Feasibility study: Pathway to autonomy for an SME factory

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Abstract

The aim of this study is to investigate a generic Advanced Abnormal Perception technology, which can be used in an easy-to-deploy way for anomaly detection of autonomous manufacturing. It can improve the reliability of the existing manufacturing system, reduce maintenance costs. At the same time, it can play a positive role in accelerating the promotion of autonomous manufacturing. DES will provide decision-making guide about production based on the live data provided by the AAP algorithm in this study.

Introduction

The application of autonomous in manufacturing presents the opportunity to increase productivity, reliability, add value in a competitive arena and compensate for an ageing skilled workforce[1]. It should be emphasised that the higher flexibility often means higher risks to reliability. Autonomy makes it a fully man-labour free factory, but it could lead to the loss of traditional advantages, such as the system failures and risks identified based on the human senses and experience of workers.

In response to these challenges, many individual AAP systems have been developed to control the quality of the production or ensure reliable operation of the system. Such as singular value decomposition of digital image has been used to detect the surface defects on steel strops[2], current signals were used to detect the broken rotor bars of induction motors[3].

The shortcomings of these AAP technologies are that their versatility is not enough, which could limit the use in autonomous manufacturing. The ideal AAP technology should be application independent, which means that It should be as follows:

[1]. A learning system with the abilities of on-site feature selection and unsupervised/ semi-supervised learning.

[2]. A measure independent system, which doesn't interfere with production line. This can reduce the deployment cost of sensing technology, especially for legacy systems.

Implement the AI with AI

As shown in Figure 1, the architecture of plug and play AAP technology will be investigated and designed, which includes three layers as follows:

a) Non-invasive sensor layer. This layer is the driver interface layer for different types of sensors, which enables the AAP technology to have the ability to access different types of non-intrusive sensors.

b) General feature extraction layer. This layer applied with unsupervised feature selection aims to reduce the time complexity and storage burden, improve the generalization ability of learning machines by removing the redundant, irrelevant and noisy features for 1D/2D inputs[5]. The flow chart of this layer is shown in Figure 2.

c) Generic abnormal perception algorithm layer. This layer is based on the outputs of the feature extraction layer, using semi-supervised learning method, such as one class SVM to achieve abnormal detection. The flow chart of this layer is shown in Figure 3.

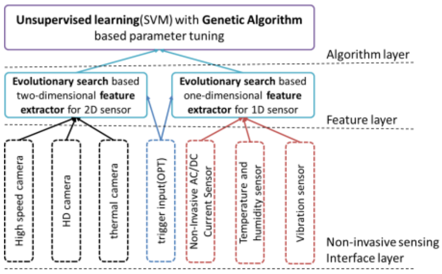

Figure 1: Architecture of plug and play AAP technology with three layers

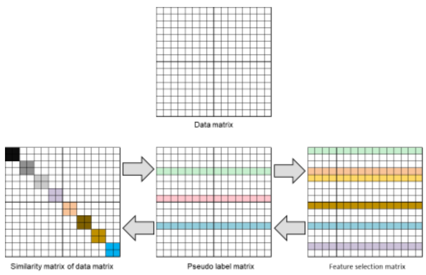

Figure 2: Flow chart of the unsupervised feature selection

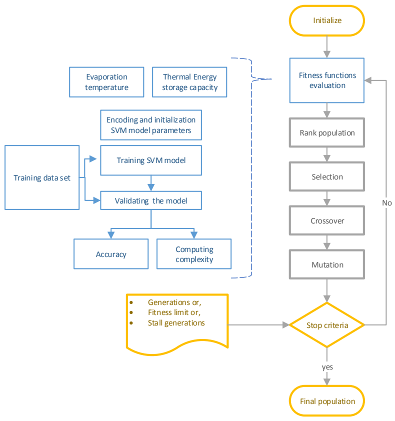

Figure 3: Flow chart of GA based parameters tuning

Discrete Event Simulation Linking with Live Data

Discrete Event Simulation (DES) is widely used in manufacturing research for optimising operational processes and validating what-if factory configurations.

Within digital manufacturing principle, DES is able to incorporate live data from machines to support near real-time decision making in response to unexpected changes.

As shown in Figure 4, DES will provide decision-making guide about production based on the live data provided by the AAP algorithm in this study.

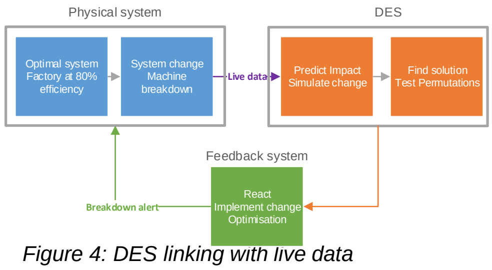

Figure 4: DES linking with live data

The complete system will be verified on the production line shown in Figure 5.

Acknowledgments

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References:

[1] Autonomous Manufacturing Workshop Report, September 2014

[2] Sun, Q., Cai, J. and Sun, Z., 2016. *Detection of surface defects on steel strips based on singular value decomposition of digital image*. Mathematical Problems in Engineering, 2016.

[3] Camarena-Martinez, D., Perez-Ramirez, C.A., Valtierra-Rodriguez, M., Amezquita-Sanchez, J.P. and de Jesus Romero-Troncoso, R., 2016. *Synchrosqueezing transform-based methodology for broken rotor bars detection in induction motors*. Measurement, 90, pp.519-525.

[4] Zhu, P., Zhu, W., Hu, Q., Zhang, C. and Zuo, W., 2017. *Subspace clustering guided unsupervised feature selection*. Pattern Recognition, 66, pp.364-374.

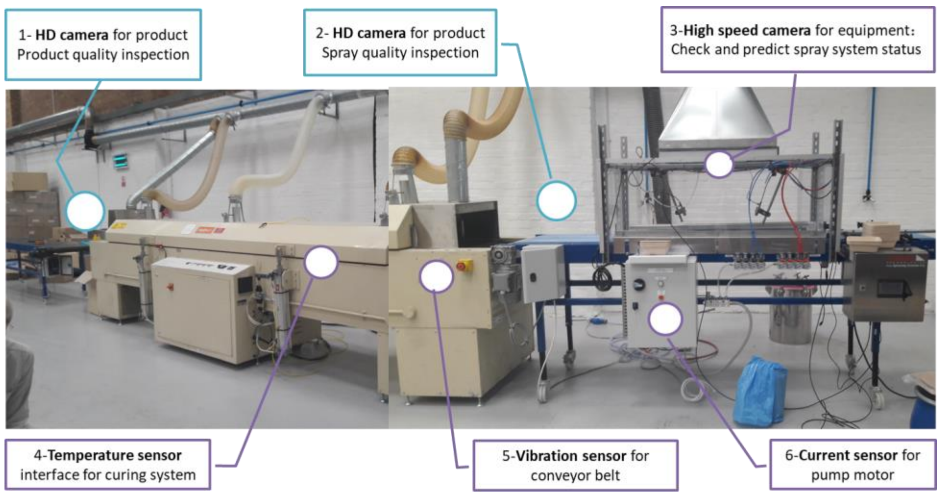

Figure 5: verification platform for the proposed system