Toolkit for Teaching Steering Behaviors for 3D Human-like Virtual Agents (Demonstration)

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ABSTRACT

Steering techniques present an important approach to navigation of 3D human-like characters; however, tools for teaching these techniques to students of courses on computer games, computer graphics or software agents are lacking. Here, we present three freely available tools that can be used for this purpose. The first one is a Java library of steering behaviors for Pogamut toolkit for developing control mechanisms of virtual agents. The second one is SteeringTool, an "off-the-shelf" simulation enabling students to investigate how steering rules work in various situations and under a variety of conditions, and the third one is a serious game SteeringGame for motivating students to study this topic.

Categories and Subject Descriptors

I.6.5 [**Simulation and modeling**]: Model Development

General Terms

Algorithms

Keywords

Steering behaviors, Human-like virtual agents, Interactive agent-based software systems, Virtual agents and interactive virtual environments, Agent-based games, Open-source software tools for agent-based system development, Education.

1. INTRODUCTION

Steering behaviors of C. W. Reynolds [1] are a well known mechanism of navigating virtual agents in a virtual environment. They are simple, predictable and computationally inexpensive. There are several tools for development and demonstration of steering behaviors [2,3] and their comparison and debugging [4,5,6]. However, these tools mostly concentrate on the navigation of boids (e.g., bird flocks or fish schools). Many applications, such as computer games or urban simulations, feature 3D human-like agents, which brings specific requirements on steering behaviors compared to non-human-like agents. For instance, a human observer has usually specific expectations concerning smoothness of the human-like agents' movement, their ability to anticipate and plan actions ahead, but also express social relations to other agents. To our knowledge, a freely available tool supporting education of steering behaviors in the context of 3D human-like agents has been lacking. Such a tool should not only allow a teacher to demonstrate various steering rules to students, but also enable students to gain "hands-on" experience with steering behaviors in a large 3D simulations featuring agents with customizable steering behaviors.

We have created a freely available Java library of several steering behaviors, based on these of C.W. Reynolds, but tailored to 3D human-like agents. Also, we have created a new steering Walk Along [7], used to steer pairs of people. This steering behavior shows that steering behaviors may not only control low-level navigation, but they may also be used to express social relations between agents. The library is connected to a tool Pogamut [8] for development of control mechanisms of virtual agents, but also to about 1 km^2 large 3D virtual town with four 3D agent avatars we developed; all freely available for educational purposes. The 3D world runs in UnrealEngine2Runtime. On the top of that, we have developed a 3D simulation SteeringTool, in which students can investigate the consequences of the steering behaviors and various settings of their parameters. Finally, we have also developed a serious game SteeringGame that challenges students with several logical tasks on practicing steering techniques. The intended audience is university students and interested high-school students, and their teachers. The toolkit is suitable for steering up to about a dozen of agents, not for crowd simulations.

In this paper, we present the Java library and the two applications. All the mentioned software and the video showing its use is available at http://diana.ms.mff.cuni.cz/pogamut-games/.

2. UT2004STEERING LIBRARY

The library has been written in Java, detailed description of its architecture can be found in [9], a shorter overview is in [7].

In our library, we have implemented the following seven steering behaviors: Target Approaching, Obstacle Avoidance, Path Following, Leader Following, Wall Following, People Avoidance, and Walk Along. The first five are based on [1]. People Avoidance uses a similar approach as in [10]. Leader Following allows for setting the agent's relative position to the leader, which is our innovation to Reynolds' version of this steering behavior. Walk Along is our new steering behavior and is detailed in [7]. All steering behaviors are detailed in [9].

Examples of our improvements to believability of human-like agents are: The agents steered by People Avoidance predict movement of nearby agents, applying further slowing, acceleration or rotation vectors to themselves, thus preventing collisions in more human-like way. Path Following has been made more fluent by adding a steering vector parallel with the current direction of the path. Followers in Leader Following may be steered to a specific location relative to the leader (e.g., 200 cm to the right from the leader), thus any formations may be made. The newly created Walk Along steering has been designed for human-like agents from the beginning.

In general, the exact impact of implemented steering behaviors on believability largely depends on the values of their parameters,

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which may be set by the user. This makes the library versatile and more interesting from the educational point of view.

3. STEERING TOOL SIMULATION

The SteeringTool simulation has been created with the purpose of easy observation, testing and thereby understanding of steering behaviors. The application contains two main windows: the window displaying our 3D virtual city and the window used to assign steering behaviors to virtual agents. The user chooses the number of agents in the scene, where they start, how they are turned and several other attributes (starting velocity, texture of the agent, etc.). The user also assigns various steering behaviors to these agents (different agents may have different behaviors) and sets the parameters of these steering behaviors (e.g., target location, who is the leader, how powerfully is the agent repelled by other agents).

The application contains a bird-eye-view map of the city, showing, for all agents, their target locations and the path chosen by Path Following steering (if used). The locations may be moved around the map by dragging.

When all parameters of the scene are set, the scene may be played and watched in the 3D virtual environment. The scene may be paused. During a pause, steering behaviors may be reassigned and/or get different parameters. It is also possible to save the scene; it may be loaded and replayed again later.

An important component of the application is Trajectories. The user may load data of previously saved scenes and display the trajectories of agents in the scene. It is displayed how the trajectories change in time, along with forces that affected the agents. This is crucial for understanding how various steering behaviors work and, most importantly, why. Trajectories of several scenes may be displayed simultaneously, thus allowing the user to compare several scenarios at once.

For educational purposes, the application contains predesigned scenes demonstrating specific features of implemented steering behaviors and their combinations. Some of these scenes concentrate on the innovations of steering behaviors that lead to higher believability in human-like agents. In the tool, it is easy to compare how the agents behave with and without the innovations.

4. STEERING GAME

Part of the toolkit is a serious logical minigame SteeringGame. The player solves various missions by assigning proper steering behaviors to agents in the mission, so that they go through a set of predesigned checkpoints. The user has to find a proper combination of steering behaviors to solve the situation and she/he has to set the steering behaviors' parameters properly. The missions are of four difficulty levels, the first being a tutorial. With the growing difficulty of missions, the player understands increasingly more delicate mechanisms of steering behaviors without reading complicated manuals. An editor of new missions is included for teachers.

5. CONCLUSION

We have presented a toolkit facilitating education in the field of 3D human-like virtual agents. The toolkit features three tools: UT2004SteeringLibrary, SteeringTool and SteeringGame. The toolkit should mainly serve to make teaching steering behaviors easy and more fun. The application has been tested by local students and evaluated as easy-to-understand. The application is finished, including a help and a tutorial in English, and it is ready to be used.

We believe that university students may use this toolkit to further their knowledge of virtual agents' navigation and that more high-school students will become attracted to computer science and software agents in particular, via playing SteeringGame.

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7. REFERENCES

[1] Reynolds, C. 1999. Steering behaviors for autonomous characters. In: Game Developers Conference, 763–782.

[2] Reynolds, C. Open Steer: http://opensteer.sourceforge.net/. (8.1.2012)

[3] Schnellhammer, Ch., Feilkas, T. The Steering Behaviors: http://www.steeringbehaviors.de/. (8.1.2012)

[4] Singh, S, et al. 2009. SteerBench: a benchmark suite for evaluating steering behaviors. Computer Animation and Virtual Worlds, vol. 20, issue 5-6, DOI=10.1002/cav.277.

[5] Singh, S, et al. 2009. An Open Framework for Developing, Evaluating, and Sharing Steering Algorithms. In Proc. of the 2nd International Workshop on Motion in Games, LNCS, vol. 5884, Springer, Heidelberg, 158-169.

[6] Kapadia, M., et al. 2009. SteerBug: an interactive framework for specifying and detecting steering behaviors. In Proc. of the 2009 ACM SIGGRAPH/ESCA, ACM Press, New York, NY. 209-216.

[7] Popelova, M., Bida M., Brom, C., Gemrot, J., Tomek, J. 2011. When a Couple Goes Together: Walk Along Steering. In Proc. Motion in Games, 2011, LNCS 7060, Springer, Heidelberg, 278-289.

[8] Gemrot, J., et al. 2009. Pogamut 3 Can Assist Developers in Building AI (Not Only) for Their Videogame Agents. In: Dignum, F., Bradshaw, J., Silverman, B., van Doesburg, W. (eds.) Agents for Games and Simulations. LNCS, vol. 5920. Springer, Heidelberg, 1–15.

[9] Popelova, M. 2011. Steering techniques library for virtual agents. Bachelor thesis. Charles University in Prague. (in Czech), http://amis.mff.cuni.cz/emohawk/ (8.1.2012)

[10] Karamouzas, I., et al. 2009. A Predictive Collision Avoidance Model for Pedestrian Simulation. In: Proc. Motion in Games, 2009. LNCS, vol. 5884, Springer, Heidelberg, 41-52.