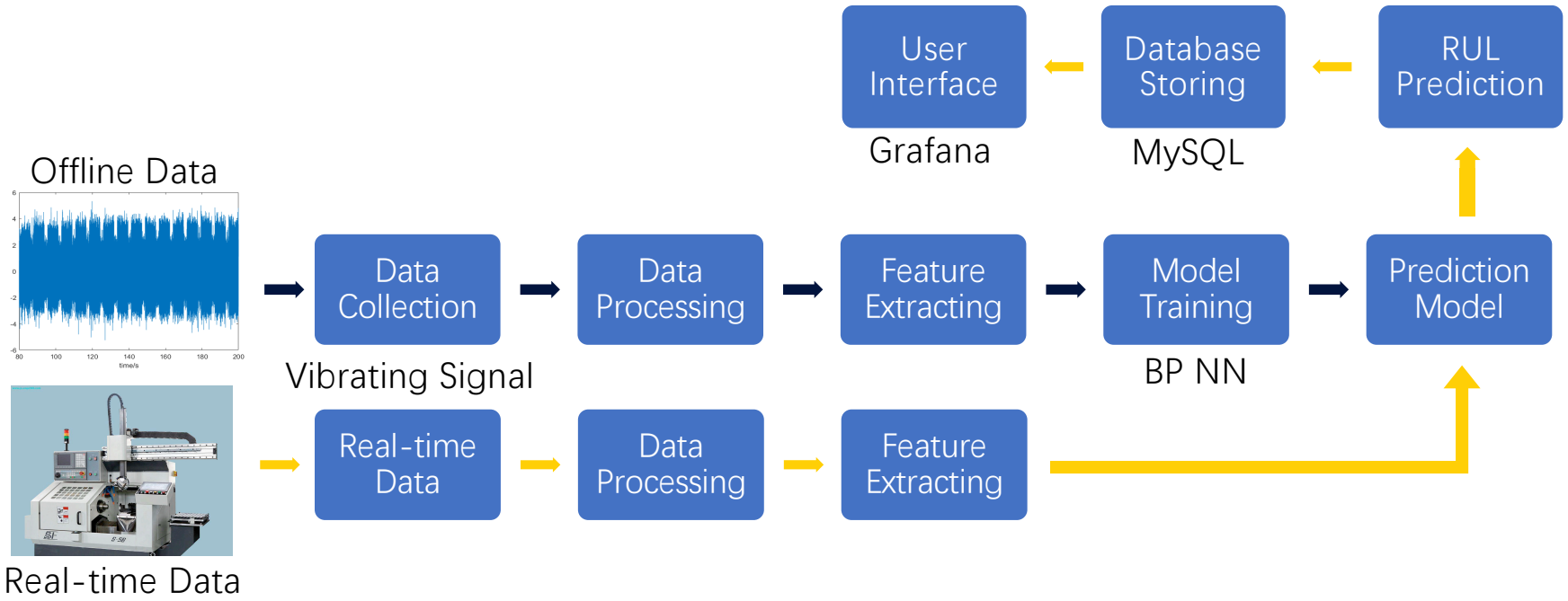
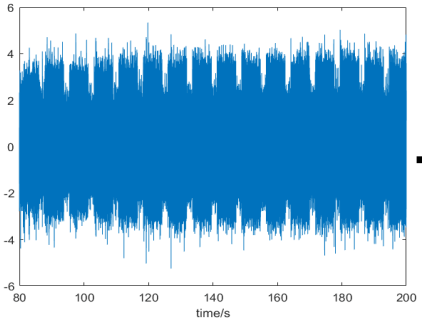
Final Design

Flow Chart


Offline Data
Vibrating Signal
Real-time Data
Data Collection
Data Processing
Feature Extracting
Model Training
BP NN
Prediction Model
Real-time Data
Data Processing
Feature Extracting
User Interface
Grafana
Database Storing
MySQL
RUL Prediction

Main Steps of Predicting RUL

Offline: Modeling



Signal processing → Features → Modeling **BP NN**

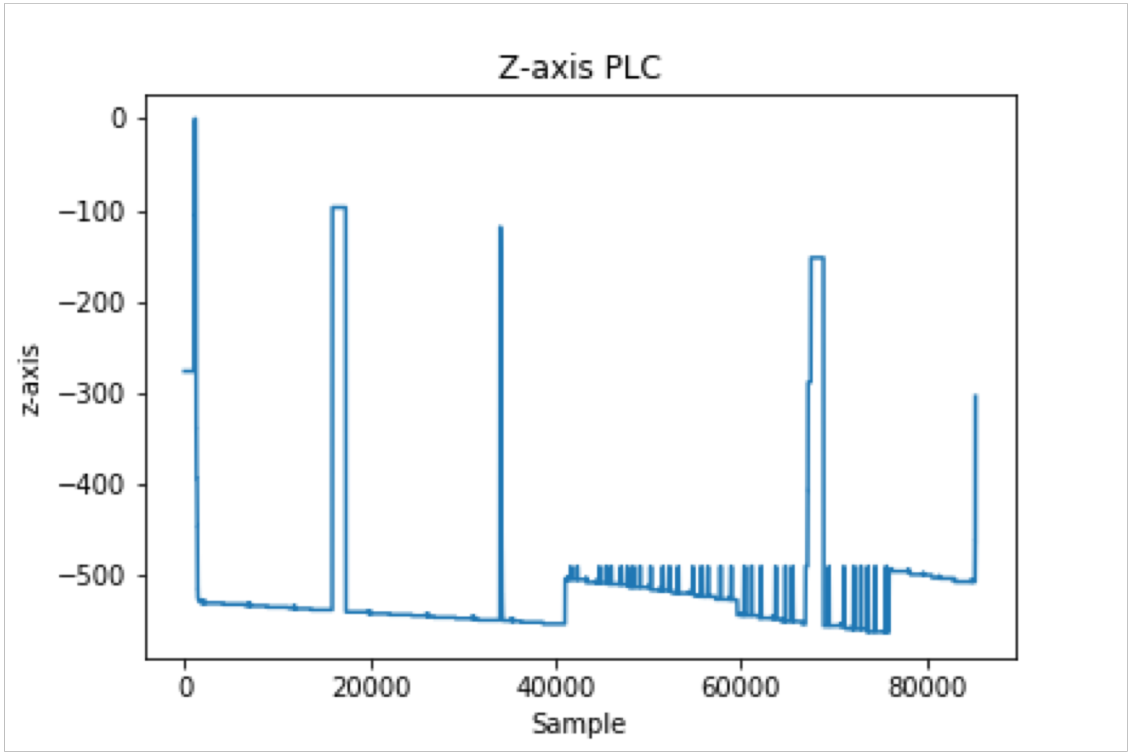
Online: Prediction

Signal processing → Features → **BP NN** predictor → RUL prediction

LRMR: logistic regression and manifold regularization

http://www.jc35.com/news/detail/dy16284_p4.html

Separating Working States



Separating Working States

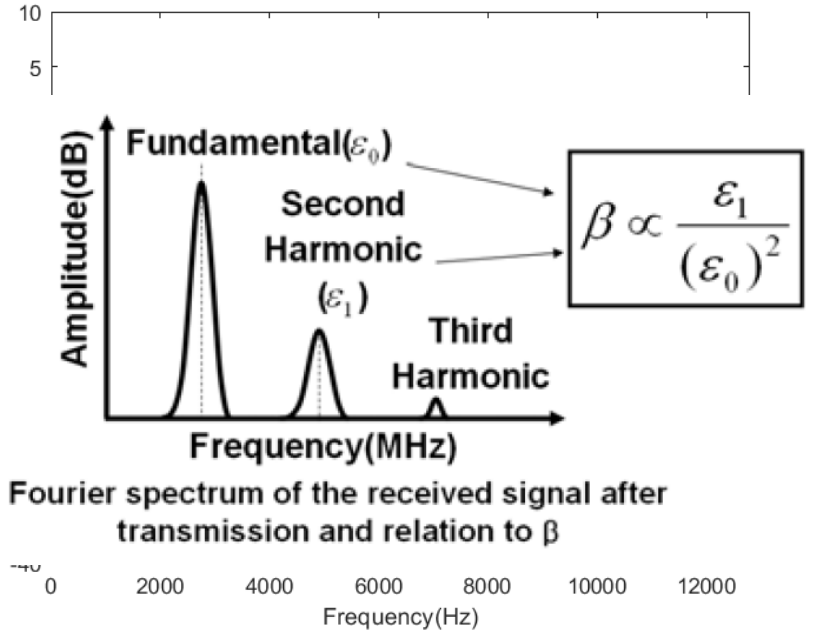
- 48 files in total for each tool, the files of data not working are listed below.

- qLua-01: 1, 26, 40, 48
- qLua-02: 1, 8, 14, 42
- qLua-03: 1, 8, 16, 30, 37
- Additional-01: 1, 38, 40, 48
- Additional-02: 1, 8, 14, 42
- Additional-03: 1, 8, 16, 30, 37

Signal Processing: Feature Extraction

- Energy of signals (e.g. 0-100Hz)

- A non-linear coefficient β_i:
  the ratio of i^{th} harmonic amplitude and power of fundamental.



Test Results (Feature Extraction)

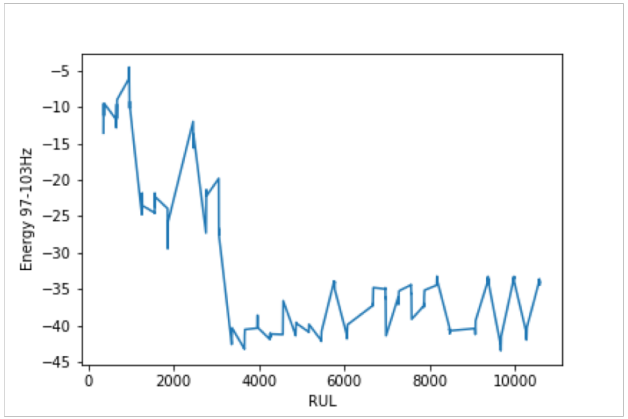


Fig. 1. Energy in 97Hz-103Hz

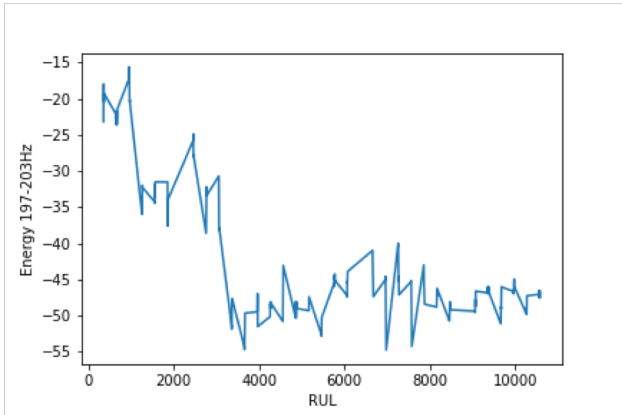


Fig. 2. Energy in 197Hz-203Hz

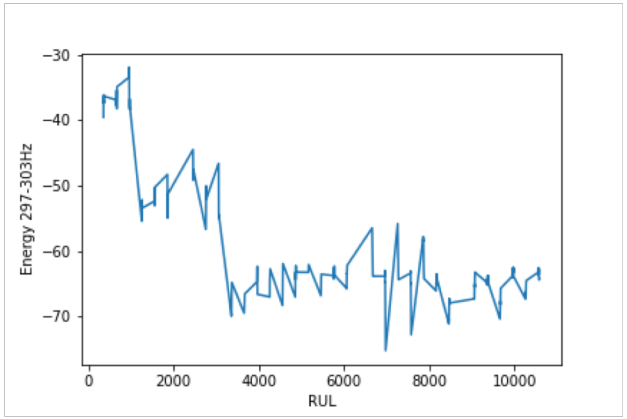


Fig. 3. Energy in 297Hz-303Hz

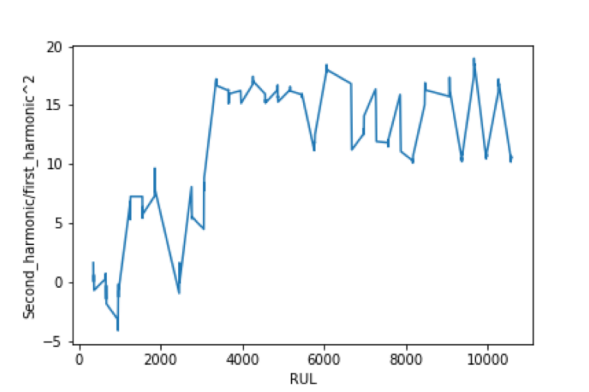


Fig. 4. Non-linear coefficient β_2

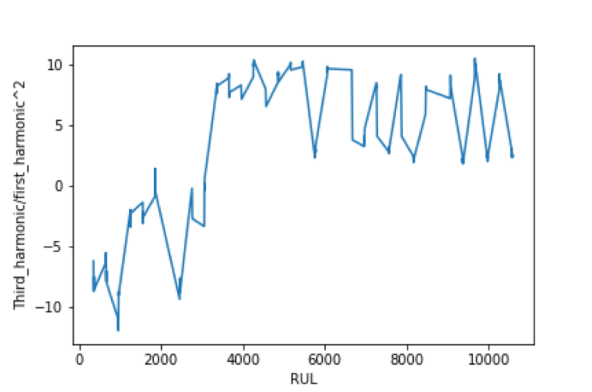


Fig. 5. Non-linear coefficient β_3

Algorithm

- BP neural network based on MATLAB toolbox Neural Network.

- Data separation for modeling
  - Training set: 70%
  - Validation set: 15%
  - Testing set: 15%

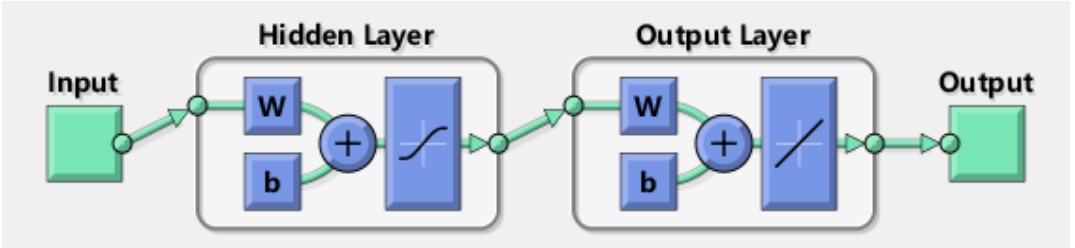
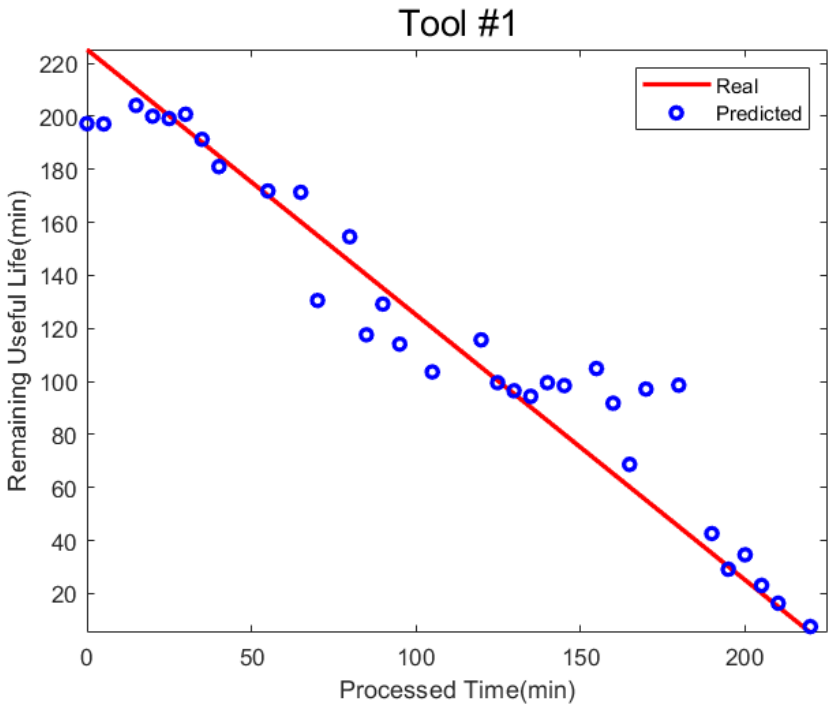
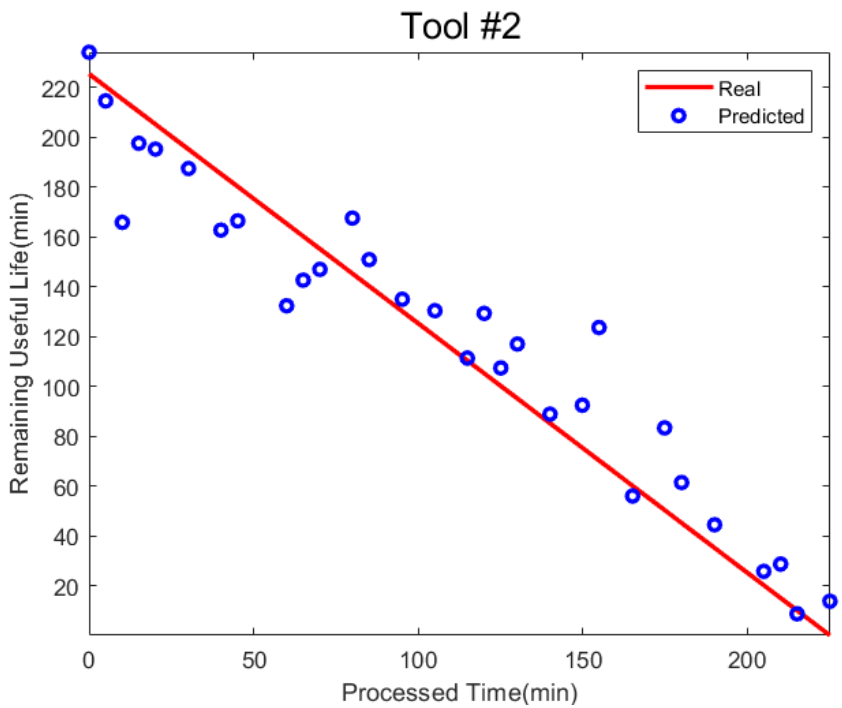


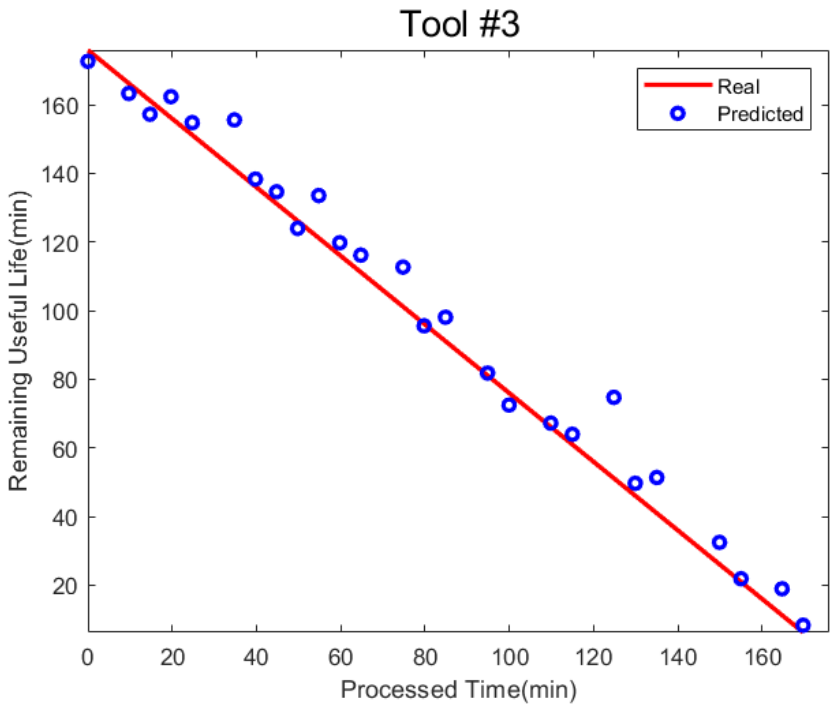
Figure. Neural Network Structure

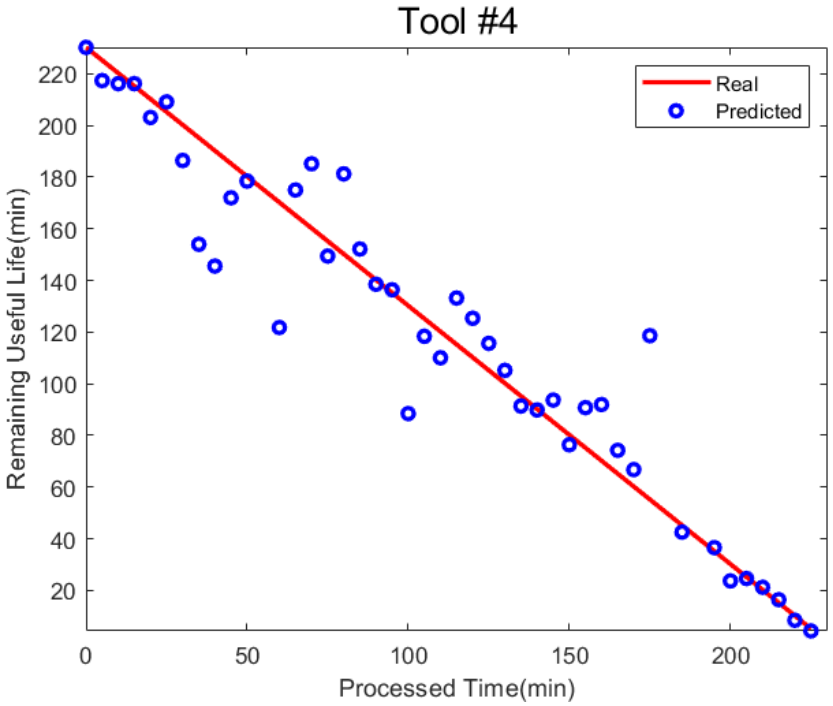
Results


Tool #1
Real
Predicted
Remaining Useful Life(min)
Processed Time(min)
220
200
180
160
140
120
100
80
60
40
20
0
50
100
150
200

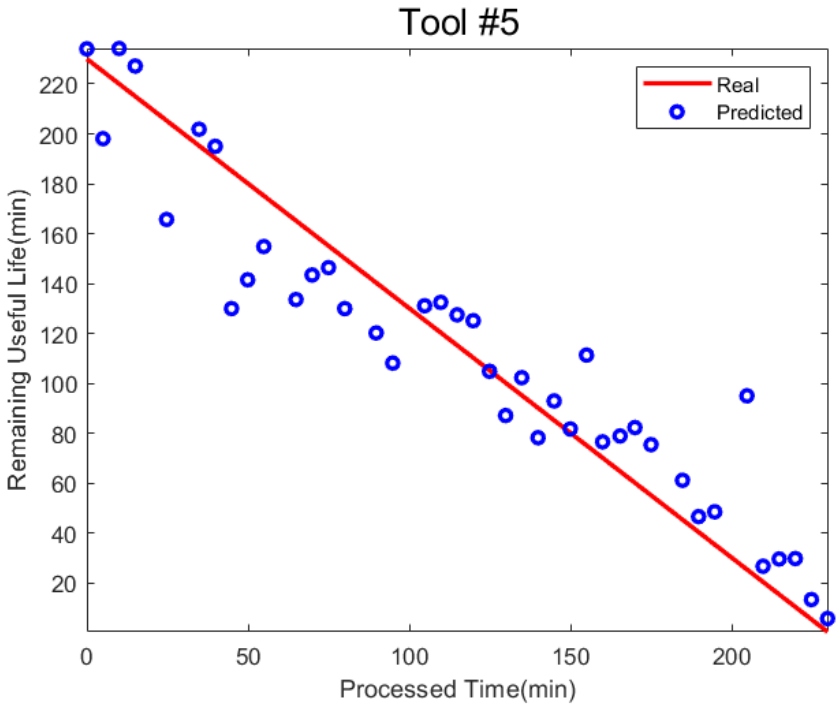

Tool #2
Real
Predicted
Remaining Useful Life(min)
Processed Time(min)
220
200
180
160
140
120
100
80
60
40
20
0
50
100
150
200

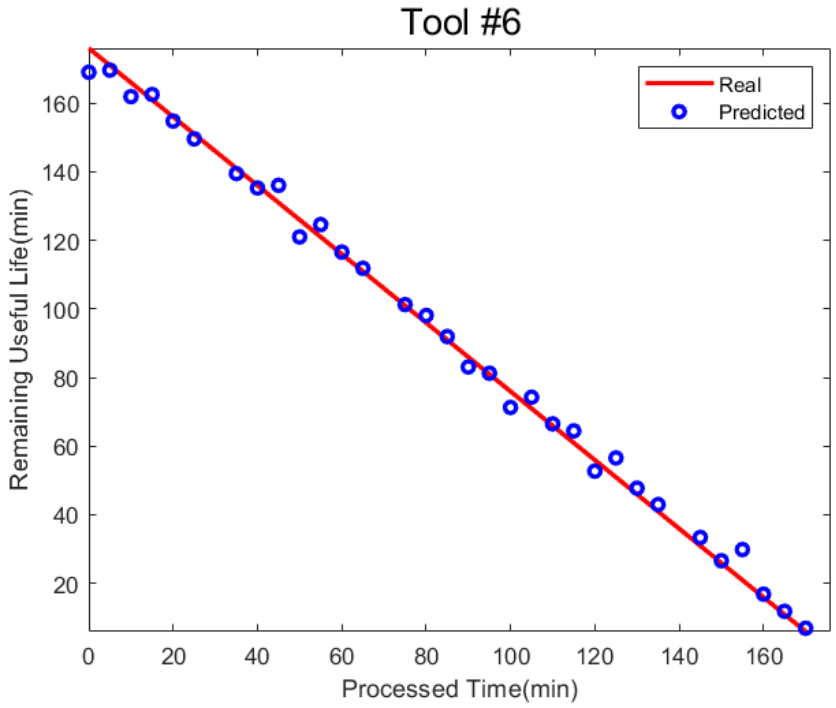
Results


Tool #3
Real
Predicted
Remaining Useful Life(min)
Processed Time(min)
0
20
40
60
80
100
120
140
160
20
40
60
80
100
120
140
160


Tool #4
Real
Predicted
Remaining Useful Life(min)
Processed Time(min)
0
50
100
150
200
20
40
60
80
100
120
140
160
180
200
220

Results


Tool #5
Real
Predicted
Remaining Useful Life(min)
Processed Time(min)
0
50
100
150
200
20
40
60
80
100
120
140
160
180
200
220


Tool #6
Real
Predicted
Remaining Useful Life(min)
Processed Time(min)
0
20
40
60
80
100
120
140
160
20
40
60
80
100
120
140
160

Discussion

Discussion – RUL Prediction

- Pros:
  - Low delay and real-time
  - Low error with available data

Discussion – RUL Prediction

- Pros:
  - Low delay and real-time
  - Low error with available data

- Cons:
  - Low ability of generalization：
    Different environment / More data

Discussion – User Interface

- Pros:
  - Clear and beautiful visualization
  - Real-time display and notification

Discussion – User Interface

- Pros:
  - Clear and beautiful visualization
  - Real-time display and notification

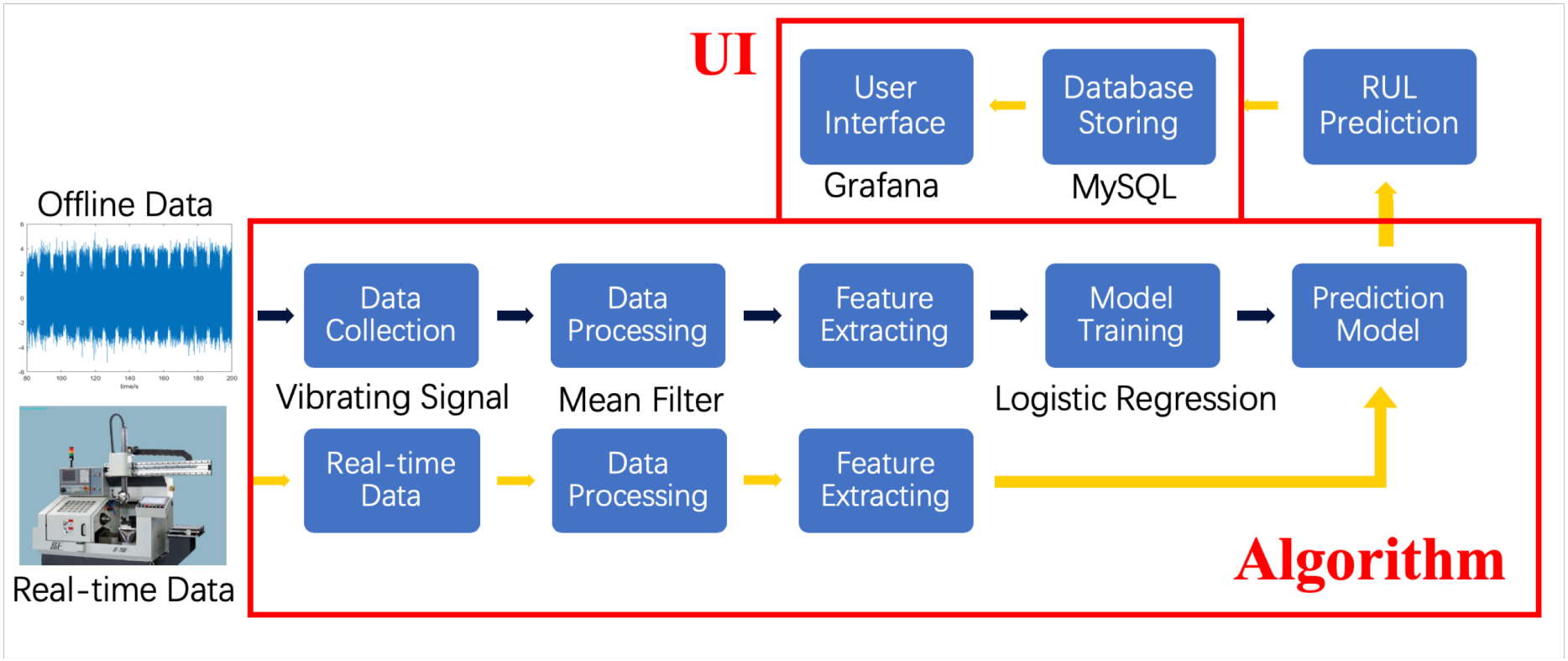
- Cons:
  - Lack of interaction with user：
    Pop-up window / User feedback

Conclusion

Conclusion

- RUL prediction system
- Analyze industrial data (vibrating signal)
- Reduce the cost of production

Conclusion


UI
User Interface
Database Storing
RUL Prediction
Grafana
MySQL
Offline Data
Data Collection
Data Processing
Feature Extracting
Model Training
Prediction Model
Vibrating Signal
Mean Filter
Logistic Regression
Real-time Data
Real-time Data
Data Processing
Feature Extracting
Algorithm

Q&A

Thank You