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Increasing the feeling of social presence by incorporating realistic interactions in multi-party VR

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Abstract

Behavioral realism and realistic interactions are major criteria for improving social presence in virtual reality environments. We focus on multi-party VR applications where computer agents and avatars interact, share and collaborate with each other using objects. Our formulation employs realistic animations to simulate human-like behavioral motions of computer agents while they interact with avatars to enhance the sense of social presence in the VR environment. We exemplify our proposed model in a VR volleyball game setup. We model specific underlying interactions like gazing, collision detection and miscellaneous reactions (like how to pick a volleyball, how to transfer the ball to server) between computers players and avatars in the VR Volleyball game. We conduct a preliminary user survey to illustrate the significance of inclusion of realistic interactions for improving sense of social presence in a multi-party VR environment.

Keywords: presence, interactions, behavior realism, agent, avatar, VR

1 Introduction

Presence in a virtual reality environment is the feeling of being physically present in a non-physical world. It is observed by a real user by

perceiving his/her surrounding agents and their behavior in the virtual environment [1] [2]. Presence is sub-categorized into Spatial presence and Social presence [1]. We focus on social presence which can be judged by the sense of perception of being together with all the virtual humans.

Environment awareness is important for humans to interact in real life. There are many situations especially sport games like football, hockey etc. where humans interact and communicate with one another using objects. We focus on improving social presence for such scenario in a multi-party VR environment. In virtual environment, computer agents can perceive signals by computer process but to make them to be more human-like, corresponding attention behavior is required. Attention behavior has been a focus of research since a long time. Researchers in [3], [4] and [5] implement gaze based model to make attention behavior more realistic. Researchers in [6] adopt a saliency map based visual attention model for the interactions between agent and the virtual scene. Most of these researches develop attention based simulations but do not focus on presence in VR.

Gaze is an important part in attention behavior and also regarded as a key aspect of non-verbal communication [7] [8]. In a virtual environment gazing can be directed to independent objects as well as other agents. Researchers in [9] propose an interactive approach, PedVR, which enables

Figure 1: Proposed behavior model architecture

real users to interact with the virtual crowd in an immersive virtual environment. They develop a high dimensional trajectory by coupling 2D navigation with full body motion synthesis combined with gaze computation. Other developments have indicated the effect of gaze in terms of interpretation of emotional expressions [10] [11]. Gaze is also increasingly being used by embodied conversational agents (ECA) [5].

There have been various developments for incorporating interactions in VR. Recently, researchers [12] propose to import AI into virtual environment to make virtual avatar more smart. Researchers in [13] illustrate how communication improves realism in crowd simulation. They focus on communication between hundreds of computer agents but it is basically for crowd simulation and there is no communication between computer agents and avatars. We propose an interaction model embodied with realistic interactions to enhance user's sense of social presence in VR.

2 Behavior Model

2.1 Model Architecture

Fig. 1 displays the overall architecture of our interaction model for an agent. Each agent inside the VR environment, perceives events using visual cues. The perceived information is passed on to the Navigation module and the Plausible behaviors module. The Navigation module consists of two entities : High level planning and Static navigation mesh. High level planning is responsible for making a decision on how an agent will behave depending on the scenario per-

ceived. Equipped with environment information, the static navigation component maps the walkable area and obstacles in the environment on the floor. The plausible behaviors module includes movements and interactions for an agent. The components in the interaction module are extendable (the blue boxes show example interactions: gazing and objects transfer). To enable movement module to perform spatially realistic actions, a navigation module is required which is passed on by the Navigation module. Using Path finding and Collision avoidance algorithms an agent performs the appropriate interaction with the avatar. Further, Locomotion animation can be applied and agent can move to the destination using the approaching method. Further, by applying these plausible behaviors combined by full body motions and non-verbal behaviors, agents interact with the avatar in a more realistic way.

2.2 Example Scenario

We exemplify our model for a volley game implementation in VR. A volleyball game is played between two teams with 6 players in each team. In our example implementation, there can be a combination of autonomous players and avatars. Each of the real users have a Kinect and Oculus which is used to capture their respective movements in the game. The main focus of our work is as follows:

- Interactions between computer agent and avatars : gazing volleyball, transferring ball etc.
- Physically modeling realistic behaviors of objects. For instance, the ball cannot appear

Figure 2: The gazing flow for the high level planning layer in the scenario of volleyball game.

or disappear at one place without player's manipulation.

- Realistic animations during interactions: walking, gazing, transferring etc.
- Miscellaneous interactions: gazing user, collision avoidance with user and other agents.

2.3 Interactions between Agents and Avatars

In a volleyball game there are many scenarios which requires the agents to interact with avatars. We consider interactions between agents and avatars using an object (ball in our example). Realistic animations improves the spatial presence in the VR environment.

2.3.1 Gaze based interactions

In the volleyball game scenario steps involved in performing gaze based interactions are summarized in Fig. 2. The gazing process is always active except when the agent is performing a higher priority activity. Once the game starts, every agent checks if the key object (ball) or an avatar/agent is in its field of view. If its true, then it checks his/her own state whether it is performing other higher priority actions like, handling the ball. If no high priority task is being performed by the agent it continues gazing at the object or avatar/agent in its field of view. Both avatars and computer agents gaze at the key objects which improves the real user's social presence experience. In Fig. 3, top row depicts the situation when no gazing is included in the game.

Figure 3: Gaze based interactions: Top row depicts the situation when there is no gazing in the VR Volleyball game. The avatar (red rectangle) looks at the ball, the agents do not gaze at the ball. The second row shows the scenario after incorporating gaze based interactions. So, along with the avatar, the agents also look at the ball.

Figure 4: The picking ball flow for the high level planning layer in the scenario of Volleyball game.

While in the image on right the avatar (red rectangle) looks at the ball, the agents do not gaze at the ball, which is unrealistic. In the second row, along with the avatar, the agents also look at the ball. Incorporation of gaze based interactions improves the feeling of being present with the computer players for the real user (as they perform actions similar to him/her).

2.3.2 Miscellaneous interactions

Picking up the ball (Fig. 4) is a specific case in the volleyball game. It is activated when game is in the pending state. A pending state is in between a win point and the next serve. The pick-

Figure 5: Collision avoidance: Top row depicts the scenario without collision avoidance, the agent collides into the avatar (red rectangle). Second row shows a similar scenario with incorporation of collision avoidance.

ing ball module is activated whenever a point has been scored. Every agent checks whether the ball has been picked or not and whether the ball is in his/her vicinity. If that's true, if he/she is nearest to the ball, the current agent will be responsible for picking up the ball. The locomotion and approaching modules are employed for animating the picking up the ball process by the agent. Animations like gazing and transferring ball to the server improves the overall social presence experience. Further, **passing the ball** between an agent and avatar gives the real user a feeling of being together in the same space as the computer players. Another important interaction for improving social presence is **collision avoidance**. Fig. 5 the top row depicts the scenario without collision avoidance, the agent collides into the avatar (red rectangle). In the second row a similar scenario is shown with incorporation of collision avoidance. When computer players avoid each other and avatars while moving to handle the ball, improves the feeling of being present for the real user.

3 User Survey

We conducted a preliminary comparative survey (Fig. 6) to evaluate the significance and effect of inclusion of realistic interactions in a multi-party VR setup with 10 participants which consisted

- Q1. In which simulation the behavior of computer players is more realistic (as the real world)?
Simulation 1 or Simulation 2
- Q2. In which simulation your interactions with the computer players is more realistic (as the real world)?
Simulation 1 or Simulation 2
- Q3. In which simulation did you observe your team mate gazing at the ball?
Simulation 1 or Simulation 2
- Q4. How much did the gazing behavior increase the feeling of being present in the same environment as the computer players?
Not at all, Very limited, A little bit, A lot, Significantly
- Q5. How much did the realistic motions improve your experience in VR?
Not at all, Very limited, A little bit, A lot, Significantly
- Q6. In which simulation did you observe a computer player choosing a path that avoids collision with you and other fellow computer players?
Simulation 1 or Simulation 2
- Q7. How much did collision avoidance amongst players improve the feeling of being present in the same environment as the computer players?
Not at all, Very limited, A little bit, A lot, Significantly
- Q8. How much do you expect from computer players to pass you the ball? Not at all, Very limited, A little bit, A lot, Significantly

Figure 6: Presence Questionnaire

of 8 males and 2 females. Their ages ranged from 20 to 40 years. There are two versions of the game. One version of the game is with the proposed realistic interactions and the other version included no interactions. The participants were asked to play both the versions. They had no knowledge of the which version of the game they were playing. Later, the participants fill the presence questionnaire (Fig. 6). We analyse the user experience amongst our participants, 9 out of 10 participants agree that inclusion of realistic interactions improve their experience in VR (Q5). Also all participants agree that addition of gazing interaction significantly increased their feeling of being present in the same as the computer players (Q4). Further, 8 out of 10 participants observed that inclusion of collision avoidance improved the feeling of being present with the virtual players (Q7).

The participants were asked to rate (1 - Not at all, 2 - Very limited, 3 - A little bit, 4 - A lot, 5 - Significantly) how much the inclusion of realistic motions increases the feeling of being present for users in the same environment as the computer

Figure 7: Box plot for visualization of user’s response to Q4, Q6, Q7 and Q8.

players. Fig. 7 displays the box plot of the user’s presence rating for Q4, 6, 7 and 8. It can be observed that incorporation of all the four interactions. It shows that addition of realistic interactions, gazing, collision avoidance and passing the ball improves user’s presence and experience in virtual environment.

4 Conclusion

We develop a model for incorporating realistic interactions to improve social presence in a multi-party VR framework. Our multi-party VR environment comprises of autonomous agents and avatars who interact with each other using objects. We exemplify our proposed scheme for a volleyball game which comprises of avatars and computer players who communicate with each other using a ball. We exhibit like gazing, collision detection and miscellaneous reactions (like how to pick a volleyball, how to transfer the ball to server) between computer agents and avatars in the VR Volleyball game. Further, a preliminary comparative user study demonstrates the capacity and importance of realistic interactions in object driven interactive multi-party VR. Currently, we focus on gazing and other miscellaneous interactions. Extending the framework to include behavior and moods into the autonomous agent characteristics would be an important avenue of future research.

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