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Social Behavior Model for Human-Machine Collaboration Systems

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Abstract: - Recently, human-machine collaboration systems are increasing their importance more than ever because machine evolution continues and the importance of human-centered design is increasing. In this paper, social and intelligent agents are employed to develop the human-machine collaboration system. In order to draw out the effectiveness and efficiency of such the system, the agents should behave consistently, context-dependently, and socially toward human. The proposed approach here for realizing such the agents is embedding mind model in the agents. The relationship between mind model, personality, and social behavior of the agents is studied with using the implementations of a primitive system and an e-learning application.

Key-Words: - human-machine collaboration system, mind model, personality, social behavior, e-learning

1 Introduction

From ancient days, human beings have been evolving with tools and machines. This is easy to understand by considering the revolutions of agriculture and industry. These revolutions had brought extension to the ability of physical aspects of the human. Now, we have been in the era of information revolution. This revolution has been bringing the extension to the brain of human, especially the functionality of communication and control of human. On and after the 21st century, we will realize that human-machine collaboration systems have been increasing their importance by reviewing a few past decades. Back in the end of 1970s, the importance of human interface design was pointed out because of the complex functionality of machines. The famous accident of the Three Mile Island power plant was the trigger for the consideration. In the '80s', expert systems were used to solve certain real-world problems. It is considered as the first industrial application of the artificial intelligence. A key factor of success was to extract sophisticated knowledge from human experts. But, it was tough because the almost all practical knowledge was tacit. In 1990s, computing power had been incredibly progressing according to the Moore's Law. The favor of the power realized many useful and complex algorithms to the real world applications with using technology of speech recognition, image understanding, data mining, etc. As shown above, technology has been spirally developed and these activities can be caught as preparation for building next-generation human-machine collaboration systems. One of the objectives of such systems is to realize that people can enjoy more creative works by entrusting machines with things that the machine can do. Under the context, it will be more important to take care of social aspects between human and machine [1]. In this paper, the functionality of human-machine collaboration systems will be studied from the view of social relationship between human and machine. Especially, it will be studied that social behavior of the machine is expressed based on its mind and personality model.

2 A Human-Machine collaboration system

The human-machine collaboration system consists of human, machine, and environment as shown in fig. 1. The human and the machine do collaborative work to achieve the objectives under the environment. They interactively communicate with each other and control each other. The important problem to be solved here is to maximize the performance of the collaboration system with satisfying better feeling of the human.

2.1 Functional requirements for the machine of the collaboration system

There are two directions of communication and control between the human and the machine in the collaboration system. In the direction from the human to the machine, the machine should understand the intention of the human to reduce the communication cost and to solve problems for achieving the objectives effectively and efficiently. In the direction from the

machine to the human, the machine should convey useful information and message effectively and efficiently. In a wide sense, these requirements belong to human-machine interaction area. Beside on them, there should be requirements related to capability and availability of problem-solving such as database retrieval, communication with other machines, numerical calculation, etc. In this paper, we focus on the human-machine interaction with considering smooth communication and confortable control.

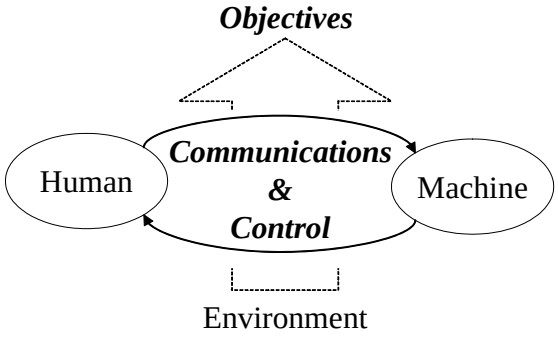

Fig. 1 The conceptual image of a human-machine collaboration system

2.2 Principle of human-machine relationship

Interaction between human and machine is a very important part of the human-machine collaboration. Human behavior is affected by machine behavior in the human-machine collaboration system. Reeves & Nass pointed out the principle of "People are not evolved to twentieth-century technology. There is no switch in the brain that can be thrown to distinguish the real and mediated worlds"[1]. According to this principle, social behavior of the machine effects essential factors of human behavior, such as motivation, persuasion, and compliance.

2.3 A type of human-machine collaboration

There are all sorts of collaborations between human and machine, ranging from movement with an automobile to corporate decision with a computer. We need to clearly define our problem by assuming a certain application. The application should have the nature of that both of human and machine have important roles each other to achieve the objectives. Moderate complexity and impact to society are also necessary for the application selection. Especially, it would be desirable that human motivation has influence to the consequence of the application process. Through discussion on these requirements, we have decided to select an e-learning application as our first study application of the human-machine collaboration system.

2.4 Problem-solving approach

We've employed a social and intelligent agent as the machine in the human-machine collaboration system. Minsky published The Society of Mind in 1987[2]. In the book, he explained mind as collection of collabrative agents. Since then, the word of agent has continued to be treated as newer generation technology in artificial intelligence field. Actually, agents have come in different names such as intelligent agents, mobile agents, interface agents, etc. Recently, Alonso pointed out that AI research should focus on interactive, autonomous systems, that is agents[3]. According to his article, agents must be autonomous, flexible, and show a social attitude. Agents are also a natural metaphor for human to understand and to use intelligent systems. These are the reasons why people need the words of agents as for using and developing intelligent systems.

In this paper, we especially focus on the problem of interaction between human and machine based on the principle as mentioned before. More concrete problems to be solved here is, then, how to generate social behavior of the agents in the e-learning environment, which effects on the essential factors for human motivation, compliance, parsuation, etc. The solution is to implement mind model embedded in the agents and to apply personality to design and development of the collaboration system.

3 Personality model

People feel personalities of other individuals that they interact with. Personality is used for explanation and prediction of people's emotion and behavior. It shoud be permanent traits of human and could be slightly changing through his experience. In psychology, "Big Five" is known to characterize some major attributes of personality [4]. Reeves and Nass found that friendly-unfriendly and dominant-submissive are dominant attributes of personality especially with mediated agents [1].

We often use the two dimensional personality space for designing the agent personality. Fig. 2 shows an example of the personality space. At the personal assistant task done with an agent, because a user interacts with the agent every day and information provided by the agent should be credible, the personality of the agent have to be dominant and may

not be so friendly. At the airline reservation task with an agent, the personality of the agent must be friendly and may not be so dominant because the task could be more complex and the users of the system may not be professinals of information technology or may be beginners. This technique is very useful to reduce the design parameters that are too many to design such agents. Besides on this, personality is important for the agents to keep consistency of behavior of themselves. These are the usage of personality in designing life-like agents.

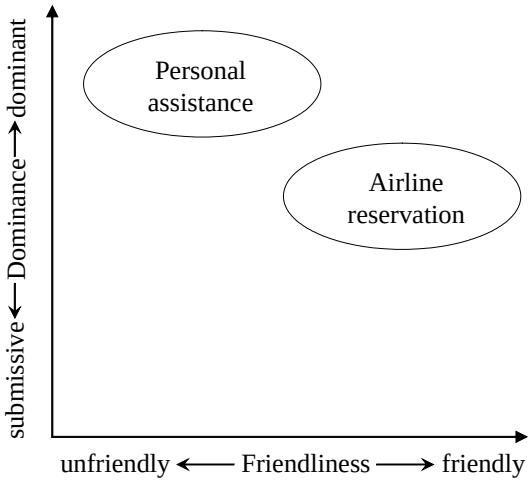

Fig.2 Personality space for specifying agents' personalities

4 Mind Model

We've been developing artificial mind model named Mind and Consciousness model (MaC model)[5]. In order to realize smooth communication and confortable control in the human-machine collaboration system, agents with mind will be required because agents must have the feature of autonomy, flexiblity, and social orientation [3]. There have been many arguments related to this topic in the wide area of philosophy, psychology, and artificial intelligence.

Dreyfus pointed out that people interpret the meaning of matters according to their desires and concerns[7]. Dennett's intentional stance is the strategy of interpreting behavior of entities such as human, animal, artifacts, and whatever. Human treats them as if they were rationally selecting their action based on the consideration of their belief and desire[8]. Humphrey said that people or higher animals communicate with simulating other's minds with using their mind [9]. These arguments refer to understanding motivation, which suggests necessity of artificial mind model.

The other reason why artificial mind model will be required is to empower the problem solving capability of agents. W.James emphasized that emotion is the predominant operation mediating both cognition and action[10]. Minsky argued that emotion has influence on goal constructing in problem soving and that artificial intelligence should have the ability of processing emotion [11]. These arguments seem to be connected with the concept of cognitive appraisal theory.

4.1 Conceptual architecture of MaC model

Fig. 3 shows the conceptual architecture of MaC model. We employed cognitive apprisal thory as the reference model of MaC model. The theory was proposed by Ortony, Collins, and Clore in 1988[6]. For that reason, the theory was known as OCC model. In the theory, appraisal of human based on their emotion consists of three main variables - *desirability*, *praiseworthness*, and *appealingness*.

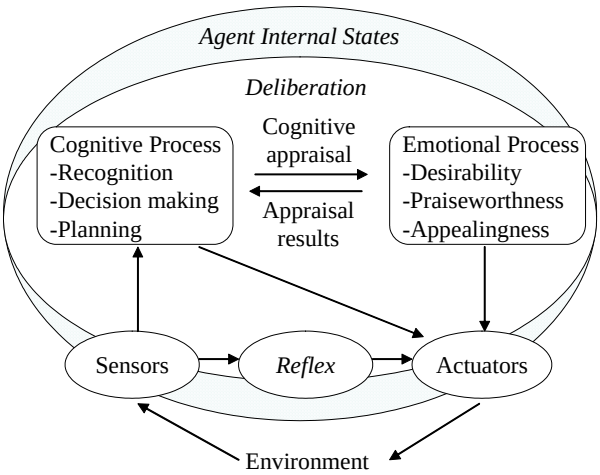

Fig.3 The conceptual architecture of MaC model

We've extended to the OCC model to realize MaC model from two points of view. The first one is to add an information path from the emotional process to the cognitive process. By this extension, cognitive process will have the capability of highly sophisticated processing mechanism with the high-level problem solution task such as recognition, decision-making, planning, etc. The second is hierarchical extension like Rasmussen's SRK model [12]. The SRK model employs the hierarchy architecture that consists of skill-based, rule-based, and knowledge-based reasoning process layers. MaC model has simply two

layered information process loops. The first one is the reflex loop, in which the reflex component processes the data from sensors to control the actuators, in the way of rough but speedy process method. The second is the deliberative loop that is corresponding to richer information processing based on the cognitive appraisal theory. Deliberative process is accurate but slow. The combination of these loops tends to give agents more flexible and intelligent capabilities.

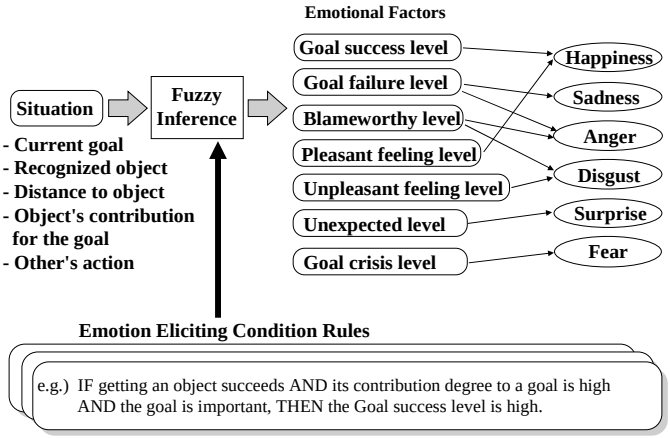

Fig.4 Diagram of emotion engine

4.2 Emotion Engine

Emotion holds dominant part in MaC model and also strongly related to social behavior. We employed the theory of the Urge system proposed by Toda to implement our emotion engine as a role of Emotional Process of MaC model in fig. 3. According to the theory, emotion occurrence can be logically explained with situation and emotional factors [13]. As shown in Fig. 4, the emotion engine calculates six basic emotions. Each component of both of the emotional factors and the basic emotions has the degree of activation level. We employed fuzzy inference to calculate the degree of the each emotional factor from the situation. Then, the each activation degree value is calculated with formula (1). Activation level of basic emotions will be used to select behavior such as facial expression and domain specific execution. The idea of mood *Mj* is also employed in the emotion engine for keeping stability of emotion and behavior of the agent.

$$Ei(t) = 1 \Big/ 1 + \exp\{(-Xi(t) + a)/b\}$$
$$Xi(t) = Xi(t-1) + si - ri + \sum_j WjiMj(t-1) \quad (1)$$

$Ei(t)(0 \leqq Ei(t) \leqq 1)$: the activation degree value at the time t of basic emotion denoted by i

$Xi(t)$: the internal state value at t of basic emotion i
a, b : coefficient values for the function $\exp(x)$
si : increase coefficient value of the emotion i
ri : decay coefficient value of the emotion i
Wji : excitatory or inhibitory gain from mood j to emotion i
Mj : the activation degree value of mood j

4.3 Mind model and Personality

MaC model has the parameters to tune behavior control, for instance desire level for innate goal, attenuating ratio for persistence, and threshold values for basic emotion and behavior selection. The simple experiment for verification of relationship between the mind model and personality had executed [5]. According to the experiment, we can control the personality of agents with MaC model and its parameter tuning. The experiment was as follows in shortly;

The experiment system provided the virtual world including three different personality agents and a tactile interface for interacting with a subject. The subject was a member of the society and is also an observer of it. He or she felt the personality by observing the social behavior of each agent.

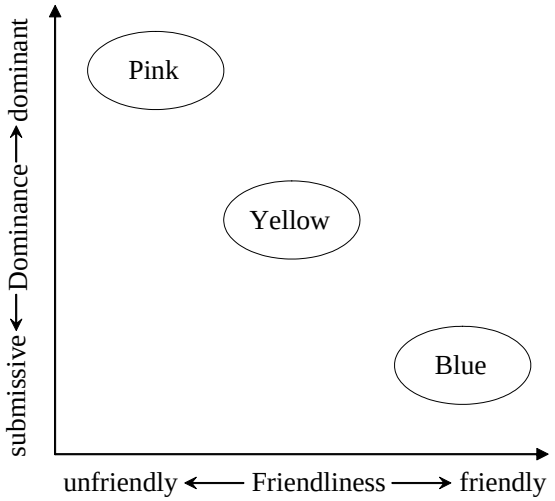

Fig. 5 Personarity Design Polcy

There were three agents named Blue, Yellow, and Pink in virtual world. The personality of each agent was designed as shown in Fig. 5. The agents can express their emotion by using facial expressions and their voices. Facial expression was designed according to the Ekman's theory [12]. The method was that after five minutes interactive session with agents, the subjects was asked to write down their impressions about emotion, motivation, and personality of each

agent. Table 1 shows the part of the results. Subjects were thirteen males and ten females. Prior to the experiments, subjects were only given the information about agents and its virtual world and how to play with the agents. Information related to emotion, motivation, personality was not told to the subjects.

As the adjective words shown in the table 1, it can be recognized to realize the personality of each agent described in the Fig. 5. The subjects observed social behavior of each agent to think of the adjective words. The personality of the agents was controlled by setting the parameters in the Table 2. These values denote threshold for each parameters; i.e. the lower the value is, the more the nature is observed.

Table1 Personality representative words written by subjects

() : the number of appearance

Blue	Timid(7), Obedient(3), Gentrle(2), Spoilt(2), Sociable(2), Curious(1), Lonesome(1)
Yellow	Normal(5), Own pace(3), Timid(3)
Pink	Irritable(15), Offensive(3), Egoistic(3), Unkind(2)

Table 2 Parameters setting for the agents

(B:Blue,Y:Yellow,P:Pink)

Categories	Setting values
Innate goal	Desire level : P < Y < B
Empirical goal	Attenuating ratio for persistence : P << B, Y
Emotion threshold	- Happiness : B < Y < P - Anger : P < Y < B - Sadness : B < Y < P - Fear : B < Y < P - Disgust : P < Y < B - Surprise : B < P < Y
Behavior threshold	- Threat : P < Y < B - Request for pat : B < Y < P - Request for food : B < Y < P

5 E-learning and social behavior

In the previous section, we've confirmed that mind model with the emotion engine can control agents' social behavior based on their personality. In this section, our expectation of a new and experimental application as a human-machine collaboration system will be described. The application is e-learning environment. The e-learning provides a very good collaboration environment for studying human-machine collaboration system and the market of e-learning has been increasing year by year.

5.1 E-learning collaboration space

Our concern is how to motivate learners by providing the learners with a classroom as certain social space. Because of this, we've employed classroom metaphor not just teacher or student metaphor. Based on the metaphor, e-learning collaboration system named e-School provides the virtual classroom shown in Fig. 6. On the other hand, so far as a first version of e-School, we've simplified it with minimum necessity because of securing experimental flexibility and reducing development cost. As shown in the figure, there are three cartoon characters who are a teacher agent, a student agent, and an avatar for a learning user. The agents behave autonomously and the avatar is controlled by the human learner. The agents and the avatar use facial expression and text information to communicate with each other including a human learner. A blackboard and workspaces for the teacher agent and the students are also available in the space. We've employed simpler mind model than MaC model and focused on studying social behavior under the e-learning context. The mind model is simple but enough to be considered for handling social factor such as liking, individualism-collectivism, etc. This is preparation for extension to our mind model with much capability of handling with social issues.

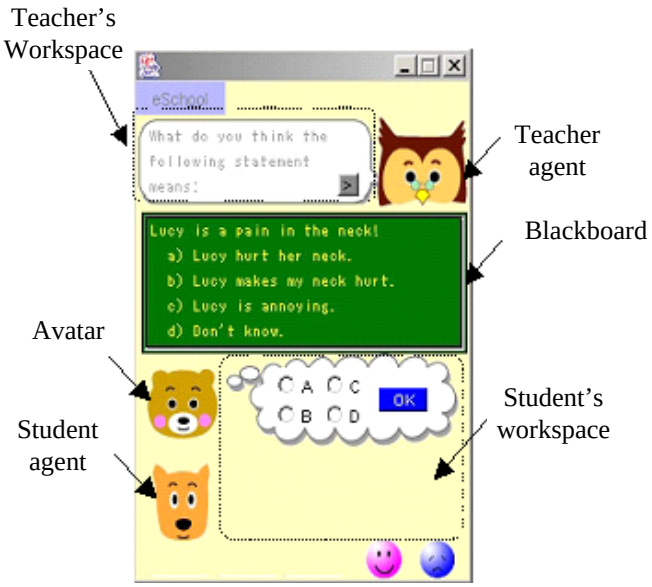

Fig.6 Display image of the e-learning space

5.2 Social relationship and social behavior in a class room

Many studies related to e-learning or intelligent tutoring with using agent technology have been done. Recently, collaborative learning or multiple learner environments has been paid attention to [16][17][18].

This concept supports the classroom metaphor. But, these studies have not mentioned about social aspect of a classroom even they said that interaction between learner and a teacher or co-learners is important. Our point is that social behavior can empower such cooperative learning environments by giving influence to essential factors for behavior of human learner, which are motivation, compliance, persuasion, etc. We think that learner's motivation is the most important for effective and efficient learning and social behavior of a teacher and co-learner effects on the essential factors. For instance, we expect that social behavior of the co-learner such as emotional praising and sympathy could draw out a learner's motivation because of their social relationship.

6 Conclusion

The functionality of human-machine collaboration systems has been discussed especially focusing on the relationship between human and machine. Our mind model can control the personality and social behavior of a certain agent by setting some parameters. The design policy is easily to be understandable and explanationable by using the two dimensional personality space. Through those discussion, it has been recognized that personality has two kinds of important aspects in the series of design, development, and usage of the agent-based system. The first one is observed personality for users of the system. Users feel the personality of the agent via his or her social behavior. The second aspect of personality is used for realizing the first one, whith is used as building up the common understanding for designers and the developers of the system. Mind model such as MaC model will provide general solution for implementation of emotion model with realizing both observed and designed personality.

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