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Framework and case study of cognitive maintenance in Industry 4.0

Key words: Cognitive maintenance; Industry 4.0; Cutting-edge equipment; Deep learning; Green monitor; Smart manufacturing factory

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Motivation

1. High-end machine tools support advanced manufacturing, and it is very important for manufacturing enterprises to improve their market competitiveness by increasing the value of these tools during their limited service life.

2. Due to the high accuracy, complex structure, and various fault types, the maintenance of high-end machine tools has always been a major problem in engineering applications.

3. In recent years, to maximize the service value of high-end machine tools in their limited service life and avoid equipment downtime as much as possible, preventive maintenance strategies have been significantly developed.

Main idea

1. Cognitive maintenance (CM) focuses mainly on technologies that are related to big data, computational intelligence (CI), and self-maintenance.

2. The CM strategy is a trend in the future development of equipment maintenance.

3. CM will be well integrated into the framework of Industry 4.0.

4. CM has changed the traditional maintenance strategy.

Method

1. CM is based on deep data mining algorithms, which are used to analyze the collected massive data to determine machine health and decide maintenance actions for equipment.

2. The CM system combines the multisource data with advanced predictive models and analysis tools to diagnose preventable equipment faults.

3. The system framework for CM includes four modules, i.e., cyber-physical system, IoT, data mining, and IoS.

Method (Cont'd)

The system framework

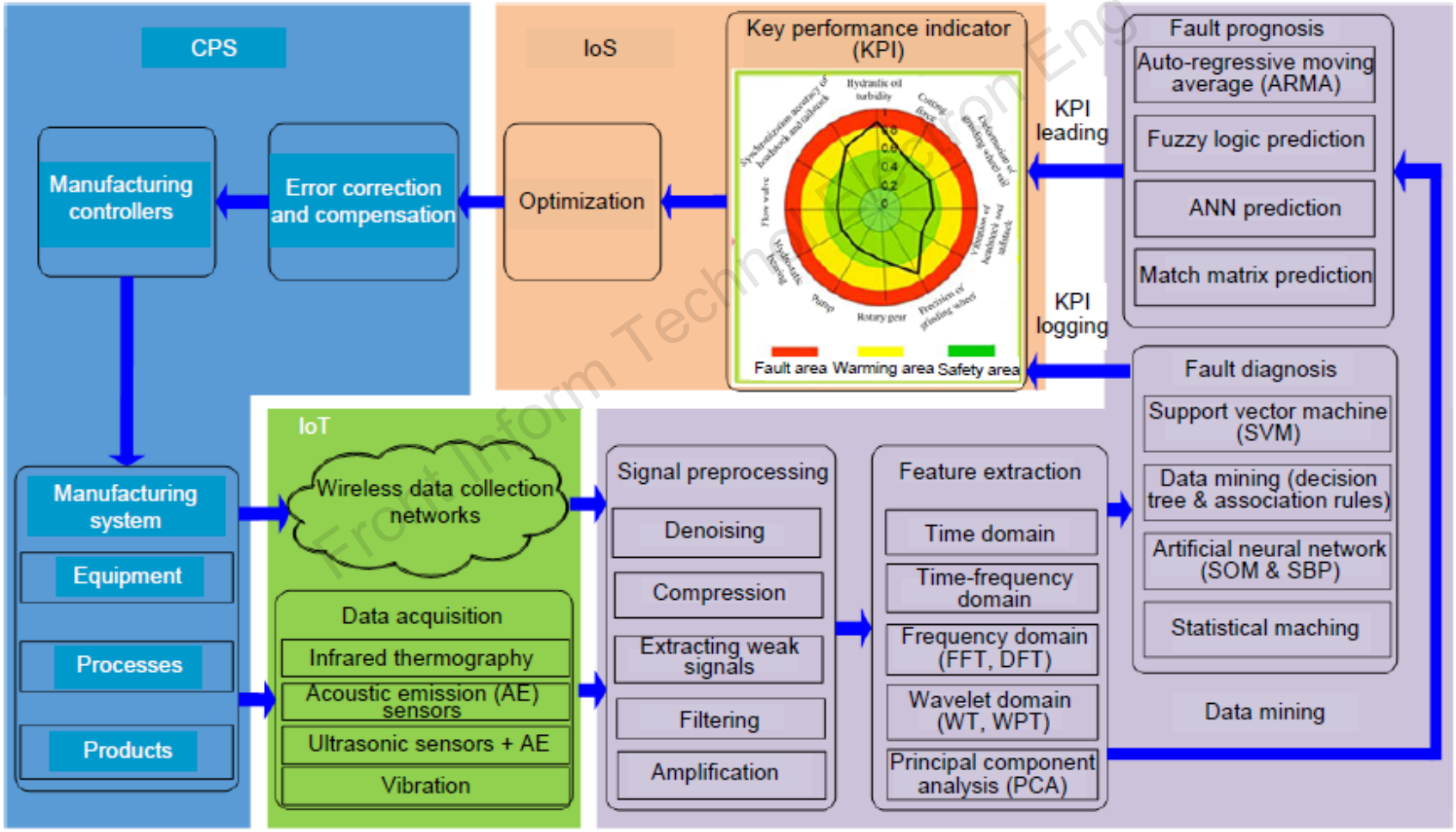

Fig. 1 General framework of the cognitive maintenance (CM) system

Method (Cont'd)

The DBN model for CM

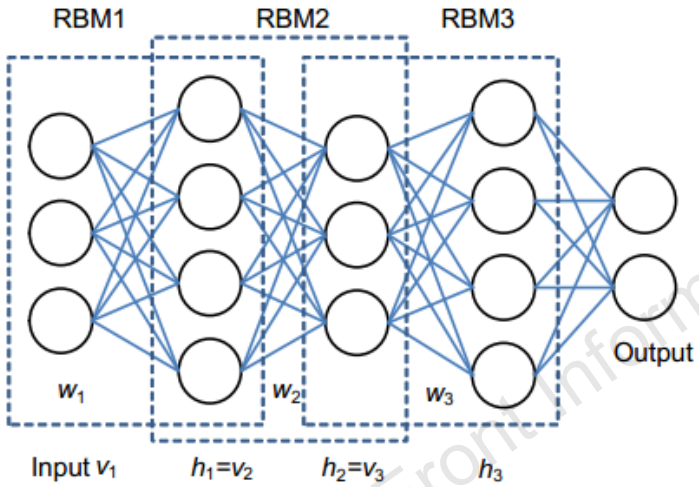

Fig. 2 Deep belief network (DBN) model construction

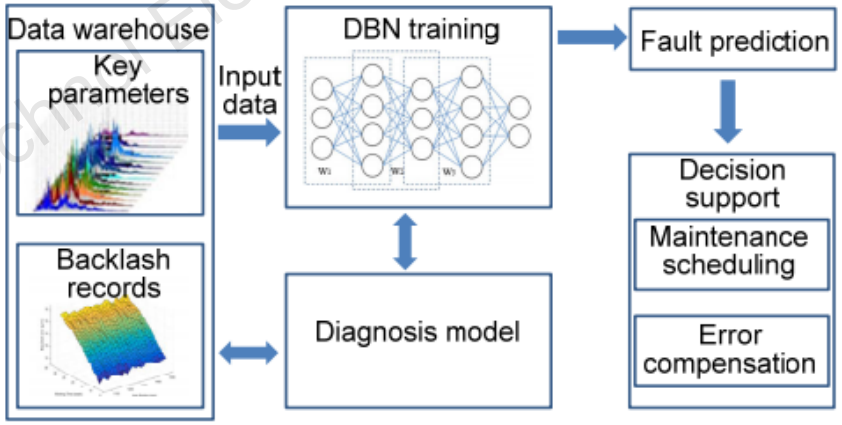

Fig. 3 Deep belief network (DBN) for cognitive maintenance

Method (Cont'd)

Green Monitor Project

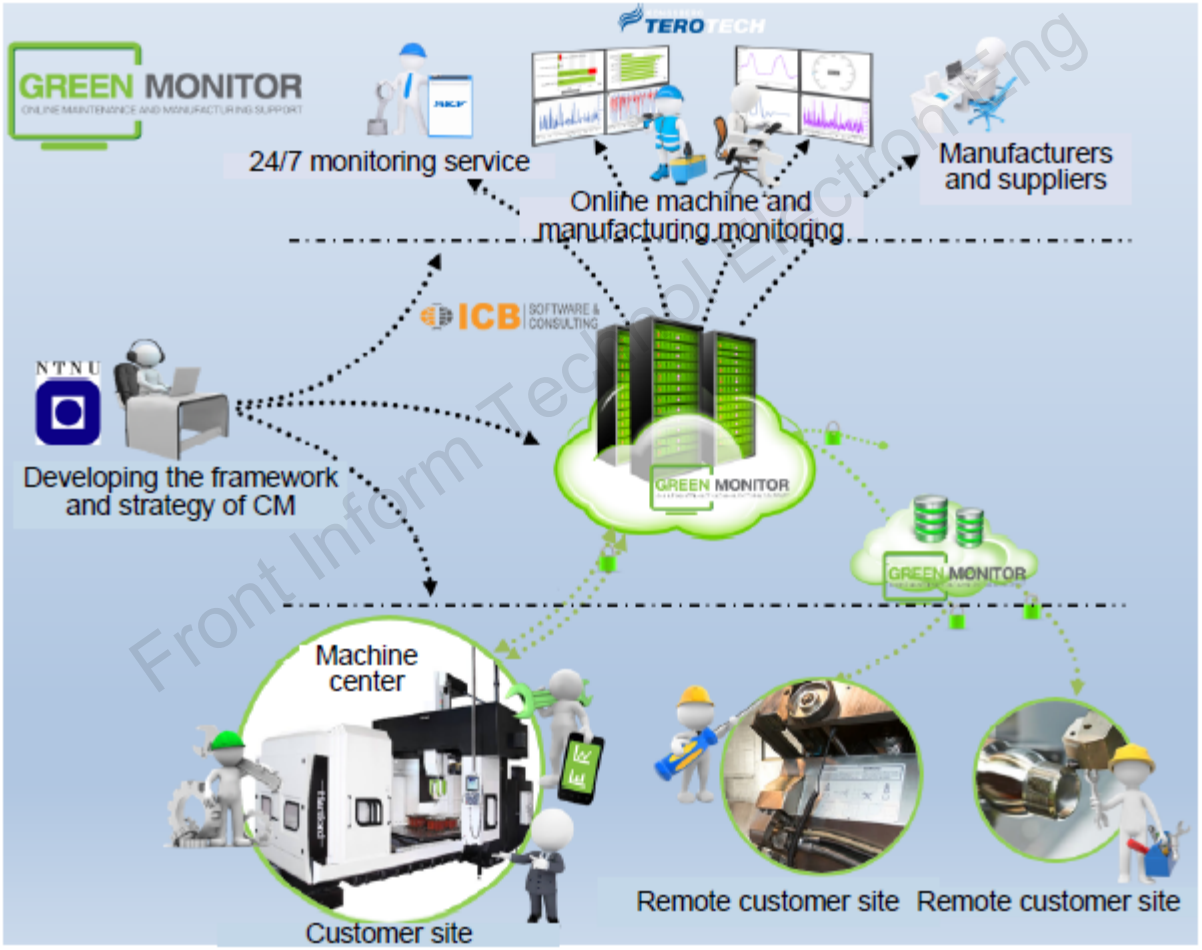

Fig. 4 Structure of the cognitive maintenance (CM) system in the Green Monitor Project

Method (Cont'd)

IoT and cloud computing system

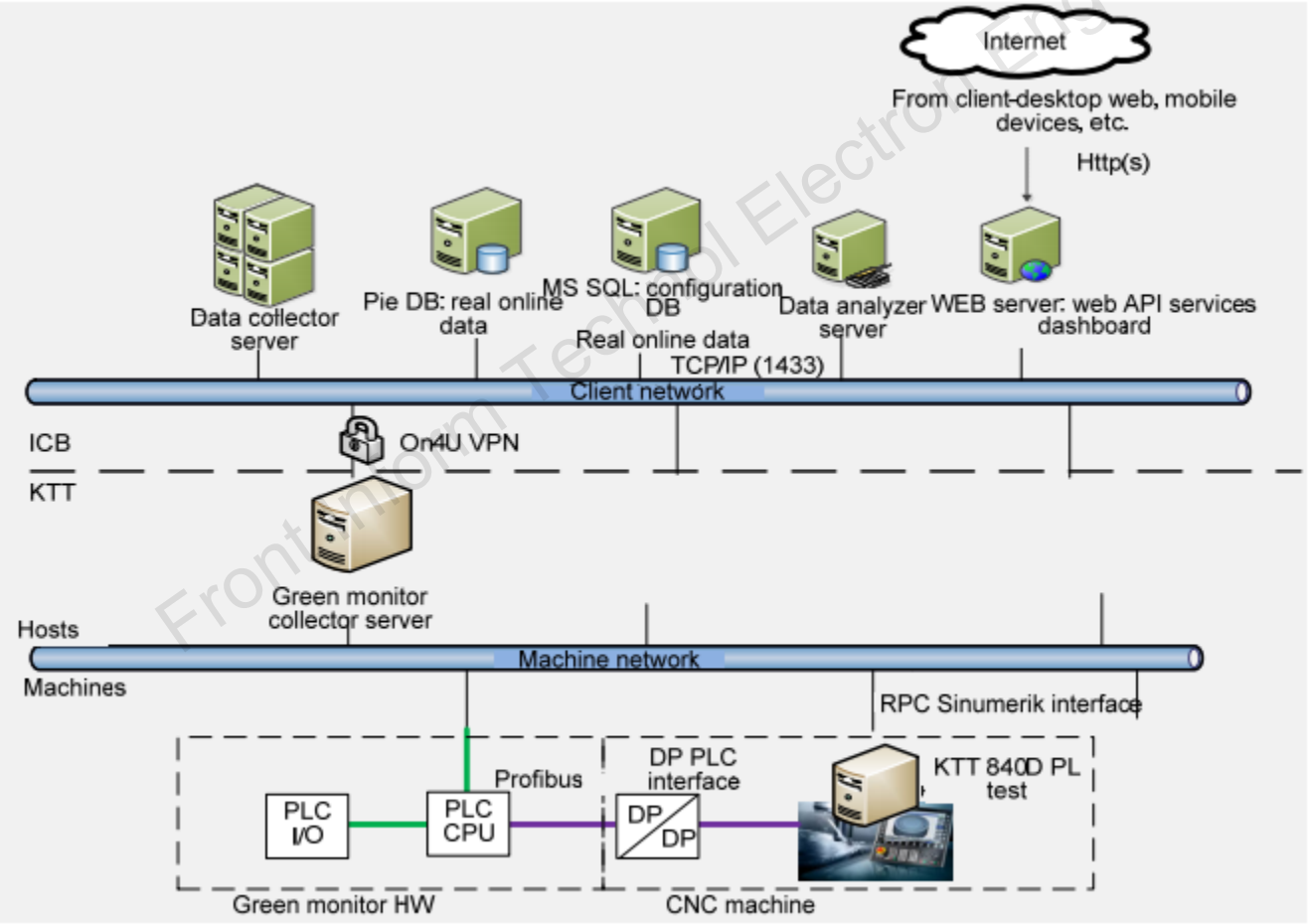

Fig. 6 Industry IOT and cloud computing structure

Major results

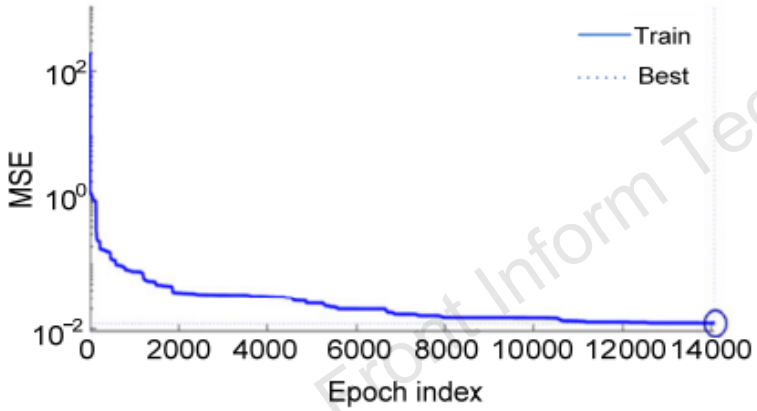

Fig. 7 Training results of deep belief network (DBN)

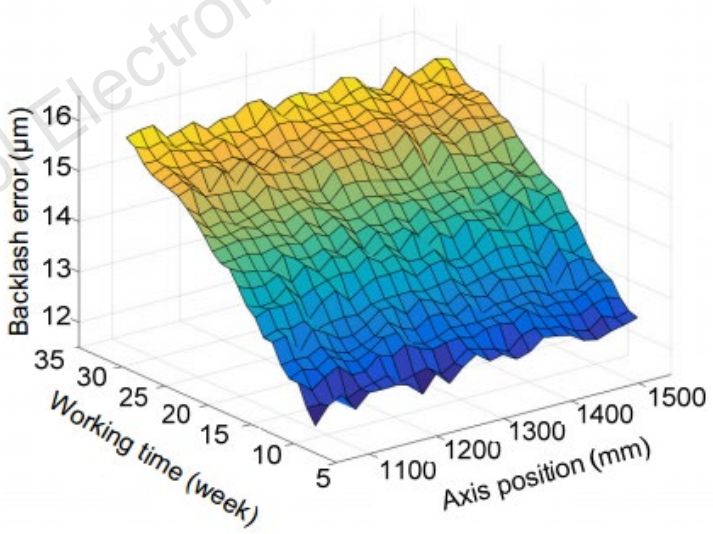

Fig. 8 Prediction results from deep belief network (DBN)

Major results (Cont'd)

Prediction results

Table 6 Comparison of the prediction results

Week	MSE	ME
32nd	0.0103	0.1807
33rd	0.0141	0.2276

MSE: mean-squared error; ME: maximum error

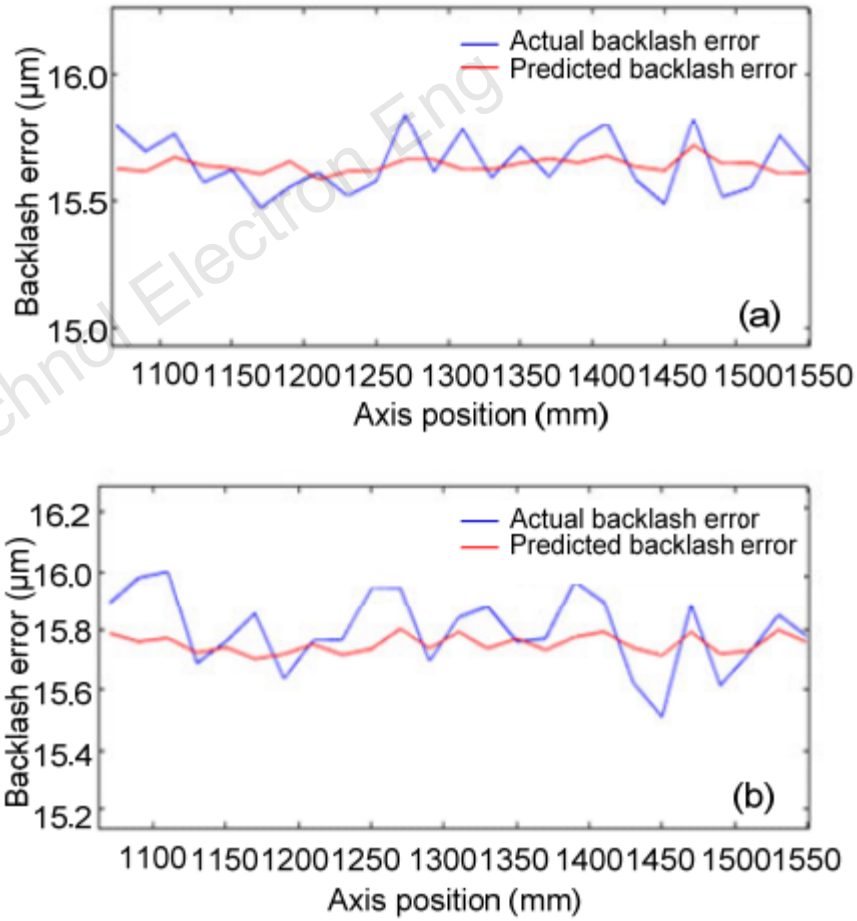

Fig. 9 Comparison of the backlash error: (a) 32nd week; (b) 33rd week

Conclusions

1. Different enterprises have different levels of equipment maintenance. Knowing the organization's maintenance requirements and the level of maintenance procedures should be the first step in running CM projects.

2. We put forward the framework of intelligent preventive maintenance for enterprises, and presented a method of CM system application.

3. We can see that the core link in the CM system is the data mining module, and the integration of advanced data mining algorithms, especially deep learning algorithms, will be promising in Industry 4.0.