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Review Article

A Review about Machine Learning in Manufacturing

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Abstract

Manufacturing industry is currently the heart of data driven revolution which is the cornerstone in transforming the traditional manufacturing systems to highly automated smart manufacturing by embedding new technologies such as Internet of Things (IoT), cyber-physical systems and cloud computing in physical advanced manufacturing processes to measure and monitor real time data. It is necessary to manage data and apply big data analytics to extract meaningful pattern. Also, it is helpful to adopt artificial intelligence techniques in manufacturing context to increase process efficiency within the framework of industry 4.0. The aim of this paper is to present a review about machine learning in manufacturing context.

Keywords: *Machine Learning, Smart Manufacturing, Internet of Things.*

1. Introduction

Nowadays there is an increasing trend in the availability of manufacturing data which arise new opportunities for improving the accuracy of the process simulation. (O'Donovan *et al*., 2015) stated that currently manufacturing industry is the heart of data driven revolution which is the cornerstone in transforming the traditional manufacturing systems to highly automated smart manufacturing. The focus of the advanced manufacturing is creating an intelligent manufacturing from real time data that support the accuracy of the decision making. The transformation needs emerging new technologies such as Internet of Things (IoT), cyber-physical systems and cloud computing and embedding them in physical advanced manufacturing processes to measure and monitor real time data. It is necessary to manage the exponential increase in data production and apply big data analytics in order to extract meaningful pattern that helps in decision making. In addition, (De Filippis *et al*., 2017) discussed the uncertainty in the situation of manufacturing processes, they said that it became more sophisticated as there is continuous variability in the processes resulting from the fluctuating in the demand of the customers and the life cycle of the products. Furthermore, they stated that the use of artificial intelligence techniques in manufacturing context allowed to yield revolutionary improvement within the framework of industry 4.0 which is beneficial to increase the efficiency and effectiveness of the processes.

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One of the most important techniques is artificial neural network (ANN) which can be used to address continuous variation problem along with monitoring, controlling and optimizing the processes and making prediction about their parameters in order to build accurate process simulation.

The aim of this paper is to present a review about machine learning in manufacturing context.

2. Machine Learning in Manufacturing

B.H. Li (Li *et al*., 2017) stated that artificial intelligence is an essential concept used to facilitate the development of intelligent systems to increase the productivity and maximize the efficiency of various processes., the life cycle of new intelligent manufacturing systems use autonomous sensing, learning, interconnection and decision making to integrate and optimize different aspects of manufacturing enterprise leading to increase the productivity, maximize the efficiency, improve the quality and reduce the cost. T. Wuest (Wuest *et al*., 2016) stated that the applications of machine learning in manufacturing include machine condition monitoring, fault diagnosis leading to apply predictive maintenance, image recognition that helps to classify damaged products and building a simulator for advanced manufacturing process to predict its parameters.

In addition, L.A.C De Filippis (De Filippis *et al*., 2017) showed that manufacturing applications include modelling and scheduling the processes which solve issues related to operational decision making. The procedure for using artificial neural network starts by

collecting experimental observations and pre-processed it to be ready for network training. Then, establish numerical relationship between the parameters and mechanical features of the part after welding. Finally, time and costs parameters of the process will be evaluated to identify the benefits and costs incurred from the prediction model. However, the following are some important applications to particular production process:

- Injection molding processes: it is a dynamic process as the control variables are the cylinder velocity, the holding, temperatures of melting, the pressure that help to produce the flow of polymer. The process is uncertain and complex making it difficult to correlate between these variables and product quality such as smoothness and geometry accuracy. To solve this issue, multilayer perceptron was used to model the process in order to predict the part quality.
- Arc welding processes: the parameters of this process are the temperature of surface, the voltage of welding and the torch speed. Again, it is difficult to correlate between these variables and product quality such as the geometry and weld defects. Also, multilayer perceptron was used for process modelling and product quality prediction.

T. Saric (Saric *et al*., 2013) simulated and predicted steel surface roughness using three different neural network algorithms which are back-propagation, modular and radial basis function neural networks. The input variables were the parameters that control the process (feed rate, depth of cut, cutting speed and number of revolutions) while the output variable is machined surface roughness. The results show that root mean square (RMS) error in radial basis function is 5.24 % in the learning phase and 8.53 % in the validation phase, the modular neural network produced an error of 6.02 % in the learning phase and 8.87 % in the validation phase. Finally, the results of back-propagation neural network in terms of RMS error is 6.46 % in the learning phase and 7.75 % in the validation phase. Furthermore, J. Moyne & J. Iskandar (Moyne & Iskandar, 2017) have been applied big data analytics in semiconductor manufacturing industry which helps to improve the current capabilities such as detecting the faults and support the recent capabilities like predictive maintenance. The most important factor was the quality of the dataset in order to deliver high quality solutions. In the future, they expected that digital twin will be used to improve the ability of the analytics.

3. Applications of Neural Network in Manufacturing

(De Filippis *et al*., 2017) stated that neural network is an efficient, effective and accurate tool for building a simulator for manufacturing processes to optimize their parameters and predict the properties of the processed product based on the optimum control variables which is beneficial to save cost, time and material resources. The classification for the functionalities of neural network in manufacturing context are illustrated in the shown figure:

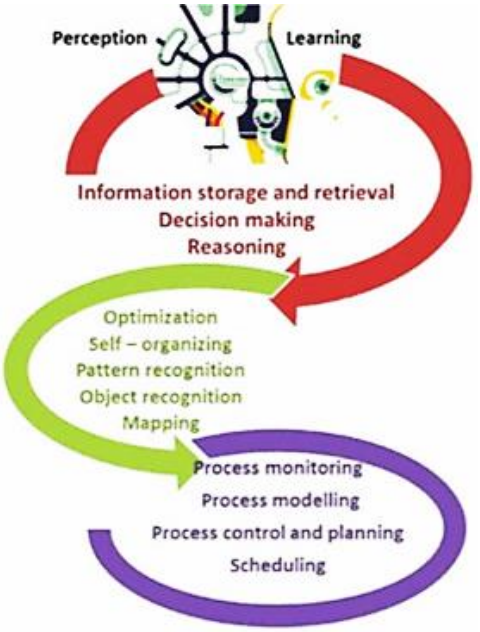

Fig.1 The functionalities of neural network in manufacturing (De Filippis *et al*., 2017)

The manufacturing applications include modelling, parameters prediction, monitoring and control, in addition to scheduling the processes which solve issues related to operational decision making. The focus will be on the use of artificial neural network to monitor, control and optimize welding processes. The procedure for this application is similar to the steps shown in the previous section by collecting experimental observations and preprocessed it to be ready for network training. Then, establish numerical relationship between the parameters and mechanical features of the part after welding. Finally, time and costs parameters of the process will be evaluated to identify the benefits and costs incurred from the prediction model. However, there are are some important applications to particular production process such as injection moulding process which is a dynamic process as the control variables are the cylinder velocity, the holding, temperatures of melting, the pressure that help to produce the flow of polymer. The process is uncertain and complex making it difficult to correlate between these variables and product quality such as smoothness and geometry accuracy. To solve this issue, multilayer perceptron was used to model the process in order to predict the part quality. Furthermore, arc welding process is another application and the parameters of this process are the temperature of surface, the voltage of welding and the torch speed. Again, it is difficult to correlate between these variables and product quality such as the geometry and weld defects. Also, multilayer

perceptron was used for process modelling and product quality prediction.

Furthermore, (Najafabadi *et al*., 2015) discussed deep learning in data mining as the main concept in deep learning algorithms is automated extraction of representation from a huge amount of dataset with a large motivation of artificial intelligence field. The extracted features from the set of data are distributed allowing for a large number of possible configurations which leads to better generalization. The relation between the number of possible configuration and the number of extracted features is exponential, generation of the observed data was based on the interaction of different factors so that obtaining a pattern through some configurations can help to obtain additional patterns of unseen data through new configurations.

Conclusion

Adopting artificial intelligence techniques in the context of manufacturing is beneficial to increase the efficiency and effectiveness of the processes within the framework of industry 4.0. Manufacturing industry is currently the heart of data driven revolution which is the cornerstone in transforming the traditional manufacturing systems to highly automated smart manufacturing by embedding new technologies such as Internet of Things (IoT), cyber-physical systems and cloud computing in physical advanced manufacturing processes to measure and monitor real time data. It is necessary to manage data and apply big data analytics to extract meaningful pattern. Also, it is helpful to adopt artificial intelligence techniques in manufacturing context to increase process efficiency within the framework of industry 4.0.

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