

Defect Detection in Manufacturing via Machine Learning Algorithms

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INTRODUCTION

In our modern world, almost everyone uses a telephone and computer. Besides, there are machines working with computer systems in our houses. Also, computers have become indispensable in public institutions and organizations, factories. With the development of technology, data collection and storage has been simplified. Institutions, governments and individuals collect a large number of data. This data is usually stored in electronic media. The transactions made with devices such as telephones and computers are recorded. It is foreseen in IDC's "Digital Universe Dijital study that digital data will double every two years and the amount of data will be 44 zettabytes (44 trillion gigabytes) by 2020 (Atalay and Çelik, 2017). Although collecting and recording each data seems to be an advantage, extracting meaningful and useful information from such big data has become increasingly difficult. This situation made the big data concept debatable. Therefore, special methods were needed to process and analyze the data. One of these methods is artificial intelligence.

Artificial intelligence studies started with the principle of transferring human intelligence to computers, and the idea of gaining human learning ability to computers has been of great importance. In line with this idea, the desire for machines and computers to learn and make the best decision like human beings has revealed the concept of machine learning.

Computers were initially designed only to perform specific tasks and built to help people in their daily work. Along with the improvements, computers and machines could perform simple tasks and collect and store the desired data about the given assignments. However, these data accumulated on computers did not make sense and did not mean anything. For people, data that can be analyzed and made sense only means meaning and knowledge. This necessitated that computers should reach a certain level by being educated and taught just like humans with the concept of machine learning. Therefore, the "Can the patterns obtained from these observations be discovered and identified by processing the data obtained from the observations with the help of computers?" question is the basis of machine learning (Emir, 2013).

Machine learning and models have been developed because it is impossible to process large amounts of multi-featured data manually. Machine learning is a computer program that optimizes performance criteria using sample data or past experiences (Alpaydın, 2004). With the help of machine learning, more accurate and valid results can be obtained by making forward-looking forecasting and planning

based on past data. This shows that machine learning is a system that makes it valuable and profitable for companies and individuals from big data stacks.

This study aims to utilize machine learning algorithms to predict and detect product defects in a manufacturing process. In this pursuit, the study was based on a real-life problem of manufacturing companies operating in the white good sector in Turkey. A set of machine learning algorithms were applied to the company's problem dealing with predicting the defects in the painting process. Although there are several algorithms in the literature, the most popular ones are selected for conducting the study: k-nearest neighbour (k-NN), support vector machines (SVM), naive Bayes and random forest. To the best of the authors' knowledge obtained from the literature review on the area, one earlier study applied machine learning algorithms to predict product defects in the painting process. The remaining paper was organized as follows: Section II presents background. Section III introduces briefly the algorithms used in this study. Section IV introduces the methodology and explain the problem the study tried to handle. This part also gives the results obtained from the algorithms. The last part, Section V presents the conclusion of the study and the future research directions.

BACKGROUND

The literature presents several studies using machine learning algorithms to solve problems faced by organizations in various sectors. The authors have employed different algorithms in manufacturing and service sectors such as education, health, finance, and banking.

For example, in their studies conducted in the financial area, Emir (2013), Yapraklı and Erdal (2016), Arsoy and Güreşen (2016) used machine learning algorithms such as SVM and Artificial Neural Networks for the problems. Then they compared the performances of the algorithms. Khandani et al. (2010) applied the techniques to construct nonlinear nonparametric forecasting models of consumer credit risk. Qi (2012), Kartal (2015), Bilgen (2014), Korkem (2013), Ayas and Ekinci (2014), Akman (2010) used different machine learning algorithms such as random forests, decision trees, support vector machines in their biology studies and also for the performance comparison. Bueno et al. (2017), in the field of wind energy using hybrid machine learning techniques, have completed the effectiveness of the wind power ramp. Also, Atasever (2011) made classification studies on satellite imagery in the field of mapping and used the method of boosting, SVM, random forest and regression trees. Priya et al. (2020) used machine learning algorithms to determine fruit quality. Due to the importance of fruit image and colour in marketing, the quality of the fruit has been classified by image processing, so image, colour and Histogram of gradient (HOG) is used on feature extractions.

On the other hand, the authors also used machine learning algorithms for defect prediction. Yildiz and Buldu (2017) used thermal cameras in the quality control unit to detect defects on the fabric and carried out studies to detect fabrics defect by using images from the cameras using the k-NN method. Wu et al. (2019) used computer-aided detection of casting defects in X-ray images with ML algorithms. Gobert et al. implemented in situ defect detection for powder bed fusion (PBF) additive manufacturing using high-resolution imaging via supervised machine learning. Chu and Wang (2014) predicted the number of defective products that may occur in new laptop products by using a robust regression method based on historical data in the computer manufacturing industry. In their studies, they established a reliable development model for error estimation in the new product development process. Zhang et al. (2017) made feature extraction from the existing data primarily in their study called feature extraction in medium plate tension analysis and machine learning approach in defective product estimation. The best sub-selection,

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