Investigation of recipe components to resolve ambiguity in cooking procedure

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Abstract

The purpose of this research is to develop a method that supports cookery amateurs to clearly understand recipes available on online recipe sites. Recently, the number of websites providing recipes is increasing, and users can easily refer to them and cook various types of foods. However, novice cooks may still find it difficult to cook using these recipes because the details on the cooking procedure provided are presented in an inconsistent manner, often confusing the beginners. To solve this problem, we collected recipes and extracted the terms that indicate the cooking process employed as well as the elements that indicate the material and/or items used in the recipes, by using an ontology.

Keywords: Recipes, Ambiguous, Data structure

1 Introduction

In recent years, opportunities for cooking at home have increased. For example, young adults who have started living alone owing to academic enrollment or new employment are often just beginning to cook on their own. Such novice home cooks regularly use online recipe sites to find recipes, either for confirming the procedure for preparing dishes they are familiar with or discovering new dishes. Many of these recipe sites are built from user-contributed content, which means people can both browse recipes and post their own cooking recipes (one prominent example is Cookpad[1]). The number of visitors and participants in these user-contributed recipe sites (hereinafter referred to as recipe sites) are increasing yearly, and the demand for such recipe sites is rising proportionally[2]. One such recipe sites, the afore-mentioned Cookpad, had posted 2,510,000 recipes as of December 2016[2]. This is approximately twice the number of recipes hosted in December 2013. The recipes posted on such recipe sites are self-created, and relied on the contributor ' s own culinary knowledge. Therefore, multiple recipes are often posted under the same name, with varying cooking procedures and ingredients. As such, there are many sources of ambiguity in the expression of these posted recipes. The notation or terminology used in these recipes commonly cause such ambiguities when posts claiming the same recipe name use different notation methods for terms expressing the same meaning. For one example, refer to the word marked with a solid underscore in Figure 1; this is a term meaning "onion." The recipe shown on the left side of Figure 1 describes this as "たまねぎ (onion)" (Hiragana only), whereas the recipe on the right side of Figure 1 uses the description "玉ねぎ (onion)" (Hiragana and Kanji). Another source of ambiguity is the fineness of the cooking step, defined as the granularity or level of detail contained in the procedure description. This varies from user to user. For an example of this, refer to the word marked with a dashed underscore in Figure 1; this is a term meaning "cut." The recipe on the left side of Figure 1 has no designation for the type of cutting that should be used. Conversely, the recipe on the right side of Figure 1 gives a more detailed, or granular, description of the type of cutting that should be performed. Ambiguous expressions such as these are common in cooking procedures. This presents beginners cannot accurately judge the degree of cutting, seasoning, and/or heating.

In order to solve this problem, it is necessary to create a standardized structure for such recipes. This structure would allow beginners to accurately judge points of ambiguity such as

[1] http://cookpad.com/

[2] https://info.cookpad.com/ir/financial_highlight (Confirmed on 12th December 2016)

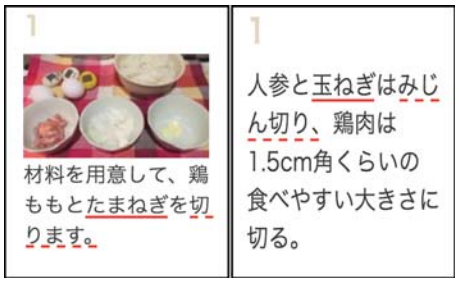

Figure 1. Differences in notation and fineness for each recipe (Cookpad Inc.: Cited from cookpad) Left figure[3]: https://cookpad.com/recipe/3124024 and Right figure[4]: https://cookpad.com/recipe/4305021

those mentioned previously. This research, with the intent of allowing novice cooks to understand recipes, focused on addressing such ambiguities, and investigated factors of ambiguity in cooking procedures. Ontology was used to clarify the relationship between the terms used to describe the cooking procedures (hereinafter referred to as cooking terms) such as "fry" and "cut," and terms related to the materials or processing methods such as "potatoes" and "bite size" (hereinafter referred to as constituent elements).

2 Related studies

2.1 Research on the structure of recipes

Studies dealing with the structure of recipes often use methods of representation for various cooking procedures (e.g., flow charts or markup languages). This research aims to make it possible to deal with the omission of cooking procedures in a posted recipe as well as the relations between procedures in the system (hereinafter referred to as structure).

Hamada et al. created and automated a system that creates flow charts from recipe sentences[1]. In order to create a flow chart, it was necessary to analyze the structure of the cooking operation. To this end, their research constructed a noun and a verb dictionary on cooking. Subsequently, the relationships between the cooking-related nouns and verbs were added. These pieces were then connected in the order of cooking procedures to create a flow chart.

Kikkawa et al. proposed a method to present recipe structures using the data flow from a programming language[2]. In their research, a data flow diagram was used to connect materials and cooking methods with lines. This was used to express cooking procedures. Furthermore, this technique showed the possibility of using structured recipes (such as diversifying the way recipes are expressed and recipe databases).

The purpose of Mori et al. was to ameliorate the omission of procedures and procedural relationships in the system[3], for which they created a corpus. The corpus is visualized as a graph expressing the flow of cooking in the cooking procedure, and tags the terms related to cooking found therein. Types of tags include "food," "tool," "duration," "quantity," "movement of the cooker," "movement of foodstuff," "state of foodstuff," and "state of tool." Using the tag attachment, the meaning of each cooking procedure is represented in a flow chart. The final product of this research expresses recipes in the form of graphs based on the information in these tags, thereby expressing the flow of cooking procedures.

Momouchi mentioned the partial classification of the control structure of actions in procedural text[4]. Based on this partial classification, a Procedural Text (PT) chart showing the structure of procedural text was presented.

Rohrbach et al. proposed a database that recorded cooking activities continuously[5].

2.2 Position of this research

In previous research supporting the utilization of recipe sites, simplifications and search recommendations have been given. However, it remains necessary to create a standardized recipe format, rather than allowing each user to write their recipes differently. This way, recipes may be treated as data. Previous research dealing with the structure of recipes has used recipe structuring to understand and define cooking procedures and support cooking. However, when the structure of these cooking procedures is complex, it cannot be handled elegantly in a flow chart. It is thus impossible to cover all cooking procedures using the previously proposed structuring methods. Therefore, these methods are unable to fully grasp cooking procedures or

[3]Prepare the material, cut the onion and chicken as well.

[4]Carrot and onion are chopped, and chicken meat is cut into sizes as large as 1.5 cm square.

support cooking in a practical setting. This research aims to solve the remaining ambiguities in cooking procedures and create improved assistive technology that will allow beginners to understand recipes. For this purpose, the ambiguity in cooking procedures was investigated with the aim of clarifying the relationships between the cooking terms and their constituent elements.

3 Efforts towards ambiguity resolution

This section describes the processing necessary to resolve ambiguities in the cooking procedure. The methodology used in this study can be broken down into three steps: first, extraction of the cooking terms and constituent elements from the recipe; second, tagging of the terms; and finally, investigation of the constituent elements for cooking terms.

3.1 Method of research

Ontology was used in this research to investigate ambiguities in the cooking procedure by clarifying the relationships between terms used in the cooking procedure. It is possible to create a recipe without ambiguity using these clarifications. For a more complete reduction of ambiguity, though, further investigation of ambiguous factors and consideration for their elimination is required. In this study, the factors constituting ambiguity in cooking procedures are examined by using ontology to arrange the relationships between cooking terms and constituent elements.

3.2 Extracting cooking terms and constituent elements

To begin processing recipes, cooking terms and constituent elements in cooking procedures were extracted. These terms and types of elements, as well as their number of occurrences, were then subject to further investigation.

Cooking procedures from recipes posted on the recipe site Cookpad were used as the subjects of analysis in this research. A randomly selected sample of 80 recipes was taken from the recipes posted on the site, and a total of 536 steps were collected from these recipes and used as the basis of the corpus.

3.2.1 Analysis method

The corpus collected in the previous section was divided into morphemes by morphological analysis. MeCab (ver. 0.996) was used to conduct the morphological analysis, and ipadic (ver. 2.7.0) was used for the dictionary. Terms related to cooking were extracted manually from these morphemes and given individual tags. Some cooking-related terms were found to be divided during the process of adding tags, and had to be reworked into cooking terms prior to tagging. For example 電子 / レンジ → 電子レンジ (electronic / range → microwave oven).

3.2.2 Results of analysis

The procedures of the 80 sample recipes were divided into morphemes, the results of which are shown in Table 1. When the frequency of morpheme appearances was evaluated, it was found that the sum of the noun with the highest frequency of appearance and verb with the third highest frequency of appearance accounted for 52% of all morphemes. In order to clarify the relationship between the cooking terms and constituent elements, it was necessary to analyze the part of speech showing "target of cooking," "cooking behavior," and "state of food and tools." These items were therefore tagged as subjects of analysis. Noise was manually removed during the addition of tags. The type of tag and the number of occurrences are shown in Table 2. Of the tags given, 67% were either "material" or "method." As a further result of removing noise from morphemes targeted for tagging, terms related to cooking in the step occupied 33% of the whole text.

3.3 Analysis of relationship between cooking terms and constituent elements

This study focuses on cooking terms, analyzing a method for clarifying the relationship between these cooking terms and the constituent elements of recipes.

A total of 1,365 cooking terms tagged with "method" were collected as shown in Section 3.2.

3.3.1 Analysis method

In this research, the relationships between cooking terms and constituent elements were investigated using ontology. These constituent elements were organized in relation to cooking

Table 1. Breakdown of recipe procedure divided into morphemes

Part of speech	morphemes	tags of target
noun	3,928	3,219
postposition	3,096	268
verb	2,036	1,738
symbol	1,335	42
auxiliary verb	604	208
adverb	177	122
adjective	137	111
prefix	92	62
adnominal	17	2
interjection	8	0
conjunction	7	3
filler	5	4
total	11,442	5,779

Table 2. Type of tag and number of occurrence

Tag	number
method	1,365
material	1,176
condition	553
tool	308
time	83
size	72
end	69
amount	60
thermal power	43
place	43
total	3,772

terms based on frequency of common extraction in sentences. It is assumed that the constituent elements related to any given cooking term are included in the same procedure number as the cooking term. In cooking terminology, the allophone synonym is summarized in a single expression. For example, “みじん切り (chop finely)” and “ざく切り (cutting into chunks)” have different meanings; however, both also have the same basic meaning of “cut.” As such, these cooking terms were unified under the umbrella term “cut.” The more specific terms, “みじん (finely)” and “ざく (into chunks),” were designated as the “cutting method,” constituent elements of the term “cut.” This method of cooking term organization was based on the ontology used in a previous study [6]. An example of this method of organizing constituent elements related to cooking terms is shown in Figure 2.

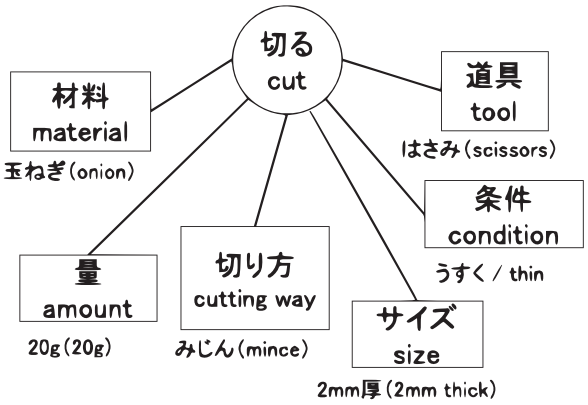

Figure 2. Constituent elements related to the cooking term “cut”

Cooking terms written within circles were given a “method” tag. The constituent elements relating to a method are found in the surrounding rectangles. An example of each constituent element is shown below the square.

3.3.2 Results of analysis

In the analysis of this study, four methods are associated with “cut”: “削ぎ落とす (scrape off),” “刻む (carve out),” “切り分ける (carve),” and “切り落とす (cut off).” The types and number of occurrences of these constituent elements when the cooking term “cut” appears are shown in Table 3. A total of 140 cooking terms are classified under the cooking term “cut.” This accounts for 10% of the total cooking terms given a “method” tag. When the cooking term “cut” appeared, a constituent element with a “material” tag appeared 100% of the time. From this, it is clear that the cooking term “cut” is not associated with omissions of the “material” tag, which represents the subject matter of cooking. Additionally, the constituent element “tool” was described when an object other than a kitchen knife was to be used. It is therefore acceptable to assume that the tool used for the operation of “cut” defaults to a kitchen knife under the premise of cooking. As such, it is considered unnecessary to explicitly state when a kitchen knife is used. The constituent element of “cutting way” appeared 56% of the time. It is thus clear that when the cooking term “cut” is used, it omits the “cutting way” tag. It was therefore shown that the constituent element “cutting way” in association with the cooking term “cut” is a source of ambiguity.

There are 257 cooking terms classified as “put in.” This accounts for 19% of the total cooking terms given in the “method” tag. In the analysis of this study, “加える (add),” “追加する (to add),” “投入する throw into),” “まわし入れる (to turn),” “まわしかける (to make a turn),” “割り入れる (to insert),” “いれる (to put),” “流し入れる (pour in),” and “足す (to add)” are all defined under the umbrella term “put in.” Table 4 shows the types and number of occurrences of constituent elements when the cooking term “put in” appears. It was seen that when the cooking term “put in” appeared, a constituent element with the “material” tag appeared 97% of the time, and in the remaining 3% of instances the recipe terminology refers to an intermediate product used in the previous procedure but omits an explicit reference. Furthermore, the constituent element “tool” appeared 60% of the time. When the constituent element “tool” did not appear, the term referring to a tool used in the previous procedure order was omitted. For these reasons, the constituent elements “material” and “tool” are causes of ambiguity in relation to the cooking term “put in.” Among the constituent elements of the cooking term “put in,” there are two meanings ascribed to the tag “condition.” The first is the timing at which the “material” are to be put in, and the second is how these elements are to be put in. Additionally, cooking terms such as “切り込みを入れる (insert a notch)” and “箸を入れる (insert chopsticks)” also appeared in conjunction with “put in.” This result shows that the cooking term “put in” can be used in multiple ways.

From the above analysis, it is suggested that the lack of unity in elements under the “method” tag associated with a given cooking term may be the cause of the ambiguity in these recipes. Future research will investigate the relationships between cooking terms beyond those that were studied in this attempt (relations between cooking terms and their constituent elements). After this, a more comprehensive discussion on methods for resolving ambiguity in cooking procedures could be conducted.

3.4 Discussion

In this study, cooking terms and constituent elements were extracted from online recipes and tagged according to various properties. Ontology was created from these extracted terms, and the relationships between cooking terms and their constituent elements were investigated. During this analysis, it became clear that the meaning of cooking term verbs (“turn on,” “put in,” etc.) differs if the constituent elements associated with the cooking term are different. For example, the cooking term “turn on” may be used for either “火にかける (to put on fire)” or “出汁をかける (put on soup stock).” When the meaning of a cooking term changes according to its constituent elements, recipes should be organized such that all constituent elements associated with the cooking terms to prevent ambiguity. Conversely, it is necessary to consider common knowledge about cooking when evaluating the relationships between cooking terms and constituent elements. For instance, the cooking term “cut” is only associated with a constituent element tagged “tool” when something other than a kitchen knife is to be used. This omission is considered allowable and unambiguous because it is common knowledge that cutting in recipes should generally be performed using a kitchen knife.

In this study, tags were given to cooking terms and constituent elements according to the author’s best judgment. Therefore, no tag types are considered to be quantitatively more valid than their alternatives. For example, the constituent

Table 3. Occurrences of elements in association with verb “cut”

cut	
elements	occurences
material	140
cutting way	79
size	67
condition	15
tool	2
amount	1

Table 4. Occurrences of elements in association with verb “put in”

put in	
elements	occurences
material	248
tool	153
condition (timing)	47
condition (other)	24
amount	23

elements of the cooking term "put in" that were associated with "condition" tags are seen to have plural meanings. This suggests that there are multiple meanings for the constituent elements under the "condition" tag associated with multiple verbs, not only the cooking term "put in." As such, a future review of this and other tags may be considered necessary.

If the ambiguities currently associated with recipes posted online can be resolved, researchers will be able to organize the flow of cooking procedures and the relationship of procedures in the system. To this end, it is necessary to structure recipes such that they can be modified according to the circumstances.

In the future, we will perform user evaluation to verify whether the recipe is ambiguous and whether it is difficult for a beginner to cook because of this. Ambiguity is not explicitly indicated in cooking recipes. Therefore, in order to resolve ambiguity, we will explicitly indicate the part not clearly indicated in the recipe. This could include complementing the lack of constituent elements such as tools and quantities used. We will collect patterns of constituent elements of cooking terms that appear in every recipe and complement the parts not explicitly indicated by using them. Furthermore, we will estimate and present the part of the procedure in which a cook can easily make a mistake. By doing these, we will develop assistive technology for beginners to understand recipes.

4 Conclusion

This research aimed to allow beginners understand recipes by eliminating ambiguities in cooking procedures. Focusing on the ambiguity as a key inhibiting factor for recipe use, investigation was conducted on the factors creating ambiguity. Using the method of creating ontologies of cooking terms, the relationships between cooking terms and their constituent elements in recipes was investigated and analyzed. As a result our analysis, the main cause of ambiguity is the constituent elements with no consistency given the "method" tag associated with each cooking term.

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References

[1] R. Hamada, I. Ide, S. Sakai, and H. Tanaka. Structural analysis of cooking preparation steps in japanese. *Workshop on Information Retrieval with Asian Languages*, pages 157–164, 2000.

[2] Y. Kikkawa and H. Miyashita. A proposal of cooking recipe programming language using graphical dataflow. *IPSJ SIG Technical Report*, 2010(4):1–7, 2010. in Japanese

[3] S Mori, H Maeta, Y Yamakata, and T Sasada. Flow graph corpus from recipe texts. *Proc. 9th Language Resources and Evaluation Conference*, pages 2370–2377, 2014.

[4] Y Momouchi. Control structures for actions in procedural texts and pt-chart. *Proc. 8th International Conference on Computational Linguistics*, pages 108–114, 1980.

[5] M. Rohrbach, S. Amin, M. Andriluka, and B. Schiele. A database for fine grained activity detection of cooking activities. *Proc.IEEE Conference on Computer Vision and Pattern Recognition 2012*, pages 1194–1201, 2012.

[6] Y. Doi, M. Tsujita, H. Nanba, T. Takezawa, and K. Sumiya. Construction of a cooking ontology from cooking recipes and patents. *IEICE technical report*, 113(468):37–42, 2014. in Japanese