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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

Kenichi Okada
Guest Editor of the Second Issue of International Journal of Informatics Society

We are delighted to have the third and special issue of the International Journal of Informatics Society (IJIS) published. This issue includes selected papers from the Second International Workshop on Informatics (IWIN2008), which was held in Wien, Austria, Sep 9-11, 2008. This workshop was the second 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, 21 papers were presented at 6 technical sessions. The workshop was complete in success. It highlighted the latest research results in the areas of networking, business systems, education systems, design methodology, groupware and social systems.

Each IWIN2008 paper was reviewed in terms of technical content and scientific rigor, novelty, originality and quality of presentation by at two reviewers. From those reviews, 12 papers are selected for publication of IJIS Journal. Among those 12 papers, six papers are related to human computer interaction. This third issue focuses on human computer interaction, and includes those selected six papers. The selected papers have been improved from their original IWIN papers based on the reviewers' comments.

We hope that the issue would be of interest to many researchers as well as engineers and practitioners in this area.

We publish the journal in print as well as in an electronic form over the Internet. This way, the paper will be available on a global basis.

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Supporting tool for student who learns usecase modeling

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Abstract - Increasing numbers of students of faculties related to information technology are learning UML (Unified Modeling Language). In order to effectively model the object area, it is necessary to understand about business. It is difficult, however, for the student who doesn't know business to call up the tacit function not described in the requirements specification. This paper proposes to use ontology as a way to draw out a tacit function when the student makes the usecase diagram, and is a verification of the effectiveness of the procedure.

Keywords: UML modeling, usecase diagram, ontology

1 INTRODUCTION

Increasing numbers of students of faculties of informatics are learning UML (Unified Modeling Language). In order to effectively model the object area, it is necessary to understand about business. It is difficult, however, for the student who doesn't know the business to call up the tacit function not described in the requirements specification. Moreover, it is necessary to learn the modeling technology in a limited time.

In this paper, we propose the study support tool for the usecase modeling that requires business knowledge.

Usecase modeling is used to extract a necessary function (it is called usecase) from the requirements specification such as RFP (required for proposal), and to make a model. The model refers to the ontology of a limited object domain. The result is described as a usecase diagram. The tacit function, i.e. knowledge not described in the requirements specification, can be discovered by referring to the ontology of the object domain.

To grasp the concept of ontology and to discover tacit knowledge of an object area, and to identify requirements specification, it will be useful for students to model a familiar object area, such as a library or convenience store.

In this paper, we aim to develop educational support for making the usecase diagram by selecting an object domain likely to be familiar to students, enabling them to make a more refined usecase diagram.

2 REVIEW OF CURRENT RESEARCH

Current research that applies ontology to UML includes the following:

Minegishi's "Supporting Software Engineering Processes with Ontologies"[1] is object modeling research aimed to support making the analysis class diagram that is the product in the systems analysis phase. It proposes to solve the following three problems:

(1) Modeling cannot be done due lack of understanding concerning business.

(2) System specific information and common domain information cannot be separated.

(3) Significant differences of interpretation pertinent to the product are generated.

To solve these problems the analysis class diagram making a support technique using ontology is proposed. The process of making the analysis class diagram is supported by the main noun extracted from the usecase description which refers to the domain ontology and general ontology that systematizes the concept in the domain.

Kamiya's "Supporting Analysis Class Modeling with Ontologies"[2] is concerned with object modeling too. If the domain ontology is insufficient, an acceptable class diagram can be derived by applying general ontology, combined with conversation processing with the modeler, etc.

To date no research of support for making the usecase diagram from the requirements specification proposed in this paper is available.

3 OUTLINE OF ONTOLOGY [3], [4]

Recently, ontology research is developing because of knowledge sharing and recycling knowledge. In current practice, ontology is the term used to conceptually systematize the targeted world rigorously and exhaustively, and to create a hierarchical description of relation. Not only objects (noun), but also the process (verb), as well as constraints, are systematized.

The primary meaning of the term ontology is existence. This term is being adapted in the world of informatics to describe a target "real world" to describe algorithmically. That actual domain is a referent more powerful than a dictionary.

Moreover, ontology can identify tacit information that differs from the data of an electronic dictionary, and exists in the background of knowledge. Tacit information might alter the significance of knowledge described by the vocabulary. It is one of the important roles of ontology to clarify such tacit information.

Ontology includes general ontology that describes the concept of specializing, and domain ontology that describes the concept of specializing in the field.

4 USECASE MODELING

UML is a typical modeling language, and 13 kinds of diagrams are defined, among them usecase diagram, which is used to describe a functional side.

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What kind of user (It is called actor) uses the system? Moreover, what function (It is called usecase) does each actor use? This relation is described as shown in Fig. 1.

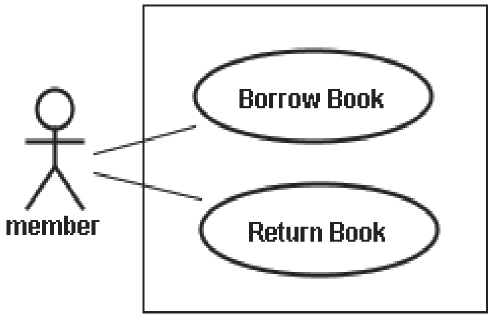

Figure 1: Example of usecase diagram

In this paper, we analyze usecase diagram that students made by the information system design study. We then extracted problems in usecase modeling study.

In this study, the procedure for each theme has been to lecture on knowledge necessary in each theme, studying the theme in groups, who make a presentation the next week. One of the themes is usecase modeling.

It lectures on usecase modeling first. Next, usecase modeling of "Equipment management system of the elementary school" is done. Afterwards, usecase modeling of "Case that each group chose" is done.

Figure 2 is example of usecase diagrams for "Equipment management system of the elementary school" that the student made.

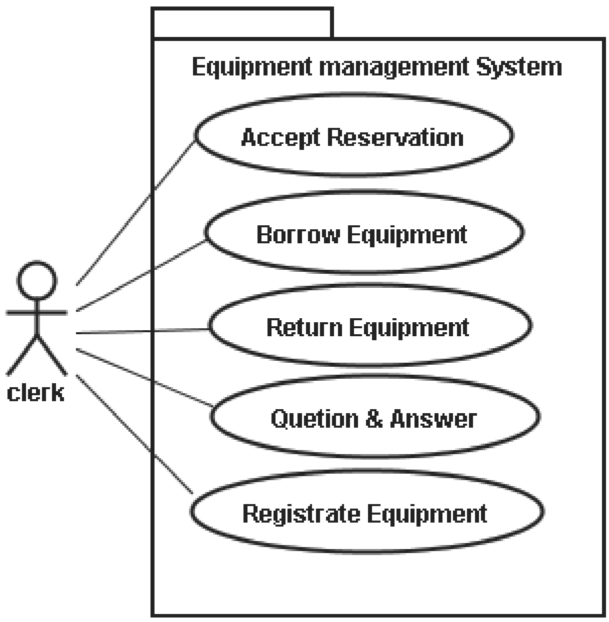

Figure 2: Example of usecase diagram for equipment management system

Most groups are describing five usecase "accept reservation," "borrow equipment," "return equipment," "question & answer," and "register new equipment." These are the descriptions corresponding to the requirement, and it is extracted correctly.

However, the system doesn't work only by these functions.

Figure 3 is usecase diagram by the teacher. Some functions not described in the requirements specification by students are added to this usecase diagram. For example, it is necessary to record what to borrow, and to whom you borrow. Therefore, it is necessary to register the equipment and the user beforehand. Moreover, there is a return if there is a borrowing. A function is necessary if the item is not returned in the time limit. Therefore, the function of press is also necessary. For this the user's name, address and telephone number are required.

Moreover, it is necessary to register information for other schools (where to make contact, and what equipment can be borrowed) beforehand to make equipment available to another school. All functions to retrieve the specification in the lending situation regarding the equipment are noted.

If there is an experienced person of the information system development present, the lack of knowledge in all the others becomes evident. This raises the problem of how to extract required functions accompanying, though not described, in the requirements specification.

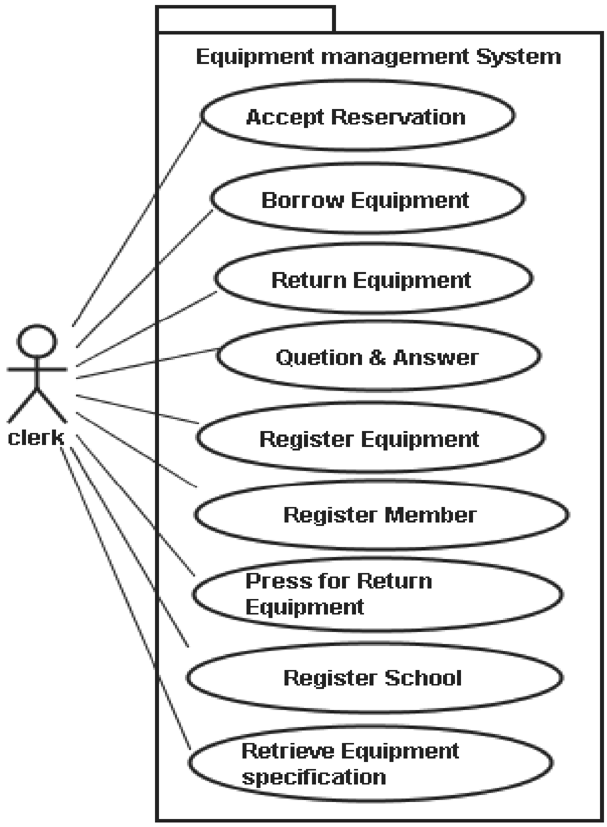

Figure 3: Model answers of usecase diagram for equipment management system

5 PROPOSAL OF USECASE MODELING USING ONTOLOGY

In this proposal, the domain ontology is classified into the object ontology and the task ontology.

The object ontology defines the hierarchical relations between objects. The relation of the noun like the person and the thing, etc. is defined. The relation is described by using the ”is-a” relation as shown in Fig. 4.

The relation of ”equivalence” is described to absorb the difference of the expression.

The task ontology is ontology that defines the attribute of the task (verb concept). It describes it with seven relational operators as shown in Fig. 5.

The feature of the proposed domain ontology was to have prepared “pre-task” and “post-task” in relational operators of the task ontology. The flow of the task can be expressed by adding these relational operators. The before task and the after task are understood by referring to this ontology.

The procedure for refining the usecase diagram that the student made is as follows.

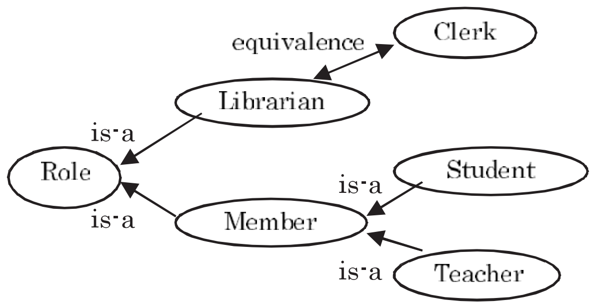

Figure 4: Composition of object ontology

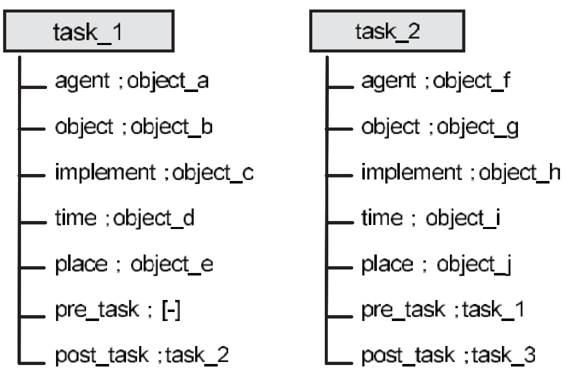

Figure 5: Composition of task ontology

At first, retrieve the task described in the usecase that the student made in the beginning, and refer to the ontology. Then, the student understands what task is necessary before and behind the task.

Moreover, relational operators such as agent and object are described in each task. How the task takes part from these relational operators in the system can be judged. It is a repetitive process to trace the flow from a certain task, and to refer again to the ontology of each task. The function that the system should offer by this operation can be discovered, and the practical oversight of the usecase can be discovered.

6 EXPERIMENT AND CONSIDERATION

6.1 Exercise

To verify the utility of the proposal technique, the case study of the library system was done. The requirements specification and model answers to the library information system were quoted from “Essence of the UML modeling” [5].

[Requirements specification of library information system]
There are insufficient clerical officers in charge of the lending business at the library at A-university. Then, A-university decided to introduce the library information system for the lending business efficiency.

The following three functions are necessary for the system.

- Acceptance processing of lending reservation
- Management of lending and return books
- Record of lending history

“Lending reservation” function is necessary for the user that wants to borrow the book as soon as possible.

The clerical officer at the library places the book in holding area when the book is returned, and reports that the book can be loaned out to the user who reserved it. It is necessary to manage which user has reserved the book to achieve this service.

The collection of books at the library is classified into books and journals. There is only one journal for each title, although there are volumes and numbers. There may be several copies of one book. Therefore, the collection of books is managed by the management indexing number, to distinguish them.

The library users are students and teachers at A-university, and all members are registered. The student and the teacher are divided because there is a restriction “Journals are not lent to the student.”

Student member’s lending limit is 6 books, and teacher member’s lending limit is 12 books. The lending period is up to three weeks.

The object ontology and the task ontology for the library were made based on the proposal technique.

Figures 6 and 7 show the object ontology and the task ontology. Each object and each task has extracted the verb and the noun from business manual [6] at the Shizuoka University library. And, words and phrases that were able to be used in this case were chosen.

6.2 Experiment

The experiment was conducted on the following hypotheses.

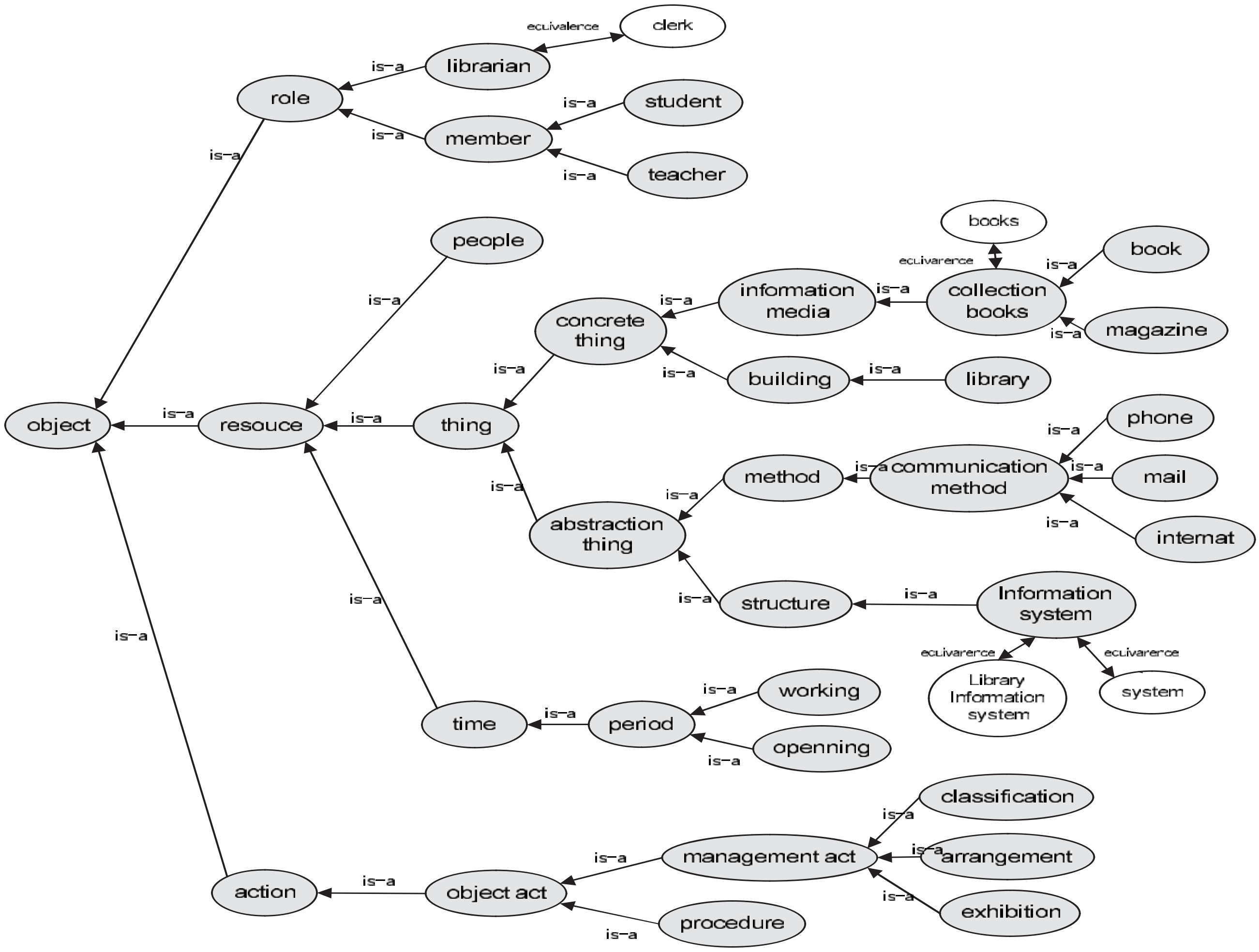

Figure 6: Example of the library object ontology

[Hypothesis 1] Usecase diagram made by using ontology is refined more than usecase diagram made without ontology.

[Hypothesis 2] The refinement result of usecase diagram made by using ontology doesn't depend on a prior lecture environment (teacher's difference, content of the lecture, numbers of students, etc).

Testees are seven beginners of UML. Three students (Hereafter, it is called group-A) have never learned UML. Other four students (Hereafter, it is called group-B) have learned some UML.

We conducted the experiment according to the following procedures.

1) We gave a lecture to the group-A concerning usecase diagram.

2) The requirements specification of the library system is presented, and all testees make usecase diagram (1st edition) from this requirements specification.

3) We explain the conceptual ontology.

Table 1: Procedure of experiment

Step	Group A	Group B
1	Lecture(usecase)	—
2	Trial(1st edition)	Trial(1st edition)
3	Lecture(ontology)	
4	Show(the library ontology)	
5	Revise(2nd edition)	Revise(2nd edition)

4) The library ontology is presented.

5) Usecase diagram (1st edition) is reviewed referring to the library ontology and 2nd edition is made.

6.3 Evaluation

We judged whether extracted usecase was more appropriate than usecase of model answers.

Hypothesis 1 was verified by the comparison usecase diagrams between 1st edition and 2nd edition. Figure 8 shows

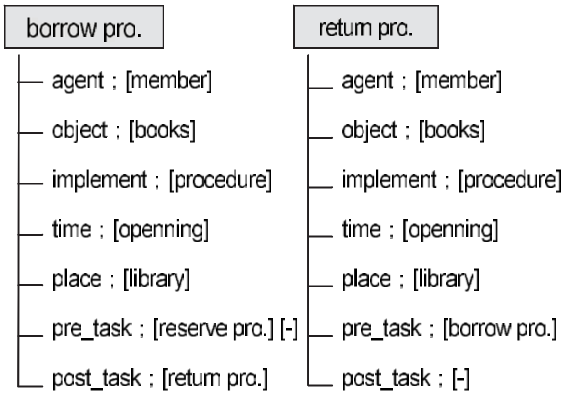

Figure 7: Example of the library task ontology

the result of comparing between usecase of 1st edition and usecase of 2nd edition.

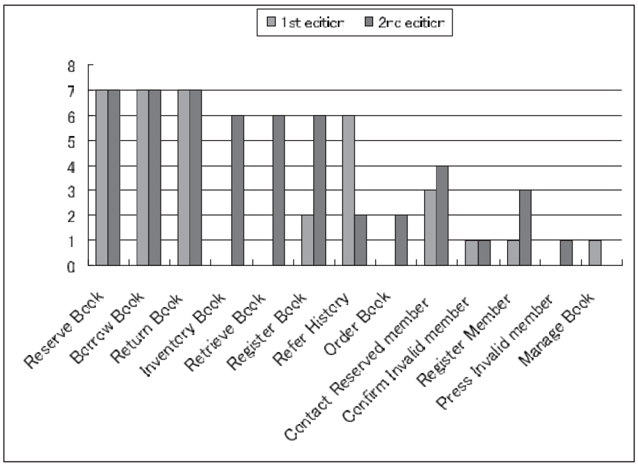

Figure 8: Comparison usecase between 1st edition and 2nd edition

If the term had the same meaning even if the usecase name was different, it counted assuming that it was the same. For instance, "Put back book" and "Return book" have the same meaning, and it counted as "Return book."

2nd edition after reference to ontology contained more refined distinctions (for example, "inventory book," "retrieve book," "register book") than 1st edition before reference to ontology as shown in Fig. 8, and the effect of ontology was proven. However, after referring to ontology, students who extract usecase (for example, "refer history," "register member") are decrease or few. This was caused by the method of describing ontology, and it is necessary to improve the description.

Next, hypothesis 2 was verified by the comparison mutually made the 1st edition and the 2nd editions by group-A and group-B.

The difference of usecase in usecase diagram (1st edition) is 0.5 or less in each usecase as shown in Fig. 9.

The difference of usecase in usecase diagram (2nd edition) is 0.5 or less in usecase other than usecase "register member"

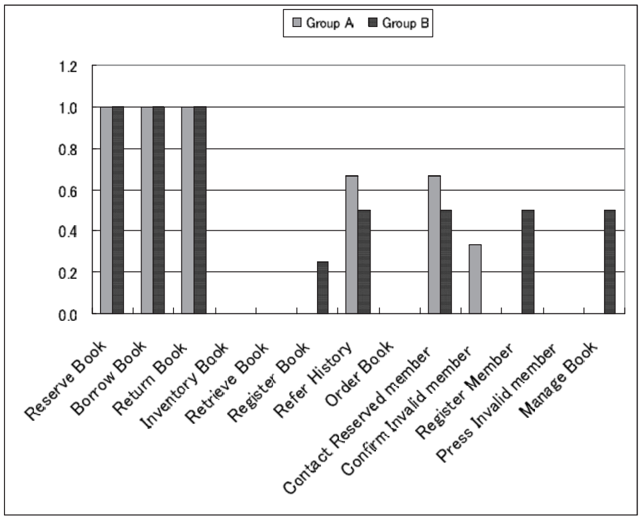

Figure 9: Comparison usecase (1st edition) between group-A and group-B

as shown in Fig. 10.

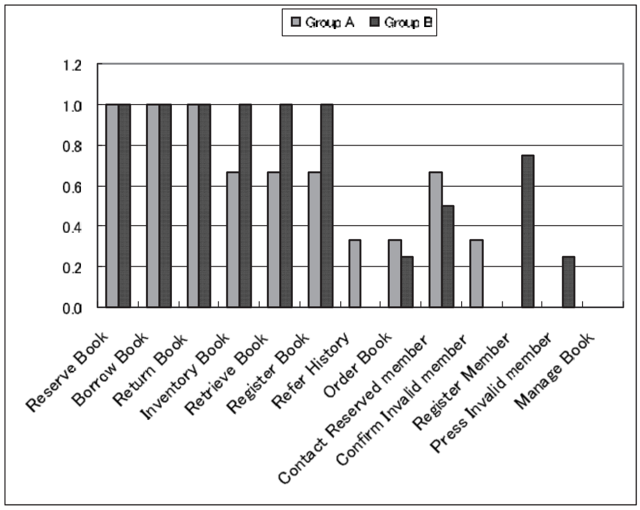

Figure 10: Comparison usecase (2nd edition) between group-A and group-B

It has been shown that the effect of the refinement by the ontology reference is independent of a prior lecture environment.

However, group-B has passed one year since usecase modeling was studied. Group-A studied usecase modeling and experimented at once. Therefore, it is necessary to verify the influence of the difference of the elapsed time after the study of modeling.

7 CONCLUSION

It has been clarified that the refinement technique based on using ontology was useful for making usecase diagram.

Future tasks are as follows.

- Review of domain ontology for making more detailed refinement
- Increase the number of experiment samples, and do a statistical verification of hypothesis 1 and hypothesis 2.
- Systematize the technique for making the proposal.

The systematization of the proposal technique is a system that traces, checks the flow of ontology for making usecase by building ontology into the usecase diagram making tool, and finds the deficiency of usecase.

The refinement level can be expected to reduce the oversight of the relating ontology by systematizing it, to be able to extract appropriate usecase, and to go up.

The constructed ontology is domain ontology that specializes in the library information system. A similar system like various rental systems and reservation systems can use the ontology for enhancing effectiveness.

Future tasks are to ascertain the domain of applicability, and to add ontology smoothly to expand the domain of applicability.

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A mirror-effect-based mutual tutorial - a tutorial system for different interface of a single information service -

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Abstract - The purpose of this paper is to propose a mirror-effect-based mutual tutorial on different kind of interfaces for a single information service. When a user operates a system via a certain interface, the mirror-effect-based tutorial helps him/her learn the operating procedures of other interfaces of the same system. When conducting a certain task, the system uses the same program and input data, irrespective of which interface is used by a user. Taking advantage of this fact, our tutorial system generates operation procedures for implementing the same function on different interfaces when a user carries out a certain task. Accordingly, our tutorial involves the following two features. (1) Presenting the procedure to perform the same task from a different interface when a user operates a system via a certain interface. (2) Providing the efficient procedure depending on each interface. The task completion time is reduced by 24% and the input acceptance rate is increased by 17%.

Keywords: mirror-effect-based, mutual tutorial

1 INTRODUCTION

There are many different information services readily available in daily life today. The types of information terminals used and the environments in which users access these services are continually diversifying. In line with these trends, the interfaces for accessing information services are also becoming truly diverse.

For example, the Shinkansen ticket reservation system [1] provides two kinds of interfaces for cell phones and PCs. Many car navigation systems also have a built-in microphone for inputting voice commands while driving, in addition to ordinary control switches and a remote controller. Users can change input devices in accordance with match their circumstances.

In addition, since car navigation systems are now connectable to the Internet, Web sites, which were previously accessed mainly from PCs or mobile phones, can now also be accessed from equipment built in vehicles [2]. As a result, such information systems must now be designed to be accessible from a wide variety of terminals.

Although there have been a lot of studies on the usability of interfaces, most of those studies examine an interface accessed from a single type of device [3][4], and there have been only a few studies[5] which examine an interface accessed from multiple types of device.

Figure 1 shows a typical example of a system accessible from multiple interfaces. In this paper, we use the term “device” to refer to such input equipment as a mouse or a microphone that is used with a PC, a car navigation system, etc. We further user the term “interaction style” in the sense of Shneiderman [6]. He cites menu selection, form fill-in, command language, natural language and direct manipulation as five typical interaction styles in interactive software. Finally, we use the term “interface” to refer to an input/output mechanism that combines the devices and the interaction styles provided by terminals.

For example, one interface combines a PC keyboard and command language, and another interface combines switches on a car navigation system and menu selection. There is also an interface that combines speech recognition through a microphone and menu selection.

Although many systems provide multiple interfaces for the purpose of selective use of multiple interfaces according to the user’s circumstances, there are virtually no examples of an interface design policy that is aimed at easy shift from one interface to another. In many cases, each interface is designed separately. Consequently, even when users operate a familiar system, they must newly learn the operating procedure if they use unfamiliar interfaces. In such a case, they must once again go through a process of repeated trial and error, just as they did the first time they operated the system. This means that we cannot improve the system’s usability by simply increasing the variety of terminals or interfaces capable of accessing a system and merely improving the individual operating ease of each device/interface.

Selective use of multiple interfaces impose a heavy burden on users, and it cannot be neglected especially when systems take advantage of a ubiquitous environment, in which people selectively use various types of information terminals according to their circumstances. For this reason, there are growing demands for interfaces such that users can smoothly shift from one to another depending on their circumstances.

For in-vehicle equipment in particular, users have substantially different circumstances depending on whether they are driving or not. Unless a separate interface tailored to each of these circumstances is provided, the usability may decline

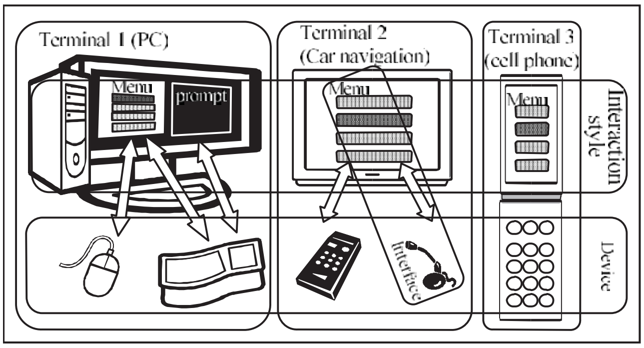

Figure 1: Example of multiple interfaces.

markedly. In addition, for systems that are intended to be accessed both from in-vehicle equipment and from outside a vehicle (e.g. from a home PC via the Internet), it is necessary to provide an interface that is easy to use from each type of device although the circumstances are completely different from each other. Consequently, systems accessible from in-vehicle equipment in particular inevitably require some mechanism that allows users' selective use and smooth shift of their interfaces.

In this regard, this paper proposes a tutorial that helps users learn the operating procedures of unfamiliar interfaces during conducting a task through a familiar interface. When users are carrying out a certain task through a familiar interface, our system demonstrates the procedures for the same task through another interface. We call this learning support system a mirror-effect-based mutual tutorial system. By adopting this tutorial system, we can construct an operating environment for information system that fully takes advantages of multiple interfaces.

This paper provides an evaluation of the mutual tutorial function. The function is implemented onto the drive planning (DP) system constructed in our previous studies [7]. The DP system is accessible from two kinds of interfaces. One interface is designed for the natural language interaction style with a PC keyboard, and the other is designed for the menu selection interaction style with a car navigation system's switches on its instrumental panel. The usability of our system incorporating the tutorial method to be proposed is evaluated on the basis of the acceptance rate of the user input and task accomplishment time.

2 MIRROR-EFFECT-BASED MUTUAL TUTORIAL SYSTEM

We propose a mirror-effect-based mutual tutorial system as a method of improving the usability of a system with multiple interfaces. This section explains the method in detail.

2.1 Definition and Key Principles

We define the term "mirror-effect-based mutual tutorial" as follows; for every task a user actually executes via one interface, the system demonstrates how to perform the same task efficiently on another interface. In the mirror-effect-based tutorial, when a user executes a task using a certain interface, the efficient counterpart operation on another interface is automatically presented to the user as if it were a mirror image of the original operation. In this way, users can unconsciously learn how to use unfamiliar interfaces without active learning of the unfamiliar interfaces.

Figure 2 shows the basic design of the mirror-effect-based mutual tutorial system, which generates an efficient procedure on an interface which corresponds to the task executed on another interface.

The role of an interface at the time of a user input is to interpret the input, identify the necessary program and generate input data into the program. To accomplish it, each interface is equipped with an interpreter that interprets the user's input. In Figure 2, the interpreter A and the interpreter B interpret the inputs from the device A and the device B, respectively.

Generally, identification of the program set to be executed and generation of the input data based on the user's input operation are conducted uniquely. In cases where the input from each interface is aimed at executing the same task, the respective inputs are converted into the same input data and trigger the same program set inside the system. Consequently, if the system has an inverse interpreter for each interface that generates the targeted operation on the interface based on the program set to be executed and the input data for each program, the input to a certain interface feeds the system so that the system generates the corresponding operations for other interfaces. In Figure 2, the interpreter A^{-1} is the inverse interpreter that generates input operations for the interface A, and the interpreter B^{-1} is the inverse interpreter that generates input operations for the interface B.

When implementing an inverse interpreter, the following three possibilities must be considered:
(1) There is no input operation corresponding to the input data and the program to be executed.
(2) There is only one input operation corresponding to the input data and the program to be executed.
(3) There is more than one input operation corresponding to the input data and the program to be executed.

In the case (1), the task to be executed on the basis of the identified program and input data cannot be performed from the interface associated with the inverse interpreter. In this case, it is sufficient to indicate to the user that the task cannot be executed via that interface.

In the case (2), the input operation is the only output from the inverse interpreter.

In the case (3), the procedure which is expected to require the shortest operating time is selected among the operating procedures that can be generated. This enables the user to learn the most efficient operating procedure. If there is no difference in the expected operating time of the generated operating procedures, a predetermined typical procedure is selected. (From the viewpoint of efficiency in this particular sense, inputting a sentence via a natural language interface is not different from inputting another sentence in which a synonymous expression is used.)

How to design inverse interpreters depends on the deference of input flexibility among interfaces. However, the number of programs to be executed is finite, and the finiteness

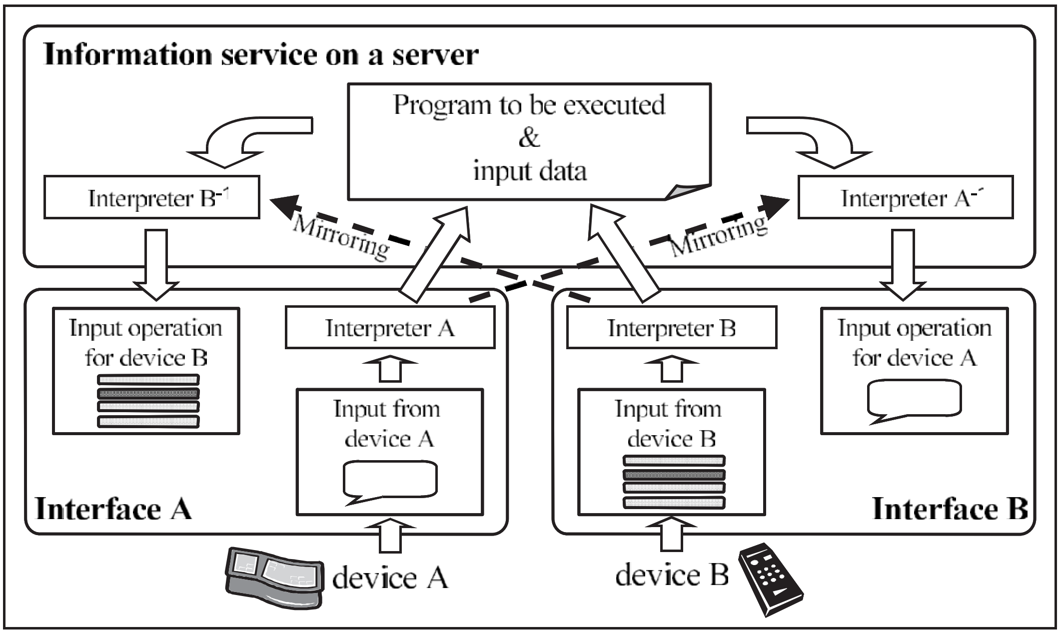

Figure 2: Basic design of mirror-effect-based mutual tutorial system.

makes it possible to define appropriate inputs for each interface to run a given program (e.g. sentence styles for natural language interface, the kind of input information and its order for menu selection interface, etc.). In addition, if the number of parameters for a given program is finite and if the specification of the parameters is definable (e.g. substituting a suitable word into an input sentence with a designated sentence style, selecting an item from a menu list, etc.), we can design an inverse interpreter for any interpreter.

2.2 Features and Expected Effects

Based on the key principles explained in the previous subsection, we can realize a mutual tutorial with the following two features.

a. When a user executes a task via a certain interface, the system teaches the procedure for the same task to be performed on a different interface.

When a user carries out a certain task, the user employs a particular strategy. In facility search, for example, there are at least two strategies: (1) specifying the genre and the landmark near the target facility and (2) specifying the genre and the address of the target facility. A user who frequently uses a particular type of strategy from one interface is expected to employ the same strategy from another interface. The mirror-effect-based mutual tutorial system demonstrates the operating procedure via another interface which corresponds to the user's strategy, only when the user actually carries out a task from one interface. This allows a user to learn operating procedures efficiently by limiting them to the functions that the person actually needs. In addition, since the tutorial is given when the user executes a task on a familiar interface, we can expect that the user learns how to use another interface while using the interface. In other words, we can expect that the user does not have to spend time to especially learn operations on unfamiliar interfaces.

b. The system teaches the most effective procedure according to each interface.

Note that operating procedures executable from different interfaces may differ in their efficiency. Some operating procedures are efficient if they are performed on a certain interface, but they are not if executed via another interface; i.e., other procedures are more efficient in the latter case. Further, there are cases where an efficient operating procedure executable from one interface is simply unavailable on another interface. These facts make it more complicated for users to learn how to operate each interface efficiently according to the task to be performed.

Taking the above considerations into account, the system teaches the most efficient operating procedure on another interface for executing the same task as the one the user actually performs. In other words, the system does not teach the operating procedure involving the same operating steps as the user's original operation if the procedure is not efficient. This feature can help users notice that the most efficient operating procedure on one interface is not necessarily the most efficient procedure on another interface and vice versa. In Figure 2, the selection of the most efficient procedure is conducted when the inverse interpreters generate operating procedures. When an inverse interpreter can generate more than one procedure, the most efficient procedure is selected and thus the system can teach the interface-specific efficient procedure.

3 MUTUAL TUTORIAL IN THE DRIVE PLANNING SYSTEM

This section describes design examples of inverse interpreters for a menu selection interface and for a natural language interface. We also explain examples of the mirror-effect-based mutual tutorial employing these inverse interpreters.

3.1 Drive Planning System

In this study, we have selected our drive planning (DP) system [7] as an example of a system in which the same functions can be used from multiple interfaces. The mutual tutorial function has been implemented in the DP system.

The DP system allows drive plan data created on a PC to be uploaded to an online server; the system supports a variety of helpful functions including route guidance, facility search and plan editing via a car navigation system or a mobile phone. We have selected the facility search function as a target of implementing the mirror-effect-based mutual tutorial function.

When users access to the DP system from a PC, the system offers a natural language interface with keyboard input in order to take full advantage of a standard input device of a PC (i.e., keyboard) and the user- friendliness of natural language input. The natural language interface is aimed at enabling users to input their requests in whatever style they like. For example, a user can simultaneously input a complex combination of search conditions as in “Please look for a hotel near the national university in Hamamatsu”.

The car navigation system interface for the DP system adopts a menu selection style manipulated by control switches on the instrumental panel. The interface also allows users to search for a facility by specifying relatively complex conditions (e.g., by designating the type of target facility and its nearby facility). Nearly all of the various facility search functions that can be used from a PC are also available on the car navigation system interface.

3.2 Generation of an Efficient Operating Procedure for Another Interface in the DP System

The facility search module of the DP system accepts search conditions like the target facility’s category, address, and nearby facility. The specified search conditions are expressed in a tree structure and transferred to the search module. Figure 3 shows an example of the tree structure for a “search for a fast food restaurant near a train station in Hamamatsu City, Shizuoka Prefecture.” The nodes of the tree are connected by links (solid lines in the figure) expressing upper/lower hierarchies or entire/partial hierarchies between concepts and by links (dashed lines) expressing the modifying/modified relationships between concepts. The tree nodes are expressed as frames that store pairs of an attribute and its value and/or pairs of an attribute and a pointer to its attribute value. For example, the address frame stores a pair of the attribute “prefecture” and its value “Shizuoka”, and a pair of the attribute “municipality” and a pointer to its value (the address frame containing

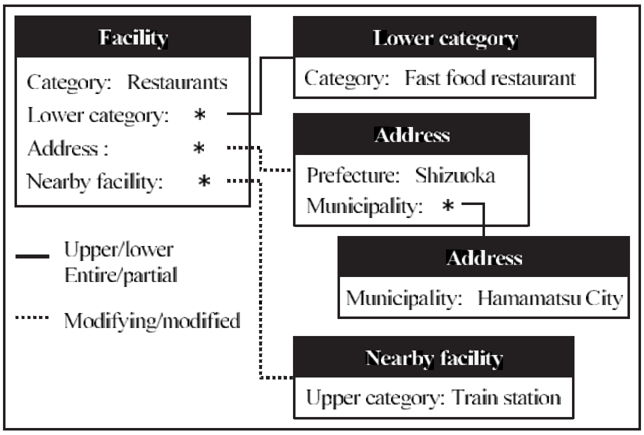

Figure 3: Example tree structure for restaurant search: “search for a fast food restaurant near a train station in Hamamatsu City, Shizuoka Prefecture”.

“ Hamamatsu City”).

Both interfaces use the same search module of the DP system. They transfer the same tree structure to the module if the search conditions are the same. Accordingly, the search module and the tree structure can be regarded as the source for the inverse generation of operating procedure on an interface. This is because the search module determines the program to be executed and the tree structure gives input data to the program irrespective of which interface is used.

We do not discuss the details of the conversion method from natural language input and menu selection input to the tree structure in the DP system since the discussion falls outside the scope of this paper. Conversion from natural language input to the tree structure is explained in [7]. The conversion from menu selection input to the tree structure involves defining the correspondence between each menu item and each attribute of the node in the tree, and transmitting the values selected from the menu to the corresponding attribute values in the tree structure. The following subsections explain the procedures for the inverse conversion from the tree structure to the operating procedure for each interface.

3.2.1 Inverse Generation of Natural Language Input from the Tree Structure

In generating an input natural language sentence from the corresponding tree structure, the system first extracts surface expressions corresponding to the attribute values in each frame. Facility categories and addresses are hierarchized according to their upper-lower or whole-part relation. An expression corresponding to an upper/whole concept is connected with an expression corresponding to its lower/part concept through “no” (the Japanese counterpart to English “of”). If the meaning of a lower/part expression is unambiguous without the restriction imposed by its upper/whole concept, the upper/whole expression is omitted and only the lower/part expression is used so as to generate a non-redundant natural language expression.

Expressions generated from modifying concepts are then connected with the modified expressions through connecting words like "no (of)", "de (in)", "no-chikaku-no (near)", etc. These processes generate a natural language expression from the corresponding tree structure. In order to deal with the cases in which a certain concept is associated with multiple connecting words and is restricted by multiple modifying concepts, their linear order is predetermined according to the attributes in a given frame. The system can use different connecting words depending on whether a modifying expression immediately preceding the modified nominal, or a modifying expression is separated from the modified nominal by another intervening modifying expression.

Suppose that the tree structure in Figure 3 is generated as a result of menu selection operation. In this case, "restaurants" and "fast food restaurants" have an upper-lower relation and "Shizuoka" and "Hamamatsu City" have a whole-part relation. Since "fast food restaurants" and "Hamamatsu City" are unambiguous without their upper/whole concepts, the lower/part concepts are used in generation of a natural language expression. The tree structure has two modifying links to "address" and "nearby facility". Their relative order is predetermined so that the address precedes the nearby facility. The connecting words used in this configuration are predetermined so that "de" is used for the address and "no-chikaku-no" is used for the nearby facility. As a result, "Hamamatsu-shi-de eki-no-chikaku-no famiresu (a fast food restaurant in Hamamatsu City near a station)" is generated as an efficient input for a natural language interface.

3.2.2 Inverse Generation of Menu Manipulation Procedure from the Tree Structure

The menu selection interface is designed to put search conditions into the tree structure for facility search; that is, each choice on the menu is uniquely associated with a particular position in the tree structure. Consequently, by taking advantage of this unique relation between the menu selection and the tree structure, the system can determine which item should be selected on which menu. The system therefore can generate menu selection procedure from the corresponding tree by checking whether each attribute has its value and by determining which choice on the menu is corresponding to the attributes that have their values.

Specification of the values of a lower/partial level of hierarchized attributes can be done only if the upper/whole concepts have been specified. For that reason, the upper/whole concepts are specified first. The order for specifying other attribute values is basically arbitrary, but it is more efficient to specify them in the order in which they are displayed on the screen. In cases where the same value can be specified for multiple selection operations, the procedure with the fewest operations is selected.

For example, the system generates menu selection procedure from the tree structure in Figure 3 as follows. Since "Shizuoka" and "Hamamatsu City" have a whole-part relation, "Shizuoka" is selected on the prefecture menu before the selection of "Hamamatsu City" on the city menu. Since "restaurants" and "fast food restaurants" have an upper-lower relation, "restaurants" is first selected on the genre

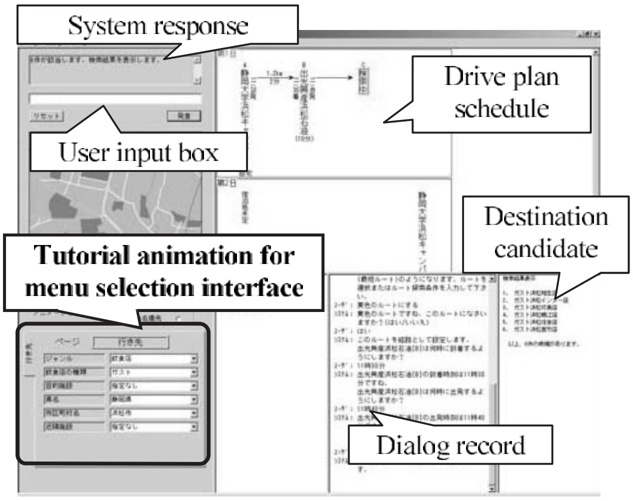

Figure 4: Example tutorial of the menu selection interface during operation on the natural language interface.

menu. Then the restaurant category menu becomes available and "fast food restaurants" is selected on the restaurant category menu. The facility category, the address, the nearby facility (station) can be specified in any order. However, since they are displayed on the screen in the order of the facility category, the address, the nearby facility, the system generates the menu selection procedure with this particular order.

3.3 Mutual Tutorial in the DP System

As the tutorial of the menu selection interface while operating on the natural language interface of the PC, we have adopted an explicit method whereby the actual input procedure is shown in an animation. The PC system has a menu display for tutorial that is identical to that of the car navigation system. Figure 4 shows an example of a tutorial of the menu selection interface during operation on the natural language interface. User requests in Japanese are input into "User input box". The response of the system is displayed in "System response". "Dialog record" shows the dialog history. In this example, the user specified a gas station as the first destination, route, departure/arrival time and travel period. Now, the user going to specify the second destination so he inputs "Hamamatsu-shi-no famiresu-ni iki-tai (I want to go to a fast food restaurant in Hamamatsu City)". The menu selection interface on the PC then shows an animation that provides how to conduct facility search with the same search conditions on the menu selection interface. The animation enables the user to directly watch which choices should be selected on which menu in what order.

The tutorial of the natural language interface during operation on the menu selection interface adopts the following method. When a user conducts facility search on the menu selection interface, the DP system gives a response sentence to confirm the search conditions. In generating the response sentence, the system use natural language expressions suitable for the most efficient search on the natural language interface and those expressions are highlighted in the response

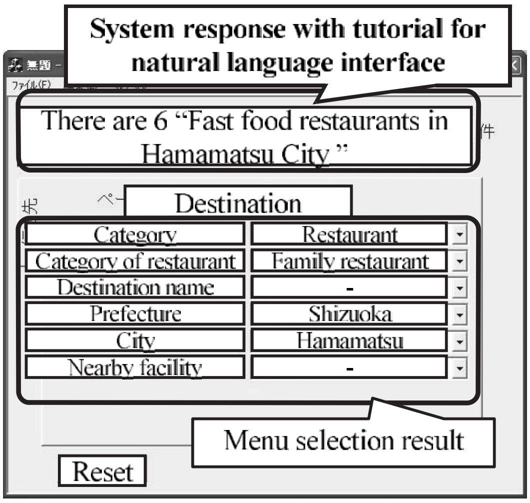

Figure 5: Example tutorial of the natural language interface during operation on the menu selection interface.

sentence. Suppose that a user selects " restaurants", " fast food restaurants", " Shizuoka" and " Hamamtsu City" on the genre menu, the restaurant category menu, the prefecture menu and the city menu, respectively. The system then replies " Hama-matsu-shi desu-ne. **Hamamatsu-shi-no famiresu-**wa 24-ken desu. (You have selected Hamamatsu City. There are 24 **fast food restaurants in Hamamatsu City**.)". In this reply, " Hamamatsu-shi-no famiresu (fast food restaurants in Hamamatsu City)" is highlighted. In repeating such tutorials, users unconsciously acquire natural language expressions suitable for the most efficient search on the natural language interface. Figure 5 shows an example of a tutorial of the natural language interface while operating on the menu selection interface.

When a user uses a function that is unavailable on another interface, the system must show the user that the function is unavailable on another interface. In our DP system, detailed editing of a drive plan such as setting the departure/arrival time can only be done from the PC system, and these operations are not available on the car navigation system's menu selection interface. When a user uses such functions on the PC system, the tutorial system shows their unavailability by not showing an animation of the operations on the menu selection interface.

4 EVALUATION OF THE MUTUAL TUTORIAL SYSTEM IN THE DP SYSTEM

This section describes the evaluation of the effectiveness of the mutual tutorial system.

4.1 Effect of the Tutorial of the Natural Language Interface During the Operation of the Menu Selection Interface

First, a car navigation system without a response-based tutorial function was selected as the system for comparison. The mutual tutorial function was incorporated in another car navigation system, and the effect of the tutorial on the operation of the PC system interface was investigated. We have evaluated the effect of the tutorial of the natural language interface during the operation of the menu selection interface. The operation results of the two user groups have been examined. One group operates the natural language interface after using the car navigation system with the tutorial function, and the other group operates it after using the car navigation system without the tutorial function.

4.1.1 Experimental Procedure

The subjects were twenty engineering students and they were divided into two groups. Group NT first used the car navigation system without tutorial function and then used the DP system on a PC. Group T first used the car navigation system with the tutorial function and then operated the DP system on a PC. The two car navigation systems have no difference except the tutorial function. In order to familiarize the subjects with their respective car navigation system, we made them practice operating the system for 30 minutes every day over a three-day period. The subjects then subjectively evaluated the car navigation system that they used. After that, a prepared conversation of a certain family talking about their desires regarding a family trip was presented to the subjects. All of the subjects then used the same PC system to create a drive plan that satisfied the desires of the family members.

The conditions under which searches could be conducted, and the operations particular to the DP system (e.g., halt a search midway by entering the command "stop search") were explained to the subjects beforehand using the same manual sheet alone.

4.1.2 Experimental Results

After creating the drive plan, the subjects evaluated the PC system subjectively by responding to a questionnaire using a 7-point evaluation scale. An objective evaluation was also made on the basis of the input acceptance rate, the number of input times, the number of key words per sentence and the task accomplishment time.

As the first step, a questionnaire was conducted among the members of both groups concerning their respective car navigation systems. The purpose of the questionnaire was to confirm that there were no differences between the two navigation systems in terms of their performance.

The questionnaire results of the two groups and the results of a t-test between the two groups are shown in Table 1. The mean scores for Question 1 concerning the ease of use (easy to use = 7) are 4.9 for Group NT and 5.3 for Group T. The mean scores for Question 2 concerning the kindness of the responses (kind = 7) are 4.9 for Group NT and 5.2 for Group T. Those for Question 4 about the ease of understanding the screen display (easy to understand = 7) are 5.0 for Group NT and 5.6 for Group T. Although the scores for Group T are slightly higher, the t-test indicates that there is virtually no significant difference between the two groups. The evaluation scores for Question 3 concerning the uncertainty about

Table 1: Questionnaire results for the two car navigation systems.

Questions	NT	T	p-value
1.Ease of use of system	4.9	5.3	0.419
2.Kindness of responses	4.9	5.2	0.624
3.Uncertainty about what to input	3.6	3.4	0.633
4.Ease of understanding of screen display	5.0	5.6	0.382
5.Discomfort from the response sentences	—	4.5	—

Table 2: Questionnaire results for the PC system.

Questions	NT	T	p-value
1.Ease of use of system	3.9	5.4	0.044
2.Kindness of responses	4.1	5.3	0.046
3.Uncertainty about what to input	2.3	3.8	0.002
4.Ease of understanding of screen display	5.0	5.5	0.486
5.Helpfulness of the car navigation system response	—	6.2	—

what to input (no uncertainty = 7) are nearly equal to each other. Thus the questionnaire results indicates that there is no difference between the car navigation systems in terms of the impression the subjects received when using their respective systems.

Table 2 shows the questionnaire results after the subjects made the drive plan on the PC system following the use of their respective car navigation systems. The scores for the questions 1, 2 and 3 show significant difference between the two groups. The mean scores of Group NT and Group T are 3.9 and 5.4 for Question 1, and 4.1 and 5.3 for question 2, respectively, indicating that higher evaluation scores have been given by Group T that used the car navigation system with the tutorial function. Presumably, the effect of the tutorial from the car navigation system makes it clear what sentences should be entered via the natural language interface when searching for a certain facility. If this is the case, it surely improves the overall ease of use of the system, thereby accounting for Group T's higher evaluation scores.

The mean score of Group T for Question 3 concerning the uncertainty about what to input (no uncertainty = 7) is also higher at 3.8 than 2.3 for group NT. The fact that Group T gave a higher evaluation to the PC system also indicates the effect of the tutorial on this group. Group T also gave a high mean score of 6.1 in response to Question 5 about whether the navigation system responses were helpful (helpful = 7). This question was only given to Group T. The high score indicates that the subjects actually felt the effect of the tutorial.

Table 3 shows the results of the objective evaluation. Significant difference is observed between the two groups for all of the evaluation items. Item 1 in Table 3 shows the total time required to create the drive plan. The other evaluation results only pertain to the input process for conducting a facility search and the other functions available on the PC system alone (e.g., a route search function, a function for setting the desired arrival time, etc.) are excluded from the evaluation. This is because the facility search function is the only function that is supported by the tutorial function.

Table 3: Objective evaluation results for the PC system.

Evaluation items	NT	T	p-value
1.Plan creation time(min:sec)	13:23	10:09	0.016
2.Number of input times	24.3	11.2	0.005
3.Number of key words per sentence	1.8	2.6	0.002
4.Acceptance rate of input sentences(%)	72.4	89.7	0.005

The mean time spent by Group T to create the drive plan is 10 minutes 9 seconds, which is more than 30% shorter than that of Group NT (13 minutes 23 seconds). Item 2 is the mean number of data inputs for conducting a facility search. The result for Group T is 11.2 times, which is less than half the number for Group NT (24.3). The results indicate the efficiency of the tutorial. The efficiency is explained in terms of Item 3, where Group T put more key words into an input sentence than Group NT whereby Group T needed fewer sentences than Group NT in making the facility search. Key words here are those words that express search conditions like facility categories, prefectures/cities of the destinations.

Item 4 represents the rate at which the system correctly understood the intention of the user inputs. Group T had a better result at 89.7% compared with 72.4% for Group NT. A good reason for this difference is that Group NT used many facility search conditions that the current system does not accept, whereas Group T almost never used such inappropriate conditions. The system does not accept search conditions that are not stored in the data base (e.g., yasui hoteru (cheap hotel)), conditions that involve the purposes of search alone (e.g., shokuji-suru (have a meal)), and so on. The difference between the two groups can be attributed to the effect of the tutorial from the car navigation system; that is, the tutorial makes it clear what search conditions can be used.

The results indicate that the tutorial greatly helps users unsure about what to input on the natural language interface, by putting efficient natural language inputs for the PC system into the responses from the car navigation system.

4.2 Effect of the Tutorial of the Menu Selection Interface During the Operation of the Natural Language Interface

We also investigated the effect of showing an animation on the PC system screen as a tutorial for the operation of the car navigation system.

4.2.1 Experimental Procedure

The test subjects were twenty engineering students who were divided into two groups, as was done in the experiment described in the preceding section. Group NT first used a PC

Table 4: Questionnaire results for two PC systems.

Questions	NT	T	p-value
1.Ease of use of system	5.4	4.9	0.358
2.Kindness of responses	4.5	5.1	0.399
3.Uncertainty about what to input	4.6	4.1	0.221
4.Ease of understanding of screen display	4.8	5.3	0.540
5.Discomfort from the displays animation	—	3.9	—

Table 5: Questionnaire results for the car navigation system.

Questions	NT	T	p-value
1.Ease of use of system	4.7	5.1	0.587
2.Kindness of responses	5.0	4.6	0.529
3.Uncertainty about what to input	3.3	2.9	0.540
4.Ease of understanding of screen display	5.1	5.1	—
5.Helpfulness of the displayed animation	—	5.9	—

system without any tutorial function before using the car navigation system. Group T first used a PC system incorporating the tutorial function before using the car navigation system. Before the experiment, each group used its respective PC system for 30 minutes every day over a three-day period and then answered a questionnaire. After that, all of the subjects were asked to read the manual of the car navigation system. They were then asked to execute six types of facility search tasks using the same car navigation system. One task, for example, was to " search for a hospital near the present location." The subjects then evaluated the car navigation system subjectively by responding to a questionnaire, and an objective evaluation was made based on their facility search time.

The test subjects were twenty engineering students, and they were divided into two groups as in the experiment in the preceding section. Group NT first used the PC system without the tutorial function before using the car navigation system. Group T first used the PC system with the tutorial function before using the car navigation system. Before the experiment, each group used its respective PC system for 30 minutes every day over a three-day period and then answered a questionnaire. After that, all of the subjects were asked to read the manual of the car navigation system. They were then asked to execute six types of facility search tasks using the same car navigation system. One task, for example, was to search for a hospital near the present location. The subjects then evaluated their respective PC systems subjectively by responding to a questionnaire, and an objective evaluation was made based on their facility search time.

4.2.2 Experimental Results

The subjective evaluation was done by a questionnaire using a seven-point evaluation scale after the subjects had completed the 6 facility search tasks. The objective evaluation was based on the task accomplishment time.

First, a questionnaire was conducted to confirm that there was no difference between the two PC systems in terms of their performance.

The questionnaire results and the results of a t-test between the two groups are shown in Table 4. Group T was asked whether they felt any discomfort from the displayed animation (no discomfort = 7). The mean evaluation score of 3.9 was slightly worse than the median. However, the scores for the other questions were virtually identical. This indicates that the tutorial animation did not influence the subjective evaluation of the PC systems.

Table 5 shows the subjective evaluation results for the car navigation system. No large difference was seen in the questionnaire results between the two groups. However, the mean score of Question 5 for Group T is 5.9. The question asked if the animation displayed on the PC system screen was helpful in operating the car navigation system. This indicates that Group T was actually aware of the effect of the tutorial.

The time needed to complete each facility search task is shown in Table 6. Since Task 1 is very simple to execute, no large difference was seen between the two groups. Task 2 is slightly more complicated because it requires the specification of a reference location. The difference between the two groups tends to increase as the complexity of the task becomes large. Task 3 requires approximately twice as many operations as the tasks 1 and 2 because multiple operations are needed to specify the reference location. A significant difference is seen between the two groups with respect to this task. Task 4 involves nearly the same operating procedure as Task 2. Since this task was performed soon after the subjects experienced Task 2, it is presumed that the effect of being familiar with the procedure resulted in there being no difference between the two groups. Task 5 is even more difficult to execute as it requires specifying the travel time (or distance). A significant difference is also seen between the two groups with respect to this task. Task 6 involves more complicated specification of the reference location than Task 5. A difference is seen in the mean task accomplishment time, although it is not statistically significant.

These results show that the tutorial has the effect of reducing the difficulty of learning the menu selection operating procedure, especially for complicated operations.

5 CONCLUSION

This paper has proposed a mirror-effect-based mutual tutorial system as a solution to the problem of having to separately learn the specific procedure for using a different interface every time a user changes an input device. This problem emerges when users use a system that can be operated from multiple information terminals with different interfaces. Even though a user has learned how to operate such a system from a certain interface, the user may well be unfamiliar to the procedure for operating the system from a different interface, and have to learn the operating procedure anew. Experiments were conducted to evaluate the mutual tutorial function incor-

Table 6: Time required for facility search using the car navigation system.

Destination	NT	T	p-value
1.Gas station in Hamamatsu City	0:47	0:37	0.529
2.Hospital near the present location	0:40	0:30	0.142
3.Hotel near Hamanako Paruparu amusement park	2:08	1:03	0.028
4.Park near the train station	1:10	1:12	0.905
5.Lawson convenience store within 30min. from the present location	1:14	0:47	0.026
6.Police station within 10 km from Hamamatsu Castle	2:13	1:35	0.256

porated in a DP system. The results obtained have shown that the mutual tutorial system is effective in shortening the task accomplishment time and in improving the input acceptance rate, among others.

The effectiveness of the mirror-effect-based mutual tutorial depends on how easily each interface is understood. If an interface is very easy to understand, the users would easily learn how to use it without the mutual tutorial. On the other hand, if an interface is very complicated and hard to understand, the users might not acquire how to use it through the mutual tutorial alone. Although we have confirmed the effectiveness of the mirror-effect-based mutual tutorial in the DP system, we may need further experiments using interfaces with various degrees of complexity (difficulty) in order to clarify the effective range of the proposed mirror-effect-based mutual tutorial. To specify the mirror-effect, we also need a comparison experiment on tutorial during operation of other tutorial systems such as a Microsoft office assistant [8].

The proposed mutual tutorial system adopts a framework that takes advantage of operating the same system; a user may well use the same set of functions irrespective of the interfaces he/she actually uses. By enabling users to efficiently learn operations of preferred functions on multiple interfaces, they are expected to be aware of the merits of using the same system from different interfaces. As a result, the same system is expected to be chosen by users irrespective of terminal types.

As a ubiquitous environment is steadily put in place, it is predicted that there will be increasing opportunities for using the same system from a variety of devices depending on the user's circumstances. These devices will include mobile terminals such as cellular phones and personal digital assistants (PDAs) as well as PCs. In such an environment, there will be an even greater necessity to be able to use multiple interfaces selectively and smoothly. The mirror-effect-based mutual tutorial system proposed in this paper should be effective toward that end.

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Proposal and Evaluation of Pictograph Chat for Communication

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Abstract - In Japan and China, pictographs have widely spread to add nuance to mails of mobile phones. We have developed a pictograph chat system, which can communicate each other using nothing but pictographs. We prepared 550 pictograph symbols. We applied the system for communication to 3 groups, which consist of the intimate friends group, the strangers group, and the foreign students and Japanese students group. We have carried out experiences 18 times. We report the results of the experiments as below. (1) The subjects understood over 70% of the content of the chat. (2) There were no difference between foreign students and Japanese students about the context of the chat. Japanese students tended to make the same context as foreign students.

Keywords: CSCW, Groupware, Pictograph, Chat, Cross-cultural communication

1 INTRODUCTION

The communication of information by E-mail, chatting, and electronic bulletin board has become widespread by the spread of networks. Moreover, communication can be easily done using MSN Messenger [1] etc. with a text base. In addition, face marks and pictographs have appeared, and are used to convey feelings [2].

Language becomes a barrier if we think about communication between different countries, and if a common language is not understood, it is difficult to communicate through conversation on a text base. Moreover, to learn a foreign language requires considerable time. Therefore, attention was given to pictographs that are used to convey feelings and slight nuances based on the idea that communication is possible if pictographs are used, even if a language such as English is not understood[1].

To add pictographs to chatting when experimenting on a teleconference between Japan and China [3], a recognition investigation of pictographs was conducted with postgraduate students from Japan and China (eight from each country). 112 pictographs were made for, and shown to, the subjects, who then evaluated their suitability for the meaning. As a result, between the Chinese and Japanese subjects, only 4 pictographs differed greatly in recognition (a school, house, motor sports, and rice ball). The pictograph for "school", for example, looked like a regular building. Though understandable to Japanese subjects, the Chinese did not see it as a school because Chinese had a grand image like a castle for school. "Rice ball" is not seen in China. There is a study that paid attention to a difference of the recognition of the pictograph of a Japanese and the foreigner [4].

As a result, it was seen that the recognition of the pictographs was almost unchanged between the Japanese and Chinese subjects. We then sought to determine whether subjects could understand even if sentences were made and chatted only by pictographs, and developed a system in which only pictographs were used for chatting [5]. This system is a chat system that can send and receive messages made only from pictographs. Some others have pictograph chat system [6], [7]. 550 pictographs were prepared including ones to do animation. This system was actually applied to chatting among the groups of "Friends of a friend," "Persons who did not usually talk," and "International students and Japanese students." From the results of the experiment we considered whether communication that used only pictographs was possible.

Chapter 2 explains the pictograph chat system. In Chapter 3 we explain the understanding level that is the standard of the evaluation of the experiment that uses this system. Chapter 4 shows the experiment that uses this system. Chapter 5 describes the experiment results. Chapter 6 is a discussion. Chapter 7 describes an additional experiment. Chapter 8 is the summary

2 PICTOGRAPH CHAT SYSTEM

2.1 Composition of system

This system was developed in C# language using Microsoft Visual Studio.NET 2003. It is a program of about 1200 lines. The system consists of a chat log screen with a pictograph input screen where pictographs are selected and sentences are made.

2.2 Functions of system

Figure 1 shows the pictograph input screen. The chat log screen is shown in Figure 2. The mark of the first animal of Figure 2 shows the speaker. A pictograph can be added from the pictograph selection screen to the input field with one click. A new pictograph can be input by selecting the pictograph in the input field, and inputting a new pictograph from the pictograph selection screen between the pictograph that exists originally in the input field and the pictograph selected by clicking.

Moreover, the selected pictograph can be deleted by clicking the select image clear button, and pushing the Back Space key and the Delete key. When the auto animated cartoon button is checked, all pictographs of possible animation begin animation.

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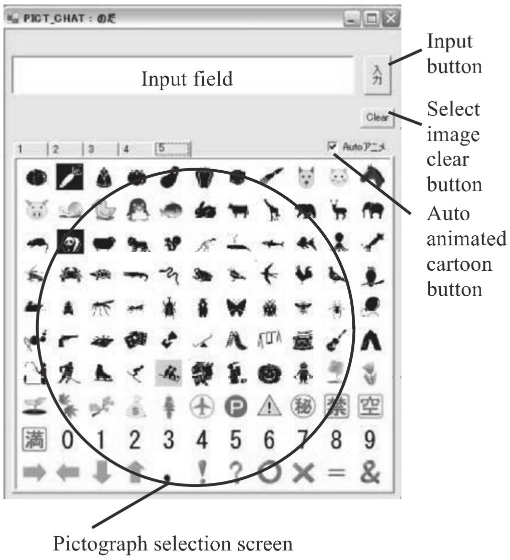

Figure 1: Pictograph input screen.

Figure 2: Chat log screen.

Pictographs were the original 255 images, 295 made of PIC-DIC [8], and 550 images in total were prepared. An original pictograph is one in which a newer pictograph was added referring to the pictograph used for cellular phones. Permission was obtained from Godai Embody Co., Ltd. for the use of PIC-DIC pictographs. Original pictographs are displayed in color, while PIC-DIC pictographs are displayed in black and white.

3 UNDERSTANDING LEVEL

For a conversation of N lines, if a line is completely understood, it gets a score of $(1/N) \times 100\%$; if the interpretation is very different, it gets 0%. In N line of M pictographs, if there is one non-understood pictograph, the understanding level is $(M - 1/M) \times 1/N\%$. In N line of M pictographs, if a pictograph is partially understood but not exactly right interpretation, the understanding level is $(M - 1/M) + 1/2 \times 1/M \times 1/N\%$.

4 EXPERIMENT

Two subjects experimented using personal computers through LAN in separate rooms. It was not possible to communicate verbally at all. The subjects were all students at Wakayama University. One was a third-year student of the Department of Economics, four were third-year students of the Faculty of Systems Engineering, 18 were fourth-year students, three were first-year graduate students of the system engineering research course major, and two were second-year graduate students. Similarly, two were third-year students, 3 of the international students were first-year graduate students, and one was a second-year doctoral student. The breakdown of the international students is four Chinese students, one Malaysian, and one Vietnamese. The subject combinations were as follows. Figure 3 shows snap shots of experiments.

Figure 3: Snap shots of experiments. Each subject experimented in different rooms.

Experiment 1: Japanese with good relations

Experiment 2: Persons with whom Japanese don't usually talk mutually (Japanese students)

Experiment 3: Japanese and international students

Subjects were 36 in total, with six pairs for each of the three patterns (18 pairs in total). Experiments were done two times for each second-year graduate student (experiment 2 and experiment 3). Otherwise, it was only one time for each. Whenever a one-line remark went out to the chat, the subject wrote the meaning of the remark of the other party and his remark while experimenting.

After about 30 minutes of chatting, they were asked to answer a questionnaire of five-point scale evaluation on the experiment and the system.

5 EXPERIMENTAL RESULTS

5.1 Example of each experimental chat

Figure 4 shows the experiment example of the screen. The result of the experiment 1 (Japanese with good relations) is shown in Figure 5, and the result of the experiment 2 (one about which the Japanese doesn't usually talk mutually) is shown in Figure 6 and the result of the Japanese and the international student is shown in Figure 7. The friend with a good relation of the fourth grader is talking with Figure 5 concerning the hour of rising, meal, and the graduation thesis. A conversation the same as usual is done. The mark of the first animal of Figures 5–7 shows the speaker.

Figure 6 is a conversation between Japanese who don't usually talk.

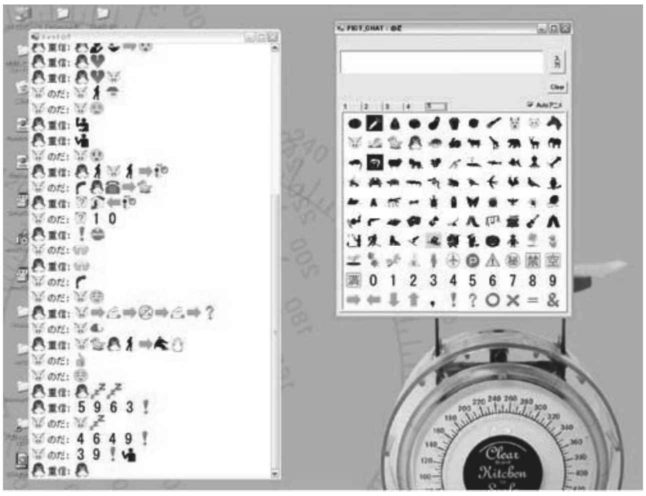

Figure 4: Example of screen of pictograph chat system.

The conversation to start getting to know the other party is done. Because the other party did not understand, it would have been written, "I am working part-time in a karaoke shop." Once, the other party's understanding is obtained by explaining again in detail in the pictograph.

Figure 7 is a conversation between a Japanese and an international student. Another singer (Mr. Children and Boys and (II) men) is mutually imagined though the conversation was going to have been approved by both people. "Pig icon" (Japanese) wrote as "I like Mr. Children." But "Penguin icon" (international student) interpreted the content as "I like Boys and (II) men."

The following is understood from the results of the questionnaire taken after the experiments of application and the chat log.

5.2 Number of distribution of pictographs by subject

Figure 8 shows the distribution of pictographs for each user. The average number of pictographs in experiment 1, experiment 2, and experiment 3 is 44. About 3.2 pictographs on an average line (one remark) are used. The maximum number of pictographs on a line (one remark) is 10 in experiment 1, 10 in experiment 2, and 12 (though, if it is excluded, eight are the maximum because the same pictograph is repeated) in experiment 3.

5.3 The use frequency of each pictograph

Table 1 shows the use frequency of each pictograph. "Question mark" and "arrow" were used very frequently. "Snow" was used frequently, because all experiments were performed in winter. Pictographs which represent agreement, "OK" or "yes," used frequently.

5.4 Understanding level of conversation

The mutual understanding level of the conversation of each experiment was calculated by comparing the meaning of the remark that the subject had written. The average of the understanding level of experiment 1 is 73%. The average of the understanding level of experiment 2 is 81%. The average of the understanding level of experiment 3 is 78%.

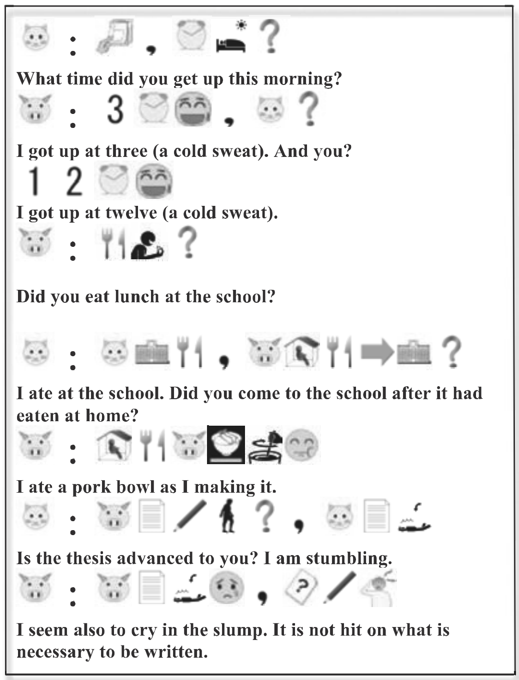

Figure 5: Chats of the experiment 1 (partly).

5.5 Questionnaire results

Part of the results of the questionnaire of five-point scale evaluation (Table 2) and opinions are shown. "5" is the highest score and "1" is the lowest.

Moreover, examples of the description-type results of the questionnaire are shown below.

- In what situation do you think that this pictograph chat can be used?
  - It is possible to use it cross-culturally.
  - It is possible for a child to use it.
  - It is possible to be used among companions usually.
  - It is possible to use it for communication with a handicapped person.
- Please write if you have an opinion about this system.
  - You should introduce the grammar.
  - As for pictographs, easy communication can be done even cross-culturally. It is far better than characters when it is used well.
  - If pictographs are expanded to do a complex conversation, it takes time to look for them. However, if one manages to do it, it is possible to use it well.

Table 1: The use frequency of each pictograph.

	Frequency	Meaning
	103	Question
	85	Go, change
	37	OK
	32	OK, yes
	32	Today
	31	Study
	26	Punctuation mark, a substitute of " "
	26	love
	26	Snow, cold
	25	Exclamation mark
	25	Please, I'm sorry
	25	Love
	25	Hello, laugh

Table 2: Results of the questionnaire.

Questionnaire items	Evaluation
When the pictograph is clicked once with this system, the pictograph is added to the input field. Was the operation easy?	4.6
Was sentence making easy?	2.0
Was the auto animated cartoon function convenient?	4.2
Could the meaning of an individual pictograph be understood?	3.6
Was a target pictograph easily searchable?	2.4
Was there a target pictograph?	3.1
Did you understand what the other party said?	3.8
Do you think that you were able to underatand the other party?	3.7
Do you think that you can conduct a conversation chatting only with pictographs?	3.3
Was this experiment interesting?	4.6

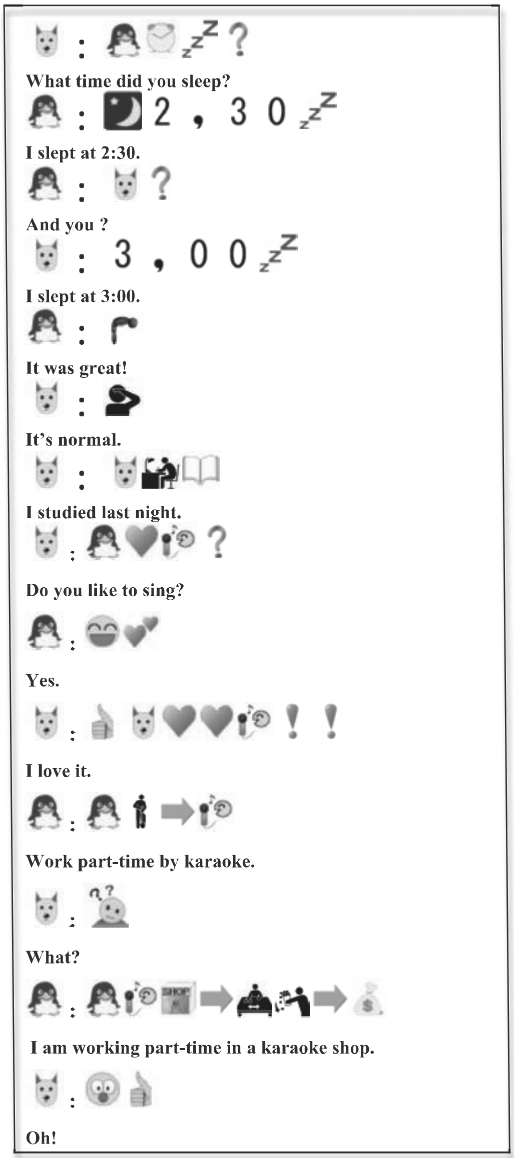

Figure 6: Chats of the experiment 2 (partly).

[Opinion]

- I think that I was able to understand more than I had expected.
- It is interesting to decipher what the other party wants to say.
- The animation is lively and happy.
- It takes time to look for a target pictograph.
- Aren't some rules needed?
- The pictographs are few (Proper nouns cannot be expressed).

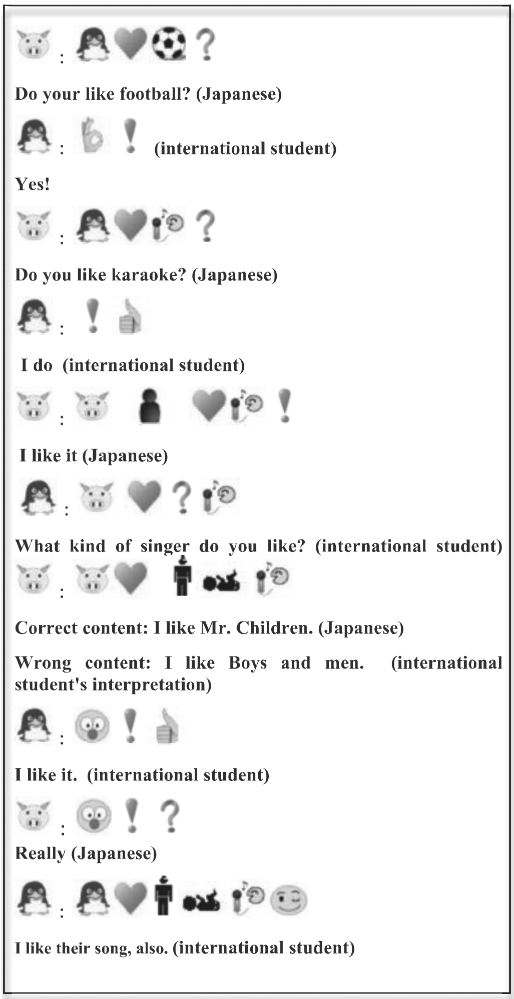

Figure 7: Chats of the experiment 3 (partly).

6 DISCUSSION

6.1 Difference by experiments in understanding level

The understanding level of experiment 1 is 73%, which is lower than the understanding level of experiment 2 and experiment 3. Two subjects in experiment 1 often talked usually, and were wellacquainted with each other. Therefore, they talked as an extension of their usual conversation, and the content of the conversation became deep. Much of the content was a continuation of the conversation of two people on the day before the experiment on topics like research, graduation travel, Valentine's Day, etc. However, there were no pictographs of proper nouns for the content of deep conversation. Therefore, we thought that it caused a gap in their interpretations, and it led to such a result. There was no topic for "Ice-breaking" that was used to be mutually friendly.

The understanding level of experiment 2 (81%) is a little high compared with the understanding level of experiment 1 and experiment 3. Two subjects of experiment 2 were two people who might not speak to each other especially. Ice-breaking topics, for example the weather, appeared in all six experiments. The sentence composition is simple. The subjects understood most though there was a slight mix up in individual pictographs. Therefore, it is thought that it led to such a result.

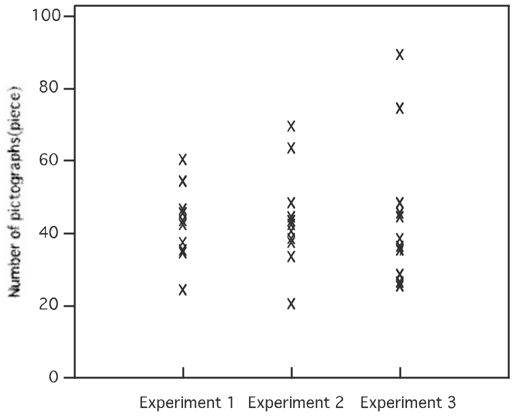

Figure 8: Distribution of pictographs for each user.

The understanding level of experiment 3 is 78%, which is higher than the understanding level of experiment 1, but lower than the understanding level of experiment 2. The subjects of experiment 3 are an international student and a Japanese student. There were a couple of subjects who did not usually speak to each other at all, and there were five pairs who met for the first. Therefore, there appeared in all of the six times in the ice-breaking conversation "What time did you sleep yesterday?" "Do you like skiing?" "Do you like soccer?" "Do you like karaoke?" "Do you like certain singer?" as well as in experiment 2. Moreover, the other party's country of origin was occasionally heard. However, the name of a country's not being given happened because in that case, there was no pictograph for the proper noun, and the topic changed suddenly. However, a panda pictograph was used to depict China. There was a conversation like "What do you like?" In this case, they were not able to talk well due to absence of expressible proper nouns. The conversation level reached an understanding level that was higher than experiment 1, because it was not different from experiment 2. We think that experiment 3 had a result that the understanding level is lower than experiment 2 due to the problem that there were no proper nouns though we tried to get to know the other party in detail. Moreover, international students alone did not differ in their evaluation scores on the questionnaire (Table 2). We think that they used the system in the same sense as the Japanese.

6.2 Difference of description of Japanese and international students

We consider whether there is a difference in the sentence composition between Japanese and international students from the chat log regarding the composition of sentences. Figure 9 shows a comparison of the conversations "What time did you get up today?" and "What time did you sleep yesterday?" that had come out while subjects did a lot of talking. Seeing this figure, it was understood that the Japanese and international students also include persons who combine pictographs of action after the pictograph of time and those who combine pictographs of time after pictographs of action.

Figure 9: A comparison of sentence construction.

6.3 Extraction and correspondence of problem

There were various devices when it was not possible to correspond directly to the pictograph. For instance, China is shown by using a panda pictograph because there is no pictograph named China in experiment 3 for the question "What country do you come from?" Moreover, there was a device to make it read by an adult pictograph and baby pictograph as Mr. Children (Figure 7).

From the results of the questionnaire, 69% said the pictographs could be understood, and 56% said there were appropriate pictographs. Especially, the lack of proper nouns was pointed out. In addition, the demand for needed pictographs were the following.

- "Yes" and "No," seasonal pictographs, and pictographs that show other people.
- Time expression such as "Former," "Old times," "Soon," "This morning," "Month," "Day," and "Year"
- What, when, where, who, how, and adverbs, conjunctions, proper nouns, units, and signs.
- Proper nouns

We have to deal with the lack of proper nouns. Hieroglyphic Tompa characters [9] have a lot of proper nouns. It is possible to show them basically by combining meanings. Japanese is expressible by Tompa characters. For instance, you may express the proper noun "Yamakawa (Mountain and river)" by combining characters that show "Mountain" and "River." It is uncertain whether this meaning can be communicated in a conversation between a Japanese and a foreigner. As for hieroglyphs [10], one alphabet character corresponds to one pictograph as a proper noun. Subjects were Japanese, Chinese, Malaysian people, and Vietnamese people. Because these subjects can at least read the alphabet, it seems that it is necessary to prepare proper nouns to write by the alphabet.

6.4 Related work

Zlango [6] is a pictograph-based system built for web and mobile messaging. The system has about 200 pictographs, which are changed from time to time, depending on its usage. Unused pictographs are deleted and new ones are being added to the system. The pictographs are divided into groups such as "People," "Actions," "Places," and "Feelings." Zlango was developed in Israel and could be installed in cell phones in 12 countries. Zlango's customers include Portugal Telecom/TMN, Globe (Philippines), Kiyv Star (Ukraine), Celcom (Malaysia) and other mobile operators.

It is a project of the NHK South Pole kids project, and there is a pictograph chat system for children all over the world to do communication using only pictographs. Concerning this system, pictographs which may be lined up to eight are expressible by the chat system of the Web base. It doesn't have an animation function. Similarly, research involving communication with children in different countries using pictographs was done [11]. However, it is a system using not a real-time chat but a mail base.

There is sign language as a method with the possibility that communication can be done excluding conversation. However, there are a lot of dialects of sign language by country. The sign language that shows Japanese is different from that which shows Chinese. At present, there is international sign language [12] common to all parts of the world though it is not so general. The comparison with this is a problem for the future. Moreover, a person in the sphere of Chinese characters can communicate in writing. The comparison with the Chinese character is a problem for the future.

7 ADDITIONAL EXPERIMENTS

That the sentence structure (order of the pictograph) is different depending on the person has been understood from the experiment. However, there is a possibility that the sentence structure is controlled by written sentences. Then, the same sentences were shown to the Japanese and Chinese who lived in China in their respective mother tongues as an additional experiment, and it was written using pictographs. The Japanese subjects were 20 students at Wakayama University, and the Chinese subjects were 11 staff members in the Institute for Digitization of the Palace Museum Heritage in Beijing. We didn't use the system, but administered a paper questionnaire form. We examined how many pictographs or face marks to use beforehand. We examined whether there was a pictograph or a face mark used in ten recent mails. As a result, subjects who used 0 to 2 pictographs or face marks were 9 people, 3 to 6 were 4 people, and seven or more were 7 Japanese subjects. Subjects who used 0 to 2 pictographs or face marks were 7 people, 3 to 6 were 2 people, and seven or more were 2 Chinese subjects.

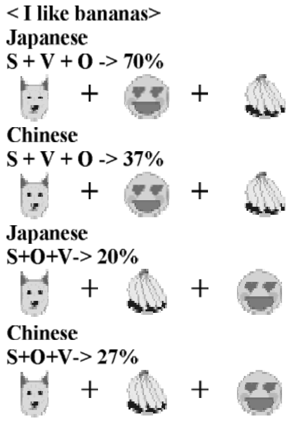

Figure 10: Results of experiment (S+O+V).

Figure 10 shows an example when the Japanese and Chinese write sentences "I like bananas" using pictographs. When these sentences were written with pictographs, the ratio that the Japanese wrote in order of subject + verb + object was 70%, and the ratio for Chinese was 37% though these sentences became the order of subject + object + verb if it was written in Japanese. The Japanese was 20% in the order of subject + object + verb that was the original Japanese order of writing, and 27% in Chinese. The total does not reach 100% because there are examples that cannot be classified like this as the pictograph is described by only one character. Next, the example when the Japanese and Chinese write sentences "I go to school at ten o'clock" with pictographs is shown in Figure 11. If these sentences are written in Japanese, it becomes the order of subject + complement + complement + verb. The order of the writing of (subject) + verb + complement + complement is 90% in the Japanese when these sentences are written with pictographs, and 64% in Chinese. The ratio that the Japanese wrote in order of complement + verb + complement was 10%, and 0% for Chinese. The total does not reach 100% because there are examples that cannot be classified like this as the pictograph is described by only one character (Chinese).

When hieroglyphic Tompa characters are seen in the word order [9], subject + verb + object it is basic, though it is not a pictograph (There are exceptions, as well). Moreover, the word order is verb + subject + object in the hieroglyph. The verb comes ahead of both objects.

Pictographs are often written in the same order in Japanese and Chinese with a different original word order. Moreover, the understanding of each pictograph hardly changes. It seems that the understanding level that exceeds 70% is obtained if it limits it to daily conversation. The questionnaire results concerning how many pictographs to use with a cellular phone and the experiment results are compared. There is nothing said that he can't write with pictographs because the age is high. Moreover, it was understood that a person who uses pictographs well is not necessarily good at communication only with pictographs.

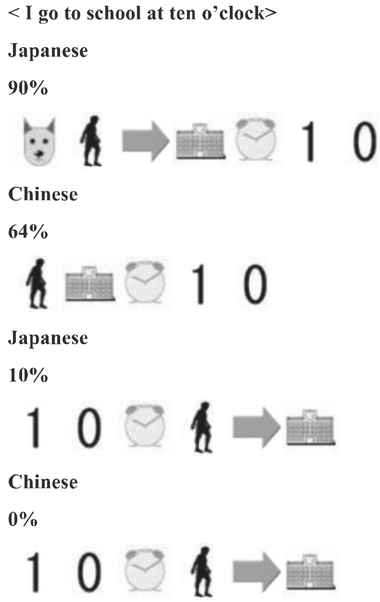

Figure 11: Results of experiment (S+C+C+V).

8 CONCLUSION

We have developed a system for chatting with only pictographs using 550 pictographs. This system was actually applied to "Japanese with good relations," "Persons who did not usually talk mutually," and "International students and Japanese students" and it was applied to 36 a total of people. The following was understood as a result.

(1) It is possible to communicate 70% or more even by sentences only of a combination of pictographs if it is a simple conversation.

(2) There is no difference of the evaluation value in the difference of the sentence composition between Japanese and international students when talking by combining pictographs, and in the questionnaire. Japanese tend to write pictographs in the same order as the international students.

(3) The correspondence such as preparing more pictographs to express proper nouns when friends have a deep conversation, and the ability to input proper nouns, is necessary.

We think it is possible to communicate enjoyably using pictograph chatting. However, we admit the need for improvement of the lack of pictographs showing proper nouns. And, we think it is an effective system as a new method of communication. Moreover, we think that between friends and persons meeting for the first time it is effective to communicate only by combining pictographs between different countries. We want to perform the experiment with a European person and the American in future.

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Pulse Ejection Presentation System of Odor Synchronized with the User's Breathing

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Abstract - Trials on the transmission of olfactory information together with audio/visual information are currently being conducted in the field of multimedia. However, the continuous emission of odors at high concentrations creates problems of olfactory adaptation and odors lingering in the air which do not match the changes in images over time. To overcome such problems, we applied olfactory pulse ejection to emit odor for very short periods of time. Humans perceive an odor when they breathe in and inhale smell molecules in the air. Therefore, it is important that the timing of pulse ejection is synchronized with breathing. We have developed a breath sensor which detects inspiration, and in this study, we combined the use of this breath sensor with that of an olfactory display in order to establish a pulse ejection presentation system of odor synchronized with breathing. The results of an evaluation experiment showed that the system has a more than 90% detection rate. In addition, a questionnaire survey of the users revealed that the system provides them with a continuous sense of smell, avoiding the effects of adaptation and lingering odor. The use of the developed system is expected to make easier the synchronization of olfactory information transmitted together with audio/visual information.

Keywords: Olfactory information, Olfactory display, Breath sensor, Synchronization with breathing, Pulse ejection.

1 INTRODUCTION

Information and communication via computers tends to be limited to visual information and audio information. However, in the real world, humans gather external information via the five senses of sight, hearing, touch, smell and taste, allowing them to react appropriately to local circumstances. Accordingly, the conveyance of such information and its communication via the five senses has lately attracted much attention among researchers in the field of multimedia [1]. Olfactory information recognized by the olfactory organs differs from the information recognized via the other four senses. The sense of smell powerfully affects humans since it is directly transmitted to the cerebral limbic system that governs emotions and memories [2]. Thus, olfactory information serves highly important functions in daily life.

In this study we focus on the development of an ejection control technique for odors, aiming at increasing the application of olfactory information and communication in the field of multimedia. Already in this field, trials are underway to supplement image media such as movies with odors. Any experimental system must control the odor presentation in accordance with the changing images and sounds presented to users. Existing systems have not yet overcome the problem of emitting too much odor over a continuous period, and fine control is necessary in order to avoid various problems such as olfactory adaptation and lingering odors in the air making it difficult to synchronize odors with the ever changing images and sounds.

In efforts to resolve these problems, we attempted to reduce the amount of odor emitted by using pulse ejection for a duration of just 100 msec. In general, it is known that humans can detect odors only when they inhale. So, in order to apply the pulse ejection, it is important that odor presentation is synchronized with breathing [3]. Therefore, we also developed a breath sensor that acquires breath data in real time and can detect the beginning of inspiration. We next combined the developed breath sensor with an olfactory display to create a pulse ejection presentation system of odor that was synchronized with the user's breathing. To examine the performance of this system, we carried out an evaluation experiment and a questionnaire survey with users. This paper presents details of the newly developed system and discusses the evaluation results [1].

2 RELATED WORK

Trials on the transmission of olfactory information together with audio/visual information are currently being conducted. Work first started in the 1950s when Heilig developed Sensorama [4], the first virtual reality (VR) system that presented olfactory information together with audio/visual information. The recently developed virtual space system, Friend Park [5], provides users with an increased sense of reality by generating the odor of a virtual object or environment. Kaye's article [6] describes some systems that add odor to web content, and computer controlled olfactory displays such as iSmell [7], [8] and Osmooze [9] are utilized in these systems. Another type of display, the air cannon olfactory display that generates toroidal vortices of odor in order to present it in restricted space, has been proposed in [10].

Nakamoto et al. [11] designed a smell synthesis device that presents the odor of a virtual object remotely. The system analyzes the smell to be transmitted and presents the analyzed data as the composition ratio of the odor elements. On the receiver side, a feedback control reproduces the target odor by changing the ratio of the odor elements for the receiver.

[1]This work was supported by SCOPE (the Strategic Information and Communications R&D Promotion Programme) of the Ministry of Internal Affairs and Communications in Japan.

A wearable olfactory display with a position sensor has also been developed [12]. By controlling the density of odor molecules, it can present the spatiality of olfaction in an outdoor environment. The olfactory information transmitting system consists of the aforementioned display, a sensing system using three gas sensors, and a matching database. The user can experience a real sense of smell through the system by translating obtained olfactory information.

AROMA [13] attempts to introduce the olfactory modality as a potential alternative to the visual and auditory modalities for messaging notifications. Experimental findings indicate that while the olfactory modality was less effective in delivering notifications than the other modalities, it had a less disruptive effect on user engagement in the primary task.

The addition of an odor to image media such as movies has been proposed by a number of researchers. Okada et al. [14] determined the viewer's mental state by measuring his/her brainwaves, and analyzed the relation between the odor and the viewer's feelings while watching. While a movie that supplements visual/audio information with olfactory information has been created, it could not be widely distributed because the synthetic perfume did not correspond with the changing images and the odor was not deodorized.

3 PULSE EJECTION PRESENTATION TECHNIQUE

In this study, we propose an odor presentation technique matched with the individual breathing patterns of the system users receiving the olfactory information. To control olfactory time characteristics, the effects of adaptation and lingering odor in the air must be minimized as far as possible. We therefore use pulse ejection to emit odor for just very short periods of time. Such pulse ejection enables the amount of the emitted odor to be reduced overall, and in a previous experiment, we confirmed that the odor did not remain in the vicinity of the user when presented by pulse ejection with the wind velocity above a certain level [15], thus avoiding olfactory adaption due to scents lingering in the air. Pulse ejection is defined as the olfactory ejection moment that stimulates the olfactory receptors repeatedly and transiently [16], as shown in Figure 1. By using an olfactory display which can provide a stable pulse ejection of 100 msec, we can realize high-precision emission control of odor released into the air.

When humans breathe in, smell molecules in the air are inhaled, and when a smell molecule binds to a receptor organ in the nose, we detect an odor. This is the recognition mechanism of an odor [17]. In addition, air intake in humans decreases during each inspiration [18]; Figure 2 shows we can reliably detect odors only during the early stages of inspiration. The synchronization of odor presentation with the beginning of inspiration is thus considered the most effective technique [19], especially since pulse ejection involves instantaneous odor emission, where the odor disappears almost immediately without remaining in the air.

Therefore, to ensure satisfactory recognition of odor, we have developed a pulse ejection presentation system synchronizing odor emission with the user's breathing pattern. This system consists of an olfactory display presenting pulse ejection, a breath sensor acquiring breath data in real time, and a control computer transmitting a signal for scent presentation to the olfactory display. Figure 3 shows a schematic of the developed system.

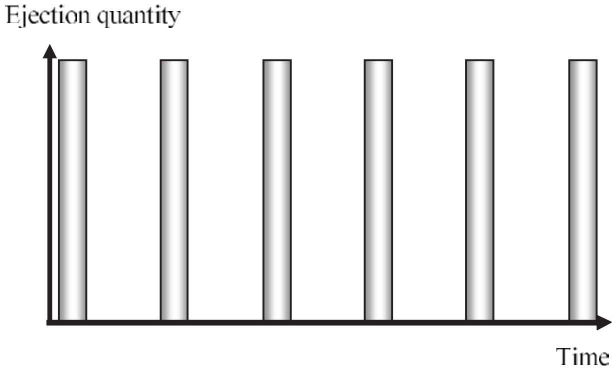

Figure 1: Presentation of bursts of odor via pulse ejection.

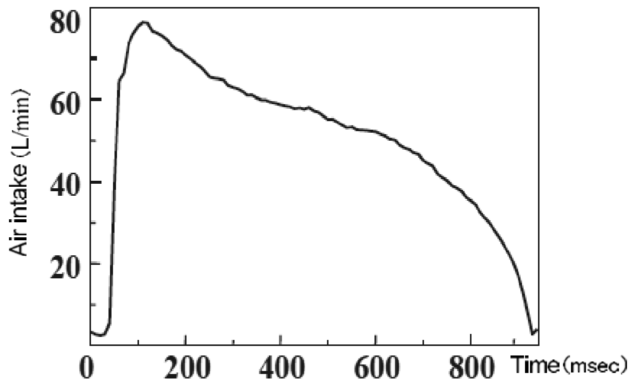

Figure 2: Change in air intake during inspiration over time.

4 OLFACTORY PRESENTATION SYSTEM

4.1 Olfactory Display

Figure 4 shows the olfactory display developed jointly with Canon Inc. used in the experiment. The inkjet display is able to produce a jet which is broken into droplets by small holes in the ink tank. As the concentration of odor emitted from the display is constant, the display adjusts the perceived strength of the odor by altering the ejection quantity. The display has the following features.

- Twelve kinds of odor tanks

  The display can utilize 3 cassettes, each of which can store one large tank and 3 small tanks, which enables the display to present, in total, 12 kinds of odors utilizing 3 large tanks and 9 small tanks.

- Olfactory ejection moment

  Ejection can be controlled for a period of 100 msec.

- Ejection quantity control: 256 phases (large tank), 128 phases (small tank)

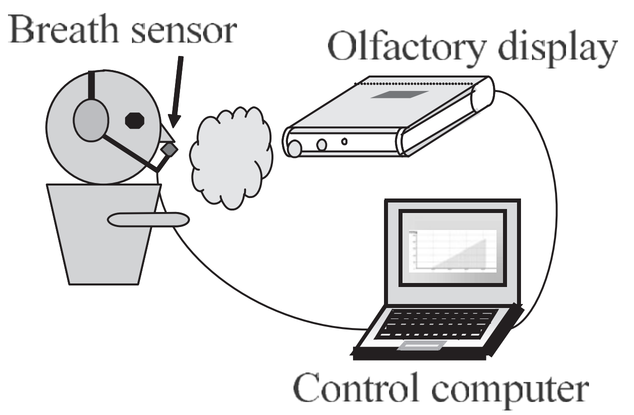

Figure 3: Pulse ejection presentation system synchronized with breathing.

Figure 4: Olfactory display.

There are 256 minute holes in the cassette connected to the large tank and 128 in the cassette connected to the small tank. The user can control the ejection quantity by changing the number of holes used.

- Wind velocity control: 10 phases

  The display is equipped with a fan that can produce 10 phases of wind velocity control in the range of 0.8 m/sec - 1.8 m/sec.

- Creation of an olfactory scenario

  The user can create a scenario in which olfactory ejection occurs multiple times and can control the amount of odor ejected by altering the tank number, quantity of ejection, ejection start time and ejection end time.

For all experiments described below, the display emitted 100 msec pulse ejections of lavender odor. The ejection quantity of the odor was set to 10, which was determined in a preliminary experiment as the value that all users could detect, of the 256 phases. Wind velocity was set to 1.8 m/sec of the display maximum.

Figure 5: Breath sensor.

4.2 Breath Sensor

To acquire breath information, we developed a breath sensor (Figure 5) which senses temperature change in air inhaled through the nose. The temperature detection element is the NTC (Negative Temperature Coefficient) thermistor which is widely used as a temperature detection element and has a negative temperature characteristic that resistance falls when temperature rises. In this study, we used the NTC thermistor [20] manufactured by Honeywell Inc. An Op-Amp amplifies each item of sensing data, an A/D converter (AMTEC Inc.) converts it to a digital signal, and the value is transferred to a computer.

The data transfer rate of the output voltage level acquired from the breath sensor is 10 sample/sec and the analysis software ”TracerDAQ” (AMTEC Inc.) records the data. Figure 6 shows a wave pattern of the recorded breath data from which the beginning of inspiration is detected. Since the temperature of the thermistor falls when air flows during inspiration, the resistance and the output voltage fall. Conversely, the output voltage rises during expiration. Thus, the timing when the wave pattern of breath data begins to fall is judged as the beginning of inspiration.

Characteristics such as breathing intervals differ from person to person, and each user must therefore calibrate the breath sensor before use.

4.3 Pulse Ejection Presentation System of Odor Synchronized with Breathing

Next we developed a pulse ejection presentation system that is synchronized with breathing. The user wearing a breath sensor sits in front of the olfactory display and is presented with odor (Figure 7). The system acquires the user’s breath data via the breath sensor and transfers the data to a control computer. The control computer runs a program to monitor breath data constantly and to detect the beginning of inspiration. At the point the program judges to be the beginning of inspiration, a signal for odor presentation is transmitted to the olfactory display, which then presents odor to the user. The above represents the process of smell presentation by the pulse ejection presentation system.

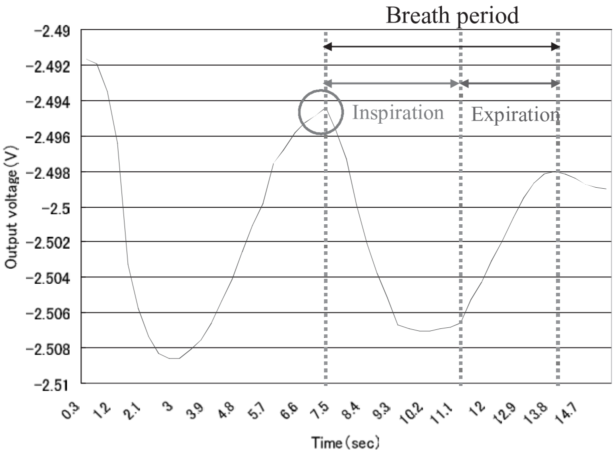

Figure 6: Breath data measured with the breath sensor.

Figure 7: User wearing the breath sensor.

5 EXPERIMENT

5.1 System Verification

To verify whether the developed pulse ejection presentation system detected inspiration and presented odor accurately, we conducted a verification experiment with 20 participants (17 males, 3 females, aged in their 20s).

In each experiment, the system monitored around 10 of the participant's breath cycles and presented lavender odor for 100 msec by pulse ejection at the beginning of each inspiration. Participants were instructed to click a mouse when they began to inhale. After the experiment, we verified the performance of the pulse ejection presentation system by comparing the timing of odor presentation as determined by the system with that of the clicking of the mouse button. Each participant performed the experiment two times.

We defined the correct detection rate and the false detection rates as follows and then calculated the rates using data obtained in the verification experiment.

$$Correct\ detection\ rate\ (\%) = NSDC \div NPI \times 100 \quad (1)$$

$$False\ detection\ rate\ (\%) = NSDW \div TNSD \times 100 \quad (2)$$

$NSDC : Number\ of\ times\ system\ detected\ inspiration\ correctly$
$NPI : Number\ of\ inspirations$
$NSDW : Number\ of\ times\ system\ detected\ inspiration\ wrongly$
$TNSD : Total\ number\ of\ times\ system\ detected\ inspiration$

The correct detection rate of this system was determined to be 93.9%, and the false detection rate was 11.3%. As a result, the developed system was confirmed to detect the beginning of inspiration with a probability of more than 90% and to be capable of presenting odor synchronized with breathing. The correct detection rate is able to increase close to 100%, but at present the false detection rate increases with it. Because of this increase in the false detection rate, there is wasteful ejection and an excess quantity of odor is emitted. Depending on the purpose of system usage, it will be necessary to adjust the balance between the correct detection rate and the false detection rate.

5.2 Questionnaire Survey on Feelings Regarding the Odor Presented

We provided 22 participants (16 males, 6 females, aged in their 20s to 60s) an experience of odor presentation using the developed pulse ejection presentation system, and then administered a questionnaire survey in order to determine the users' feelings about the odor presented.

In the experiment, while wearing the breath sensor, participants were exposed to lavender odor that was presented for 100 msec by pulse ejection. The odor was emitted when the system detected the beginning of inspiration and was repeated for 10 breath cycles. As the average time of each breath is 5 seconds [21], it took about one minute to complete the experiment with each participant, and the ejection time of odor was just 1 second in total. After each participant smelled the odor, he/she responded to the following questionnaire items.

Question
What did you notice about odor presented by the pulse ejection presentation system?

The answers presented for the respondent to choose from were as follows:
① Noticed it continuously
② Noticed it on every breath
③ Noticed that the strength of the odor alternated between strong and weak
④ Noticed that the strength of the odor gradually got stronger
⑤ Noticed that the strength of the odor gradually got weaker
⑥ Noticed the odor in fragments
⑦ Did not continually notice the odor

The questionnaire results are shown in Figure 8. Despite the presentation of odor by pulse ejection, many participants noticed the odor continuously (①) or on every breath (②), indicating that the system works effectively. In addition, many participants noticed the odor in fragments (⑥). We think one

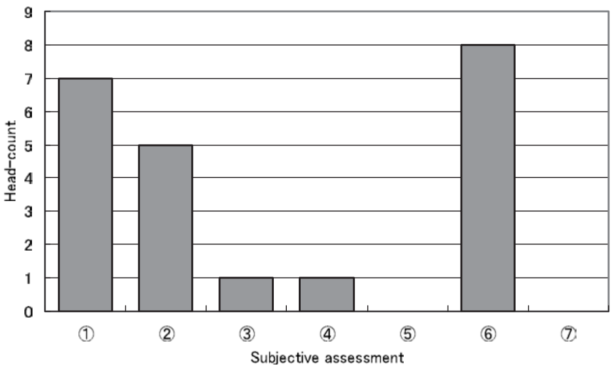

Figure 8: Questionnaire results

reason for this is that participants are not able to detect odor during expiration. Another reason is that there were cases when odor was not present because the pulse ejection presentation system likely did not accurately detect inspiration.

It should be noted that there were no participants who noticed the strength of the odor gradually got weaker (⑤) or could not continue perceiving the odor (⑦). This indicates that the presentation of pulse ejection synchronized with breathing could provide the participants with a continuous sense of smell, avoiding the effects of adaptation and lingering odor in the air at least for about one minute.

6 CONCLUSION

In the field of multimedia, trials using odor to supplement audio/visual media are being conducted and it is necessary to control the presentation of odor in order to synchronize it with changes in audio/visual information over time. However, problems of olfactory adaptation and odor remaining in air remain to be solved. To approach these problems, we developed a pulse ejection to present odor synchronized with the inspiration of the receivers of olfactory information.

Pulse ejection of odor for a very short period of 100 msec was stably presented during inspiration by combining the use of a breath sensor which could acquire breath data in real time with an olfactory display that has high emission control.

System verification experiments showed that the system could detect the beginning of inspiration with a probability of more than 90% and present odor synchronized with breathing. In addition, a questionnaire survey of users' opinion of the odor presented by the system revealed that most users could notice odor continuously or on every breath during the trials and none were considered to have been affected by adaptation and lingering odor in air.

The developed system will make the fine control of odor presentation possible, enabling further advances to be made in the transmission of olfactory information together with audio/visual information. As a result, the synchronization between media is expected to become easier.

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Multi-agent system for User-oriented Healthcare Support

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Abstract - In this paper we propose an advanced healthcare support system in ubiquitous computing environment. By utilizing knowledge about healthcare and various information including vital sign, physical location, and video data of a user under observation from real space, the system provides useful information regarding health condition effectively and in user-oriented manner. In this paper, we describe a user-oriented healthcare support system based on concept of symbiotic computing, focusing on design and implementation of the system with multi-agent system.

Keywords: Healthcare support system, Ubiquitous computing, Multi-agent system, Context-aware service, Multimedia communication

1 INTRODUCTION

With the increase of people with lifestyle-related diseases such as obesity, hypertension, diabetes, and hyperlipidemia, health maintenance to prevent these diseases has been an issue of social concern. Information technologies are expected to give practical solutions to this issue, and some research groups have been investigating the solutions from engineering viewpoints [1]–[7]. In this context, ubiquitous computing technologies are promising, because they contribute to expand the scope of system support to users' daily lives. Hand-held terminals, wearable vital sensors, wireless communications, etc. are playing important roles in this application domain [8]–[18].

However, these existing systems are designed by using some specific vital sensors and electronic devices, therefore these systems are limited in ability of healthcare support. In order to provide useful information for healthcare of an object person, not only to him/herself but also to related people of the person, the system should acquire variety of information, knowledge, data, etc. from real space and store/manage them in a methodical manner. This means that we have to treat a new dimension of design and construction of large-scale systems that can cope with many kinds and amount of information on unstable processing environment of ubiquitous computing.

We have been investigating an advanced healthcare support system in ubiquitous computing environment. By utilizing knowledge about healthcare and various kinds of information obtained from real space, the system provides useful information regarding health condition effectively and in user-oriented manner. In this paper, we describe the concept and design of user-oriented healthcare support system based on multi-agent. The grand design of our healthcare system is based on symbiotic computing [19]–[21] that is a concept of post-ubiquitous computing according to co-existing of real-space and digital-space. Especially, this paper focus on the concept, design, and implementation of several function of our system with multi-agent technology that matches to realize this kind of large-scale and complex systems by employing such properties as autonomy, cooperativeness, and adaptability of agents. We also show the effectiveness of our prototype system with results of initial experiments.

The remainder of the paper is organized as follows. Section 2 describes related studies. The concept and an agent-based framework for healthcare support system are described in Section 3, and designs and implementation are illustrated in Section 4. We describe experiments and evaluation in Section 5. Finally, we conclude this paper in Section 6.

2 RELATED WORKS AND PROBLEMS

2.1 Related Works

There have been many attempts to assist healthcare support based on information technologies. In this section, we present related works about healthcare support systems, and summarize their problems.

Administrative organizations provide various kinds of information about healthcare on the Web [1], [2]. Several companies have developed a medical device and provide a healthcare service utilizing the device [3].

Some research groups developed support systems which recognize health condition of a user by monitoring user's vital signs using compact sensors, hand-held PCs, and wireless network in ubiquitous computing environment [8]–[13]. There exists the system which can infer user's behavior, activity, and emergency situation according to the vital signs and location information of the user's by using wearable sensors. In [14], Chang et al. studied methods that automatically recognize what type of exercise the user is doing and how many repetitions he/she has done so far. They incorporated a three-axis accelerometer into a workout glove to track hand movements and put another accelerometer on the user's waist to track body posture.

A project [5] was promoted to develop a prototype of next generation network system which can provide high quality health service with sufficient security and protection of user's privacy. Under the project, a health advice derivation system has been developed [6]. This system can derive health advice according to the user's condition and knowledge about health.

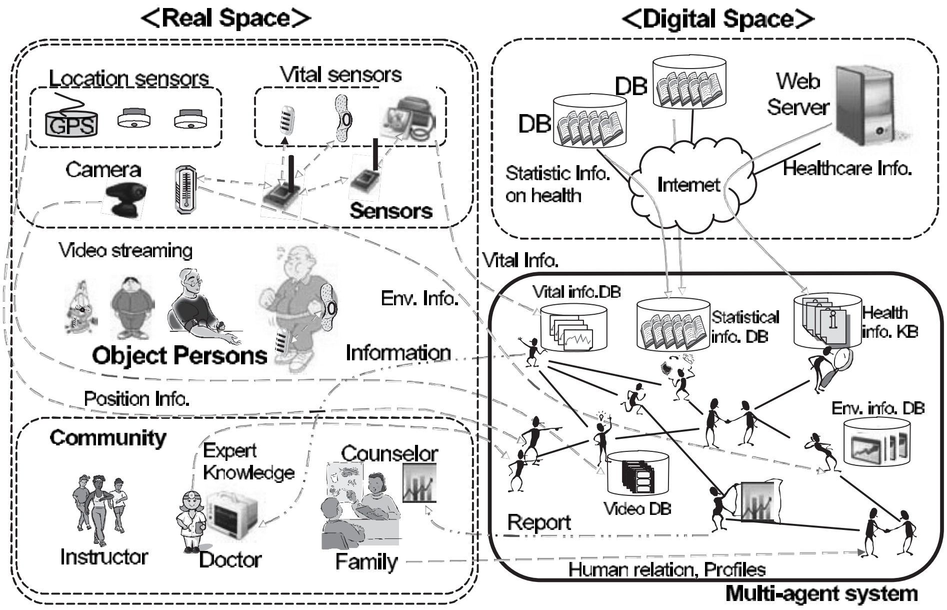


Figure 1: Concept of user-oriented healthcare support system based on multi-agent

2.2 Problems

¿From discussion on previous works in Section 2.1, we point out technical problems in existing healthcare support system as follows.

- **Effective acquisition of various and amount of information for multiple object persons (P1):** There are studies determining the health condition based on vital sign by specific sensing devices in real-time. But the information has limitations for obtaining an accurate estimation of the health condition because the information is obtained by the vital sign limited piece of information on only a certain individual. It would be possible to perceive the health conditions of multiple object persons with greater accuracy using physical location of the persons, environmental information such as ambient temperature and room brightness, and video information of the persons, as well as the vital sign. However, it is difficult to acquire all the information in real space for multiple object persons because of the limitation of computational resources and network resources in the ubiquitous computing environment. Consequently, we need to consider the effective way of information acquisition from real space.

- **Effective inference mechanism using various kinds of information of real space (P2):** After acquisition of various kinds of information from real space, effective information and real-time service provisioning using the information would be a challenge. The data and information including vital sign, location information, environmental information, multimedia data, specialized knowledge, etc. contain significant diverse aspects in both quantitative and qualitative. By using existing inference mechanism, we cannot cope with these kinds of information and knowledge in real-time. Therefore, we need an effective inference mechanism for actively-provisioning in real-time.

- **Infrastructure of system construction (P3):** In the related works, specialized systems in each area of healthcare have been developed in an ad-hoc manner. Thus, we do not have an infrastructure of system construction to facilitate implementation of systems for various healthcare areas. The infrastructure needs system extendibility to introduce new sensor device, wireless network technology, diagnosis algorithm for analyzing condition of health, DB system etc. in easy ways. In order to enhance extendibility and flexibility of system implementation, we require consideration of common software infrastructure containing platform and components dedicated to healthcare support.

3 CONCEPT OF USER-ORIENTED HEALTHCARE SUPPORT SYSTEM BASED ON MULTI-AGENT

3.1 Overview of User-oriented Healthcare Support System

Figure 1 shows the concept of our proposed system. We propose a methodology of construction of user-oriented healthcare support system based on multi-agent to solve the problems mentioned above in Section 2.2.

This system assists the object persons and community members related healthcare support services. The community members are related to the object person such as family member, sports gym instructor, doctor, etc. to circulate healthcare related information and knowledge effectively. The system collects information on the object person such as profiles, preferences, history of exercise, medical records, human relation, etc. from the healthcare community members. The system actively observes the current status of the object person and his/her surrounding environment such as physical location, temperature, body warmth, HR, BP, etc. by using various types of sensors. These are the information flows from real space to this system.

On the other hands, the system accesses to the Web site and databases (DBs) via the network to fetch useful information on healthcare. These are the information flows from digital space to this system. The information, data, and knowledge are accumulated in the system in adequate forms. If needed, they are used to analyze the situation of the object person in detail. The information is sometimes provided to the person and the community members by proper timing and forms, considering privacy concerns and resource limitations of the devices.

¿From the viewpoint of the symbiosis between real-space and digital-space, this support system is an accelerator of information circulation in order to promote the healthcare tasks. However, huge amount and functional diversity of the information, involving the privacy concerns, make it very difficult to accomplish.

3.2 Applying Multi-agent Technology

A multi-agent system is a distributed autonomous coordination system. Various types of system component are wrapped (this wrapping is called "agentification"), and then it gets possible to work as an agent. The multiple agents can dynamically configure organization to process some intended tasks.

Consider the situation where some vital data or location information is acquired by a sensor device, transmitted via the network and stored in a DB. Each agent individually resides in various sensor devices. The agent monitors and controls corresponding hardware. Also the DB which stores acquired data is made to work as agent. Quality of information and frequency of the acquired data should be controlled depending on network status, operational condition of the sensor device, and load of the DB. The proposed system can effectively control the data flows based on the situation and health condition of the object person by cooperation among sensor agent, DB agent, and network agent. This will be a solution to (P1).

The accumulated information is basically in the form of raw data. It should be converted into more user-friendly forms such as tables and graphs. Some data can be used to analyze the situation of the object person to create knowledge or advice with high-level expression. These analytical results can be used by agents' organizational behaviors. For example, when the object person is in bad health condition, the sensor agent that observes the vital data of the person would try to acquire more detailed information in shorter time intervals. To realize these kinds of intelligent analysis, each agent has basic inference mechanism based on the rule-base system. For more special knowledge processing, some kinds of powerful tools, such as ontology-base, data mining algorithms, software for statistics, etc. are needed to cooperate with each other. Therefore we need to wrap each tool as an autonomous agent. The various health conditions are elicited in an efficient and effective by assistance based on collaboration and cooperation with the workable agents. This would be a solution to (P2).

In addition, agentification of various devices, database, knowledge, algorithm for analysis, software components, etc. makes reusable module, and agents can dynamically configure a complex system. It is possible to build a new component into the existing system at the lowest possible cost when the component is introduced. Thus the infrastructure of system construction based on multi-agent system will realize reduction of system development cost and advancement of the system. This is another important aspect for ubiquitous applications whose technologies are proceeding at a rapid rate daily. This will resolve the (P3).

Concretely, an agent for managing and controlling vital sensor sends vital data of an object person as stream data to a data stream mining agent. The data stream mining agent analyses the stream data including vital data using data stream mining technology, in real-time. Then the agent detects the health condition of each person. Based on the health condition, agents in sensor devices control the data quality and frequency of data acquisition. By this function, our system can collect vital data of the persons, send and store the data in the database stably, according to the condition of the persons. Moreover, our system can provide a useful information and advice about healthcare for the persons in real-time, according to the person's location and available devices, combining vital data, environment data and knowledge (ontology) on health effectively.

3.3 Agent-based Framework AMUSE

We employ a multi-agent-based framework for service provisioning in ubiquitous computing environments based on concept of symbiotic computing [19]–[21], called AMUSE (Agent-based Middleware for Ubiquitous Service Environment) [22], [23], as a software platform to build user-oriented healthcare support system. The fundamental framework of AMUSE is shown in Figure 2. The basic idea of this framework is "agentification" of all the entities in the ubiquitous computing environments. The agents can perform advanced cooperation and intelligent behavior as follows:

- Recognition of statuses of each entity: Each agent can autonomously observe detailed situation of the target entity such as devices and users, based on the domain knowledge of the entity.
- Coordination of multiple contexts: Multiple entities can effectively exchange context information each other by agent. When agent informs other agent about own context, Inter-Agent Relationship (IAR) is efficiently constructed to reduce unnecessary communication between agents.
- Service composition by combination of entities: Agents can make contract to configure organization of entities in order to dynamically build healthcare support services.

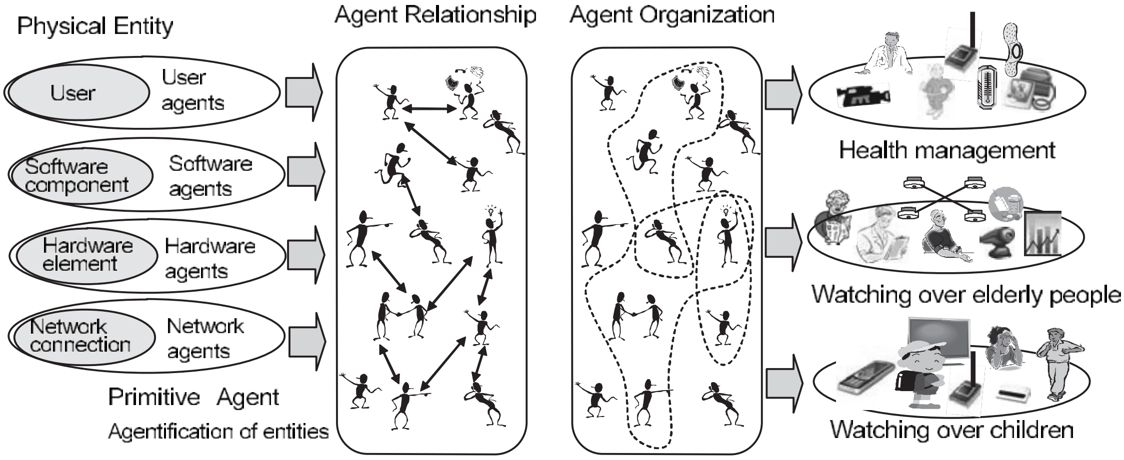


Figure 2: Framework of AMUSE

We have discussed the details of AMUSE in [22], [23], so we omit them in this paper.

4 DESIGN AND IMPLEMENTATION OF USER-ORIENTED HEALTHCARE SUPPORT SYSTEM

4.1 Multimedia system for healthcare support

We suppose the healthcare support system consists of various daily life support systems such as health management system, multimedia supervisory system, remote medical care system, etc. Here, we assume a multimedia supervisory system as one of the healthcare support systems. The multimedia supervisory systems are widespread as care-support systems that enable supervision of children and elderly people from remote sites connected by a wide-area network. Figure 3 shows an example of real-time multimedia supervisory system that delivers live video streaming captured with cameras at the watched person's site, with a PC or a hand-held device at the distant supervisor site.

Our system displays a live video with suitable quality on one of the displays considering the watching person's requirement for the watching over and the status of devices. The agents basically reside in computers, and they manage corresponding entities that are connected to, or are running on the computer. The agents cooperatively work to accomplish QoS that meets to user's requirements on a watching task and device situations. Therefore, our system makes the construction of agent organization by considering the most appropriate camera, the PC with reasonable network connection, and the display devices based on multiple contexts. These contexts are individually maintained by each agent, and its effective coordination would be performed by cooperation among related agents.

4.2 Implementation

In anticipation of our healthcare system, we are developing part of the real-time multimedia supervisory function that delivers live video streaming. Agents were implemented based on AMUSE framework. As for implementation of agents, we used DASH [24]. DASH is an agent-based programming environment based on ADIPS [25]. We also used IDEA [26] for the development and simulation of the agents. It is an integrated development tool for the DASH.

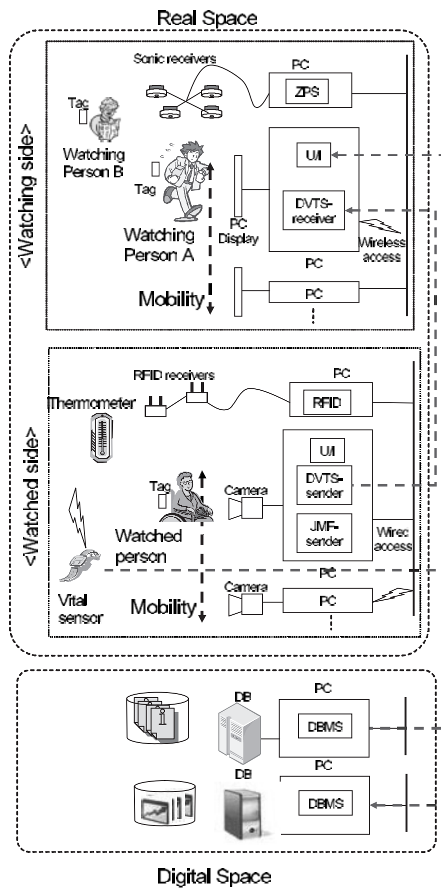


Figure 3: An example of real-time multimedia supervisory system for healthcare support

Table 1: Description of agent library

	Function	Agent Name	Base Process	Description
Hardware	Location information	ZPS	ZPS	Identifying location of tags using ultrasonic sensor
		RFID	RFID System	Identifying location of tags using RFID system
	Image input	DV-camera	DV camera	Control a DV camera to capture video image.
		USB-camera	USB camera	Control a USB camera to capture video image.
	Image output	PC-Display	PC Display	Control a connected PC display to show video image.
		TV	TV set	Control a connected TV set to show video image.
	Audio input	Mic	Microphone	Control a connected microphone to capture audio.
	Audio output	Speaker	Speaker	Control a connected speaker to play audio.
	Computer monitoring	Comp	CPUcheck	Monitoring of the status of computational resources such as CPU usage rate in a target computer.
	Biological information	Bio	Heartbeat	Monitoring target person's heartbeat.
Software	Location information	Location_manager		Management of the up-to-dateness specified by the other agent or application developer.
	Video receiver	DVTS-rec	DVTS application	Video receiving in very high quality by using DVTS Software.
		JMF-rec	JMF application	Video receiving in various formats by using the Java Media Framework (JMF).
	Video sender	DVTS-send	DVTS application	Video sending in very high quality by using DVTS Software.
		JMF-send	JMF application	Video sending in various formats by using the JMF Software.
	Management	Manager		Management of behavior of all the agents in the corresponding PC
	Interface	UserReq	U/I component	Maintenance of the GUI-based software component to acquire the user request directly.
	Human relation	Human-Relation-Ontology	Ontology base	Management of the knowledge on human relationship of users.
	Daily activity support	Daily-Activity-Ontology	Ontology base	Maintenance of knowledge on daily activities of users.
	Common sense support	Common-Sense-Knowledge	Knowledge base	Maintenance of common knowledge used in the target application.
	Situation recognition	Situation-Recognizer		Recognition of situation of a target user.
	Relation recognition	Relation-Recognizer		Specifying human relationship between users.
	Decision making	Advisor		Making decisions of action for a specific application.
	Database management	DBMS	DBMS	Management of the data such as vital sign, environmental information, and location information, and multimedia data.
	Technical knowledge support	Technical-Knowledge	Knowledge base	Management of the knowledge on experts for healthcare.
Network	Network monitoring	W-Net	NETcheck	Monitoring status of an wired network.
		WL-Net	NETcheck	Monitoring status of an wireless network.
User	User manager	User name		Management of requirement, preference, profile, etc. of a user.

We summarize the agent library for AMUSE Framework as shown in Table 1. The agents are categorized into four classes: hardware, software, network, and user agents. The base process is the corresponding entity for each agent. We constructed these agents using ADIPS/DASH.

As for hardware configurations for sensing the location information, we use two sensor types to sense the location information of users in the room: an ultrasonic-based sensor and an RFID system. We use Furukawa Sanki's positioning system Zone Positioning System (ZPS) [27] as the ultrasonic sensor. We also use an active-type RFID system (Fujitsu Software Technologies) [28]. Also, as for delivering live video, we implemented two types of software: DVTS [29] and JMF [30].

5 EXPERIMENTS

5.1 Experiments based on watched person's situation

This section describes some examples of behavior of our system function. We suppose a situation where a watching person (son) watches over a elderly watched person (his father) in remote sites.

In the first experiment, we observed our system behavior based on the watched person's situation. Figure 4 shows the watched person's room. In this room, we set two cameras for delivering a live video: a DV camera and a USB camera as shown in the left picture in Figure 4. The watched person has ZPS tag for sensing tag height and location information. The right picture in Figure 4 shows the ZPS receivers in the watched person's room. We performed some experiments using different situations of the watched person.

Case of normal situation: Figure 5 shows the watching site. The watching person always brings the user terminal. When the watched person is normal situation such as taking meal in the dining room, the nearest user terminal from watching person displays the watched person's image with reasonable quality by USB camera. Moreover when the watching person approaches the plasma television, the live video stays the user terminal. It means agents selected the user terminal and USB camera respect to their personal relationship with the watched person and the watched person's situation (normal situation).

Case of emergency situation: In Figure 6, we compare our system with a location-based service configuration to show the effectiveness of our framework. This case shows emer-

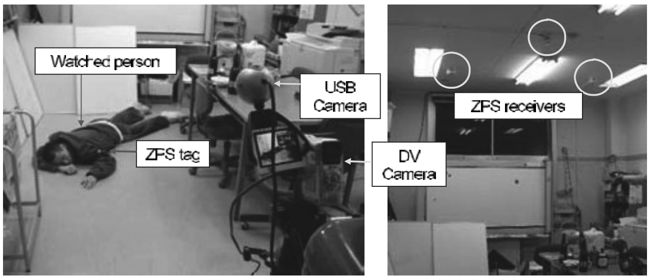


Figure 4: Room setting for experiments based on watched person's situation

Figure 5: The case of normal situation

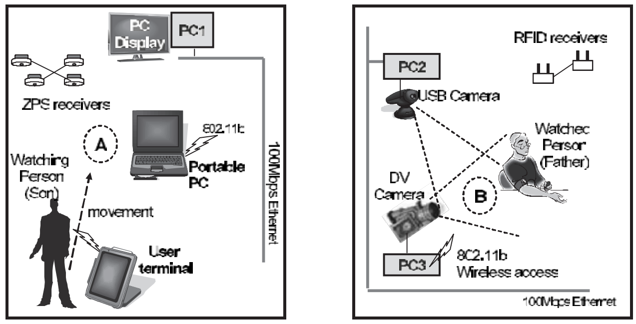
gency situation of the watched person. The system can understand that this is an emergency situation by inference from the period of time (he has not moved), the location information, and tag's height. For example, the watched person lying in the dinning room is unusual and it is an emergency situation. The left picture in Figure 6(a) shows the behavior of our proposal-based scheme when the watching person moves closer to the plasma television. The video streaming was migrated to the high definition television to show the situation more clearly when the watched person lay down. Then, the most adequate display devices around the watching person, and finally the most suitable display, video streaming software and network connection were selected and configured to deliver the live video. On the other hand, in the case of a location-based scheme, the video service stayed in the user terminal because it was judged as the nearest display, as shown in Figure 6(b).

¿From these experiments, we confirmed the individual agent could decide its own action by considering the situations of the watching person and watched person.

(a) Our proposal-based service configuration

(b) Location-based service configuration

Figure 6: The case of emergency situation



(a) Watching site: Living room in home

(b) Watched site: Living room

Figure 7: Room setting for experiments based on watching person's requirement

5.2 Experiments based on user requirement

Next, we experimented following application scenarios to evaluate feasibility and effectiveness of our system. Figure 7 shows two experimental rooms.

Figure 7(a) is regarded as the watching person's living room. Additionally, Figure 7(b) shows the room settings of the watched sites. Here, the watching person's user terminal is shown in Figure 7(a). The user terminal is always brought with the watching person. This terminal is selected for receiving the video of the watched person, when other displays cannot be available. A User agent resides in this terminal. The agent monitors the user's requirements and presence. Also, we used ZPS ultra-sonic sensor to sense the watching person's location information. Figure 7(b) is supposed to be a living room in a watched person's home. As for location sensor, we employed an active-type RFID system in this room.

In this experiment, we observe our system behavior based on user requirement. The User agent provides a user interface about the option on the user's terminal. Then, a watching person specifies a user requirement.

We compare our system with a location-based service configuration. In case of a location-based service configuration, the scheme selects the nearest camera and display (except the user terminal) to the watched /watching people, respectively, without any consideration of total quality of the service. Additionally, we fix his father's location for simplification at point "B" in Figure 7(b). Agents cooperatively work together to select the most adequate sets of entities based on the son's requirements and location.

As a user request, the son requires the high smoothness of movement of the video to watch in his father's health condition. When he moves to the location at point "A" in Figure 7(a), a user terminal and a PC display can display the video. It means the point "A" is the service area of the portable PC and the PC display.

In the case of a location-based scheme, because the portable PC was judged as the nearest display, the video service moved to the portable PC from the user terminal, as shown in Figure 8(a). However, the video frame rate was too low to view the movement of his father's body smoothly because it was moved with the same video frame rate parameters as it was in the user terminal.

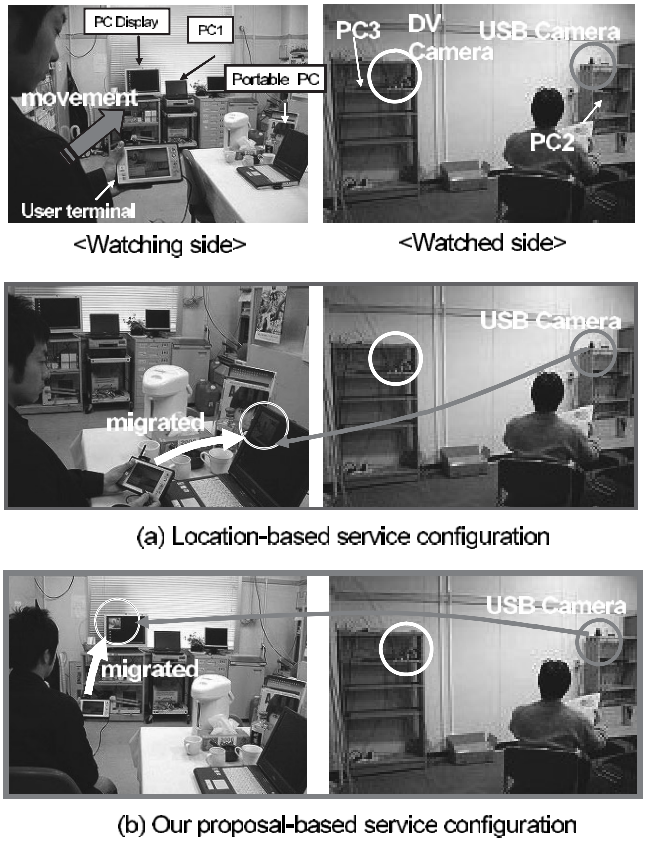


Figure 8: Service configuration in case of high smoothness requirement

At the same time, Figure 8(b) shows the behavior of our proposal-based scheme. Our scheme selected the PC display and the USB camera connected to PC2, with high frame rate to fulfill the user's requirement. As for the network context, PC2 is the best because it is connected by a wired link with 100 Mbps. Additionally, agents recognized that because DVTS software was not installed in PC1 of PC display, the display cannot play DVTS video. Consequently, the USB camera connected to PC2 with the JMF-send agent is selected. In this case, we confirmed that our scheme could deeply consider the multiple contexts, and our scheme could satisfy the user requirement for high smoothness of the video.

5.3 Performance Evaluation

In this experiment, we show the switching time during video service migration for performance evaluation of our system. We used the user terminal with two kinds of access networks: IEEE 802.11g (54 Mbps) and PHS (128 kbps) in this experiment. We measured the switching time during the video service migration in the cases of IEEE 802.11g and PHS, respectively. We measured two cases as follows:

Case-1: The video service migrated from the user terminal to the other PC based on the user request.

Case-2: The video service migrated from the average PC except the user terminal to the other PC (except the user terminal).

When the user terminal used IEEE 802.11g, both Case-1 and Case-2 were able to switch within 3.0 s, on average. It is in an acceptable range for practical use. When the user terminal used PHS, Case-1 took more than 7.0 s in some cases, but Case-2 switched within 3.0 s on average. This reason of the time delay in Case-1 with PHS is a latency of inter-agent message exchange for video service migration between agents in the user terminal and the other PC, during which time the user terminal is receiving the video streaming.

On the other hand, the switching time in Case-2 with PHS was almost the same as the Case-1 using IEEE 802.11g. This result shows the effectiveness that the individual agent could effectively exchange context information while reducing unnecessary communication based on IAR and decide the video service migration by considering the situations of the other agents.

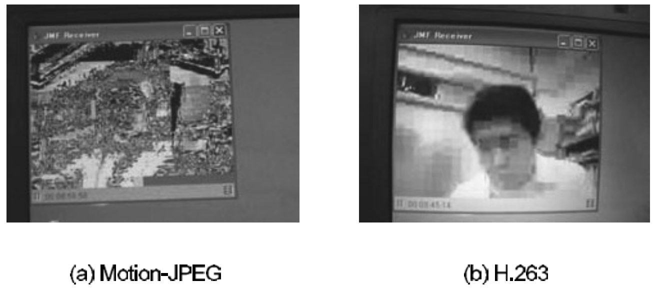


Figure 9: Privacy protection function of video streaming in case of Motion-JPEG (a) and H.263 (b)

5.4 Privacy protection function by controlling quality of service

We think privacy concerns are important aspect in healthcare support system. We are now trying to give privacy protection function to our system. Figure 9 shows the privacy protection function using JMF by controlling the quality level. This function adjust the parameters related the video quality of JMF such as frame rate, bit rate, etc., in accordance with the video format (Motion-JPEG and H.263). In fact, JMF-send agent and JMF-rec agent cooperate to adjust the parameters and the format depending on the situation of network resource. Figure 9(a) shows the case of Motion-JPEG; Figure 9(b) shows the case of h.263. We can see from Figure 9(a) and Figure 9(b), the quality of the video is too low to see the person's face clearly, but we can only judge the person's movement. We consider this function can useful as one of the method to protect the privacy easily.

5.5 Visualization function

Additionally, we are developing the visualization function of the watched person's situation. As an initial development, we are trying to visualize the sensor data such as vital information, location information, and environmental information. We suppose DB agents cooperate with various agents depending on the situation. Here, we show an example of the coordination with a DB agent which is managing watched person's location information. Figure 10 shows a map agent which displays the watched person's position information in his house.

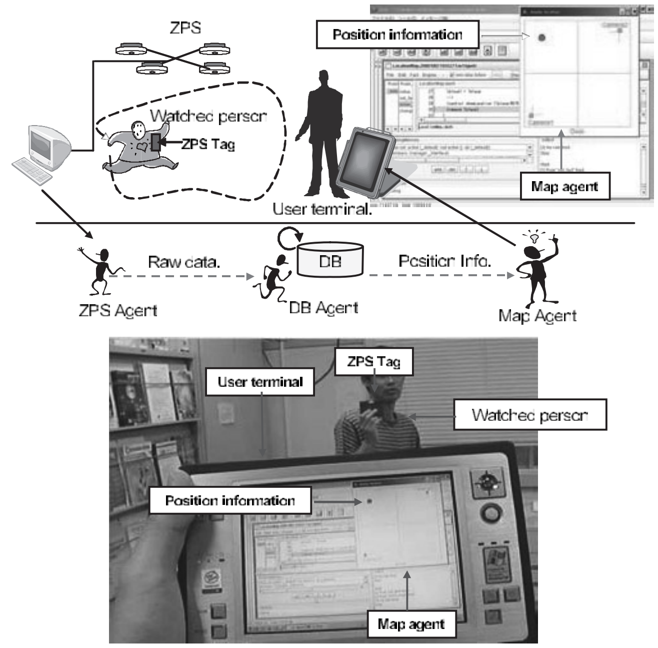


Figure 10: An example of Visualization function

The watched person walks around with a ZPS tag. ZPS agent sends the watched person's location information in the raw to DB agent. The DB agent processes the information and sends the information to Map agent in the watching person's user terminal. The Map agent shows the watched person's position information. We think this function will be helpful for the watching person and the watched person when the camera can't deliver the video streaming and the system think the great deal of the watched person's privacy.

5.6 Discussion

We discuss the effectiveness of our system through the experiments as follows:

Feasibility: We evaluated our proposal-based service configuration scheme. Our scheme could effectively configure service that matches person's requirement, coping with not only the user location information, but also the device status around the users in the ubiquitous computing environment. In our multimedia supervisory function for healthcare support system, heterogeneous entities like display devices, capture devices, PCs, networks, different kinds of sensors, software components, etc., are efficiently integrated in real-time.

And our system can control the privacy level depending on human-relationship and watched person's situation. When the watched person's situation is normal situation, our system protects the watched person's privacy on suitable format; when the emergency situation, our system delivers the high quality video considering multiple contexts.

Effectiveness: Because of the introduction of our agent-based framework, the integration of many entities was successful. Our system provides useful information related healthcare to the object persons and community members. The various types of information are acquired, managed, and provided by cooperation of agents. We confirmed the modularity, the autonomy, and the loose coupling characteristics of the agents from the experiments related visualization function. The function was constructed by agent organizations such as the location information agent, DB agent, and the map agent by easy way. It can adapt to diversity of types of entities and scalability of system size. The system development and extension will be easily accomplished by using this architecture.

6 CONCLUSION

We presented a concept of user-oriented advanced healthcare support system based on multi-agent system in ubiquitous computing environment. The system provides useful information regarding health condition effectively and in user-oriented manner by utilizing knowledge about healthcare and various kinds of information obtained from real space. We also designed and implemented an initial prototype system.

As future work, we would like to advance detail modeling and design to adapt to a variety of the supervisory system such as the healthcare support system and multimedia watching over system for elderly people, and we plan to extend current implementation using various vital sensors, environmental sensors, and DB systems. Moreover we will try to consider the detailed design of data actuation mechanism using data stream mining technology and effective inference mechanism combining an ontology and sensor data. We will integrate these kinds of mechanism into our healthcare support system.

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Remote consultation system using hierarchically structured agents

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Abstract - In fields of technological innovation the speed of advance is fast, and while it is difficult for some people to keep up, there are few experts in new technologies. Since consultation is focused on a small number of experts, phenomena such as being unable to obtain sufficient information in a timely manner occur, and are one of the major reasons for the increasing social-technological divide. This paper proposes a 2-level hierarchical remote consultation system using two types of agent. The system possesses the features that through the responses to consultation made in advance by multiple agents, experts can focus on only complex questions, and consulter's waiting times are reduced. Its effectiveness is demonstrated experimentally.

Keywords: remote consultation system, agent, remote communication, expert, TV conferencing.

1 INTRODUCTION

Society has been aging in recent years, and service functions for poorly informed aged persons and patients will be sought. While the number of healthcare professionals is small, remote healthcare consultation which is efficient and yet maintains an appropriate level of service is being sought. In addition, while forms of employment are diversifying, models of employment such as the teleworking remote office are gathering attention. Further, in fields of technological innovation the speed of advance is fast, and while it is difficult for some people to keep up, there are few experts in new technologies. Since consultation is focused on a small number of experts, phenomena such as being unable to obtain sufficient information in a timely manner occur, and are one of the major reasons for the increasing social-technological divide according to which the benefits of advancing technology cannot be fully realized. Regarding policies for resolving this issue in society at present, research focusing on the theme of efficient remote communication support is important. In particular, support for fostering communication among disparate groups of fellow persons is essential.

So far, remote consultation systems have been conducted via TV conferencing and so on [1]–[4]. However, in such cases, it has been usual for consultation to be conducted with 1 consultee exclusively occupying the services of 1 expert. Regarding information sharing there are also remote conferencing systems [5] such as Skype. Functions for visualizing the topic of a discussion among its members in a shared manner have also been proposed. However, remote conferencing has been centered on discussions along a common theme among all members, and they are inefficient for situations in which experts possessing knowledge and information in a given field present solutions to laypersons lacking such information.

In order to solve these problems, this paper proposes a 2-level hierarchical consultation model using 2 levels of agent. The two types of agent established are Service Agent systems (SA) for the clients, and Supervisor Agent system (SVA) existing between the SAs and experts, who provide easily understood support by responding to requests for support from SAs in cases when they are able to do so, or otherwise forwarding the existing message history to experts. This system possesses the features that experts are able to focus on only complex questions, and in addition, consultees' waiting times are reduced.

2 PROBLEMATIC POINTS

2.1 Existing Remote Consultation

Remote consultation operations over the internet are increasingly tending towards communication among people from different cultures and institutions. This is because the internet generation, new technologies, new organizations and new establishments are being developed, constructed and disseminated on a daily basis, and it has become necessary to rapidly assimilate this flow.

In remote consultation, there are synchronous and asynchronous models. Synchronous models are those such as a telephone, where both parties exchange discourse during the same period of time. Asynchronous models are those such as email in which discourse may be exchanged without adopting a specific time period. Asynchronous models are mainly being applied by means of email, but with the rapid speed of business in the present day, there is an increasing need for synchronous models. The objective of this research is a synchronous remote consultation system over the internet among these kinds of disparate groups and individuals.

Figure 1 shows an example of an existing remote consultation system which has already been investigated [6], [7]. Basically, consultees initiate consultation from a convenient location, while on the other hand, a small number of experts oversee these consultations from a central office and respond to complex queries.

Remote consultation is currently being conducted in many fields. PC user support and so on, is widely active in general. Also, remote consultation has also come to be provided in financial and healthcare fields.

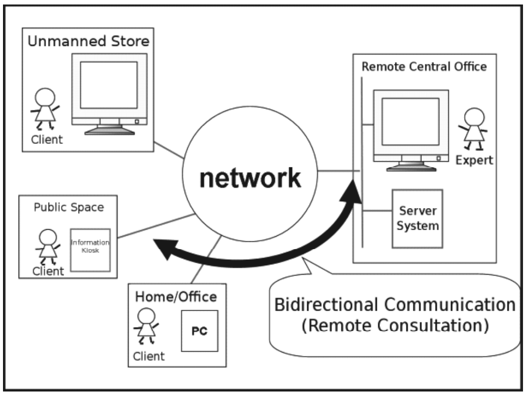

Figure 1: Existing model of a remote consultation system

Along with this model, the provider model has also diversified. At present, remote consultation services are being provided by email, homepages, TV, telephone, and models combining these technologies. However, services using asynchronous communication models such as email incur a time-lag between the receipt of a consultation and the response, so problems cannot be solved immediately. For reasons such as this, the telephone, with its synchronous communication model, is the main channel for the provider model of remote consultation services.

It is thought that the general flow of consultation may be broadly divided into 3 phases [6], and in this research the following definition is adopted (see Figure 2).

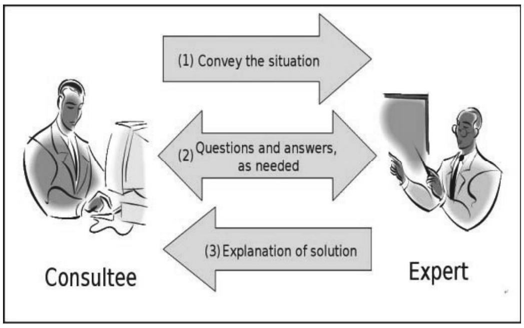

Figure 2: Phases of remote consultation

2.2 Problems With Existing Systems

Remote consultation has the following features (communication patterns). Basically, partners from different cultures (clients and experts) communicate as fellows. The disparate groups may include for example, a) groups of experts and laypersons, b) intradepartmental and interdepartmental staff groups, and c) groups of company staff and non-company persons, which thus constitute groups of people with different values, knowledge and objectives. People belonging to heterogeneous cultures often have different levels of knowledge, and the range and content of their basic assumptions also often differ, yielding obstacles to communication.

Also, the number of consultees is usually overwhelmingly greater than the number of experts, so if experts respond to consultees on a 1-to-1 basis, the efficiency of consultation is poor.

3 SOLUTION STRATEGY

3.1 Concept

This paper proposes a formula for conducting remote consultation in which experts and agent systems are combined. Consultation is therefore first conducted between consultees and service agent systems (SA), and the SAs are supported by experts in the basic model proposed. This allows consultation to be conducted between consultees and agent systems, without the need for 1 to 1 consultation between consultees and experts.

Next, the multiple SAs seek support from the experts in cases when they are unable to respond themselves. However, when multiple SAs seek support simultaneously, experts must deal with multiple support requests at once. Agent system (SVA) with different functions (meta-knowledge and scheduling functions) is therefore placed between the experts and the SAs. By constructing the agent system in 2 layers (SVAs and SAs), consultation is made efficient. By including the SVAs, experts need only deal with a single SVA, rather than multiple SAs.

3.2 System Structure

The consultation model of this research is shown in Figure 3. Adopting this structure gives rise to the following advantages.

- The problem arising when multiple SAs directly request support from experts simultaneously, thus increasing the burden on experts and decreasing the efficiency of consultation, is avoided.

- The problem arising when multiple SAs directly request support from experts simultaneously, thus increasing the burden on experts and decreasing the efficiency of consultation, is avoided.

- Also, the problem associated with consultee stress arising when multiple SAs send requests for support simultaneously, and one SA must wait for another SA's support to be concluded, thus increasing their consultee's waiting time, can be solved.

The function of each agent is as follows.

SA: conducting information exchanges with consultees. In this research, SAs question consultees regarding essential items and obtain their replies. When SAs are unable to respond themselves, these replies are forwarded to SVAs as requests for support.SA makes some questions to consultee in order to complete related documents.

SVA: providing support for experts, acting between the SAs and experts. When requests for support from SAs are within the range they can respond to, SVAs respond themselves, and in cases when they cannot respond, the requests are scheduled according to importance, and

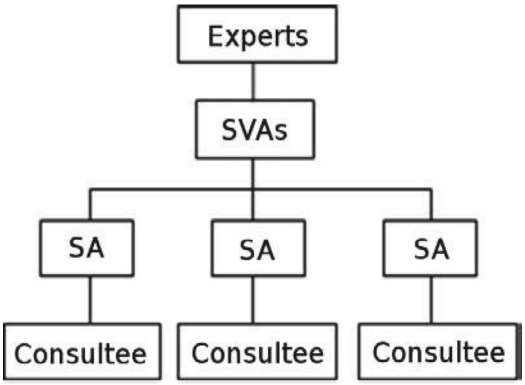

Figure 3: The model proposed in this research

presented to experts in an easily understood manner along with the message history to date. SVA answer request from SA using meta knowledge and expert's judge..

4 REMOTE CONSULTATION UTILIZING HIERARCHICAL AGENTS

4.1 Processing

The following procedure is proposed as a method for realizing the concept.

(1) Consultation is promoted between SAs and consultees. SAs ask questions of the consultees, and the consultees return their replies. Only the SAs respond during this process, without involving the experts.
When the consultees' replies are correct, the SAs present the next question.

(2) The SAs send the consultees' replies to the SVAs, and the SVAs process the data, presenting individual SA consultation cases to the experts. Under this process, the experts only observe the data reported to them.

(3) When replies from a consultee incur exceptional handling, SAs request support from SVAs, i.e., when the content of replies from consultees cannot be processed by SAs, SAs request support from SVAs.

(4) When requests for support received by SVAs can be handled using the meta-knowledge they maintain, they return replies to the SAs. When they are unable to reply themselves, the preceding message history is attached, and support is requested from the experts.

(5) Experts receiving requests for support send replies to the SVAs.

(6) Messages from the experts are sent, via the SVAs, to the SAs originating the requests, and presented to consultees. After receiving these messages, SAs resume questioning.

(7) When consultees are satisfied, consultations are concluded.

4.2 Specific Flow of Consultation

Existing consultation systems have mainly advanced using audio, but in this research, audio is not used. Consultation is conducted using a chat format in free text. The consultation advances as the agent poses questions to the consultee, and the consultee returns the answers, or asks questions. Then, when the consultee is satisfied, the final result is displayed at the consultee side and the consultation ends. The flow of consultation in shown in Figure 4.

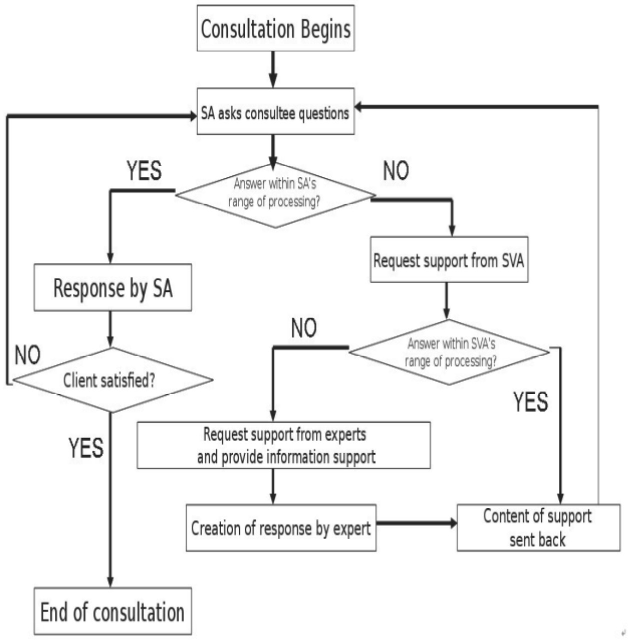

Figure 4: Flow of consultation

5 EXPERIMENTAL ASSESSMENT

5.1 Experimental Objectives

In the remote consultation system using agents, the case when SAs and SVAs are utilized, and the case when only SAs are utilized are compared and the variation in the burden on experts is ascertained. The number of consultees for each SA is taken to be 3.

5.2 Experimental Conditions

Condition 1 Consultation is conducted with an agent system in which 3 SAs respond to the 3 consultees. Experts respond to all of the requests for support from the SAs.

Condition 2 Consultation is conducted in a hierarchically structured system with an SVA added for the 3 SAs. SVA automatically reply when they are able to respond using their own knowledge, and send the problems to which they cannot respond, as requests for support along with the preceding message history, to experts.

Consultation is conducted using only text, without audio, in both Conditions 1 and 2.

Table 1: Results of the consultees' questionnaire

	Without SVAs	With SVAs
Smoothness of consultation	3.3	1.6
Level of concentration	3.3	2.6
Atmosphere	3	3
Reliability	2.3	2.6
Ease of consultation	2.6	2.3
Degree of stress	3.3	2.6
Level of satisfaction	3	2

5.3 Experimental Task

As a task, consultation was conducted regarding the bureaucratic procedures involved in registering for a new insurance policy. Consultees do not have any knowledge, and ASs have procedural knowledge, and SVA has exceptional knowledge.

5.4 Experimental Subjects

As experimental subjects, there were 1 expert and 5 groups of 3 consultees, making a total of 16 people. The subjects were students, and all had experience using a PC.

5.5 Experimental Results

(1) Data

In the experiments, as an indicator for measuring the burden on the expert, the expert's operating time was determined. The expert's operating time is shown in Figure 5. The average operating time of the expert in Condition 1 was 1570 seconds, and in Condition 2, it was 1150 seconds, so when SVAs were included, the result was a drop of about 27%. Also, the total number of messages to the expert was 245 in Condition 1, and 117 in Condition 2, so the result was a decrease of about 47%.

Regarding the consultees' waiting times, these were measured as the period during which they could not conduct their own operations, i.e., the processing time of each consultee's agent, and the expert's operating time. The experimental results are shown in Figure 6. The waiting time in Condition 1 is 915 seconds, and in Condition 2 it is 412 seconds. This result is a drop of about 57%.

(2) Questionnaire

A questionnaire was completed after the experiment, by both consultees and experts. The experiment was evaluated on a scale of 1 to 5 (1 was best, and 5 was worst). The results of the questionnaires are shown in Tables 1 and 2.

6 DISCUSSION

6.1 Expert's Operating Time

Looking at the expert's operating time, when SVAs are present the time is reduced in comparison to when SVAs are not present. It was thus proven that the presence of SVAs reduces the expert's burden. From interview to expert, it made clear that using SVA, expert could concentrate to difficult questions from consultees.

However, there is a big difference in the reduction of the expert's messages by 47% as compared to the reduction of 27% in operating time. The content of the questions directed at the experts is therefore classified in Table 3. According to this data, it can be seen that when SVAs are present, there is a reduction in questions regarding phrasing which present, there is a reduction in questions regarding phrasing which do not require the experts long to answer, and an increase in other types of time-consuming question, particularly those regarding the service. According to the consultees' post-experiment questionnaire, consultation is smooth when SVAs are present, which means that there is an environment in which it is easy to ask questions. It was thus understood that while there are individual differences, making the consultation smooth may increase the consultees' motivation to ask questions.

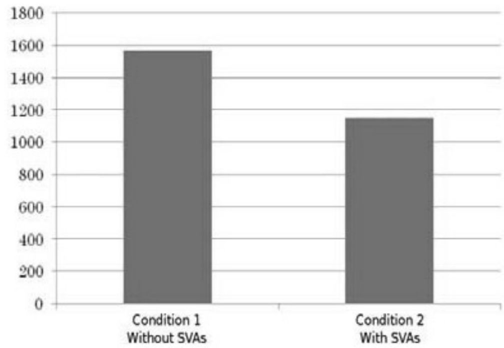

Figure 5: The average operating time of the expert in each condition

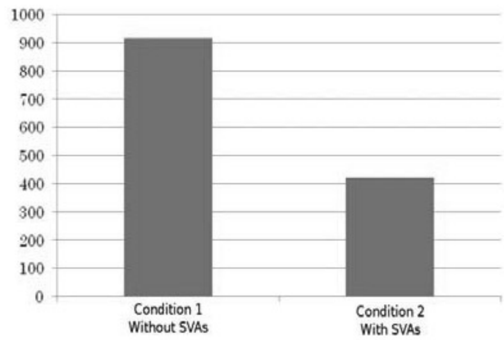

Figure 6: Consultees' average waiting times in each condition

Table 2: Results of the experts' questionnaire

	With SVAs	Without SVAs
Ease of use	3	3
Ease of information acquisition	3	2
Level of concentration	2	3
Level of stress	2	3

Table 3: Total number of questions in each classification

Evaluation Items	Without SVAs	With SVAs	Average response time (seconds) with SVAs
1. Phrasing	77	62	17.055556
2. Price	30	32	31.875
3. Service	6	15	33.125
4. Personal circumstances	16	18	32

6.2 Consultees' Waiting Times

Looking at the results regarding the consultees' waiting times, the waiting times are reduced when SVAs are present, in comparison to the case when they are not. It was thus understood that consultees' waiting times may be reduced through the use of SVAs.

6.3 Questionnaire results

Looking at the results of the questionnaire, as shown in Table 1, the consultees' overall evaluation is increased when SVAs are present. In particular, the evaluation of the smoothness of consultation is very much increased. However, while the overall evaluation is increased, the evaluation of reliability is decreased. According to the post-experiment questionnaire, this means that there is a little resistance to the fact that the responses to questions come from a computer. It was thus understood that in contrast to the increase in the efficiency of consultation, there is a demerit in the sense that the reliability ends up decreasing.

Looking at the results of the questionnaire shown in Table 2, when SVAs are present the expert's ease of acquiring information is increased, so it can be seen that consultation has also been made easier for the expert. However, the evaluations of the degree of stress and level of concentration are decreased. This is thought to be related to the fact that the expert's operating time is decreased, so their free time is increased, which may affect their levels of stress and ability to concentrate.

7 CONCLUSION

This paper proposed a 2-level hierarchical remote consultation system with 2 levels of agent. The proposed system is established with SA agents who respond to clients, and SVA agents existing between the SAs and experts, who respond to requests for support from SAs when they are able, or if not, request support from an expert by sending an easily understood request along with the preceding message history. Experimental evaluations proved that the establishment of SVAs shortens experts' operating times, and that the system is applicable as a one-to-many remote consultation system.

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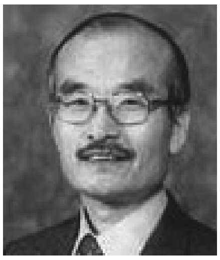

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