Development of Head-motion Communication System with Avatar

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Abstract

The Internet is now being widely used for communications. Although audio and video communication tools are finding widespread use, text-based commutation tools such as chat and instant messengers remain the primary communication medium. We believe that adding nonverbal information to a text-based communication tool enhances communication support. Thus for, the transmission of body or hand gestures is no used in daily communication. We focus our attention on "head motion" as one of the important body gestures; it can express agreeable responses during daily conversation. We have developed a head-motion communication system with an avatar called AwareCap. AwareCap uses an acceleration sensor attached to a cap to detect a user's head motion. A user's head motion is shown by each user's avatar. The purpose of this research is to show the effect of head motion in text-based communication. AwareCap detects four types of head motions: nod, waggling, tilting, and looking down. We carried out a communication experiment using AwareCap. The result of this experiment revealed that "nod" and "tilting" are used in chat communication naturally, and they show the other user's situation clearly. Moreover, the avatar used to show user's head motion is referred frequently. AwareCap may potentially encourage chat commutation.

1. Introduction

The Internet is now being widespread used for communication. It can be used to communicate with people diving at locations. Although audio and video communication tools are finding widespread use, text-based communication tools such as chat and instant messengers remain the primary communication medium [1, 2]. Body language is a important factor in face-to-face communication since it expresses a lot of information. However, a text-based communication tool cannot convey such non-verbal cues. Some researchers have been attempting to solve these issues. For example, a researcher studied the use of pictographic characters to send nonverbal information. Another researcher studied the combination of e-mail and face-to-face communication to convey emotions.

We believe that adding the ability to convey nonverbal information to a text-based communication tool will enhance the communication process. Thus for, the transmission of body or hand gestures is not possible in such forms of communication. We focus our attention on "head motion" as one of the important body gestures; it can express agreeable responses during daily conversations. Nonverbal information such as body and hand gestures provide important context for communication. In particular, head motions, such as nodding, are a noticeable part of nonverbal information; such motions have attracted the attention of researchers since they can make the communication process smooth.

We have developed a head-motion communication system with an avatar called AwareCap. AwareCap uses an acceleration sensor attached to a cap to detect a user's head motion. A user's head motion is mimicked by the user's avatar. AwareCap detects four types of head motions; nod, waggling, titling, and looking down. The purpose of this research is to show the effect of head motion in text-based communication.

2. Related Works

Gestures such as emotion, facial expression, voice, and body language are important additional information in face-to-face communication.

Kapoor and Picard have developed a real-time head nod and shake detector [3]. The system is a vision-based system that detects head nods and head shakes in real time. It can also act as a useful and basic interface to a machine. The

objective of the researchers was to develop an accurate head nod and shake detector.

Lu et al. have also developed a head nod and shake recognition system [4]. They proposed a detection method based on a multi-view model. Their objective was to develop an accurate head gesture recognition system.

The objective of our research is to clarify the effect of the transmission of the head motion.

3 Head-motion Communication System AwareCap

We focus our attention on "Head motion" as one of the important body gestures; it can express agreeable responses during daily conversation. We have developed a head-motion communication system with an avatar called AwareCap. AwareCap uses an acceleration sensor attached to a cap to detect a user's head motion. A user's head motion is shown by each user's avatar. AwareCap detects four types of head motions: nod, waggling, tilting, and looking down.

3.1 System configuration

Figure 1 shows the configuration of AwareCap. AwareCap consists of a cap attached with an acceleration sensor and a chat system with a head-motion avatar. The values of the sensor on the cap are sent to a data transfer unit. Figure 2 shows the cap and the attached sensor of AwareCap. The acceleration sensor is attached to the top of the cap. A data transfer unit is connected to the sensor. The data transfer unit calculates the values of the sensor and sends them to the chat system. The chat system uses the sensor values to determines the type of head motion. Then, the avatar of the chat system is changed, and the information is sent to the server. The sever sends the received information to other chat systems.

We use a three-dimensional acceleration sensor, KXM52-1050 (Kionix, Inc.) The sensor outputs the spatial position depending on the head angle.

3.2 Head motion avatar

AwareCap uses an "avatar" to express a user's head motion. The motion of the avatar corresponds to the a user's head motion.

Figure 3 shows the motion of the avatar. The head is stationary in the start position. AwareCap detects four types of head motion: nod, waggling, tilting (right or left), and looking down. We assume the following meanings for each motion.

- a. Nod: expresses a positive response

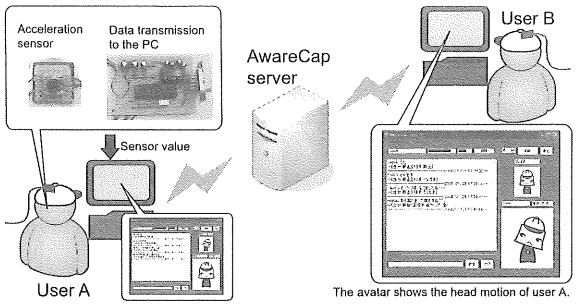

Figure 1. System configuration of AwareCap

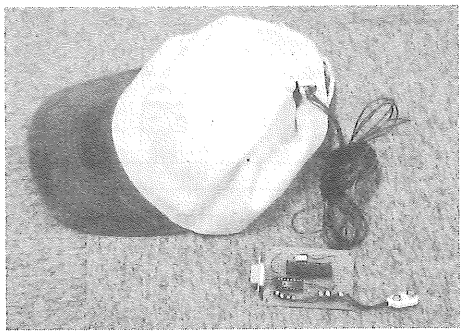

Figure 2. A cap and an attached sensor in AwareCap

- b. Waggling: expresses a negative response
- c. Tilting (right/left): expresses doubt
- d. Looking down: indicates that the user is performing a keyboard input.

Figure 4 shows the user's head motions and the corresponding avatar motions.

3.3 Chat screen

Figure 5 shows the chat screen of AwareCap. The chat screen consists of the chat display area and avatar area. The avatar area displays a small and a large avatar. The small avatar displayed above the avatar area is the user's avatar. The large avatar shown below the avatar area is the other user's avatar.

3.4 Determination of head motion type

The baseline of head inclination is the startup position of the cap used in AwareCap. Table 1 shows the method used to determine the head motion type. The process of detecting the head motion and updating the avatar occurs every

Table 1. Method used for determining the head-motion type

Head motion pattern	Condition	Determination
Shake the head twice or more in a second.	Change into a back and forth motion of approximately 20°.	a. Nod
	Change other than a back and forth motion.	b. Waggling
Shake the head less than twice in a second.	Incline the head to the right by approximately 21° or more.	c. Tilting (right)
	Incline the head to the left by approximately 21° or more.	c. Tilting (left)
	Inclines ahead by approximately 15° or more.	d. Looking down
	None of the above.	Stationary

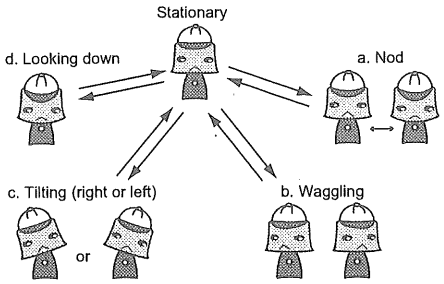

Figure 3. Motion transition of an avatar in AwareCap

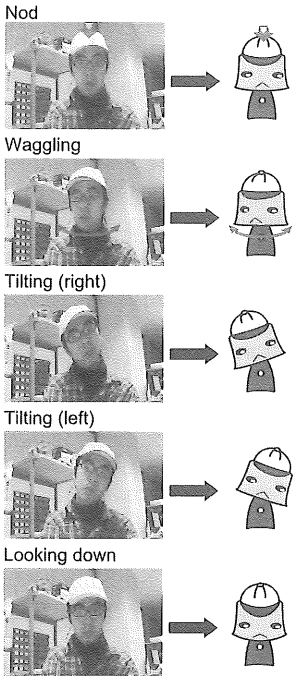

Figure 4. Head motions and their corresponding avatar motions

0.4 s. The determination method and the update interval are adjusted by authors.

4 Experiment and Result

4.1 Communication experiment using AwareCap

We carried out a communication experiment using AwareCap. The subjects were 20 students of Wakayama University. The purpose of the experiment is to investigate how the subjects use the head-motion information.

4.2 Experimental method

The experimental method is as follows. We recorded videos of the subjects during the experiments.

1. A pair of subjects practice the use of AwareCap for around 5 min.
2. They then go to different rooms and communicate with each other for 20 min.
3. We specify certain chat topics to the users. After 10 min from at the beginning, we ask the users change the topic to another one.
   (a) likes and dislikes about foods
   (b) visits to tourist locations
4. After the experiment, we ask a subject to answer the questionnaire.

Figure 6 shows the users' situation during the experiment.

4.3 Result of the experiment

Table 2 shows the number of head motions detected using AwareCap in the experiment. Table 3 shows the number of head motion in a conventional chat communication environment. Subjects A to J in Tables 2 and 3 are the same. Subjects K to T only joined the AwareCap experiment. The number of head motions varies greatly from person to person. A statistical test between AwareCap and conventional chat does not indicate a significant difference ($p = 0.86$). We

Table 2. Number of head motions during experiments using AwareCap

Subject	Nod	Waggling	Tilting	Looking down	Total	Number of times per min
A	1	1	0	4	6	0.3
B	13	16	46	20	95	4.8
C	10	5	86	12	113	5.7
D	18	4	244	38	304	15.2
E	2	1	6	8	17	0.9
F	3	0	35	14	52	2.6
G	16	1	1	3	21	1.1
H	17	15	39	549	620	31.0
I	4	10	49	14	77	3.9
J	47	4	18	6	75	3.8
K	73	21	257	435	786	39.3
L	29	6	24	235	289	14.5
M	61	6	45	36	148	7.4
N	34	1	78	41	154	7.7
O	3	0	0	0	3	0.2
P	32	21	68	103	224	11.2
Q	19	10	64	0	93	4.7
R	40	17	28	0	85	4.3
S	7	0	5	135	147	7.4
T	88	22	98	39	247	12.4
Average	25.9	7.8	59.6	84.6	177.8	8.9
Ratio	18%	5%	31%	47%	100%	—

Table 3. Number of head motions in a conventional chat communication environment

Subject	Nod	Waggling	Tilting	Looking down	Total	Number of times per min
A	20	1	83	48	152	15.2
B	62	6	25	0	93	9.3
C	14	0	2	57	73	7.3
D	14	1	5	26	46	4.6
E	3	0	0	0	3	0.3
F	24	6	0	57	87	8.7
G	4	0	18	164	186	18.6
H	5	9	8	146	168	18.6
I	5	0	4	6	15	1.5
J	3	1	0	1	5	0.5
Average	15.4	2.4	14.5	50.5	82.8	8.3
Ratio	19%	3%	18%	61%	100%	—

found that AwareCap does not effect the number of head-motion.

Table 4 shows the result of the five-point questionnaire survey. In the table, a five-point Likert scale was used for the evaluation: 1: Strongly disagree, 2: Disagree, 3: Neutral, 4: Agree, and 5: Strongly agree.

From the result of Q1 shown in Table 4, 15 among the 20 subjects felt happy when using AwareCap. From the result of Q2, AwareCap does not effect the number of head motions. The subject did not care about the head motions. From the result of Q3, most of the subjects did not feel any stress about the operation of the cap used in AwareCap. The result of Q4 is different. 16 subjects said that they referred to the head motion, while four subjects said that they did not refer to the information. From the result of Q5, 15 among the 20 subjects realized that the information about head motions is effective for communication.

We asked the subjects to rank the head motions. Tables 5 and 6 show the ranking list of the head motions. Most subjects answered that "nod" is the most useful head motion. We found that the second most useful head motion is tilting.

Table 7 shows the reasons for their rankings. The reasons of greatest importance are as follows.

- Head motions can be performed naturally.
- The meaning of a head motion is clear.
- Head motions are used often in daily life.

The reasons of lesser importance are as follows.

- Head motions are not used regularly in daily life.
- No head motions are performing during chatting, and it is unsuitable for chatting.

Table 4. Result of the questionnaire

Question items	1	2	3	4	5	Average
Q1. I felt happy when I used this system.	1	1	3	13	2	3.8
Q2. I positively shook my head when I used this system.	1	6	7	5	1	3.0
Q3. I felt some pressure when using AwareCap.	6	8	7	2	2	2.8
Q4. I noted the head motion information received from the other user.	1	3	0	15	1	3.6
Q5. Head motion information is effective as a means of knowing the appearance of the other user.	0	3	2	12	3	3.8

*A five-point Likert scale was used for the evaluation:
1: Strongly disagree, 2: Disagree, 3: Neutral, 4: Agree, and 5: Strongly agree.

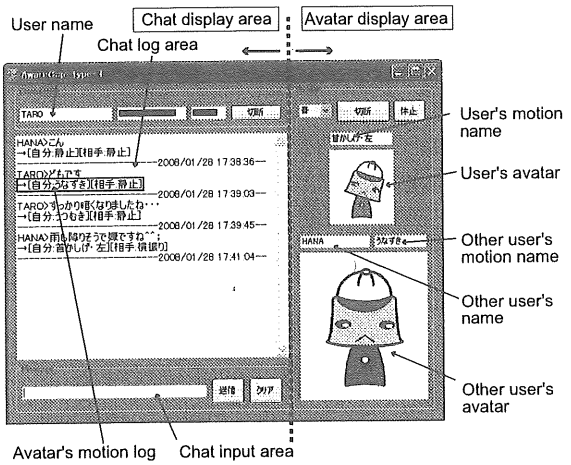

Figure 5. Example of a chat screen in AwareCap

Table 5. Ranking of usefulness of head motions from a user to another user

Order of usefulness	1st	2nd	3rd	4th
a. Nod	15	3	2	0
b. Waggling	0	3	9	8
c. Tilting	4	12	4	0
d. Looking down	1	2	5	12

Table 6. Ranking of usefulness of head motions from another user to a user

Order of usefulness	1st	2nd	3rd	4th
a. Nod	11	6	3	0
b. Waggling	0	3	9	8
c. Tilting	6	9	4	1
d. Looking down	3	2	4	11

The motion "Looking down" depended on the subjects. From the video recording, we found that this might any depending on result whether the other user can type without looking.

We conducted a descriptive questionnaire survey and obtained the following comments and impressions from the subjects. The subjects requested a smooth animated avatar and an easily understandable layout of the chat screen. Moreover, the subjects stated that they wanted to know the appearance and emotion of the other user. This is because they want to know more about the other user's situation. The subjects stated that the impression of AwareCap is interesting.

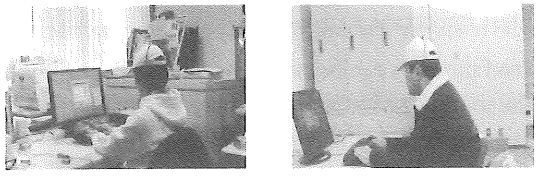

Figure 6. Photograph of users' situation during the experiment

4.4 Change in communication

Table 8 shows the comparison of the number of messages per 10 min between conventional chat and AwareCap. A statistical test between AwareCap and conventional chat revealed a significant difference ($p < 0.01$). We found that the chat session using AwareCap has a greater number of chats. The use of AwareCap results in an increase in the number of chats. Although additional experiments are necessary, we believe that AwareCap has some effects leading to an increase in the number of chat messages.

Table 7. Reasons for the ranking of a head motion type

a. Nod	From me to another user	From another user to me
Positive comments	- This motion is useful because it is natural. - This motion can show an expression of agreement.	- This motion is useful because it was used often. - This motion can show that an agreement was reached. - This motion can encourage remarks.
Negative comments	—	—

b. Waggling	From me to another user	From another user to me
Positive comments	- This motion is useful because it is used even in daily life.	- This motion can clearly express YES and NO.
Negative comments	- There was no chance to use this motion often. - This motion is not used often while chatting.	- The partner did not use this motion often.

c. Tilting	From me to another user	From another user to me
Positive comments	- This motion can be used to express doubt. - This motion can be used without feeling any stress.	- This motion shows that the other party is worried. - This motion can show that a partner is tired.
Negative comments	—	—

d. Looking down	From me to another user	From another user to me
Positive comments	- This motion can be shown while typing.	- This movement shows what a partner is typing.
Negative comments	- This movement shows that I cannot type without looking.	- There was no situation wherein this motion was used often.

Table 8. Comparison of the numbers of messages between conventional chat and AwareCap (number of chat messages per 10 min

Subject	A	B	C	D	E	F	G	H	I	J	Average
Conventional chat	18	28	25	28	10	13	15	13	39	22	21.1
AwareCap	28	37	28	36	17	20	19	18	39	23	26.5

5 Conclusion

We believe that adding nonverbal information to a text-based communication tool enhances communication support. We have developed a head-motion communication system with an avatar called AwareCap. We carried out a communication experiment with AwareCap. From the result of the experiment, we found the followings.

1. Users can use head motions such as "nod" and "tilt" naturally during chat communication. Users can express their intentions using AwareCap.
2. The experiment using AwareCap revealed that 80% of the subjects used information about head motions frequently during chat communication.
3. A comparison of chat communication between AwareCap and conventional chat revealed that the former potentially enhances chat communication.

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