Artif Life Robotics (2011) 16:78–81
DOI 10.1007/s10015-011-0891-2

© ISAROB 2011

ORIGINAL ARTICLE

Hirotaka Osawa · Seiji Yamada

Social modification using implementation of partial agency toward objects

Received and accepted: February 24, 2011

Abstract This article considers what kind of partial agency can be implemented for objects to bring about better agencies for interacting with humans. We humans have the ability to inform our fellows about our intentions, internal states, and requirements through verbal means, gestures, attitudes, timings, and other representations. These representations help us to maintain our belief that we are sufficient agents. Robots and virtual agents also mimic these representations; they act as if they have such an agency. However, their agencies are sometimes too excessive compared to their task. This mismatch leads to a high cognitive load being placed on users and consequently leads to breakdowns in interaction; it prevents human–agent interaction from being a modality in certain applications. We have devised an agency with multiple selectable features. We believe that selectable features promote good designs of virtual agents, robots, machinery, and home appliances according to their intended traits. We categorized these agencies into several groups and discuss what elements lead to these features. The article also describes a method of identifying these features in human behavior.

Key words Anthropomorphization · Human–agent interaction · Human–robot interaction · Human interface

1 Introduction

The field of modern human–computer interactions has attracted researchers with varied backgrounds. The availability of various robotics technologies, such as actuators and sensors, means that researchers in informatics have many methods to access the real world. Moreover, the rapid development of computers has enabled mechanical engineers to develop more sophisticated control methods, and much effort is aimed at developing ubiquitous and human–robot interaction interfaces.

Studies of human–computer interaction are conducted with two different policies. One is an extension of human abilities. Figure 1A illustrates the concept of this policy. Technologies are extensions of humans, like a third arm or some sort of machine interface. For example, glasses equipped with augmented reality (AR) technology give users more visible information. If someone wears such glasses, they effectively have what is akin to upgraded eyes. Tele-operation is another kind of extension of our bodies. These actuators behave as a third arm or leg to let us manipulate objects at another location according to our will.

The other sort of policy places a social buffer between users and the system, and this buffer converts input/output (shown in Fig. 1B). The buffer is called an agent.[1] The agent concept uses several metaphors, such as internal states, emotions, and requirements, to inform users. This method is grounded by several studies in cognitive science and artificial intelligence, and its validity is evidenced by the enthusiasm some people have toward life-like agents. Here, we use the term human–agent interaction (HAI) to cover this ideology, and we also use the term human–robot interaction (HRI).

The HAI method has the advantage of being able to inform users of several complex states, especially those implying intentions and internal states by metaphors. For example, the states of video recorders and computers can be represented as emotional states. If the object behaves with a sad emotion, it suggests that something bad is happening. On the other hand, if the object represents a happy emotion, it implies that a transaction of some kind is in order. A human-like social stance can restrict the determination of meanings. Ishida et al. showed how a conversation system improves in quality as a result of using several roles in a conversation.

H. Osawa (✉)
JST PRESTO, 4-1-8 Honcho, Kawaguchi, Saitama, Japan
e-mail: osawa@nii.ac.jp

S. Yamada
National Institute of Informatics, Tokyo, Japan

This work was presented in part at the 16th International Symposium on Artificial Life and Robotics, Oita, Japan, January 27–29, 2011

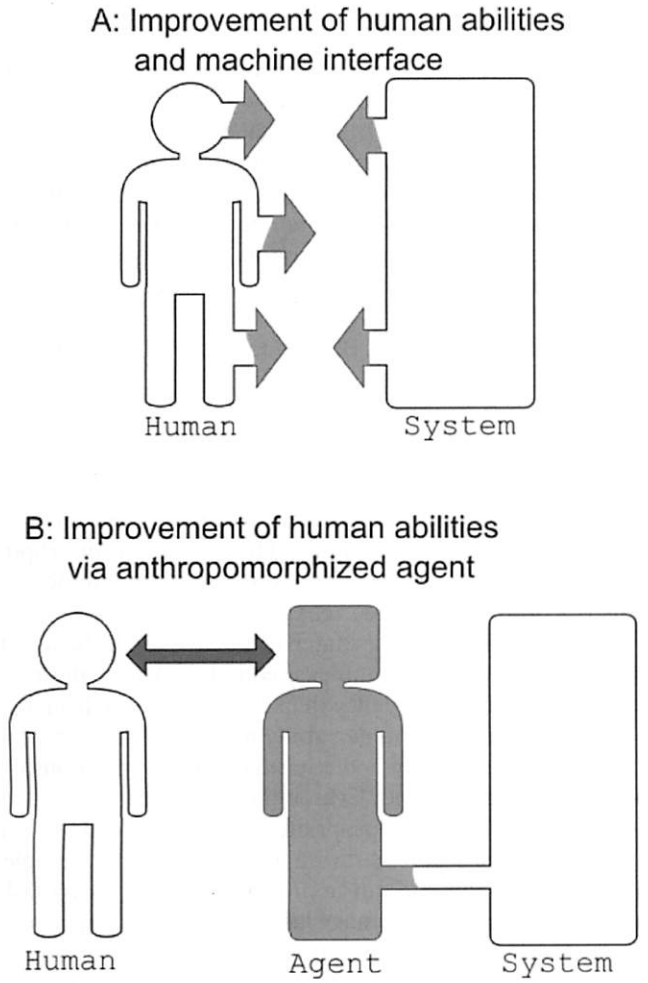

Fig. 1. Differences between extension and agent technologies in human–computer interaction

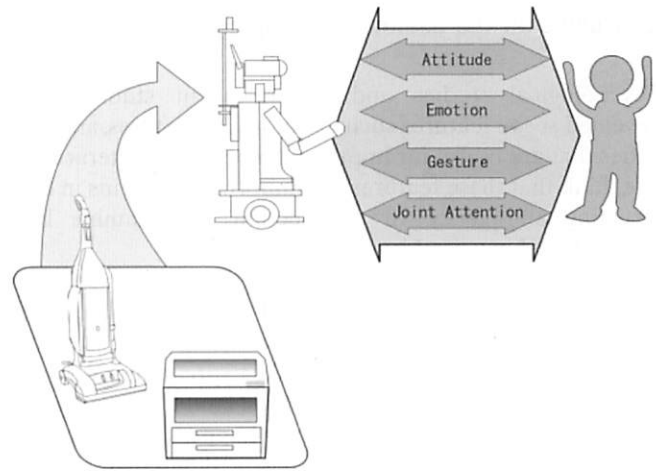

Fig. 2. Conventional agent system

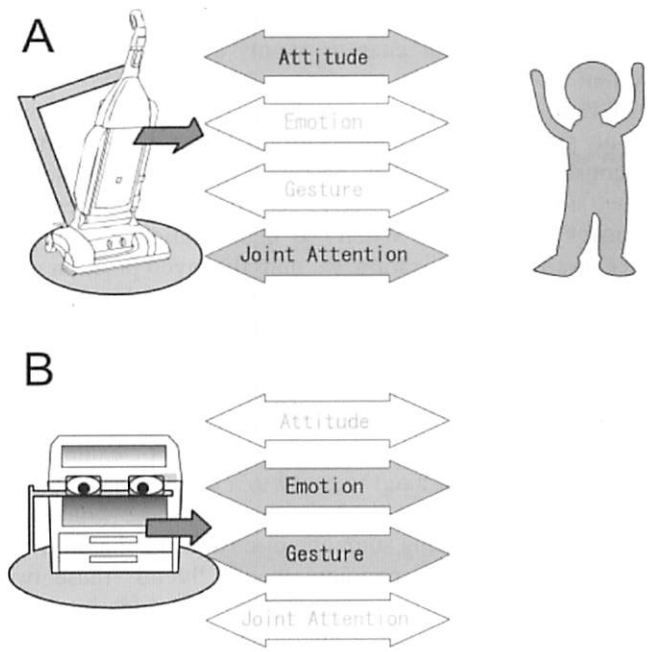

Fig. 3. Concept of partial agency

Our study focuses on broadening the field of application of human–agent interactions by using the separation of agencies. We define an agency as any kind of representation that indicates a user's intentional stance, as described by Dennett.[2] If we select and add agencies separately according to the currently required task of the system, the system's ability will increase. Figures 2 and 3 show how our approach extends human–agent interactions. Figure 2 shows the normal human–agent interaction method. An agent is placed between the system and the user. It wraps the system's input and output by using social channels such as attitude, emotion, gestures, and joint attention. These channels are separated according to the task and type of machinery being used. Figure 3 illustrates the concept of partial agency. If a machine runs a location-based task such as the vacuum cleaner shown in Fig. 3A, it uses location-related social channels. An attitude can emphasize the direction in which the vacuum cleaner should be moved. This works as a restriction on the representation. Joint attention has a more sophisticated role in human–human interaction, but it also works to show clues about a place.[3] On the other hand, emotions and gestures work in situations where a machine does not have actual movements, but does have complex states, like the printing machine shown in Fig. 3B. These social channels can inform a user of several states through the use of metaphors.

This article is organized as follows. Section 2 describes the psychological and HAI studies that have been conducted. Section 3 considers what kinds of problem might affect the use of agents in an application field. Section 4 describes the notion of partial agencies, and also how to identify a partial agency from interactions in several implementations. Section 5 concludes the article.

2 Studies on the usefulness of agents and agencies

Psychological studies and human agent studies have revealed social features such as emotions, gestures, and attitudes that are useful for improving mechanical interactions. We think that these features are important elements in constructing an agency. In this section, we examine how researchers have used such elements.

Emotions are very important ways to evoke a sense of agency in users. Human beings and other animals express emotions. One of the earliest studies on emotion was conducted by Darwin.[4] He compared the expressions of several animals and discussed their influences. Paul Ekman[5] categorized human facial expressions into happy, sad, angry, fear, disgust, and surprise. Robert Levenson[6] devised an abstract model for evaluation. Even if the emotions cannot be conveyed solely by abstract appearances, virtual agent and communication robots can profitably embody such abstract models. The usefulness of emotions to a robot or virtual agent has been proposed on more than one occasion. For instance, Rosalind Picard[7] proposed effective computing that uses emotional cues as inputs and outputs of the system.

Gestures are also used to realize agencies. They are commonly used to support conversations.[8] We use some gestures unconsciously and other gestures intentionally. Mental space studies have attempted to describe how these gestures transfer information. When we hear spatial information such as a feature's location, we map the given position into our mental space. Psychologists have analyzed this situation using the concept of a blended mental space, as proposed by Fauconnier.[9] Liddell[10] suggests that the mental space concept is also applicable to analyzing gestures. The blended mental space helps us to analyze the meaning of conversations using the virtual space of each user. For example, if you used your right hand to point to a dial on the wall and your left hand to make a turning gesture, these would not be good for instructing someone else to turn a dial in front of them. Rather, the recipient would "blend" these two gestures into the same mental space and interpret them as meaning that you wanted them to turn that dial one way.

These human-like features are identified by observing and thinking about human activities. They have enough salience to give the impression of agency to an object. Several human–robot interaction and HAI studies have used the above results to improve interactions.[1]

3 Problems with human–agent interaction and its application

The above section showed what sorts of basic knowledge about human beings supports HAI technologies. However, agent-based interactions are not always used in real applications, despite their usefulness. In this section, we discuss several defects of agents and HAI studies.

3.1 Compatibility problems

The sheer variety of agents has prevented researchers from organizing them into a standard body of knowledge. For instance, Rene Descartes[11] said that it was important "to divide each of the difficulties under examination." This policy is the basis of science. However, HAI and HRI studies sometimes fail in this requirement because *their results are* strongly related to the agents/robots themselves, and they are difficult to discuss separately from the embodiment. That is, a result based on agent A may not be applicable to another study using agent B when the agents have different attributes.

3.2 Excessive anthropomorphization and agency

Some researchers have hypothesized that anthropomorphism sometimes attracts people. However, over-anthropomorphism sometimes distracts people from the interaction. This is a problem for three reasons.

The first reason is a mismatch of the agency. If the agent interacts in a way that implies a complex agency, the user estimates much more agency than is actually there from the behavior. An adaptation gap study noted this problem.[12]

The second problem is the mismatch of the relationship between task and agents. Even if an agent is attractive and able to express the appropriate agency, a mismatch of appearances may still harm an interaction. For example, bug-shaped robots are not appropriate for a cooking task because of the "dirty" image users would develop about them. As examples of this problem, a robot designer has illustrated several mismatches in the design of robots.[13]

The third problem is disgust toward anthropomorphization itself. An overwhelming feeling of social connection leads to too much cognitive load. Epley et al.[14] showed that people may be satisfied by a certain level of anthropomorphization when they are socially disconnected. Their findings mean that if one is satisfied with a certain level of social connection, any additional anthropomorphic representation becomes an unwanted exaggeration.

4 How to identify agencies

In Sect. 3, we considered what shortcomings interfere with the smooth application of an agency to an interface. To solve these problems, we simply propose to separate evaluations of agencies using separated anthropomorphic devices. That is, each device embodies a feature for an agency. An agency can be subtracted from the interface of an agent equipped with all agencies.

Figure 4 shows what is achieved by our method. Figure 4A shows the kinds of feature that could be separated. Each feature has been discussed in the studies referred to in Sect. 2. Previous HAI studies have researched which kinds of agency are useful.[1] However, we can evaluate each feature simultaneously and separately if we separate agencies. As a result, we can evaluate more precise arrangements of

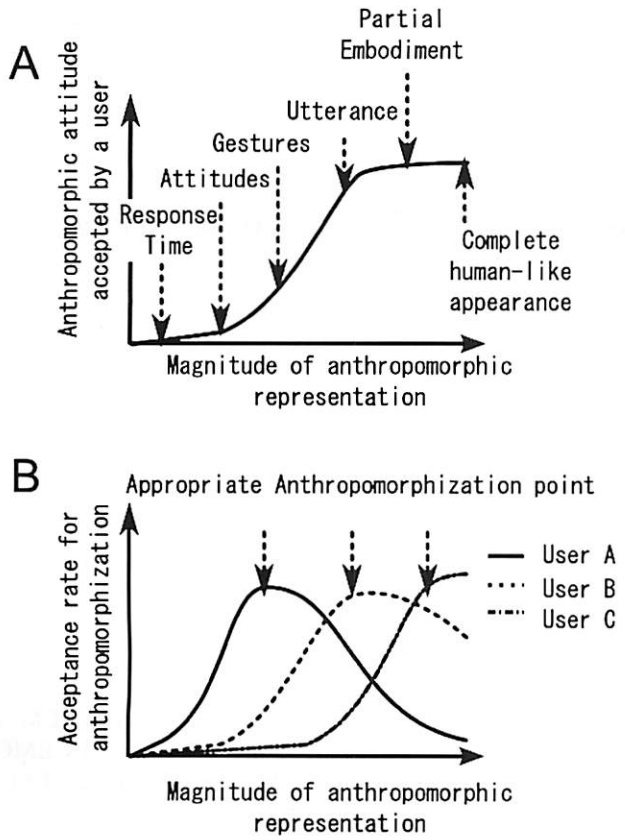

Fig. 4. **A** Separated anthropomorphic elements. **B** Appropriate anthropomorphization for each user

agencies according to the individual users' tendencies and attributes (as in Fig. 4B). Our previous study suggested that female users like anthropomorphic representations more than male users.[15] If a user does not want too much anthropomorphization, we can decrease features to the most appropriate agency for each user. Figure 5 shows implementations of our method. Figure 5A shows a partial embodiment. Eyes and arms are attached to the vacuum because the vacuum requires precise positioning toward the user during cleaning. On the other hand, the microwave oven in Fig. 5B lacks arms or eyes. Instead of aiming for a complex appearance, simple two-axis motors are installed on it in order for the oven to show an attitude; a microwave oven does not require precise positioning.

5 Conclusion

We consider that an agency should have multiple separable features. By making features selectable, we can make suitable designs for virtual agents, robots, machinery, and home appliances according to their function. We categorized agencies by referring to previous studies and considered

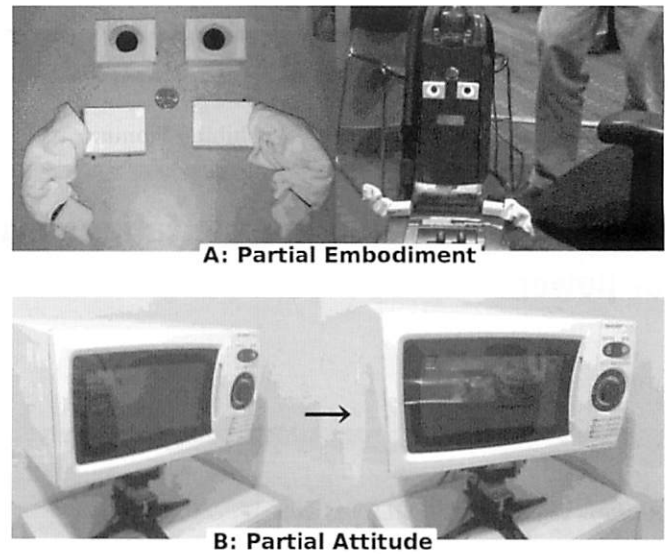

Fig. 5. Partial embodiment and partial attitude

what elements are required. We also discussed a method to identify these features by studying human behavior.

Acknowledgment This work was supported by the JST PRESTO program.

References

1. Yamada S, Kakusho K, Ono T, et al (2008) Designing space between humans and robots (in Japanese)
2. Dennett DC (1987) The intentional stance. MIT Press, Cambridge
3. Tomasello M (1995) Joint attention and social cognition. In: Moore C, Dunham P (eds) Joint attention: its origins and role in development. pp 103–130
4. Darwin C (1872) The expression of the emotions in man and animals
5. Ekman P (1999) Handbook of cognition and emotion. Wiley, New York
6. Levenson RW (1999) The intrapersonal functions of emotion. Cognition Emotion 13:481–504
7. Picard R (1997) Affective computing, MIT Press, Cambridge
8. Morris D (1995) Bodytalk: the meaning of human gestures. Crown
9. Fauconnier G (1995) Mental spaces, MIT Press, Cambridge
10. Liddell S (1996) Spatial representations in discourse: comparing spoken and signed language. Lingua 98:145–167
11. Descartes R (1637) Discourse on the method. http://www.gutenberg.org/ebooks/59
12. Komatsu T, Utsunomiya A, Suzuki K, et al (2005) Experiments toward a mutual adaptive speech interface that adopts the cognitive features humans use for communication and induces and exploits users' adaptation. Int J Hum Comput Interact 18(3):243–268
13. Sonoyama T (2007) Introduction for robot design (in Japanese)
14. Epley N, Waytz A, Cacioppo JT (2007) On seeing human: a three-factor theory of anthropomorphism. Psychol Rev 114(4):864–886
15. Osawa H, Mukai J, Imai M (2007) Display robot. Interaction between humans and anthropomorphized objects. 16th International Symposium on Robot and Human Interactive Communication, Jeju, Korea, vol 16, pp 451–456