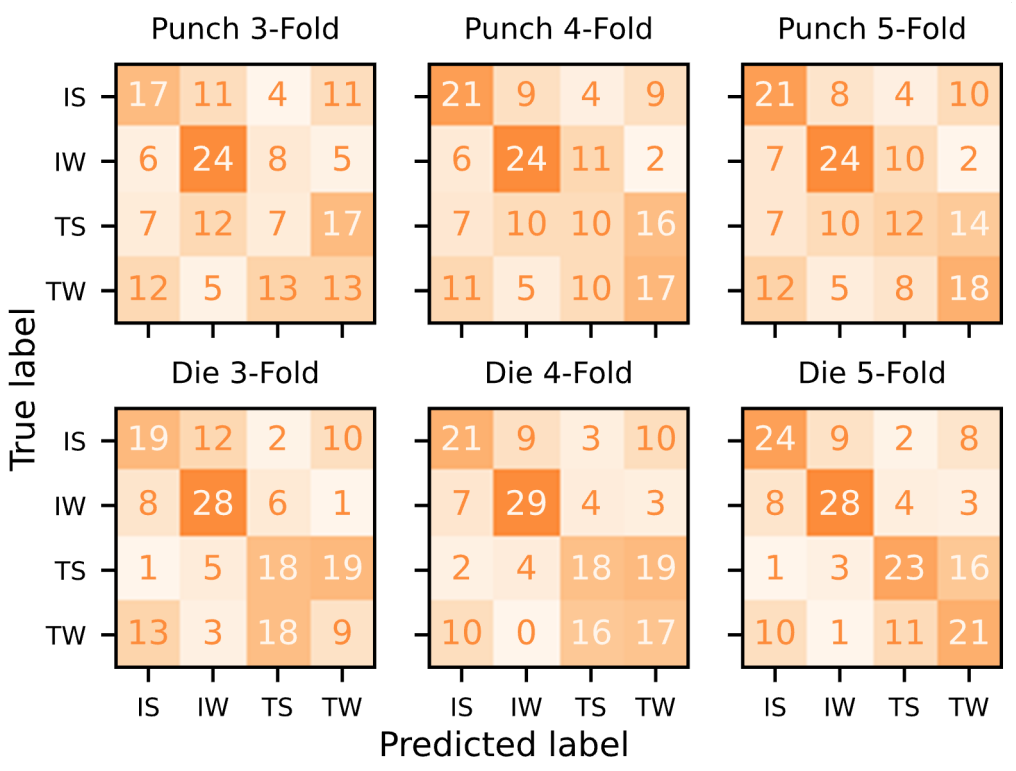
No significant speed difference

Python libraries fast enough for single-core real-time processing

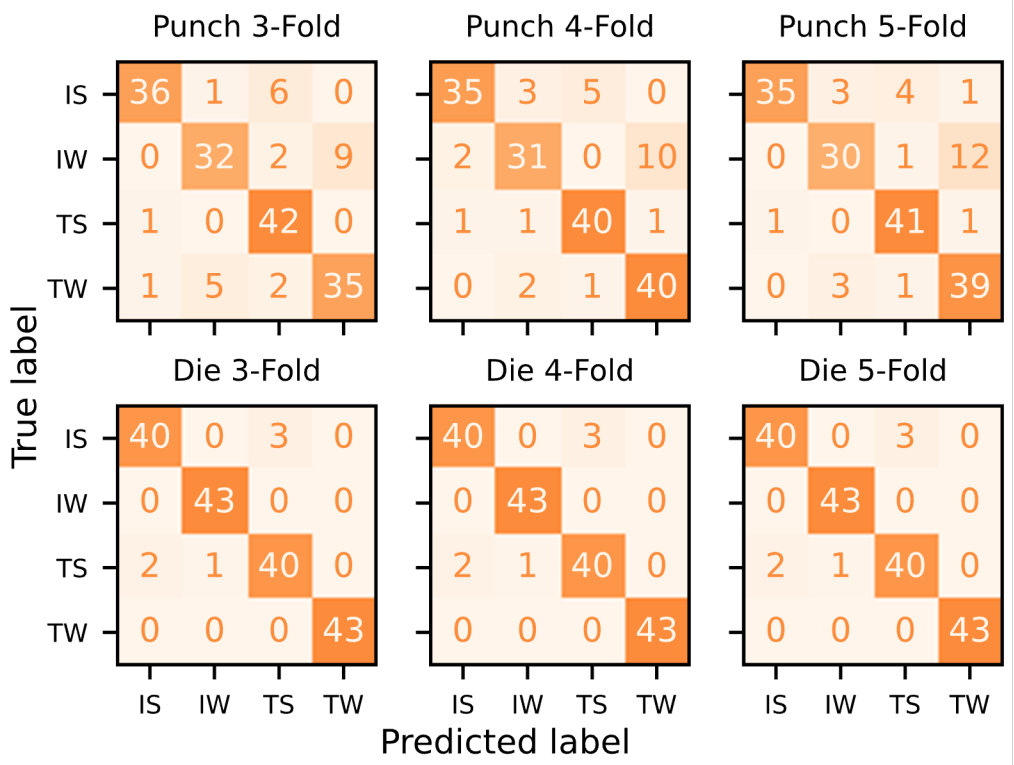
Confusion matrices

- 3, 4, and 5 fold cross validation

TSFEL

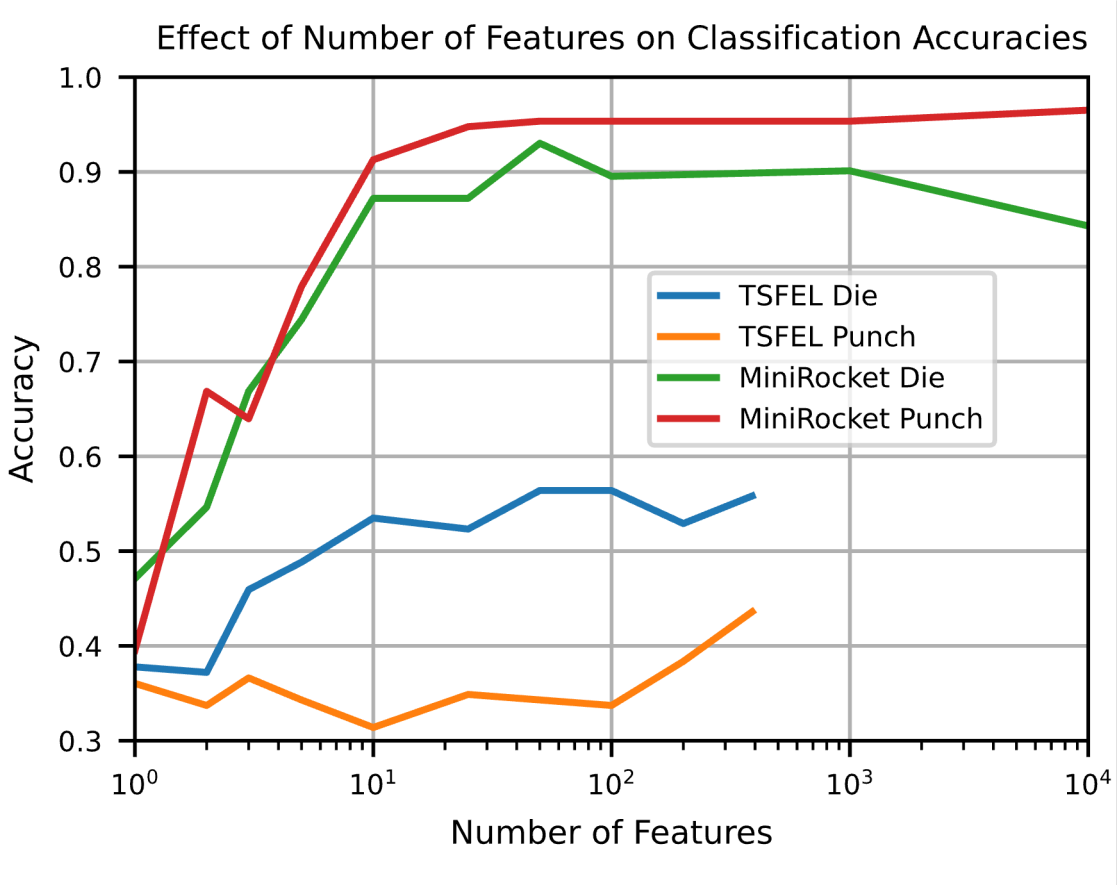


MiniRocket



Number of features

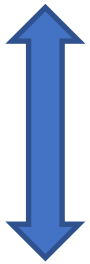
- **Ca. 400 / 10 000 features**
  - Execution speed isn't a problem
  - How many are needed?
  - Danger of overfitting?



Decision support

Measurements

Edge analytics



- Tool wear information to machine operator
  - Short-term decision support
  - When to change / sharpen a tool
  - Especially important before unsupervised operation during night

Cloud analytics

- Benchmarking information to planning
  - Long-term decision support
  - Performance of different makes and materials
- Configuration updates

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Thank you!

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