A CONCEPTUAL FRAMEWORK FOR INTERACTIVE VIRTUAL STORYTELLING

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Abstract. This paper presents a framework of an interactive storytelling system. It can integrate five components: management centre, evaluation centre, intelligent virtual agent, intelligent virtual environment, and users, making possible interactive solutions where the communication among these components is conducted in a rational and intelligent way. Environment plays an important role in providing heuristic information for agents through communicating with the management centre. The main idea is based on the principle of heuristic guiding of the behaviour of intelligent agents for guaranteeing the unexpectedness and consistent themes.

1. Introduction

Research in interactive storytelling has attracted substantial interests over the last few years, due to progress in the integration of artificial intelligence techniques and graphic environments, driven by potential applications in entertainment. Fairly amount of approaches and techniques have been proposed for building virtual agents, storyline and Character-based, interactive systems to ensure a consistent and engaging storyline (Jean-Claude 2004, M 2002, M 2003, W 2001, K 1998, Hayes-Roth 1995, Rickel 1999, D 2003). But more interaction and cooperation in a high level are needed to create a more unexpected story with coherence. In this paper, we present a framework of the conceptual design of an interactive system consisting of five components as shown in Fig.1. Interactions among these components involve more complex interactive narratives and cooperation through its evaluation component. Actions to be performed by intelligent agents are based on various interactive factors evaluated by the evaluation centre. In order to design such a system, a couple of issues should be considered:

1) How does the system allow the user to heuristically guide the development of the plot?
2) How to communicate among the user, the virtual agent, virtual environment? How does the environment receive information and how does the intelligent agent get information from the environment (Tatiana, 2004)?
3) What is the relationship among the intelligent agent, the intelligent environment and the user (Michael, 1995)?

4) How does the agent make its decisions based on its previous experiences (Cedric 2003)?

2. Architecture Design

The architecture of the system shown in figure 1 contains five components: the user, evaluation centre, management centre, intelligent virtual agent, and intelligent virtual environment.

- The user is a real human being, who can create and authorise the virtual environment, virtual human being (Avatar) and their interaction with each other. The user can be a director, or can play a role of a character in a story as well as a spectator.
- The evaluation centre is an information exchange system which controls the behaviour of intelligent agent and the environment based on the Management Centre.
- The intelligent environment is made up of virtual geometric models and associated environmental agents.
- Management Centre acts as the key role in high-level interaction. It computes the communicating messages among other components.
- A virtual human agent contains a human geometric model and multiple-layered intelligence such as motion, emotion, personality etc. All of these components share information or messages with each other and work together towards the scheduled objectives.

A three-level interaction will be involved in the proposed system: low-level, medium-level, and high-level. At the low-level, the user can input instructions for plot without being evaluated by Evaluation Centre. The virtual intelligent agent just implements the instructions without any intelligence involved. The instructions can be input by keyboard, mouse, microphone, data gloves and other equipments. At the medium-level and high-level, the evaluation centre will play a decisive role in motivating intelligence of the intelligent virtual environment and intelligent virtual agents. The user will manipulate objects and change the scene in the virtual environment heuristically only through the evaluation centre. That is, at medium-level and high-level, there will be intelligent communication among the user, intelligent virtual environment, and intelligent virtual agents. All interactive messages will be evaluated by evaluation centre. Even messages from the user, will be weighted and then sent to the intelligent virtual agents. Messages will be weighted based on the role of character to ensure the consistence of characters and the storyline.

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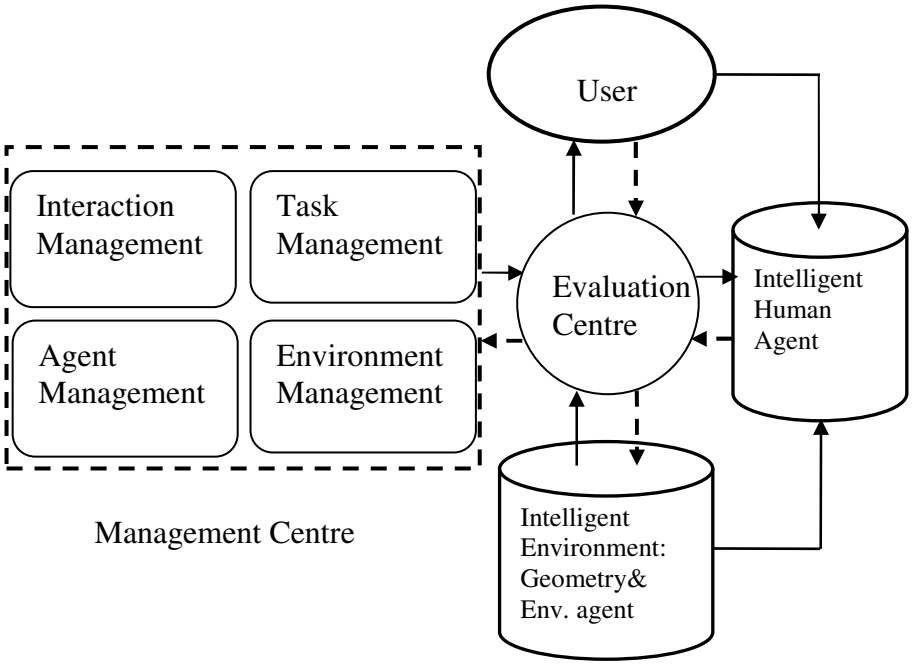

Figure1. Relation Diagram of the System

2.1 USER

User plays a central role in creating new applications. User here can be referred to the director of the storytelling, as well as a system operator such as environmental builders, and virtual human creators. The user is able to interact with the system at two levels. The user can also have a role as an avatar in the virtual environment such as a football coach, and directly interfere with the unfolding of the storyline. For example, the avatar representing the user can participate in a scenario to add or remove some objects, which will increase the unexpectedness of the plot. But the avatar has no ability to kidnap other agents or stop other agents' action directly.

2.2 EVALUATION CENTRE

The evaluation centre shown in figure 2 is an information exchange system which controls the behaviour of intelligent agent and the environment based on the Management Centre. It receives and sends messages to the intelligent agent and environment after computing all the information. Messages from the intelligent agent and environment will be weighted differently, which

means that the influences on the final decision will be different according to varied factors of messages. The evaluation centre is composed of several layers (Fig.2), which carry various weights used to calculate and compare messages. The action made by the intelligent virtual agent is based on the information from evaluation centre, which is a result after considering the five factors (corresponding to five layers) as in Fig. 2.

Emotion layer includes two aspects: emotion and personality. Personality is composed of curiosity, fatigue, and so on (Badler 1997). Emotions play an extremely important role in human mental life. Emotional state may influence decision-making, actions, memory, attention, voluntary muscles and so on, which, conversely, may have an impact on emotional state of the intelligent virtual agent. Emotions will arise from the evaluation of the relationship between environmental events and human agent. Then emotions will have an impact on the physical expressions of emotional state which is manifested by gestures, body languages and natural language (Marsella 2001, Fiedler 2000). Emotion evaluation will improve the believability and may increase the suspense of the storyline. The consistence of the storyline is concerned closely with the emotional state of intelligent virtual agents. So, a bigger weight will add to the emotion layer. Motion layer is used for controlling the motion of agnets. Reasoning layer will apply some reasoning analysis based on previous knowledge. Target layer will provide target analysis. For example, it can provide information on rule-searching though sub-target. Location layer may get the location information of the virtual agents in real time, which makes the intelligent virtual environment more recognisable.

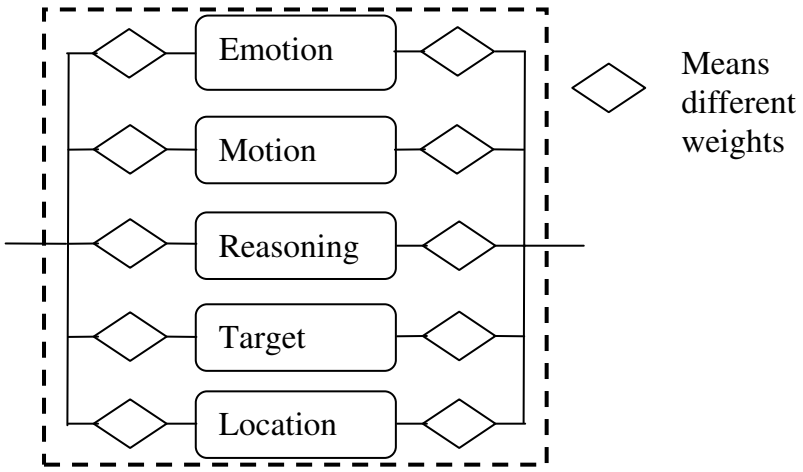

Figure 2. Diagram of Evaluation Centre

Messages are exchanged through Evaluation Centre, which will analyse and parse all messages and then send them to different components. Decisions made in Evaluation Centre are classified into three levels: low-level, medium-level and high-level. Numerous conditions are considered and organised in a tree structure. Three branches representing the three levels of decision originate from the root. And then lots of branches come out from these three branches. Different positions on the tree structure mean different weights. When a fact occurs, the system will calculate the weight on the correspondent branch or joint. If the system can not find the correspondent description on the structured tree, the reasoning layer will give some solutions based on previous experiences, the personality and emotion of the intelligent virtual agent and information from the intelligent virtual environment.

Generally, virtual agents are controlled based on pre-programmed scripts, which do not give much flexibility to the character to interact with the unanticipated context. In the proposed framework, some high level personalized behaviour will be created, which may make the story more unexpected. However the high-level behaviour is partially based on some pre-programmed scripts, so, the ability of the intelligent virtual agent is also limited in some degree, which is one of the challenges.

Actually, even a low-level decision will have a large amount of data transmission. To make the system more efficient, we think the low-level decision can involve less evaluation layers according to different purposes, which can go through less analytical computing (Please see table 1).

TABLE 1. Layer Involvement for 3 Level Decisions

Layer / Level	**Emotion**	**Motion**	**Reasoning**	**Target**	**Location**
Low-level Decision	No	Yes	No	No	No
Medium-level Decision	No	Yes	No	Yes	Yes
High-level Decision	Yes	Yes	Yes	Yes	Yes

2.3 MANAGEMENT CENTRE

Management Centre makes the basic part of the intelligence of the Intelligent Environment consisting of four modules, which are used to store and

manage all the information of this system. Environment Management is responsible for the information about the environment which is dynamic and updated with the development of the storyline. Environment Management plays a very important role in guiding virtual agents. Some guiding rules are pre-programmed in advance for directing virtual agents in various ways. However, what is more important is that these rules can be updated with the interaction between the intelligent virtual environment and intelligent virtual agents. This will guide intelligent virtual agents going through the dynamic terrain and with rational controlled behaviour. Obviously, finding the right path and updating the interactive information are challenges for this system. That is, both of intelligent virtual environment and intelligent virtual agents may have some abilities to learn from the interaction.

Agent Management controls the dataset of the continuously changing intelligent agent. Task Management provides the information of all tasks needed to be carried out in the story with a well structured planning. Interaction Management contains a high level communication system. It has a priority to communicate with the Evaluation Centre when a new fact appeared or interaction from the user. Experiences and heuristic values are remembered by the Interaction Management component.

As is mentioned above, intelligent virtual agents have the ability to learn from the interaction with the intelligent virtual environment. Three-level behaviours are designed for intelligent virtual agents: low, Medium, and high level behaviours. The low level behaviour is concerned with daily life. With the interaction with the intelligent virtual environment, intelligent virtual agents can behaviour according to the pre-programmed rules. For example, intelligent virtual agents can recognise a door, knob, right side of the way, and some daily commodities like cup, table and computer. Medium level just involves three factors. The high level behaviour is related to the personality and emotion of intelligent virtual agents. For example, whether the intelligent virtual agent would like to answer a phone call when he is watching TV depends on his emotional state at that moment, which is nothing to do with the low level action like how to pick up the phone before a decision is made. An analyser will receive from Evaluation Centre or send messages to it. Every management component has high-level, medium-level low-level management and analyser sub-components (see figure 3). The high level management, medium and low level management should not be separated from each other. They have to work together to finish a behaviour sometimes.

Emotional status, personality, physical condition et al will be involved when heuristic value is calculated for the intelligent agent to carry out a task. Some exploring work has been done by (Smith 1998, Marc 2002). When an

action is made, this action information will be sent back to the Agent Management module of the Management Centre.

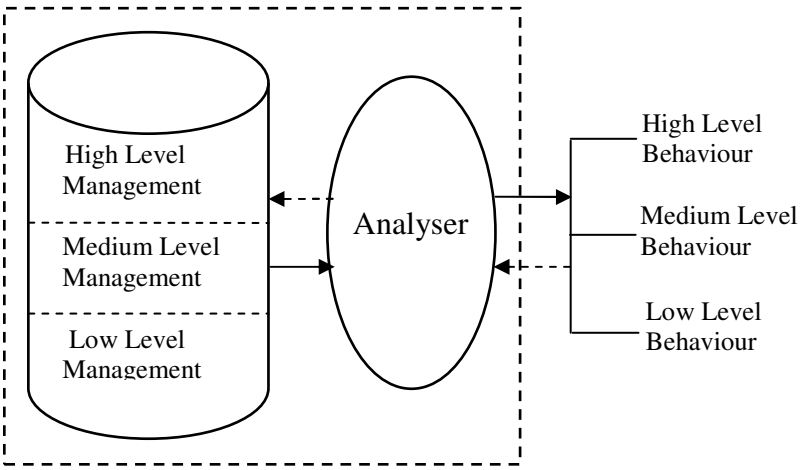

Figure 3. Diagram of Management Component

2.4 INTELLIGENT ENVIRONMENT

Intelligent virtual environment is the virtual platform for agents in it. Like the intelligent agent, intelligent virtual environment also has some properties: a realistic appearance, intelligence which is the ability to provide information for the agent to perceive and the ability to locate objects in it.

We regard the intelligent environment as a dynamic system, which provides numerous amount of information for the intelligent agent. In real word, human beings have the ability to adjust their behaviours according to the information they obtained from the environment. For example, people are able to perceive the distance between themselves and a wall or barrier to avoid danger or bumping into it.

Much research has been carried out in recent years (Plumert 2004, Jodie 2005).The reaction of a virtual human being in a virtual world can go through the same principle with people in real world. But we think the mechanism can be different, which means that the virtual environment may carry some information itself being perceived by the intelligent agent. With the ability to collect information from the environment, the intelligent agent is able to evaluate the environment and adjust its behaviour according to the pre-concerted task without too much tedious interference by the user.

2.5 AGENT

Intelligent virtual Agent is the representative of virtual human which possesses some necessary properties: a realistic geometrical appearance, deformable structure and skin, and intelligence: perception and action. Perception is the ability to perceive the environment information and exchange messages with the Management Centre. Action ability means that it can have motion behaviours according to the messages from the Evaluation Centre. The behaviour of the intelligent virtual agent must be believable, which includes at least two aspects: one is about the action of the intelligent virtual agent and the other is concerned with the interaction of virtual agent with the intelligent virtual environment and other intelligent virtual agents. The behaviour and emotion of the intelligent virtual agent can be influenced by the intelligent virtual environment and the interaction related to them. As we mentioned above, those kind of interaction put forward a challenge for the intelligent virtual environment.

Realistic body modelling requires an accurate geometric surface during the simulation. A lot of artistical and technical skills are required during the procedure of modelling, even some powerful approaches available in current software such as 3DS MAX and Maya. However, even with the software, it is still difficult to generate and edit high-level body shape. An alternative way is to develop a generic parametric model so that the body shape can be carried out via a set of parameters. The complete shape of the human body can be kept as low as possible but give users the flexibility of changing the shape with more choice in the size of various parts of the geometry model. Much research has been done about body modelling (Allen 2002, Kry et al. 2002, Sand 2003, Seo 2004, Blanz, 1999). These methodologies are all focus on the geometrical appearance without any semantic categories. In a sense, some high-level body can be generated bearing some personal and emotional information.

To create a high-level behaviour, the movement of the intelligent virtual agent should be coincident with the emotional state, which requires a high-level animation technology. Nowadays, motion capture is gaining popularity as a source of motion data. Compared with model-based approach, the animations created by motion capture system contain the subtle movement details recorded from a human actor. But for some interactive movement like grasping a cup or a knob of a door, it becomes difficult. We believe a better way of creating appropriate movement is to a self-control system for the intelligent virtual agent. There is much exploring research (Reynolds 1987, Terzopolous 1994, Kevin 2006). The idea is inspired by the principle of movement of a robot in the real world. What we think is much of the information that motivates the intelligent virtual agent to generate a proper movement is from the intelligent virtual environment. The advantage is with

the changing of the environment, the intelligent virtual agent can be very adaptive. The development of this animation technique remains one of the big challenges for researchers.

2.6 RELATIONSHIPS

Generally, the relationship between the intelligent agent and the user is simple as the intelligent agents just receive commands from the user. In storytelling, agents as the characters of interactions are deeply intertwined with the plot. The character directly influences the agent's behaviour which in turn contributes directly to an unfolding plot. So, the hierarchical relations ignoring the intelligent agent's reaction to their environment will fail to present a high level story. More interaction should be carried out among the user, the intelligent virtual environment and intelligent virtual agents. Maybe, interactivity is becoming of the most factors in creating a high-level virtual storytelling.

To improve the interactivity in the intelligent virtual environment, the relationship this proposed system between the user and the intelligent agent will have more cooperation instead of hierarchical commands. Intelligent virtual agents may obtain more information from the intelligent virtual environment, which in a sense increases the realism of the interactivity and behaviour of intelligent virtual agents. The user's interaction will be evaluated by the Evaluation Centre to compare with the corresponding objective, personality and so on. That is, the user will never be omniscient to absolutely control the intelligent environment and the intelligent agent management in real time when the plot and structure of the story are well planned. In the Evaluation Centre, empathy (Ana 2004) is an important element to influence the final action, endowing the empathy a high weight to make it more influential than other factors. Along with other layers, the emotion layer will make the storyline consistent, with the actions and events in a natural and rational manner.

3. Conclusions

We have briefly described a conceptual design of an interactive storytelling system with five integrated components. Co-operations are carried out among the intelligent agent, the user and the intelligent environment with the empathy introduced as important criteria. The architecture allows a strong autonomy of the characters by establishing a special communication mechanism using management centre and evaluation centre. Environment is created with intelligent properties used for involved agents to sense the information around them, which contributes to the consistent storyline and

emotion state of intelligent agents. The behavioural control depends on the cooperation of all the components allowing a natural and attractive plot. Since interaction between agents and related characters is one of the main difficult tasks, our framework is expected to provide an alternative exploration for this work.

Reference

Allen B., Curless B., Popovic Z., "Articulated body deformation from range scan data", Proceedings SIGGRAPH 2002, pp.612 – 619, Addison-Wesley, 2002.

Ana Paiva, Joao Dias, Daniel Sobral. Ruth Aylett, Polly Sobreperez. Sarah Woods. Carsten Zoll. Lynne Hall. Caring for Agents and Agents that Care: Building Empathic Relations with Synthetic Agents. *Proceedings of the Third International Joint Conference on Autonomous Agents and Multiagent Systems* - Volume 1 New York, New York 2004 Pages: 194 - 201

Badler, N. I., Reich, B. D., and Webber, B. L. (1997). Towards personalities for animated agents with reactive and planning behaviors. In Trappl, R. and Petta, P., editors, *Creating Personalities for Synthetic Actors*, pages 43–57. Springer-Verlag.

Blanz, V., and Vetter, T. 1999. A morphable model for the synthesis of 3D faces. In Proceedings of ACM SIGGRAPH 99, ACM Press/Addison-Wesley Publishing Co., New York, A. Rockwood, Ed., Computer Graphics Proceedings, Annual Conference Series, 187.194.

Brian Magerko, John Laird: 2002. Towards Building an Interactive, Scenario-based Training Simulator. In *Proceedings of the 10th Computer Generated Forces and Behavior Representation Conference* , Orlando, FL.

Cedric Buche, Ronan Querrec, Pierre De Loor, Pierre Chevaillier. .MASCARET: pedagogical multi-agents systems for virtual environment for training. *Proceedings of the 2003 International Conference on Cyberworlds (CW'03). Singapore. 2003*

D. Christian and R. M. Young , "Comparing Cognitive and Computational Models of Narrative Structure", *Liquid Narrative Technical Report TR03-001*, North Carolina State University, 2003.

Fiedler, K. & Bless, H. (2000). The interface of affective and cognitive processes. In Frijda, Manstead & Bem (eds.), Emotions and Beliefs. Cambridge University Press.

Hayes-Roth, B., Brownston, L., & van Gent, R. (1995). Multiagent collaboration in directed improvisation. In *Proceedings of the 1st International Conference on MultiAgent Systems*, San Francisco, CA, 1995.

Hayes-Roth, B., van Gent, R. and Huber, D.. Acting in character. In R. Trappl and P. Petta (Eds.), *Creating Personalities for Synthetic Actors*. Berlin, New York: Springer. 1997

A CONCEPTUAL FRAMEWORK FOR INTERACTIVE VIRTUAL STORYTELLING

Jean-Claude Heudin: 2004, Evolutionary Virtual Agent. *Proceedings of the IEEE/WIC/ACM International Conference on Intelligent Agent Technology.*

Jodie M. Plumert, Josephk. Kearney, James F. cremer, and Kara Recker. Distance Perception in Real and Virtual Environments. *ACM Transactions on Applied Perception*, Vol. 2, No. 3, July 2005, Pages 216–233.

Jonathan Steuer: 1992. Defining Virtual Reality: Dimensions Determining Telepresence. *Journal of Communication*, 42 (4): 73-93.

K Dautenhahn : 1998, Story-Telling in Virtual Environments, *Working Notes: Intelligent Virtual Environments, Workshop at the 13th Biennial European Conference on Artificial Intelligence* (ECAI-98), Brighton, UK.

Kevin G. Der RobertW. Sumner† Jovan Popovic. 2006. Inverse Kinematics for Reduced Deformable Models In *Proceedings of ACM SIGGRAPH 2006*, Annual Conference Series

Kry, P. G., James, D. L., and Pai, D. K. 2002. Eigenskin: Real time large deformation character skinning in hardware. In ACM SIGGRAPH Symposium on Computer Animation, 153.160.

Loyall, A.B. and Bates, J. Personality-Rich Believable Agents That Use Language. *Proceedings of the First International Conference on Autonomous Agents*, February 1997, Marina del Rey, California.

Marc Cavazza, Fred Charles, Steven J. Mead. Interacting with Virtual Characters in Interactive Storytelling. *Proceedings of the first international joint conference on Autonomous agents and multiagent systems*: part 1 Bologna, Italy, 2002, Pages 318 -325

Marsella, S., & Gratch, J. (2001). Modeling the interplay of plans and emotions in multi-agent simulations. Paper presented at the Cognitive Science Society, Edinburough, Scotland.

Michael. Wooldridge and N.R. Jenings. Intelligent agent: Theory and practice. *The Knowledge Engineering Review*, 10(2): 115-152, 1995.

M. Mateas and A. Stern: 2002, A Behavior Language for Story-based Believable Agents, *IEEE Intelligent Systems*, 17(4).

M. O. Riedl, C. J. Saretto, R. M. Young, "Managing interaction between users and agents in a multiagent storytelling environment", *Second ACM Joint Conference on Autonomous Agents and Multi-Agent Systems*, AAMAS 2003: pp. 741-748

Plumert, J. M., Kearney, J.K., and Cremer, J.F: 2004, Children's perception of gap affordances: Bicycling across traffic-filled intersections in an immersive virtual environment. *Child Development, 75*, 1243–1253.

Reynolds, C. Flocks Herds and Schools: A Distributed behavioural model. *Proc. SIGGRAPH '87*, Computer Graphics 21(4) 25-34 1987

Rickel, J. & Johnson, W.L: 1999, Animated agents for procedural training in virtual reality: perception, cognition, and motor control. *Applied Artificial Intelligence*, 13.

P. Sand, L. McMillan, J. Popovic. Continuous capture of skin deformation**.** ACM Transactions on Graphics (TOG) Volume 22 , Issue 3 (July 2003) Special issue: Proceedings of ACM SIGGRAPH 2003

Seo H, Magnenat-Thalmann N. An example-based approach to human body manipulation. Graph Models 2004;66(1):1–23.

Sgorous, N. M: 1999, Dynamic generation, management, and resolution of interactive plots. *Artificial Intelligence* 107: 29-62.

Smith, S.J.J., Nau, D.S., and Throop, T: 1998, Computer Bridge: A Big Win for AI Planning. *AI Magazine*, 19(2):93-105.

Stern, A. Frank, A. and Resner, B: 1998, Virtual Petz. A hybrid approach to creating autonomous, lifelike Dogz and Catz. In *Proceedings of the Second International Conference on Autonomous Agents*, 334-335. Menlo Park, Calif.: AAAI Press

Tatiana A. Tavares1, Samue A. Oliveira, Anne Canuto, Luiz M. Goncalves, Guido S. Filho1:2004, .An infrastructure for providing communication among users of virtual cultural spaces. Proceedings of the WebMedia & LA-Web 2004 Joint Conference 10th Brazilian Symposium on Multimedia and the Web 2nd Latin American Web Congress.

Terzopolous, D; Tu, X. & Grzeszczuk, R. Artificial fishes: Autonomous, Locomotion, Perception, Behavior, and Learning in a simulated physical world, Artificial Life 1(4) 327-351, 1994

W. Swartout, R. Hill, J. Gratch, W.L. Johnson, C. Kyriakakis, C. LaBore,, R. Lindheim, S. Marsella., D. Miraglia, B. Moore, J. Morie, J. Rickel, M. Thiebaux, L. Tuch., R. Whitney and J. Douglas: 2001, Toward the Holodeck: Integrating Graphics, Sound, Character and Story, *in Proceedings of the Autonomous Agents 2001 Conference*.