

# **An Automatic Menu Creation Model for School Lunch Based on Mathematical Optimization Considering the Frequency of Dishes and Ingredients**

**Himawari Takeuchi**

Department of Industrial Engineering and Management,  
Graduate School of Engineering  
Kanagawa University  
Kanagawa, Japan  
[r202270137cl@jindai.jp](mailto:r202270137cl@jindai.jp)

**Hideki Katagiri**

Department of Industrial Engineering and Management,  
Faculty of Engineering  
Kanagawa University  
Kanagawa, Japan  
[katagiri@kanagawa-u.ac.jp](mailto:katagiri@kanagawa-u.ac.jp)

## **Abstract**

According to a survey conducted by the Ministry of Education, Culture, Sports, Science and Technology, school lunch is provided in approximately 98.5% of public elementary schools in Japan. Each region has different rules regarding the kinds of dishes and ingredients provided in school lunch menus and the frequency of serving dishes and ingredients. It is time-consuming and labor-intensive for menu planners to prepare menus when manually adapting them to the actual conditions of each region. As a result, the workload of menu planners and nutrition teachers is high. In the field of school lunch menu planning, the menu planning systems are needed to support nutrition teachers. The menu creation process is time-consuming and labor-intensive because there are many constraints to be taken into account, such as nutritional intake standards, ingredient costs, and cooking time. In Japan, the intake of 13 nutrients is determined according to the School Meal Intake Standards established by the Ministry of Education, Culture, Sports, Science and Technology. Therefore, when preparing menus, it is necessary to keep within the upper and lower limits of the standard's intake. Numerous studies have been conducted on automatic menu planning systems for school lunch programs. For example, some studies have been conducted on budgets and coloring of dishes, as well as studies that focus on the diversity of ingredients and flavors by calculating the similarity between dishes or ingredients. All of these studies have been formulated as combinatorial optimization problems and have proposed automatic menu creation models. However, it takes a lot of time and effort to reflect the actual situation of each region in the automatic menu creation model. In these previous studies, the engineers who proposed the menu planning model interviewed nutrition teachers who work in the menu development field many times. After the interviews, they manually modify the proposed model based on the feedback they received. Specifically, they manually calculate the frequency of serving dishes and ingredients and generate constraints. They have done this work many times to improve the automatic menu creation model. In this study, we propose an automatic menu creation model for school lunch that automatically reflects the actual conditions of each region regarding the frequency of serving dishes and ingredients. We aim to propose a menu creation model that can be used in school lunch programs in elementary and junior high schools throughout Japan. First, morphological analysis is used to segment the dishes and ingredients in the daily menu into meaningful words such as nouns and adjectives, and to automatically calculate the frequency of serving the dishes and ingredients during a month. Next, we use the results of the calculation to construct an algorithm that automatically adds constraints to the mathematical optimization problem. As a result of the analysis using actual data from school lunch menus, we succeeded in automatically calculating the frequency of serving dishes and ingredients, and generating an algorithm for automatically adding constraints.

## **Keywords**

School lunch menu planning, Mathematical optimization, Frequency of serving ingredients and dishes, Algorithm for automatically adding constraints, Morphological analysis

## **Biographies**

**Himawari Takeuchi** is with Department of Industrial Engineering and Management, Graduate School of Engineering, Kanagawa University. Her research involves school lunch menus based on combinatorial optimization. She entered Kanagawa University in 2018 and joined the Management Systems and Engineering Laboratory in 2020. After she received her undergraduate degree in Industrial Engineering and Management in 2022, she entered the graduate school of Kanagawa University. Her presentation was given at the Mathematical Systems Academic Conference FY 2021 held online on February 10, 2021, and she received the "NTT Data Mathematical Systems Student Research Encouragement Award, Honorable Mention, 2021". Also, she received the "Student Research Presentation Excellence Award" at the 69th National Research and Presentation Conference of the Japan Association for Management Systems held at Kushiro Public University in Hokkaido on October 2, 2022.

**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.