A Next-Generation Recipe Recommendation System for Health and Environment

Ryo Mikami, Hiromi Nakano, Kiyoshi Dowaki, and Hayato Ohwada

***Abstract*—In recent years, recipe search sites have proliferated with the spread of the Internet and the smartphone. Many recipes are available on the Web. In addition, today's Japan is experiencing problems such as aging and the increase in persons suffering from lifestyle-related disease due to westernization of their eating habits. It is often necessary for them to manage their eating habits. For home-bound aging and living alone, having to think about a menu every day is a major burden.**

At the same time, as the carbon dioxide emission of the whole world increases year by year, significant action on carbon dioxide reduction is underway in Japan. For example, there is a Carbon Foot Print (CFP) on which the Ministry of Agriculture, Forestry and Fisheries works.

This study seeks to support menu management and the construction of a system which is conscious of the carbon dioxide emission associated with a given meal. It uses recipes on the Web and prepares a recommended menu. We propose a system that displays the carbon dioxide emission of each menu. Finally, we had subjects use this system and determined the effectiveness of this study by performing a user evaluation.

***Index Terms*—Menu recommendation system, recipe search sites, Carbon Foot Print, carbon dioxide emission.**

I. Introduction

In recent years, recipe search sites have increased with the spread of the Internet and smartphones in Japan. Various recipe search sites exist on the Web, including "Cook pad" and "the recipes of Bob and Angie". Moreover, people pay more attention to meals with the recent increase in the aged population in Japan. Therefore, we thought about a system of menu recommendations that could answer various demands. However, many search results on recipe search sites are individual. In previous studies of menu recommendation, many systems recommend only one meal [1], [2]. In addition, a system performing medium- and long-term menu recommendations was proposed [3], but there is little choice in the kind of menu to recommend, and the characteristics of a menu the user requests is typically not retained by the system for the optional medium and long term.

Actions are being taken to resolve environmental problems including global warming, but the carbon footprint continues to increase. The Ministry of Agriculture, Forestry and Fisheries conducts the Carbon Foot Print Program as one strategy for carbon footprint reduction, but it is very important to display a numerical value to indicate carbon footprint reduction [4].

Therefore, this study suggests a system in which a user opts for the medium- and long-term characteristics of the recommended menu. Furthermore, the user is targeted by constructing a menu recommendation system that considers environmental problems by displaying a carbon footprint both with the basic information about the dish and with the dish itself when we recommend a menu considering current social movements.

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Ryo Mikami, Hiromi Nakano, Kiyoshi Dowaki, and Hayato Ohwada are with the Department of Industrial Administration, Faculty of Science and Technology, Tokyo University of Science, Japan (e-mail: j7413613@ed.tus.ac.jp, {dowaki, ohwada }@rs.tus.ac.jp).

II. Proposed System

This system recommends a menu created using recipe data from recipe search sites. A one-meal menu consists of a main dish, a side dish, and soup. We set the caloric balance of breakfast, lunch and dinner to 3:3:4. The same dish is offered once every two weeks. Moreover, this system is available on a browser. It displays a calendar and indicates its recommendations on the calendar.

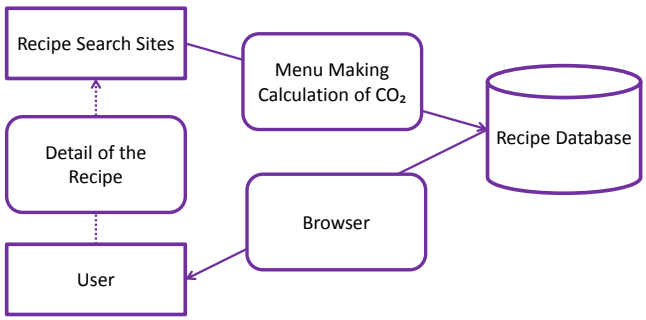

Fig. 1. System summary.

Fig. 1 summarizes the system. First, we obtain the data necessary for menu recommendation from recipe search sites. For example, we acquire recipe data from "the recipes of Bob and Angie" using this system. Second, we create a menu based on the obtained data. The system calculates the quantity of carbon dioxide emission for every menu at the same time. We add the carbon dioxide information to the recipe information and store it in a database. Third, the users create accounts for using this system. Finally, the system makes its recommendations using a calendar on the browser and recommends a menu from the account information provided by the user. The user can confirm the details of each menu through links on the calendar. The detail pages display information such as the number of calories, how to make the dish, and the carbon dioxide emission.

A. Extraction of the Recipe Data

This system extracts recipe data from "the recipes of Bob and Angie", a recipe search site.

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B. Calculating Carbon Dioxide Emission

Carbon dioxide emissions are divided into two stages, the production of ingredients and cooking, and the system calculates the total value automatically.

The calculation of the carbon dioxide emission of the production of ingredients stage uses the "food related materials CO2 emission coefficient database" [5] (Fig. 2). This correspond 3EID (Embodied Energy and Emission Intensity Data for Japan Using Input-Output Tables) [6] of the version in 2000, 1995 and 1900. 3EID is a database from which one can determine the carbon dioxide emission by multiplying the purchased amount by the carbon dioxide emission basic unit per 1 million yen.

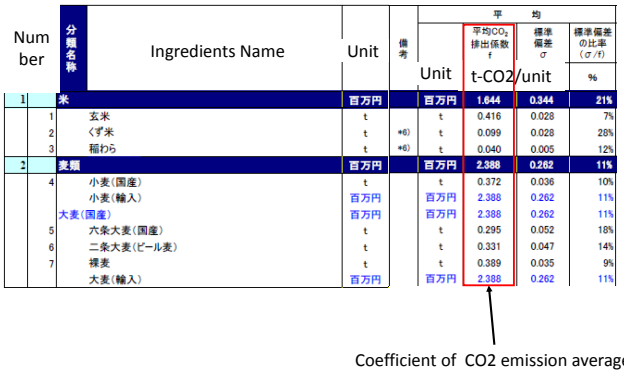

Fig. 2. Food-related materials CO2 emission coefficient database.

The carbon dioxide emission of the cooking stage is calculated based on the energy consumption of the cooking. Theoretically, the energy consumption equals the amount of energy necessary for specific temperature rises in the ingredients. These are not equal to the heat loss with a kitchen utensil. Therefore, we calculate the thermal efficiency of the kitchen utensil to find the energy consumption. We calculate the carbon dioxide emission during cooking by multiplying carbon dioxide emissions coefficient on it (1).

Cooking carbon dioxide emission

= energy consumption * CO2 emission coefficient (1)

The energy consumption is calculated by the following formula.

$$\text{energy comsumption} = \frac{\text{Energy requirement EN}}{\text{Themal efficiency of kitchen utensil } \eta} \quad (2)$$

C. Menu Recommendation

We believe that we can satisfy the demands of more users with this system because each user can choose the menu characteristics. Therefore, we set up the following four menu types that are important for menu management in Japan today, and the user chooses from these.

1) Menu for the aged

The aged menu assumes 1800kcal a day. It doesn't seek to minimize salt but rather seeks to achieve meal enjoyment.

2) Menu for the healthy

The appropriate daily caloric intake for a Japanese adult is 2200kcal for men and 2000kcal for women. However, if you take in extra calories, you find yourself in ill health and gaining weight. Therefore the system recommends a menu assuming a caloric intake of 2000kcal for men and 1800kcal for women.

3) Low-salt menu

The Japanese Ministry of Health, Labour and Welfare specifies the optimum daily salt intake for an average adult to be under 10g, or under 6g for those with high blood pressure. Therefore, we recommend a menu with a daily salt intake of 6g.

4) Balanced menu

This menu is for people who are not dieting. We use an index called the "protein, fat, carbohydrate (PFC) balance" to determine nourishment balance. We recommend a menu that fulfills this PFC balance and does not exceed the maximum caloric intake.

D. Making a Menu

We make each menu based on the nutrients specified in the recipe data that we extracted from the recipe search site using the following procedure.

1) Determine the main dish.
2) Select a sub-dish and soup fulfilling the conditions of the given menu type. The system creates a menu that is unified, based on the main dish.
3) Check whether the conditions for each menu are met and that the same recipe has not been included within the last two weeks. A user will get tired of the same menu every day. Therefore the system does an overlap determination, such that the same dish is not recommended for two weeks. If an overlap is seen, return to step 1.
4) Add the menu to the database if the determination in step 3 is satisfied.
5) Repeat steps 1 through 4 for two weeks. This system makes menus for two weeks in advance.

E. PFC Balance

To optimize the nourishment balance of the menu, this system uses as index called the PFC balance. The PFC balance is the ratio of the energy of the three major nutrients included in the meal: proteins, fats, and carbohydrates. Protein per gram is equivalent to 4kcal, fat per gram is equivalent to 9kcal, and carbohydrates per gram is equivalent to 4kcal. The energy derived from each of the three major nutrients determines the amount of energy in the gross weight of the meal (Table I).

One can evaluate whether the three major nutrients are in proper balance by looking at the PFC balance of the meal. A suitable ratio for the PFC balance is roughly P = 9-20%, F = 20-25%, and C = 50-70%. Therefore the balance was set with the ideal caloric intake in mind, resulting in a ratio of P:F:C=15:25:60 in this study.

TABLE I: CALCULATING THE PFC BALANCE

P	Protein(%)=Protein(g)*4(kcal/g)/total energy(kcal)*100
F	Fats(%)=Fats(g)*9(kcal/g)/total energy(kcal)*100
C	Carbohydrate (%)= Carbohydrate(g)*4(kcal/g)/total energy(kcal)*100

III. Operating Result

A. Extraction of Data

The data extraction used Java code that acquires the recipe page, loads the source text, and extracts the necessary information from the source text. The system currently loads 10,000 recipes.

B. Operating Example

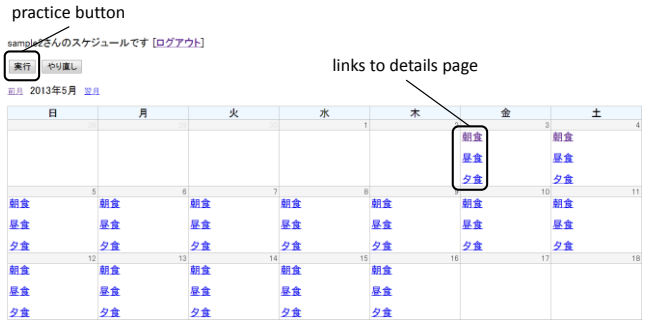

Fig. 3. Practice screen for the system example.

The practice screen for this system is presented in Fig. 3. A calendar such as that in Fig. 3 is displayed when one first accesses the system. The recommended menu for the next two weeks is obtained by clicking the practice button located in the top right corner of the page. For the day on which the menu is recommended, the links for all three meals are displayed. In addition, links that haven't been recommended are not displayed on the calendar: for example Fig. 3.

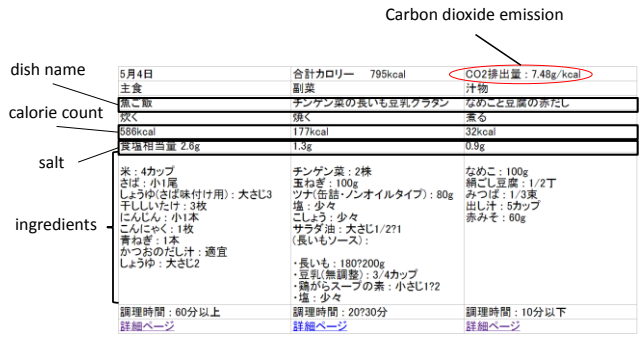

Fig. 4. Menu details page.

One can obtain detailed menu information by accessing its link. The details page displays the dish name, the recipe, the calorie count, the recommended amount, the ingredients, the rough time required, and a link to the recipe search site (Fig. 4). The total calories and carbon dioxide emissions are displayed near the name of the dish. In addition, one can confirm the detailed information using the recipe search site by accessing the link to the details page.

IV. Assessment

A. Assessment Method

We asked people to use this system and assessed its effectiveness by means of a survey. For each subject, we have an answer profile, the satisfaction score, the frequency of use, good and bad points, and whether they would continue using the system (Table II). The subjects assigned point scores, with 5 being the highest and 1 the lowest, in response to the questions involving satisfaction and whether they would continue. In addition, we assigned numbers to the good and bad points (Tables III and IV).

B. Assessment Results and Considerations

Seven subjects, four students and three housewives, used this system for a week and answered a questionnaire afterward. The questionnaire results are listed in Table V.

TABLE II: Questions

question number	QUESTION
1	Please choose your sex
2	Please choose the nearest thing as your job
3	Please choose the thing which is near to your eating habis(multiple answer OK)
4	When you usually think about menus, do you use the Internet?
5_1	Whether when you usually think about menus,you can care?
5_2	(only the person who answered "yes" by Q5)What kind of dou you care about?
6	How was you able to use this system?
7	Do you satisfy with this system?
8	What is the good point of this system?
9	What is the bad point of this system?
10	Would you like to use this system in future?
11	Free comment

TABLE III: Good Points of This System

number	answer
1	Become easy to think about a menu
2	There is the menu which matched oneself
3	Can look back on one's eating habits
4	Coma to think about enviroment even a little
5	It's easy to use

TABLE IV: Bad Points of This System

number	answer
1	Didn't intend to cook recommended menu
2	Recommended menu doesn't match oneself
3	Menu is monotonous, and there are few kind of the recipe
4	Don't understand notation of CO2
5	It's complicated and hard to use

TABLE V: Questionnaire Results

number	1	2	3	4
1	M	M	M	F
2	student	student	student	student
3	own cooking、restaurant	own cooking、restaurant	restaurant	own cooking、restaurant
4	once a mounth	nothing	nothing	once a week
5	no	no	no	yes
6				calorie
7	sometime	sometime	nothing	everyday
8	4	3	2	4
9	1,4,5	1,3,5		1,2,3,4,5
10	1,2	2,4	1,2,4	
11	3	3	1	4

TABLE VI: Average Satisfaction and Whether the Subject Would Continue, Categorized

distinction		satisfaction	whether it continue
total	average	3.57	3.14
sex	M	3.00	2.33
	F	4.00	3.75
eating habits	own cooki	3.83	3.50
	others	3.20	2.60
jobs	student	3.25	2.75
	housewife	4.00	3.67

In the results, the average satisfaction among users of this system was 3.57, and the average of whether they would continue was 3.14. We classify the data according to category for these two assessments and present the result in Table VI. Table VI indicates that the average of housewives and the "own cooking" group was higher than that of the overall group. Users seem to consider planning an everyday menu to be a burden. Therefore, they evaluated the system as a way to reduce this burden.

TABLE VII: Results of Good Points

number	answer	number of subjects	rate
1	Become easy to think about a menu	5	71%
2	There is the menu which matched oneself	2	29%
3	Can look back on one's eating habits	4	57%
4	Coma to think about enviroment even a little	3	43%
5	It's easy to use	5	71%

TABLE VIII: Results of Bad Points

number	answer	number of subjects	rate
1	Didn't intend to cook recommended menu	3	43%
2	Recommended menu doesn't match oneself	3	43%
3	Menu is monotonous, and there are few kind of the recipe	0	0%
4	Don't understand notation of CO2	4	57%
5	It's complicated and hard to use	1	14%

Tables VII and VIII present the questionnaire results for the good and bad points. The two best good points are "Becomes easy to plan a menu" and "It's easy to use". The system thus reduced the burden of creating a menu. The most common bad point was "Don't understand notation of CO2". This system displays the carbon dioxide emission, but it seems difficult to recognize the values. In addition, three subjects responded "Didn't intend to cook the recommended menu" and "Recommended menu is unsuitable for me". The subjects who responded "Don't intend to cook recommended menu" tend to live alone and do not always cook their own meals. Even if they cook their own meals, they avoid troublesome dishes. Regarding the answer that the recommended menu is personally unsuitable, the system recommends only four kinds of menus, and these may not satisfy the tastes of all users.

V. Conclusion

This study built a menu recommendation system for medium- and long-term use that acknowledges the importance of managing the menu. In addition, we propose a system that displays the carbon dioxide emissions generated when the dish was cooked.

In the future, we will think further about carbon dioxide emissions. We expect to consider improvements to the system that would choose a menu with a specified carbon dioxide emission and would utilize plainer notation for the carbon dioxide emission values. Furthermore, the system would gain more users by adding a function allowing it to manage a meal when eating out. We plan to improve the system to make it easier to use.

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Ryo Mikami is a master of Industrial Administration. He is from Tokyo University Science. His e-mail address is j7413613@ed.tus.ac.jp. He received Degree from Tokyo University of Science 2012.

Kiyoshi Dowaki is a professor of Tokyo University of Science. He was graduated from the graduate school of Waseda University in 1992. After that, he worked at New Energy and Industry Development Organization (NEDO, the governmental office) as personnel. Then, he enrolled the doctoral course of University of Tokyo and took the doctor degree of engineering in 2001. Also, he worked at University of Hawaii in US and Research Institute of Innovative Technology for the Earth (RITE). His topics are mainly related to the environmentally friendly technologies and/or their estimations.

Hayato Ohwada is a professor of Industrial Administration and director of Division of Next Generation Data Mining Technology, Tokyo University of Science. His e-mail is ohwada@rs.tus.ac.jp. He received Doctor Engineering from Tokyo University of Science 1988. He has been working on Machine Learning and Inductive Logic Programming.