IJBSCHS
[Original Article]

Biomedical Soft Computing and Human Sciences, Vol.18, No.2, pp.41-47

(Accepted on 2012.5.9)

A Note on Supporting Method for Making Recipe for a Measure against Metabolic Syndrome

Yasunari MAEDA*, Fumito MASUI*, Hideki YOSHIDA** and Masakiyo SUZUKI*

*Dept. of Computer Science, Kitami Institute of Technology
**Dept. of Information Science and Biomedical Engineering, Kagoshima University

This is an English translation of "A Note on supporting method for making recipe for a measure against metabolic syndrome," Journal of Biomedical Fuzzy Systems Association, Vol.13, No.1, pp.81-86(2011).

Abstract: *In this study, we examine a supporting method for making recipe for a measure against metabolic syndrome. We use existing recipes to produce new recipes as a countermeasure against metabolic syndrome. Some ingredients with fewer calories are used in new recipes instead of original ingredients in existing recipes as a countermeasure against metabolic syndrome. We therefore produce an ingredient thesaurus, which is useful to support making of new recipes as a measure against metabolic syndrome. We assess the effectiveness of the proposed method using experiments.*

Keywords *metabolic syndrome, supporting method for making recipe, measure against metabolic syndrome, ingredient thesaurus.*

1.Introduction

In recent years, according to guidance[1] by the Ministry of Health, Labour and Welfare, living practices designed to avoid metabolic syndrome are recommended in Japan. Improvement of living practices through diet and exercise is cited specifically. Improving living practices by meal planning, avoiding high-calorie meals, and taking low-calorie meals are all important. Regarding methods of finding low-calorie recipes to produce low-calorie meals, purchasing cookbooks with low-calorie recipes is one method. However, the recipes in such books are inadequately few. Although those who are quite familiar with cooking might devise low-calorie recipes, producing numerous low-calorie recipes by oneself is difficult.

However, many studies have examined cooking recipes for the study of cooking media. In a report of a conventional study[2], a technique was proposed by which vector space method, which is used for search engines and text searches, is applied for finding and recommending existing recipes. Existing recipes using a related food ingredient are sought by inputting a food ingredient as a keyword. In reports of conventional studies[3][4], techniques were proposed that automatically prepare and recommend a nutritionally well-balanced menu through a combination of existing recipes by application of combinatorial optimization methods. Other reports of conventional studies[5][6] describe a user-friendly support technique for preparing contents for a method of cooking existing recipes by application of multimedia processing techniques that deal with animation, voice, and text. Nevertheless, no report in the relevant literature has described preparation of a new low-calorie recipe automatically.

Therefore, this basic study was performed to devise a method of supporting making of a recipe as a measure against metabolic syndrome. The system generates candidates for a new low-calorie recipe based on information related to existing recipes and ingredients. After a new low-calorie recipe is prepared using the method proposed herein, various techniques proposed in the above conventional studies will be available to search

165 Koen-cho, Kitami-shi
Hokkaido 090-8507 Japan
Phone: +81-157-26-9328, Fax: +81-157-26-9344
e-mail: maeda@cs.kitami-it.ac.jp

recipes, to prepare a menu by combining two or more recipes, and to prepare contents related to cooking techniques.

For this research, a basic study is performed to verify that candidates of a new low-calorie recipe can be generated based on information related to existing recipe and ingredients. However, no systemization has been achieved yet. The method proposed herein is necessary for generating candidates of new low-calorie recipes, so that additional studies must be undertaken for its systemization in view of convenience and safety.

2.Information to be used

Here, various information is defined for use in this research. In the supporting method for producing recipes as a measure against metabolic syndrome, three DBs are used: an ingredient database(DB), an existing recipe DB, and an ingredient thesaurus.

Information about ingredients is stored in the ingredient DB. For this description, g_i, $g_i \in G$ denotes the i-th ingredient and G, $G = \{g_1, g_2, \ldots, g_{|G|}\}$ denotes a set of ingredients. $c_1(g_i)$ denotes the energy(kcal) per 1 gram of ingredient g_i. Information related to nutrients other than energy is denoted by $c_j(g_i)$ (j is other than 1) and stored. For example, $c_2(g_i)$ denotes iron(mg) per 1 gram of an ingredient g_i. According to purposes, information related to various nutrients is presumed to be stored.

Information related to existing recipes, which serves as the original information for generating candidates of a new cooking recipe for a measure against metabolic syndrome(low-calorie recipe), is stored in the existing recipe DB. Herein, r_i, $r_i \in R$ denotes the i-th existing recipe and R, $R = \{r_1, r_2, \ldots, r_{|R|}\}$ denotes a set of existing recipes. $f(r_i, j)$, $f(r_i, j) \in F(r_i)$ denotes the j-th ingredient of the existing recipe r_i and $f(r_i, j) \in G$. $F(r_i)$, $F(r_i) = \{f(r_i,1), \ldots, f(r_i, |F(r_i)|)\} \subset G$ is a set of ingredients of the existing recipe r_i. Additionally, $w(r_i, j)$ denotes an amount(gram) used for one person of the j-th ingredient of the existing recipe r_i.

When cooking, one sometimes uses no ingredients specified in the recipe but substitutes other ingredients for them. That practice requires the knowledge of the cook who substitutes ingredients to provide delicious foods. In this way, knowledge related to ingredients having lower calories than the original ones(ingredient to be substituted) is used as an ingredient thesaurus for such substitutable ingredients.

In the field of natural language processing, synonym dictionaries for computers are provided as a thesaurus[7]. For information retrieval in natural language processing, the thesaurus is used for query expansion[8], by which new information that was unretrievable using only an original keyword can be retrieved by adding a logical sum of synonyms having the same meaning as the original keyword, but a different notation. The idea of substitute ingredients in this research resembles the idea of synonyms in natural language processing. Therefore, it is called an ingredient thesaurus in this research. b_i, $b_i \in G$ denotes the i-th ingredient to be substituted(original ingredient to be substituted) stored in the ingredient thesaurus and B, $B = \{b_1, b_2, \ldots, b_{|B|}\}$, $B \subset G$ denotes a set of ingredients to be substituted. $a(b_i, j)$, $a(b_i, j) \in A(b_i)$, $a(b_i, j) \in G$ denotes the j-th ingredient to be substituted that is substitutable in that an ingredient b_i to be substituted is edible as delicious food, even by being substituted for the relevant ingredient and $c_1(b_i) > c_1(a(b_i, j))$ holds. $A(b_i)$, $A(b_i) = \{a(b_i,1), a(b_i,2), \ldots, a(b_i, |A(b_i)|)\}$, $A(b_i) \subset G$ is a set of substitute ingredient regarding the ingredient to be substituted b_i.

3.Supporting method for making recipe as a measure against metabolic syndrome

First, some definitions will be made using information stored in the ingredient thesaurus described in the previous chapter. $m(r_i, j)$, $m(r_i, j) \in M(r_i)$ denotes the j-th ingredient stored in the ingredient thesaurus as an ingredient to be substituted among the ingredients in the existing recipe r_i. $M(r_i)$, $M(r_i) = \{m(r_i,1), m(r_i,2), \ldots, m(r_i,|M(r_i)|)\}$, $|M(r_i)| \le |F(r_i)|$ denotes a set of ingredients stored in the ingredient thesaurus as an ingredient to be substituted among the ingredients of the existing recipe r_i.

Next, descriptions will be given for the supporting method for making recipes as a measure against metabolic syndrome. The algorithm shown as follows generates candidates of a new low-calorie recipe based on existing recipe r_i.

```
for ( j1 = 1 ; j1 ≤ |A(m(ri,1))| ; j1 ++ ) {
  for ( j2 = 1 ; j2 ≤ |A(m(ri,2))| ; j2 ++ ) {
    ⋮
    for ( j|M(ri)| = 1 ; j|M(ri)| ≤ |A(m(ri,|M(ri)|))| ; j|M(ri)| ++ ) {
      generation of a candidate of recipe r'i,j1,j2,…,j|M(ri)|
    }
    ⋮
  }
}
```

In the algorithm presented above, regarding each element(ingredient to be substituted) $m(r_i, j)$ of the set $M(r_i)$ of the ingredient stored in the ingredient thesaurus as the ingredient to be substituted among ingredient of existing recipe r_i, all combinations are listed while each element is made to be substituted for from $a(m(r_i, j),1)$ to $a(m(r_i, j),|A(m(r_i, j))|)$. The total number of candidates of the new low-calorie recipe listed based on the existing recipe r_i is $|A(m(r_i,1))||A(m(r_i,2))|\cdots|A(m(r_i,|M(r_i)|))|$. The number of the substitution ingredients to be substituted is expressed by j_k, $1 \le k \le |M(r_i)|$, $1 \le j_k \le |A(m(r_i,k))|$ and a candidate of the new low-calorie recipe $r'_{i,j_1,j_2,\ldots,j_{|M(r_i)|}}$. Also, a use amount of the substitute ingredient $a(m(r_i, j),k)$ for one person is assumed to be equal to that of ingredient to be substituted $m(r_i, j)$.

The candidate of recipe $r'_{i,j_1,j_2,\ldots,j_{|M(r_i)|}}$ is a recipe generated by substituting the ingredient to be substituted of the existing recipe r_i for a lower-calorie substitute ingredient. Therefore, calories for one person are fewer than those of the existing recipe r_i. The calories for one person of the existing recipe r_i is $\sum_{j=1}^{|F(r_i)|} c(f(r_i, j))w(r_i, j)$ and those of the candidate of the new low-calorie recipe $r'_{i,j_1,j_2,\ldots,j_{|M(r_i)|}}$ being $\sum_{j=1}^{|F(r')|} c(f(r', j))w(r', j)$. r' is an abbreviation for $r'_{i,j_1,j_2,\ldots,j_{|M(r_i)|}}$.

By generating the candidates of the new low-calorie recipe for all the elements of the set R of the existing recipes, all the candidates of the new low-calorie recipe can be listed based on the proposed method.

4.Examples of application of proposed method

Here, examples will be introduced in which the supporting method for making recipes for a measure against metabolic syndrome proposed in the previous chapter is applied to actual data. No systemization is

performed for this research and only a minimum environment is prepared for obtaining examples of the application. Specifically, an existing recipe DB is made using text file and a program for generating a candidate of the new recipe is produced using Java language.

At the time of the experiment, a recipe collection[9] is used for reference regarding the existing recipe DB. A food number table[10] prepared by the Ministry of Health, Labour and Welfare is used for reference regarding conversion of weight of ingredients(e.g. gram conversion of a tomato). A food composition database[11] prepared by the Ministry of Education, Culture, Sports, Science and Technology is used for reference regarding information related to the energy and nutrients of the ingredient DB. Regarding the ingredient thesaurus, the ingredient DB is used for reference to determine the amount of an ingredient's energy. Whether the substituted ingredient in the ingredient thesaurus tastes good is determined by us, subjectively.

Tab.1 and Tab.2 show the lowest calorie candidates(example 1 and 2 of the application) among candidates of the new low-calorie recipes generated when the proposed method is applied to the existing recipes "tatsuta-age of saury" and "stir-fried potatoes and beef." In example 1 of the application, the saury of the original recipe is replaced by sardines. In example 2 of the application, beef and potatoes of the original recipe are replaced by chicken and taros. For reducing the food energy, candidates for example 1 and 2 of the application having the minimum energy are regarded as the best with data used in actual experiments.

Tab.1. Example 1 of the application(for one person).

name of the existing recipe	tatsuta-age of saury
ingredients of the original recipe	saury, soy sauce, sake, starch powder, onion, garlic, oil
substitute ingredient	saury → sardines
energy of the original recipe	579(kcal)
energy of the candidate of recipe	440(kcal)

Next, aside from caloric energy, other nutrients are added to subjects to be considered. Information related to iron(mg) per 1 gram of ingredient g_i is stored as $c_2(g_i)$ in the ingredient DB. Therefore, iron is added to subjects to be considered. According to Tab.2, the candidate of example 2 of the application has less iron than the original recipe does. When the intake of iron is the purpose of a meal, a candidate is expected that reduces energy lower than the original recipe and which increases iron. Among candidates generated when the proposed method is applied to the original recipe of the example 2 of the application, the candidate that satisfies such conditions is presented in Tab.3 as example 3 of the application.

Tab.2. Example 2 of the application(for one person).

name of the existing recipe	stir-fried potatoes and beef
ingredients of the original recipe	beef, potatoes, beans, soy sauce, sake, starch powder, onion, garlic, coarse salt, pepper, oil
substitute ingredient	beef → chicken, potatoes → taros
energy of the original recipe	504(kcal)
energy of the candidate of recipe	292(kcal)
iron of the original recipe	1.26(mg)
iron of the candidate of recipe	1.08(mg)

Tab.3. Example 3 of the application(for one person).

name of the existing recipe	stir-fried potatoes and beef
ingredients of the original recipe	beef, potatoes, beans, soy sauce, sake, starch powder, onion, garlic, coarse salt, pepper, oil
substitute ingredient	beef → horse meat, potatoes → taros
energy of the original recipe	504(kcal)
energy of the candidate of recipe	293(kcal)
iron of the original recipe	1.26(mg)

iron of the candidate of recipe	3.64(mg)

In example 3 of the application, beef and potatoes are replaced by horse meat and taros, so the energy of this dish is 293 kcal, with iron of 3.64 mg. The caloric energy is almost identical to that of example 2 of the application, and iron is as almost three times that of the original recipe. However, considering that the shops where horse meat can be purchased are few, example 3 of the application is not practical.

In other candidate generated using the proposed method, beef and potatoes are replaced by lamb(mutton) and taros. The candidate is shown in Tab.4 as example 4 of the application.

Tab.4. Example 4 of the application(for one person).

name of the existing recipe	stir-fried potatoes and beef
ingredients of the original recipe	beef, potatoes, beans, soy sauce, sake, starch powder, onion, garlic, coarse salt, pepper, oil
substitute ingredient	beef → lamb(mutton), potatoes → taros
energy of the original recipe	504(kcal)
energy of the candidate of recipe	360(kcal)
iron of the original recipe	1.26(mg)
iron of the candidate of recipe	2.20(mg)

In example 4 of the application, energy is 360 kcal and iron is 2.20 mg. Although not being so low in calories as example 2 and 3, example 4 of the application is a more practical candidate than example 3 considering that it is easy to increase one's iron intake and to purchase the substitute ingredients.

5.Examination and problems in the future

Many problems were identified through the present basic study. Here, descriptions will be given of problems in the future through discussions.

The first problem is the amount of data in various DBs such as the ingredient thesaurus. Completeness of the candidate generated using the proposed method depends on the completeness of data retained by various DBs. Therefore, data completeness of the variety of DBs constitutes an important issue for future examination. For example, when considering oil registered in the ingredient DB, only general vegetable fats and oil are presumed at present. When adding ingredients such as lard to the subject, the names of items will be subdivided and data will be registered additionally. Some manufacturers produce special product such as vegetable fats and oil with fewer calories. Therefore, it is also necessary to study the registration by products of each manufacturer.

The second problem is how to narrow down candidates to be generated(or candidates to be registered). Using the proposed method, as many candidates are generated as the number of combinations of substitute ingredients. Consequently, the number of candidates sometimes becomes enormous. Therefore, problems in the future will include the study of how to narrow down registered candidates(whose data are saved) by the system user after candidates are generated, in addition to limitation of the generation of surplus candidates according to various conditions when candidates are generated.

The third problem is how to narrow down candidates for users of systems to seek new recipe candidates that are generated using the proposed method and which have been already registered in the system. Problems to be addressed in future investigations will be study of a function for the user of the system to input and search for any ingredient and target intake amounts of various nutrients and a function to remove inappropriate candidates that cannot be provided with the user in advance by registering information related to diet restrictions of the system user with the system.

The fourth problem is to add a study of safety. This is related to removal of inappropriate candidates based on diet restriction information of system users described in the above third problem. To enhance the level of satisfaction based on the tastes of users is important as well. Diet restrictions related to chronic illness and allergy are particularly important because they threaten the life of the user. Therefore, at the time of systemization, readily changeable specifications are favored for setting conditions related to taste. However, specifications requiring doubled and redoubled confirmation are favorable with respect to safety so that no wrong settings or changes are

performed for conditions set on diet restrictions because of allergies and chronic illness.

The fifth problem is to study the updating of the ingredient thesaurus and new recipe candidate data stored in the system after being generated. Regarding the initial ingredient thesaurus, two cases are conceivable: a case in which a basic thesaurus is delivered and a case in which it is prepared by individual users. In either case, the ingredient thesaurus must be updated to reflect personal tastes and changes in tastes. Accordingly, studies of readily updatable functions are necessary for the ingredient thesaurus according to users' tastes. New recipe candidate data stored in the system increase when data are added to the existing recipe DB. Many cases are conceivable for the frequency of update of the existing recipe DB, and updates are presumed to be frequent at the time when someone starts using the system and to be infrequent after some degree of operation. Such a function must be studied to remove the new recipe candidate data stored in the earlier system according to the users' tastes. Specifically, a function for the user to remove unnecessary data and a function for the system to propose removal based on adopted status by asking the user to keep some records on the system when the user actually prepares the candidate recipe are considered.

The sixth problem is a study of the consistency of cooking methods of the new recipe candidates generated by the proposed method. Using the proposed method, a combination of ingredients is treated as a recipe. No review of the cooking method is performed when the ingredient is substituted. However, for example, the time that is necessary for heating of beef differs from that of chicken. To leave a review of the cooking method to the user is conceivable, but studies of the change in the cooking methods according to the substitution of ingredients are necessary presuming that some users are not good at cooking.

In this research, as a basic study of the supporting method for making recipe for a measure against metabolic syndrome, using various DBs such as an ingredient thesaurus, a recipe candidate whose calories are fewer than those of the original recipe and a recipe candidate that is low in calories and which contains more nutrients than the original recipe are confirmed to be generated. However, no evaluation was performed for the taste(or presumed taste) of the cooking according to that recipe. The seventh problem is the evaluation of the taste by an examinee.

6.Conclusion

This basic study examined a supporting method for making recipes as a measure against metabolic syndrome. It was performed to generate new low-calorie recipe candidates based on existing recipes and information related to ingredients. The proposed method was applied to actual data, although the samples were few, and a recipe candidate with fewer calories than those of the original recipe and a recipe candidate with few calories and containing more nutrients than the original recipe were confirmed to be generated.

Along with examination of the problems described above, we would like to deepen the study of supporting methods for making recipes as a measure against metabolic syndrome.

References

[1] Japan Labour Health and Welfare Organization: "Metabolic Syndrome Handbook for the Prevention & Relief", Roudou Chousakai, 2008.(in Japanese)

[2] Ishihara, K., Ueda, M., Hirano, Y., Kajita, S., and Mase, K.: "An Evaluation on the Recommendation Method for Personal Taste Recipe Based on the FF-IRF", IEICE Tech. Rep., Vol.107, No.454, MVE2007-77, pp.51-56, 2008. (in Japanese)

[3] Karikome, S. and Fujii, A.: "A Retrieval System for Cooking Recipes Considering Nutritional Intake Balance", IEICE Transactions on Information and Systems(Japanese edition) D, Vol.J92-D, No.7, pp.975-983, 2009. (in Japanese)

[4] Tsuji, A., Kurashige, K., Kameyama, Y.: "Selection of Dishes Using Fuzzy Mathematical Programming", Journal of Japan Society for Fuzzy Theory and Intelligent Informatics, Vol.20, No.3, pp.337-346, 2008. (in Japanese)

[5] Miura, K., Takano, M., Hamada, R., Ide, I., Sakai, S., and Tanaka, H.: "Associating Semantically Structured Cooking Videos with their Preparation Steps", IEICE Transactions on Information and Systems(Japanese edition) DII, Vol.J86-D-II, No.11, pp.1647-1656, 2003. (in Japanese)

[6] Yamakata, Y., Kakusho, K., and Minoh, M.: "A Method of Recipe to Cooking Video Mapping for Automated Cooking Content Construction", IEICE Transactions on Information and Systems(Japanese edition) D, Vol.J90-D, No.10, pp.2817-2829, 2007. (in

Japanese)

[7] Ikehara, S., Miyazaki, M., Shirai, S., Yokoo, A., Nakaiwa, H., Ogura, K., Ooyama, Y., and Hayashi, Y.: "Goi-Taikei: A Japanese Lexicon", Iwanami Shoten, 1997. (in Japanese)

[8] Kuriyama, K.: "Query Expansion using Thesauri", Information Processing Society of Japan, 98-FI-52, pp.1-8, 1998. (in Japanese)

[9] Nippon Television Network Corporation: "Kewpie 3 Min Cooking", http://www.ntv.co.jp/3min/index.html, referred Jan.4.2011. (in Japanese)

[10] Ministry of Health, Labour and Welfare: "Food Number Table", http://www.nih.go.jp/eiken/nns/system/bangohyo.pdf, referred Jan.4.2011. (in Japanese)

[11] Ministry of Education, Culture, Sports, Science and Technology: "Food Composition Database", http://fooddb.jp/index.html, referred Jan.4.2011. (in Japanese)

Yasunari MAEDA

Associate Professor, Kitami Institute of Technology. Engaging in knowledge information processing and natural language processing. A member of IEICE, IPSJ, and others.