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THE SENSORY ARCHITECTURE OF VIRTUAL CREATURES

Chang Maiga, Chung Ivory and Heh Jia-Sheng
(*Department of Information and Computer Engineering, Chung Yuan Christian University, Chung Li*)

Abstract Communicative factors among creatures in the real world can be treated as multimedia senses, such as text, image and sound. These communications can be detected by the sensory organs then to accomplish some interactive behaviors in the society. On computer network, it is possible to design a virtual society, in which a lot of virtual creatures with multimedia sensory organs live. This paper studies the communication of virtual creatures and designs their sensory architecture, which improves the practicability of their cooperation through multimedia sensory patterns. Based on the sensory communication of human being, the virtual sensory architecture includes Sensory Register, Sensory Transmitter, Short-Term Memory, Long-Term Memory, Perceptual Analyzer, Knowledge Base and Response Generator. By this design, virtual creatures possess the abilities of human sensory communication to control their interactive behaviors. To prove our idea, a prototype Zoo is implemented as an experimental system, which simulates the behaviors of real animals in real world.

Keywords Virtual creature, sensory organ, multimedia, OLE (Object Linking and Embedding).

虚拟生物的知觉架构

张明治 钟佳伶 贺嘉生
(中原大学资讯工程学系)

摘 要 在真实世界中的生物之间,彼此沟通的方式为使用多种不同的媒体,如文字、影象以及声音.这些媒体可以被感觉器官所侦测到,进而完成社会中的一些互动行为.在电脑网路中去设计一个存在着一些拥有多媒体感官的虚拟生物的虚拟社会是可行的.本文旨在研究虚拟生物之间的沟通方式并设计其知觉架构,藉以增进虚拟生物透过多媒体合作的可行性.以人类知觉沟通的方式为依据,知觉架构的设计可包含七个部分.而根据这个设计,虚拟生物将以与人相同的沟通方式去控制它们之间的互动行为.为了证明该想法,本文给出一个实验系统——Zoo来模拟真实世界中的动物行为.

关键词 虚拟生物,感觉器官,多媒体,OLE.

1 Introduction

Interactive behaviors in a society includes cooperation, coordination and competition, which need communication among the participants[1]. The communicative factors vary from invisible hormones to different media, such as text, images and sound waves. All these factors can be treated as multimedia senses and detected by the sensory organs of the creatures living in the society. On computer network, a virtual society can be designed with virtual creatures living in.

The effective solutions of group cooperation problem have been studied by many scholars[2,3], especially in the area of Computer-Supported Cooperative Work (CSCW). In virtual society, the participants are not only the real persons in the group but also the processes representing virtual creatures. Therefore, the communication problems among processes emerge. The sensory architecture of virtual creatures for communicating multimedia is investigated in this paper.

Based on sociology and psychology, the models of virtual society and virtual creature are described in Section 2. In Section 3, several communication methods will be introduced and the virtual sensory architecture is proposed. Then, the analysis and design for each part of the architecture is studied in Section 4. Finally, Section 5 implements an experimental prototype system Zoo with OLE technology. Section 6 is a conclusion.

2 From Virtual Society to Virtual Creature

For the study of society, many researchers[1] have deeply investigated the structure, the components and in-between interactive social behaviors, including cooperation, coordination and competition. On the other hand, a complete CSCW system which concurrently provides participants more than one utilities (cooperating processes in computers), such as white board and audio phone, will include many interactive relationships, not only between users and computers but also among processes[4]. These interactions in CSCW systems are similar to those in a real society; therefore, it is possible to simulate a *virtual society* on a computer network for accomplishing a general-purpose CSCW system model.

A real society is composed of members, groups and group leaders, so is a virtual society. For the purpose of cooperation, group members always proceed some communication to achieve their common goals[5]. When transferred to computer network, the cooperation methods make two basic models of virtual society: centralized and distributed models[6]. The former model originates from the client-server model , in which a virtual society is constructed on a specific server and then each client joins this society through a network connection. Whereas, Figure 1 describes the distributed architecture of virtual society, which is proposed based on sociology of real society[4].

In addition to members, groups and group leaders, a society should still contain several other factors, including person, structure, resource, coordination and goal[7]. Among these elements, "person" is the one that is emphasized here, although other elements are also indispensable. "Person" indicates not only the participants of society but those creatures in the society. For virtual society, these virtual creatures are always implemented by some special processes, called *agents* in general[8].

The role that an agent plays is similar to the above meaning of "person"[9]. There are many types of agents, such as communication agent, listener agent and interface agent. In spite of the versatility of agents, some regular works done by almost all the agents can still be listed:[10]

- to make the responsibility clear.
- to define the relationships among agents based on the actions taken by users.
- to generate some results to affect others or the environment.

Furthermore, virtual creature is one kind of agents which involve a set of sensory organs, therefore it needs to do two additional works:

- to recognize (feel) the surrounding world with its perceptual sensors.
- to communicate with other virtual creatures by means of multimedia sensory patterns.

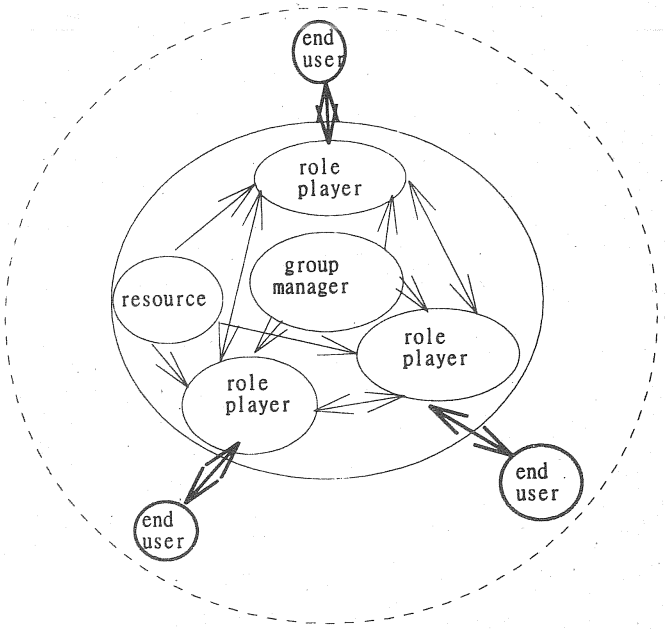


Figure 1 The architecture of virtual society.

Figure 2 illustrates a model of virtual person whose perceptual sensors prove the above proposed analysis[9].

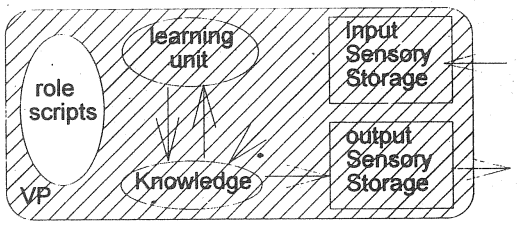


Figure 2 Virtual person model.

Although the model of virtual person has included sensory storage to perceive multimedia sensory patterns, its description of virtual sensor is not detailed enough. Besides the above virtual person, another example of ant world and its creatures, called ants and queens, has been investigated[8]. The virtual ants live in the virtual world, and communicate with each other by using a special endocrine, which can be detected (smelt) by all these creatures. These ants not only can "smell" the endocrine in the environment, but also can "see" the position of food. Therefore, these perceptual sensors seems to be an integrated mechanism, and to be an agency of communication.

3 Virtual Sensory Architecture of Virtual Creatures

Notwithstanding the independent working ability of agents, the more important thing is how they can work together with each other. However, different agents are created by different designers with different methods, which make agents heterogeneous. These difficulties of agent communication give the cooperation problem of agents, which is widely studied by many researchers[8,9,11].

Take the previous ant world as an example. Each race of virtual ants has several specific endocrines as its communication media, and an ant will send some information to others through some kinds of endocrines. In another exemplary system, Oz project[11], this communication style is quite different. In Oz project, a leader of virtual world, called Lyotard, interacts with other persons by using some fixed function calls. However, no matter which communication method is chosen for the dialogue among agents, there are still some disadvantages[12].

The communication process among agents is very like to that among people. When a person talk with another, his/her brain will perceive and analyze a large amount of information. It is mentioned by some cognitive psychologists that these stimuli given by the environment will be perceived and then transferred in a sequential order. After the stimuli go through the transformation process, they will form a meaningful structure, which is called "internal representations"[13]. And the reflection shown by a person is due to the internal representation transformed from the input stimuli. Hence, the reason why there are different cognitive responses for the same thing is that there are different internal representations formed from the same stimuli.

The processing of external phenomena that converts input stimuli into the internal representation is described as follows. When external physical energy is detected by the sensory organs of human being, this energy will be transduced and briefly held in the sensory storage. And then this energy will be processed and transferred to memory systems (short-term memory or long-term memory) for further processing, whose results can initiate an appropriate response for external stimulus.

In the above conversion process, the sensory model plays an important role and is deeply investigated in literature[14]. As shown in Figure 3, the sensorymodel is composed of four parts:

- **Sensory Storage**: to perceive any stimulus sent from the virtual world and then to convert the stimulus to neural energy.
- **Short-Term Memory**: to deal with immediate events, and to forget something imper-

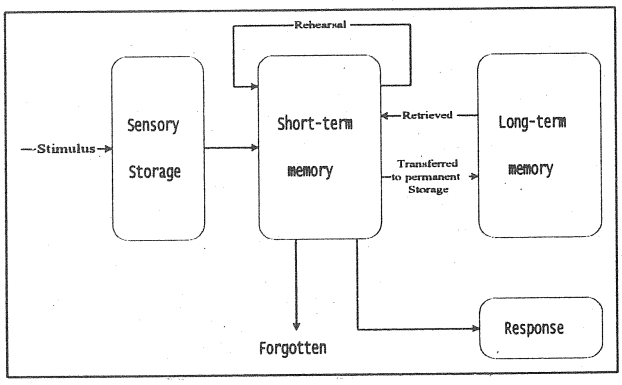


Figure 3　Sensory model of human being.

manently.

·**Long-Term Memory**: as contrasted with short-term memory, long-term memory deals with permanent, indestructible vestiges of experience.

·**Response Generator**: to generate appropriate reflections for the current stimulus input.

According to the sensory model described, *the virtual sensory architecture* of virtual creature can be proposed. In previous researches, there has been a functional model of interacting system[15]. In this model, a text is transmitted into a signal of this system; for example, the word "S" is transformed into the signal "blip, blip, blip". Then the receptor of another system will get this signal and store it to derive the semantics. Finally an appropriate T-message will be created and transmitted as the reflection.

For virtual creature, this paper proposes a more general virtual sensory architecture, which is consistent with the analysis of cognitive psychology. The proposed architecture allows virtual creature to communicate with not only text or signals, but also multimedia sensory patterns, such as images or sounds. The overall mechanism of virtual sensory architecture is shown in Figure 4, including sensory register, short-term memory, long-term memory, sensory transmitter, perceptual analyzer, knowledge base and response generator. All these components are explained as the following.

·**Sensory Register**: to detect virtual energy (virtual senses) in the virtual world in which the virtual creatures lives.

·**Sensory Transmitter**: to convert virtual energy to neural energy or other forms of energy and to store the converted energy in short-term memory.

·**Short-Term Memory**: to store the temporary sensory patterns that are transferred from the sensory transmitter.

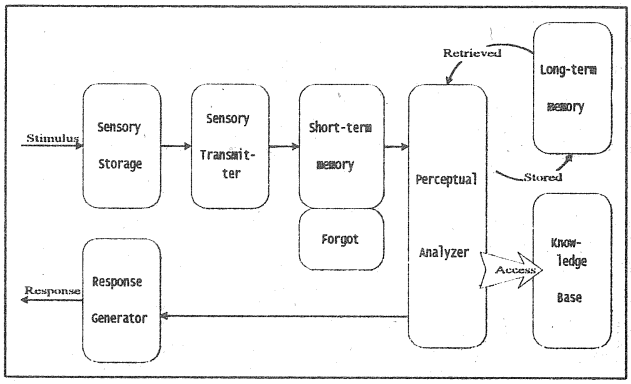


Figure 4 Virtual sensory architecture.

·**Long-Term Memory**: a storage for indestructible vestiges of experience.

·**Perceptual Analyzer**: to process all internal representations by use of knowledge base and to generate the corresponding results.

·**Knowledge Base**: to help perceptual analyzer make decisions and generate correct results.

·**Response Generator**: to get the result analyzed by the perceptual analyzer and to generate an appropriate reflection.

4 Design of Virtual Sensory Architecture

Based on the theory of cognitive psychology, the general virtual sensory architecture of virtual creature has been constructed. However, this virtual creature is not a fictitious character, rather a real living creature in virtual society, the computer network. Thence, this

virtual sensory architecture has to be implemented by nowaday computer techniques, which are illustrated in this section.

In this virtual sensory architecture, *Sensory Register* is the most important part, because it controls the timing for the virtual creature to get the senses transmitted from other virtual creatures. It is difficult to maintain a correct timing among virtual creatures. To solve this problem, this paper gives *The Third Party method*, where the environment (the third party) is proposed with the ability of catching all of the sensory behaviors and dispatching these senses into appropriate receiver. On computer network, this method can be easily implemented with IPC (Interprocess communication) technique.

The task of *Sensory Transmitter* is just to transform the multimedia senses obtained by Sensory Register into another kind of sensory patterns, also called internal representation here. This internal representation can be recognized then decoded by Perceptual Analyzer. In computer science, there are several transformation methods, for example Neural Network, which can be used to translate the physical energy into neural energy.

As mentioned above, *Short-Term Memory* turns out to be a buffer used as a storage of some temporary multimedia sensory patterns. As time goes, those temporary patterns which is out-of-date should be forgotten, unless they appear later and are renewed in this memory. Take vision as an example. Whenever we "see" several irrelevant images, those appeared earlier will be forgotten first. Many cognitive psychologists even thought that only four or five letters of unconnected matter can be gathered by human being at the same time. Following the principle of Short-Term Memory, this buffer is built by FIFO (first-in-first-out) mechanism, with fixed refreshing time and fixed buffer size.

Similar to Short-Term Memory, *Long-Term Memory* is the storage for saving permanent multimedia sensory patterns. In addition to the storing function, Long-Term Memory can also allow Perceptual Analyzer to retrieve the stored multimedia information. Compared to Short-Term Memory, Long-Term Memory possesses unlimited sizes in varied multimedia databases, each of which is used for storing different types of sensory patterns.

As the task it takes, *Perceptual Analyzer* can be treated as the core of virtual sensory architecture. It receives the neural energy, i. e. multimedia sensory patterns, sent from Sensory Transmitter, and chooses some appropriate processing methods. These multimedia sensory patterns can be stored and retrieved in Long-Term Memory at any time. The simplest processing method to decode the neural energy is to follow the rules in Knowledge Base. The *Knowledge Base* is used for supporting Perceptual Analyzer to make correct decisions. Some script languages can be used to construct such a Knowledge Base.

Finally, the above appropriate reflection is just as another sensory patterns or actions, which are generated by *Response Generator*. And these reflections, of course, vary with the rule chosen by Perceptual Analyzer from Knowledge Base. Like Sensory Register, Reflection Generator will send all of the appropriate actions to the third party (environment), who will decide which creature(s) should be the next receiver.

5 Experimental System

To demonstrate the practicability of virtual sensory architecture, a prototype system *Zoo* is designed. In Zoo, an environment is constructed with two species of virtual creatures, *lion* and *rabbit*. Naturally, when a rabbit "sees" a lion in its dangerous vicinity, the rabbit should run away. On the contrary, as a lion "sees" any rabbit, it will treat this rabbit as food and go rabbitting.

When considering the implementation of this prototype system, we choose the most popular platform, Microsoft Windows System. The possible techniques of MS-Windows for this prototype are discussed as follows.

- **Sensory Register**: DLL (Dynamic Data Linkage) is possible for implementing the third party method.
- **Long-Term Memory**: The current database management system in MS-Windows, Microsoft Access, can be used to store the multimedia sensory patterns, and be manipulated through the ODBC (Open DataBase Connectivity) mechanism.
- **Sensory Transmitter**: Any simple pattern matching method can work.
- **Perceptual Analyzer**: Decision tree method can be used to make this component easier, but poorer, obviously.
- **Response Generator**: Besides DLL technique, Windows Socket can be chosen for the transmission between sensory register in virtual creature and environment.

In spite of possibly implementing the prototype with DLL, ODBC and Windows Socket techniques, it is much more suitable to establish the overall system with Microsoft OLE (Object Linking and Embedding) technique. With COM (Component Object Model), OLE technique makes possible data-transferring among multiple clients and multiple servers, which is unattainable by other IPC techniques, such as DLL, global memory, named pipe and socket. There are at least two advantages of using COM to transfer data. Firstly, the transferred data might be of any forms, such as sound wave, text, image and even animation, which should be of different complex forms if they are transmitted by Window Socket. Secondly, many techniques except OLE are maladjusted in different computer environments; for examples, global memory can not be used in Windows 32-bit environment and DDE (Dynamic Data Exchange) is usually too hard for programming.

Consequently, OLE client-server framework is selected as the technology of achieving the multimedia communication between environment and Response Generator (or Sensory Register). The implementation with *OLE Automation Server and Controller* may be easier than that with *OLE Client and Server*. An *OLE Automation Controller* can introduce more than one *OLE Automation Server*, and then control and communicate with them simultaneously. With this mechanism of OLE controller, the tasks of virtual environment can be appropriately integrated.

A real prototype system , Zoo, is built on IBM Compatible Personal Computers to prove

the idea of virtual sensory architecture. The software platform is Microsoft Windows 3.1/95, which can support many features of IPC technologies, such as Windows Socket, DLL, DDE and OLE. To complete every part of the prototype system, the software development environment of Microsoft Visual C++ is chosen.

In this prototype system, the environment will create two rabbits first, and as they "see" each other, they will come close. After a few minutes a lion will be sent in by the environment. And the lion goes rabbitting if it catches sight of the rabbits. All the actions of these virtual creatures and the multimedia senses will be transferred through the environment. The snapshots of the experimental system are shown in Figures 5 and 6.

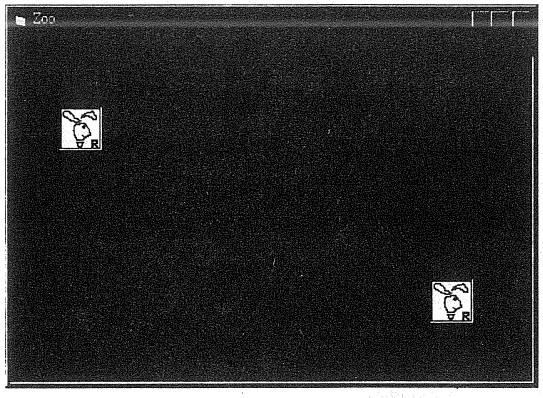


Figure 5　Snapshot 1: two rabbits.

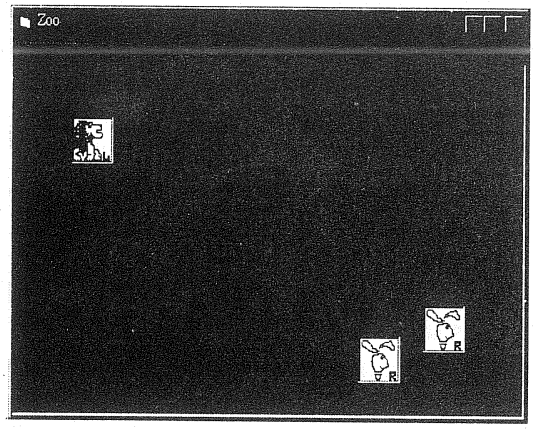


Figure 6　Snapshot 2: one lion joins.

6 Conclusion

The cooperation in virtual society occurs not only among real users and computers but among virtual creatures. This paper studies the communication of virtual creatures and designs their sensory architecture, which improves the practicability of their cooperation through multimedia sensory patterns. The research focuses on applying the human sensory communication to the creatures living in virtual society, and controlling their behaviors and actions by the perceptual sensors. For proving the concept of the virtual sensors, a prototype Zoo is implemented as an experimental system. This experimental system is built on low-cost PC and to simulate the behaviors of real animals in real world.

In the near future, the virtual sensory architecture will be integrated with distributed communication, neural network and machine learning to construct more useful and powerful virtual creatures to work and cooperate in virtual society. Meanwhile, a multimedia database will be used to establish Long-Term Memory.

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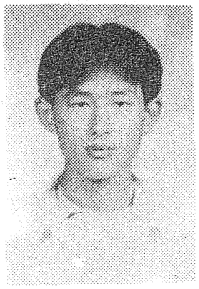
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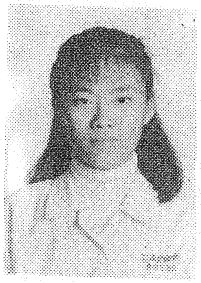
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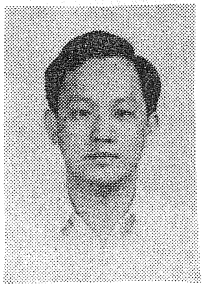
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Chang Maiga (张明治) is now a graduate student of Institute of Information and Computer Engineering, Chung Yuan Christian University.



Chung Ivory (钟佳伶) is now a college student of Department of Information and Computer Engineering, Chung Yuan Christian University.



Heh Jia-Sheng (贺嘉生) is an associate professor of Institute of Information and Computer Engineering, Chung Yuan Christian University. He received his Ph. D. degree from Institute of Electrical Engineering, National Taiwan University in 1991. His present research area includes multimedia communication system, computer-supported cooperative system, social learning system and neural network.