식품 소매 수요 예측에 대한 연구: 날씨와 기후의 영향

An Empirical Study on Food-Retail Demand Forecasting: The Impact of Weather and Climate

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Abstract

Accurate demand forecasting in the food-retail industry is an important task since it can reduce costs caused by shortage or overflow of food materials. In this study, we present a deep learning-based method for demand prediction in the food-retail sector using a long short-term memory (LSTM) model while aiming at examining the impact of weather and climate variables on demand forecasting. Using a café point-of-sale (POS) dataset, we investigate which variables help improve the predictive performance.

I. Introduction

In the food-retail industry, demand forecasting is crucial since accurate forecasts can reduce costs by reducing wasted materials and prevent shortage of ingredients. With the recent increasing attempts to predict demands, we aim to solve this problem by adopting deep learning-based models. Due to the fact that weather is known to have a significant impact on the food retail, especially beverage sales [1], we analyze the impact of weather and climate variables on demand forecasting.

II. Dataset and Model Description

A. Data Description

We use the "Christmas Bean" point-of-sale (POS) dataset collected from August 3, 2018 to March 31, 2021. In the dataset, we select the following three most popular menus for demand forecasting: Ice-Americano (Dataset #1), Hot-Americano (Dataset #2), and Ice-Caffelatte (Dataset #3). In order to reduce the noise such as daily variances driven by potential events in the prediction, we convert the existing daily data into the weekly one by summing up weekday sales records. We also obtain the weather and climate data in Seoul collected from the Korea Meteorological Administration, which are converted to weekly data as well. The weather-relevant dataset consists of the following fields: temperature, precipitation, humidity, daylight hours (i.e., the time of sunrise to sunset). We split each dataset in chronological order into training/test sets with 80/20%.

B. Baseline and Proposed Models

We adopt the long short-term memory (LSTM) model [2], which would be appropriate in solving our demand forecasting problem since sales data are time series. We use a simple LSTM model consisting of a LSTM layer and a dense layer as the baseline. To see the impact of weather and climate variables on the performance, we present several new models in which sales data pass through the LSTM layer and the weather-relevant data separately pass through the embedding layer. The output of the two layers is combined in the concatenation layer and then passes through the dense layer to return a prediction value.

III. Experimental results

To evaluate the performance of our models, we use the root mean square error (RMSE) as a metric, which is defined as $\sqrt{\frac{1}{n}\sum_{t=1}^{n}(y_t-\hat{y}_t)^2}$. Here, y_t and $\hat{y}_t$ are the actual and predict values of the sales, respectively, at time t.

Table 1. Performance comparison of several models

	Dataset #1	Dataset #2	Dataset #3
Baseline	44.54	21.01	19.32
Proposed	39.64	19.34	16.67
Proposed–temperature	42.33	20.99	18.77
Proposed–precipitation	41.30	18.86	16.75
Proposed–humidity	39.45	20.60	15.73
Proposed–daylight hours	43.51	20.63	19.03

Table 1 shows the RMSE of 6 models for three datasets. The proposed model leverages all given weather-relevant variables. "Proposed– X" indicates the proposed model in which a field X is excluded. Our empirical findings include that 1) the proposed model using weather-relevant variables is indeed beneficial in better predicting the demand, 2) the RMSE increases when the temperature was excluded, which means that the temperature is vital information on prediction, and 3) the RMSE decreases when the humidity was excluded, which implies that this variable is not conducive to prediction.

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REFERENCES

[1] I. Štulec, "Effectiveness of weather derivatives as a risk management tool in food retail: The case of Croatia," *Int. J. Financial Stud.*, vol. 5, pp. 1-15, Jan. 2017.

[2] S. Hochreiter and J. Schmidhuber, "Long short-term memory," *Neural Computation*, vol. 9, no. 8, pp.1735-1780, Nov. 1997.