Towards Predictive Maintenance for Textile Machinery: an Edge-based Vibration Monitoring System in Practice

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***Abstract*—Due to the high acquisition and operation cost of industrial machinery, the cost-effectiveness is highly influenced by the quality and continuity of their production. In this context, Predictive Maintenance emerges as a maintenance strategy aiming to maximize uptime by constantly monitoring a quantity related to the machine's health, such as vibration patterns, in order to perform maintenance stops only when strictly required. The implementation of this strategy, however, faces multiple challenges. One of them is related to the design, installation and operation of the sensoring systems required, which are subjected to budget constraints and also technical constraints such as sensor battery lifetime. Another challenge is given by the intelligence required for analysing real-world data generated within uncontrolled industrial environments and producing a machinery health indicator from it. This work illustrates a vibration monitoring system currently operating in a textile manufacturing machine; proposes a versatile Anomaly-Detection-based procedure for the analysis the real-world data produced by such systems and extraction of a machine health indicator from it; and also proposes an extension to the system in order to adapt it to the connectivity requirements set by the current context of Industry 4.0.**

***Index Terms*—Predictive Maintenance, Anomaly Detection, Vibration Monitoring**

I. Introduction

A. The Way to Predictive Maintenance

Here I will include the first few paragraphs of the thesis in a shorter form.

1) Vibration analysis - a glimpse into the condition of rolling machinery: Here we talk concretely about vibration.

B. Associated challenges

This will also be a resumed version of the respective part in the thesis.

C. Industry 4.0 - Enabling Predictive Maintenance

Here we can make a generalization of the term Industry 4.0 to say that it brings not only connectivity but also encompasses the intelligent data analysis philosophy. We can, for example, talk about Anomaly Detection here.

II. Related work

Here I will present some articles and other sources about vibration analysis and talk about their shortcomings which we intend to overcome. I will also write about some cases where PM was sucessfully implemented.

III. Implementation concept

Here we say that the company DELTA system designed and installed this sensor system in a textile machine in a plant in Turkey. We will also introduce the problem that we didnt know what to do with the data and also the desire to improve battery autonomy, which are the challenges we wish to overcome.

A. Data acquisition setup

1) An overview of the system's architecture: Include concept Figure 1.

Electronic sensor: microcontroller unit. Wiereless. Radio communication and battery power. Energy constraints. Fully-fledged Linux system: internet connectivity, Python scripting, etc. Power-over-Ethernet, no energy constraints.

2) Data acquisition flowd: Here we talk about the communication protocols, data-storage and data processing aspects.

B. Data analysis techniques

Here we talk about the techniques. Figure 2 presents an overview of the techniques.

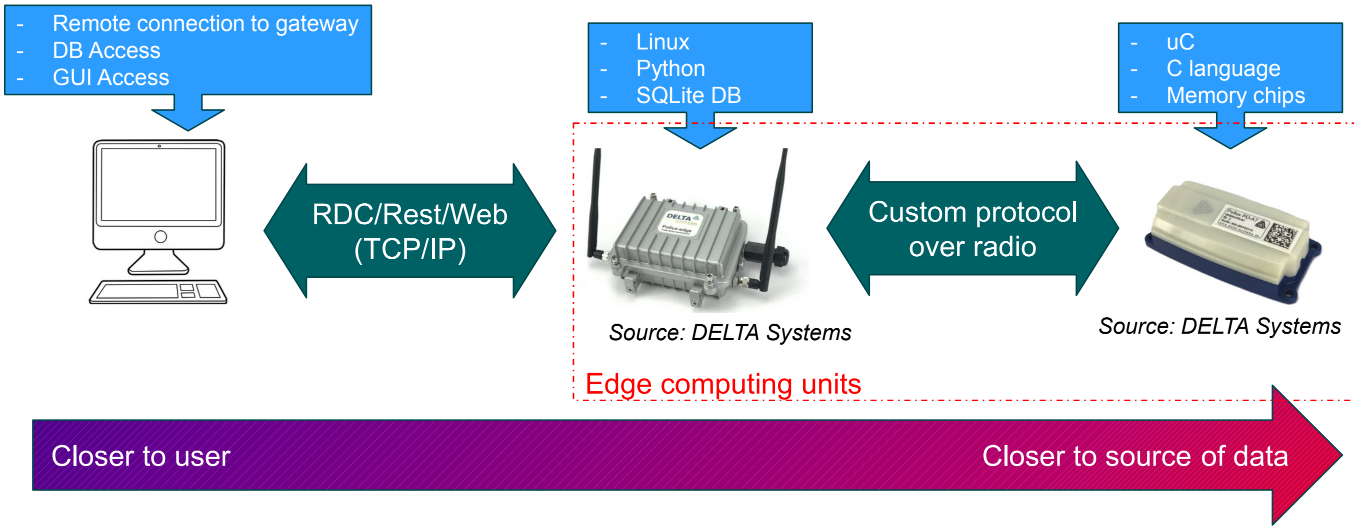

Fig. 1. Overview of the system's architecture.

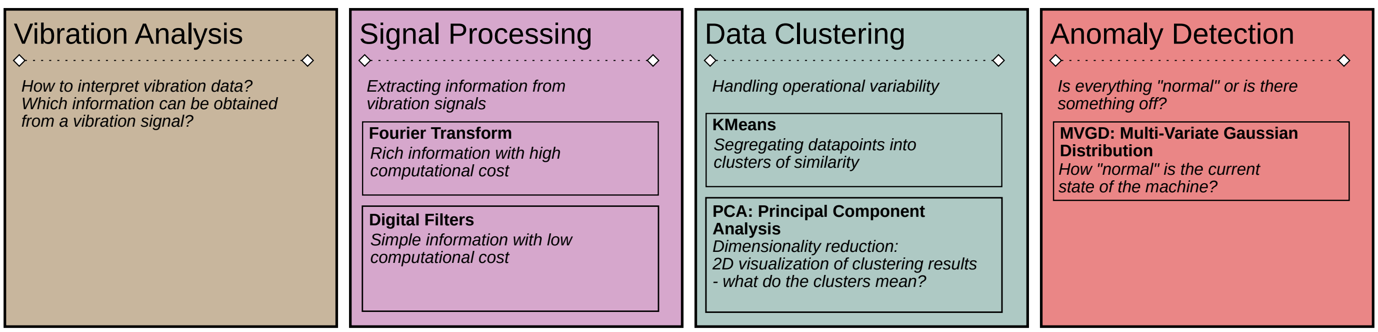

Fig. 2. Overview of the techniques employed in the data analysis.

1) Vibration Analysis: RMS numerical value of total vibration. Speed is always important. Induction motors. Frequency Analysis: helps identifying source of problem. Which features are important.

2) Signal Processing: Used to extract information from vibration signals

a) Fourier Transform: Rich but expensive information. Equations. Explain how to extract a specific range.

b) Digital Filters: Simple and computationally effective implementation. Information not very rich: we can extract RMS of frequency ranges.

3) Clustering: Handling operation variability. dads

a) K-Means: Segregation into clusters.

b) Principal Component Analysis: Helps applying human expertise to associate data clusters to physical operational modes of the machine.

4) Anomaly Detection:

a) The Multi-Variate Gaussian Distribution:

b) Quantile Transform - Ensuring the data is Gaussian:

IV. Results and Discussion

A. Data Exploration

Explain vibration signals: Length, sampling rate, axes.

B. Clustering: Segregation of Operational Modes

C. Approach to Anomaly Detection

D. The Way to the Internet of Things

V. Conclusion

Acknowledgment

Who should we thank?

References