FASHION PRODUCT DEMAND PREDICTION MODEL BASED ON ARTIFICIAL NEURAL NETWORK CONSIDERING PRODUCT VARIANCE

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ABSTRACT

Demand prediction is a crucial activity in managing supply chain. It is going to trigger all operational activities in supply chain. In fashion industry, demand prediction becomes challenging. Previous researchers have identified many factors are affecting demand of fashion product. Short life cycle, trend, season, high product variance are among factors that creating complexity in fashion product demand prediction. This research develops demand prediction model based on artificial neural network for fashion product considering product variance. The model applied feed-forward backpropagation technique as training algorithm with Levenberg-Marquadt training function. Application of the model in real industrial data is showing promising result.

Keywords: fashion product, demand prediction, artificial neural network

1. INTRODUCTION

Demand prediction is a crucial activity in managing supply chain. It is going to trigger all operational activities in supply chain. In fashion industry, demand prediction becomes challenging because of uncertainty due to lack of historical data, short life cycle, trend, season, and high product variance (Nenni et al., 2013; Liu et al., 2013). This complexity leads into inaccurate demand prediction, which latter create a lot of resource waste, dead stock, and high production cost. Demand prediction is one of popular research topic and many models for predicting fashion product have been proposed in the literature over past decades (Nenni et al., 2013). However, statistical forecasting model, which have been widely employed in conducting demand prediction for a long time may fail to perform well in industry with complex data (Yu et al., 2011). Time-series based forecasting techniques consider seasonality, trend, auto-regressive, and cyclic factor that may not suitable for fashion industry where many factors are affecting product demand (Caglayan et.al, 2020). This situation encourage many researchers, Yu et al. (2011), Fumi et al. (2012), Fereirra et al. (2016), and Caglayan et al (2020)), to develop demand prediction model in fashion industry.

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Artificial Neural Network (ANN) is found to be accurate prediction method in many industries and cases, especially in fashion industry. In this study, Artificial Neural Network (ANN) is proposed to predict demand fashion products of a local brand company in Indonesia. The company sells products that categorized in basic product and seasonal product in various style and color. High product variance and lack of historical data create complexity in developing accurate demand prediction model. ANN model is developed to predict demand for each color of product using several variables, which is predicted able to explain customer's purchasing behavior. The stores sales history, promotion, product information, demography, temperature, and statistics related to Indonesian purchasing behavior are included in the model. Many attempts are done and the most suitable ANN architecture for the case has been found for both product categories.

The rest of this paper is organized as follows. Brief explanation of ANN based demand prediction model in fashion industry is presented in Section 2. Development of ANN model for a local fashion brand in Indonesia and model analysis can be seen in Section 3. Finally, conclusion of this study is given in Section 4.

2. ARTIFICIAL NEURAL NETWORK DEMAND PREDICTION MODEL

Artificial neural network is part of artificial intelligence (AI) method that emerges with advance computer technology. AI can derive an approximation function from a set of data. Artificial neural network is a structure inspired by the biological system, particularly human brain which able to learn from experience (Zhang et al., 1998). ANN has been used to solve many prediction problems because its ability to model any type parametric or non-parametric process (Hill, 1994). ANN is trained by available historical data. ANN is data driven. It is analyzing the target based on data which being feed into the network. If target obtained from training is not match with the real data, ANN will send feedback to adjust weight until it reaches the appropriate target. This learning behavior is known as backpropagation algorithm. Backpropagation algorithm enables ANN to learn by adjusting weight in the network.

Several researchers already attempt to predict demand in fashion industry with ANN. Yu et al. (2012) employed ARIMA, ANN, and GM to predict fashion color trend and shows result that ANN surpass other models. Frank, et al (2003) tried to predict women's apparel sales and compared results among statistical method and ANN. Caglayan et al. (2020) predicted sales of fashion product with seven variables taken into account in their ANN Model. However, these researches, especially sales prediction ANN model, limited to aggregate product family. In this study, we try to predict demand in product lowest level considering product variance, in term of product color.

ANN methodology used in this study as follows: (a) Providing a selection of input and output data for ANN training, (b) Normalizing the input and output data in order to increase correlation, (c) Training the normalized data to obtain the best ANN architecture. (d) Testing the ANN model, and (e) Comparing the predicted demand with desired output.

3. MODEL DEVELOPMENT AND ANALYSIS

This section presents development of ANN prediction model on a local fashion brand company in Indonesia who sells their product in e-commerce, online store, and brick-and-mortar stores. There are two types of products: (i) basic product category, which the shoes are sold continuously, and (ii) seasonal product category which the shoes is only sold in one time in short period. ANN model is proposed to predict demand of both product categories. The model is extended model of Caglayan et al. (2020). Daily sales data for 15 months are used in this study.

Demand prediction is detailed to each product's color quantity which this study aims at. The variables entering ANN are sales related data such as average daily air temperatures, each store's sales of shoes, special days, the percentage of discount (Caglayan et al. 2020); demography related data such as income, percentage of Indonesian expense for fashion product, e-commerce user trend, and number of population at store's city; and product related data such as articles similar with the new product, style, and material used in a product. Input variables include numeric, binary, and nominal data, explained in Table 1.

Table 1. Variables information

Variables	Scale	Data References
Temperature	Numeric	Indonesia meteorology, climatology, and geophysical agency
Special Days	Binary	Sales data
Sales of stores	Numeric	
Store location	Nominal	
Discount percentage	Numeric	
Price per unit	Numeric	
Article	Nominal	
Income	Numeric	Indonesia central bureau of statistics
Percentage of Indonesian expense for fashion product	Numeric	
Population	Numeric	
Style	Nominal	Brand product data
Material (upper and outsole)	Nominal	
E-commerce users trend	Numeric	Statista

All input and output data is being normalized by applying min-max normalization, range of normalized data is [0,1]. Next step is to train input data using nntool, a MATLAB toolbox for neural network, with feed-forward backpropagation technique and Levenberg-Marquadt training function. The training takes only 70% of the input data and the rest are kept for testing the training network. ANN architecture is found by conducting many trials to reach the best performance in terms of MSE. The architecture consists of two layers, fourteen input neurons, twenty-eight hidden neurons, sigmoid activation and logsig transfer function which the best network design. For basic product category, the result is presented in **Figure 1**, while for seasonal product category is presented in **Figure 3.**

Demand prediction for basic product category shows a promising result. MSE of ANN model for this category is 0.0011035 and R value above 0.85. For each product variance, ANN model can predict demand accurately. After returning the normalization value to its real value, prediction value of the product can be obtained. A basic product category demand prediction for 15 months is presented in **Figure 2**.
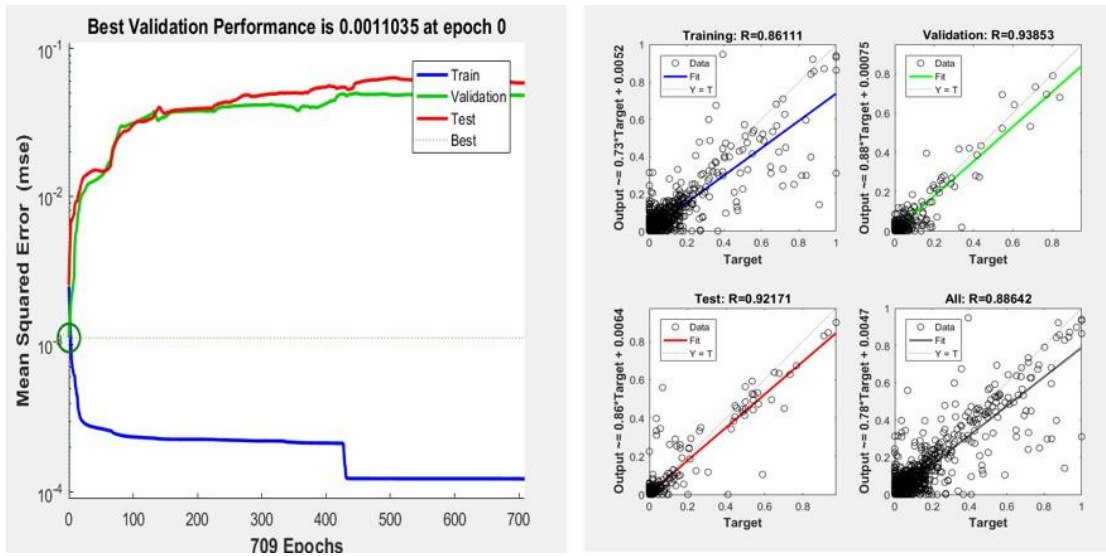
Figure 1. Performance and regression plot of ANN model for basic product category
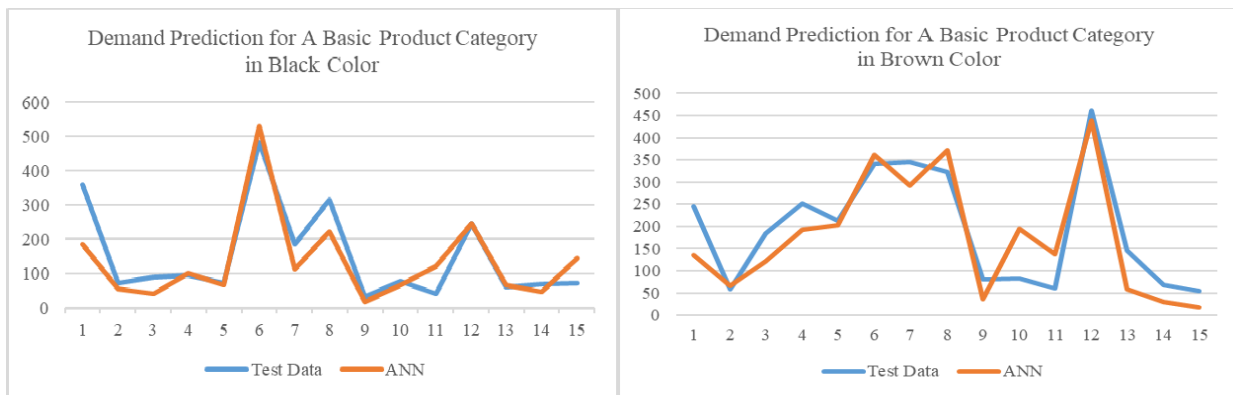

Figure 2. Demand prediction result for basic product category

Demand prediction for seasonal product category shows a good result eventhough not as accurate as basic product category. MSE of ANN model for this category is 0.00075424 and R value shows fitness around 0.7. A seasonal product category demand prediction for a life cycle (10 months) is presented in **Figure 4**.
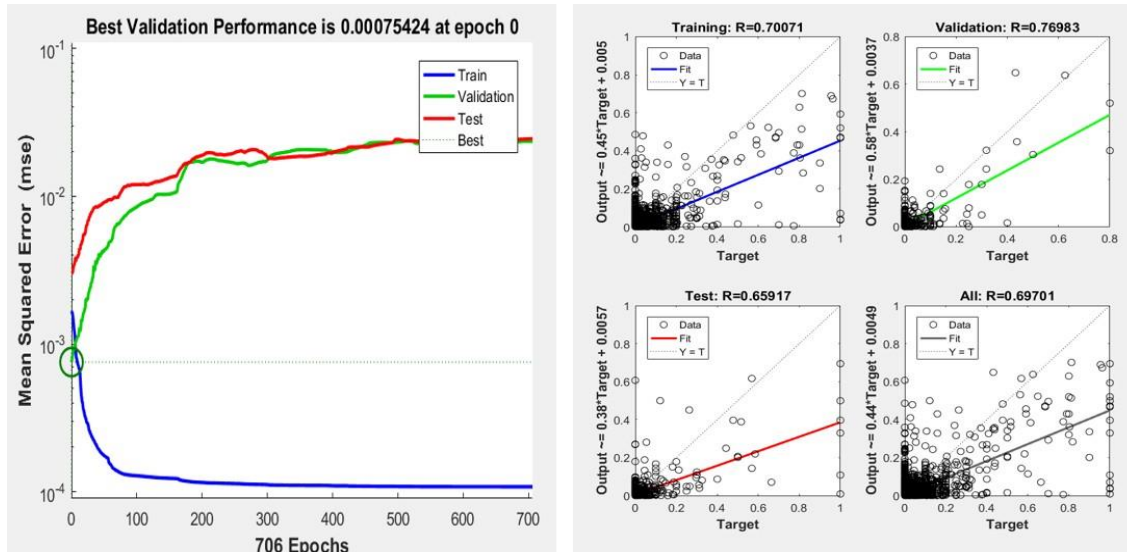
Figure 3. Performance and regression plot of ANN model for seasonal product category
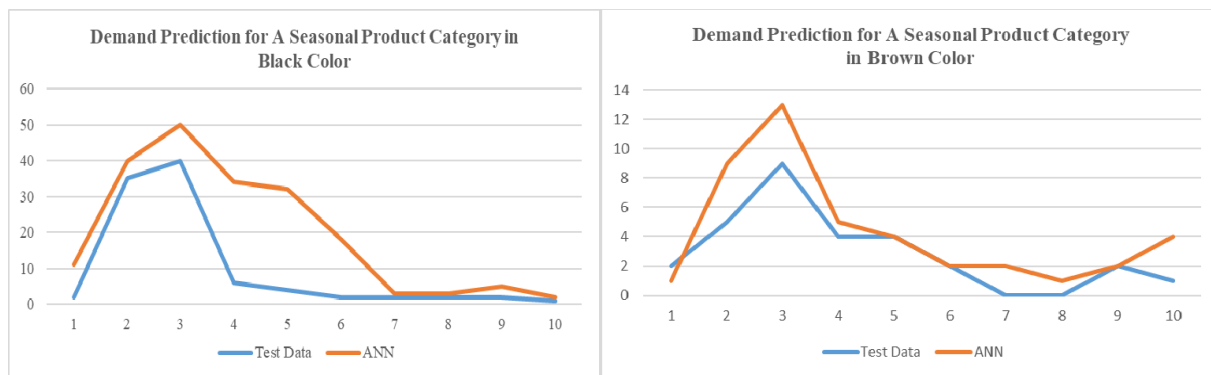

Figure 4. Demand prediction result for seasonal product category

4. CONCLUSSION

Demand prediction in this study is conducted by ANN based on real data of a local fashion brand company in Indonesia. One of this study's objective is determining predictor variables to develop ANN model which can give a promising result for demand prediction. Unlike other demand prediction in fashion industry, which aim to predict total sales of a product, we tried to make a detailed demand prediction considering color variance of the product. ANN model shows a promising result especially for basic product category which shows high accuracy. However, for other category the model is less accurate to predict the quantity of demand. Further research will be directed into model development of one-time product and how to integrate demand prediction model with other planning activities in e-commerce based supply chain.

5. ACKNOWLEDGEMENT

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