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Design of Cognitive Memory for Autonomous Virtual Characters Based on Information of Visual Sensing

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Abstract

When gamers interactively play with such agents, they lose their interest and feel that the agents are unfriendly and unrealistic. In this paper, we present a cognitive memory model for autonomous virtual agents, which manages recognized information by visual attention. Virtual agents assume adaptive actions for the situation by utilizing the stored information in the memory system. To effectively utilize memory capacity, we devise an algorithm of rapid visual attention, which is well suited to game environment. We have implemented our memory system experimentally in order to confirm its feasibility and availability. From the experiments, we confirm that autonomous virtual agents perceive the static and dynamic objects of a 3D virtual world by a visual attention mechanism with approximately 1.6 times improvement in time complexity; further, the virtual agents utilize the information of memory, searches the target object, and establishes a path plan.

Keywords: Autonomous virtual agent, Artificial intelligence, Synthetic vision, Attention, 3D game

1 Introduction

Today, the importance of autonomous virtual agents in the field of animation has increased considerably [1]. Thus far, most autonomous virtual agents have used programmed information and have always performed their functions according to established information and rules in a virtual environment. Further, if autonomous virtual agents perform their functions in accordance with the programmed information, they can properly handle given situations. In order to solve such problems, many studies have been conducted to develop new autonomous virtual agents that are capable of handling new situations by recognizing new information and saving and learning it on their own. In this paper, such an autonomous virtual

agent that autonomously recognizes virtual environments and saves the recognized information is referred to as AVA (Sensible Autonomous Virtual agent).

A considerable amount of information on the recognized environment is saved in the memory of virtual agents. Thus far, numerous studies have been performed on the memory systems of autonomous virtual agents [2-6]. Conventional studies on such memory systems have focused on simple storage functions that will provide necessary information to the agents to help them perform functions based on the programmed information [2-4][7][9]. Further, if a large amount of information has to be processed on a realtime basis, for example, in a game environment, efficient management of resources is essential. In addition, necessary information should be provided to make the virtual agents realistic. In other words, it is necessary to conduct integrated studies on the storage structure, management, and usage techniques of the information stored in a memory system.

This paper is structured as follows: Chapter 2 introduces related research papers. In Chapter 3, the overall design and visual attention algorithm of autonomous virtual agents are described. Chapter 4 states the structure and algorithm of the memory structure of autonomous virtual agents. In Chapter 5, the results of the implementation and the performance of the algorithm suggested in this paper are comparatively analyzed. Lastly, Chapter 6 describes the conclusion and future research directions

2 Related Researches

Autonomous virtual agents recognize information through a visual system and save it in their memory system [6-8]. Conventional studies on the memory system of autonomous virtual agents have recently evolved into an analysis of recognition memory and search functions as well as of simple information storage [9][10]. Such studies can be divided into two types—studies on memory from cognitive psychology and studies on memory systems and structures. Furthermore, the studies on memory from cognitive psychology can be divided into two models—the Atkinson-Shiffrin memory model [11] and Tulving memory model. The Atkinson-Shiffrin memory model can be divided into three stages by applying stage theory—sensory memory, short-term memory, and long-term memory. Further, each recognized information is separately stored in each memory module. Thus far, many studies have been conducted on the gradual storage and management of information that has been perceived after applying the Atkinson-Shiffrin and Tulving memory models to the memory system of autonomous virtual agents [9]. Kuffner investigated a method of finding a quick path in a 3D virtual environment wherein virtual agents dynamically change using visual and memory systems [7][8]. In his paper, Kuffner used a record storage method in which a direction vector is included to memorize the recognized objects through artificial vision. C. Peters studied autonomous virtual agents that had visual perception under the assumption that humans in a virtual environment would perceive external stimuli through comprehensive visual systems [10]. The virtual agents perceive and store their environment using both visual and memory systems. Each memory system stores information on the perceived objects according to the

different memory module stages in the filtering process. The data are then stored using the data record method. If attributes that are clearly distinguishable from other objects are stored, fast information search can be possible on the basis of the memory theory of cognitive psychology [11]. In the case when the first witnessed environment is remembered visually, such distinguishable attributes are information on the status and location of space. Thalmann attempted to investigate the agentistics of the visual memory of cognitive psychology using an octree method for the memory data structure of virtual agents. In this case, the information perceived through a visual system is stored in the octree. The objects in 3D space are stored in an octree data structure. Information can then be searched and learned on the basis of the database. Conde expanded the detection system into multi-detection functions, which include hearing, touch, and vision, on the basis of Thalmann's study. In this paper, the storage memory structure and management technique of information that has been perceived through artificial vision is proposed. For efficient management of the memory of autonomous virtual agents, virtual environment information should be properly filtered and stored. Furthermore, a storage structure that is capable of searching and storing information quickly and information expression methods are designed.

3 Designed and Visual Attention Algorithm of Sensible Autonomous Virtual Agent(AVA)

3.1 Architecture of AVA

The AVA structure consists of a visual attention system, memory system, cognitive system, learning system, planning system, and behavior system based on the basic functions of autonomous virtual agents.

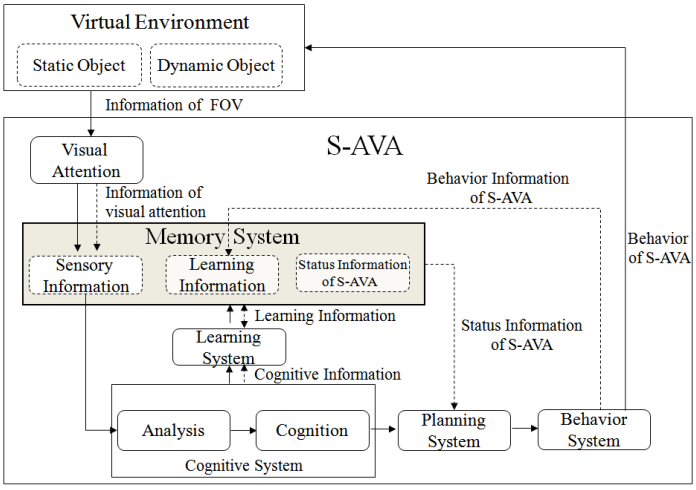

Fig 1. Architecture of AVA based of Memory System

In the planning system, the action with top priority is chosen, and an action plan that can optimize an action is prepared. In an behavior system, the action planned

by AVA is expressed in animation in a 3D virtual environment. The memory system stores and manages the perceived information. The information stored in the memory mostly consists of information on virtual environment, learned information, and internal information on the agents.

Among the six systems, this paper investigates the visual attention system and memory system. Other systems will be used in designing the visual attention and memory systems if necessary.

3.2 AVA Memory Functions using the Visual Attention Model

To calculate the visual attention in a visual attention algorithm, an operation that creates a map summarizing color, brightness, and motion agentistics is performed. First, each map is created through three extracted filters against R/G, B/Y, and Bk/W according to the opponent-process theory of color vision. Then, a map of color agentistics is created through an integrated module of color agentistics. Using Equations (1) and (2), the following channels (r, g, b, and y) are created.

$$r = R–(G+B)/2, \quad g =(R+B)/2 \tag{1}$$

$$b= B–(R+G)/2, \quad y=R+G–2(|R–G|+2) \tag{2}$$

The parameters (r, g, b, and y) created through the equations represent red, blue, green, and yellow channels, respectively. Using these channels (r, g, b, and y) as shown in Equation (3) below. F1 according to the “red/green” color opponent and F2 according to the “blue/yellow’” color opponent are created as follows:

$$F1 = r/g \text{ , } F2 = \quad b/y \tag{3}$$

In color agentistics, “Bk/W” refers to the brightness of an image. This information is also used in creating F3, as shown in Equation (4) below:

$$F3 = (R+G+B)/3 \tag{4}$$

It is assumed that input images have no tremble in a motion map model. By using an image differencing model, the range of tremble is discovered, as given in Equation (5) below:

$$F4 = F3(t)–F3(t–1) \tag{5}$$

F3: Frame images stored, t: Time measured

After integrating color, brightness, and motion maps, as shown in Equation (6), a single saliency map (S) is created.

$$S(\text{Saliency Map}) = (F1+F2+F3+F4)/4 \tag{6}$$

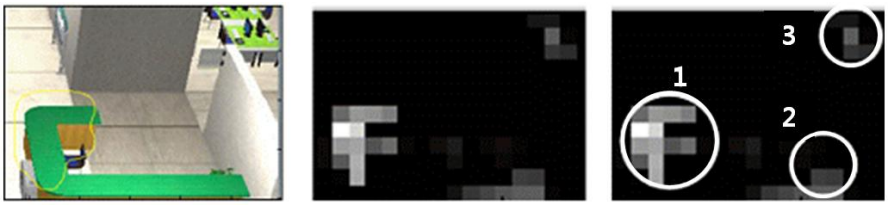

Fig 2. Object sensing and saving order

Fig. 2 illustrates a saliency object sampling process after applying visual attention algorithm to a library; this represents the experimental environment in this paper. After creating a saliency map

4 Memory Architecture of AVA

4.1 Structure of AVA Memory System

The structure of the AVA memory system consists of three processors (memory processor, short-term memory manager, and long-term memory manager) and a single cognitive memory. Fig. 3 shows the AVA memory model.

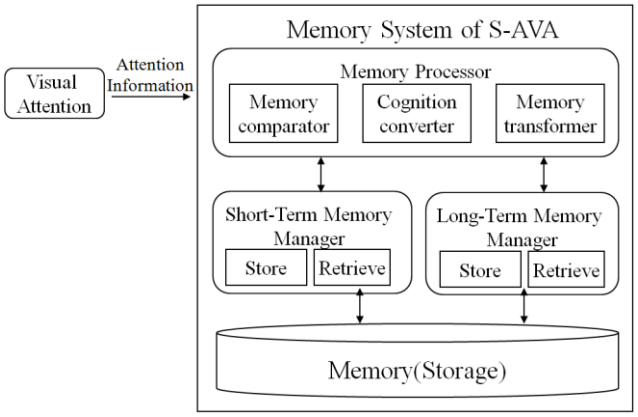

Fig 3. Memory structure of AVA

A memory processor processes the information that is memorized until the information observed by AVA is stored in the cognitive memory. This memory processor consists of a memory comparator, cognition converter, and memory transformer. A memory comparator examines whether the acquired information is the first observed object. If it is the first observed object, it is stored in the cognitive memory through a short-term memory manager. If it is not the first observed object, the changed attributes are only updated. By using such a discernment function, wastage of system resources as a result of data redundancy can be reduced.

A short-term memory manager stores short-term memory data; it consists of a

reservoir and explorer. The former stores the perceived information in memory devices while the latter examines if the selected object is the first observed object and locates the target object.

A long-term memory manager stores long-term memory data. Its inner structure is the same as the short-term memory manager. The process is repeated more than twice, and then the observed data are stored.

The data that have passed through short-term and long-term memory managers are stored in the cognitive memory. The cognitive memory is configured with visual memory in which the attributes of objects, such as location and shape, are stored.

4.2 Structure of AVA Visual Memory Storage

1) Definition and Agentistics of Basic Structure

This paper expresses 3D spatial information by combing quad-tree and graph structure into the storage structure of AVA visual memory. Even though the quad-tree can quickly locate a position, only 2D data are stored. The objects that exist in the height data and space of saliency objects are expressed by connecting graphs with the Y-axis.

In a quad-tree node, the existence or non-existence of data is stored in a sub-tree. The actual data are directly stored in a graph node. Fig. 4 shows a conceptual diagram of the storage structure system. The storage of space information is illustrated using tree and graph areas. The virtual environment ‘P’ can be divided into equal quadrants (D1, D2, D3, and D4). By connecting graph nodes with the Y-axis, as shown in Fig. 4, the objects that exist in the height data and space can be expressed.

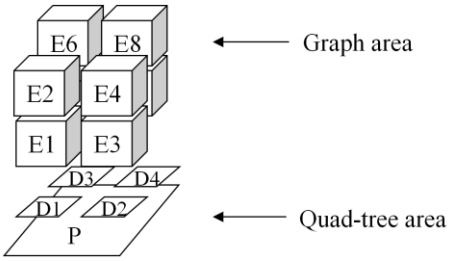

Fig 4. Conceptual diagram of the storage structure system

2) Object Expression

If objects exist in a virtual environment, the quad-tree node information becomes “1,” and two columns of graphs are connected to express the height values of the objects. The detailed attributes of the objects are stored in the graph nodes.

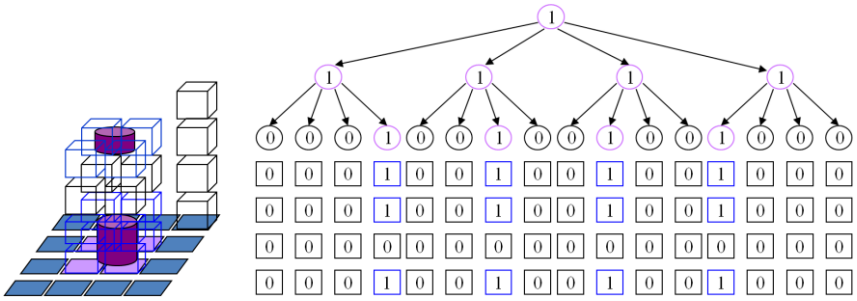

Fig 5. Quad-graph storage structure of objects in virtual world

3) Storage and Implementation of Object Information Attributes

The attribute information of objects is stored in the graph nodes that are connected to the quad-tree. The object information is expressed in totally 8 fields, which include 1 pointer and 7 attributes. The actual information such as the location, size, and time of objects are stored in graph nodes, as shown in Fig. 6. The number of node attributes is variable and expandable depending on the set functions and according to the virtual environment in which AVA would be used and the type of information to be stored.

5 Experiment and Performance Analysis

This paper tests whether the objects sampled from an actual 3D virtual environment through visual attention are correctly stored in the AVA memory, and whether the stored memory information is available. In the test, the objects in a virtual environment are perceived and stored after creating a 3D library virtual environment system, and the application of the proposed memory model to AVA is examined. The test system is then configured using Direct X and G-blender with an Intel Pentium DualCore 2 1.86GHZ CPU (3.2 G, Geforce 7900GS, 256 MB).

In this section, whether the object information perceived by the AVA through a visual attention module is sent to the memory by sequence or not is examined. In order to test the AVA memory functions proposed in this paper, a saliency map that tests the AVA visual attention module theory is established in advance as pre-processing.

Fig 6. AVA's obtained saliency map

In the obtained saliency map, the objects are observed and stored in the order of brightness, as shown in the saliency map window in Fig. 6. In terms of memory size, record structures (the storage structure of conventional games and AI agent information), octree, and quad-graph must be compared. However, the storage structures of Thalmann's octree and quad-graph are based only on humans' visual memory structure.

6 Results and Discussion

In this paper, memory system models that store and manage information perceived through the visual attention of AVA has been proposed; further, its implementation is described.

A fast visual attention algorithm that is optimal in a game environment was designed for the efficient use of limited memory sizes. The information observed by AVA was stored after proposing a new storage algorithm that combine graph with quad-tree. Such a storage structure was designed to memorize the information detected by AVA on a realtime basis in a dynamically changing 3D virtual environment. As a result, the information search cost is reduced. According to the tests conducted based on the design method proposed in this paper, AVA quickly searched the target objects using the stored memory information and established a path plan. In terms of performance, the processing speed improved by more than 1.6 times after a map with the agentistics that would elicit maximum attention from AVA was configured.

References

[1] Korea Game Industry Agency Press, A game white paper-2008 Korea, Korea Game Industry Agency, 2008.

[2] X. Tu and D. Terzopoulos, "Artificial fishes: Physics, locomotion, perception, behavior," In A. Glassner, editor, Proc. SIGGRAPH '94, Computer Graphics Proceedings, Annual Conference Series, ACM SIGGRAPH, ACM Press, pp. 43-50. July 1994.

[3] S. Chopra and N. Badler. "Where to look? Automating attending behaviors of virtual human agents," In Autonomous Agents and Multi-Agent Systems, Vol.4(1/2), pp. 9-23, 2001.

[4] B. Blumberg, M. Downie, Y. Ivanov, M. Berlin, M. P. Johnson and B. Tomlinson, "Integrated Learning for Interactive Synthetic Agents," 2002 ACM Transactions on Graphics (TOG), Vol.21, No.3, pp. 417-426, 2002.

[5] B. Blumberg, R. Burke, D. Isla, M. Downie and Y. Ivanov, "Creature smarts: the art and architecture of a virtual brain," In Proc. Game Developers Conference, pp. 147-166, 2000.

[6] D. Isla and B. Blumberg, "Object Persistence for Synthetic Agents," In the Proceedings of the First International Joint Conference on Autonomous Agents and Multiagent Systems, AAMAS 2002, pp. 1356-1363, 2002

[7] J.J. Kuffner, "Autonomous Agents for Real-time Animation," PhD thesis, Computer Science Dept., Stanford University, Stanford, CA, December, 1999.

[8] J.J. Kuffner and J.C. Latombe, "Fast synthetic vision, memory, and learning models for virtual humans," In Proc. CA '99:IEEE Int'l Conf. on Computer Animation, pp. 118-127, Geneva, Switzerland, May 1999.

[9] D. Thalmann, "A vision based approach to behavioral animation Human Factors," In Visualization Research Melanie Tory and Torsten Moller IEEE Transactions on Visualization and Computer Graphics, Vol.10, No.1, January/February, 2004.

[10] C. Peters and C. O' Sullivan, "Synthetic Vision and Memory for Autonomous Virtual Humans," 1Image Synthesis Group, Department of Computer Science, Trinity College, Dublin 2, Republic of Ireland submitted to COMPUTER GRAPHICS Forum (9/2002).ACM, pp. 1-9, 2002.

[11] J. R. Anderson, Cognitive psychology and its implications, W.H. Freeman and Company, New York, 1995.