ENHANCING REALISM IN EXPLORING IN VIRTUAL ENVIRONMENTS

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Abstract. A virtual environment is a place which requires context, content and actors to promote realism in the exploration process. With the advancement in technologies and computing power, the context of virtual environments could be sculpted in finely. Referencing movie and video games, it would not be difficult to draft the content. The only component being overlooked is the actor. In this paper, I will address the mechanism and challenges in the implementation of autonomous agents as actors in virtual environment so as to promote social sense and enliven the environment, hence enhancing realism in the exploration.

Keywords. Virtual environment: autonomous agents; place; place-making.

1. Introduction

With “digital revolution”, virtual environment has become an alternative ‘space’ that supports many human activities which heretofore were conducted exclusively in physical space, with all its benefits and limitations.

Virtual environment is different from traditional mode of architecture as there is no limitation in time, gravity, distances, and other attributes which we regard as fixed constraints in physical space. There is much more freedom, which we can bring to life ancient sites that no longer exist; futuristic environments that do not yet exist; and environments that cannot exist in physical space. Though so, virtual environments must still be designed according to the same principle that guides the design of physical spaces, including: form-related aspects (what does it look like?); social aspects (what kinds of social and cultural interactions does it convey?); and phenomenological (what does it feel like ‘being’ in the virtual environment?) so as to enhance realism in the virtual environment.

Presently, with advanced technologies and computing power, the setting of virtual environments could be sculpted in a very fine manner. However, this does not imply realism in exploration.

Here, I will address the autonomous agents used to enhance realism in exploration in a virtual heritage project. In this project, users are free to explore in the virtual environment. To enhance realism in the exploration, autonomous agents, inventory, music and other features were implemented to induce various experiences. In this paper, I will focus on the mechanism and challenges of the implementation of autonomous agents.

2. Virtual Environment: Developing a Place

According to Kalay (2007) and Chen (2007), sense of place is essential in promoting realism in virtual environment. Using the metaphor of stage-play, he identified three components for creating a place, a stage (a context), a narrative (the play), and actors (the player) (Figure 1).
• The stage is the context of the environment which consists of spatial components like buildings, topography, sky, etc., and objects that can be manipulated by actors or can act on their own (trains, cars, etc.).
• The narrative is the content of the environment. It includes all aspects of the activities that take place in the environment which provide a reason and a purpose for being there (Kalay and Marx, 2001). Shopping, learning and entertainment are examples of content which turns lifeless settings into inviting places.
• The actors are the inhabitants of the environment, including visitors, who are controlled by physical players; agents, who are pre-animated, semi-autonomous entities that perform pre-scripted roles and have action modification capabilities based on some sensory input; and animations, which are pre-scripted action sequences that are not responsive to the presence of visitors or agents.

In architectural practice, architects generally do not design content or actors directly. They design a physical setting (space) within given context (physical, cultural, social, etc.). The settings they design imply certain contents and actors.

In movie and video games, the storyboard (narrative) drives a series of activities and events which the stage is designed as corresponding backdrops that supports the occurrence and development of the narratives.

In virtual environment, with the advancement of computing power and modelling techniques, the context can be sculpted finely. Supported by narratives, as in movie and video games, a fully “content-wise” environment could be easily drafted. The only component being overlooked is the actor.

In virtual environments, actors are different from passive movie audience as they are active participants. They have limited pre-defined socio-cultural practice to follow which they have much freedom to do as they please. In some cases, even there exists well defined context and content, we still need some “cooperative” actors to help direct others so as to achieve some sense of coherence (Chen 2007).
3. The Context and Content

The context being concerned is a reconstruction of the 7th Street in West Oakland, California in the 1940s and 1950s. It was a bustling commercial district, anchored by dozens of jazz and blues clubs that earned it a reputation as a West Coast rival of the Harlem music scene.

By the mid 1960s, there had been great changes in the area that a remarkable part of this Oakland’s heritage was destroyed. Today, the street is marked by boarded up buildings and empty lots and plagued by drug dealing and crime. Only a scattering of businesses now exist along 7th Street. The only remaining music club from the 1950s is Esther’s Orbit Room. A walk down the 7th Street reveals almost no hint of the vitality of the area and the once thriving jazz and blues club scene.

Since 2005, the Digital Design Research Group at UC Berkeley has been reconstructing the scene into a multi-user virtual environment. In this environment, multiple players could participate in the jazz scene simultaneously through internet connections. They can explore, interact with the environment, characters and other fellow players. Players can then obtain information about the history of the environment through all these interactions. The aim is to provide an entertaining educational tool for young people to learn about the splendid history of West Oakland in its golden times. Supported by School of Journalism, much information regarding building styles, characters, music, and commercial environment etc. was obtained to enrich the virtual environment, which increases the engagement and appeal of the environment (Figure 2).

![Figure 2. Two views from the reconstructed 7th Street.](image)

4. The Actors

Following the narrative, actors of the virtual environment were designed with special care. Avatars were designed in the types and dressing styles corresponding to the narrative. There were colourful characters such as “The Reverend” who, along with his wife, preached from street corners, and Charles “Raincoat Jones”—a former bootlegger turned loan shark and dice game operator—who was known as the unofficial mayor of 7th Street and helped finance some of the jazz and blues clubs. There were also legendary blues and jazz singers and musicians, as well as soul and rhythm and blues artists, performed at the clubs, including Jimmie McCracklin, Sugar Pie DeSanto and Ivory Joe Hunter. Though so, the actor component was not really successful in terms of place-making in the early trials.

In the early trials, new users have limited understanding of the background which they had no pre-defined socio-cultural practice to follow. This induced some difficulties in the exploration of the environment. That is, users simply “did not know what they need to do”. Also with limited testers in the trials, players could hardly see other players in the virtual environment. We indeed experienced limited level of presence and participation from the testers.
Therefore, we used autonomous agents to populate the environment and induce socio-cultural practice which new users could follow. In fact, later trials revealed that players prefer the presence of the autonomous agents as they promote the sense of place. Also, by reviewing agents’ activities in the environment, players had much better ideas of how to perform (what to do and what can be done) in the environment.

Though so, it would be impractical to employ a fully distributed autonomous behaviour algorithm, as this requires real-time computation of hundreds of bots simultaneously present in the environment. Therefore, we developed an optimized model to simulate autonomous behaviour.

As in the first line, we differentiated bots from non playing characters (NPCs). Bots are agents which have no direct interaction with players, but just exist to populate the environment. NPCs are special characters which players need to interact with. They follow a predefined interaction and conversation script so that they could react appropriately to the players.

In addition to the bots and NPC’s, running cars and trams were introduced to enhance the dynamic feeling of this commercial district. These dynamic components will be responsive to the players’ actions, but not interact with them. There are also parked cars on the sides of the streets. Parked cars are treated as other street features like lamp posts. They are stationary and will not interact with any humans and vehicles in the environment.

4.1. MECHANISMS

Previous studies on agents typically include goals and behavioural rules for agents so that they could behave in a sensible way in the environment. In this project, the autonomous agents are background objects that do not require specific goals. In terms of intelligence, we only expect them to possess the following behavioural capabilities:

- **Detour or stop and wait** when meet obstacles on path (for both bots and vehicles)
- **Turn / go forward** at street corners (for both bots and vehicles)
- **Find** seats available (for bots, inside bars)
- **Meet** with people (for bots, on street and inside bars)

Therefore, instead of behavioral rules and the demanding distributed real-time decision making systems, we introduced another concept for the autonomy of the agents, the *switch-nodes*. These nodes are points that give information to the background dynamics on available choices and the associated probabilities at that particular point of interest (Figure 3). The agents will continue their actions until they arrive at the nodes. They will then make decisions at the nodes based on the available choices and the probabilities associated with each choice. With careful placement and arrangement of the nodes, agents would move around in the environment and behave according to the narrative. The decision making algorithm is distributed to each node, this method efficiently distributes the responsibility of making decisions between the agent and the node.

![Figure 3. Switch-nodes on street corners.](image-url)
4.2. THE SWITCH-NODES

The switch-nodes are location-based triggers to possible behaviours of the agents. The nodes could trigger an action, a series of actions, an animation or a mixture of actions and animations. Decisions are made by the usage of a randomization function, where probability of each choice is weighted by distribution preferences (Table 1). There are several advantages of using this system instead of, or even in conjunction with, an agent-based artificial intelligence function. The nodes provide 1) agent-independent behaviour patterns, shared by many agents, 2) a context-based behaviour palette. 3) parameterization of behaviour probabilities in response to environmental dynamics and agent-based preferences, 4) and the possibility of a branched organization, avoiding repetition and ensuring variability in actions.

<table>
<thead>
<tr>
<th>Variability function</th>
<th>Probability %</th>
<th>Action Trigger</th>
</tr>
</thead>
<tbody>
<tr>
<td>f(E,a)</td>
<td>40%</td>
<td>WALK TO bar node1</td>
</tr>
<tr>
<td>f(E,a)</td>
<td>30%</td>
<td>WALK TO street node2</td>
</tr>
<tr>
<td>fixed</td>
<td>10%</td>
<td>PAUSE for 30 seconds</td>
</tr>
<tr>
<td>f(a)</td>
<td>10%</td>
<td>ANIMATE &quot;WaveHand&quot;</td>
</tr>
<tr>
<td>f(a)</td>
<td>10%</td>
<td>ANIMATE &quot;LookAround&quot;</td>
</tr>
</tbody>
</table>

As shown by the table above, an action could be simply as “go to node n” or “pause 30 seconds”. An animation could be “wave hand”, “dance”, or “play music”. A combination of different actions and animations could create an endless variety of possibilities for the scene. There is also instruction in the nodes linking one node to the next, allowing us to pre-design complex walk-paths. Agents could then go through series of actions and behave differently depending on the nodes and the choices made. Moreover, the probability distributions of the variety of actions can be determined through parametric functions \( f() \) that take environmental variables (E) or personal characteristics and preferences of an individual agent (a) into the equation. As an illustration, a node located at the entrance of a bar can direct more bots into the bar when it is night time, or when the band is playing inside, while the same node can direct more bots out when the show is over. Another node can direct female avatars into one action, while males into another, for example, in a clothing store where sections are divided by gender.

5. Challenges

As we only use switch-nodes to govern the behaviour of the agents, there were no concrete set of behavioral rules to define the social behavior of the agents in the place-making process. As a result, we came up with some challenges which we need to deal with very carefully.

5.1. NATURAL BEHAVIORAL PATTERN

A big challenge of using agents without goals and rules is to create varieties in the scene so that it does not look like having zombies running around in the environment. To achieve variation, one method is to include options as specified within the nodes that agents would not behave the same way even they reach the same node. At a macro scale, the routes taken by all the agents will not be identical, so as the experience throughout the trip will never be the same.

Another way is to vary the speed of the agents. With different speeds, two agents walking in the same direction would not appear as robots with synchronized motions.

The third method is to start the lives of the agents at different positions in the scene. At time 0, the agents are distributed all around the environment, some on the streets, some in the...
bars and other buildings. All agents face different directions and start to move forward when the game starts and their activities will be changed upon arrival at the next node.

5.2. SOCIAL COMPONENTS

7th Street was famous for its richness in cultural and commercial activities. People would go to bars and clubs in groups. They will also meet on the street and may even talk for a while on the street. Therefore, it would be sensible to include some social characteristics on the street. An example is that we put a group of kids jumping around on a street corner to create the scene of a group of children playing on the street. This is a continuous activity which is not really autonomous.

For the autonomous agents, we intended to include meeting and parting events. We specified some nodes on the street where bots could gather in groups and part. To simplify the process, the bots would not know who they are meeting. They will just choose to meet with others at the nodes. In fact, it is not necessary to decide in advance which bots will meet each other since it is never apparent on the street that Bot A might know Bot B.

To characterize the meeting and parting behaviour, we intended to use a combination of simple activities in the representation. For meeting, the bots will wave to each other and stop for a while. At this point, the bots will be gathered next to each other to denote a meeting acquaintance. The same principle is applied to parting events. The group would stop for a while, engage in idle conversation, wave to each other and move in a different direction.

5.3. COMPUTING RESOURCES

In this virtual environment, all of the background objects are situated in the environment since the beginning of the game. They do not just appear as players are nearby. Also, we have carefully designed the mechanism so that the autonomous background objects would not use a large amount of resources in order not to affect the performance of the game. Therefore, apart from the nodes mechanism, we have few other means to control the consumption of computing resources.

- Various levels-of-detail for objects in the scene. The detail levels of the objects would increase as they become closer in the view.
- Careful planning of nodes. In the environment, the players mainly move along the 7th Street. Therefore, the nodes are carefully planned such that the agents would stay in viewable areas in the environment. This could greatly reduce the number of agents to be located in the environment.
- Create complex behaviour by combination of simple activities. Instead of creating a big pool of activities to accommodate all possible behaviours, we used combinations of simple activities to represent different human behaviours in the scene. These activities are clustered around nodes according to the specifics of the contexts that the nodes are placed in. Currently, we only include mutually exclusive motions like sitting, standing, walking and dancing for bots. Combining with other, but not mutually exclusive, motions like waving, getting and drinking, we have created many behavioural varieties in the scene.

8. Conclusions

In the process of reconstructing the bustling commercial district of 7th Street in West Oakland, California, in its 1940s and 1950s, we attempted to employ autonomy for bots and running vehicles so as to create the liveliness of the environment. Instead of using goals and behavioural rules which are traditionally used in virtual user simulation, we used another mechanism, the switch-nodes, to govern the behaviours of the agents in the environment. The nodes system differs from goals and behavioural rules in this sense that it does not fully distribute the
autonomy to the agents. In our case, this is advantageous as we do not want the background dynamics to impose too much computation load on the system.

Though so, we also experienced some challenges as the node system does not prevent conflicts or unreasonable behaviour in the environment even for a narrow range of behavioural needs. Nevertheless, with some adjustments, careful planning and some creativity, we were able to achieve “naturally appealing” behavioural patterns without receiving a significant penalty on the overall gaming performance.

In fact, trials of the game show that the agents are effective in directing behavior of players as in real life. Also, “population” is a key to attract players to place of interest.

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References


