Strategies using Facial Expressions and Gaze Behaviors for Animated Agents

Masahide Yuasa

Tokyo Denki University
2-1200 Muzai Gakuendai, Inzai, Chiba, 270-1382, Japan
yuasa@sie.dendai.ac.jp

Abstract. This paper presents two strategies for selecting volitional facial expressions and gaze behaviors of animated agents, in the case of Online Negotiation and Soft Game Theory. It is difficult to make general models select volitional facial expressions for their use in many kinds of applications. In this paper, in order to develop these strategies, I investigated the effects of facial expressions and gaze behaviors through experiments based on Online Negotiation and Game Theory. I describe strategies by using estimations of reserve prices based on facial expressions in the case of Online Negotiation. Additionally, I deal with Soft Game Theory, which considers players' emotions, and describe strategies for using facial expressions. We can apply these strategies to animated agents and robots as a mechanism to select facial expressions and gaze behaviors.

1 Introduction

In recent years, animated agents have been used in a wide range of application areas, including entertainment, virtual environments, and e-commerce. If we do not wish to reveal our personal identity, we can use an animated agent who represents us to an opponent on a computer network. By using a tool that controls the animated agent, we can not only use verbal language but also select facial expressions, body posture, gaze behaviors, and so on. These nonverbal signals enrich communication among participants. Additionally, a tool that automatically selects the facial expression reduces the participants' burden of selection. Some researchers have developed models that can be used for producing the facial expressions of an animated agent automatically, such as the HMM model [1], the OCC model [2], and the Cathexis model [3]. However, these models have not been adapted to select volitional facial

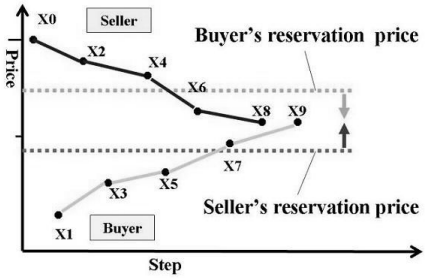

Fig. 1. Online Negotiation Process

expressions. A model should be able to distinguish between emotional and volitional facial expressions because both are used by humans [4].

However, it is difficult to make general models select volitional facial expressions for their use in many kinds of applications because humans use situation-specific strategies and intentions when selecting volitional facial expressions. If a user is provided with information on an opponent for each situation, the former could select a suitable volitional facial expression that gives him/her an advantage over the opponent.

In this paper, I propose strategies for selecting volitional facial expressions and gaze behaviors of animated agents through a computer network, in the case of Online Negotiation and Soft Game Theory. Online Negotiation is a kind of e-commerce in which negotiations are made with an opponent through a computer network. I describe strategies for using facial expressions in the case of Online Negotiation. Additionally, I deal with Soft Game Theory, which considers players' feelings, and describe strategies for using facial expressions. In the future, we can apply these strategies to animated agents and robots as a mechanism to select facial expressions and gaze behaviors.

In order to develop these strategies, I investigated the effects of facial expressions and gaze behaviors through experiments based on Online Negotiation and Game Theory.

In Section 2, I explain the method of selecting facial expressions based on Online Negotiation. In Section 3, I present the method of selection based on Soft Game Theory. This is followed by some concluding remarks in Section 4.

2 Method of Selecting a Volitional Facial Expression in Price Negotiation

2.1 Online Negotiation

Figure 1 shows an example of the Online Negotiation process. This example includes two participants – a buyer and a seller. They take turns sending

Fig. 2. A Panel of the Online Negotiation Tool Using Facial Expressions

proposals to each other. X0, X2, X4... represent the proposals made by the seller, and X1, X3, X5... denote the proposals made by the buyer. They reach an agreement when they make the same proposal. The seller and the buyer have reserve prices in negotiation. They can reach an agreement in the area between the seller's and the buyer's reserve prices. It is important for each to estimate the opponent's reserve price.

2.2 Effect of Changing an Estimation of the Reserve Price

The effect of changing estimation is that the receiver may change his/her estimation of an opponent's reserve price based on the opponent's facial expression. For example, when the buyer's facial expression is ANGRY, the seller may guess that the buyer does not want to compromise further because the seller's proposal is close to the reserve price; therefore, the buyer expresses himself/herself with the use of an ANGRY facial expression. The seller then estimates that the buyer's reserve price is raised and makes the next proposal based on this estimation.

I conducted an experiment to observe the relationship between estimation and facial expression. For this purpose, I developed a user interface to negotiate with an opponent through a computer network (Figure 2). Through this interface, a participant can send not only a proposal but also a facial expression to an opponent. The facial expressions used by the participant are displayed on the opponent's screen.

On receiving a proposal and facial expression from the opponent, the participant can send a new proposal and facial expression. The participant can select any one of the facial expressions of the animated agent (COOL, ANGRY, SAD, HAPPY, or SURPRISED) [5]. I used MFACE [6] to produce the facial expressions.

I obtained probabilities of participants' estimations by observing their decisions during price negotiation. I assume that they estimate the reserve price on the basis of the last four proposals as follows: $D = |X_n - X_{n-2}| - |X_{n-1} - X_{n-3}|$ (n indicates the number of proposals made while negotiating).

Table 1 shows the results of this experiment. Eight students from the department of computer science in the Tokyo Institute of Technology were

Table 1. An Estimation of the Reserve Price (In the Case of Buyers)

Facial Expression	D	Buyer's Estimation of Seller's Reserve Price		
		Up	0	Down
HAPPY	$D \geq 0$	0%	30%	<u>70%</u>
	$D < 0$	8%	46%	46%
ANGRY	$D \geq 0$	21%	50%	29%
	$D < 0$	<u>62%</u>	13%	25%
SAD	$D \geq 0$	15%	33%	52%
	$D < 0$	8%	77%	15%
....	....	...	...	...

the subjects of this study. In the case of a HAPPY expression, when the compromise made by the seller is higher than the reserve price ($D \geq 0$), the estimation is lowered (70%). In the case of an ANGRY facial expression, when the compromise made by the seller is lower than the reserve price ($D < 0$), the estimation is raised (62%).

Based on the effects of facial expressions, I describe a method of selecting a suitable facial expression in order to change the opponent's decision. In the case of using the effect of changing the estimation, the following is the main method to select a suitable facial expression. If the seller wishes to have an advantage, the seller should use an ANGRY expression. The buyer would then increase the estimation, the point of agreement would be raised, the buyer would compromise by a large margin, and the seller could have an advantage. If the seller uses a HAPPY expression, the buyer would decrease the estimation, the point of agreement would be lowered, and the buyer would compromise by a small margin, and the seller would have a disadvantage.

In this manner, the participants can estimate the effects of facial expressions and accordingly make an appropriate selection of their facial expression. If we consider many cases and tendencies of probabilities during negotiation in detail and for each individual, we could estimate the reserve price and the opponent's next move. I have attempted to develop strategies for more complex negotiations in which the effect of facial expressions may be changed.

3 Method of Selecting a Volitional Facial Expression in Game Theory

3.1 Soft Game Theory

Soft Game Theory deals with the decisions of two players who exhibit feelings toward each other in a situation similar to Prisoners' Dilemma [7]. Traditional models based on Game Theory do not consider these feelings among players.

However, practically, players may have certain feelings toward their opponents; for example, player A likes player B or player B does not like player C. 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 2), 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. For example, the player could select "Defect" despite informing the opponent that he/she would select "Cooperate." Soft Game Theory assumes that this temptation is resolved by the players' feeling toward the opponent. Although there is a temptation to deceive the opponent, if the player has a positive feeling toward the opponent, the player could trust him/her.

3.2 The Effect of Changing a Choice in a Dilemma

Although the Soft Game Theory deals well with the feelings of players, it does not describe the generation of these feelings in the players. Instead, it assumes that players already have feelings. It is not unnatural for the player to have unmotivated feelings.

Therefore, in this paper, I assume that the player's feelings toward the opponent are caused by the opponent's nonverbal behavior (for example, facial expressions and gaze behaviors) with the messages that are exchanged in the Soft Game Theory. Additionally, I assume that the player's trust is affected by the nonverbal behavior. For example, Prisoner A says the following to Prisoner B along with a HAPPY expression: "I will select Cooperate, so please select Cooperate." The HAPPY expression makes Prisoner B trust the message sent by Prison A and select "Cooperate," although the former may notice that the

Table 2. A Game of Prisoners' Dilemma. The first number in each cell represents Prisoner A's benefit and the second number represents that of Prisoner B

		Prisoner B	
		Cooperate	Defect
Prisoner A	Cooperate	3,3	1,4
	Defect	4,1	2,2

Fig. 3. CG animations: BOW, LOOK AWAY, HAPPY, ANGRY, SAD, COOL (This is only a sample. I used other animations in this experiment)

Table 3. Probabilities of Selecting Cooperate and Defect

	BOW	LOOK AWAY	ANGRY	HAPPY
Cooperate	36.1%	29.0%	30.0%	30.0%
Defect	63.9%	71.0%	70.0%	70.0%

latter is tempted to deceive him/her by selecting "Defect." On the other hand, if Prisoner A sends the same message to Prisoner B but avoids making eye contact, the latter will not trust the message and he/she will select "Defect."

I conducted an experiment to observe the relationship between selection and CG animation. I developed a new tool to send facial expressions and gaze behaviors through a computer network by using a tool for animated agent (TAA) [5]. In this tool, players must select "Cooperate" or "Defect" after they receive the message with CG animations as nonverbal information. There are six patterns of CG animations (Figure 3).

Eight students from the department of computer science in the Tokyo Denki University were the subjects of this study. As their opponent, I used a program to automatically and randomly select "Cooperate" or "Defect" and send messages to them. The subjects did not know who their opponent was. After receiving these messages with CG animations, they were required to select "Cooperate" or "Defect." Table 3 shows the results of this experiment. This table indicates the probabilities of the messages – sent with animation – from the opponent to the subject stating "I will select Cooperate, so please select Cooperate." I received 204 messages from the eight subjects during this experiment. The cases involving the use of the SAD and COOL facial expressions are not shown in this table due to insufficient usage. Before performing this experiment, I observed that four subjects selected "Cooperate" and the remaining four selected "Defect" without CG animation through a computer network.

This table shows that the subjects selected "Cooperate" a greater number of times in response to the use of the BOW expression (36.1%) than in the case of other CG animations. I infer that the subjects trusted the message to a greater extent because of the use of the BOW, and thus, selected "Cooperate." On the other hand, the use of the HAPPY expression may not have resulted in the same effect, and some subjects agreed to this possibility. Additionally,

it appeared that the subjects were unable to understand the opponent's intention when the ANGRY and LOOK AWAY expressions were used. I will attempt to perform the experiment with other subjects and obtain the same results by using another game in Game Theory.

4 Conclusion

In this paper, I proposed two strategies for selecting volitional facial expressions and gaze behaviors of an animated agent based on Online Negotiation and Soft Game Theory. Although these strategies have limited application, i.e., negotiating and playing the game, they will be used for producing facial expressions and gaze behaviors of animated agents and robots in the future.

Acknowledgments. I would like to thank Katsumi Nitta, Yoshiaki Yasumura, Daisuke Katagami, and other members of Nitta laboratory in the Tokyo Institute of Technology, for advising me with this work.

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