Implementation of Avatar Mediated Communication Environment with Thinking Awareness

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Abstract

In interpersonal communication, the reaction of the listener plays a very important role. Lack of reaction can be an obstacle to natural and smooth communication. However, it is hard to read a partner's reaction intuitively in the virtual space mediated communication system which is in the limelight today. With those issues in mind, in this research, we proposed an environment in which a speaker could be aware of the listener's thinking condition (whether he/she is thinking or not) by using electroencephalograph and visualized the thinking condition. We had implemented the system with the proposed features.

1. Introduction

In interpersonal communication, the partner's reaction such as nodding, chiming in with the speaker, changing expression and leaning out plays an important role. Customarily, humans look at the partner's reaction and attitude, then analyze those information and dynamically change the composition of the topic and the tone. Then devise to construct a most suitable conversation between the listeners. When lack of those information occurs, problem such as loss of mood speaking to the partner and loss of speaker's confidence leads to loss of courage to speak.

In recent years, many studies of avatar communication system which is a system that a user utilizes avatar as a substitute in the virtual space built on the network and communicate with other users in remote places, are done and becoming to put in practical use [1][2][3]. However, since many of a user's non-verbal information are missing, the communication system using the avatar cannot recognize the listener's reaction which is important to communication. Although it is necessary to offer many non-verbal information in order to obtain a partner's reaction, the more it provides, the more it becomes a trade-off that ends with high cost and large-scale equipments. Therefore, we proposed this avatar communication, which is able to recognize participant's thinking condition intuitively in visual form by utilizing electroencephalograph to extract the thinking condition.

In this paper, chapter 2 describes the partner's reaction through avatar communication, chapter 3 mentions the proposal of thinking awareness for speaker's support, and chapter 4 explains the process of extracting and evaluating the thinking degree. The implementation of thinking awareness in avatar communication is explained in chapter 5, the evaluation task and its results are introduced in chapter 6, and conclusion and image of the future study of this research is added in Chapter 7.

2. Listener's reaction in avatar communication

2.1. The importance of the listener's reaction

A communication is built by an interaction between a listener and a speaker which means that a listener's reaction and attitude plays an important role for a speaker.

The speaker changes a topic and its tone dynamically according to the reaction of the listener to offer the optimal topic for the listener. Therefore, if the listener takes an attitude which looked to be no interest in the topic, a speaker will change its tone, the structure of the topic or even the topic itself, to attract the listener's attention. On the contrary, if the speaker recognizes that the listener is actually interested in the topic, attempt such as speaking in depth with more detail, using more gesture or modulated tone will be done. Moreover, according to Matarazzo's and others research [4], the more the reaction such as nodding is shown by the listener, the longer and more detailed the speech will become is known. Therefore, it can be understood that the speaker changes the contents of conversation according to the listener.

Lack of the reaction of the listener generates following problems.

- The speaker will be unable to recognize whether the listener is interested, and he/she may become anxious.
- It will become difficult for the speaker to change its tone and will go on talking in a same tone.
- A listener will be listening to what he/she does not want to hear much.
- A speaker will easily become to feel as if he/she is talking in to the wall.

2.2. Lack of reaction in avatar communication

A system that uses virtual space built on the network to communicate with other users in remote places is in practical use. The user utilizes avatar as a substitute in the virtual space to communicate. Since information such as age, a status, sex, looks, etc are hidden entirely by the anonymous characteristic of avatar, deciding the user's personality is largely depended on the conversation between the users. The conversation progresses smoothly by offering an appropriate topic according to the partner's reaction. Therefore, in avatar communication, it is important to inform the partner's reaction to the users.

However, non-verbal information, which is required to understand the partner's reaction, is missing and is not offered in avatar communication.

Non-verbal information is classified into four groups; physical action, spatial movement, semi-language, and physical contact. Physical action indicates gesture, posture and attitude, spatial movement indicates distance and position from a person, semi-language indicates the tone and rhythm of the voice, and physical contact includes touching, stroking, etc. Communication in virtual space lacks all of those information except for the semi-language.

The lacking information and the according problem are listed below.

- Lack of physical action: In a virtual environment, communication is attempted through avatar. The avatar created in 3DCG is especially deficient in expression or in attitude [5]. Many researches were done to give expression and attitude to avatar, equipping with various equipments. However, the more it attaches equipment, the more the problem such as burden on the user and increase of the cost breaks out.
- Lack of spatial movement: By building virtual environment, each user is able to recognize the distance and the position from and of the partner. However, keyboard and mouse take most part of the input interface for moving in virtual space, and thereby, intuitive operation cannot be made into reality. Many input interfaces for moving intuitively in virtual space are also proposed. However, each of these interfaces imposes a burden on the user.
- Lack of physical contact: Tactile senses are mostly not offered within virtual environment. Although many interfaces are offered in order to realize tactile senses, all impose a burden on the user.

In an environment where the speaker and the listener face each other, the speaker is able to understand the partner's reaction by acquiring non-verbal information. However, by avatar communication, which non-verbal information will be intercepted as mentioned above, it is difficult to understand the partner's reaction, and the more it supports non-verbal information, the more burden will be imposed on the user.

3. Proposal of thinking awareness for speaker's support

If the speaker cannot understand the listener's reaction in avatar communication, offering suitable topic may become difficult. Although the speaker is able to understand the listener's reaction by non-verbal information in an environment with many sensors, equipment will become large and more burdens will be imposed on the user to compensate non-verbal information with many sensors.

Therefore, we proposed a new environment, which speaker could understand the change of a listener's reaction from the user's thinking condition (if the listener is thinking or not) instead from non-verbal information, on real time. In avatar communication, the speaker can judge the listener's reaction only from the language and the semi- language, but if the speaker could recognize the thinking condition (thinking awareness), the index that shows whether the listener is interested will increase. Moreover, in the case where the listener has not emitted a word, it becomes the only index, which shows the listener's interest. If the speaker is able to recognize the listener's interest, more suiting topic for the listener will be offered.

3.1. Use of brain wave information

By analyzing brain waves, it can acquire information such as feelings and emotions, which are not expressed in a person's appearance. As an example of a research, there is a research of Emotion Spectrum Analysis Method (ESAM) by Musha which tries to analyze human's feelings and emotions [6].

We use brain waves, in order to extract a user's thinking condition. The reasons are as follows.

- Brain waves change under the influence of thinking activity of the brain. Especially, the zone of beta wave (12-40Hz) appears frequently at the time when thinking process is required, and there is the feature of seldom appearing at the time when thinking is not required [7].
- Change of reaction of the user, which does not appear in appearance, such as change of expression and attitude, is also detectable with brain wave.
- Brain wave is information that is continuously generated which is different from change of expression and attitude.

In this research, we extracted the information on whether it is thinking or not thinking by analyzing the brain wave.

3.2. Extraction of thinking degree by beta wave

The value between 12Hz - 40Hz in the frequency spectrum of brain wave is called beta wave [8][9]. Beta wave has the feature to generate more strongly than usual at the time when thinking is required.

Therefore in this research, we compared the value of beta wave level of newest 12 seconds samples with the minimum value, which was set up beforehand, and the rate of the sample beyond the value was defined as the instantaneous thinking degree to numerate the thinking state.

The reasons for using the past sample for calculation of the thinking degree are as follows.

- Thinking is not performed in an instant [10].

- Need to reduce the effect of noises which appears momentary.

4. Extraction of the thinking degree using the electroencephalograph

Electroencephalograph IBVA [11] was used for extraction of the thinking degree in this research. IBVA consists of headbands which three electrodes attached, and measures brain waves by winding this around the head and measuring the potential of the frontal lobe. This equipment sends data to the receiver linked to the computer on real time from the transmitter linked to the headband. Since it is wireless and lightweight, it has an advantage that it will lighten the burden imposed on the user.

In order to use the information sent from the transmitter of IBVA on real time, we created the program (Fig. 1), which analyzes data sent from a receiver on real time. In this program, the function of Hanning window was applied (Fig. 1(1)) to the data first from the serial port, which was originally sent from the transmitter of Electroencephalograph IBVA. Then, Fast Fourier Transform (FFT) of the obtained data is carried out at overlap 75%, 128 points so that more numbers of data may be obtained, and it enabled to obtain the frequency spectrum of 0Hz - 60Hz on real time.

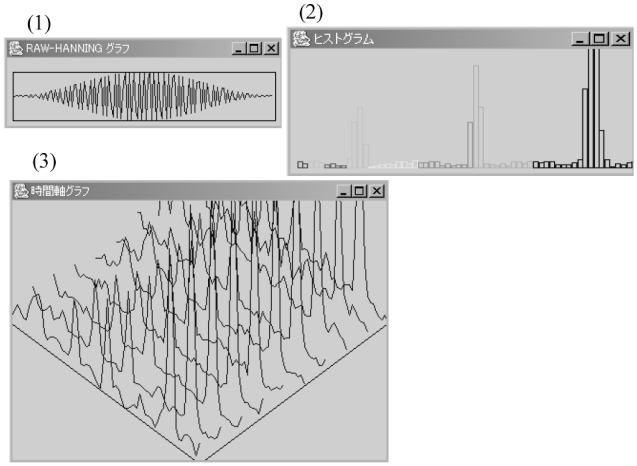

Fig. 1: Implemented brain wave analyzing application

Fig. 1(2) shows the present frequency spectrum, Fig. 1(3) shows the frequency spectrum arranged in time series.

We compared the value of beta wave level of newest 12 seconds samples with the minimum value, which was set up beforehand, and the rate of the sample beyond the value was acquired to calculate the thinking degree.

5. Implementation of interpersonal communication environment with thinking awareness

In this research, the prototype system was mounted in order to investigate whether the proposed thinking awareness is supporting the speaker and is effective in avatar communication.

5.1. The architecture of an evaluation system

A prototype system is built in virtual space in order to realize seamless communication space, and is designed so that users in maximum of 4 different places can join in the conversation. Avatar, which is the user's embodiment, is made to exist in the virtual space and participants communicate through their avatars.

The picture of the system is shown on Fig. 2. Thus, in this system, it enables four persons to exist including him/her self in virtual space and they communicate through their avatar.

Fig. 2: Display of the implemented system

5.2. Avatar's display and space displaying method according to the thinking degree

In this prototype system, the thinking degree obtained from brain wave was divided into five levels, and was defined as the thinking level.

Each participant's avatar changes according to the participant's thinking level. That is, when the thinking level is low (Level 1), an uninterested attitude is shown, and conversely, when a thinking level is high (Level 5), a more interested attitude is shown (Fig. 3).

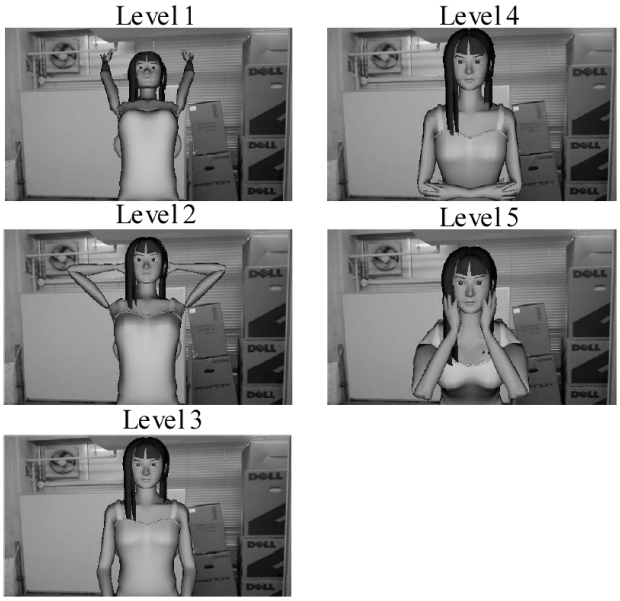

Fig. 3: Thinking level and movement of the avatar

Avatar carries out a natural movement between each level by morphing.

In this prototype system, whether the partner is thinking or not can be recognized intuitively by reflecting the user's thinking level to the avatar. For example in Fig. 2, it can be recognized that the avatar in the center and in the right side is thinking, and the one on the left side is in the state of not thinking.

6. Evaluation

To reflect the user's thinking condition in this research, we proposed the communication, which offers thinking awareness, which is measured from brain waves and made to reflect in avatar. Therefore, we conducted an experiment to check whether the thinking degree, defined in Chapter 3, is accurately reflecting the user's thinking condition.

6.1. The contents of an accuracy evaluation experiment of the thinking degree

20 subjects went through this evaluation. A subject performs the following three tasks, equipped with an electroencephalograph measuring the thinking degree.

- Conversation task: talk based on two or more given topics.
- English examination task: Solve the listening problem of an English examination.
- Relaxed task: release all power, stay quiet for about a minute, and be in the state of considering nothing.

As a task, which needs thinking, the conversation task was set up, and conversely, the relaxed task was set up as a task which does not need thinking. In conversation task, flexibility is high because the contents of the topic are depended on the speaker. Therefore, English examination was added as another task which needs thinking, but has a low flexibility where all participants solved the same problem in the same situation.

Although this experiment equipped the subject with the electroencephalograph, in order to make subject act normally, the purpose of it was not told. In this experiment, the thinking degree was computed from the data obtained from the electroencephalograph, and those data were compared between those three tasks.

6.2. The experiment result and discussion

Table 1 shows the average and standard deviation of all users' thinking degree for every task, and Table 2 shows the value of Wilcoxon's Paired Signed Rank Test in each task. By comparing the average of each user's thinking degree in Table 1, a conversation task or an English examination task shows higher value than that of relaxed task. It is also significant looking at the value of Wilcoxon's Paired Signed Rank Test in Table 2, which shows 1% or less in value of p-value. Therefore, these results show that the thinking degree, which we have defined, truly reflects thinking state of the subject.

Table 1: Result of thinking degree in each tasks

Task	Conversation	English Exam	Relax
Average	0.715255	0.629718	0.268269
Deviation	0.042422	0.028825	0.054392

Table 2: *p* value of Wilcoxon's Paired Signed Rank Test in each task.

comparing pairs	*p* value
Conversation vs. English Exam	*0.04405
Conversation vs. Relax	**0.00000
English Exam vs. Relax	**0.00008

(N=20; **:$p<0.01$, *:$p<0.05$)

In Table 1, the English examination task shows smallest value in standard deviation. The English examination task has a low flexibility, and is set it up so that the thinking degree will come out of anyone. Therefore, the result, which shows small deviation value, is what we had expected.

Fig. 4 is the graph which shows the change of two subjects' thinking degree. These figures show that high value of thinking degree appeared in the middle of the conversation and the English examination task, compared to the middle of a relaxed task where thinking degree is low. This result also shows that a subject's thinking degree is reflected appropriately. The time zone of (1) in Fig. 4 shows the time zone where the subject changed the topic of conversation, and it can be surmised that thinking was repeated to understand the new topic when it was changed. Furthermore, all subjects also showed high value in thinking degree in time zone (2). As a result of investigating, it became clear that the rate of a correct answer to the problem that was set during this time zone were higher than others. From this result, we presumed that other problems were too difficult making subjects to stop thinking, but this problem was judged that it was easy enough for them to solve if they tried, which made them think to

reach the correct answer ending with high value of thinking degree.

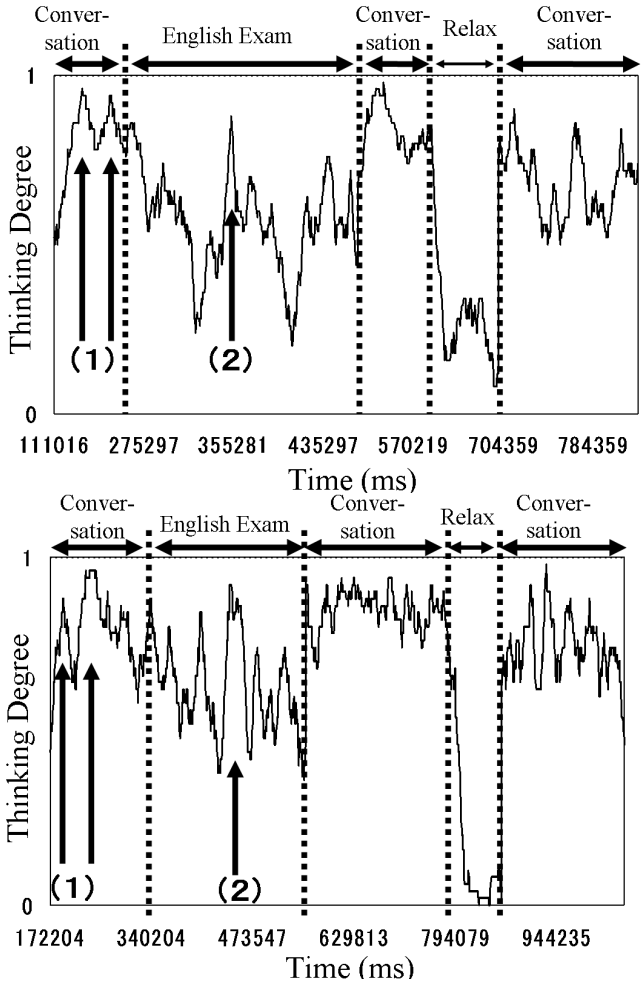

Fig. 4: Change of two participants' thinking degree

7. Conclusion and Future Work

This paper described the importance of the listener's reaction in communication. Moreover, the point that the most of the information of the listener's reactions cannot be recognized by the avatar communication using virtual space was described. We extracted the brain wave of the participants thinking condition and proposed the communicating environment to recognize the participant's thinking condition by visualizing it and we discussed the communicating environment where the speaker is able to recognize the listener's thinking condition.

As the future work, we are trying to build a distance learning environment with thinking awareness, because it is thought especially that the communication, which can recognize the thinking condition of the participant which is stated in this paper, is effective in relation such as a teacher and a student. It could be used as a reference for the teacher to compose a class by considering the reaction of the students. Moreover, the teacher will be able to judge whether it is better to speak in modulated tone, or to give more detailed explanation and choose the better content for the students by looking at their reaction in thinking awareness enabled environment.

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