# A Tool for Animated Agents in Network-Based Negotiation

Masahide Yuasa, Yoshiaki Yasumura, Katsumi Nitta
Department of Computational Intelligence and Systems Science,
Tokyo Institute of Technology,
Nagatsuta 4259, Yokohama, Japan
Email:{yuasa, yasumura, nitta}@ntt.dis.titech.ac.jp

**Abstract**

*In this paper, we describe a tool for developing animated agents with facial expressions in negotiation through a computer network. The tool learns a user's tendency to select facial expressions of the animated agent, and generates facial expressions instead of human. In order to estimate facial expressions, the tool has an emotional model constructed by Bayesian Network. We can easily develop animated agents if we use this tool as a component. And we describe the estimation of an opponent's emotional state, based on observed data, by using the Bayesian Network.*

## 1 Introduction

As computer networks have spread into our lives, the opportunity that people communicate through computer networks has increased. As current user interfaces are not convenient for ordinary people to negotiate with each other, it is required to develop more user-friendly interfaces. For this purpose, several researchers have developed applications of animated agents with facial expressions, synthesized speech and gestures [1, 2]. However, they have not developed practical application systems using animated agents yet.

Our target is to develop animated agents which participate in the negotiation instead of a human. During the negotiation, the agent generates next proposal and controls its facial expression. We also focused on the facial expression of the animated agent in the negotiation, and we have conducted the research of controlling facial expressions in the negotiation [3, 4].

We should pay attention that people use two kinds of facial expressions in negotiation [5]. The one is an unintentional facial expression, which reflects a human's emotional state directly just after he receives the opponent's proposal. The other is an intentional facial expression, which is controlled intentionally according to some negotiation strategy when a user sends the user's proposal to the opponent.

Therefore, when we apply animated agents to the network-based negotiation, we need a mechanism in the agents which observes the situation of the negotiation and controls both kinds of facial expressions according to the situation.

However, it is troublesome to implement animated agents that control two facial expressions. We assume that the unintentional facial expression depends on only the each personality of a human and it is independent of the application domain. And we assume that we can make the model of the personality by machine learning technologies. Then, by learning the personality, the tool can generate the unintentional expression. By implementing this part beforehand, we can reduce a cost of developing the agent.

In this paper, we describe such a tool, named TAA (a Tool for Animated Agent), which constructs the model of human personality and generates the unintentional facial expression. The model is used as a part of an animated-agent that negotiates instead of a human. TAA uses an emotional model, which is an extension of ABX model which describes psychological relationship between people [6].

In Section 2, we introduce an animated negotiation agent. The emotional model in the architecture and experimental results are shown in Section 3. Section 4 presents the estimation of an opponent's emotional states. Finally, Section 5 is the concluding remarks.

## 2 Animated Negotiation Agent

### 2.1 Functions

In order to negotiate with an opponent through a computer network, a user interface of negotiation has been developed. In this interface, the user exchanges not only a proposal but also animated facial expressions, because the facial expression has an important role in negotiation. By using the interface, the user inputs a proposal and selects a facial expression in a panel. Then, they are sent to the opponent (Fig. 1). Fig. 2 shows facial expressions that the user can select

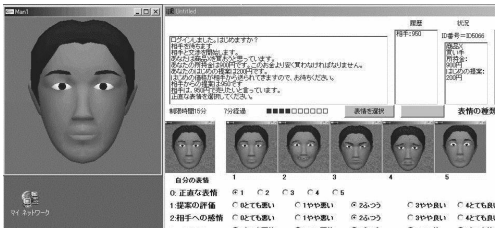

Figure 1: User Interface of network-based negotiation

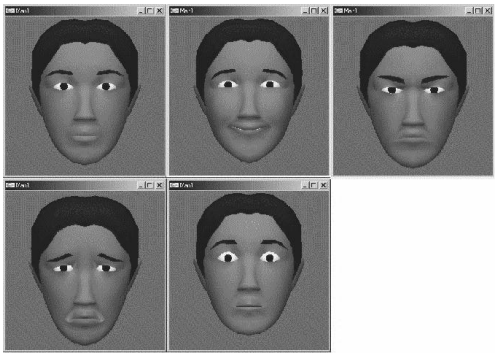

Figure 2: Facial Expressions

(i.e., COOL, ANGRY, HAPPY, SAD, SURPRISED).

Usually, participants of the online negotiation exchange their proposals and their facial expressions using this user interface. However, if the participant is busy, the user may use the animated negotiation agent temporarily. The agent generates new proposal and new facial expression and sends them to the opponent instead of the user.

Examples of the application areas of an animated negotiation agent are a plaintiff or a defendant of an online court, a trader of e-commerce, and a bidder of an online auction.

## 2.2 Architecture and Modules

Fig. 3 shows the architecture of an animated negotiation agent. The lower part of this figure is a user interface. The middle part and the upper part of this figure show the sub-modules of the animated negotiation agent. The middle part shows TAA, which function is to generate unintentional expressions. It depends on the user's personality and is independent of the domain knowledge. The upper part shows modules for each application modules. It generates a new proposal and a new intentional facial expression.

(1) User Interface

- Message Management Module
  This module transmits messages (a proposal and two types of facial expressions) among an opponent, sub-modules of the animated this agent, and "Operating Panel". When a proposal and facial expressions are come from the opponent, they are sent to "Proposal Evaluation Module", "Next Move and Intentional Facial Expression Generation Module", and "Operating Panel". And the messages made by "Unintentional Facial Expression Generation Module", "Next Move and Intentional Facial Expression Generation Module", and "Operating Panel" is sent to the opponent.
- Operating Panel
  An "Operating Panel" is used when the user negotiates with the opponent without the agent. This panel displays the opponent's animation on the screen. The animation talks the opponent's proposal with changes of the facial expressions. At first, the user inputs the user's unintentional facial expression using this panel, and then the user inputs the user's new proposal and the intentional facial expression (Fig. 1). This information is sent to "Message Management Module" and "Learning Module".

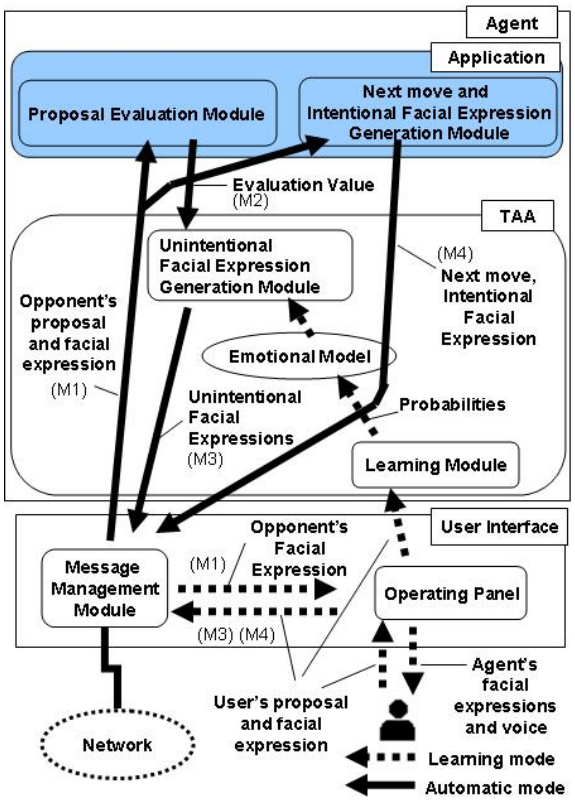


Figure 3: Architecture of agent

(2) TAA

TAA constructs the model of the personality of the user, and generates unintentional facial expressions. According to these two functions, TAA has two modes, a learning mode and an automatic mode. In the learning mode, TAA learns the human's tendency when the user uses the unintentional facial expression after the user receives a proposal from the opponent. In the automatic mode, TAA works as a part of an agent and generates the unintentional facial expression instead of the user.

- Emotional Model
  This model represents the user's personality. It consists of 9 emotional states. During the negotiation, when a user receives new proposal and new facial expression from the opponent, the user's emotion moves from one state to the other state, and the user's unintentional facial expression is generated when the state transition occurs. The personality of a user is reflected as the state transition probabilities. Using these probabilities, Bayesian Network is constructed which is used to estimate the facial expressions of the user. We explain a detail of the emotional model in the next section.
- Learning Module
  This module observes the user's actions (the user's proposal and facial expressions), and then it generates the state transition probabilities. The result is used for constructing the emotional model.
- Unintentional Facial Expression Generation Module
  This module generates the unintentional facial expression, based on the emotional model. The generated facial expression is sent to "Message Management Module".

(3) Application

The modules of this part are application programs which generates the new proposal and the new intentional facial expressions. These modules are used only in automatic mode.

- Proposal Evaluation Module
  This module evaluates a proposal, based on an evaluation function, and outputs an evaluation value as a real number between 0 and 10. The user needs to prepare the evaluation function in advance. The evaluation value is sent to "Unintentional Facial Expression Generation Module".
- Next Move and Intentional Facial Expression Generation Module
  This module makes a new proposal and a new intentional facial expression and sends them to "Message Management Module".

### 2.3 Flow of Message

During negotiation, several messages are transmitted among sub-modules. Fig. 4 shows example messages among the modules. (M1) - (M4) in Fig. 4 correspond them in Fig. 3. In this example, the agent receives (M1) from an opponent, makes (M3) and (M4), and sent them to the opponent. (M1) means a proposal and a facial expression from the opponent. (M3) is a new message for the opponent with an unintentional facial expression from Unintentional Facial Expressions Generation Module. (M4) is a new message of an intentional facial expression and a next proposal for the opponent. (M2) is a message with an evaluation value of the opponent's proposal from Proposal Evaluation Module.

In a message, the "action" means an action in negotiation. It takes one of "propose", "concede", "deny", "ask", and "answer". The "character" is a name of character. Users can select one from some characters. In this example, Taka uses "zen" and Yuasa uses "jony". The "evaluation_value" is an evaluation value between 0 and 10, which is calculated by Proposal Evaluation Module. The "face" is a facial expression against a receiver (i.e., HAPPY, ANGRY, COOL, etc.). In this message, the emotional model selects the "COOL" as an unintentional facial expression and it is sent. The proposal and "HAPPY" are selected by the user's module as an intentional expression. The "sender" and the "receiver" are a sender and a receiver of the message.

## 3 Generation of Unintentional Facial Expressions

### 3.1 Emotional Model

The emotional model in TAA is based on Newcomb's ABX model [6] (Fig. 5). The ABX model describes emotional states among two participants and one proposal. The relation among two of these entities is indicated by a plus sign, minus sign, or 0. The plus sign means a person has a positive feeling. The minus sign means a person has a negative feeling. The 0 means intermediate state.

In this model, each state is categorized into unbalanced states and balanced states. If one person has both positive relation for one entity and negative relation for another entity, then the state is unbalanced. Otherwise, the state is balanced. The unbal-

(M1) <MESSAGE action="propose" character="jony.acf"
face="HAPPY" sender="yuasa" receiver="taka" >
I want to sell it at $ 50.
</MESSAGE>

(M2) <MESSAGE character="jony.acf"
face="HAPPY" sender="yuasa" receiver="taka"
evaluation_value="5" >
</MESSAGE>

(M3) <MESSAGE character="zen.acf"
face="COOL" sender="taka" receiver="yuasa" >
</MESSAGE>

(M4) <MESSAGE action="propose" character="zen.acf"
face="HAPPY" sender="taka" receiver="yuasa" >
I want to buy it at $ 35.
</MESSAGE>

Figure 4: Messages among modules

anced states are unstable and tend to move to the balanced states.

In the case of negotiation, we regards A and B as participants, and X as a current proposal. And we view arrows from participants to X as evaluation values of a proposal by participants [3, 4].

During the negotiation, when a participant receives a proposal from the opponent, the state transition occurs. When a participant B offers a proposal X, B must like X. Therefore, just after A receives B's proposal X, A and B's emotional state must be one of 9 states of Fig. 5. The state (S1) and state (S9) are unbalanced states and the other balanced states.

We assume that the participant's emotional state transits from one state to another state with some probability, when the participant receives a new proposal and a facial expression. And one of unintentional facial expressions is generated with some probability, when the transition occurs. We use Bayesian Network in order to learn the probabilistic relations (Fig. 6). The network shows that the transition from a previous emotional state (P3) to a current emotional state (P4) when the user receives a new proposal (P1) and a facial expression (P2). And a facial expression is generated when the transition from (P3) to (P4) occurs (P5).

### 3.2 Learning Emotional Model

The probabilities among the emotional states depend on a personality of a human. An emotional model is defined as probabilities of state transitions and generating unintentional facial expressions. To

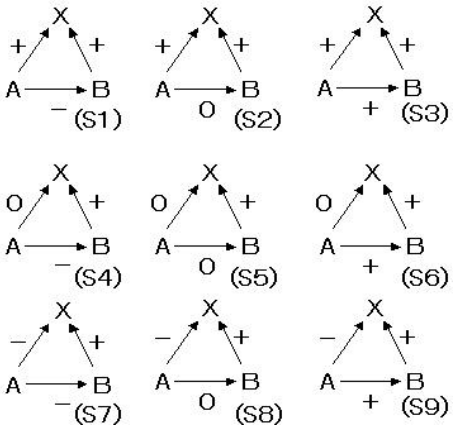


Figure 5: Emotional States for B

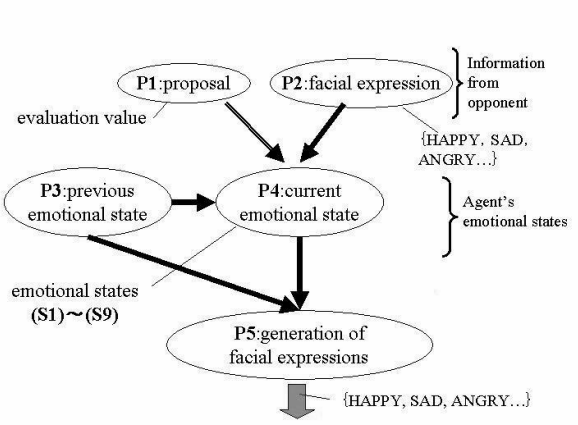


Figure 6: The generation of facial expressions by Bayesian Network

construct the emotional model, TAA needs to learn these probabilities from a participant.

We carried out the experiment of learning the emotional model in TAA. At first, we acquired probabilities by observing users' selections in an experiment using price negotiation. Next, we compared a selection of the users' and that of TAA.

The interface of learning is shown in Fig. 1. Fig. 2 shows facial expressions in the experiment (i.e., COOL, ANGRY, HAPPY, SAD, SURPRISED). We used MFACE[7] to display facial expressions. In this negotiation, users play a role of buyer and a program plays a role of seller, but users don't know whether the seller is human or not. And users must input an evaluation (+, 0, or -) of a feeling against the opponent on the panel.

Eleven students conducted the negotiation game. Fig. 7 shows a sample result after the tool learned

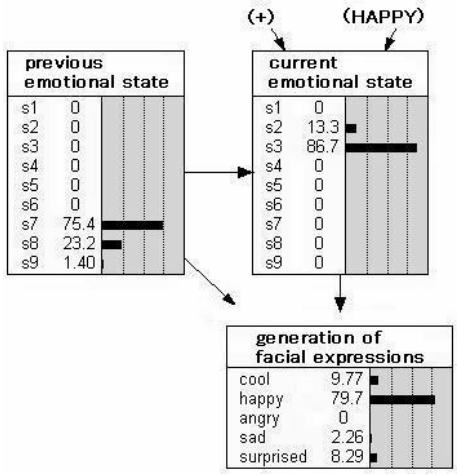


Figure 7: The case of (+) and (HAPPY)

Table 1: The accuracy of estimating facial expressions by using emotional model of the first-half and the second-half

| | (1)First - Second | (2) Second - First |
|---|---|---|
| X | 62.3 % | 73.0 % |
| Y | 52.8 % | 68.5 % |

the probabilities of transitions among emotional states and generations. Probabilities in Fig. 7 means existence probabilities of the each states and facial expressions. We used a Bayesian Network Tool "Netica" to calculate existence probabilities [8].

The upper right part of Fig. 7 shows the existence probabilities of "current emotional states" when the user received (+) in proposals and (HAPPY) in the facial expressions, at the state was "previous emotional states". And the lower part shows the existence probabilities of facial expressions at that time. In that case, the probability of S3 has an 86.7% and the probability of HAPPY has a 79.7%. This means that when the user receives a good proposal and good facial expressions, the state tends to transit a better one, and the user selected the HAPPY in many times. As above, our emotional model is a good model, which can consider the feelings for the opponent and the transitions of the emotional states.

Next, we tested an accuracy of the estimating the user's facial expression by the tool. We selected two students, X and Y, in this experiment. And we divided the students' data into two parts, and used the one of them as Training data and the other of them as Test data. We compared the following two cases. First case is that we use first-half as Training data and second-half as Test data. Second case is that we use second-half as Training data and first-half as Test data. Table 1 is the result of the accuracy of the estimation. The table shows the accuracy by the tool has a high percent in both cases and the users' selection of facial expressions is stable.

Table 2: The accuracy of estimating facial expressions by using the emotional model of X and Y

| | | Training data | |
|---|---|---|---|
| | | X | Y |
| Test data | X | X-X<br>73.0 % | Y-X<br>19.4 % |
| | Y | X-Y<br>48.8 % | Y-Y<br>68.5% |

Table 2 shows an accuracy of estimating the facial expressions by using the emotional model of X and Y. We compared two cases; one case is that X as Training data and Y as Test data. The other case is that we use Y as Training data and X as Test data. In this table, "X-Y" means that we compared the TAA's selection with Y's selection, after TAA learned the pattern of X. In this table, the accuracy by TAA has a 73.0% in case of X-X. In the same way, the accuracy has a 68.5% in case of Y-Y. However, in case of X-Y, it the accuracy has a 48.8% and in case of Y-X, the accuracy has only 19.4%. These result shows that TAA learns the user's pattern for each individuals and generates the unintentional facial expression appropriately.

## 4 Estimation of an Opponent's Emotional State

In the previous section, we showed that if the opponent's proposal and facial expression are given, the facial expression selected by the user could be estimated using Bayesian Network. In the same way, if the user's proposal and facial expression and the opponent's facial expression are given, we can estimate the opponent's emotional state by the Bayesian Network of the opponent. If the opponent's emotional state is estimated, the user will succeed in the negotiation because the user can select a proposal and a facial expression to take more advantage.

### 4.1 Method of Estimating an Opponent's Emotional State

In order to estimate the opponent's emotional state, we use Bayesian Network in Section 3. In the network, the opponent's emotional state is estimated from the user's proposal and facial expressions to the opponent, and the opponent's facial expressions.

For example, Fig. 8 shows existence probabilities of the opponent's emotional state, when (P1), (P2)

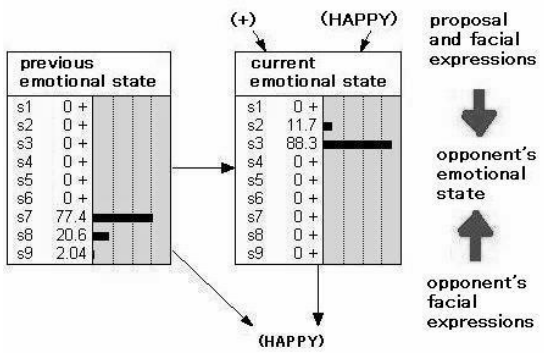


Figure 8: The example of the estimation of an opponent emotional state

Table 3: The estimation of an opponent's emotional state.

| | Facial Expressions | |
|---|---|---|
| | use | don't use |
| Opponent's data | 71.0 % | 48.3 % |
| Average data | 45.5 % | 42.3 % |

and (P5) are given. (P1) is a proposal (+), (P2) is (HAPPY) and (P5) is (HAPPY). In this case, the states have the probabilities; (S3) has an 88.3% and (S2) has an 11.7%.

### 4.2 Experiment

We tested an accuracy of estimating the opponent's emotional state. We compared two cases. First case is that we know the opponent's Bayesian Network accurately. Second case is that as we don't know the opponent's Bayesian Network, we use the Bayesian Network of average people instead of the opponent's one. For each case, at first, we experimented the performance of estimation using the opponent's facial expression, and then we investigated the performance not using opponent's facial expression.

Table 3 is the result of the accuracy of the estimation. In the case of using the opponent data and facial expressions as a hint of the estimation, the accuracy of estimation has a 71.0%. However, in the other cases, the accuracy has a low percent.

## 5 Conclusion

We developed a tool to make an animated agent in negotiation, based on the emotional model constructed by Bayesian Network. And this tool can select the user's facial expressions instead of the user. The user could make the agent easily and reduce a cost of developing the agent.

The experimental result showed that the agent could express the unintentional facial expression appropriately and the tool could estimate the opponent's emotional state using Bayesian Network.

As another application of the animated agent, we have been making an online ADR (Alternative Dispute Resolution) system. This is a mediation system for two participants to solve a dispute through computer network. We have developed an animated mediator agent which mediates participants in the ADR system.

## References

[1] Justine Cassell, Hannes Vilhjalmsson and Tim Bickmore, "BEAT: the Behavior Expression Animation Toolkit", *In Proceeding of SIGGRAPH 01*, 2001.

[2] Tsutsui, Saeyor and Ishizuka, "MPML: A Multimodal Presentation Markup Language with Character Agent Control Functions", *In Proceeding of WebNet 2000 World Conference. on the WWW and Internet*, San Antonio, Texas, USA, 2000.

[3] Masahide Yuasa, Yoshiaki Yasumura and Katsumi Nitta, "Negotiation Support System Using Physiological Information", *In Proceeding of IEEE-SMC2000*, pp. 248-253, 2000.

[4] Masahide Yuasa, Yoshiaki Yasumura and Katsumi Nitta, "Negotiation Support Tool Using Emotional Factors", *In Proceeding of IFSA-NAFIPS2001*, pp. 2096-2911, 2001.

[5] Ekman, P., Friesen, W.V, "Unmasking the face", *Prentice-Hall*, 1975.

[6] Theodore M. Newcomb, "An Approach to the Study of Communicative Acts", *In Psychological Review*, pp. 393-404, No. 60, 1953.

[7] Osamu Hasegawa and Katsuhiko Sakaue, "CG Tool for Constructing Anthropomorphic Interface Agents", *Proc. IJCAI-97 WS (W5) , ANIMATED INTERFACE AGENTS*, pp.23-26, 1997-8

[8] Netica, http://www.norsys.com/