Accessibility-driven cooking system *

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Abstract. Research area of designing recipes is an attractive problem for the CBR community. In this paper we deal with the problem of presenting the recipe information in an understandable format for a certain user. As different users have different presentation needs, we discuss the suitability of taking the user profile into account to personalize the presentation of a suggested recipe in a cooking system. Our system relies on text simplification processes that were born from the need of people who have difficulties reading and understanding textual contents. Our system collects a case base with the best choice of *presentation* for a certain collective. Given a recipe plus details on the user profile (age, genre, educational level, languages, disability and special needs) the system retrieves from a case base the best presentation and modify the recipe presentation according to the specific user needs. The system includes learning capacity as if the final presentation is difficult for the specific user the system can easily provide her with alternate presentations. Results on the preliminary experiments are very promising and show the applicability of a CBR approach to personalize and simplify textual recipe presentations for different collectives.

1 Introduction

The Computer Cooking Contest (CCC) is an open competition where participants submit software that creates recipes. The system relies on a database of basic recipes from which appropriate recipes must be selected, modified, or even combined. Given a query describing different aspects, like the must have or desired ingredients, the type of dish (dessert, main course,..), allergies, diet, among others, a CBR approach retrieves and reuses similar recipes. For most of the queries there is no single correct or best answer. That is, many different solutions are possible, depending on the creativity of the software [1]. Our research group has participated in this contest with different systems JaDaCook[12] [13], JADAWeb[1] solving different challenges: single dish, negation and menu composition.

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[1] http://ccc2015.loria.fr/

Although we have previously obviated this aspect, one problem with knowledge formalization in the cooking domain is the use of different measure units, different math representations of the quantities and different presentations of the information, for example pictograms or videos. Case acquisition, comparison and reuse needs to deal with the different ways of measuring different ingredients: liquid ingredients and small quantities are measured by volume units, dry bulk ingredients, such as sugar and flour, are measured typically by weight ("125 g sugar"), although it is measured by volume in North America and Australia ("1/2 cup flour"). Many ingredients are measured by count: "two pieces of bread", "one chicken", "three eggs", "two carrots", although it is imprecise due to the variability of size and weight on the individual units.

Recipes as cases require a preprocessing phase to homogenize the information of the recipe (units and quantities for ingredients). Comparison between query and cases requires normalizing measure units, as there are different possibilities.

If we take different recipes from different countries, we can observe that both cuisine and bakery there is a tradition to use the system of measure units "The Imperial System of units" from English-speaking countries where they use "cups', "tablespoon" (tbsp), "teaspoon" (tsp), "ounce" (oz) such as volume units. However in Europe, they use "The International System of units" and they have different measures such as "litre"(l), "milillitre" (ml), "grams" (gr) or "kilograms" (kg). In Table 1 we can see some examples of conversion of measure units from the different systems. In addition, we can observe that not only the measure units changes in the recipes, we can see that the math representations of the quantities can be different, sometimes fractions are used (3/4 cup), other times real numbers express the measure (5.5 gr) and even percentages (50% of water) are used to represent different ingredients in the recipe.

Table 1: Some examples of conversion of measure units

Cups	**ml**	**Teaspoon**	**ml**	**Pounds**	**Ounce**	**gr**
1 cup	240 ml	1 tsp	5 ml	1 lb	16 oz	454 gr
1/2 cup	120 ml	1/2 tsp	2.5 ml	2 lb	32 oz	908 gr
1/3 cup	80 ml	1/3 tsp	1.66 ml	3 lb	48 oz	1362 gr
1/4 cup	60 ml	1/4 tsp	1.25 ml	4 lb	64 oz	1816 gr

In addition, we can observe other kinds of presentation of the information in the recipes. There is a specific collective, people with special needs, who have some problems to understand the information because they have any kind of disability or cognitive problems such as people with autism, people with aphasia, people with dyslexia or other kind of people such as children with ADHD (Attention-Deficit/ Hyperactivity Disorder) or elderly people. For many of these kinds of people, pictograms are used to represent the information that we want to offer. Pictograms are pictures that represents an object or concept, e.g. a picture of an envelope used to represent an e-mail message, it is a familiar pictograms nowadays. If we can represent different information using pictograms, we can provide access to the information for people with special needs. All these changes of presentations both of units of measure and math representations of quantities are simplifications of the original recipe for different kind of people with special needs. Text simplification process is important to adapt the information for persons who have problems to understand the information that they access. There are different type of text simplification systems to carry out this task automatically (different approaches are presented in Section 3). Nowadays, a lot of information is generated without considering the needs and factors of such target users.

We personalize different aspects to generate a human understandable presentation modifying for instance measure units, math representations of the quantities and different presentations of the information, for example pictograms or text. Variations are used to generate different presentations of the same representation of the recipe (how the recipe is manipulated by a computer) for different kind of people. In this paper we only deal with variations on the textual (and images in the case of pictograms) presentations for the recipes. Each recipe is internally represented using an structured sequence of ingredients, quantities and units of measure. We do not consider presenting the information in video format.

Therefore if we want to simplify the recipes for different end users, we have to consider different factors like age, cultural level, English level and some kind of disability to personalize the original recipe to the user presentation needs. We propose a CBR approach to personalize cooking recipes to the user presentation needs. Our system relies on a case base that collects what is the best choice of *presentation* for a certain collective. Our system proposes enriching the query with details on the user profile: age, genre, educational level, languages, disability, special needs and others, and we personalize the recipe representation to the specific needs using simplification strategies. The system includes learning capacity as if the final representation is difficult for the specific user the system can easily provide her with alternate presentations.

The rest of the paper is organized as follows. Section 2 describes existing related work on cooking systems and representation. Section 3 presents related work on text simplification systems for improving accessibility. Section 4 introduces the different representations we are using in our approach and motivates the decisions. Section 5 describes a CBR approach that combines cases of representation with the results of the cooking system JaDaCook. Section 6 presents some initial experimental results and section 7 concludes the paper and describes the lines of future work.

2 Cooking Systems

In CBR research area choosing and designing recipes is an attractive problem. Two of the more well-known CBR cookery systems, CHEF [10] and Julia [14], have proven popular over the years. CHEF is a case-based planner which rep-

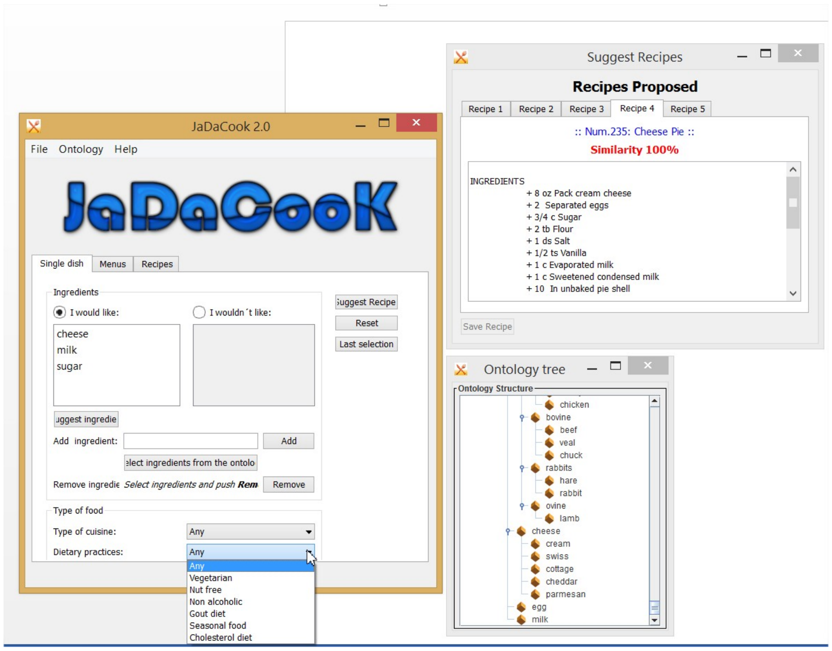


Fig. 1: JaDaCook 2 interface

resents recipes as cases using goals and problems, while Julia is a case-based design system. Both systems include an extensive semantic memory to hold the definitions of the terms needed, using frames organized into a semantic network in CHEF, and a large taxonomy of concepts in Julia.

Several systems have been presented at the last years in the Computer Cooking Contest (CCC). CookIIS [11] recommends and adapts recipes or creates a complete menu regarding to the user's preferences like explicitly excluded ingredients or previously defined diets. Taaable system [9] participated to the 2015 CCC. A formal concept analysis approach was used to improve the ingredient substitution, which must take into account a limited set of available foods. In addition, the adaptation of the ingredient quantities had improved in order to be more realistic with a real cooking setting. The adaptation of the ingredient quantities is based on a mixed linear optimization. CookingCAKE [18] is a framework for the adaptation of cooking recipes represented as workflows. CookingCAKE integrates and combines several workflow adaptation approaches applied in process-oriented case based reasoning (POCBR) in a single adaptation framework, thus providing a capable tool for the adaptation of cooking recipes. To our knowledge these previous systems do not consider different kinds of presentations of the recipe information. Most of the systems save all ingredients with the same units and they do not modify the math representations of the quantities. The simplification process in order to adapt the presentation of the recipe information for improving accessibility has not been previously considered in the systems developed in the CCC.

Our research group has developed previous approaches, namely JaDaCook [12] [13], JADAWeb[1]. Both systems rely on an ontology with reusable knowledge about ingredients, types of ingredients, types of cuisine and dietary practices. The ontology is used as background knowledge to measure similarity between ingredients and single dishes, and to substitute ingredients during adaptation. Ontology has more than 300 ingredients, organized in types and classes that cover the 1484 recipes in the case base (originally provided by the CCC-09 organizers). JaDaCook 2 reasons using different knowledge sources: (1) a case base of recipes (available from textual sources), (2) a cooking ontology, (3) a set of association rules, obtained using data mining techniques, capturing co-occurrences of ingredients in the recipes. JaDaCook 2 has been implemented using the jCOLIBRI [7] framework. Regarding presentation (see Figure 2), the JaDaCook uses "The Imperial System of units" where "cups', "tablespoon" (Tbsp), "teaspoon" (tsp), "ounce" (oz) are used such as units (see Figure 2). Each recipe describes ingredients, and quantities, plus a natural language description of the detailed preparation steps. In this paper, we propose connecting JaDaCook solution with a CBR system that simplify the recipe presentation to the user features. However, our CBR system is not dependent on JaDaCook (see Figure 5) and it could be used with other recipe recommendation system that generates on structured recipe representation with ingredients, quantities and units (see Section 4). Before describing our system in section 4 we review some state of art in text simplification systems for improving accessibility.

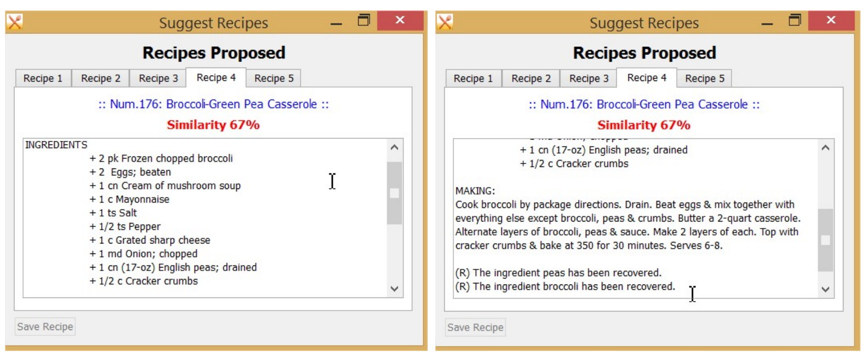


Fig. 2: Retrieved recipes, ingredients + preparation

3 Text Simplification Systems for Improving Accessibility

The text simplification process was born of the need to adapt content texts for people who have difficulties reading and understanding a text in order to be part of society because access to information is a right for all persons. Text simplification consists of the transformation of a text into a similar text, but easier to read and understand. The objective is to achieve more accessible, attractive and communicative texts so that they are interesting and motive people with difficulties to read them. Access to reading is a social need and a recognized right and reading is a pleasure that lets people share ideas, thoughts and experiences.

30% of the population [19] has reading difficulties that can be caused by different factors and this group of people needs a simplified version of texts in order to have access to information. These factors may be intercultural difficulties, complex daily texts and cognitive aspects of the reader. People who may need a text adapted from the original version in order to understand its content are older people, people learning other languages, people with cognitive problems and a range of people with special educational needs (autism, aphasia, dyslexia, etc).

In order to communicate using written texts, it is important to use simple, clear and direct expressions in order to ensure better comprehension of the texts, to achieve good communication with the target user, to work towards an inclusive social model. By carrying out certain operations at the lexical and syntactic level, linguistic complexity is taught, thus obtaining a simplified text for the final user.

There are several initiatives designed to develop the manual processing of text simplification following the European guidelines established by the IFLA [8], published by Inclusion Europe Association [15]. All of these initiatives work in the area of Easy-to-read, a movement to create special material (books, documents, website, etc.), while tending the content and layout (format, margins, fonts, spacing, etc.) so that people with reading difficulties can read and understand the material.

Simplifying a text manually is hard work in time and resources. Nowadays, information is generated very quickly and it is impossible to manually adapt accessible real-time texts. In order to solve this problem, automatic text simplification approaches have begun to appear.

The PSET (Practical Simplification of English Texts) [5] project was perhaps the first to apply natural language technologies to create reading aids for people with language difficulties. [16] proposed a rule-based system to simplify English texts for deaf people. They defined rules at the syntactic and lexical level to apply them in the original text in order to generate a easier version for these people. [6] applied automatic simplification at sentence level to generate subtitles in TV programs in Dutch and English for deaf people. [22] presented a text generation system that adapted its output for readers with low literacy.

The system *PorSimples* [4] for Portuguese was developed in order to help low-literacy readers process documents on the web. With the development of the *Guidelines for materials in readable* IFLA [8], in the work of [3] a subset of these guidelines was used to design and implement automatic rules at the syntactic and lexical level. The main objective of the project *Simplext*[2] [20] was

[2] http://www.simplext.es/

to develop the product support for text simplification in Spanish for groups of people with special reading and comprehension needs.

The *FIRST (Flexible Interactive Reading Support Tool)* project [2] is developing a tool to assist people with autism spectrum disorders to adapt written documents into a format that is easier for them to read and understand. [21] developed a project focused on the treatment of educational texts in Spanish in order to reduce language barriers to reading comprehension for the hearing-impaired, or even people who are learning a language other than their mother tongue.

We can see that in all systems of automatic simplification developed so far both the language with which they work, the target user, the kind of text and the level of difficulty to adapt the texts to play a key role in one way or another. Each system considers a set of operations to simplify at various levels, syntactic or lexical, to carry out the adaptation of the original text. In our system, we consider a special kind of texts, recipes. We need to determine the level of difficulty to simplify the text and what kind of choices for the end user, measure units, math representation of the quantity and so on, which we have to make in the original recipe to adapt for a new presentation.

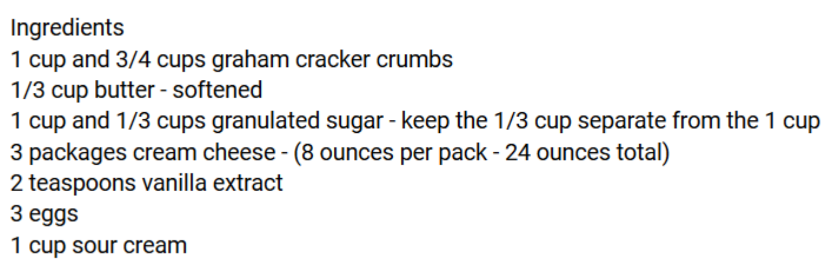
4 Variability on the Presentations

We need to chose different presentations to evaluate them. Inside the variability of the presentations we select textual representation for the ingredients, from the original language, in this case in English, in addition, in current language where we are doing the experiment, in our case, in Spanish. We select a recipe with high frequency of use, "The Cheesecake", with typical measures used in the "The Imperial System of units", such as "cups" or "tsp". This kind of recipe is easy to find in all recipes books and online webpages related to cooking. We introduce the use of pictograms to represent the ingredients of the recipe because we would like to evaluate different presentations considering different kind of people, included people with special needs who use pictograms to communicate between them. Figures 3 and 4 show some of the different presentations of the recipe used in the experiment (presented in Section 6).

We can identify different conversion rules to adapt the original recipe to final presentation. We consider rules to convert measure units, math representation of quantities and different kind of ways to present the information, using only text, using pictograms or adding video. In Table 2 we can see some examples of these conversion rules considered in our system.

We choose the following types of presentations for the case of study of "The cheesecake" recipe:

- R1: The Imperial System of units (cups, teaspoon), using fractions, Spanish language.
- R2: The Imperial System of units (cups, teaspoon), using decimals numbers, Spanish language.



Ingredients
1 cup and 3/4 cups graham cracker crumbs
1/3 cup butter - softened
1 cup and 1/3 cups granulated sugar - keep the 1/3 cup separate from the 1 cup
3 packages cream cheese - (8 ounces per pack - 24 ounces total)
2 teaspoons vanilla extract
3 eggs
1 cup sour cream

Fig. 3: Original recipe of the Cheesecake using the “The Imperial System” of units representation. Corresponding to representation 8 (R8).

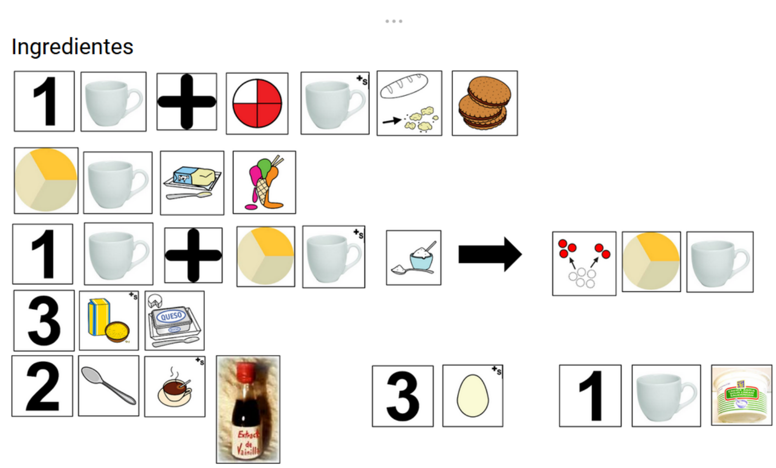


Fig. 4: Cheesecake recipe using pictograms representation for the quantities and for the ingredients. Corresponding to representation 7 (R7).

Table 2: Conversion rules from units, quantities and text.

Original Units	**Adapted Units**
1 cup	240 ml
1 tsp	5 ml
1 lb	454 gr
Original Quantities	**Adapted Quantities**
1/2	0.5
25%	1/4
0.75	3/4
Original Text	**Adapted Text**
Single String	Pictograms
Single String	Video
Pictograms	Video

- R3: The International System of units (litre, milillitre), using fractions, Spanish language.
- R4: The International System of units (litre, milillitre), using decimals numbers, Spanish language.
- R5: The Imperial System of units (cups, teaspoon), using pictograms for quantities, fractions, Spanish language.
- R6: The Imperial System of units (cups, teaspoon), using pictograms for ingredients, fractions, Spanish language.
- R7: The Imperial System of units (cups, teaspoon), using pictograms for quantities and ingredients, fractions.
- R8: The Imperial System of units (cups, teaspoon), using fractions, English language.
- R9: The Imperial System of units (cups, teaspoon), using fractions, Spanish language.

5 Accesibility driven Personalization with CBR

Our proposal uses the JaDaCook CBR system to discover a recipe that better fits the input query. The retrieved recipe is used itself as the input of our CBR system in order to simplify the recipe to the presentation needs depending on the user profile. Figure 5 shows our ideas to combine two CBR systems to personalize cooking recipes to the user presentation needs. The second CBR system relies on a case base that collects what is the best choice of presentation for a certain collective. This case base has been compiled from the answers of people who participated in the experiment (see Section 6). We have created a case base CB of around 200 cases with the following $c =< P_c, Rc_i >$ case structure:

- P_c - User description using features:

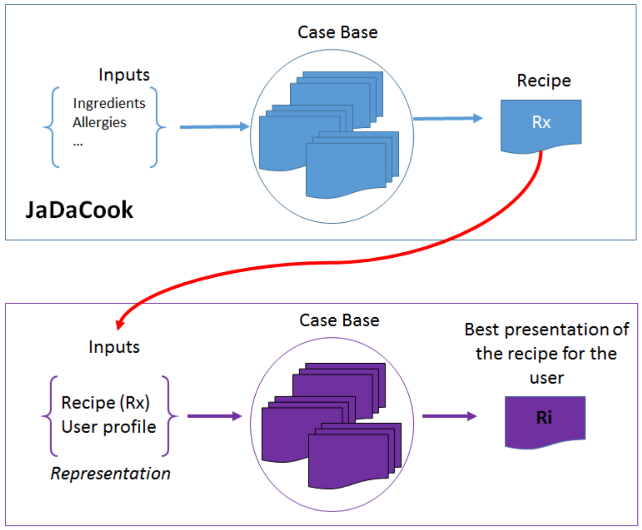


Fig. 5: Diagram of the CBR system to retrieve the best presentation of the recipe depending on the input user profile.

  - age_c: age grouped in intervals: children (6-12), teenagers (13-17), young people (18-24), adults (25-67) and elderly (more than 67).
  - ed_c: education level using enumerated values: primary school, secondary school, university, basic.
  - dis_c: disability type: dyslexia, aphasia, autism, deaf people, cognitive disability, ADHD (Attention-Deficit/ Hyperactivity Disorder) or None.
  - en_c: English reading comprehension level: none, basic, intermediate, high.
  - $cook_c$: cooking level: none, low, high.
- Rc_i, where i $\in [1, 9]$, models the different presentation according to the unit system, mathematical format, ingredients (pictograms or texts) and quantities (pictograms or texts) (see Section 4).

In Table 2 we can see some examples of these conversion rules considered in our system in order to adapt from a presentation to other presentation of the recipes.

Query Q is a description on the current user according to the P_i features. The CBR system retrieves the presentation (R_i),$i \in [1..9]$ that better fits the user needs and uses the representation features to present the recipe information.

Similarity function is a weighted average between the case description $P_c = < age_c, ed_c, dis_c, en_c, cook_c >$ and the query $Q = < age_q, ed_q, dis_q, en_q, cook_q >$.

Equality has been used as the local similarity function between attribute values and weights have been adjusted for our experiment using a Genetic Algorithm (GA). We have calculated the set of weights that maximizes the perfor-

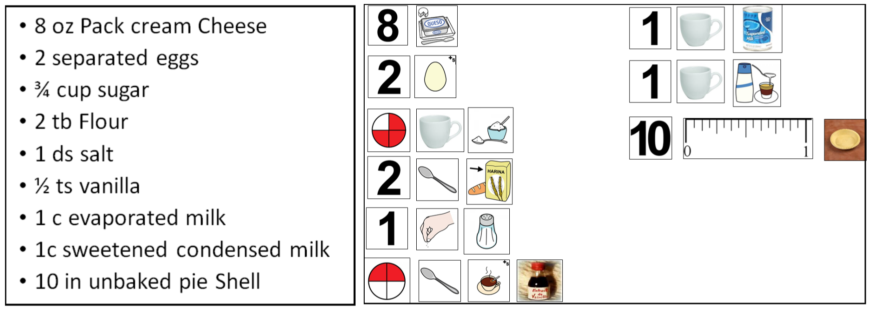


Fig. 6: Original recipe presentation (R8) and simplified recipe (R7)

mance of the system right answer rate. This is a satisfactory solution to learn the optimal weights [17]. This algorithm uses a population of individuals representing different weights. This population evolves until the algorithm obtains the individual (i.e. the weights) that returns the best performance. We obtain higher weights in order for attributes ed_c, dis_c, en_c, age_c and $cook_c$ for the case base population used in the experiments described in Section 6. Weights reflects importance on the different features but the obtained values reflects dependencies between attributes. ed_c is higher as there is a dependency with dis_c and the type of presentation needs. $cook_c$ is lower because the cheese pie recipe is easy and it doesn't affect much the presentation needs.

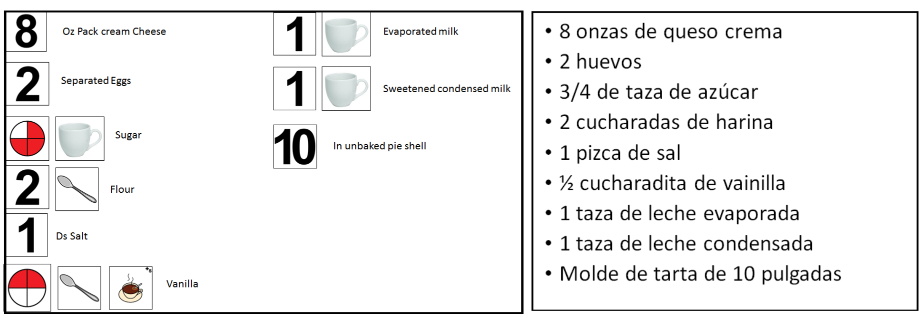


Fig. 7: Recovered recipes (R5 and R9)

We use some examples to illustrate the operation of our system. We take the recipe retrieved by JaDaCook system in the query of the example shown in Figure 6 like original recipe corresponding to “Cheese Pie” recipe (R8). Then, depending on the input profile user, our system recover different personalized recipes, based on our experiment and using our collected data. For example:

– If the input profile user is a child between 6-12 years old, at primary school, with some cognitive disability, low level of English and no cooking skills,

then the best case of representation of the recipe is using pictograms (corresponding to R7, see Figure 6).
- If the input profile user is the same but without some cognitive disability, then the best case of representation of the recipe is using pictograms only for quantities (pictograms to represent 1/4) and the kind of ingredient expressed in words (milk)(corresponding to R5, see Figure 7).
- If the input profile user is an adult between 25-67 years old, with university level, without disability, basic English level and few cooking skills, then the best case of representation is the original recipe but translated to Spanish (corresponding to R9, see Figure 7).

User profile is represented as P_u using the features described above. Input recipe is represented as a set of structured ingredient lines with quantity and units. Besides, a textual field is used to provide recipe preparation details. An example is given in Figure 1. Output of JaDaCook is used as the input of the CBR system that personalize the recipe presentation.

6 Experimental results

We carried out an experiment with different kind of users. The total of participants was 202 people, 17 persons with some special needs ($8,41\%$) and 185 without special needs ($91,58\%$). In total, we collected 21 answers of children from 6 to 12 years old. 98 answers of young people from 12 to 17 years old. 2 answers of people between 18 and 24 years old. 75 answers of people from 25 to 67 years old. Finally, we collected 6 answers of people with more than 67 years old. We defined a questionnaire using Google Form in order to use it online and collect the vast of the answers. In addition, we carried out the experiment inside of different schools in Madrid[3] where we collected the answers from children and young people who participated in the experiment. The experiment is available online in the following link[4].

We defined a questionnaire with a first part of demographic data: age, education level, disability, English-level and cooking-level. In the second part we present 9 different representations of a selected recipe, in our recipe "Cheesecake" (presented in Section 4). Each user ranked the representations and chose which ones are more easy understood and would be preferred to cook the recipe. From the collected data, we have compiled a case base CB_p with 202 cases, where each $case_i$ has a solution set with two possible presentations $S_i = R_{i1}, R_{i2}$. First presentation R_{r1} in the solution S_r is used to present the retrieved recipe in the cooking system JaDaCook (see Figure 5). Only when the user chooses an alternate presentation R_{r2} is used to present the recipe. As we have described case description uses 5 features: age, education level, disability, English-level and cooking-level. We have run an experiment using leave one out cross-validation.

[3] Thanks for the participation of students of schools "La Asunción Santa Isabel" and "La Asunción Cuestablanca"

[4] http://bit.ly/1SV0fJ3

Each case $c_i \in CB_p$ is used to query the system. CBR retrieves the most similar case c_r and propose its solutions in order, $S_r = \{R_{r1}, R_{r2}\}$. We compare solution S_r with the already known solutions of the query case: $S_i = \{R_{i1}, R_{i2}\}$. R_{r1} success is evaluated as *success*@n (R_{r1}) for $n = 1, 2$, where *success*@1 (R) = 1 if $R = R_{i1}$ *success*@2 (R) = 1 if $R \in S_i$ and is 0 otherwise. Besides R_{r2} success is also evaluated. We obtained the following experimental results:

- *success*@1 (R_{r1}) = 77.7228%
- *success*@2 (R_{r1}) = 81.2178%
- *success*@1 (R_{r2}) = 62%
- *success*@2 (R_{r2}) = 73%

We have obtained good preliminary results (around 80% in the percentage of hits) on the first presentation R_{r1}. However, results with presentation (R_{r2}) are lower and it has not resulted on useful alternative presentations. In future experiments we will consider diversity measures to propose alternative presentations that are different from the first option and let the user acquire diverse visions from the same recipe.

Solutions distribute evenly according to the different age groups, educational level, disability type, English comprehension level and cooking level. We have observed that R9 is the preferred solution for most of the age groups, although children chose R7 (pictograms for quantities and ingredients) and disable people chose R5 (pictograms for quantities) as the best presentation.

7 Conclusions and Future Work

Different people have different needs of information presentation. That is specially important in collectives of people with any kind of disability or cognitive problems, and also for children or elderly people where information needs to be simplified to be understood. In this paper we have reviewed alternative textual representations in the cooking domain. Using solutions from the cooking system JaDaCook [13] we experimented with different measure units, different formats for numeric quantities, and pictograms are used to represent recipe ingredients. In this paper we propose a CBR approach to personalize cooking recipes to the user presentation needs. Our system relies on a case base that collects what is the best choice of *presentation* for a certain collective. This case base has been collected from a questionnaire where each participant indicated her/his profile features and ranked the different choices of recipe presentations.

The CBR system uses as query a description of the user profile (age, cultural level, English level, disability, ..), compares the query with the stored cases, retrieves the most similar and reuse as solution the most suitable recipe presentation. Then the cooking system use the case solution, i.e. user preferred presentation, to personalize the original recipe to the user presentation needs.

This paper discussed the suitability of taking the user needs into account when trying to simplify and personalize the presentations of the ingredients of the recipe. Results on the preliminary experiments are very promising and show the applicability of a CBR approach to personalize and simplify presentations for different collectives. According to the obtained results people with similar features share similar presentation preferences. Of course, there are personal variations that have not been captured by the cases in the case base. We will experiment further with more people. We plan to extend the experiment to more people with special needs, as we hypothesize that the system would improve results in those collectives. We would like to test our system with a variety of collectives. The work presented in this paper opens several lines of future work. Our future work involves not only the complete development and improvement of our system to include the part of preparation of the recipe but also the development of evaluation techniques that validate the suitability and portability of our proposal to personalize the presentation of the ingredients of the recipe for different target users. We would like to compare our approach with others, for example, we could compare our result with a basic classification approach by building group (set of users) profiles for each Rx presentations, and use these 9 profiles to classify a new user according to her features and to determine the best visual presentation for her, and discuss if our CBR approach gives better results. In addition, we plan to design a GUI where the user can select the easiest presentation, included the language and possible visual presentation for preparation part of the recipe.

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