A System to Help Creation of Original Recipes by Recommending Additional Foodstuffs and Reference Recipes

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Abstract - Recently, many people use online recipe sites when they cook. As recipe sites are rapidly increasing in number, even recipe sites that have over 1 million appear. When the number of recipes is large, it is difficult for users to find the recipe that meets their requirements. To solve this problem, several web sites provide useful search interfaces, and several academic studies present methods to use the database effectively. We can classify these studies into two approaches, i.e., search for, and create recipes. In the studies to search for recipes, although these methods recommend recipes to users considering various aspect of users' requirements, users have no choice but to compromise because the recipe database would not include the one that perfectly satisfy the users' requirements. On the other hand, the study to create recipes only begins recently. Currently, many of them propose to recommend foodstuffs to add to, or delete from a base recipe. So, users who are beginners in cooking cannot cook the recommended foodstuffs because they have no idea how to cook them. In this study, we propose a method and a system to help users create their own original recipes. Specifically, the system first provides users with information that helps them to add or delete foodstuffs with a base recipes to determine the set of foodstuffs used in their original recipes. Next, it provides reference recipes, which is the selected recipes retrieved from the database, to help users get useful ideas on how to cook the set of foodstuffs determined in the previous step. We evaluated the system through a test experiment, and confirmed the effectiveness of the proposed system in creating users' own original recipes.

Keywords: Cooking, Recipes, Recommending Foodstuffs, Reference Recipes

1 INTRODUCTION

Recently, as reference materials for cooking, many recipe sites (see Table 1) have provided various recipes in the Internet, and are populated instead of the traditionally used materials such as books, magazines, and TV programs on cooking. Having grown rapidly, these recipe sites include a significant number of cooking recipes. For example, Cookpad [1], one of the most famous Japanese recipe sites, includes more than 1 million cooking recipes. However, among these tremendous number of recipes, it is difficult to find recipes for people that meet their requirements. To solve the difficulty, not only the recipe sites prepare keyword or categorical search in their sites, but also many academic studies have been performed that tries to enrich users' experiments to satisfy users' requirements [6]. These studies are classified to two approaches: one is to "search" recipes, and the other is to "create" recipes.

Table 1: Recipe Databases

Site name	# of recipes	URL
Cookpad [1]	140 million	http://cookpad.com/
CDkitchen [2]	120 thousands	http://www.cdkitchen.com/
RecipeSource [3]	70 thousands	http://www.recipesource.com/
All recipes [4]	50 thousands	http://allrecipes.com/
E-recipe [5]	20 thousands	http://erecipe.woman.excite.co.jp/

The approach that "search" recipes typically computes the similarities between recipes from various aspects to find or recommend recipes that is likely to meet users' requirements. This approach enables us to retrieve recipes according to a common characteristics between recipes that reflect requirements or testes of users. However, these methods only search for recipes from a limited set of recipes in a database so that users will possibly find recipes that nearly meets their requirements, but cannot do the perfect one that completely satisfies their requirements.

On the other hand, the approach that "create" recipes is potentially able to retrieve the perfect recipes that meets the requirements, although they needs higher level techniques. Towards this goal, several proposals are presented that help users create their own recipes by modifying existing cooking recipes. For example, there is a study that recommends foodstuffs that are likely to be added/deleted in a recipe easily [10]. However, because they do not support to design the operational steps to cook dishes using the modified set of foodstuffs, it is difficult for many beginners to complete the original recipes, i.e., they do not know how to cook the modified foodstuffs. We have to help constructing the operational steps of cooking in their original recipes.

In this paper, we present a method and a system that not only recommend foodstuffs that can be added/deleted in a recipe, but also present information to help users constructing the operatinal steps of their own original recipes. Specifically, in recommending foodstuffs, we display several sorts of supporting information that indicates the foodstuffs likely to be added/deleted in the base recipe from several aspects. In helping operational-steps design, we present reference recipes that includes the operation steps to cook the added foodstuffs in combination with the other foodstuffs in the base recipe. With these two functions, we help users create their own original recipes.

The remainder of this paper is organized as follows: In Section 2, we present the related work. In Section 3, we present the design of our system to help users create their own original recipes, and in Section 4 we give the algorithms and formula

that underlie in our system. We evaluated the effectiveness of our study in Section 5, and finally we conclude the work in Section 6.

2 RELATED WORK

2.1 The Current State on Recipe Sites

In the last decade, people have become to use recipe sites as materials to refer cooking recipes, in addition to books, magazines, and TV programs. These web sites are strongly supported not only by young people but also by middle-aged people, mainly because (1) they are free to access, (2) they include significant number of recipes, and (3) they are available at all time.

In Febrary 2009, iShare Coorporation surveyed the media to refer when people cook in Japan [7]. 274 people answered for it, in which 53.3% is men and 46.7% is women, including 11.6% of twenties, 46.3% of thirties, 31.6% of fourties, and 10.5% of others. The result shows that people use recipe web sites the most when they cook. Specifically, 58.8% of men and more than half of the twenties and fourties (men and women) answered to use web sites the most among other media.

The most outstanding reason that people refer to these recipe sites is the number of recipes available in these site, which is far larger than those of books or magazines. In general, users has various and sensitive requirements for recipes such as likes and dislikes of foodstuffs, allergies, foodstuffs stored in refrigerater (so they want use them), etc. To find recipes that satisfy these sensitive requirements, recipe sites where a vast number of recipes are stored are convenient.

In the recipe sites, almost all sites provide keyword-search function, with which users try to search for recipes that meet their sensitive requirements. Keyword search alone, however, hardly enables users to find the best recipe that meets users' requirements, since the number of search results is also large in proportion to the total number of recipes. For example, if we search for recipes with two keywords "potatoes" and "gratin" in a major recipe site "cookpad," in which 1.4 million recipes are stored in it, we will have about 4,000 recipes retrieved from the database. Consider that an user checks the results one by one to find recipes that satisfy his/her own requirements the most. It is hard and laborious to find suitable recipes with keyword search alone.

Many sites provide further functions to help users to find suitable recipes effectively. Specifically, many sites provides a function that narrow the search space using several properties such as objective (e.g., for health, for beauty, for body building), categories (e.g., main course, soup), cooking time, and cooking methods. Each sites provides various original filters to help searching. As shown above, user interfaces to support efficient recipe searching have been developed with significant care.

It is, however, still hard to find recipes that completely satisfies users' sensitive requirements, as long as we tries searching for recipes from a limited set of recipes. Customising recipes is essential to achieve higher level recipe searvices on the web.

2.2 Related Work

Studies that target recipe data are roughly classified into two categories: studies that search for recipes, and those create recipes. In this section, we describe the state of the art of these two categories of studies.

Among the studies that search for recipes, we introduce several searching methods based on foodstuffs, as the related work with this paper. Ueda et al. [8] proposed a method to recommend recipes that considers likes and dislikes of users. Their method recommends recipes based on the frequency of foodstuffs appearing in an user's cooking history. Iwagami et al. [9] proposed a method to recommend recipes that also considers likes and dislikes of users. Their method first acquires foodstuffs that the user likes to use from the history of recipes users refer in the system, and second computes scores of recipes according to the acquired information of each foodstuff. These two proposals to recommend recipes help efficient searching for recipes that considers users' tastes, by utilizing additional data that include the history of recipes referred in the system.

On the other hand, the approach that creates recipes is still in the stage of beginning. We can only introduce several studies that treat addition and deletion of foodstuffs in a recipe. Shidochi et al. [10] proposed a method that suggests foodstuffs to add to the base recipe. Their method is based on a typical pattern of cooking steps in each sort of dishes; they suggest an alternative foodstuff that can be used in each operational step of cooking, under the assumption that the sort of dishes and so the typical pattern in cooking is given. Tsukuda et al. [11] also proposed a method to suggest foodstuffs to add to, or delete from the input recipe, based on the conbination of foodstuffs included in the set of recipes in the database. They compute the stability of a combinations of foodstuffs from the frequency of combinations that appear in the recipes in the database. Based on this stability scores, their method suggest a foodstuff to add that increases the stability of the set of foodstuffs. Although these studies suggest foodstuffs to add to, or delete from the input recipe, they do not consider the operational steps of cooking in the newly created original recipes. Thus, unless the users are accustomed to cook, it would be difficult to complete the recipe with the new set of foodstuffs by determining the operational steps to complete their original recipes.

3 SYSTEM DESIGN

3.1 Requirements

As users of the proposed system, we suppose people who are not so accustomed to cooking that they cannot modify recipes by themselves, although they can cook by pursuing a recipe that includes full description of operational steps. In fact, this kind of people frequently refers recipe sites when they try cooking. However, as mentioned in the previous section, it is laborious for them to search for suitable recipes that meets their sensitive requirements.

In this case, many people will come to the idea to modify the existing recipes to meet their own requirements. We de-

signed our system to be useful in this case. In the case, users first try to select a base recipe, and try to change foodstuffs to meet the requirements they have. Users then find a problem that they do not know which foodstuff is suitable to add/delete in combination with other foodstuffs in the base recipe. To help users on this point is the first task for us to perform.

When a set of foodstuffs is determined, users next try to decide how to cook them. However, because the cooking operations are different among foodstuffs (i.e., imagine that some foodstuffs such as fish require special handling or preliminary operations, or even for basic foodstuffs, cutting size may be different for each foodstuff), it is hard to find the appropreate operation steps for the modified set of foodstuffs. To help users on this point is the second task for us to perform.

In this paper, we design an information system that helps users on these two points, so that users can create their original recipes by modifying the base recipe to meet their sensitive requirements, using helpful informations suggested by the system.

3.2 Functional Design

We designed a system that provides valuable information for users to help them in the two troublesome situations in creating recipes, i.e., (i) the first is the situation where users select foodstuffs to add/delete, and (ii) the second is the one where users decide cooking operations over the selected set of foodstuffs. In this section, we describe a basic design of the functions in our system for these two target situations.

We first describe the functions to support users selecting foodstuffs to add/delete. When people cook, they easily think of several requirements such as: "I want to eat omuraisu," "I want to eat salmon in today's dinner," or "I want to use spinach left in my refregirator." These examples imply that users can easily think of dishes (e.g., omuraisu) they want to have, and also of the foodstuffs they want to use; they can easily select the sort of dishes and foodstuffs to use. It is difficult, however, for users to judge whether a set of foodstuffs goes well in cooking. Note that there are combinations of foodstuffs that are easy or difficult to cook well together. So, it is valuable that our system provides information that helps users to be aware of good and bad combinations, for each soft of dishes.

In our design, we implement a function that provides three sorts of information that helps users select foodstuffs to add/delete, as follows:

(a) Frequency of foodstuffs used in each sort of dishes.

(b) The degree of compatibility between a newly added foodstuff and the other foodstuffs.

(c) Foodstuffs that have good compatibility with a current set of foodstuffs.

First, (a) provides information that indicates which foodstuffs are used frequently in the sort of dishes chosen by users. For each sort of dishes (e.g., omuraisu), the foodstuffs used frequently are considered compatible, and are suitable to use in cooking it. This information is considered useful to know the generally used foodstuffs for each sort of dishes.

Second, (b) provides information that indicates the degree of compatibility between a newly added foodstuff and the other foodstuffs included in the editting recipe. When a user add a new foodstuff in our system, we display the compatibility between the new foodstuff and the other foodstuffs listed in the screen. This function is useful for users to know which foodstuff is suitable for the current set of foodstuffs through trial and error of repeated addition and deletion of foodstuffs. Also, it is useful to decide foodstuffs to delete, instead of the newly added foodstuffs.

Third, (c) provides information that indicates the foodstuff that have good compatibility with a current set of foodstuffs. This function recommends foodstuffs to users to add into the current set of foodstuffs.

These three sorts of information are displayed in the user interface of our system with small icons beside the name of foodstuffs. Because users see these icons easily, our system enables users to operate it intuitively. The detail of the user interface is shown in Section 3.3.

As the functions that help users to decide cooking operations over the selected set of foodstuffs, we display recipes retrieved from the database that in high probability includes the cooking operations over the added foodstuff. Hereafter, we call such recipes as *reference recipes*. The reference recipes that the system displays should involve a similar set of foodstuffs, and simultaneously should have similar pattern of cooking operations with the base recipe.

The reference recipes are displayed for users in the order of the similarity between the set of foodstuffs selected by users and the set of foodstuffs in each reference recipe. By displaying several reference recipes, users can refer variety of cooking operations for the newly added foodstuffs, to which we expect users to refer for ideas how to cook them in their original recipes. Also, we can expect an effect that the system suggests users not only conventional cooking operations, but also rare and surprising operations, which give users a precious hint for their own original dishes.

3.3 User Interfaces

Based on the functional design described in the previous section, we designed the user interface of our system. In this section, we will show how users use our system by introducing our interface design.

The overview of the usage of our system is shown in Fig. 1. Users use the system with the following three steps. First, users select a sort of dishes to cook among several candidate sorts of dishes provided by the system (①). Hereafter, we call the typical recipe of the selected sort of dishes a *base recipe*. Second, users determine a set of foodstuffs to use in their original recipes by adding (or deleting) foodstuffs to (or from) the base recipe (②). Third, users decide how to cook the set of foodstuffs determined in step ② with the help of reference recipes provided by the system (③). In the following, we explain the detail of steps ② and ③.

In step ②, users determine a set of foodstuffs by modifying the base recipe selected in step ①. The user interface of this

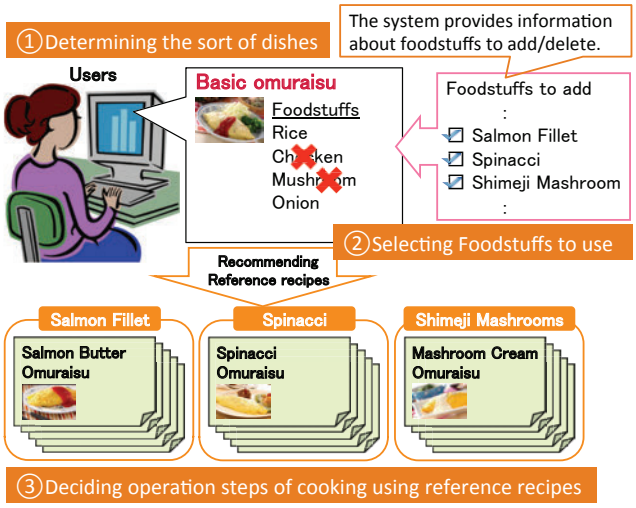

Figure 1: Overview of Usage of Our System

Figure 2: User Interface of the System

step is shown in Fig. 2. In Ⓐ, the base recipe selected in step ① is displayed. In Ⓑ, users add or delete foodstuffs for their original recipe. In this field Ⓑ, many candidate foodstuffs to add or delete are listed, which includes all the foodstuffs in the base recipe.

Because the number of all existing foodstuffs is tremendous, we have to create a subset of them to be displayed in this field. We limited the number of foodstuffs to display according to the criterion (a), the frequency of each foodstuff used in all the recipes that belong to the sort of dishes selected in step ①. The criterion (a) is introduced in Section 3.2, and is described specifically in Section 4. Also, to have users select foodstuffs to add/delete easily, we classified foodstuffs into several categories according to "the standard tables of food composition" [12]. In the user interface of our system, each category of foodstuffs (e.g., vegetables, meat, fish, mushrooms, etc.) forms an "island" with its own color, as shown in Fig. 2.

In this field Ⓑ, users add or delete foodstuffs repeatedly by clicking icons placed at the rightside of the text. (The zoomed image of Field Ⓑ is shown in Fig. 3.) For each operation of users, the system reacts with the three types of information (a), (b) and (c) recalculated and displayed at the rightside of the foodstuff texts.

Figure 3: User Interface (Zoomed)

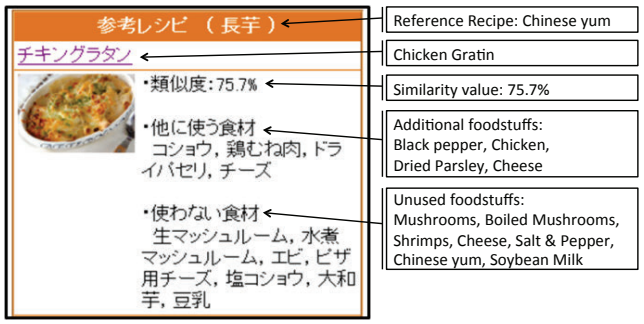

Figure 4: Layout of a Reference Recipe Displayed in the field Ⓒ of Fig.2

The first type of information, i.e., (a) the frequency of each foodstuff used in the sort of dishes, is expressed by the text size of each foodstuff. Figure 3 is the zoomed snapshot of field Ⓑ. Frequently used foodstuffs are shown with bigger fonts, whereas rarely used foodstuffs are shown with smaller fonts. Here, the numbers at rightside of foodstuff texts in brackets are the number of recipes that includes the foodstuff.

The second type of information, i.e., (b) the degree of compatibility between a newly added foodstuff and the other foodstuffs, is expressed by icons. The icons are displayed at the rightside of foodstuff texts when a user newly adds a foodstuff, where the different icons are displayed according to the level of compatibility between them, as shown in Fig. 3. If a foodstuff is very compatible with the new one, a star icon appears. If a foodstuff is moderately compatible, a red arrow with upper direction appears. If a foodstuff is not compatible at all, no icon appears. And, if a foodstuff and the new one are in bad combination, a blue arrow with lower direction appears.

The third type of imformation, i.e., (c) foodstuffs that have good compatibility with a current set of foodstuffs, is expressed with "heart" icons, displayed in the rightside of the foodstuff texts. The arithmetic formula to compute the degree of three criteria (a), (b) and (c) is presented in Section 4.

Next, in the step ③, users decide how to cook the set of foodstuffs determined in step ② with the reference recipes provided by the system. When users add a foodstuff, the system searches the database for the recipes that can be used for reference in deciding the cooking operations, and the found reference recipes are displayed in the field Ⓒ. As the reference recipes, the system selects the ones that include the added foodstuffs, and simultaneously that the similarity of

Table 2: Example of Reference Recipes Listed in the System

Chinese Yum	White Leek	Soybean Milk
Chicken gratin	Cod gratin	Shrinps and macaroni gratin
Chinese yum and shrimp gratin	Chinese yum gratin	Potatoes and shrimp gratin
Seafood and chinese yum gratin Japanese style	Oysters and trout gratin	boiled eggs and soybean milk gratin
Chinese yum gratin	Chinese yum gratin Japanese style	Seafood and chinese yum gratin Japanese style
Chinese yum gratin Japanese style	Chinese yum gratin Japanese style	Mushroom gratin

the set of foodstuffs to those selected in step ② is high. Figure 4 shows the example of the layout of reference recipes displayed in the field ©. In the field, there are several items of useful information such as the similarity value, the additional foodstuffs (i.e., the foodstuffs used in the reference recipe only), and the unused foodstuffs (i.e., those used in the original recipe only). When users click the field, users can refer full information of the recipe in another window.

Table 2 shows the examples of the listed reference recipes for each of added foodstuffs "chinese yum," "white leeks," and "soybean milk," in the case where the base recipe is "gratin."

4 UNDERLYING ALGORITHMS

4.1 An Algorithm to Recommend Foodstuffs

In this section, we introduce an arithmetic criteria to provide information to help users in step ②. We first present the criterion (a), the frequency of each foodstuff used in all recipes that belong to a sort of dishes. We define the set of recipes R in the database as

$$R = (r_1, r_2, \ldots, r_n), \tag{1}$$

where $r_k (1 \leq k \leq n)$ is a recipe and n is the number of recipes in the database. We also define a set of foodstuffs M. If a foodstuff $m \in M$ is included in a recipe r_i, we write $m \in r_i$. Let C denote a sort of dishes selected in the step ①. Then, the frequency $F_c(m)$ of a foodstuff m in a sort of dishes C is represented as follows:

$$F_C(m) = \frac{|\{r | r \in C \text{ and } m \in r\}|}{|\{r | r \in C\}|}. \tag{2}$$

In our system, we use four sorts of fonts according to this value $F_C(m)$.

Next, as for the criterion (b), the degree of compatibility between a newly added foodstuff and the other foodstuffs, we let the degree of compatibility among two foodstuffs m_i and m_j be $Comp_C(m_i, m_j)$, as follows:

$$Comp_C(m_i, m_j) = \frac{|\{r | r \in C \text{ and } m_i \in r \text{ and } m_j \in r\}|}{|\{r | r \in C \text{ and } (m_i \in r \text{ or } m_j \in r)\}|}. \tag{3}$$

In our system, we classify the combinations of foodstuffs m_i and m_j with the value $Comp_C(m_i, m_j)$ into four classes, and display icons accordingly.

Finally, we present the criterion (c), foodstuffs that have good compatibility with a current set of foodstuffs. We let r_0 be the original recipe created by a user, and $S(r_0, r_i)$ be

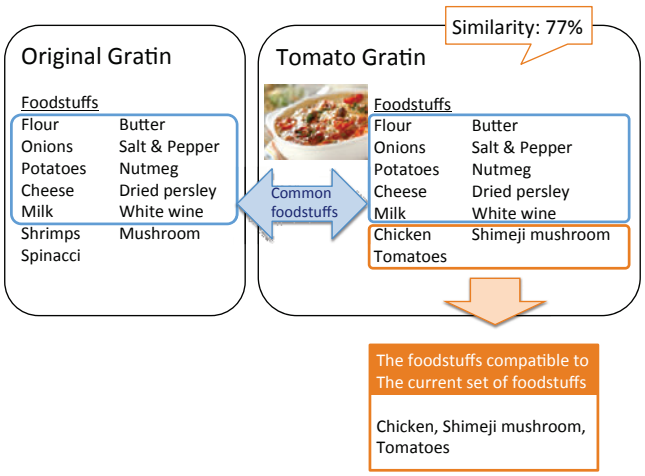

Figure 5: Computing Foodstuffs Compatible with The Original Recipe (Criterion (c))

the *similarity* between these two recipes. Then, $S(r_0, r_i)$ is computed according to the ratio of commonly used foodstuffs, as follows:

$$S(r_0, r_i) = \frac{|\{m | m \in r_0 \text{ and } m \in r_i\}|}{|\{m | m \in r_0 \text{ or } m \in r_i\}|}. \tag{4}$$

In our system, we retrieve a set of recipes from the database with all recipes r_i that satisfies $S(r_0, r_i) > 0.7$, and display the icon to the foodstuffs included in the retrieved recipe set, except for the foodstuffs included in r_0 (Fig. 5).

Note that the computational complexity for each criterion (a), (b) and (c) is $O(|R|)$, where $|R|$ is the number of recipes in the database.

4.2 An Algorithm to Select Reference Recipes

A list of reference recipes are displayed when users add a foodstuff when they are creating their recipes. Thus, the reference recipes are computed from the added foodstuff, the sort of dishes, and the current set of foodstuffs in the original recipe. Specifically, the system first retrieves all recipes that belong to the sort of dishes, and that include the added foodstuff. The system then sorts the retrieved recipes by the similarity between each of them (r_i) and the original recipe (r_0) presented as formula (4). Top 5 of the recipes are displayed as the reference recipes.

The time complexity for searching reference recipes is the same as the algorithms presented in the previous section. That is, we can compute all the criteria (i.e., (a), (b) and (c)) and the reference recipes within a single scan for each recipe.

Table 3: Foodstuffs Specified to Use in the Experiment for each sort of dishes

Gratin	Omuraisu
Chinese yum	White radish sprout
White miso	White leek
Mincemeat	Ginger

5 EVALUATION

5.1 Methods

To evaluate the effectiveness of the proposed system in creating original recipes, we conducted an experiment. In the experiment, we asked users to create their own original recipes, i.e., to write down them, using the proposed system with the following two conditions, and compared the results.

Condition 1: Using the proposed system with all functions.

Condition 2: Using the proposed system with all functions, except for reference recipes.

Because what is new in this system in the literature is the function to provide reference recipes, we confirm the effectiveness of the reference recipes in creating original recipes by comparing the systems with and without reference recipes. Note that, to conduct fair comparison, when users use the system without reference recipes (i.e., the case of Condition 2), we allow users to search recipes using the web site E-recipe [5] to decide their cooking steps in their own original recipes. The sorts of dishes we asked users to create recipes were “gratin” and “omuraisu.”

In our system, we imported the recipes from the web site E-recipe [5]. We select the site E-recipe because the recipes in this site relatively includes low fluctuation of words and the name of foodstuffs. Although the fluctuation is relatively low, we integrated names of foodstuffs according to the reference [12]. (E.g., if both “potato” and “danshaku” are used in the recipes, we integrate them into a word “potato.”)

The experiment is done as follows: We form two groups of users A and B. For users in group A, we first ask them to create their own original recipes with the base recipe “gratin” in Condition 1, and next asked them to do the same operation with the base recipe “omuraisu” in Condition 2. For users in group B, we asked them to do the same with the exchanged base recipes, i.e., they first create recipes of “omuraisu” in Condition 1, and next “gratin” in Condition 2. We also asked them to write down the operational steps of their own original recipes concisely and to answer the questionaire when they finished creating each of their original recipes.

In the experiment, we specified foodstuffs that users must use in their own original recipes, as a “requirements” in their modification of recipes. Namely, for each of two sort of dishes, we specified three foodstuffs to use, while other foodstuffs are free to use. The three foodstuffs specified are shown in Table 3. We selected these three foodstuffs because they are not frequently used in the given sort of dishes, and also because they have more than one ways in cooking. By specifying foodstuffs that have several ways to cook, we intend to have users being not easily able to decide the operational steps to cook their original recipes.

In the questionaire, we have questions on how the three sorts of information for steps ② is useful in selecting the foodstuffs in their recipes. Also, we have questions on how the reference recipes for steps ③ are useful in deciding operational steps in cooking. For each questions, users answer with a 5-grade rating, where 5 means “very useful” or “strongly agree,” and 1 means “not useful at all” or “strongly disagree.” Furthermore, we checked that the written operational steps in their original recipes are proper or not, and compared them between the cases with and without reference recipes.

5.2 Results

In Table 4, we show the results on usefulness of the three sorts of information for adding/deleting foodstuffs. In the results of questions (i), (ii), and (iii), all medians and modes are equal to or more than 4, meaning that users answered that these three sorts of information were useful in selecting foodstuffs to add/delete. However, for the question (iv), users answered that they did not feel like sufficiently easy to select foodstuffs to add/delete with this system. One of the possiblity that the results indicate is that, to select foodstuffs to add/delete in creating recipes, users may require not only the information on compatibility among foodstuffs, but also the information that recall the idea of creating recipes.

In Table 5, we show the results on usefulness of reference recipes. In the results of questions (v)-(ix), all medians and modes are equal to or more than 4 with reference recipes, whereas they are equal to or lower than 3 without referene recipes. There were big difference between the cases with and without reference recipes. The difference was confirmed by checking p-values in t-test of the two cases. The results are shown in Table 6, where the statistical significance was confirmed in all the questions (v)-(ix). We also had a result that most users answered that the reference recipes are better to be recommended automatically. Consequently, we concluded that the reference recipes are useful in deciding how to cook foodstuffs in their own original recipes.

On the other hand, as a result of checking the recipes written by users, we found that the recipes created with reference recipes are all proper, i.e., it does not include wrong operations, whereas those without reference recipes includes several faults. For example, in cooking gratin, some original recipes cut raw chinese yum and throw directly into white source. Note that chinese yum are usually lightly fried before mixed with white source. As another example, an original recipe first bakes the gratin in an oven, and after that, puts the fried ingredients on it. The ingredients are usually mixed with white source before the gratin with white source is baked. The reason why users made such mistakes would be that they referred the recipes that belong to other sorts of dishes. Consequently, they only understood how to cook it, but not understood the timing and the sequence of operations in gratin. This also indicates that the reference recipes recommended from the same sort of dishes work effectively to decide operational steps in cooking in their own original recipes.

Table 4: Results: usefulness of three sorts of information for adding/deleting foodstuffs

	Questions	Evaluation 5	4	3	2	1	Median	Mode
(i)	The information "frequency in the sort of dishes" was useful.	7	5	4	4	0	4	5
(ii)	The information "the degree of compatibility between a newly added foodstuff and the other foodstuffs" was useful.	5	13	1	1	0	4	4
(iii)	The information "foodstuffs that have good compatibility with a current set of foodstuffs" was useful.	4	14	1	0	1	4	4
(iv)	Selecting foodstuffs to add/delete was easily done.	2	7	5	6	2	3	4

Table 5: Results: usefulness of reference recipes

		Questions	Evaluation 5	4	3	2	1	Median	Mode
With reference recipes	(v)	I am satisfied with my original recipe.	6	8	5	1	0	4	4
	(vi)	Deciding how to cook the selected foodstuffs was easily done.	8	8	4	0	0	4	5
	(vii)	This system is useful to get an idea in creating recipes.	10	9	1	0	0	4.5	5
	(viii)	I would like to use this system again.	4	15	1	0	0	4	4
Without reference recipes	(v)	I am satisfied with my original recipe.	0	6	7	6	1	3	3
	(vi)	Deciding how to cook the selected foodstuffs was easily done.	0	3	4	9	4	2	2
	(vii)	This system is useful to get an idea in creating recipes.	1	5	6	7	1	3	2
	(viii)	I would like to use this system again.	0	3	6	10	1	2	2
	(ix)	It is better that the reference recipes are automatically recommended.	18	2	0	0	0	5	5

Table 6: Results: usefulness of reference recipes (p-values)

	Questions	With reference recipes Average	Stddev	Without reference recipe Average	Stddev	p-value
(v)	I am satisfied with my original recipe.	3.95	0.89	2.90	0.91	0.0003
(vi)	Deciding how to cook the selected foodstuffs was easily done.	4.20	0.77	2.30	0.98	0.00000003
(vii)	This system is useful to get an idea in creating recipes.	4.45	0.92	2.90	1.02	0.000001
(viii)	I would like to use this system again.	4.15	0.60	2.55	0.83	0.00000001

6 CONCLUSION

In this paper, we proposed a method and a system to help users to create original recipes. The proposed system provides users with the information that helps users to select foodstuffs to add to, or delete from their own original recipes, and also with reference recipes that helps users to decide operational steps in cooking in their original recipes. With this system, users are able to create their original recipes that meet their own requirements with the helpful computational aids.

We evaluated the system how effectively it helps users to create their own original recipes. Through the experiment to create original recipes, we confirmed that the proposed system is useful in creating their own recipes, and this proves the effectiveness of the system.

One of the challenges for the future is to recommend reference recipes for various objectives of users, e.g., reference recipes for basic cooking methods, or those for stimulative idea in cooking, etc. Other customizations and characterizations to fit the system to users' various requirements would also be a possible task for the future.

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