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Informatics Society

Aims and Scope

The purpose of this journal is to provide an open forum to publish high quality research papers in the areas of informatics and related fields to promote the exchange of research ideas, experiences and results.

Informatics is the systematic study of Information and the application of research methods to study Information systems and services. It deals primarily with human aspects of information, such as its quality and value as a resource. Informatics also referred to as Information science, studies the structure, algorithms, behavior, and interactions of natural and artificial systems that store, process, access and communicate information. It also develops its own conceptual and theoretical foundations and utilizes foundations developed in other fields. The advent of computers, its ubiquity and ease to use has led to the study of informatics that has computational, cognitive and social aspects, including study of the social impact of information technologies.

The characteristic of informatics' context is amalgamation of technologies. For creating an informatics product, it is necessary to integrate many technologies, such as mathematics, linguistics, engineering and other emerging new fields.

Guest Editor's Message

Takuya Yoshihiro

Guest Editor of Eighteenth Issue of International Journal of Informatics Society

We are delighted to have the eighteenth issue of the International Journal of Informatics Society (IJIS) published. This issue includes selected papers from the Seventh International Workshop on Informatics (IWIN2013), which was held at Stockholm, Sweden, Sep 1-4, 2013. The workshop was the seventh event for the Informatics Society, and was intended to bring together researchers and practitioners to share and exchange their experiences, discuss challenges and present original ideas in all aspects of informatics and computer networks. In the workshop 24 papers were presented in five technical sessions. The workshop was successfully finished with precious experiences provided to the participants. It highlighted the lasts research results in the area of networking, business systems, education systems, design methodology, groupware and social systems.

Each paper submitted IWIN2013 was reviewed in terms of technical content and scientific rigor, novelty, originality and quality of presentation by at least two reviewers. Through those reviews 15 papers are selected for publication candidates of IJIS Journal, and they are further reviewed as a Journal paper. This Eighteenth includes three papers among the accepted papers, which have been improved through the discussion of IWIN2013 and the reviewer's comments.

We publish the journal in print as well as in an electronic form over the Internet. We hope that the issue would be of interest to many researchers as well as engineers and practitioners over the world.

Takuya Yoshihiro received his M.I. and Ph.D. degrees from Kyoto University in 1998, 2000 and 2003, respectively. He was an assistant professor at Wakayama University from 2003 to 2009. He has been an associate professor in Wakayama University from 2009. He is currently interested in graph theory, distributed algorithms, computer networks, wireless networks, medical applications, bioinformatics, etc. He is a member of IEEE, IEICE, and IPSJ.

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

Mana Tanaka[†], Etsuko Inoue[‡], Takuya Yoshihiro[‡*], Masaru Nakagawa[‡]
[†]Graduate School of Systems Engineering, Wakayama University, Japan
[‡]Faculty of System Engineering, Wakayama University, Japan
[*]tac@sys.wakayama-u.ac.jp

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 designed 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 approprate 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

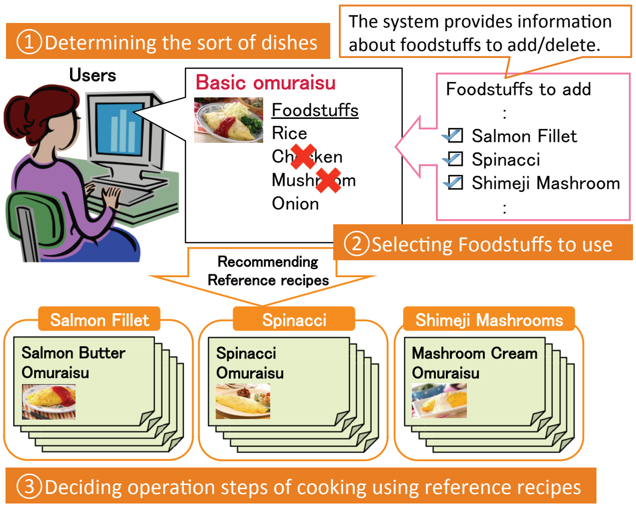

Figure 1: Overview of Usage of Our System

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)

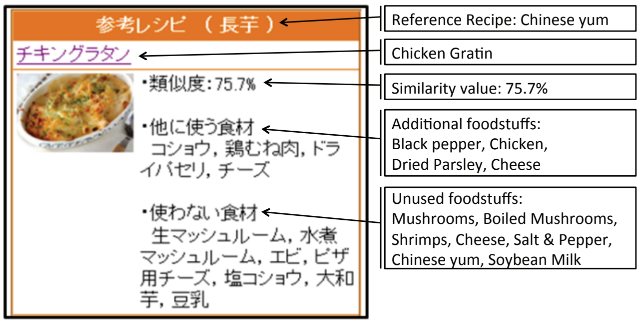

Figure 4: Layout of a Reference Recipe Displayed in the field Ⓒ of Fig.2

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

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

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

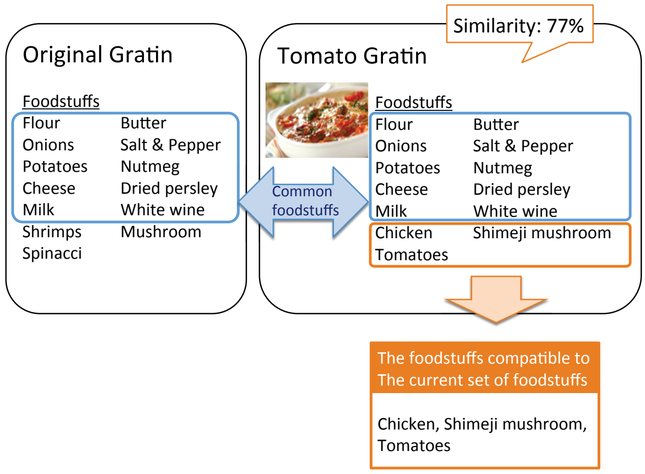

Figure 5: Computing Foodstuffs Compatible with The Original Recipe (Criterion (c))

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

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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Mana Tanaka received the B.E. and M.E. degrees from Wakayama University in 2011 and 2013, respectively. She is currently working with Hitachi Solutions, Ltd.

Etsuko Inoue received the B.E., M.E. and Ph.D. degrees from Wakayama University in 2002, 2004 and 2007, respectively. She is an Assistant Professor in Wakayama University from 2007. She is interested in database systems, web applications, data visualiza- tion, and so on. She is a member of IPSJ.

Takuya Yoshihiro received his B.E., M.I. and Ph.D. degrees from Kyoto University in 1998, 2000 and 2003, respectively. He was an assistant professor in Wakayama University from 2003 to 2009. He has been an associate professor in Wakayama University from 2009. He is currently interested in the graph theory, dis- tributed algorithms, computer networks, medial applications, and bioinformatics, and so on. He is a member of IEEE, IEICE, and IPSJ.

Masaru Nakagawa received the B.E, M.E, and Ph.D. degrees from Osaka University in 1970, 1972, and 1990, respectively. He was a researcher in NTT laboratory from 1972 to 1994, and from 1994 he was a Professor in Kinki University. He is a Professor in Wakayama University from 1994. He is interested in Database Design and Computer System Engineering. He is a member of IPSJ, JSAI and JSIK.

Disaster-Relief Training System Using Augmented Reality and Voice Input Triage

Misaki Hagino†, Yoshiaki Ando†and Ken-ichi Okada‡

†Graduate School of Science and Technology, Keio University, Japan
‡Faculty of Science and Technology, Keio University, Japan
{misaki, ando, okada}@mos.ics.keio.ac.jp

Abstract - When a large disaster happens, health care workers need to determine the priority of medical treatment and perform triage. In order to carry out emergency lifesaving activities at an actual disaster site quickly and accurately, frequent training is very important. However, current training has issues such as cost, many time and effort to prepare, as well as not being able to consider changes of patient's vital signs. In addition, they cannot use any hands while writing paper tags or using PDAs, so it is difficult to perform necessary medical treatment in parallel. In this study, we propose triage training system where health care workers get patient information through a monocular HMD (Head Mount Display) and perform triage via voice input, so their hands are free to conduct necessary treatment even while doing triage. Moreover our system can reproduce the situation through the HMD by superimpose dynamic information about patients onto real space, and allow sharing the training status. The evaluation shows that our system enables to perform triage quickly and accurately with health care workers' hands free and make disaster-relief trainings more meaningful.

Keywords: Triage, Disaster-Relief Training, Monocular HMD, Voice Input, Augmented Reality

1 INTRODUCTION

When a large-scale disaster occurs, a large number of people are injured at the same time, so medical workers first need to do triage in order to decide the priority for treatment depending on their severity of injury and the urgency of treatment. The purpose of triage is to save more lives through efficient use of a limited medical resource.

Currently, paper triage tags are often used to indicate the condition of patients and to record information of their injuries. However, in a confused situation, it may be difficult to record information due to loss of paper tags attached to the patients and it may be impossible to respond and adjust quickly to fast changing conditions. In addition, writing something on paper tags is also one of the factors that disturb diagnostic actions from busy health care worker's hands.

Therefore, in recent years, electronic triage systems have been researched in order to support lifesaving emergency activities. We have been developing an electronic triage system where patients information is sensed by electronic tags and is presented to PDA (Personal Digital Assistance) terminals which health care workers hold [1].

Frequent training is very important for health care workers to be accustomed with real disaster situations and to master the method of triage by performing tasks such as decision of tag color and transportation of patients, however, current training has issues such as cost and human resource for preparing and conducting the training. In addition, while patients' vital sign in training is static and does not change because a healthy person plays the patient. Furthermore, writing on triage tags or using PDAs requires use of the hands, hampering immediate medical treatment.

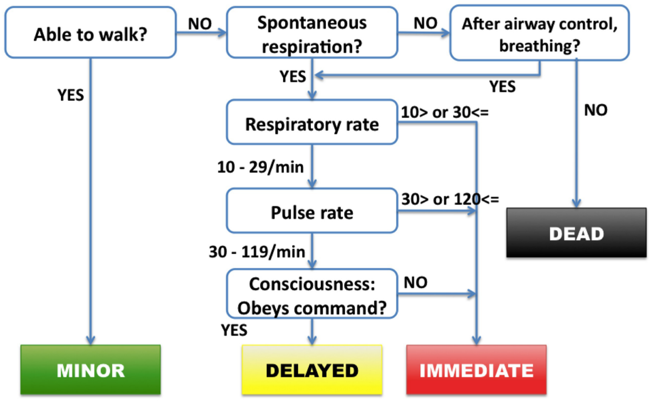

Figure 1: START method

In this study, we propose triage training system where health care workers can get information such as patient's vital signs through a monocular HMD and can perform triage via voice input. Our system can reproduce realistic situations through monocular HMDs, change patients' biological information such as vital signs dynamically and allow sharing the training status among participants.

In Section 2, we provide outline and discuss issues. In Section 3, we show our proposal of solving the issues. Section 4 explains the implementation of our system. Section 5 discusses the assessment of our system and Section 6 discusses future work of our system. Finally, Section 7 presents our conclusion.

2 LIFE SAVING ACTIVITIES AT DISASTER SITE

2.1 Medical Services Based on Triage

In Japan, health care workers perform the triage based on START (Simple Triage and Rapid Treatment) method shown in Fig. 1 at a triage post [2]. The purpose of the triage is to classify patients according to their vital signs such as respiratory rate and pulse rate, so health care workers only perform eastriction' and eairway control' as immediate medical treatment. patients are categorized for their treatment priority into the following four: Red (immediate) $\rightarrow$ Yellow (delayed) $\rightarrow$ Green (minor) $\rightarrow$ Black (dead). After each triage, a health care worker writes necessary information, such as person's name, age, blood type, transportation, organization and the name of the health care worker in charge, on a paper tag shown in Fig. 2, removes unnecessary colors, and attaches it

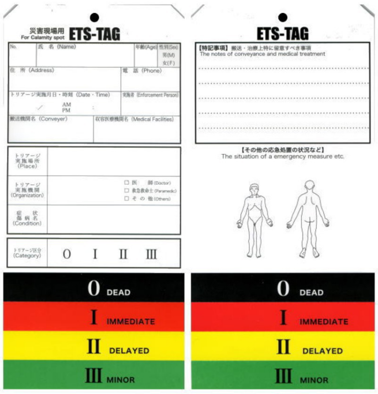

Figure 2: Paper triage tag

to the patient [3].

After the triage, patients are taken to each tag color's post and health care workers perform the second-triage in order to determine priority with transportation to hospitals. In this paper, we focus only on the triage.

2.2 Current State of Disaster-Relief Training

After the Hanshin-Awaji Great Earthquake in 1995, residents of the surrounding area have had more opportunities to participate in disaster training with health care workers. Furthermore, since JR Fukuchiyama Line derailment accident, the concept of triage in lifesaving emergency activities has been widely recognized, and triage training has become essential in order to perform actual triage quickly and accurately in a real situation [4]. Triage training process and its procedure may differ by medical centers, but the basic procedure is as follows. People who play patient role have a piece of paper describing their imitating symptoms and biological information. They need to pretend the written symptoms to health care workers. Then, health care workers determine the priority for treatment by observing the behavior of a patient role and information on the paper. After that, health care workers writes necessary information on a paper tag and makes an order to transport patient role to the corresponding tent.

For example, Fuji city has conducted a training of doing triage, conducting treatment, recording information and transporting patients depending on the result of triage [5]. Yamanashi School of Medicine has also conducted an experiment of an electronic triage system, TRACY, where FeliCa IC cards are used [6]. The system aims to share widespread disaster information. In addition, the Emergo Train System, which is a disaster training system with desktop simulation, has also been employed in recent years [7]. Using this training system, health care workers can study proper arrangement of personnel by moving magnets instead of patients and health care workers on a whiteboard which represents a disaster site and hospitals.

2.3 Related Work and Issues

In recent years, systems based on RFID (Radio Frequency Identification) tags and sensors have been researched to be used for emergency lifesaving in disasters [8]. In the Code-Blue Project [9], vital signs obtained from sensors are collected through an ad hoc wireless network. MEDiSN [10] is a sensor network platform for automating physiological monitoring of patients in hospitals and in mass disasters. Furthermore, studies that collect patient's vital signs using mobile information terminals, such as PDA (Personal Digital Assistance), have been conducted [11], [12].

However, in order to check information and to enter information, health care workers have to hold the PDA on their hand. Therefore, they cannot use any hands prohibiting them from performing necessary immediate medical treatment in parallel. In addition, there are other problems in current training systems. In the case of current training systems, biological information of patients does not change as an actual disaster situation, because health care workers make diagnosis based on written paper. Moreover, health care workers perform treatment action and transportation action according to the given manual. An additional problem is that frequent training is impractical, because it requires participation of many health care workers and people acting patients, and also requires considerable time and effort to create a scenario of the training and setting up the equipment. The Emergo Train System allows for frequent training because it does not need any actors to play patients, but it does not reproduce a real disaster site or gives a sense of reality. Moreover, the existing training systems cannot utilize triage records or action histories.

3 DISASTER-RELIEF TRAINING SYSTEM USING AUGMENTED REALITY AND VOICE INPUT TRIAGE

Disaster-relief trainings need to be done frequently in order to make effective use of the developed system in real disaster situations and carry out emergency lifesaving activities at an actual disaster site quickly and accurately. However in the current training patient's vital signs does not change actually so it is less of a reality. Moreover reproducing a real disaster site is difficult and sharing the status of training is insufficient. Also writing paper tags or using PDA hinders the necessary immediate medical treatment that they must conduct in parallel, and slows down the speed of triage.

Therefore we need to develop disaster-relief training system where health care workers can perform triage with their hands free and conduct training in consideration of biological information without imposing time and effort.

3.1 Reproducing Disaster Situation

In triage based on the START method (Fig. 1), vital signs such as respiratory rate, pulse rate and SpO_2 (oxygen density in blood) become the key element to determine the priority. Therefore, it is necessary to prepare those patient information upon conducting a training. However, it is difficult to ask persons who are actually injured to participate in a training. Although vital signs can be gathered from healthy participants, their values are normal and cannot be used for the training to detect any abnormality. In a current training, abnormal values of vital signs are written on a piece of paper and triage is performed by referring to those static information. However, actual vital signs changes constantly. It is sometimes necessary that some play a role of indicating a sudden change to symptoms. Therefore, training system is desirable which can reproduce dynamic patient information that constantly changes.

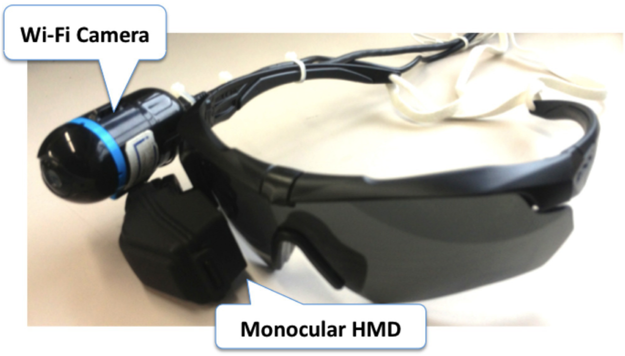

Figure 3: Monocular HMD and Wi-Fi camera

In addition, it is important in a real diagnosis to see the positional relationship between a patient and a health care worker. A health care worker approaches a patient, touches the body directly and checks the detail of injury. In order to make a diagnosis correctly, a health care worker needs to see the body closely. Therefore, we need to reproduce the state changes associated with the positional relationship in the training system. In our system, the distance between a health care worker and a patient and the direction are used to change how much patient information is shown.

3.2 The Voice Input in the Triage

It is desirable to conduct triage in less than one minute per patient. However, in a chaotic situation, there is a possibility that health care workers may make a mistake to determine the priority, or may forget the detail of the START method. Furthermore, they cannot use any hands while writing paper tags or using PDA, and cannot fully perform treatment actions allowed for the triage, such as 'astriction' and 'airway control'. As a result, the triage may take more time.

We have designed voice input function with which health care workers can perform triage quickly and accurately while keeping their hands free. In addition, we use Vuzix's TacEyeLT as our monocular HMD, Ai-Ball's Trek as our Wi-Fi camera to recognize AR (Augmented Reality) markers attached to patients, and Apple's iPhone4S as our terminal for screen output to the HMD (Fig. 3). Health care workers operate our system by answering questions displayed on the HMD screen. The questions are also offered as sounds through the earphone so that they can operate without relying wholly on the screen. Answers to the questions are either two choices such as 'Yes' or 'No' or simple choices which they can answer easily. Moreover, the questions are customized according to each patient's vital signs such as respiratory rate and pulse rate. These functionalities reduce the burden of the thinking of the health care workers and their mistakes of triage.

3.3 Sharing of Training Result

One of the important things in training is to repeat basic trainings [13]. Especially, it is important that health care workers can find their weak points by themselves after each training is done. However reviewing the result of training is really hard because current training systems use a whiteboard to share training logs such as progress of triage, patients' biological information, health care workers' actions, and so on.

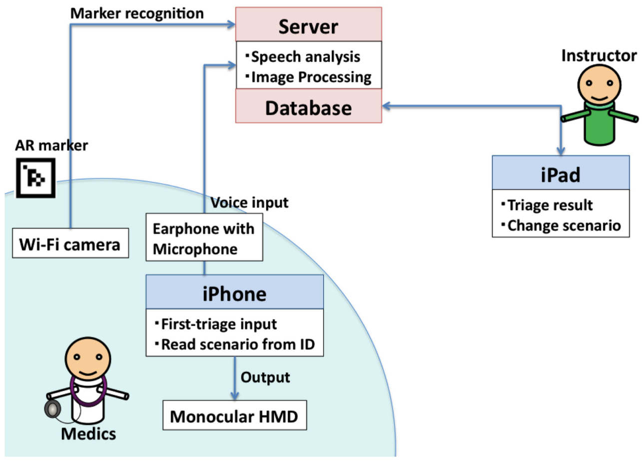

Figure 4: Configuration of the system

Only those who wrote texts on the whiteboard may understand them. The training is more effective when it is carried out with a group of people. After the training, it is important to review the training logs as well as to understand the situation of other participants. Reviewing the action history after the training enables to analyze mistakes of triage.

4 IMPLEMENTATION

4.1 System Configuration

Figure 4 shows the overall configuration of the system. A health care worker and an instructor use the system as a pair. The health care worker who performs triage is equipped with an iPhone and a monocular HMD to which an earphone-mike and a Wi-Fi camera are attached. Sight of user's one eye is not always be completely blocked, and users can see the HMD screen by looking at the upper part of the glasses. The instructor evaluates health care worker's training using an iPad.

First, in the training site the instructor places AR markers which are used instead of patients. When the health care worker looks at an AR marker via the Wi-Fi camera, the scenario of the patient corresponding to its ID number can be read. Beforehand, the instructor sets up each patient's biological information such as vital signs and the tag color, as that person's scenario. During the training, the vital signs simulating a real patient is generated depending on the tag color, and the information management server keeps updating the information at regular intervals. When viewing the AR marker, the health care worker can carry out triage with voice input by referring patient's information in the monocular HMD. After the triage result is stored, health care workers can check the tag color by looking at the AR marker again. Via the network, the database stores scenario information created by the instructor, the voice inputs from the health care worker, the result of triage, the result of marker detection and the result of monocular HMD output. This database enables output of the training result in real time.

4.2 Training System by Reproducing Disaster Situation Through the Monocular HMD

In our training system, patients are represented by AR markers in a training space. Therefore, the preparation is easy:

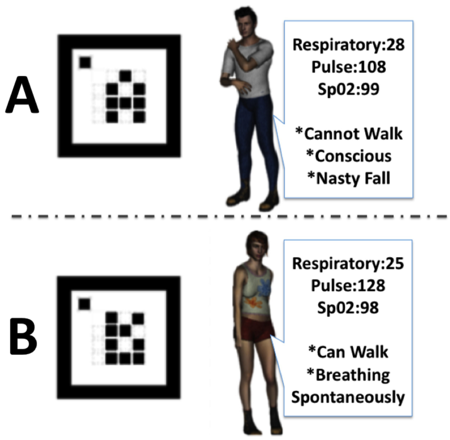

Figure 5: Different scenario depending on ID numbers

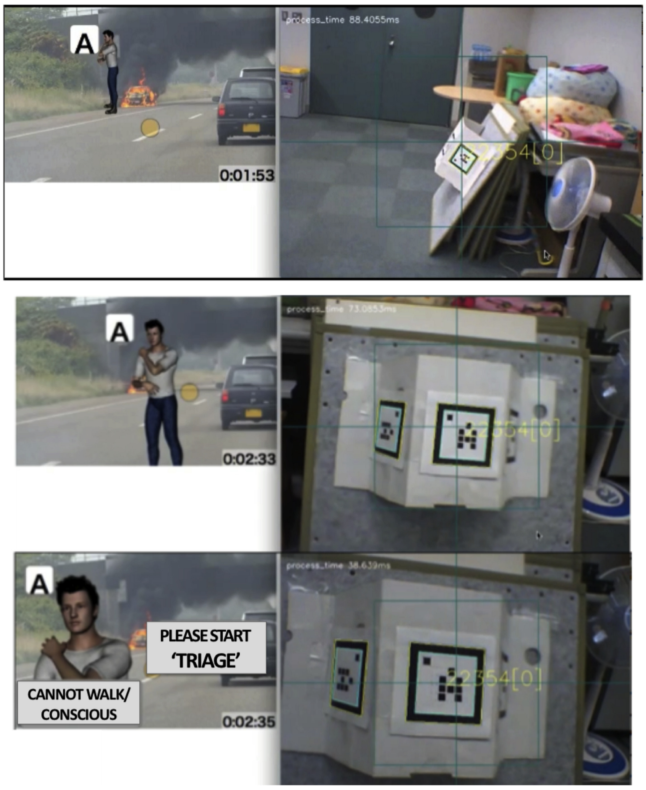

Figure 6: Difference by distance and orientation from markers

placing AR markers in the training space. When a marker is recognized by a Wi-Fi camera, the patient's scenario can be read according to its ID number (Fig. 5). The reasons why we use AR markers are: anyone can create them easily, and they prevent from misreading ID numbers. We use AR markers looking like alphabets.

The presentation of patient's information changes according to distance and direction of markers. When performing triage, a health care worker should face the patient. Therefore, we reproduced the difference of face-to-face state and side state by the orientation of markers (Fig. 6). The left images are displayed on the health care workers' monocular HMD and the right images represent the direction and the distance of AR markers.

Also Figure 6 shows the states depending on the distance

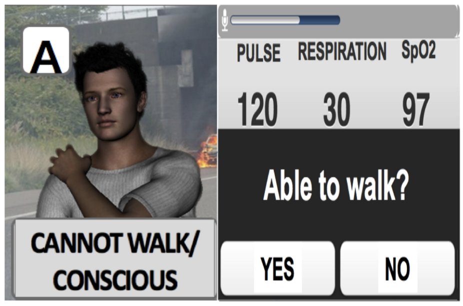

Figure 7: Interface of the triage input during training

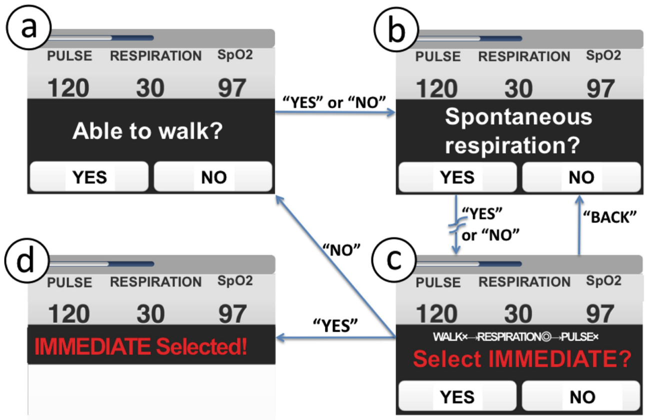

Figure 8: Triage input flow

from markers. For example, triage can be done only when the distance is less than one meter. According to the distance, the displayed patient's information changes as follows:

- One marker within one meter:
  Can perform triage and can see all the patient's information.
- More than one marker or one marker beyond one meter:
  Cannot perform triage and can see only some information of patients. The scene is displayed from afar and a diagnosis cannot be made.
- Marker outside of view:
  Cannot triage and cannot see patient information.

If the health care worker says "start" in the bottom screen of Fig. 6, interface of the triage input is displayed at the right side of the screen (Fig. 7).

4.3 Input Interface of the Triage

Figure 8 shows the input interface flow of the triage. The bar on the top of the screen shows the best timing of voice input. Underneath the bar, health care workers can see respiratory rate, pulse rate and SpO_2. The questions for determining the medical treatment priority based on the START method are displayed in the middle of the screen, and health care workers can answer the questions using voice input. We have designed each item so that it can be recognizable on a small display of monocular HMD.

If the camera recognizes an AR marker, it will move to the state where triage can be started. If the health care worker

Table 1: Vital sign parameters

Triage color	Consciousness	Parameter		
		Respiratory	Pulse	SpO_2
Red	Yes or No (Pattern I)	under 10 or over 30	50–180	90–99%
	Yes or No (Pattern II)	1–50	under 50 or over 120	90–99%
	No (Pattern III)	1–50	20–180	90–99%
Yellow	Yes	10–30	50–120	90–99%
Green	Yes	10–30	50–120	90–99%
Black	No	0	0	0%

says "start", it changes the screen as is shown in (a), and the health care worker can answer questions one by one. The system judges automatically the value of vital signs acquired from the patient, and the next question is selected as is shown in (b) and (C). After selecting the priority as is shown in (d), the triage result is sent to the database. If the health care worker makes a mistake, he/she can say "back" and the triage can be redone from the beginning. Thus, the health care worker can conduct triage without using any hands, and necessary immediate medical treatments can be performed in parallel.

4.4 Generation of Simulated Vital Signs

Our system generates simulated vital signs such as respiratory rate, pulse rate, and SpO_2 dynamically as Table 1 according to each tag color. The values have been determined from the discussion with emergency medical specialists at Juntendo University School of Medicine.

The vital signs are generated at random by our system. We set the upper limit of respiratory rate to 50 breaths per minute and pulse rate to 180 beats per minute. We also set the delta per unit time. Breathing rate's delta is less than 10 breaths per minute, pulse rate's delta is less than 20 beats per minute and SpO_2's delta is less than 1 percent per minute. This is to eliminate the impractical values and changes in a real situation. We have three patterns which generate vital signs depending on patients' condition in a case that the triage color is red. Pattern I is when the breathing rate is abnormal and pattern II is when the pulse rate is abnormal. Pattern III is when patients are unconscious. This provides health care workers with criteria by means of biological information to decide who need to be given priority for treatment and transportation among multiple numbers of casualties with red tag. In our system, when patient's condition changes from green or yellow tag to red tag, it is defined as 'sudden change'. If there is sudden change to somebody, health care workers can recognize it via the monocular HMD.

4.5 Interface of Training Result

After a training, reflecting on one's own actions is very important. Figure 9 shows the display of the training history as seen on the iPad by the instructor. The instructor can see information such as patient's image according to its ID, when each patient was carried, when each patient was transported, when each patient got sudden change, when triage started, when it finished, how long it took, and how many mistakes were made. The instructor can look back on the flow of triage and the cause of mistakes based on this information. In addition, since the information will be updated in real time during the training, the instructor can continuously monitor how each

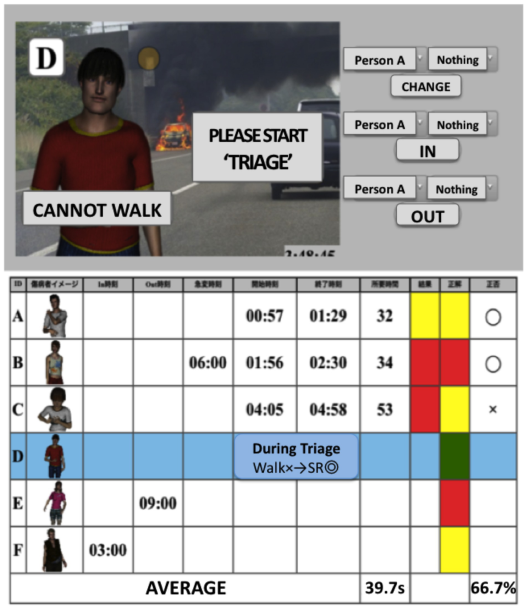

Figure 9: Interface of training result

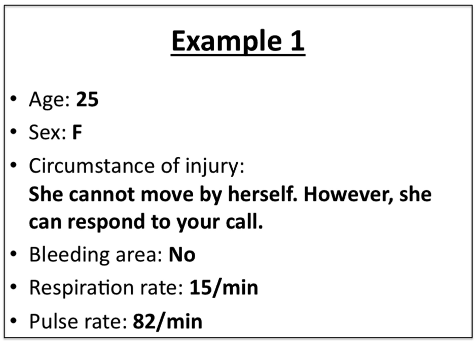

Figure 10: Example of a patient

health care worker is performing. The top left of Fig. 9 shows the monocular HMD display as seen by a health care worker. The top right shows buttons to change scenario during training. By using these buttons, the instructor can add other patients or delete current patients and make sudden change to arbitrary patients.

5 EVALUATION

5.1 Evaluation of the Triage Input Interface

5.1.1 Procedure

In the first evaluation, we compare our triage input system by voice and the current system of using paper based tags. Each examinee performs ten times of the triage based on the example of the patients shown in Fig. 10. In the experiment, person type sleeping-bags are used instead of patients. An examinee performs 'airway control' by raising the patient's head, and 'astriction' by connecting bleeding part with a string, and 'check of consciousness' by talking to the patient. A sheet of paper on which injury is written (i.e. Fig. 10) and an AR marker are attached to each patient (i.e. a sleeping bag). In the case of paper tag system, we asked to write the patient number, the start time, examinee's name, the tag

Table 2: Result of the triage input

	Paper Tag	Our System
Required Time (sec)	67.7 ± 17.4	32.7 ± 12.8
Correctness (%)	86 ± 35	97 ± 17

Table 3: Questionnaire result of the triage input

Question	Score
Was the triage input easy?	4.5
Were you able to perform medical treatment in parallel?	4.0
Was the screen on the monocular HMD easy to understand?	3.7
Did you feel tired?	3.8

color, and the diagnostic flow on the paper tag. In the case of using our system, the system records these items automatically. We selected ten students as examinees. Five of them started off with the paper tag system and then used our system, and the other five did in the reverse order. Because we wanted to compare the paper tag system with our system by the first evaluation, we did not consider the distance and the direction with the AR marker. We wanted evaluate whether examinees were able to perform triage using the monocular HMD with voice input.

5.1.2 Result

Table 2 shows the results. In the T-test, there are significant difference of 5 % levels of significance both in Required time and Correctness. Firstly, we focused on the ‘required time’ for input the triage. When our proposed system was used, the required time for triage per person was shortened for 35.0 seconds compared with the paper tag. In addition, it is desirable to conduct triage in less than one minute per patient. With our system the examinee was able to perform triage in 32.7 seconds. In the case of using paper tags, it was hard to carefully choose selection conditions of the START method and it also took time to record many things on paper tags. In the case of our system, examinees only needed to answer to given questions, and could perform the triage easily. In addition, they were able to perform medical treatment in parallel.

Secondly, if we focus on the ‘percentage of correct answers’, our system is 11 point better than the system using paper tags. The main reason of the improvement is that our system supports examinees to determine the priority by only judging patient’s vital signs so that they may not need to remember the START method fully.

Furthermore, Table 3 shows the result of the questionnaire about usability. In the evaluation, five is best, one is worst in each item. The questionnaire result shows the triage input was easy and hands free was realized. For those reasons, we have confirmed the usefulness of our input interface for the triage.

5.2 Evaluation of Simulation Disaster-Relief Training

5.2.1 Procedure

We examined whether examinees were able to easily construct training environment and perform simulation training while wearing the monocular HMD. Examinees were put into pairs consisting of a health care worker and an instructor, and carried out preparing a training environment, responding to sudden patient’s condition changes, transporting patients, and performing triage. The disaster scenario used in the evaluation was a traffic accident involving two automobiles, and seven people were injured. There were two persons with red tag (Patient B and E), three persons with yellow tag (Patient A, C and F), two persons with green tag (Patient D and G), and none with black tag. These data are taken from a report of the triage training conducted at the Urayasu Hospital of Juntendo University School of Medicine.

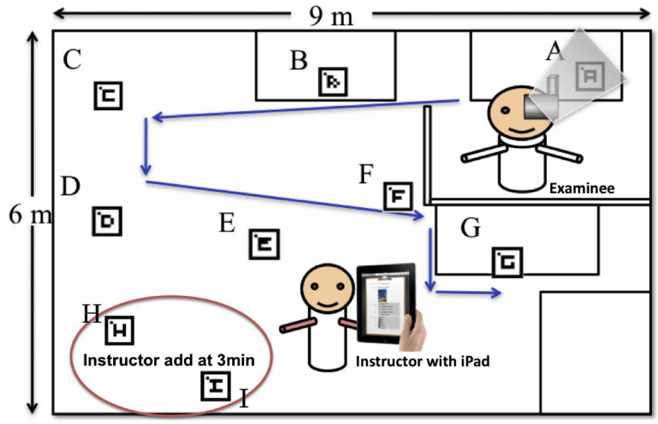

Figure 11: Evaluation of simulation disaster-relief training

Before training, the instructor prepares the training environment by placing AR markers according to Fig. 11 for the scenario prepared in advance (instructor’s event 1). Once the training started, the health care worker perform voice input triage while looking at patients and their information displayed on the screen through AR marker recognition by the Wi-Fi camera attached the HMD (health care worker’s event 1). At this time, the health care worker conducted triage in turn from Patient A to G along the blue arrow in Fig. 11. Also, the instructor produced/added the following events according to the scenario while confirming the triage officer’s performance. As the notification of the added events were displayed on the triage officer’s monocular HMD, he/she needs to stop conducting triage and respond to the events. For instance, if the instructor adds Patient H as the event, the notice “Patient H was newly added” is displayed on the triage officer’s monocular HMD.

- At 3 min: The instructor adds Patient H with red tag and Patient I with yellow tag (instructor’s event 2). The instructor place AR markers corresponding to the patients. The health care worker confirms new patients and accepts the event (health care worker’s event 2).
- At 6 min: The instructor generates a sudden change to patient B’s condition (instructor’s event 3). The health care worker goes to the patient and handles accordingly (health care worker’s event 3).
- At 9 min: patient can be transported out from the scene (instructor’s event 4). The health care worker decides that two patients assigned red tags should be transported (health care worker’s event 4).

Table 4: Average time required for instructors

(event 1)	Time required to place AR markers	75.2 s
(event 2)	Time required to place AR markers for additional scenario	18.4 s
(event 3)	Time required to create scenario when sudden change occurs	7.6 s
(event 4)	Time required to create additional scenario of removing patients from scene	9.3 s

Table 5: Average time required for health care workers

(event 1)	Triage time per person	32.6 s
(event 2)	Time required to respond to notice new patients	8.4 s
(event 3)	Time required to take action in response to noticing sudden changes	47.1 s
(event 4)	Time required to decide on which patients to transport from scene	73.3 s

Table 6: Results of training questionnaire

	Question	Score
Health care worker	Was it easy to understand the presentation of patients information?	4.3
	Was it easy to see patient information on the HMD?	3.7
	Did voice recognition work satisfactorily?	3.1
	Was it easy to notice events?	4.6
	Did you see improvement in results?	4.1
	Did you work without feeling fatigue?	3.5
Instructor	Was it easy to understand the implementation status of triage?	4.3
	Was it easy to change the scenario?	4.5
	Did you feel like an active participant in training?	4.0
	Was it easy to find areas of improvement for the health care worker?	4.2
	Was it easy to implement training using this system?	4.1
	Did you work without feeling fatigue?	4.6

After the training, the instructor informs the health care worker of the elapsed time and the accuracy rate, and they exchange some comments. The examinees in this experiment were 10 pairs of students.

5.2.2 Result

Table 4 shows the average time required by the instructor for each event, and Table 5 shows the average time required by the health care worker for each event. The health care worker's event 1 represents the ten health care workers' average time required for conducting triage per one patient. The other event was only once occurred in each training and the average time of ten people, the instructors and the health care workers each, was calculated. The experimenter measured the time in a stopwatch. In the health care worker's event 2, the experimenter measured the time between when the notice of the added event was displayed and when he/she accepted.

For instructors, the results show that the required time for each event was very short. It was possible to construct a training environment around one minute, and to modify scenario less than 20 seconds during training. On the other hand, the required time of health care workers needed to determine tag colors was an average of 32.6 seconds per patient. Because triage is ideally performed in one minute per patient or less, we can say this is a useful result. Moreover, the results were similar to the experiment 1 and the trainees could make efforts in training without disturbing becoming skilled in triage even if the patients were virtualized. Health care worker's event 2, 3 and 4 show that health care workers completed correct actions in a short time when instructors added those events. These results show that health care workers responded quickly to various situations that occurred in triage. In addition, Table 6 shows the questionnaire results about the training. In the evaluation, five is best, one is worst in each item. The questionnaire results show high score for all items pertaining to both health care workers and instructors. Thus we have confirmed the usability of the training using our system.

However, according to the network crossing and the light quantity in the training environment, our system was hard to detect of AR markers. Furthermore, the pronunciation that was hard to be performed voice recognition depending on a user was found. The improvement of the system which is not influenced by the personality of user and training environment will be necessary.

6 FUTURE WORK

The problem of introducing this proposed system is how to recognize the patients and obtain biological information. The research and development of the electronic triage system are now carried out flourishingly and the small electronic tags that incorporated a biological sensor in the radio sensor network device equipped with a small CPU were developed as the substitute of the paper triage tags [14]. We consider that it is possible to use this proposed triage system in the real spot by sticking the AR markers on the electronic tags and attaching them to the patients. We would like to inspect whether our system can be introduced into the real spot with combining the electronic triage tags and the AR markers.

7 CONCLUSION

When a large number of people are injured at the same time, health care workers first need to perform triage in order to decide the priority for treatment depending on their severity of injury and the urgency of treatment. Nowadays, electronic triage systems that use PDA have been studied intensively. However, the operation of the devices may slow down the triage and become an obstacle for conducting necessary treatment in parallel. In addition, disaster-relief training is very important for health care workers to be accustomed with real disaster situations and to know how the electronic triage system works before it is actually used. In the case of current training systems, biological information of patients does not change as an actual disaster situation, and frequent training is impractical. Furthermore, there are many other problems in current training system.

In this study, we have developed disaster-relief training system with monocular HMD and AR markers and can control the system via voice input. In our training system, patients are represented by AR markers, so the preparation is easy, and enables to reduce cost and human resources. The presentation of patient's information changes according to distance and direction of markers and their vital signs are generated at random by the system. In addition, the training result can be shared after the training. We also enables to health care workers perform triage with their hands free to conduct necessary immediate medical treatment even while doing triage.

After conducting the experiments of triage input interface and simulation disaster-relief training, we have confirmed that it is possible to determine the priority faster and more accurately with voice input than the current paper tag system, and make disaster-relief trainings more meaningful.

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Misaki Hagino B.S. degree from the Department of Information and Computer Science of Keio University, Japan in 2013. She is currently working toward an M.S. degree in Open and Environment Systems at Keio University. She received the Student Award from IWIN'13. Her research interests include group work support.

Yoshiaki Ando B.S. degree from the Department of Information and Computer Science of Keio University, Japan in 2012. He is currently working toward an M.S. degree in Open and Environment Systems at Keio University. His research interests include group work support.

Ken-ichi Okada received his B.S., M.S. and ph.D. in instrumentation engineering from Keio University, in 1973, 1975, and 1982, respectively. He is currently a chief professor in the Department of Information and Computer Science at Keio University. His research interests include CSCW, groupware, human computer interaction, and ubiquitous computing. He has published 140 journal papers, 170 international conference papers, and 18 books entitled "Collaboration and Communication", "Designing Communication and Collaboration Support Systems", "Introduction to Groupware" and so on. He is a member of IEEE, ACM, IEICE and IPSJ. He was a chair of SIGGW, a chief editor of IPSJ Magazine, and a chief editor of IPSJ Journal. Dr.Okada received the IPSJ Best Paper Award in 1995, 2000, and 2008, the IPSJ 40 the Anniversary Paper Award in 2000, IPSJ Fellow in 2002 and the IEEE SAINT Best Paper Award in 2004.

Reducing Probe Data in Telematics Services Using Space and Time Models

Ryozo Kiyohara†, Hirohito Kakizawa†,
Shinji Kitagami‡, Yoshiaki Terashima‡and Masashi Saito‡

†Kanagawa Institute of Technology, Japan
‡Mitsubishi Electric Corp., Japan
{kiyohara@ic, s1485010@cce}.kanagawa-it.ac.jp
{mail52}@contact.kitagamishinji.net
{Terashima.Yoshiaki@eb, Saito.Masashi@bc}.MitsubishiElectric.co.jp

Abstract - In-vehicle information devices such as car navigation systems and smartphones are now widely used and they provide drivers with a lot of information, such as traffic jam information, weather forecast, etc., by a communication function such as cellular networks. These services gather a lot of information from cars or traffic sensors on the road, which results in many small pieces of data being transmitted over cellular networks. We propose a method that, by predicting car behavior, reduces the amount of such data. We observe the amount of traffic data, simulate vehicle behavior, and evaluate our models. Our conclusions show good results.

Keywords: Telematics service, ITS, Smartphone, Probe data, Car navigation System

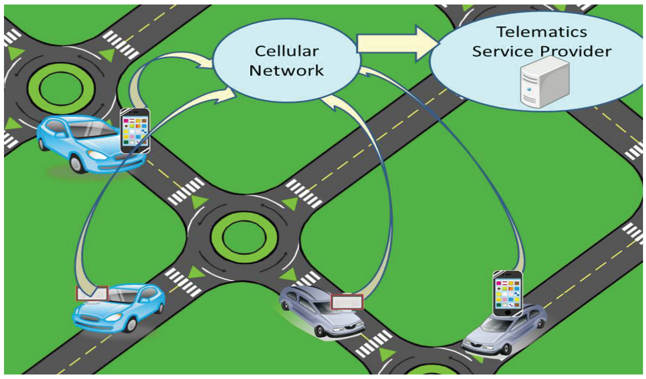

Figure 1: Telematics service

1 INTRODUCTION

Recent years have witnessed the emergence of many telematics services. For example, vehicle information devices can assess traffic conditions and display the fastest route to a destination. Such services provide information obtained from traffic sensors, historical traffic data, and in-vehicle information devices or smartphones, which are in widespread use [1]-[4].

Nevertheless, vehicle information devices for these services have to connect the cellular networks, and drivers have to pay additional costs for telematics services. If drivers use smartphones, then they do not have to pay these additional costs; however, the display sizes on these devices are too small. A new device called gDisplay Audioh [5] can display the same image with a smartphone connected by wireless or wired communication functions.

Therefore, smartphones can become popular telematics terminals that have several sensors and wireless communication functions [6]. Each smartphone frequently transmits a small amount of probe data. Therefore, a large amount of probe data can be transferred from vehicles to telematics service providers (TSPs). However, such increasing volumes of data traffic need to be regulated because of the high communication costs for both users and TSPs.

In a previous study [7], we proposed data compression methods for probe data by considering only the data itself, but we were unable to reduce the amount of communication of control information that is a task that requires peak cutting methods. Therefore, in this paper, we propose a new method for reducing probe data on the basis of vehicle behavior prediction.

2 TELEMATICS SERVICE

2.1 What are Telematics Services

Telematics services are services that provide useful information to the driver. These services have to gather a lot of information from each in-vehicle device (See Fig. 1). There are four types of telematics services:

1. A TSP gathers a large amount of information from in-vehicle information devices through the cellular network for each service; such information includes traffic jam information, weather information, route guidance, etc. The TSP then analyzes the data and delivers useful information to each in-vehicle information device.

2. If an accident takes place, the in-vehicle information device calls an emergency center, providing, automatically or manually, location information synchronized with the airbag information.

3. Entertainment services such as SNS, messaging, Internet, etc.

4. Vehicle relationship management (VRM), which gather a large amount of different types of information from the controller area network (CAN) for monitoring the vehicle status, etc.

Current in-vehicle information devices communicate with the TSP's server through a cellular network. Therefore, most of those services are able to run on the smartphones. Many drivers have smartphones and can use the cellular network at fixed costs and without having to pay additional money.

However, smartphones' displays are too small to show drivers a map or other information, which they cannot use when they are driving. In the near future, it is expected that display-audio devices, which show the smartphones display image on the in-vehicle devices, will be used widely.

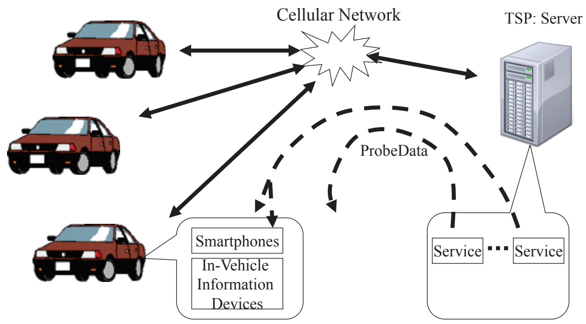

Figure 2: Probe data

2.2 What are Probe Data

Probe data are gathered from many vehicles to the TSP's servers, as shown in Fig. 2. There are three types of probe data:

1. Probe data that are gathered from various vehicles at short fixed intervals (e.g., 1 min and 5 min). This data includes average speed, travelling time, location information, and wiper information. The data are analyzed for traffic information, weather forecast, etc.

2. Probe data that are transported to the TSP or other services as soon as possible; these include airbag information and broken information for making emergency calls.

3. Probe data that should be stored and gathered to the manufactures for VRM; these include error logs in various Electronic Control units (ECUs), etc.

In this paper, we focus on the first type probe data. The size of each data is very small, but the number of communications is very large. Therefore, we have to solve the following three problems for minimizing the total packet count of them:

- Minimizing the probe data
- Minimizing the control information for each communication
- Minimizing the number of communications

In our previous research, we proposed a compression method for minimizing the probe data. In this paper, we propose a new method for reducing the number of communications in telematics services.

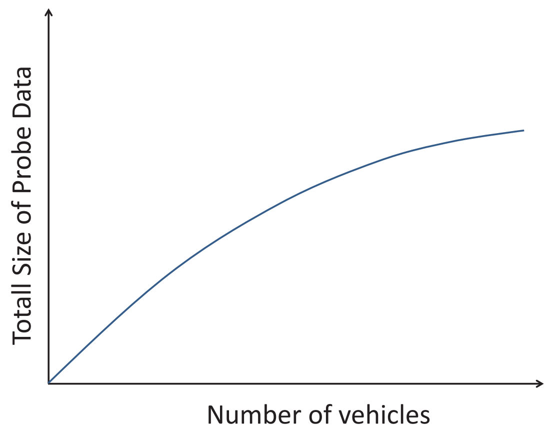

Figure 3: Number of vehicles and total size of probe data

2.3 Amount of Probe Data

Let x be the number of vehicles in a fixed area, which are able to communicate with the same base station through a cellular network. $0 \leq x \leq$ "miximum number of vehicles in the fixed area" Let s be the size of probe data transmitted in a single communication. Let t be a period of sending the probe data. Let t be a period of sending the probe data. In this case, the total size T of the probe data is given by the following equation:

$$T = st \sum x_i. \tag{1}$$

In our previous research [7], we proposed a data compression method. The data size depended on the number of vehicles. When the number of vehicles is small, the data are not compressed effectively; but when the number is large, the data can be compressed effectively. The relation between the number of vehicles and the total size of probe data is shown in Fig. 3. If all in-vehicle information devices transmit probe data, the total size of probe data increases monotonically.

3 RELATED WORKS

There are many studies on the reduction of probe data in a cellular network. These studies may be categorized into three types:

1. **Reducing the number of vehicle information devices that communicate to TSPs through a cellular network.**
   In [9], inter-vehicle communication technologies (V2V) were used, and good results were obtained. However, few vehicles have the equipment required for V2V communications, which accounts for a significant problem. In [10], roadside communication (V2R) technology was used, but the covered area was very small.

2. **Reducing the data size.**
   Our previous method [7] showed good results, but it could not be used for peak cutting.

3. **Controlling the number of vehicles driving in a fixed area.**
   In [9], the TSP sent a message to a vehicle and guided it along its route. In this case, control of the vehicle was limited.

We thus propose a new space and time model for reducing the size of probe data without requiring V2V or V2R technologies.

4 METHOD OF REDUCING PROBE DATA SIZE

4.1 Proposed Architecture

Figure 4 shows the architecture of a telematics service system based on a telematics agent model that we propose. In this model, there are two types of agents: one runs on smartphones, whereas the other runs on the servers in a TSP.

The TSP agent monitors vehicular traffic in certain areas divided into zones. If the number of vehicles in a zone exceeds a certain threshold, the TSP agent selects smartphones according to the space-and-time strategy and instructs the smartphone agents to cease probe data transfer.

The basis of this idea is that the amount of probe data that is needed to provide a large amount of information is not very large. Therefore, we can select some appropriate vehicles. The number of selected vehicles is defined by two threshold values as follows (Fig. 5).

1. If the number of smartphones is less than the threshold1, all vehicles are selected.

2. If the number of smartphones is less than the threshold2 and greater than the threshold1, a fixed number of vehicles are selected.

3. If the number of smartphones is greater than the threshold2, a fixed numbers of vehicles are selected.

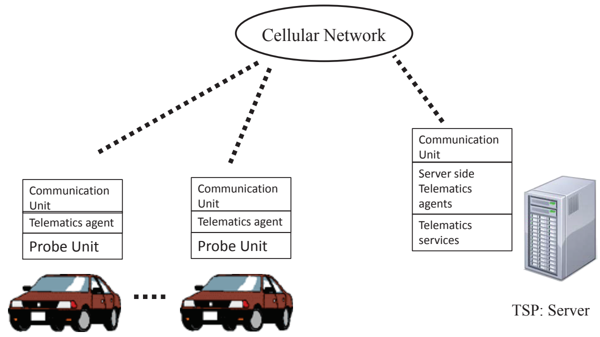

Figure 4: Proposed Architecture

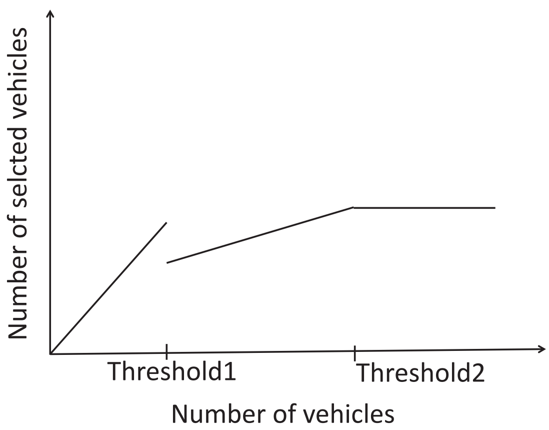

Figure 5: Number of vehicles and number of selected vehicles

The number of selected vehicles is limited and fixed. Therefore, communication traffic through the cellular network is limited.

4.2 Space and Time Strategy

The algorithm for selecting smartphones that should not transmit probe data is based on the following conditions.

1. In a particular area, a fixed number of smartphones are allowed to transmit probe data.

2. A smartphone transmits probe data only when its behavior cannot be predicted.

Thus, the volume of communication is limited. Actually, if there is less traffic in an area, then the number of smartphones will be relatively small. Hence, all the smartphones in the area

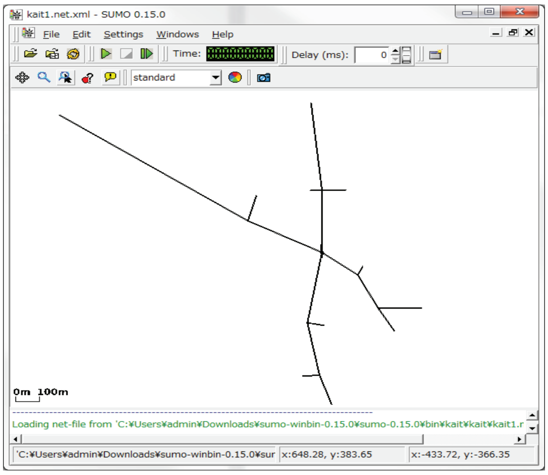

Figure 6: Atsugi City (near the Kanagawa Institute of Technology)

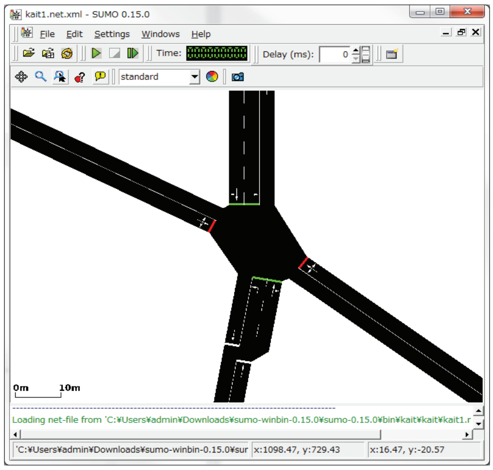

Figure 7: Atsugi City (near the Kanagawa Institute of Technology (zooming))

can connect to the TSP. Conversely, if an area has heavy traffic, it will have a large number of smartphones. Therefore, only a fixed number of smartphones will be allowed to transmit probe data.

4.3 How is the Behavior of a Vehicle Predicted

The prediction algorithm for the behavior of a vehicle is as follows:

- If a smartphone uses a route guidance application, the TSP can predict the route. Therefore, the smartphone can communicate with the TSP only illegally.
- If the smartphone does not use the route guidance application, it is difficult to predict the route. However, in many cases, the vehicle may be on a long street. Therefore, the smartphone can communicate with the TSP either illegally or drive on any route except the main route.
- In a fixed size area, the number of smartphones that communicate with the TSP is limited. Therefore, the TSP provides communication ratio as it decides.

5 EVALUATION

We evaluated our algorithm by carrying out a traffic simulation [11]. In a previous study [7], simulations were conducted using real traffic data and maps. We adopted the same approach in the present study to obtain accurate results.

5.1 Base Experiment

Table 1 and 2 show the avarage speed and the avarage travelling time, respsctively.

We observed the amount of traffic near the Kanagawa Institute of Technology. we shows them in the Figures 6 and 7.

Table 1: Average Speed in that area

Sparse case	8.3 m/s
Nomarl case	7.5 m/s
Crowded case	5.3 m/s

Table 2: Average travelling time

Sparse case	196s
Nomarl case	216s
Crowded case	328s

On a weekday morning, the number of vehicles in an hour is 1,729, which is normal in that area and is not considered as crowding. The number of signal turns is 52.

In addition to these numbers, for the simulation, 2,593 (150%) vehicles constitute a crowded case, and 864 (50%) vehicles constitute a sparse case.

We then changed the number of vehicles and obtained the probe data from each vehicle. Figure 8 travelling time in that area, and Figure 9 shows the average speed of each vehicle in that area.

5.2 Reducing the Probe Data Based on the Space Model

We obtained the probe data from selected vehicles by space model. Selected ratio in that area is from 3% to 100%. Table 3,4, and 5 show the average speed and average travelling time from each simuralation.

This result means we have to select the smartphone at least

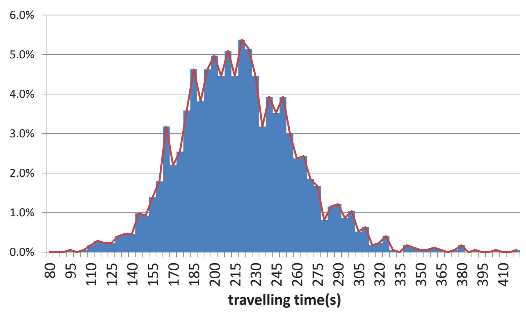

Figure 8: Travelling time in Atsugi City

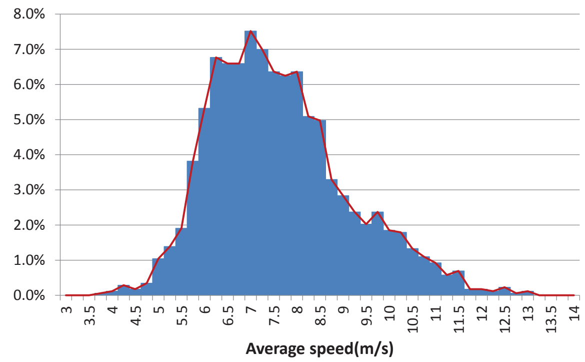

Figure 9: Average Speed in Atsugi City

20% in the crowded case.

5.3 Reducing the Probe Data Based on Time Model

We obtained probe data from the selected vehicles using the time model. The selection ratio for each vehicle varied from 20% to 100%. Tables 6, 7, and 8 show the average speed and average travelling time from each simulation.

The results indicate that we can reduce the number of selected smartphones in at least 80% of the normal cases in the time model. In other words, each smartphone should communicate with a TSP 20% of the time.

5.4 Discussion

From these results, we can reduce the traffic at most 80 by the space model. Because, we have to select the smartphones which communicate with the TSP is at least 20. Also, we can reduce the traffic by the Time model. Therefore, we should combine these two models. However, the result is obtained by the simulation. Therefore, we are planning the experiment by real vehicle and smartphones before the evaluation of combined model.

6 CONCLUSION

We proposed a new method for reducing the amount of probe data in telematics services. In addition, we confirmed the effectiveness of the proposed method by conducting simulations using real traffic data and maps.

In future work, the time and space models will be combined, and we will perform simulations on larger areas.

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Table 3: Average speed and travelling time on space model (sparse)

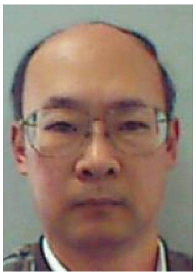
Selecting ratio	Average speed	Average Travelling Time
100%	8.3m/s	195.8s
50%	8.3m/s	196.4s
20%	8.2m/s	197.4s
10%	8.4m/s	196.7s
5%	8.5m/s	194.1s
3%	8.7m/s	194.9s

Table 4: Average speed and travelling time on space model (normal)

Selecting ratio	Average speed	Average Travelling Time
100%	7.5m/s	216.5s
50%	7.5m/s	216.2s
20%	7.4m/s	220.3s
10%	7.5m/s	216.0s
5%	7.6m/s	216.8s
3%	7.1m/s	232.3s

Table 5: Average speed and travelling time on space model (crowded)

Selecting ratio	Average speed	Average Travelling Time
100%	5.3m/s	328.2s
50%	5.3m/s	326.2s
20%	5.4m/s	322.6s
10%	5.5m/s	318.1s
5%	5.6m/s	311.9s
3%	5.7m/s	315.1s



Ryozo Kiyohara received B.E., and M.E. degrees from Osaka University in 1983, and 1985. Since joining Mitsubishi Electric Corporation in 1985, he had been engaged in developing a machine translation system. From 1989, he had been at the Institute for the New Generation Computing Technologies engaged in the Fifth Generation Computing Project until he returned to Mitsubishi Electric Corporation in 1992. He received Ph.D. in 2008 from Osaka University in Information Science and Technology. He is a professor of Kanagawa Institute of Technology sice 2012. His current research interests include software upgrade systems and Java processing in on-vehicle information devices. He is a member of IEEE(Senior Member), ACM, IPSJ(Information Processing Society of Japan), and IEICE (The Institute of Electronics, Information and Communication Engineers).

Table 6: Average speed and travelling time for each selecting ratio on time model (space)

100%	8.3m/s	195.8s
50%	8.3m/s	194.8s
33%	8.3m/s	194.0s
20%	8.3m/s	192.0s

Table 7: Average speed and travelling time for each selecting ratio on time model (normal)

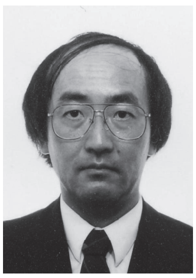
100%	7.5m/s	216.5s
50%	7.5m/s	215.5s
33%	7.5m/s	214.5s
20%	7.5m/s	212.4s

Table 8: Average speed and travelling time for each selecting ratio on time model (crowded)

100%	5.3m/s	328.2s
50%	5.3m/s	327.2s
33%	5.3m/s	326.2s
20%	5.3m/s	324.0s

Hirohito Kakizawa received B.E. degree from Kanagawa Institute of technology in 2014. He is a master degree student of Graduate School of Kanagawa Institute of Technology, He is a member of IPSJ(Information Processing Society of Japan).

Shinji Kitagami received B.E., and M.E. degrees from Toyama University in 1981, and 1983. Since joining Mitsubishi Electric Corporation in 1983, he had been engaged in developing computer graphic systems, and database systems. He is a researcher of Information Technology R & D Center, Mitsubishi Electric Corporation, and also he is a doctoral student of Tohoku University from 2011. His current research interests include M2M (Machine-to-Machine) service systems, and energy management systems. He is a member of IPSJ (Information Processing Society of Japan), and IEEJ (The Institute of Electrical Engineers of Japan).



Yoshiaki Terashima received B.E. degree in Engineering from Saitama University in 1984. He is a head researcher in the Information Technology R & D Center, Mitsubishi Electric Corporation in Japan. He received his Ph.D. degree from Shizuoka University in 2005. His research interests include distributed processing architecture and a testing methodology for an ad-hoc network. He is a member of IPSJ(Information Processing Society of Japan) and IEICE (The Institute of Electronics, Information and@Computer Engineers).

Masashi Saito received B.E degree from Tokyo Institute of Technology in 1983, M. E. degree from Cornell University in 1992 and Ph.D degree from Osaka University in 2006. In 1983, he joined Mitsubishi Electric Corporation and has developed engineering workstations, Internet TVs, cellular phones, car navigation systems especially for operating system extension, Internet services and distributed processing. In 2006, he moved to Mitsubishi Electric Research Laboratories as a senior principal technical staff. He is Head Researcher of Information Technology R&D Center of Mitsubishi. Since 2014, he has been a director of IPSJ(Information Processing Society of Japan) and a manager of SIG ITS(Intelligent Transportation Systems and Smart Community). His current research interests include ITS, smart city, distributed systems, smart systems. He is a member of IEEE, ACM and IPSJ.

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