Toward a design of human-computer co-drawing system

- preliminary experiments on effects of imitation and interference -

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ABSTRACT

The purpose of this work is to develop an artificial agent which can entertain human by drawing together and keeping the interaction for a long time. In this paper, we focused on extending duration of human-agent drawing instead of measuring enjoyment directly and increasing it. We assumed that two parameters which determine virtual agent's drawing behaviour, the imitation rate of drawing style and the spatial interference rate, have effects on the duration of human-agent drawing, and we developed a virtual co-drawing system on tablet. In this system, as the imitation rate increases agent's drawing speed is close to the speed of human, and as the spatial interference rate increases lines drawn by the agent is close to the overlapped lines drawn by human. To find causality of the parameters change and the interaction duration we conducted experiments using the system and participated 8 subjects, but the experimental results did not show any significant differences so far.

CCS CONCEPTS

• **Human-centered computing** → Empirical studies in HCI;

KEYWORDS

Co-Creation, Co-Drawing, Human-Virtual Agent Interaction

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1 INTRODUCTION

The computers which work together with human for creative purpose differ from the computers which create products by almost only themselves in some points. The former ones obviously have more interactions with human, and the interactions help more creative productions even if the computers themselves are not so creative.

In paintings, AARON[3] and the Painting Fool[4] are typical examples as the computers which create products scarcely with human's assistance. They can create original paintings alone except the initial inputs, so their creativity affects directly on their products.

As the computers which work together with human for creative purpose in paintings, there are projects[1][5][2] for examples. In particular, Chung's project "Drawing Operations"[2] shows they can produce creative products even if they are not so creative. D.O.U.G. which is the arm machine used in the project has a drawing skill, but it is not appreciative and imaginative. From the viewpoints of Colton's creativity tripod [6], D.O.U.G. itself has a few creativity. However, Chung respond to D.O.U.G. as a collaborator, and their products and their interactions are regarded as artworks.

In the case of the computers which create products with scarcely human's help, their usefulness are determined by the evaluation of products quality, but the usefulness of the computers which work together with human for creative purpose can be determined by evaluation of the interactions in addition to products' quality. If the interaction is enjoyable, the computers can be used for not only artwork but also the other purpose.

Therefore, we focus on the interaction between human and computer when they do co-creative works, and we aim for enjoyable human-computer co-drawing. However, it is difficult to measure the degree of enjoyment directly. For measuring enjoyment of entertainment systems, Shirai[7] proposes using the duration of interaction instead.

As the first step for developing an agent which can entertain human and can keep the interaction for a long time, in this paper, we attempted to investigate factors which affect to the duration of interaction.

2 PRELIMINARY EXPERIMENT

We assumed two hypotheses suggested from our simple preliminary experiment. To investigate factors which affect the duration of human-agent co-drawing, we conducted a preliminary experiment as follows. First, we developed the system which draws lines of predefined data while avoiding human drawing lines. In the experiment, ten subjects drew together with the system while looking at a presented picture for a given model. After that, subjects filled out a questionnaire and commented freely about the interaction.

Based on the answers and the comments, we assumed that the positional relation among lines and relation between the drawing speeds of agent and human affect whether a subject regards the agent as drawing partner.

Additionally, we assumed following hypotheses about drawing duration:

- it would be extended if the virtual agent imitates human drawing speed, and
- it would be shortened if the virtual agent draws lines over human lines.

To verify these hypotheses, we developed a new co-drawing software as described in the next section.

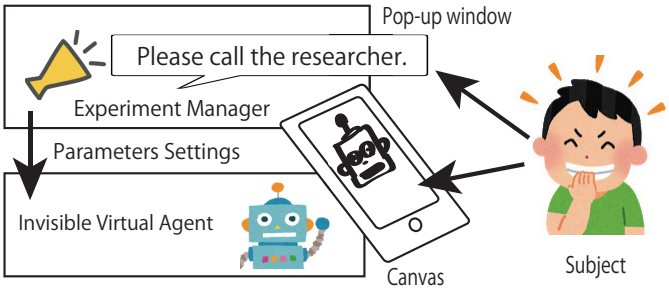

Figure 1: The construction of experiment software

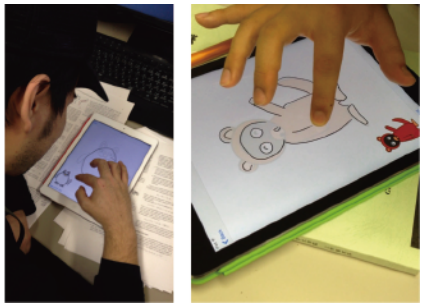

Figure 2: A subject draws together with invisible virtual agent

Figure 3: Examples of illustrations presented to human subjects

3 THE VIRTUAL AGENT DRAWING TOGETHER WITH HUMAN

Our experiment software implemented on the tablet device includes a virtual agent which draws together with human, an experiment manager which guides subjects, and a virtual canvas. Figure 1 illustrates the construction of the software.

The virtual agent is given a predefined data which indicates what the agent should draw and two parameters called imitation rate and interference rate which alternate the agent's behavior for drawing. The agent basically draws following the data, but it can update the data according to some rules influenced by the interference rate in the case where the agent detects human drawings through the virtual canvas.

3.1 The imitation rate

One of the agent parameters is the imitation rate, which decides how much the agent imitates the drawing speed of the subject who draws together with the agent. The range of the parameter is not less than 0.0 and not greater than 1.0, and the larger value indicates stronger similarity between the agent's drawing speed and the person's one.

3.2 The spatial interference rate

The other parameter is the interference rate, which specifies how much the agent interferes spatially with the drawing by the subject who draws together with the agent. The range of the parameter is not less than 0.0 and not greater than 1.0, and the larger value indicates more spatial interference for the lines being drawn by the person, where more interference means that the probability which the agent draws a line close to or overlapping lines drawn by human increases.

4 EXPERIMENT

The purpose of this experiment is to verify the two hypotheses described in a former section 2. We asked eight subjects to draw with the experiment software three times, and to answer the questionnaire after each drawing. Figure 2 shows the situation where a subject is drawing with the experiment software on the tablet device. In the experiment, the software displays a target illustration, and the subject draws what he/she interprets it as while he/she is observing it. Figure 3 shows examples of the target illustrations.

Table 1: Experiment conditions

		Imitation rate		
		0.0	0.5	1.0
Interference rate	Higher	A	C	E
	Lower	B	D	F
Drawing by only human subject			S	

The software repeatedly presented target illustrations until each subject chose the end of the experiment.

4.1 Experiment conditions

To investigate the changes of drawing duration with affecting changes of the imitation rate and interference rate, the imitation rate varied in 0.0, 0.5 and 1.0, and the interference rate was prepared in two values. Furthermore, to compare to duration of drawing by only human subjects we added the case where each subject draws alone. Table 1 shows whole conditions.

4.2 Questionnaire

After each drawing, subjects answered to questions below. Followings show questions, question abbreviations, and options.

(1) "How much did you enjoy the drawing together with the computer?" (Question "enjoy").
(I enjoyed that) 5 4 3 2 1 (I did not enjoy that)
(2) "Did you concentrate on the drawing together with the computer?" (Question "concentrate").
(I concentrated) 5 4 3 2 1 (I did not concentrate)

(3) "How much do you want to draw together with the computer again?" (Question "again").
(I want to do it again) 5 4 3 2 1 (I never want to do it)
(4) "How much did *the computer* cooperate in the drawing together with you?" (Question "computer cooperation").
(It cooperated) 5 4 3 2 1 (It did not cooperate)
(5) "How much did *you* cooperate in the drawing together with the computer?" (Question "human cooperation").
(I cooperated) 5 4 3 2 1 (I did not cooperate)

5 RESULTS

Figure 4 through 9 show all of the results. Hereinafter, each experimental condition is called the alphabet defined in table 1.

5.1 Drawing duration

Under conditions A to F, the average of drawing duration was about 638 seconds (about 10 minutes and 38 seconds), and under condition S, the average was about 536 seconds (about 8 minutes and 46 seconds). Summarizing the conditions for each value of the imitation rate, when the rate was 0.0 (condition A and B) the average was about 599 seconds (about 9 minutes and 59 seconds), when the rate was 0.5 (condition C and D) the average was about 581 seconds (about 9 minutes and 41 seconds), when the rate was 1.0 (condition E and F) the average was about 774 seconds (about 12 minutes and 54 seconds). Similarly, summarizing the conditions for each value of the interference rate, when the rate was higher (condition A, C, and E) the average was about 719 seconds (about 11 minutes and 59 seconds), when the rate was lower (condition B, D, and F) the average was about 545 seconds (about 9 minutes and 5 seconds).

5.2 Answers to questions

For each item, following list shows the average of whole interactions together with the computer (condition A to F) and the average of interactions when subjects drew alone (condition S). Hereinafter, each question is reffered as abbreviation defined in section 4.2.

The average of Question "enjoy"
Whole interactions together with computer – 4.07
When subjects drew alone – 3.00
The average of Question "concentrate"
Whole interactions together with computer – 4.47
When subjects drew alone – 4.00
The average of Question "again"
Whole interactions together with computer – 4.20
When subjects drew alone – 3.00
The average of Question "computer cooperation"
Whole interactions together with computer – 3.60
The average of Question "human cooperation"
Whole interactions together with computer – 3.87

6 DISCUSSION

6.1 Verifying hypotheses

The results showed no significant differences because a number of subjects was a few, but there were some margins among averages of each result.

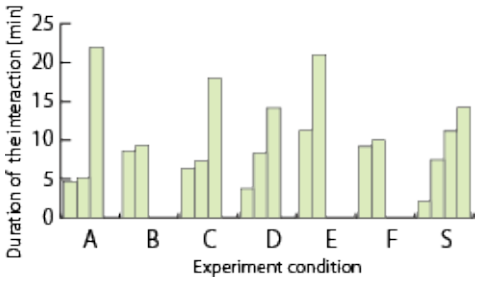

Figure 4: Each duration of the interactions under agent conditions

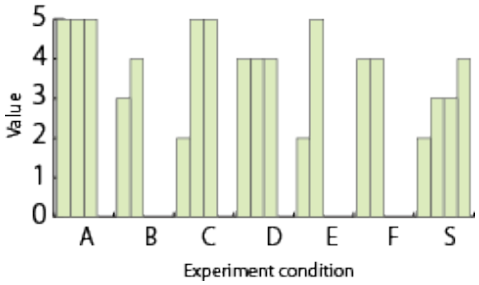

Figure 5: Answers to the question "How much did you enjoy the drawing together with the computer?"

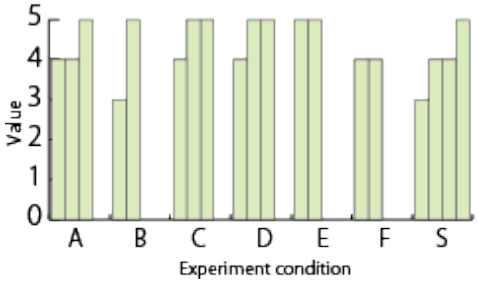

Figure 6: Answers to the question "Did you concentrate on the drawing together with the computer?"

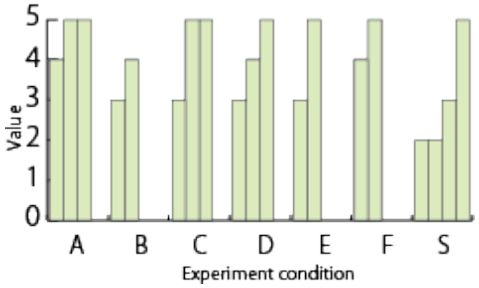

Figure 7: Answers to the question "How much do you want to draw together with the computer again?"

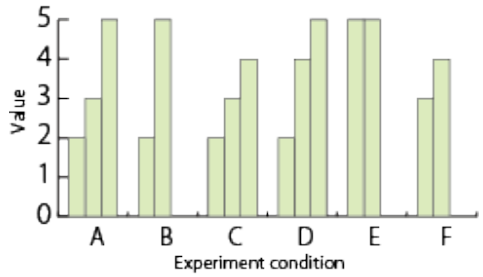

Figure 8: Answers to the question "How much did *the computer* cooperate in the drawing together with you?"

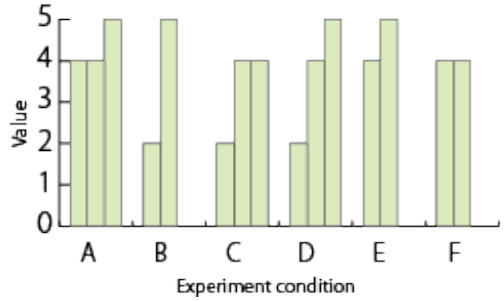

Figure 9: Answers to the question "How much did *you* cooperate in the drawing together with the computer?"

In comparison with the average of drawing duration when the imitation rate less than 1.0 (condition A, B, C, and D), the average when the imitation rate was 1.0 (condition E and F) was over 1 minute long, so it seems to support the hypothesis "The duration of drawing together with the virtual agent is extended with increasing agent's imitation rate".

On the other hand, in comparison with the average when the interference rate was lower (condition B, D, and F), the average when the interference rate was higher (condition A, C and E) was over 1 minute long, so it seems to against another hypothesis " The duration of drawing together with the virtual agent is shortened with increasing agent's interference rate".

6.2 Human sensitivity to agent's drawing speed and spatial interference

In answers to questionnaires, there are pairs which has more than 0.4 points difference between averages of answers to questions when we compared the averages when the imitation rate was 0.0, 0.5, and 1.0, whereas no difference more than 0.4 points when we compared averages of answers when the interference rate was lower and higher. Specifically, in Question "enjoy", the average of answers was 4.40 when the imitation rate was 0.0, 4.00 when the rate was 0.5 and 3.75 when the rate was 1.0, compared with when the rate was 0.0, the value when the rate 1.0 was 0.75 points lower. Moreover, in Question "computer cooperation", the average of answers was 3.40 when the imitation rate was 0.0, 3.33 when the rate was 0.5 and 4.25 when the rate was 1.0, compared with when the rate was 0.0, the value when the rate 1.0 was 0.92 points higher.

Accordingly, it seems that human subjects are more sensitive to the changes of the imitation rate than the changes of the interference rate.

6.3 Remaining works

We have some remaining works in this study. First, we should experiment with more subjects, and analyze about causality of virtual agent's parameters change and the duration of drawing with the computer.

Furthermore, we have to consider whether the correlation between duration of the interactions and the amount of enjoyment is positive. The results of section 6.1 and 6.2 showed the possibility of that there is negative or weak correlation between them. Because it is difficult to measure enjoyment directly we decided to measure the duration of interactions, but now we need to investigate carefully about the correlation concurrently.

7 CONCLUSION

In this paper, we assumed that two parameters which determine virtual agent's drawing behavior, the imitation rate of drawing style and the spatial interference rate, have effects on the duration of human-agent drawing, and developed a virtual co-drawing system on tablet device. Then, to find causality of the parameters change and the interaction duration we conducted experiments using the system and participated 8 subjects. Because of the number of subjects was a few the experimental results did not show any significant differences, but indicates some new issues.

In future work, we would like to imprement a creative mechanism on the agent, and develop the co-drawing interaction into collaboration based on evaluation of the products and the interactions.

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