Impact of Social Distancing to Mitigate the Spread of COVID-19 in a Virtual Environment

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ABSTRACT

A novel strand of Coronavirus has spread in the past months to the point of becoming a pandemic of massive proportions. In order to mitigate the spread of this disease, many different policies have been adopted, including a strict national lockdown in some countries or milder government policies: one common aspect is that they mostly rely around keeping distance between individuals. The aim of this work is to provide means of visualizing the impact of social distancing in an immersive environment by making use of the virtual reality technology. To this aim, we create a virtual environment which resembles a university setting (we based it on the University of Derby), and populate it with a number of AI agents. We assume that the minimum social distance is 2 meters. The main contribution of this work is twofold: the multi-disciplinary approach that results from visualizing the social distancing in an effort to mitigate the spread of the COVID-19, and the digital twin application in which the users can navigate the virtual environment whilst receiving visual feedback in the proximity of other agents. We named our application SoDAlVR, which stands for Social Distancing Algorithm in Virtual Reality.

CCS CONCEPTS

• **Human-centered computing** → **Information visualization**.

KEYWORDS

Virtual Reality, Digital Twin, Prototyping/Implementation, Usability Study, Simulation.

ACM Reference Format:
Diego Marti Mason, Matej Kapinaj, Alejandro Pinel Martínez, and Leonardo Stella. 2020. Impact of Social Distancing to Mitigate the Spread of COVID-19 in a Virtual Environment. In *26th ACM Symposium on Virtual Reality Software and Technology (VRST '20), November 1–4, 2020, Virtual Event, Canada.* ACM, New York, NY, USA, 3 pages. https://doi.org/10.1145/3385956.3422093

VRST '20, November 1–4, 2020, Virtual Event, Canada

ACM ISBN 978-1-4503-7619-8/20/11.
https://doi.org/10.1145/3385956.3422093

1 INTRODUCTION

To control the COVID-19 pandemic, governments worldwide adopted different measures, aiming at preventing gatherings and at keeping a physical distance between people. More specifically, one of these measures, namely *social distancing*, relies upon a safe space between different household members. As experts try to look for ways to go back to a "new normal" ensuring that a safe distance is maintained between individuals, we study the impacts of social distancing in an immersive scenario by developing an interactive application which makes use of Virtual Reality (VR). We called our application "SoDAlVR", which stands for Social Distancing Algorithm in Virtual Reality and includes the same root of sodality, i.e. community, brotherhood.

We used Unity to implement our application. Unity is a renowned game engine, used widely in the industry for a variety of purposes, spanning from games to VR applications. The use of an immersive environment to investigate crowd dynamics is not new, see [1] for an example in the context of emergency evacuations, and [2] for the modelling of crowd dynamics in a game theoretic framework. The environment is based on an educational institution (University of Derby), but it can easily accommodate an office setting or similar. Figure 1 shows one part of the building with the university logo. The building, with a U-shape form, consists of two doors, each situated at different ends, both being restricted to serve only one purpose, either entrance or exit. This approach is based on similar measures taken by other centres to avoid congestion at entry/exit points, such as supermarkets or cinemas, see [3].

Figure 1: Agents walking around the entrance of our scene.

The environment is populated with agents that roam around the scene with different goals, such as attending classes or interacting with one another in conversation. Each agent has random parameters such as speed, random goals and models, to increase diversity and player immersion. Our aim is to show the impact of social distancing, and therefore we used a variety of techniques to help the player visualize whether he/she is breaking the physical distancing policy. We assume that an ideal physical distancing is at least 2 meters as reported from the Centres for Disease Control and Prevention (CDC) in [4].

2 AGENTS MODELLING

Our agents are composed of various parts, these being navigation, infection data, and a state machine. To create the illusion of diversity and avoid agents looking identical to one another, we used eleven different models, in addition to have a range of speed between 1.5 m/s and 2.0 m/s and different goals.

The agents navigate the virtual environment following a graph of waypoints. We implemented a version of Dijkstra's algorithm tailored on our network graph, allowing agents to reach their goal waypoint via the shortest path. Waypoints are classified depending on their purpose: *spawn* - agents enter the scene through this waypoint; *normal* - a simple waypoint used for transitioning to another one; *speak* - a waypoint designated for agents to exchange conversations; *sit* - a waypoint where agents can stop and sit down on available chairs; *exit* - agents exit the scene through this waypoint. The state machine detects when the agent arrives to a goal so it can perform the next state, and the states are: *walk* - agents navigate to a random point; *sit* - upon arriving to a sit waypoint, the agent will sit down for at least 10 seconds; *speak* - upon arriving to a speak waypoint, the agent will wait for another to start a conversation whose duration is 15 seconds.

Agents are constantly spawning throughout the whole duration of the application, at a constant rate of 1-5 new agents every 10 seconds. And a maximum of 50 agents simultaneously. Each agent can exit the building and despawn with a base probability of 10%, increased by a further 10% after completing a goal.

Figure 2: Agents' outline: a yellow color denotes a distance between 2m and 1.5m, and a red color less than 1.5m.

(a) Yellow warning sign.

(b) Red warning sign.

Figure 3: Visual cues for the end user: a distance between 2m and 1.5m triggers a yellow warning symbol (left), whilst less than 1.5m the warning symbol is in red (right).

3 USER IMMERSION

The benefit of using VR in our application is to provide the user with a visual feedback on breaking the social distancing rules. The user can therefore visualize the social distance in two ways: between any two agents and between himself/herself and another agent. In both cases we use the same color palette: yellow for a distance between 2 meters and 1.5 meters, and red when the space less than 1.5 meters. In the event where three agents are relatively close to one another, and the first agent is closer than 1.5m to the second one and between 2m and 1.5m with the third one, the red outline is shown as it takes precedence over the yellow outline. Figure 2 shows the scenario between any two agents, where the yellow and red outlines provide a visual cue for the user. Figure 3 depicts the situation where the player gets closer to any of the agents, breaking social distancing policy with them.

To enhance the user experience and give clear feedback we use Spatial UI, displaying a warning sign on top of the agent's position when near the user. This Spatial element rotates towards the user position, so it is always visible from all angles.

The user can move through the environment using the Virtual Reality controller analog sticks. This project has been tested with the Oculus Rift S VR kit. To reduce motion sickness, a common side effect produced by Virtual Reality, we eased the user movement speed to $2m/s$, making a satisfactory user experience. The environment has been crafted to enhance the player experience and truly portrays the feeling of walking in a real educational institution. Our inspiration was based on the ground floor of the Markeaton St. campus at the University of Derby. The areas intend to represent a main reception, a canteen, the different classrooms and a long hall.

4 CONCLUSION

We have developed an digital twin application that serves as a utility tool to visualise the impact of social distancing in our day-to-day life through an immersive environment in VR. The application its made with modular systems allowing for other environment settings or different simulation parameters. This enhances the potential of our application as allow others to accommodate the simulation to suit its needs. Future works include the visualization of the epidemiological spread of the disease among the agents and the extension to an Augmented Reality application to expand the usability outside VR.

REFERENCES

[1] M. Moussaïd, M. Kapadia, T. Thrash, R. W. Sumner, M. Gross, D. Helbing and C. Hölscher, "Crowd behaviour during high-stress evacuations in an immersive virtual environment", *Journal of The Royal Society Interface*, vol. 13, no. 122, p. 20160414, 2016. Available: 10.1098/rsif.2016.0414.

[2] D. Marti-Mason, L. Stella and D. Bauso, "Evolutionary Game Dynamics for Crowd Behavior in Emergency Evacuations", in *Proceedings of the 59th IEEE Conference on Decision and Control*, 2020.

[3] *Cinemauk.org.uk*, 2020. [Online]. Available: https://www.cinemauk.org.uk/wp-content/uploads/2020/07/CINEMAS-keeping-workers-and-customers-safe-during-COVID-19-JULY-2020-V1.3.pdf. [Accessed: 13- Jul- 2020].

[4] *"Coronavirus Disease 2019 (COVID-19)", Centers for Disease Control and Prevention*, 2020. [Online]. Available: https://www.cdc.gov/coronavirus/2019-ncov/prevent-getting-sick/social-distancing.html. [Accessed: 24- Jul- 2020].