AI-based Decision Support System for Proactive Maintenance

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1 Research Motivation

This thesis proposal aims to develop AI-based proactive maintenance decision making approaches for manufacturing systems in the context of Industry 5.0 to improve the current system of the subsidiary OCP Maintenance Solutions (OCP-MS) [1]. Indeed, OCP-MS is developing a platform dedicated to predictive maintenance, an action is performed based on an estimate of the health status of an equipment. However, although this strategy makes it possible to satisfy customer demand by reducing unanticipated stoppages and ensuring product quality, it has the major disadvantage that it leads to the replacement of equipment when the latter is still capable of producing sufficient quality and when the breakdown may still be some time away (intervention "too early").

2 Problem Statement

The transition to a proactive maintenance is a priori only possible by making available all the relevant data to build the algorithms for the detection and prediction of failures [2]. In this context, OCP-MS already has 400 sensors installed and running, it is designed to manage a sensor network of up to 15000 measurement points. This thesis is built on this original combination of process and business data exploitation for the joint development of prognostic and decision support processes in proactive maintenance.

3 Research Scope

The application of machine learning in proactive maintenance has gaining attention in recent years, due to (*i*) the increase of the amount of data in manufacturing processes, (*ii*) the need to maintain and survey the machines intelligently, and (*iii*) to identify the source of failures [3]. This problematic is an important research topic because specific models has to developed depending on the number of sensors installed, the IoT architectures, and the complexity of the dependencies between the different

signals. In this context, the objective of the thesis is to develop a proactive maintenance system for the OCP-MS platform with the following features:

- Data storage and processing: data science techniques will be applied in this part to clean and complete the missing data. These data have a temporal dimension, so they will be stored as time series data in the influxdb database.

- Anomaly detection and prediction: the analytical part of the system will include anomaly detection, which will alert the user to various non-normal states of the systems where the sensors are installed. The analytical part will also contain prediction, to see the dynamics and estimate the evolution of the system in the future. In terms of methods, these features will be based mainly on deep learning, more precisely recurrent neural networks (e.g., LSTM and GRU networks) and transformers, because on one side there will be a lot of data, we estimate 5 years of data (OCP-MS was launched in 2016), and on the other side, we have to consider the temporal aspect of the data.

- Explainable AI and recommendation: the explainable AI part will be the main result of this tool. It will be in charge of identifying the factors that represent the sources of the problems. From these system outputs, and using domain knowledge. The idea is to provide concrete recommendations to the business expert on the state and use of the different machines.

- Visualization: the envisaged decision support system will also include the visualization part which can rely on the already deployed platform, *Allens*.

4   Admission Criteria

The PhD position is proposed by the International Center of Artificial Intelligence of Morocco, of the Mohammed VI Polytechnic University. Applicants with excellent cursus must be holders of a Master's, an engineering or an equivalent recognized degree in Industrial Engineering or Computer Science. In addition, they should have skills in Programming (Python and C++) and good communication skills in English. Particular attention will be given to the suitability of this research project with the applicant's background.

References

[1] Abdenour Jbili and Mounir Lahlimi. A moroccan leading use case for predictive maintenance, iot and industry 4.0. *SYMPHOS 2019 – 5th International Symposium on Innovation Technology in the Phosphate Industry*, 2020.

[2] Xiaoning Jin, Brian A Weiss, David Siegel, and Jay Lee. Present status and future growth of advanced maintenance technology and strategy in us manufacturing. *International journal of prognostics and health management*, 7(Spec Iss on Smart Manufacturing PHM), 2016.

[3] Thyago P Carvalho, Fabrízzio AAMN Soares, Roberto Vita, Roberto da P Francisco, João P Basto, and Symone GS Alcalá. A systematic literature review of machine learning methods applied to predictive maintenance. *Computers & Industrial Engineering*, 137:106024, 2019.