Predicting Demand for Catering Lunchboxes Using Machine Learning to Respond to Rapid Changes in Bento Sales

Yasunori Iwata, Kazuki Ota and Hideki Katagiri
Department of Industrial Engineering and Management,
Graduate School of Engineering and Faculty of Engineering
Kanagawa University
Kanagawa, Japan
r202270086xs@jindai.jp, r202170199fz@jindai.jp, katagiri@kanagawa-u.ac.jp

Abstract

Bento is widely known as a part of Japanese food culture. There are many companies in Japan that produce and sell thousands of boxed lunches every day. Bento companies have multiple menus. In this study, we focus on the catering lunchbox industry, which handles everything from the production of lunchboxes to their delivery.

The catering lunchbox industry needs a demand forecasting model that accurately predicts. Catering companies produce and sell boxed lunches every day. The sales data of catered lunches are time-series data. The number of boxed lunches sold fluctuates daily depending on customer schedules and the day of the week. It is difficult to accurately forecast the demand for catered lunches. On the other hand, if demand forecasting is not done accurately, a large amount of food loss will occur. Creating a demand forecasting model that accurately predicts can reduce food loss.

In a study of demand forecasting for boxed lunches, the model's forecasting accuracy becomes worse during periods of rapid changes in the number of boxed lunches sold. The machine learning model used in previous studies cannot respond unless there have been similar rapid changes in the number of boxed lunches sold in the past. This study aims to improve the accuracy of forecasts during periods of rapid changes in the number of boxed lunches sold.

The phenomenon in which the data distribution changes over time is commonly referred to as concept drift. Concept drift has been extensively studied. Four types of concept drift exist. This study analyzes two of the four types. The first type is "A new concept occurs within a short time". The second type is "An old concept may reoccur after some time".

This study establishes criteria for detecting sudden changes in the number of boxed lunches sold. In addition, we propose a demand forecasting model with high forecasting accuracy even after changes. Two criteria were established for detecting sudden changes in the number of lunches sold. The first criterion is "Number of consecutive days of rapid changes in the number of boxed lunches sold". The second criterion is "Number of types of lunchboxes". The post-change demand forecasting model emphasizes the most recent information to make forecasts. The most recent information available is important to respond quickly to rapid changes.

Numerical experiments using real data showed that the proposed model improved prediction accuracy compared to the conventional model. The usefulness of the proposed model was demonstrated. The usefulness of the proposed criteria for detecting sudden changes in the number of boxed lunches sold was also demonstrated.

Keywords
Bento, Demand forecast, Time-series data, Machine learning and Concept drift.

Biographies
Yasunori Iwata is with Department of Industrial Engineering and Management, Graduate School of Engineering, Kanagawa University. He research involves predicting demand for catering lunchboxes using machine learning. He entered Kanagawa University in 2018 and joined the Management Systems and Engineering Laboratory in 2020. After He received his undergraduate degree in Industrial Engineering and Management in 2022, He entered the graduate

school of Kanagawa University. His presentation was given at the Mathematical Systems Academic Conference FY 2021 held online on February 10, 2022, and he received the "NTT Data Mathematical Systems Student Research Encouragement Award, Honorable Mention, 2021".

Kazuki Ota is with Department of Industrial Engineering and Management, Graduate School of Engineering, Kanagawa University. He entered Kanagawa University in 2015 and joined the Management Systems and Engineering Laboratory in 2017. After he received his undergraduate degree in Industrial Engineering and Management in 2019, he entered the graduate school of Kanagawa University. In March 2019, he received the Excellent Paper Presentation Award at the Electrical Society "Electronics, Information and Systems Division Study Group". This award is given to presenters under the age of 35 who presented outstanding papers at the Institute of Electrical Engineers of Japan "Electronics, Information and Systems Division Study Group" last year. Also, he received the "Best Student Paper Award" at the "International Conference on Machine Learning and Data Analysis 2019" held at the University of California, Berkeley in the United States. This award is given to outstanding papers from the viewpoint of uniqueness and importance from among student research presentations. He received his master's degree in Industrial Engineering and Management in 2021.

Hideki Katagiri is a Professor of Department of Industrial Engineering and Management at Kanagawa University, Japan. He earned his B.E., M.E. and Ph.D. in Engineering at Osaka University in 1995, 1997 and 2000, respectively. He was the Chair of IEEE SMC Hiroshima Section Chapter (2008-2010) and a Visiting Scholar at the University of Chicago Booth School of Business (2014-2015). He was a Visiting Professor of Hiroshima University (2016-2020). His research and teaching activities are in the areas of operations research and soft computing, especially, multi-objective optimization under uncertainty and data analysis using machine learning techniques. He is the author or co-author of more than 100 refereed journal papers and several co-authored or co-edited books in English.