Speculative Experience based on Internet Technology and Autonomous Robotics

Takashi KUROMIYA Takaya ARITA
Graduate School of Human Informatics, Nagoya University
Furo-cho, Chikusa-ku, Nagoya 464-8601, Japan
E-mail: {kuromiya, ari}@info.human.nagoya-u.ac.jp

Abstract

This paper reports our innovative view on the subject which by proposing the framework of an integrated system based on Internet technology and autonomous robotics, which has been designed in order to remove/minimize the fundamental restrictions on time and space. The basic idea is the realization of consistent agents that conduct themselves as mobile agents in the virtual world and as robotic agents in real world. Each agent, as a kind of a user's "Alter ego", runs around both the virtual world and real world, gathers necessary information and has communication with humans in the real world or other agents in the virtual world. Furthermore, we introduce the novel function of "Speculative Experience" (in the sense that it goes to waste if the user will not want to experience it) into the system in order to reduce our fundamental restrictions on time. Computing resource and robotic resource in the world that are not busy are utilized by this process. Information produced by Speculative Experience is stored in database. A user can experience the past personally in the case that his/her agent experienced the corresponding event in the past and the information was stored in the database.

1 Introduction

The history of technologies might be considered the history of freedom acquisition by human beings. If this view is true, from what are we becoming free thanks to the information technologies that are quintessential of our modern life? We focus on the fundamental restrictions on time and space in this paper. Nowadays the communication through the network brings an innovation to the information transmission, and reduces the restrictions on space to some extent. Our sense of time and space is also varying greatly as the information technology improves exponentially. For example, telephones, portable wireless terminals and Internet are the media that make communication possible beyond the restriction of the distance, and brought an innovation to the information transmission. Our sense of space is changing by using these media. Furthermore, communication realized by information technology can be asynchronous and adaptive. We believe that fusion of advanced information technology could reduce the restrictions on time, which would result in radical change in our sense of time.

This paper reports our innovative view on this subject based on a system paradigm of an integrated system based especially on the Internet and autonomous robotics. The first idea is the realization of consistent agents that conduct themselves as mobile agents when they are in virtual world (Internet) and as robotic agents when they are in real world. Each agent is a kind of a user's "Alter-ego" and passes freely between both worlds gathering necessary information and communicating with humans in real world or other agents in virtual world.

Furthermore, we introduce the novel function of Speculative Experience into the system. This scheme consists of the repetition of Speculative Experience (in the sense that it goes to waste if the user will not want to experience it) by the agents in autonomous mode. The content of the Speculative Experience can be independent of the users' intention. This function utilizes redundancy of computing resources and robotic resources in the world. Information obtained by Speculative Experience is stored in database. Users can experience their past ("Reenacted Experience") in the case that the corresponding events in the past were experienced by their agents and the information was stored in the database. In this context, it can be said that implementation of the function of "Speculative Experience" and "Reenacted Experience" are the challenge to reduce the fundamental restrictions on time.

The rest of the paper describes the central idea of

the system and discusses related issues based on the design and implementation of the minimal system.

2 System Paradigm

2.1 The Alter-ego Agent

We designed first an agent system which reduces the fundamental restrictions on space. In the system, each agent, termed Alter-ego Agent, conducts itself in a user's stead anyplace possible. Alter-ego Agents conduct themselves as software mobile agents when they are in virtual world and as robotic mobile agents when they are in real world (Figure 1). Each agent, as a user's alter-ego, runs around both virtual world and real world, gathers necessary information and has communication with humans in real world or other agents in virtual world. Each agent provides the other agents or humans with enough information of the user when the agent meets them. Therefore, when we meet the robotic agents, we can recognize the users quickly by their appearance and behavior.
Agents are either in autonomous mode or in live mode. Agents conduct themselves in autonomous mode based on the methods of artificial intelligence and artificial life [1]. They are in autonomous mode when they are generated, and users can switch between two modes at any time. In live mode, users can communicate with other humans or the other robotic agents as if they were in real world with them face to face, which is realized by the "Telepresence" [2]. Telepresence is a concept named for the technology that enables a human to have a real time sensation of being at the place other than the place where he/she actually exists. Therefore, users can experience (see, listen, move, manipulate and so on) surrounding environments of their robots and can communicate with the other humans or other robotic agents as if they were in real world face to face (Figure 2). Personal history of the agent behavior and obtained information are stored in the database for the future requests of the corresponding users. In principle, human beings could minimize space constraint by using this system with enough resources of robotic agents connected through the Internet across the globe. The technologies developed in the R-Cube (Real-time Remote Robotics) project [3] can be utilized when implementing the live mode of the robotic agents, though in our study greater emphasis on autonomy of mobile/robotic agents and seamless integration of the virtual and real world by adopting the concept of Alter-ego Agents is placed on.

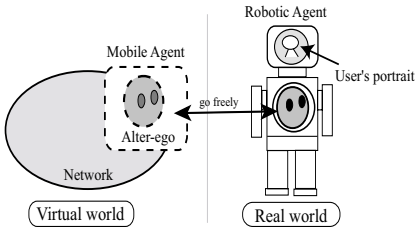

Figure 1: Alter-ego agent.

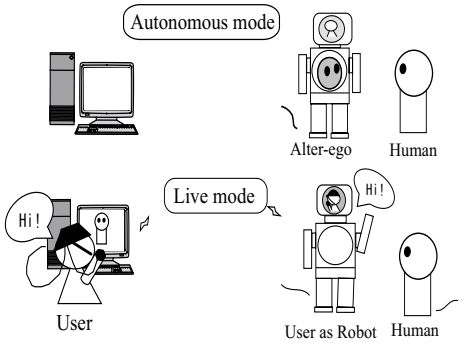

Figure 2: Autonomous mode and live mode.

2.2 Speculative Experience

People of today are conscious of the fundamental restrictions on time imposed on us, and enjoy an imaginary concept of time machines in science fiction novels or movies. However, the history of recording media might be regarded as the steps toward the freedom to go back in time. Suppose that the obtained and recorded information becomes personalized, realistic, and abundant, ultimately. The key idea is implementation of Speculative Experience by the Alter-ego Agents (Figure 3). This scheme consists of the repetition of Speculative Experience (in the sense that it goes to waste if the user will not want to experience it) by the Alter-ego Agents in the autonomous mode. For example, an Alter-ego Agent in a robot might visit a tourist spot, encounter a friend of its user, and have a chat. Basically, the contents of the Speculative Experience are independent of the users' intentions, though the agents take behavioral patterns and preferences of the users. Speculative Experience utilizes redundancy of computing and robotic resources in the world. Information obtained by Speculative Experience is stored in database. Users can experience their past if they want in the case that the corresponding events in the past were experienced by their agents and the information was stored in the database (Figure 4). In other words, the system enables the users to go back in time and to experience the past events in other places person-

ally. It is termed "Reenacted Experience". In this context, it can be said that implementation of the function of "Speculative Experience" and "Reenacted Experience" are the challenge to reduce the fundamental restrictions on time.

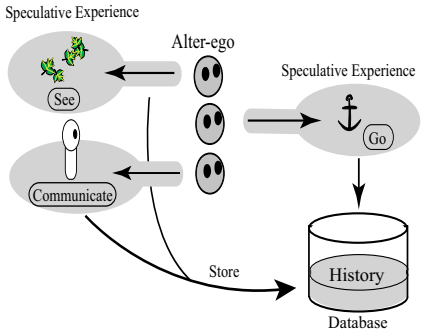

Figure 3: Speculative Experience.

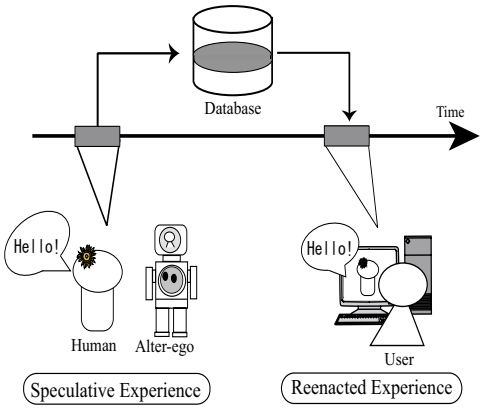

Figure 4: "Going back in time" experience.

3 System Model

3.1 General Organization

Alter-ego Agents in virtual world are implemented based on the mobile agent technique. The system is planned to be worldwide and a large number of people and computers on the Internet are expected to join the system. Alter-ego Agents in real world are implemented based on the autonomous robot technology. Various types of autonomous robots can be registered as an element of the robotic agents. Typically, they are connected to the network by wireless LANs. Users can change the mode of their agents between autonomous mode and live mode at any time. While Alter-ego Agents are not busy, they repeat Speculative Experience using idle resources autonomously.

Table 1: Two types of experience in the system

	Speculative Experience	Reenacted Experience
scape	Alter-ego	user
space	real/virtual	real/virtual
tense	present	past

There are three types of database in the system. The Management Database (MDB) processes information concerning all of the host computers and robotic agents, and is responsible for resource management. Each user has his/her own Experience Database (EDB) in which information obtained by Speculative Experience is stored and a Knowledge Database (KDB) in which information concerning its user's behavior patterns and preference are stored.
It requires careful consideration what kinds of Speculative Experience should be allowed to be conducted by Alter-ego Agents, because information of Speculative Experience is not assured to be accessed by their user, which means that there is a possibility that inconsistency or disadvantage might be produced as is discussed in Section 4.

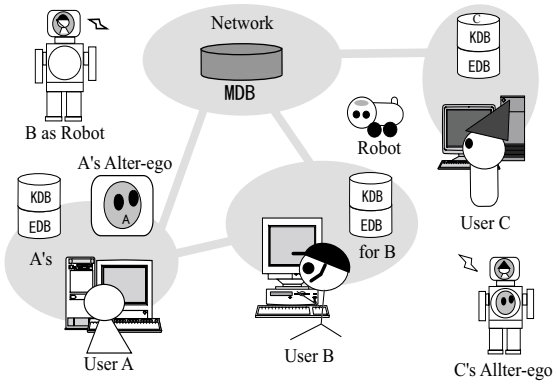

Figure 5: System organization

3.2 Minimum Implementation

We are developing a minimum system embodying above-described system paradigm beyond thought experiments in order to explore the possibility of the system and the technical obstacles to be overcome towards practical application. In the minimum system we develop, the robotic agents are the autonomous mobile robots composed of a modular block robot [1] with a notebook computer equipped with a Wireless LAN module, a camera, a microphone and a speaker on it. While an Alter-ego Agent is in an robotic agent, the

[1] ROBOCUBE: http://www.watt.co.jp/

user's name and facial portrait are displayed on LCD so as to show whose Alter-ego it is. Robotic agents communicate with humans by character representation and keyboard input. They recognize and generate specific verbal messages including the names of registered places. They are equipped with an automatic function of recording movie data when some event happens. EDB stores information including movie files and supplementary data such like date, time and location. MDB stores information including IP address and state of all robotic agents. KDB has limited information in the current system. Suppose a user issues a command "Go to Spot A!". The Alter-ego Agent obtains information about Spot A by accessing KDB, and it looks for an idle robotic agent near the destination by accessing MDB. It moves into the robotic agent, and then moves to the destination physically in real world based on the information of KDB. When the Alter-ego Agent arrives at the desired destination, the agent informs the user of its arrival by E-mail. The user can have a real sensation of being at Spot A, and can interact with the remote environment in live mode. If there is no task assigned to Alter-ego Agents, they repeat Speculative Experience, that is, searching an idle robotic resource, moving into it, going to registered places, communicating with others, and so on. Experience is stored in EDB for later use in Reenacted Experience.

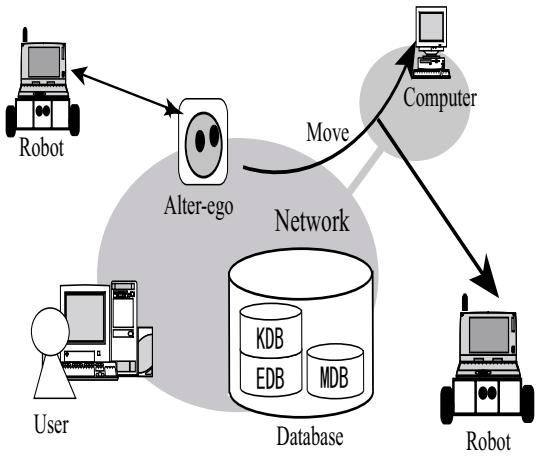

Figure 6: Overview of the minimum system

4 Concluding Remarks

This paper has reported on our efforts to explore the potential of information technology to minimize the fundamental restrictions on time and space. We have proposed a system paradigm based on the concepts of Alter-ego Agents, Speculative Experience and

Figure 7: A robotic agent of the minimum system

Reenacted Experience. One of the most important subjects of the study to be investigated is how much the autonomy of Alter-ego Agents should be allowed. Suppose that an Alter-ego Agent meets a friend of the user and promises to do something. If this promise is against the wishes of the user or if this event will not be gone through by Reenacted Experience after all, bad situations will arise as a matter of course. However, there is no problem, if the promise can be cancelled. As a result, at least following three measures should be adopted when investigating this subject in design and implementation of Speculative Experience.

1) How much will the behavior affect the future?
2) What types of influence will be made by the behavior?
3) How much can the behavior be cancelled?

For example, it would appear that the Alter-ego Agent can do the behavior as Speculative Experience without causing no problems as long as the produced influence is negligible, the influence is good for the user, or the behavior can be cancelled at any time (corresponding to above measures respectively). Our future work includes detailed consideration of this subject as well as implementation of the system.

References

[1] T. Arita, " Artificial Life: A Constructive Approach to the Origin/Evolution of Life, Society, and Language" (in Japanese), Science Press, 2000.

[2] S. Tachi, K. Tanie, K. Komoriya and M. Kaneko, "Tele-existence: Design and Evaluation of a Visual Display with Sensation of Presence", Proceedings of the Fifth Symposium on the Theory and Practice of Robots and Manipulators (RoManSy '84), pp. 245-254, 1984.

[3] S. Tachi, "Real-time Remote Robotics - Toward Networked Tele-existence", IEEE Computer Graphics and Applications, pp. 6-9, 1998.