Attractive Interface for Human Robot Interaction

Michita Imai  
ATR MI&C Labs.  
2-2, Hikaridai, Seika, Souraku, Kyoto  
619-0288, Japan

Tetsuo Ono  
ATR MI&C Labs.

Tamayuki Etani  
Fujitsu Kansai Communication Systems Ltd.  
2-2-53, Shiromi, Chou-ku, Osaka-City,  
540-0001, Japan

Abstract

This paper describes a human robot interface named the Attractive Interface, which promotes rich encounters between humans and robots. Considering the expected participation of robots in human society, the interface employs not only communication devices like a speech synthesis system but also a mechanism to promote the rich encounters. This key mechanism of the Attractive Interface is an agent migration mechanism that employs a personal CG agent as the interface between a human and a robot. This paper also proposes a robot tour guide system based on the Attractive Interface, and discusses the effect of agent migration.

1 Introduction

In recent years, a number of personal robots [8] or pet robots [9] have been developed to assist humans in daily activities. These developments have enabled humans to interact directly with robots. However, more research not only on robotic control but also on human robot interfaces is required in order to allow personal robots to participate in human society. Along that line, this paper describes a new human robot interface.

An important property of human robot interfaces is to promote rich encounters between humans and robots, because all good relationships in human society can be attributed to how people interact. Also important is the development of dialogue systems or multimodal systems for the robots. However, unless users can be made to successfully encounter robots, they will not use these systems. Therefore, considerations are necessary on encounters between users and robots for robots to participate in human society.

There are several applications [6, 4] that handle encounters between users and robots. For example, the robot in Takeda's research [6] can recognize the user's hand gesture commanding it to proceed toward the user. In this application, it is the user who introduces interaction with the robot by using the gesture. In short, the user brings about the encounter with the robot.

However, a robot must also be able to create an encounter with a user if it is to take the initiative in communications when participating in actual human society. Of course, there is the problem that people will not regard the robot as a partner in communications. This phenomenon has been confirmed in an experiment [7]. In fact, people may be startled by the sudden appearance of the robot, or may frequently ignore the robot. Should this be the case, there will be seldom interaction. Accordingly, to be able to participate in human society, the robot must have a human robot interface that promotes encounters arranged by the robot.

This paper proposes a human robot interface called the Attractive Interface, which enables a robot to attract a user for interaction purposes using a personal CG agent. The personal CG agent can easily migrate from one display to another while maintaining its relationship with the user.

Each user of the Attractive Interface has his/her own personal CG agent and interacts with the agent when using a computer application or a robot. The personal CG agent can migrate from the computer display to the robot's display in order to support the user's activities. We call the mechanism for the migration the agent migration mechanism. Since the personal CG agent obtains familiarity with the user throughout the interaction while the computer application is running, the user is able to begin interaction with the robot naturally when the agent migrates. Such an encounter between the user and the robot is opposite the case the robot suddenly appears in front of the user.

We have developed a tour guide system in our laboratories as an application of the Attractive Interface. The guide system consists of a mobile PC and an autonomous mobile robot.

The rest of this paper is organized as follows. Section 2 describes encounters between users and robots in terms of a robot tour guide system. Section 3 proposes the Attractive Interface and explains how the interface promotes encounters between users and robots with an agent migration mechanism. Section 4 shows an example of a tour guide using the Attractive Interface. We discuss the effect of the agent migration mechanism in Section 5, and conclude the paper in Section 6.

2 Encounter with a Robot

This paper considers encounters between users and robots in terms of a robot tour guide system. A guide robot in a museum must communicate directly with a user. The direct communication shows a contrast between the guide robot and industrial robots, because industrial robots do not need to interact with non-expert users. Burgard [1] has already developed a tour guide robot that can wander in a museum while avoiding obstacles.

In direct communications between users and robots, the robots must be able to develop relationships with
the users. For example, would people follow a robot that suddenly appears in front of them and says “Hi! I’m your guide robot. Please follow me.” The answer is probably No. Most people would likely ignore the guide robot, although they would in all likelihood be curious about it. The robot would have to obtain the chance to develop relationships with the users to have any hope of communicating with them.

To give robots the skill to develop relationships, this paper deals with the question of how robots can attract users to the robots’ guides.

2.1 Tour Guide with a Mobile PC

Before explaining the robot tour guide system, we describe the development of a tour guide system with a mobile PC. The tour guide system [2] was developed for our research exhibition. The system guides visitors through our exhibition based on their preferences.

Figure 1 shows the monitor of the mobile PC for the guide system. There is a personal CG agent (the right side) and a map of our laboratories (the left side). In addition, the monitor displays two icons on the map: one (the small agent) shows the current location of the visitor and the other (the circle) shows the location of a recommended exhibition.

The guide system employs an infrared identification system produced by ELPA Corporation. The infrared system tracks the visitor’s location. The location system is fixed on the ceiling of our laboratories. The location system locates the visitor by reading the ID of a badge attached to the mobile PC. According to the information from the location system, the visitor’s icon on the mobile PC moves on the map of our laboratories.

The guide system recommends a tour route to the visitor. The tour route is generated according to keywords selected by the visitor. The recommended exhibition in Figure 1 shows the next location that he/she should visit based on the generated route.

2.2 Autonomous Mobile Robot

Figure 2 shows the autonomous mobile robot named Pioneer I that we employed for the tour guide system. The left picture shows the rear of Pioneer I and the right picture shows the left side of Pioneer I. Pioneer I in the picture is taller than the original one so users can easily see the monitor. The monitor displays a personal CG agent.

Pioneer I is actually able to move around our laboratories. Pioneer I has several sensors for movement purposes, i.e., ultra sonic sensors for obstacle avoidance, infrared location sensors, encoders, and a compass for the identification of Pioneer I’s location.

Our goal is to develop a new human robot interface where an autonomous mobile robot like Pioneer I develops relationships with users to help the users navigate naturally. In other words, Pioneer I requires relationships with users to make them follow it.

3 Attractive Interface

This paper proposes a new human robot interface named the Attractive Interface, which attracts each user to Pioneer I’s guide. The Attractive Interface employs an agent migration mechanism that makes it easier for the user to develop a relationship with Pioneer I. This paper also describes a tour guide system with the Attractive Interface.

The main idea of the agent migration mechanism is to provide a personal CG agent for each user that migrates from the user’s mobile PC to pioneer I. Since each user becomes familiar with his/her own personal CG agent, he/she can be naturally navigated by Pioneer I according to the migration of the personal CG agent. The personal CG agent in the Attractive Interface is the same as the one shown in Figure 1. The familiarity of a user to the personal CG agent strengthens through interaction on the user’s mobile PC.

Figure 3 shows the overview of the agent migration. The figure indicates that the personal CG agent disappears from the mobile PC and simultaneously migrates to Pioneer I. The principal concept of the migration mechanism is to maintain the interaction with the user.

3.1 Personal CG Agent

The personal CG agent is the virtual CG creature shown in Figure 1. This agent gives the user guide information using its voice and gestures. The guide information is based on the route plan generated with the user’s keywords. For example, the personal CG agent points at the circle (Figure 1) and suggests “there is a recommended exhibition in this room.” In addition, each personal CG agent has its own individual design to enable its user to identify it.
3.2 Structure of the Attractive Interface

Figure 4 shows the structure of the Attractive Interface. The Attractive Interface has an infrared identification system and a search system server which tracks the locations of visitors and Pioneer I. The mobile PC and Pioneer I are connected to our LAN through a wireless LAN.

There are several infrared readers on the ceiling that track the badge attached to the mobile PC and Pioneer I. According to the layout of the readers, our laboratories are divided into several reader sites.

The infrared identification system determines the location of the mobile PC and that of Pioneer I depending on which reader site the badge is in. The search system server collects the location data of the mobile PC and Pioneer I from the infrared identification system. Each terminal (mobile PC or Pioneer I) asks the search system server about the location of the terminals.

3.3 Agent Migration

The personal CG agent has a dynamic structure whose components can be replaced depending on the situation. This dynamic structure enables the personal CG agent to migrate, and to maintain a history of its interaction with the user and the recommended route plan. The dynamic structure consists of the following three software components (Figure 5).

Agent Personality (AP): This mechanism has data on the user and environment, and selects the agent's policy based on the data.

Agent Core (AC): This mechanism generates a sequence of behaviors that depend on the current task and the policy selected by AP.

Agent Shell (AS): This mechanism manages physical resources such as the network, Pioneer I, and the mobile PC.

There are several factors in the selection of the agent policy. More concretely, AP uses the information about the user, knowledge of the external environment, and location data from the search system server. AC gives several units of AS a sequence of behaviors generated based on AP's policy. Each AS unit actually controls the physical resources along with the sequence of behaviors. For example, when AP selects a policy named "navigate", AC generates a path plan to a destination. In addition, if AS is a shell on a mobile PC, AS puts a circle on the map, makes the personal CG agent indicate the circle, and opens a home page about the destination. If AS is a shell on Pioneer I, AS moves it to directly navigate the user.

The agent migration is a change in the combination of these three components. For example, let us look at Pioneer I without a personal CG agent. This Pioneer I has a dummy core as AC. Depending on AC, AS makes Pioneer I wander around our laboratories. However, if AP and AC migrate from the user's mobile PC to Pioneer I, new agent components are generated using the user's AP and AC instead of the dummy core (Figure 5). In addition, if AP and AC migrate from Pioneer I, the dummy core gives Pioneer I's AS a behavior sequence again.

Since the user information accompanies AP and AC, the context of the interaction with the user also migrates to Pioneer I. As a result, Pioneer I can support the user according to the migration knowledge.
3.4 Guide Task

The Attractive Interface guides the user in our laboratories using Pioneer I, the mobile PC, and the personal CG agent. The agent migration mechanism provides the necessary interface between the mobile PC and Pioneer I for the navigation.

The migration of the personal CG agent occurs when the policy of the agent’s AP is “navigate” and Pioneer I is at the user's reader site or at the reader site next to him/her. However, Pioneer I must not have another personal CG agent at the migration. In short, the dummy core must manage Pioneer I when the agent migrates. If another personal CG agent already dominates Pioneer I, the user’s personal CG agent cannot migrate to it.

4 Tour Guide with the Attractive Interface

The tour guide by the Attractive Interface uses the following processes:

1. Login on the mobile PC,
2. Generate a tour route,
3. Navigate by the mobile PC, and
4. Navigate by Pioneer I.

Figure 6 shows the login window of the Attractive Interface. The user must input his/her name, E-mail address, keywords, and a topic at login. After the login, the Attractive Interface generates the AP of the personal CG agent with the information.

AC generates a tour plan because AP selects the policy “planning”. AP has knowledge on the exhibition categories that are divided according to the given keywords. Depending on AP’s knowledge of the user’s keywords and the categories, AC decides the tour route. At this time, the personal CG agent strikes a thinking pose to inform the user that the Attractive Interface is generating a plan.

After the planning, AP selects a policy named “navigate”. Since the personal CG agent is initially on the mobile PC, AC gives the generated path plan to the AS of the mobile PC. The AS of the mobile PC shows a circle as the recommended location, controls the personal CG agent to point out the location, and generates an utterance for the personal CG agent.

When the user moves according to the guidance, the location data on the search system server is updated. As the locations are updated, AC provides the user with explanations of the location, and controls the personal CG agent's explanation by voice and gestures. For example, the personal CG agent says “This is department 1. The research theme is computer vision”, and opens a Web site related to that department. In addition, if the user does not obey the recommended route, AC generates a new guide route.

AC always monitors the same reader site as the mobile PC and the next site to locate Pioneer I. If AC locates Pioneer I, the personal CG agent on the mobile PC communicates with the agent on Pioneer I. AC uses the communication to decide whether the personal CG agent should migrate or not. If the agent on Pioneer I is a dummy core, the personal CG agent migrates to it, and takes over the AS of Pioneer I. If not, the agent does not migrate.

After the migration, AP and AC use Pioneer I’s controller instead of the function of the mobile PC. Therefore, AC guides the user by controlling Pioneer I (Figure 7).

5 Discussion

We discuss the Attractive Interface in terms of an experiment [5] that confirmed the effect of the agent migration mechanism.

The experiment investigated the response of subjects to Pioneer I which suddenly appeared in front of them. In other words, the experiment confirmed whether each subject followed Pioneer I depending on the migration of the personal CG agent.

Figure 8 shows the experimental environment. Each subject was instructed to interact with his/her personal CG agent on a mobile PC at the location shown in Figure 8. In addition, the subject was informed that the purpose of the experiment was to estimate the design of the CG agent, and was not informed of the existence of Pioneer I.

Pioneer I proceeded from the lower side in Figure 8,
and turned back in front of the subject. After the turn, Pioneer I went back to its former position. The migration of the personal CG agent occurred when Pioneer I turned back.

We prepared two conditions in order to examine the effect of the agent migration. One was the condition where the personal CG agent migrated from the subject's mobile PC to Pioneer I. The other was the condition where the agent did not migrate. The number of subjects was 20.

Figure 9, 10 show experimental scenes. Figure 9 is a scene under the condition the personal CG agent migrated to Pioneer I. The subject in the picture followed Pioneer I according to the migration of the personal CG agent.

Figure 10 is a scene under the condition the personal CG agent did not migrate to Pioneer I. Figure 10 shows that the subject was surprised when Pioneer I suddenly appeared in front of her and she ignored Pioneer I.

The result of the experiment was the same as shown in Figure 9, 10. In short, the subjects followed Pioneer I when their personal CG agents migrated to Pioneer I.

As a result, the agent migration helped Pioneer I develop relationships with the subjects. The experiment did not examine the sound effect from the personal CG agent. If the personal CG agent employs speech generation system, however, the effect of the agent migration will become much larger than with only the use of CG.

6 Conclusion
This paper has proposed the Attractive Interface, which employs a personal CG agent. The personal CG agent can migrate between a mobile PC and Pioneer I. The paper has also discussed an agent migration mechanism that gives the interface between the user and Pioneer I.

All users of the Attractive Interface have their own personal CG agents. Since each CG agent migrates from the mobile PC to Pioneer I, the user can naturally follow Pioneer I even though he/she meets it for the first time.

Figure 9: A subject following a robot after her agent migrates to the robot.

Figure 10: A subject judging a robot to be strange when her agent stays in her mobile PC.

We applied the Attractive Interface to a tour guide system in our laboratories. With the agent migration mechanism, the mobile PC and Pioneer I could seamlessly guide users.

This paper has described one aspect of agent migration, i.e., a tour guide system. However, a significant theme involving migration is the development of social relationships between users and robots. Therefore, we would like to tackle the problem of robot sociability in the future.

References


