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ÖZGÜN ARAŞTIRMA

FORECASTING ORDER DELAYS WITH ARTIFICIAL INTELLIGENCE-BASED APPLICATIONS[1]

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Abstract

The digitalization trend in the world in the last two decades has begun to transform business processes. Departing from the traditional business approach, the use of technology in every field has changed business processes and, accordingly, the approach of managers. On the other hand, cloud computing, the internet of things, sensors and instant notification systems through these components brought by the last industrial revolution have transformed supply chains into a smart structure. Now, the information that a product sold by a retailer, which is the last link of a supply chain, is out of stock is transmitted to the raw material supplier in the first link of the chain. In this way, a perfect supply chain structure is formed and operations are carried out in lean working principles. The products prepared according to the reduction of the retailer's stocks are continuously supplied, which shows flawless operation. On the other hand, through digital components such as sensors and the Internet of Things, each step in workflows is instantly converted into data and stored in virtual environments called cloud computing. At this point, besides the problem of data storage and security, the main problem is to process the data in a meaningful way. Analyzing big data generated by AI-based components and systems is also possible with AI-based systems. Methods called machine learning have been developed for this situation and their application area is increasing day by day. In the light of this information, within the scope of the study, forecasts of order quantity delays for future periods using historical order data from customers for the products produced by an enterprise were analyzed using machine learning algorithms. The results of the analysis made through the Microsoft Azure Machine Learning Studio platform will contribute to the use of digital tools in the sector as well as increasing the application examples of machine learning. According to the results obtained as a result of the analyzes, recommendations were developed for the enterprise. Finally, suggestions for the application of machine learning in the field of business administration are presented.

Anahtar kelimeler: Big Data, Machine Learning, Forecasting, Artificial Intelligence.
Jel Kodu: C55, C88, E17

YAPAY ZEKA TABANLI UYGULAMALAR İLE SİPARİŞ GECİKMESİ TAHMİNİ

Özet

Dünyada son yirmi yılda yaşanan dijitalleşme akımı ile beraber iş süreçleri başkalaşmaya başlamıştır. Geleneksel işletme yaklaşımından ayrılarak, teknolojinin her bir alanda kullanılmaya başlanması iş süreçlerini ve una bağlı olarak yöneticilerin yaklaşımını değiştirmiştir. Bir diğer yandan son sanayi devriminin getirdiği bulut bilişim, nesnelerin interneti, sensörler ve bu bileşenler aracılığıyla anlık bildirim sistemleri tedarik zincirlerini akıllı bir yapıya dönüştürmüştür. Artık bir tedarik zincirinin son halkası olan perakendecinin satmış olduğu bir ürünün stoklardan düşme bilgisi, zincirin ilk halkasındaki hammadde tedarikçisine kadar iletilmektedir. Bu yol ile kusursuz bir tedarik zinciri yapısı oluşmakta, yalın çalışma prensiplerinde işlemler yapılmaktadır. Perakendecinin stoklarının azalmasına göre hazırlanan ürünler devamlı bir şekilde temin edilmekte, bu durumda kusursuz çalışmayı göstermektedir. Bir diğer yandan, sensörler ve nesnelerin interneti gibi dijital bileşenler aracılığıyla iş akışlarında yer alan her bir adım anlık olarak verilere dönüştürülerek, bulut bilişim denilen sanal ortamlarda depolanmaktadır. Bu noktada ortaya çıkan verileri depolama ve güvenliği probleminin yanında asıl sorun, söz konusu verileri anlamlı hale getirecek şekilde işleyebilmektedir. Yapay zeka tabanlı bileşenler ve sistemler tarafından üretilen büyük verilerin analiz edilmesi de yapay zeka tabanlı sistemler ile mümkün olmaktadır. Bu durum için makine öğrenmesi olarak isimlendirilen yöntemler geliştirilmiştir ve günümüzde gitgide uygulama alanı artmaktadır. Bu bilgiler ışığında, çalışma kapsamında bir işletmenin ürettiği ürünlere müşterilerinden gelen geçmiş sipariş verileri kullanılarak gelecek dönemlere dair sipariş miktarı gecikmelerine dair tahminleri makine öğrenmesi algoritmaları kullanılarak analiz edilmiştir. Microsoft Azure Machine Learning Studio platformu aracılığıyla yapılan analiz sonuçları,

[1] This study is derived from the author's PhD thesis.

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makine öğrenmesinin uygulama örneklerinin artırılmasının yanında sektöre dijital araçların kullanılması konusunda katkı sağlayacaktır. Yapılan analizler neticesinde elde edilen sonuçlara göre işletmeye öneriler geliştirilmiştir. Son olarak ise makine öğrenmesinin işletmecilik alanında uygulanmasına dair öneriler sunulmuştur.

Keywords: Büyük Veri, Makine Öğrenmesi, Tahmin, Yapay Zeka.
Jel Codes: C55, C88, E17

1. INTRODUCTION

The concept of digitalization, the foundations of which were laid in the 19th century when George Boole revealed the relationship between mathematics and logic (Say, 2018), is spreading and expanding at an extraordinary speed today with the effect of technological developments. There have been many developments in the period from this development until 2010. For example, storage was moved from physical environments to virtual environments such as google drive and similar virtual environments, and sensors were included in business processes. However, in 2010, these developments were defined as Industry 4.0 in Germany. With Industry 4.0, artificial intelligence components such as the internet of things, cloud computing and sensors (Kagermann et al., 2010) have rapidly become influential not only in business processes but also in all aspects of our lives. Every individual has become a data source.

With these developments in the field of technology and the impact of smart devices, decision-making processes in businesses have changed. With this change, traditional decision-making methods have become inadequate. Now, it is necessary to make analyzes by taking into account too many variables and big data belonging to these variables. These analyzes are possible with machine learning techniques, which are one of the artificial intelligence-based applications and widely used.

The ability of businesses to compete with their competitors in intense competition conditions depends on their ability to meet the needs of their customers within the principles of just-in-time production. When the literature is examined, it is seen that there are few application examples of machine learning algorithms in the field of order quantity forecasting. For this reason, in order to contribute to the literature and with an up-to-date method, the issue of order quantity forecasting is addressed with machine learning. In this study, the data obtained from a paint production company were organized and used.

In the next section of this paper, we will first provide information about machine learning and the implemented algorithm. Then, a literature review will be presented, and in the last part, an application of order delay prediction with machine learning as a real-world application will be presented.

2. CONCEPTUAL FRAMEWORK

With the definition of artificial intelligence by John McCarthy in 1956 (Moor, 2006), artificial intelligence has been used in problem solving and programming (Brewer, 2000). Over time, it was determined that the analysis performed by computers gave faster and more accurate results compared to the processes performed by human hands, and computers started to be used rapidly in the field of problem solving. Over time, studies on how machines can think like humans have entered the literature as machine learning and have become widespread (Gupta et al., 2017).

The foundations of the concept of machine learning were laid by Arthur Lee Samuel in 1959, just after the concept of artificial intelligence was introduced (Samuel, 1959). Machine learning, which aims to obtain more accurate results by making more precise predictions (Helm et al., 2020), is a branch of science that is closely related to data mining and enables machines to learn by thinking like humans and to make predictions based on past experiences (Kavakiotis et al., 2017). In machine learning algorithms, data on a problem or business process is generally divided into training and test data, and

machines are taught with training data containing past experiences and develop predictions with test data (Zhang et al., 2020).

As machine learning algorithms have evolved over time, they have been divided into four classes: supervised, unsupervised, semi-supervised and reinforcement learning, as shown in Figure 1, according to whether the data is labeled or not, and regression, classification, clustering, dimensionality reduction and Q-Learning operations are performed in these classes (Kumar et al., 2019).

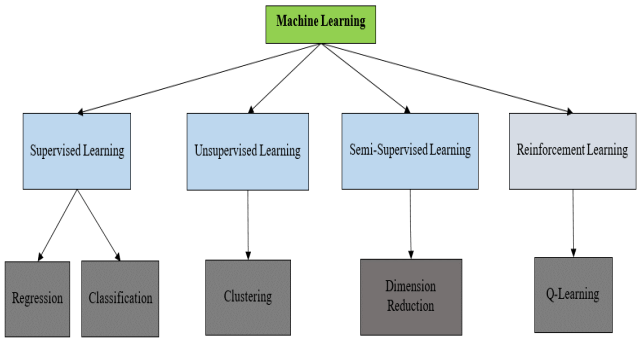

Figure 1: Machine Learning and its Types

Source: Kumar et al., 2019

Since the data belonging to the problem addressed in this study are labeled data, supervised learning is applied. As an application methodology, regression analysis from supervised learning algorithms was applied.

3. LITERATURE REVIEW

Machine learning algorithms are methods that have ancient origins but have recently developed in parallel with the popularization of computers and artificial intelligence. In this respect, machine learning algorithms are algorithms that provide highly accurate results by considering the problem as a whole and provide the most optimum possible result as fast as possible (Dey et al., 2016).

When the literature is examined, it is seen that machine learning algorithms have few application examples in many supply chain problem types such as sales forecasting, order quantity forecasting, order delay (Chaharsooghi, 2008; Kilimci et al., 2019), health (Sevli, 2019; Abbasi et al, 2020), risk identification (Erdal and Yapraklı, 2016), food (Shahbazi and Byun, 2020), social media analysis (Kaynar et al., 2016), meteorology (Gültepe, 2019), banking (Zhang et al., 2021), performance measurement (Hong et al., 1999; Jomthanachai et al., 2021).

4. METHOD

As the data obtained within the scope of this study is labeled data, supervised learning was performed and prediction was performed with a regression method using supervised learning. As a machine learning application, predictions with regression analysis were performed on the Microsoft Azure Machine Learning Studio (AMLS) platform.

The application method of the study, the supervised machine learning algorithm regression analysis, will be used to predict some values based on a given set of features. Basically, the mathematical formulation used in regression analysis is as follows (Myers et al., 2012):

$$y=f(x)+\varepsilon$$

In the above formula, Y is the dependent variable, x is the independent variable, f is a function that provides the relationship between x and Y, and ε is the possible random error. Using the training and test data introduced to the system, first, feature selection is made and then the regression model is selected and machine learning is applied (Fox, 2018; Kumar et al., 2019).

5. APPLICATION

In this study, data on the raw material supply of a company were obtained by obtaining the necessary permissions. The obtained data will be organized and it will be determined whether there is an order delay situation. A cross-section of the obtained data and application results are presented in Table 1. According to the data, the enterprise receives raw materials from 3 suppliers (distances 280, 875 and 2400 km) and there are 254 order data. The

distribution of these orders to suppliers is shown in Figure 2.

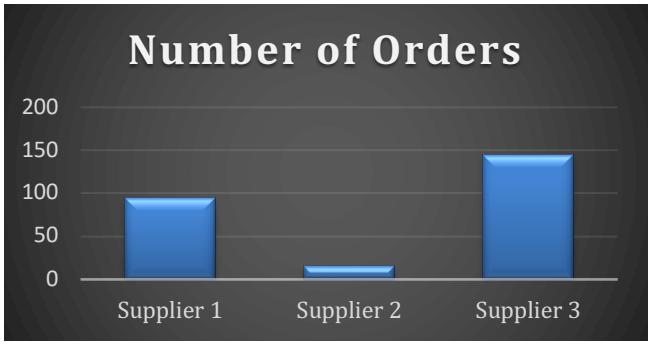

Figure 2: Number of Orders from Suppliers

It is important to know the raw material supply in terms of quality, time, cost and quantity in advance for the future planning of the enterprise and to respond to customer demands. The fact that there are few examples of applications with machine learning in the literature shows that this study will contribute to the literature.

Forecasting of order delay with machine learning was performed over AMLS. Distance, weather, raw material quantity, month, delivery time and order delay variables were used in the analysis. 254 order data were processed as 70% training data and 30% test data. The process steps applied in AMLS are presented in Figure 3. It is assumed that the company orders 24,750 kg of raw materials as a fixed quantity.

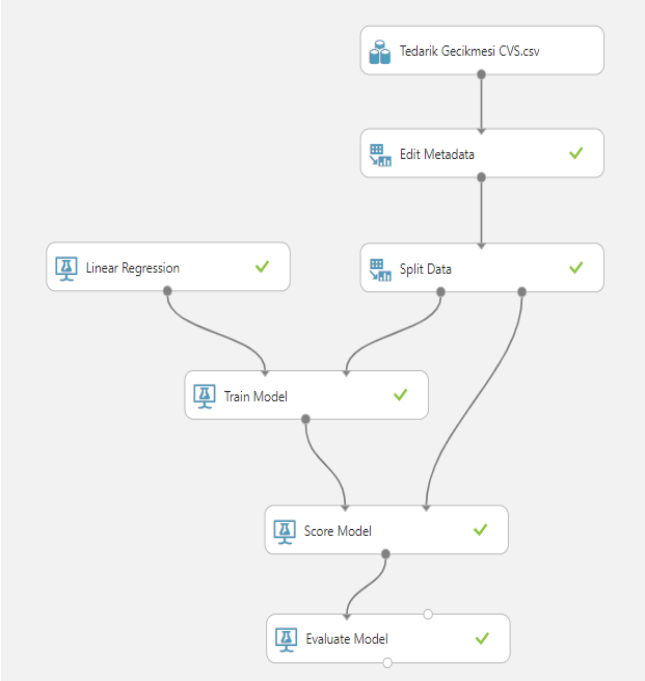

Figure 3: AMLS Application Flow

Table 1: Supply Information and Order Delay

Suppliers	Distance (km)	Weather Forecast (B/G)	Raw Material Amount (Kg)	Moon	Supply Time	Order Delay Status (N/Y)
Supplier I	280	1	12375	April	1	0
Supplier I	280	1	1125	April	1	0
Supplier I	280	1	24750	April	2	1
Supplier II	875	1	24750	April	3	1
Supplier II	875	1	24750	April	3	1
Supplier II	875	1	24750	April	3	1
Supplier II	875	1	24750	May	2	0
Supplier I	280	1	24750	May	1	0
Supplier I	280	1	24750	August	1	0
Supplier I	280	1	24750	June	2	0
Supplier II	875	1	24750	June	2	0
Supplier I	280	1	24750	March	2	1
Supplier III	875	1	24750	May	3	0
Supplier I	280	1	24750	July	1	0
. . .	. . .	. . .	. . .	. . .	. . .	. . .
Supplier I	280	1	24750	July	3	1
Supplier I	*280*	*1*	*24750*	*January*	***1,5***	
Supplier I	*280*	*0*	*24750*	*January*	***3.1***	
Supplier II	*875*	*1*	*24750*	*January*	***2.75***	
Supplier II	*875*	*0*	*24750*	*January*	***4.25***	
Supplier III	*2400*	*1*	*24750*	*January*	***3.84***	

Supplier III	*2400*	*0*	*24750*	*January*	***5.34***	
R^2=0.77						

6. CONCLUSIONS AND RECOMMENDATIONS

The problem of order delay in the raw material procurement process, which is considered as a real world application, is handled with machine learning. In this context, 254 order data were coded as 70% training data and 30% test data in machine learning. In the processes carried out, both the presence of order delay was determined and predictions were developed for the orders that the enterprise will obtain from its suppliers depending on good and bad weather conditions in the future.

As a result of the analysis made through AMLS, it is estimated that artificial intelligence will supply orders from the first supplier in 1.5 days in good weather conditions and 3.1 days in bad weather conditions. The same values were determined as 2.75 and 4.25 days for the second supplier and 3.84 and 5.34 days for the third supplier. When the information in the training data is analyzed, the average time for the suppliers of the enterprise to deliver the raw materials is determined as 2.19 days.

In addition, it was determined that the independent variables used in the regression model, which consist of supplier, distance, weather, incoming raw material quantity and month variables, explained 77% of the dependent variable determined as delivery time (R2=0.770). According to the results obtained as a result of the machine learning application, it was determined that the delivery time of orders from raw material suppliers will be approximately 1 day earlier as a result of a correct planning.

A real-world example is presented on the problem of order delay prediction with machine learning, which has very few application examples. The use of the flow can be used as a framework, and similar studies will provide significant gains to sectors and businesses.

The developed model and application results will make a significant contribution to the organization's ability to provide days to customers without keeping stock according to future order situations, to make human resource planning and production planning correctly.

REFERENCES

Abbasi B, Babaei T, Hosseinifard Z, Smith-Miles K & Dehghani M (2020). Predicting solutions of large-scale optimization problems via machine learning: A case study in blood supply chain management. Computers & Operations Research, 119, 104941.

Brewer PC (2000). An approach to organizing a management accounting curriculum. Issues in accounting education, 15(2), 211-235.

Chaharsooghi, S. K., Heydari, J., & Zegordi, S. H. (2008). A reinforcement learning model for supply chain ordering management: An application to the beer game. Decision Support Systems, 45(4), 949-959.

Dey A, Singh J & Singh N (2016). Analysis of supervised machine learning algorithms for heart disease prediction with reduced number of attributes using principal component analysis. International Journal of Computer Applications, 140(2), 27-31.

Erdal H & Yaprakli TS (2016). Firm failure prediction: A case study based on machine learning. International Journal of Informatics Technologies, 9(1), 21-31.

Fox C (2018). Bayesian inference. Data Science for Transport: A Self-Study Guide with Computer Exercises, 75-92.

Gupta A, Baid P & Chaplot N (2017). Sentiment analysis of movie reviews using machine learning techniques. International Journal of Computer Applications, 179(7), 45-49.

Gültepe Y (2019). Makine öğrenmesi algoritmaları ile hava kirliliği tahmini üzerine karşılaştırmalı bir değerlendirme. Avrupa Bilim ve Teknoloji Dergisi, (16), 8-15.

Helm JM, Swiergosz AM, Haeberle HS, Karnuta JM, Schaffer JL, Krebs VE, ... & Ramkumar PN (2020). Machine learning and artificial intelligence: definitions, applications, and future directions. Current reviews in musculoskeletal medicine, 13, 69-76.Hinton, 2013

Hong, H. K., Ha, S. H., Shin, C. K., Park, S. C., & Kim, S. H. (1999). Evaluating the efficiency of system integration projects using data envelopment analysis (DEA) and machine learning. Expert Systems with Applications, 16(3), 283-296.

Jomthanachai, S., Wong, W. P., & Lim, C. P. (2021). An application of data envelopment analysis and machine learning approach to risk management. Ieee Access, 9, 85978-85994.

Kagermann, H., Österle, H., & Jordan, J. M. (2010). IT-driven business models. Global Case Studies.

Kavakiotis I, Tsave O, Salifoglou A, Maglaveras N, Vlahavas I & Chouvarda I (2017). Machine learning and data mining methods in diabetes research. Computational and structural biotechnology journal, 15, 104-116.

Kaynar O, Görmez Y, Yıldız M & Albayrak A (2016). Makine öğrenmesi yöntemleri ile Duygu Analizi. In International Artificial Intelligence and Data Processing Symposium (IDAP'16) (Vol. 17, No. 18, pp. 17-18).

Kilimci, Z. H., Akyuz, A. O., Uysal, M., Akyokus, S., Uysal, M. O., Atak Bulbul, B., & Ekmis, M. A. (2019). An improved demand forecasting model using deep learning approach and proposed decision integration strategy for supply chain. Complexity, 2019.

Kumar B, Vyas OP & Vyas R (2019). A comprehensive review on the variants of support vector machines. Modern Physics Letters B, 33(25), 1950303.

Moor JH (2006). The nature, importance, and difficulty of machine ethics. IEEE intelligent systems, 21(4), 18-21.

Myers RH, Montgomery DC, Vining GG & Robinson TJ (2012). Generalized linear models: with applications in engineering and the sciences. John Wiley & Sons.

Samuel AL (1959). Some studies in machine learning using the game of checkers. IBM Journal of research and development, 3(3), 210-229.

Say, C. (2018). 50 Soruda yapay zekâ. Bilim ve Gelecek Kitaplığı.

Sevli O (2019). Göğüs kanseri teşhisinde farklı makine öğrenmesi tekniklerinin performans karşılaştırması. Avrupa Bilim ve Teknoloji Dergisi, (16), 176-185.

Shahbazi Z & Byun YC (2020). A procedure for tracing supply chains for perishable food based on blockchain, machine learning and fuzzy logic. Electronics, 10(1), 41.

Zhang Z, Gao M, Yu G, Arık SÖ, Davis LS & Pfister T (2020). Consistency-based semi-supervised active learning: Towards minimizing labeling cost. In Computer Vision–ECCV 2020: 16th European Conference, Glasgow, UK, August 23–28, 2020, Proceedings, Part X 16 (pp. 510-526). Springer International Publishing.

Zhou J, Zhang Q & Li X (2021). Fuzzy factorization machine. Information Sciences, 546, 1135-1147.