A Prototype using Territories and an Affordance Tree for Social Simulation Gameplay

Tilman Geishauser, Yun-Gyung Cheong, Mark J. Nelson
Center for Computer Games Research
IT University of Copenhagen, Denmark
{tgei,yugc,mjas}@itu.dk

ABSTRACT

Smart objects are a representation strategy for games and virtual worlds, in which information about object interactions is distributed into the objects themselves: an object knows how it can be used, what kinds of effects it has, etc. In this work, we describe a prototype that aims to explore social simulation using smart objects. We extend the concept of smart objects to include a model of human behavior with regard to territoriality. To manage complexity in worlds with many such objects we employ a tree structure, which we call an *Affordance Tree*. The *Affordance Tree* allows the spatial containment of the affordances in the environment to be hierarchically organized.

1. INTRODUCTION

Smart objects embrace the idea of locating information on how to interact with an object in the object, instead of modeling it in agent logic [4]. One common approach is to have objects broadcast offers to take action with the object, in which case they can be seen as an implementation of the concept of affordances. *The Sims* is a well-known game based largely around smart objects [1]. Among other advantages, they make it easier to create expansion packs, as smart objects are self-contained and thus can just be plugged into the simulation. Smart objects do not need to be aware of any external animation states. For example, a bed object needs to be concerned about sleeping and wake-up states but does not need to manage animation states for cooking food.

In the work discussed here, we extend the smart-object concept to account for a model of human territoriality. With a new concept called *Territories* we attempt to step away from playing animations in rigidly fixed slots as seen for example in *The Sims* series. It is a step towards expressing nuances of how people interact in space, which are more difficult to model in text-based social simulation games such as in the *Versu* engine [3]. In the turn-based social simulation *Prom Week* [6], interactions have complex effects, but they happen rarely. The presented prototype allows agents to interact with each other and the player with high frequency by simulating in real-time. Our *Affordance Tree* structure generalizes the solution that was applied in *The Sims* to manage smart objects. In our work, each node in the *Affordance Tree* can be any *Territory*, and parent nodes offer a promise to consume affordances of contained *Territories* via auctions. We developed a prototype in 2D graphics simulating a multi-agent society, as shown in Figure 1. It was implemented based on Microsoft XNA and a demo video is available at: `http://www.bt-medien.de/thesisvideo.html`.

2. TERRITORIES

Territorial behavior can be defined as those behaviors that control the positional and orientational relationship of humans during social interaction [10]. Kendon [5] presented F-formations to explain spatial arrangement of people in interactions. In his work, a F-formation is seen as frame in which a set of social norms and rules are to be maintained by participants, and in that regard they are similar to smart objects [4] that manage social situations. Based on these theories, Pedica and Vilhjálmsson [7] automated 3D animation in social situations using a library they called the Impulsion Engine. However, this agent-based approach was implemented in open spaces only, and not in a furnished world.

In our prototype, *Territories* are smart objects that can be placed anywhere in the game world; they provide a set of affordances to agents. *Territories* calculate slots in 2D space after being spawned. These slots provide positions agents can navigate to. In the store table example in Figure 1, the table has one slot with a merchant role, and three slots with customer roles. The space in the vicinity of the table is divided into o-space, which is space that should not be invaded, and p-space, space in which agents should be placed. Artists can use various settings for a type of *Territory* to quickly, and with computer assistance, express proxemic behavioral patterns.

Territories provide sets of interactions to agents. Each interaction has a rate at which it satisfies needs of agents over time, as well as methods testing availability and applying effects to agents and territories. *Territories* together with interactions form a lightweight approximation of Social Practices seen in *The Sims* and *Versu* [3] and Social Exchanges seen in *Prom Week* [6]. Each *Territory* has limited resources, which are allocated via auctions.

3. AUCTIONS

Auctions separate *Territory* objects from agent implementation; agents can use any decision-making algorithm to determine when to bid and the price they are willing to pay. The bids are resolved as Vickrey auctions [8], which are second-price sealed-bid auctions. Every auction starts with a zero bid, so only one agent has to bid more than zero to win. Only allowing each agent to place one bid on each auction means agents can almost immediately be informed whether the good was allocated to them. The dominant strategy is to bid the true valuation: bidding too much can end in a loss as too much is paid, and bidding too little reduces chances to win but does not lower price. This means agents can avoid having to reason about potential bidding behavior of others.

From all interactions that have been added to a *Territory*, the *Territory* calculates an optimistic summary of need satisfactions that might be achieved by agents participating in the *Territory*. The summary is used as the good of the auctions offering slots. Agents bid based on their own need satisfaction status. Each *Territory* currently has only one interaction running, but can have multiple participants. *Territories* thus auction the option to decide on the next interaction. Agents that have been participating a *Territory* for a longer time have more currency available than newcomers, making occupying a *Territory* a source of authority over how it is used. This is a phenomenon that was observed when Scheflen [9] looked at distribution of space in cramped living conditions. Further aspects of how humans treat objects in the environment as resources can be modeled in the approach, for example by adding a new currency based on social status.

4. AFFORDANCE TREE

In *The Sims*, agents can first decide to which lot to go, and then which agent to interact with [2]. The *Affordance Tree* generalizes this reduction of the number of affordances offered to agents during one evaluation of the environment. Each node of the tree refers to a *Territory*. Unlike in *The Sims*, any *Territory* can be placed at any depth in the *Affordance Tree* at runtime. This could e.g. be used to partition a town into districts as it grows.

In the form of auctions for slots, each node computes a snapshot of the goods potentially provided by the affordances of its children. For example, a house that contains a bed and vegetables promises sleep-satisfaction and hunger-satisfaction. An agent that wants to sleep can bid on a slot in the house. Upon winning the auction the agent can go to the house, and upon arrival bid on the bed. It can however be that the bed is already in use, information that is not available when bidding on a slot in the house. In this event the agent will have to bid on a different house.

Figure 1: On the left one merchant and three customers are using a store table to sell or respectively buy weapons. On the right debug information for a similar store table shows placements of slots, taking into account o-space and p-space.

Without ever having visited a house, agents know which affordances it provides. This is a simplification for games where the player will not track how single agents gain knowledge of the world.

5. CONCLUSIONS

We present the *Affordance Tree*, as a general structure to manage spatially situated affordances in a game world. By hierarchically structuring *Territories*, a simulation can scale to complex worlds taking linear time. Affordances are resources that can be allocated to agents based on definable currencies. This can be used to simulate real world phenomena that inspired Scheflen's theory of human territoriality. Objects can determine where to play animations based on a simple model of human territoriality. Meaningful proxemic behavior creates more variety than fixed animation slots. At the same time artists do not have to sacrifice control. Our future plan is to make agents into *Territories*, allowing us to generalize territoriality computations and to place them in the *Affordance Tree*.

6. REFERENCES

[1] A. J. Champandard. Living with The Sims AI: 21 tricks to adopt for your game. `http://aigamedev.com/open/review/the-sims-ai/`, October 2007.

[2] R. Evans. Modeling Individual Personalities in The Sims 3. `http://www.gdcvault.com/play/1012450/Modeling-Individual-Personalities-in-The`, 2010.

[3] R. Evans. The Praxis Manual. Unpublished, 2012.

[4] M. Kallmann and D. Thalmann. Modeling objects for interaction tasks. In *Proceedings of the 1998 Eurographics Workshop on Computer Animation and Simulation*, pages 73–86, 1998.

[5] A. Kendon. *Conducting Interaction: Patterns of Behavior in Focused Encounters*. Cambridge University Press, 1990.

[6] J. McCoy, M. Treanor, B. Samuel, A. A. Reed, M. Mateas, and N. Wardrip-Fruin. Prom Week: Designing past the game/story dilemma. In *Proceedings of the 8th International Conference on the Foundations of Digital Games*, 2013.

[7] C. Pedica and H. H. Vilhjálmsson. Spontaneous avatar behavior for human territoriality. *Applied Artificial Intelligence*, 24(6):575–593, 2010.

[8] T. W. Sandholm. Distributed rational decision making. In *Multiagent Systems: A Modern Approach to Distributed Artificial Intelligence*, pages 201–258. MIT Press, 1999.

[9] A. E. Scheflen. Living space in an urban ghetto. *Family Process*, 10:429–450, 1971.

[10] A. E. Scheflen. *Human Territories: How We Behave in Space and Time*. Prentice-Hall, 1976.