Impression Analysis of Animated Agents in Soft Game Theory

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Abstract—In this paper, we investigated users' impressions of animated agents by conducting an experiment involving subjective evaluation. In order to devise strategies by using an agent's nonverbal information, it is important to investigate not only the effects of facial expressions but also the user's impression of the agent. To evaluate such impressions, we developed an experiment based on Soft Game Theory, which considers players' emotions. Based on factor analysis, we found "friendly" and "truthful" as the users' impressions of the agent. The findings are useful in devising the strategies.

I. INTRODUCTION

In recent years, animated agents (they are sometimes referred to as life-like agents, avatars, interface agents, etc.) have been developed[1], [2]. They have been used in a wide range of application areas including entertainment, virtual environments, e-commerce, and online negotiation[3], [4], [5], [6], [7], [8], [9]. If we do not wish to reveal our personal identity, we can substitute the agents for ourselves to represent us to an opponent. The use of an agent allows us not only to use verbal language but also to select facial expressions, body postures, gaze behaviors, and so on. These nonverbal signals enrich the communication between computers and users. In addition, some researchers have proposed strategies to control users' decisions by controlling the facial expressions of agents. Yuasa et al. investigated the effects of facial expressions in online negotiations[10], [3], because the use of facial expressions is important in negotiation[11]. For example, when an agent shows a happy face to a user, the latter tends to agree with the agent's proposal. Therefore, it is important to use facial expressions for each case.

However, users may change their decisions not only on the basis of the facial expression shown by the agent but also on the basis of their impression of the agent. It is significant to investigate the relationship between a user’s impression of an agent and the user’s decision. Investigating not only the effect of facial expressions but also the user’s impression of the agent is important for devising strategies using the agent’s nonverbal information.

Therefore, in this paper, we design a human like agent and investigate the impression that the users have of the agent by conducting an experiment involving subjective evaluation. In conducting the experiment, we deal with Soft Game Theory, which considers players’ emotions. We found the evaluation to be useful in devising the strategies.

In Section 2, we explain prisoners’ dilemma in Soft Game Theory and the manner in which the dilemma has been used in this research. In Section 3, we present an experiment involving animated agents. In Section 4, we discuss the results, and in Section 5, we present the concluding remarks.

II. PRISONERS’ DILEMMA IN OUR RESEARCH

A. Soft Game Theory

Traditional models based on Game Theory do not consider these feelings among players. However, practically, players may have certain feelings toward their opponents. Soft Game Theory deals with the decisions of two players who exhibit feelings toward each other in a situation similar to Prisoners’ Dilemma [12]. Additionally, the relationships between players may influence their decisions. For example, if a player likes an opponent, he/she may select a better option for the opponent. Soft Game Theory proposes that the player may estimate the opponent’s choice by using the feelings exhibited by the opponent.

The models of Soft Game Theory assume that players have just one opportunity to exchange messages with each other. The player must estimate the opponent’s choice and select his/her own option solely on the basis of the exchanged messages. For example, in Prisoners’ Dilemma (Table I), prisoner A can send the following message to prisoner B: "I will select Cooperate, so please select Cooperate." After sending the message to their opponents, the players must select that option. Traditional models based on Game Theory do not consider the exchange of messages between players.

Nevertheless, after sending the message, the player may be tempted to deceive the opponent. Soft Game Theory assumes

<table>
<thead>
<tr>
<th>Prisoner B</th>
<th>Cooperate</th>
<th>Defect</th>
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<tbody>
<tr>
<td>Prisoner A</td>
<td></td>
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<tr>
<td>Cooperate</td>
<td>3,3</td>
<td>1,4</td>
</tr>
<tr>
<td>Defect</td>
<td>4,1</td>
<td>2,2</td>
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TABLE I
A GAME OF PRISONERS’ DILEMMA. THE FIRST NUMBER IN EACH CELL REPRESENTS PRISONER A’S BENEFIT AND THE SECOND NUMBER REPRESENTS PRISONER B’S BENEFIT.
that this temptation is resolved by the players’ feeling toward the opponent.

B. Prisoners’ dilemma in our experiment

We adopted the prisoners’ dilemma of Game Theory in this research. We assume the situation of gas stations competing with each other for customers through strategic pricing. In this case, the players are the owners of station A and station B (owner A and owner B, respectively).

Each of the owners has been selling buyers one liter of gas for 100 yen. One day, the owners estimate the benefit of choosing a new pricing strategy (the manner in which to set a new price). The estimate is as follows:

- Both owner A and owner B continue to sell gas to buyers at the rate of 100 yen per liter, each of them notches up sales of 20 million yen.
- When either one of them sells gas at 90 yen per liter, he/she can attract more buyers than the other. As a result, the sales of this owner amount to 30 million yen. The other owner cannot attract buyers and consequently suffers a loss of 10 million yen.
- When both owner A and owner B sell gas at the rate of 90 yen per liter, each of them notches up sales of 10 million yen.

The owners are required to decide the rate, 100 yen or 90 yen. Table II shows the situation of this dilemma.

In this research, we investigate the impression before the game and that after the game. Based on a model of Soft Game Theory, we assume that an agent has one opportunity to deliver a message to a user. The user is required to evaluate his/her impression of the agent. After the evaluation of the impression by the user, the agent selects a price of either 100 yen or 90 yen. Then, the user is required to reevaluate his/her impression on the basis of the agent’s action. In the next section, we describe our experiment based on this dilemma.

III. Experiment

A. Implementation of animated agents

To control animated agents with CG animation, we used the TVML (Television program Making Language) tool, which is a software that can interpret the script and generate a TV program[13]. Further, the tool provides certain helpful functions, offers interfaces to control animated agents through external applications, enables the development of interactive applications. By using the interface, in our experiment, we developed an interactive application that has a “key input” function. Figure 1 shows the agents, David, Bruce, and Michele, which were created for our experiment.

B. Experiment procedure

The following is a description of the procedure used in our experiment:

(1) The subject is required to select one agent.
(2) The selected agent declares his/her promise with CG animation.
(3) The subject is required to evaluate his/her impression of the agent.
(4) The subject is required to decide whether the price of the gas should be 100 yen or 90 yen per liter.
(5) The agent selects his/her decision.
(6) The result is displayed.
(7) The agent declares his/her comment regarding the result with CG animation.
(8) The subject is required to evaluate his/her impression of the agent.
Our application begins with the appearance of three agents (David, Michele, and Bruce) on the screen (Figure 3). The subject is required to select one of them as an opponent (1). Upon the subject’s selection of an agent as an opponent, the camera focuses on the agent (Figure 1), and the subject can view the agent in the center of the display. The agent then declares his/her promise (2), for example, "I will select 100 yen." with CG animation. The subject is required to evaluate his/her impression of the agent (3). Next, the subject is required to select the decision (100 yen or 90 yen)(4). The agent also selects a decision (5), the result is displayed in another window (6), for example, "You selected 100 yen, and the opponent selected 90 yen. The opponent’s sales are 30 million yen, but you have lost 10 million yen." During this time, the agent makes a comment regarding the result (7). In this experiment, the subjects have several opportunities to select an agent and decide the price (4-7). After the selections and the decision, the subject is required to evaluate his/her impression of the agent several times over. Table III shows the patterns of the three agents and Figure 2 shows the patterns of facial expressions in our experiment. For example, in the case of David, when a subject selects him, David says "I will select 100 yen." with a happy face. With this promise, the subject selects his/her decision. When the subject selects "90 yen", he exclaims "That’s cheating!" with an angry face.

C. SD method

The semantic differential (SD) method is a way to evaluate an impression of a target by using pairs of adjectives. Subjects are required to evaluate the impression using a variety of adjectives. In the SD method used in our research, a list of bipolar adjectives was prepared for the evaluation. The subjects were given a variety of adjective pairs for the evaluation, for example, from "Weak" to "Strong", "Cold" to "Hot," and "Active" to "Passive" to be rated on a seven-point scale (from 1 to 7). Based on the result of the subjects’ responses, the subjects’ connotations can be determined.

The subjects received a questionnaire containing pairs of bipolar adjectives. We adopted the 20 pairs (heartless, immodest, thoughtless, narrow-minded, unsuccessful, uncoordinated, careless, irresponsible, confident, internal, weak, diligent, truthful, attractive, flexible, interested, friendly, warm,
Fig. 4. Result of the factor analysis for the three agents

tight, companionable).

D. Results

The subjects in this study were 10 students from our university’s department of computer science. The evaluation data were processed by factor analysis. Two factors were extracted after choosing the adjectives. Figure 4 shows the factor scores. In Figure 4, "before" refers to the subject’s impression when the agent declared his/her promise, "after" refers to the subject’s impression after the subject and the agent have selected the price and the result is displayed. The first factor is related to impression adjectives such as "warm" and "companionable" (Factor scores: heartless -0.773, immodest -0.755, thoughtless -0.644, ... , warm 0.711, tight 0.713, companionable 0.782). The second factor is related to the impression adjectives such as "confident" and "diligent" (Factor scores: weak -0.714, unsuccessful -0.503, irresponsible -0.494, ... , attractive 0.313, diligent 0.361, confident 0.754).

Two impression factors, "friendly" (Factor No.1) and "truthful" (Factor No.2) were extracted from the group. We detected differences between the subjects’ impressions before and after the agents’ decisions.

IV. DISCUSSION

In the case of Michele, before his selection, the subjects perceived the "friendly" and "truthful" impressions more strongly for her than others. However, even though she declared that she would select 100 yen, she selected 90 yen. Further, like selfish people, she said "The sale were decreasing." This behavior of her’s appreciably diminished her rating on the "friendly" and "truthful" impressions.

In the case of Bruce, before his selection, the subjects perceived the "friendly" impression more strongly and the "truthful" impression less strongly than the others. He promised that he would select 100 yen, which is exactly what he did, however, his rating on the "truthful" impression did not increase, and that on the "friendly" impression diminished appreciably. The reason why David’s rating on the "truthful" impression did not increase is that there was no element to judge his truthful in his actions.

Based on the results, we found that users form impressions of each agent. Further, their impressions depend on the actions that the agent selects. These impressions (friendly and truthful) may be related with the result of Oshikawa’s study using personification agents[14]. They focused on the relationship between a space and agents and investigated the impression of agent with space arrangements. Based on factor analysis, they found "friendly" and "authority" as the users’ impressions. The first factor "friendly" is common factor in our research and their one, and "friendly", "authority", and "truthful" may be important factors for animated agents. In order to investigate the effects of agents, we should conduct an experiment considering an impression of an appearance, actions, and the space.

In this research, the impressions were generated by only two actions. We should investigate the impressions generated by more actions and by applying a long-term strategy. Additionally, we should make an additional experiment when the role of the same three agents is changed, in order to investigate the influence by the agents’ appearance and gender.

V. CONCLUSION

In this paper, we investigated the impressions of animated agents in the situation of Game Theory. Through our experiments, based on factor analysis, we found "friendly" and "truthful" as the users’ impressions of the agent. These factors may be important elements for agents.

In the future, we will investigate the impression generated by medium-term and long-term strategies and the effects of these impressions.

Acknowledgments We would like to thank Yasushi Tanaka, Tokyo Denki University, for the assistance rendered in conducting our experiment for this research.

REFERENCES


