COVID-Vision: A Virtual Reality Experience to Encourage Mindfulness of Social Distancing in Public Spaces

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Figure 1: COVID-Vision is a multi-user virtual reality experience that simulates a grocery store. The network-synchronized environment is populated with both live users and non-player characters that move dynamically through the indoor space.

ABSTRACT

Social distancing is currently the most effective known countermeasure against the rapid proliferation of the virus that causes COVID-19. This project aims to encourage mindfulness about maintaining interpersonal distance in shared public spaces through a multi-user virtual reality experience that simulates shopping in a grocery store. The virtual environment is populated with non-player characters that navigate through the store and also supports up to 20 concurrent live users represented as avatars. Real-time feedback is implemented using a dynamic visual effect that reacts to physical proximity, and comparative performance metrics are also provided for users to reflect on after the task is completed.

Index Terms: Human-centered computing—Human computer interaction (HCI)—Interaction paradigms—Virtual reality; Computing methodologies—Computer graphics—Graphics systems and interfaces—Virtual reality;

1 INTRODUCTION

The COVID-19 pandemic has drastically impacted daily life due to its transmission approach and fast transmission rate. The virus's primary vector is through airborne droplets exhaled by infected individuals, and physical distancing (also known as social distancing) is the most effective known strategy to slow the spread of the pandemic. The U.S. Centers for Disease Control and Prevention recommend maintaining at least six feet minimum distance (approximately 1.8

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meters) from other people who are not members of the same household. However, consistent physical distancing can be challenging in indoor environments with multiple people moving through spaces that contain clutter and obstacles.

This paper describes COVID-Vision, a multi-user virtual reality experience designed to encourage mindfulness of social distancing protocols in public spaces. The scenario is modeled after a grocery store because shopping is one of the most common daily activities that often requires entering a shared public space (see Figure 1). Users have to navigate through the store to retrieve items from a shopping list while simultaneously avoiding risky encounters with other people, who may be either non-player characters or avatars controlled by other live users. Following established community guidelines, we define a risky encounter as a situation in which the distance between two people is less than six feet.

To encourage mindfulness of social distancing protocols, users are provided with a visualization of their "safe zone" that can be optionally toggled on or off during the simulation. Personalized statistics about their risky behaviors are also provided after the task has been completed. We hypothesize that providing individualized feedback for "after action review," coupled with a real-time visualization of social proximity, can make users more aware of potential situations that are associated with elevated risk of virus transmission.

2 RELATED WORK

Our original vision for this project was to simulate infection risk for COVID-19 in a dynamic virtual environment. One method identified in recent work involves creating a quantitative model that simulates the spread of the virus [2]. However, one of the assumptions of this model is that the air in the space is well-mixed, thus cannot be used for our project which focuses on dynamic changes in micro-environment. Another work is based on a stochastic model that

Figure 2: The user uses the grip button to grab items in the grocery store (left). When an item is put in the basket, it shrinks down and is removed from the shopping list (right).

Figure 3: The safe zone is green when the distance between users is greater than six feet. It gradually turns yellow during risky encounters (left) and red when the distance is close to zero (right).

simulates the spread of virus and the activity of mobile people [3], yet the equations for computing the infection state are unclear. In general, there does not yet appear to be sufficient scientific data to simulate real-time infection risk. Therefore, in this project, we shifted focus to objective metrics that are well known to be associated with increased infection risk.

3 VIRTUAL REALITY EXPERIENCE

The virtual reality experience is implemented in Unity 2019.4.11 and Steam VR, and therefore works with multiple PC-based virtual reality headsets. The multi-user platform is built using Photon Unity Networking 2 [1]. The application can achieve performance upwards of 90-120 frames per second, although results vary depending on the particular computer, graphics card, and headset. The shared virtual environment supports up to 20 concurrent live users. During our tests, the network round trip time on the client's end ranges from 50-60ms, and the variance ranges from 5-10ms. The environment is also populated with non-player characters that navigate through the environment to provide a challenge when no other users are present. They move among pre-defined waypoints in a predetermined order; however, we plan to implement agent path planning and local collision avoidance in the future.

At the beginning of the experience, users are presented with a shopping basket and a list of items. They are instructed to retrieve all the items in the shortest amount of time possible while maintaining a safe distance from other people. Users can freely move through the shared virtual environment using a controller thumbstick or clickpad. Forward and backward translation is accomplished using view-directed steering, and virtual rotation is implemented using snap turns in increments of 45 degrees.

Each user's list contains ten random items generated by the system and is displayed on a clipboard attached to a shopping basket held in the user's non-dominant hand. Users can pick up objects by grabbing them with the controller grip button, and large objects will be dynamically scaled down to a handheld size so they can be easily placed in the shopping basket. As objects are added or removed from the basket, the shopping list is dynamically updated. Items in the grocery store are organized by logical category, similar to how they would be placed in a real store (see Figure 2).

A virtual timer is attached to the non-dominant hand of the user's avatar. It is generally advisable to minimize time spent in public indoor spaces because the virus can remain suspended in aerosolized respiratory droplets for up to several hours. After the user retrieves all the items on the shopping list, they can exit the store, and the quantitative feedback about their risky encounters is provided.

4 RISK FEEDBACK

Real-Time Visualization   To provide real-time feedback about risky encounters, a visual effect can be displayed with a radius of six feet for each user. This represents the "safe zone" and is generated by an open-source Unity asset that provides various force field visual effects to change the appearance of a mesh. The color of the visual effect represents the minimum distance between the local user and all other users in the environment and changes dynamically (see Figure 3). The color is linearly interpolated between green (greater than six feet), yellow, and red (zero distance). The visual effect is rendered as semi-transparent to ensure that the user can see the color of the safe zone while being able to clearly see their surroundings.

Post-Experience Feedback   The system records a number of quantitative statistics to provide the user as a form of "after action review" when they exit the virtual store. For each user, we compute the number of unique people they were exposed to, the total number of risky encounters, and the shortest and average distance observed between the user and another person during risky situations. Since this is a multi-user experience, we also display the value and the rank of the current user among all previous users regarding total time spent in the store and the total elapsed time spent in risky encounters to provide a context through which users can interpret their individual statistics and compare their performance to other people. In both cases, shorter times are ranked higher. After the user exits the store, a summary board shows local user metrics and quantitative performance data aggregated from all previous users.

5 CONCLUSION AND FUTURE WORK

This project aims to contribute to ongoing COVID-19 prevention efforts by encouraging mindfulness of social distancing in shared public spaces. We presented a multi-user VR experience that simulates a grocery shopping task and provides a both real-time visualization feedback and a quantified summary with respect to the avoidance of situations associated with increased transmission risk.

Currently, the quantitative metrics computed by the system are intuitive, yet simplistic. We are interested in integrating more sophisticated models of virus transmission risk in indoor spaces when such scientific data becomes available. We also plan to conduct a study to investigate the effectiveness of virtual reality in promoting mindfulness of physical distancing when performing cognitive tasks such as shopping in shared public spaces.

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