IAGENT: A REAL TIME INTELLIGENT AGENT ANIMATION TOOLKIT

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ABSTRACT

This paper describes the design and implementation of IAgent: a real time intelligent agent animation toolkit on a PC platform. The animation system consists of 5 main components, namely environment, perception, behaviours, motion generator and rendering. The intelligent agent in the system is represented as a 3D human-like avatar that has a complex underlying structure with multiple degrees of freedom (DOFs). The agent relies on a fast virtual perception system to capture information from its environment and a behaviours system to determine what actions should be taken. A novel motion generation architecture and animation blending system have been developed to produce non-repetitive behaviours for the intelligent agent based on its momentary goal, internal and emotional states. The proposed system has been implemented in DirectX. Experiments have been carried out using the toolkit and the results have clearly demonstrated that the method produces convincing real time behaviours for a 3D virtual human agent.

INTRODUCTION

Today software titles demand ‘smarter’ participants in the simulated virtual world. For instance, in the entertainment industry like PC games, the Non-Player-Characters (NPCs) controlled by the computer are expected to exhibit convincing behaviours in respond to dynamic change of the environment and human player’s activities. The major problem for characters in those real time applications is that the character often performs its motion in the same way resulting in repetitive and unrealistic behaviours. Furthermore, the creation of human like virtual intelligent agent for real time applications presents even more challenges due to the complex underlying structure of the character. The main objective of this paper is therefore to design and implement an innovative intelligent agent animation system that integrates research efforts from several fields, notably computer graphics and animation and artificial intelligence, to animate a complex and realistic human like virtual agent in a 3D environment on a PC platform.

The virtual agent has a complicated underlying hierarchical skeleton for producing real time motion according to its perception from environment and behaviours module. The final rendering of the agent is implemented by using the skinned mesh algorithm to achieve smooth skin deformation effect. The proposed animation system has the mechanism to dynamically generate realistic agent’s motions based on a hybrid method that combines parameterized motions, kinematics and animation blending.

Section 2 describes the design of the animation system and its major functional components. Section 3 briefly illustrates the implementation and a simple animation example. Section 4 finally draws conclusions.

THE ANIMATION SYSTEM

The animation system is divided into 5 main components, namely environments, perception, behaviours, motion generator and rendering module. Figure 1 shows high-level functional architecture of the framework.

The *virtual environment* normally contains geometrical objects, sound objects, and events. Geometrical objects refer to 3D objects with vertices and texture maps, which are detectable by the agent’s virtual vision. In a complex virtual environment containing large number of 3D objects, spatial partition techniques are useful to arrange these objects in some kinds of hierarchy that accelerate the agent’s objects detecting process (Mehdi et al. 2002). Geometrical objects are normally “seen” by the agent with additional properties being memorized such as the location of the object, time of being detected, ID of the object etc. Sound objects in the environment can be detected by the agent’s virtual audition sensor, subsequently affecting the agent’s behaviours.

The environment contains another special object called events. Events can generally be divided into two categories, namely functional events and dynamics events. Functional events can be considered as the “built-in” behaviours of the objects and they can be triggered by under some conditions. For instance, a door in a scene can be opened or closed by the agent. Dynamics event is generally generated in related to agent’s activities. This type of event will have significant impact on the agent’s emotional state, which will subsequently affect the agent’s behaviours or the way the agent execute its behaviours. For instance, the result of an agent’s attempt to capture some objects will cause agent become happier or angrier. One of the novelties of the proposed animation system is that it has the mechanism to visualize the subtle change of agent’s emotional states via its animated behaviours.

The *Behaviours module* contains several key functional components to perform action selection for the agent, namely decision-making, emotion, personality, memory, and internal states. The decision-making component relies on a hierarchical action network to select actions for agent according to its perceptual information, internal states, memory and goals. Emotion plays an important role in creating believable agent behaviours (Bates 1994; Blumberg 1994). Psychological and neuroscience research indicates that emotions have a significant impact on human behaviours, both through their use as a non-verbal communication channel such as gesture, posture, facial expression and so on (Oatley and Johnson-Laird 1987). It is therefore important to incorporate emotion into our

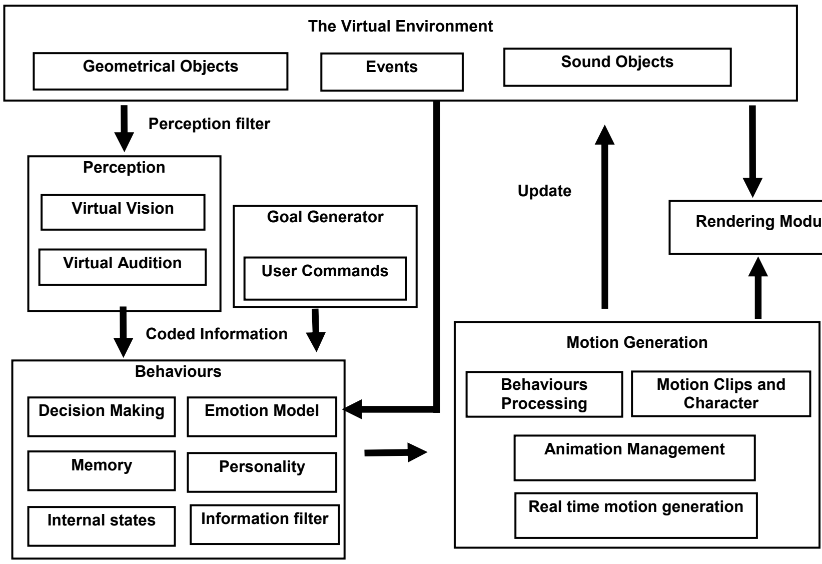


Figure 1 Architecture of animation system

animation system. Emotion model in the system is based on the OCC model (Ortony et al.1998). The OCC model specifies how events, agents and objects are appraised according to respectively their desirability, praiseworthiness and appealingness, which are defined by a set of parameters such as goals and attitudes. The process of integrating OCC model into agent behaviours can be divided into 4 steps, namely classification, quantification, interaction, and mapping (Bartneck 2002).

It is believed that personality and emotion have significant influences on behaviours and how behaviours are expressed (Marsella and Gratch 2002; Ball and Breese 1998). Different personality model has been studied in the psychology community such as the OCEAN model (Costa and McCrae 1992). This model has five dimensions, namely openness, conscientiousness, extraversion, agreeableness, and neuroticism. The link between personality and OCC emotion model is described in (Egges et al. 2004). Their idea is essentially to construct a *Personality-Emotion Influence Matrix*, in which indicates how each personality factor influences each emotion. A simple emotion update equation as proposed in (Egges et al. 2004) is therefore used in the animation system.

$$e_{t+1} = e_t + \alpha(p,\omega_t,a) + \beta(p,\omega_t)$$

Function $\alpha(p,\omega_t,a)$ is to calculate the changes of the emotional state based on personality p, emotional state history ω_t, and emotion influence a from OCC model. $\beta(p,\omega_t)$ is calculate the decay of emotional sates based on personality and emotional state history.

Emotion in the developed animation system is primarily used to decide how the selected behaviours will be executed depending on agent's momentary emotional states, which is realized by the *Motion Generation module* described in the following contexts (Figure 2).

The *Motion Generation module* decomposes those behaviours into low-level motions with control parameters that can be realized by the motion clips library. The *Motion Coordinator*, upon receiving motions with parameters, retrieves base motions from the motion clips library and joints from the character skeleton that are required to perform the motions. Base motions are primarily produced by motion interpolation. On top of these base motions, parameterized motions are generated based on outputs from the *Emotion to Motion Module*. Such outputs are normally motion control parameters that are used to alter the way the base motions are animated or parameters to change the posture of the agent. All these

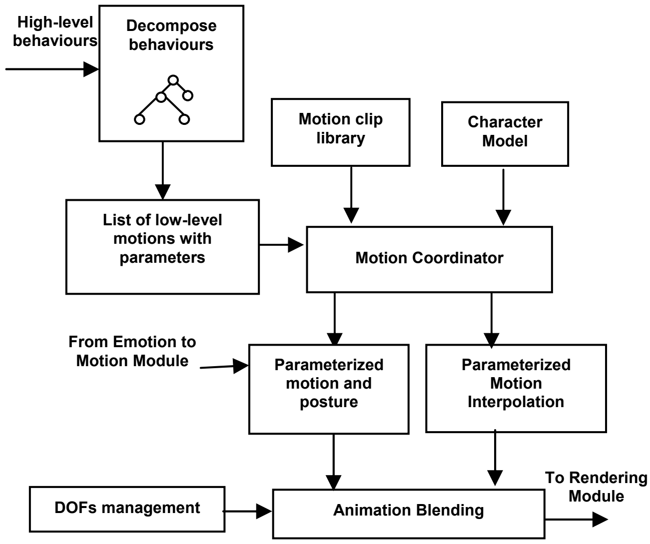


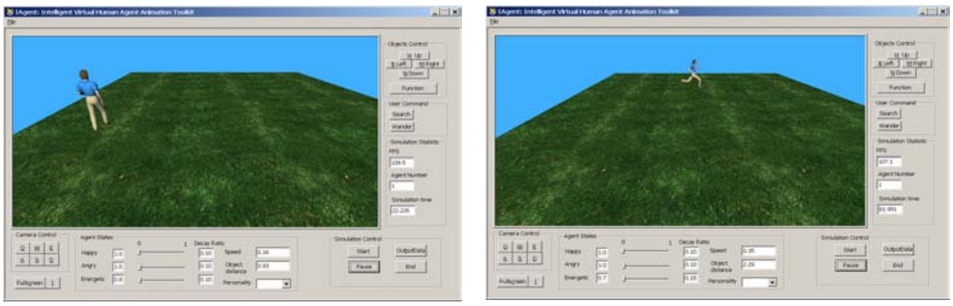
Figure 2 Architecture and functionalities of the motion generation module

generated motions are finally blended together to produce the final motions for the agent. The DOFs management assure that motion blending does not violate the limits of character's joints therefore avoiding un-natural motion. The functionalities of this *Motion Generation* module can be extended by incorporating new developed components. For instance, a physically-based modelling based motion module can be incorporated to increase the motion realism. In such cases, the adjustments (e.g. the update to involved DOFs) from this module can be blended into the existing motions via animation blending and DOF management.

Rendering module is responsible for displaying both of character animation and the virtual world onto the screen. It receives animation requests from the *Motion Generation module* and activates corresponding animation procedures with control parameters. The major challenge of designing such module is to achieve a balance between visual realism and the controllability of the animated 3D agent. The skinned mesh animation algorithm is used in the system (Wen et al. 2002).

IMPLEMENTATION AND RESULTS

The system was implemented in DirectX with MFC on a PC platform. The initial 3D human model contains around 6000 polygons and has around 23 degree of freedoms. The agent, for simplicity and experimental purpose, has 1 internal state (*Energy*) and two emotional states (*Happy, Angry*). The agent has base motions, namely *Walking, Running, and Resting*. It also has three parameterized motions, namely *HeadMovement(), PostureChange(), and ArmMovement()*. Its motions are arranged into a hierarchical actions network. Agent changes its base motions based on the fuzzy internal state *Energy*. Parameterized motions are generated based on the two emotional states, *Happy* and *Angry*. Figure 3 shows that the agent is in wandering state. In this state, the agent only exhibits its base motions and emotional states are not being updated.



(a) Agent is walking.
Energy=0.8, Speed=0.16, EnergyDecay=0.1

(b) Agent is running.
Energy=0.7, Speed=0.35, EnergyDecay=0.15

Figure 3 Agent in wandering state (emotional states is not taking effect)

Figure 4 shows that the agent is in searching state. In this state, the agent is given the task to capture a object controlled by the user. Its emotional states are updated based on dynamic events in the environment. In this case, the failure or success to capture the object has impact on his two emotional states. Emotion states are also updated according to time passing. This simulation used a default personality profile.

As shown in Figure 4, the events of failure or success to capture the object is evaluated and used to update the agent's emotional states, which subsequently resulting in different way of exhibiting its motions. The *Motion Generation module* produces parameterized motions and subsequently blends into the existing base motion animation sequences to achieve non-repetitive behaviours without the need to explicitly model such different style of animations in advance in modelling packages. The user is able to alter the agent's internal and emotional states through the user interface, observing the instant change of agent behaviours. Frame rate of the above simulation achieves an average of 100 based on a machine with *Pentium IV 2.8 GHz* CPU and a *Geforce 2 MX 400* graphics card. The graphics card used for the simulation is obsolete and current graphics hardware can deliver much better rendering performance.

CONCLUSIONS AND FUTURE WORK

This paper has presented an integrated system to animate human-like virtual intelligent agent. The agent has the ability to capture information from its environment and determine what actions should be taken based on its *behaviours module*. An innovative *Motion Generation module* is developed to realize the selected behaviours and produce parameterized motion along with pre-generated animation sequence depending on agent's momentary emotional states. Furthermore, as the *Motion Generation module* has the control of the character model to a degree of freedom level and a flexible animation blending component, it is possible to integrate various existing motion planning, kinematics, and physically based motion into the framework in order to increase the realism of the human agent's motions. Future work can be enhanced by investigating the relationship between agent's mental states and body motions (e.g. posture, gesture) and how emotions can be expressed by such body motion.

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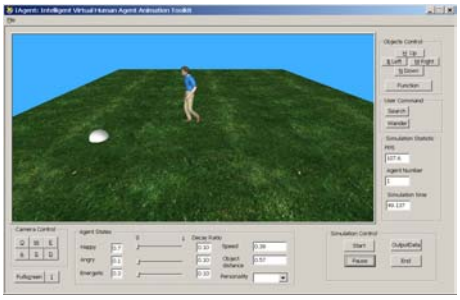
(a) Agent is trying to capture the object

Happy=0.9, Angry=0.1, Energy=0.9



(b) Agent changed from running to walking due to insufficient energy. Agent’s happiness decreases when time passes but has not captured the object. PM *PostureChange()* starts to be active but is still not obvious. This function has the control parameters “body lean angle” that is affected by emotional state *Happy*. Happy=0.7, Angry=0.1, Energy=0.3

(c) Agent is in resting mode. The agent has to stop to rest once the energy level drops to a low level. As the agent is in searching mode, he is still trying to locate the object by moving his head and body. Parameterized motions *HeadMovement()* and *BodyRotation()* are generated and blended into the base motion resting. The HeadMovement() has a number of control parameters such as rotation speed and rotation amplitude that are affected by emotional state *Angry*. The level of *Angry* increases when the agent expects to capture the object but subsequently fails to do so. The agent will rotate more rapidly with higher anger level. Happy=0.5, Angry=0.2, Energy=0.4

(d) Agent’s happiness is at a very low level. The value of the “lean angle” parameter for the *PostureChange()* is significant and the agent looks “really sad and disappointed”. Happy=0.2, Angry=0.5, Energy=0.4

Figure 4 Agent in searching mode (emotional states influence action)

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BIOGRAPHY

Zhigang Wen currently works as a research fellow in the *eDrama* project at the School of Computer Science, University of Birmingham. His main research interests include real time virtual human animation, gesture generation system and natural language processing for 3D embodied conversational agent.