# Serious Game Development of COVID-19 Social Distancing Simulator using Agent-based Modelling

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*Abstract* — **A social distancing protocol has been acknowledged and encouraged practically everywhere, since the global COVID-19 epidemic in 2020. This research resulted in the Serious game to simulate social distance using agent-based modeling so that it can be used as a medium of entertainment and educate the public during the Pandemic COVID-19 conditions by developing simulation games using UNITY 3D to educate in the middle of the COVID-19 pandemic and reduce transmission rates on an individual scale.**

*Keywords* — **COVID 19, Serious Game, Social Distancing, Unity 3D.**

## I. INTRODUCTION

CORONAVIRUS (COVID-19) has been declared by the World Health Organization (WHO) as a World-Anemic Public Health Emergency (KKMMD) / Public Health Emergency of International Concern (PHEIC) in consideration of a significant increase in cases from countries reporting cases [1]. Communication is the most important part of dealing with the threat of epidemics by building public trust and guarding against panic in the community so that handling can proceed smoothly [1].

Sars-CoV-2 is the virus that causes COVID-19. COVID-19 exhibits general signs and symptoms of acute

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respiratory diseases such as fever and cough. While the incubation period is 14 days, the usual incubation duration is 5-6 days. COVID-19 can cause pneumonia, acute respiratory syndrome, kidney failure, and even death in severe cases. The most common signs and symptoms are fever, with shortness of breath in some instances, and X-rays indicating severe pneumonia in filtrates in both lungs [2].

COVID-19 is spread through other individuals and social interactions such as cough drops, sneezing, handshakes, clothing, cups, general touching, and behavior toward common objects due to the nature of vector transmission [3]. Then the practice of Social Distancing can be done as a change of behavior that can prevent transmission of the disease by reducing the level of contact between vulnerable individuals and infected individuals who can transmit the disease [4].

This paper simulates the practice of Social Distancing in 3D life simulation games using serious game media as a training and learning tool and agent-based modeling method used to describe agent models that interact with each other in simulations of transmission and behavior in public social distancing with a divsion into three agents, namely 1. Population Agent 2. Agent player 3. Infected agent [5]. Unity 3D version 2019 is a game development engine used by the author to build the game "COVID-19 Social Distancing Simulator". Unity 3D 2019 is the latest version of the Unity game development engine series, using the Unity 3D developer engine it can publish on various platforms, such as PC, Mac, iPhone, iPad, Android, and console devices, [6].

This paper is arranged as follows: Section II briefly presents the literature review of COVID-19 and Social Distancing, serious game and agent-based modelling Then, Section III describes the research methods, while the result and discussion are elaborated in Section IV. Finally, Section V provides conclusions and directions for future work.

## II. LITERATURE REVIEW

Before the research was conducted and a serious social grouping simulation game built, the authors had conducted a literature review based on existing research and findings were similar to the research conducted by the author and were divided into two types of themes, namely literature on COVID-19 along with social distance and the second was literature on serious game.

*A. Covid-19 and Social Distancing*

In the first literature, the author takes from a circular letter from the Indonesian republic of health minister regarding communication of the handling of coronavirus disease 2019 (COVID-19) which establishes COVID-19 as a disease that causes an outbreak and its mitigation efforts. According to this literature COVID-19 is a public health emergency that is troubling the world by WHO. In this literature, there are also various health protocols that must be obeyed such as public transport protocols and public areas, large scale event organizing protocols, market protocols, restaurant protocols, protocols in the educational institution, protocols in Indonesia, along with other information about handling distribution COVID-19 [1]. Although each infectious illness has its own unique characteristics, such as SARS or MARS, prevention and control are based on three factors: the pathogen, transmission channel, and susceptible population. Isolation is made up of three main components: discover and manage the source of illness; close the transmission channels; and safeguard the most vulnerable [12]. Surprisingly, the provinces and territories responded positively and swiftly when this plan was discovered. The residential zones also devised suitable transportation systems, such as restrictions on community activities, the use of social software to track each resident's movement ("Peduli Lindungi"), and the flow of people between different areas [13].

In the second part of the literature the author also obtained from the official document the guidelines for the prevention and control of coronavirus disease (COVID-19) issued by the directorate general of disease prevention and control in March 2020. This document describes the status of people who are in a COVID-19 pandemic, including patients under surveillance, i.e., people who have been infected and have symptoms such as acute respiratory infections, fever over 38oC, severe pneumonia, people in monitoring are people who have fever more than 38oC, people without symptoms are people who have no symptoms and are at risk of contracting it because they have made a contact close in the form of a physical contact or in a room within a radius of 1 meter with the patient's case under surveillance. This document also describes the home quarantine in the form of (Self Isolation), Quarantine special facilities such as COVID-19 emergency hospital and the last is hospital quarantine [2].

In the literature entitled The Effectiveness of Social Distancing in Mitigating COVID-19 Spread: a modeling analysis also raised social distancing on the COVID-19 pandemic which explains that there are 4 different social distancing steps for health authorities including school closures, closure of workplaces, isolating cases, and reducing contact with the whole community. The results of the simulation model carried out concluded that social distancing measures have a large effect on reducing the number of people infected in a pandemic situation [3].

This fourth literature also explains social distancing policy under the COVID-19 pandemic, this literature explains the aspects of social distancing that apply physical distance. Most respiratory infectious diseases can be prevented by social distancing, which involves keeping our distance about 1-1.5 meters between people. Distancing oneself from others is one of the most efficient ways to slow the transmission of the virus, which is conveyed by air droplets. Coughing, sneezing, and forceful speech all produce droplets with a particular transmission distance. We can block the virus from spreading if we retain this distance. [14]. The implementation of social distancing has been carried out in various countries, one of which is Indonesia, in addition to other protocols such as wearing masks and city disinfection [15]. Finally, this fourth paper has important implications for policymakers to adopt globally and can be used as an individual scale prevention method [7]. This is in accordance with WHO recommendations that nations improve case detection, track and monitor contacts, practice isolation from close contacts and isolate cases, as well as adopt traffic control and suspend big gatherings, in order to limit the disease [14].

*B. Serious Game and Agent-Based Modelling*

The first paper that discusses this serious game also has the same theme as the writer who uses the game as a social simulation medium that drives away the pandemic situation. This paper will explain how individuals will use social grouping and self-protection during epidemics. The epidemic is published by simple differential statistics and is mixed up by using differential games to get the potential value of social distance. The results of this study indicate that social research focuses on the analysis of pathogens [5].

The second paper also has similarities with the research conducted by the author and will be a serious game and modeling based on virus modeling agents in the middle of a pandemic. The background of this study is based on the epidemic of influenza cases on people's behavior from control measures. In the research carried out in the study, multi-agent modeling is done, namely, participation agents, agent rules that are in accordance with the rules of the agent, and the third is a virus. The results of this study are agents that will affect all social networked agents. Thus, the chosen agent increases in accordance with the number of agents who are rejected on their social networks [8].

The third literature has a function in the use of serious games that are used as educational media. In the literature "The Educational effectiveness of serious games" this paper discusses the review of video game modalities for learning to emphasize the serious aspects of play and the contribution of their pedagogies when they are integrated into the learning situation. We will also explain various approaches to serious game integration in the classroom. Finally, generating conclusions by describing serious game models and trends for education presented by several researchers as well as some recommendations for better exploiting these tools in a pedagogical context [9].

The next paper entitled "Concepts of Serious Game In Education" also uses serious games as a supporting media in education and in this literature the authors present various serious game concepts that can be used in

education by trying to develop models for adaptive education with the results of research that is to provide the first serious educational game version for adaptive Kurdish language learning by children [10].

In the fifth paper the authors also use serious games as education and training. In this literature they try to increase the interest of education and training by utilizing the latest simulation and visualization technology by contextualizing the experience of players in challenging and realistic environments, supporting cognition. This study presents the main mechanisms and models used in SG design, with a particular focus on assessment, feedback, and analytic learning. An overview of tools and models for SG design is also presented [11].

## III. RESEARCH METHODS

The research conducted by the author has eight stages as shown in Fig 1. In the first stage of the study, the authors conducted a literature review or study as a theoretical basis and initial research concepts and valid data to build a real simulation game with valid information. After studying the literature and collecting valid information, the next step is the writer starts to make a game "COVID-19 Social Distancing Simulator" which begins with making a game story and implementing it in the game that will be made. The third stage of the process of building various 3D human characters will be used in the game and grouped into three modeling agents. The writer's animation phase involves animating the human character to make it appear more lifelike and dynamic, as well as allowing it to interact with the player's character. Following the creation of the plot and the animation of the human character, the next stage is to create the environment in line with the game's tale. The author's environment is in the form of a 3D world so that the game's characters may explore the 3D world and mimic social distancing. The author uses three environments: the home environment, the city environment, and the store environment.

The game's next phase includes a range of background sounds that help to enhance the true 3D world and the player's sensation of presence. To create this UI, the author adds support for the game's user interface, focusing on the UI status bar, which shows the player's current health, virus infection, and symptoms caused by interaction with COVID-19 infected NPCs. In 3D space, the player may interact and move about.

## IV. RESULTS AND DISCUSSION

This chapter provides results from our experiments and is illustrated in Fig 2. In the first stage of the serious game development process with the title "COVID-19 Social Distancing Simulator" which determines the genre of the simulation game and at this stage the writer also determines the game's mission and game status.

The mission of this game is that the player must prepare the COVID-19 pandemic conditions for self-quarantine so the player must shop at the supermarket, but the player must explore the city with a large number of NPCs and the player must keep a distance from the crowd or personal with the NPC in the city. For the Game status, the writer prepares the health condition of the player's character which will decrease the player's health condition.

If the player has found the supermarket building, then the scene will move to the environment in the supermarket and the player must look for needs such as masks and pay to the cashier and will return home scene. When you get home, players can immediately wash their hands in the bathroom. After players wash their hands, the player's health condition will rise, and the level of infection and symptoms of COVID-19 also decrease. The plot Game Storyline is illustrated in Fig 3.

In the second stage, a variety of characters that will be in a 3D environment is developed and the authors group them into 3 types of 3D human characters, like the example in Fig 4 but the authors design the character of the player with the first person view mechanism.

In this second stage, the concept of agent-based modeling in designing Non-Player Character (NPC) into various agents with different conditions as well as do the Agent list as in table 1 List Agent and Condition.

TABLE 1: LIST AGENT AND CONDITION

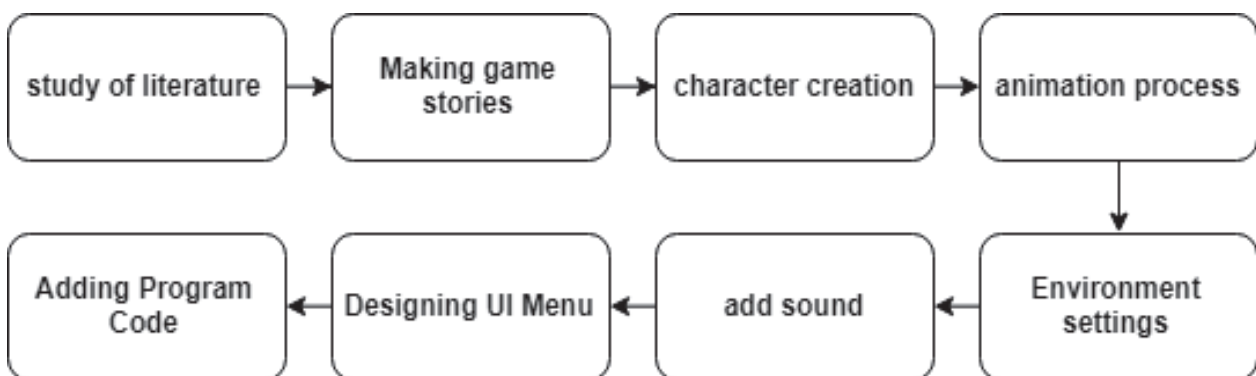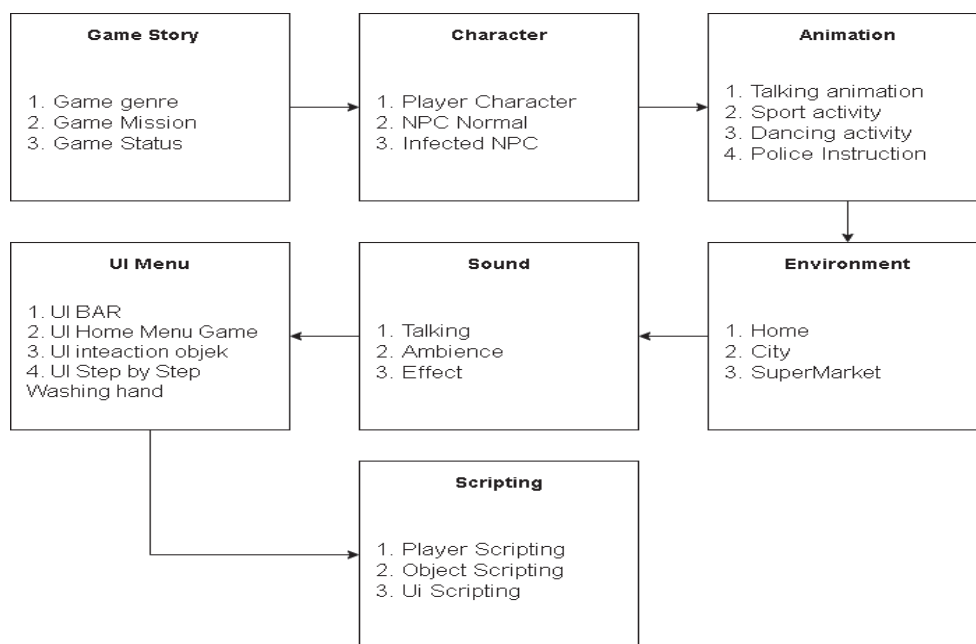| Agent | Condition | Total Character |
|---|---|---|
| Player Character | Potentially infected by covid-19 VIRUS | 1 Character |
| NPC Normal | Potentially infected by covid-19 VIRUS. | 35 Character |
| Infected NPC | Potential to Spread Covid-19 Viruses | 15 Character |



Fig. 1. Research Block Diagram.

**Game Story**

1. Game genre
2. Game Mission
3. Game Status

**Character**

1. Player Character
2. NPC Normal
3. Infected NPC

**Animation**

1. Talking animation
2. Sport activity
3. Dancing activity
4. Police Instruction

**UI Menu**

1. UI BAR
2. UI Home Menu Game
3. UI inteaction objek
4. UI Step by Step Washing hand

**Sound**

1. Talking
2. Ambience
3. Effect

**Environment**

1. Home
2. City
3. SuperMarket

**Scripting**

1. Player Scripting
2. Object Scripting
3. Ui Scripting

Fig. 2. Detail of Work Processes.

STATUS UP
health : 98
infection: 2
cough : 0
fever : 0
out of breath :0

washing hand

Home

Back to

MARKET

A group of human

Player

Start

Explore

Meet

Infected human

STATUS
health : 100
infection: 0
cough : 0
fever : 0
out of breath :0

STATUS DOWN
health : 90
infection: 10
cough : 3
fever : 5
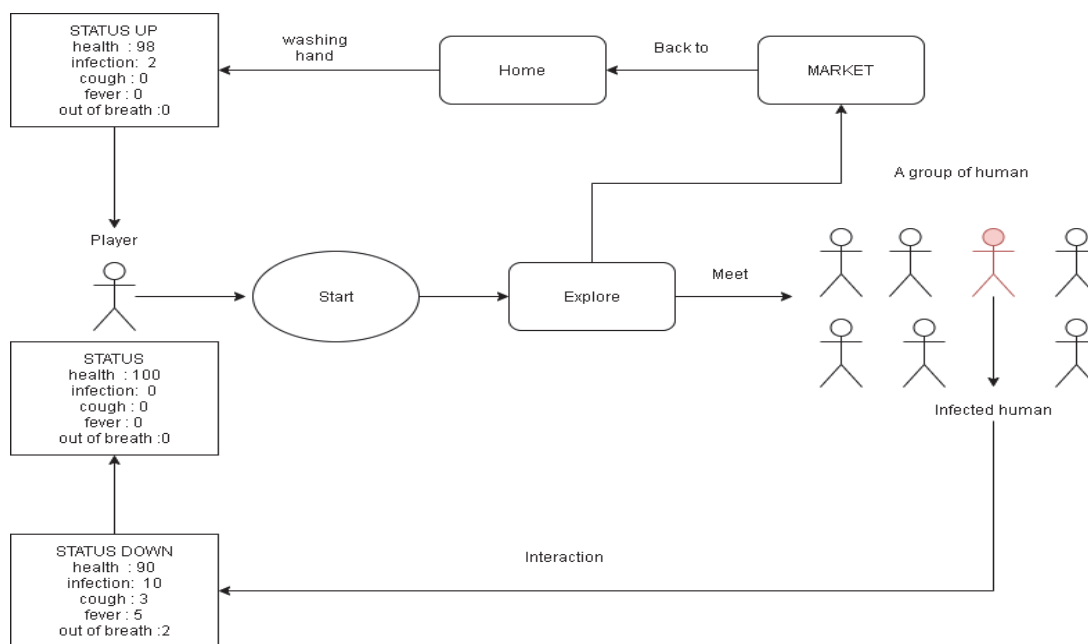out of breath :2

Interaction

Fig. 3. Research Block Diagram.

The first agent is the player character that can be controlled and can interact with the scope of the object and the NPC, for the condition of the player character has the potential to be infected with a total of one character. Player characters also carry out the mission given and simulate Social Distancing to avoid infection with the COVID-19 Virus with health conditions displayed in the form of UI.

The second agent is a normal NPC that is located and spread in the city environment and supermarket environment with a total of 35 characters, the second agent is also static - does not move and to animate the author's character to give animation to look alive, the normal NPC condition is the same as the Player's condition that is potentially infected with COVID-19 The last agent is Infected NPC, that is, NPC that has been infected with COVID-19 with the condition can spread the virus to the player character and Normal NPC, the number of characters is 15 characters and is placed at random locations either in groups or are single. The author also provides a simulation of Social Distancing into the trigger system in a circular shape and if a player's character enters the trigger then the player will be infected and will be displayed in Fig 5 Social Distancing trigger.

In the next stage, we have designed three environment locations, namely the house, the city, and the supermarket. The first environment tof the house was designed by the author focused on indoor with a variety of rooms. At this stage also the player gets a variety of information related to COVID-19 and quarantine needs. The home environment is shown in Fig. 6 Indoor home environment.

Fig. 4. Example 3D Human Character.



Fig. 5. Trigger Social Distancing.



Fig. 6. Indoor Home Environment.

The second environment shows the urban, in this environment, the player can also explore the city to carry out game missions and perform social distancing simulations and interact with NPCs and various objects. The Outdoor City Environment is shown in Fig 7.



Fig. 7. Outdoor City Environment.

The last environment is a supermarket where the character of the player buys various mission needs that are given. In this environment, social distancing simulation is also done. Indoor supermarket environment is shown in Fig. 8.

In the next stage, the variety of sound effects such as the sound of conversations between NPCs, the sound of the environment in each environment, and the sound when interacting with objects or activities such as opening doors, washing hands and other activities is developed.



Fig. 8. Indoor Supermarket Environment.

The author also made the UI to add display support for additional information in the game. UI that the author made is used for the main user interface of the game when opening the game and various menus to enter the game. The second UI displays the stages of washing hands as in Fig. 9 Example UI Washing Hands.
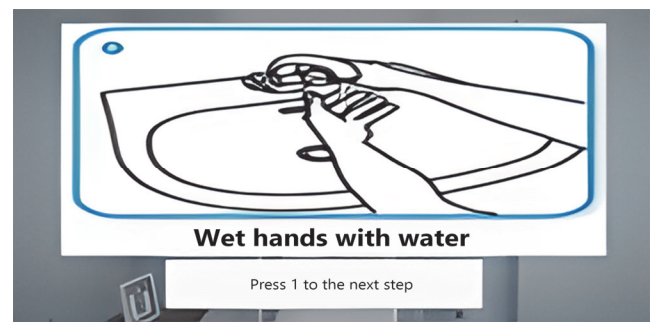


Fig. 9. UI Washing Hands.

The final stage of the development of the serious game "COVID-19 Social Distancing Simulator" is scripting to provide various interactions and controls on the character of the player. Scripting first is to give control to the character of the player that is using a first-person view system to improve the impression of the simulation so that players can feel realistically in playing. The next process involves the scripts on several objects such as doors that can be opened, some activities to display additional information such as washing hands or when shopping at supermarkets. And the final and main stage in the scripting process is determining the conditions on the character of the player consisting of health levels, infection rate, as shown in Fig 10.
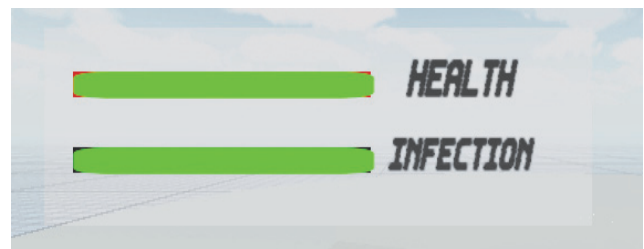


Fig. 10. Health and Infection UI Bar.

To provide additional information about COVID-19, the author also provides a UI Bar for the level of symptoms consisting of cough levels, fever rates, and shortness of breath, as shown in Fig. 11.

Each bar has an initial value and the value when the condition is infected due to not doing social distancing, as the author shows in Table 2.
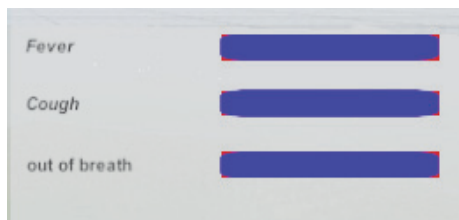
Fig. 11. Fever, Cough and Out of breath UI Bar.

TABLE 2: UI VALUE BAR

| Bar | Initial Value | Infected Value Condition |
|---|---|---|
| Health | 100 | 90 |
| Infected | 0 | +10 |
| Fever | 0 | +5 |
| Cough | 0 | +3 |
| Out Of Breath | 0 | +2 |

In conditions when the player's character interacts or when the player passes the trigger social distancing, the value of the bar will change, and the author performs a manual calculation of changes in the level of values that exist on the bar with the equation as follows:

$$\frac{Infection}{Fever + Cough + OutofBreath} = Damage \quad (1)$$

If you enter a value after the player's character violates social distancing and enters the trigger it will be like in equation 2.

$$\frac{10}{5+3+2} = 7 \quad (2)$$

So, when the player's character violates social distancing and enters the trigger NPC that has been infected, the player's UI health bar level which has an initial value of 100 will decrease by 7 points and the Infected Bar point increases by 10 points, followed by the increase in UI Bar Fever, UI Bar Cough, and UI Bar Out of Breath. For the value given to the three symptoms such as fever, cough and out of breath varies because the authors adjust to the condition of the initial symptoms that appear and are easily detected such as high fever, coughing and the last is shortness of breath in patients with COVID-19.

## V. CONCLUSION

The serious game development process with the title "COVID-19 Social Distancing Simulator" has some stages. In the first stage one determines the genre of the simulation game, the game's mission and game status. In the second stage, a variety of characters that will be in a 3D environment into 3 types of 3D human characters is developed. The third stage involves designing three environment locations, namely the house, the city, and the supermarket. In the next stage, the author provides a variety of sound effects such as the sound of conversations between NPCs, the sound of the environment in each environment. In the final stage, the authors do scripting to provide various interactions and controls on the character of the player.

Based on the research that has been done, the authors conclude that Serious Games can be used as a medium of entertainment and educating the public during the Pandemic COVID-19 conditions by building simulation games related to behavioral changes in the middle of the COVID-19 pandemic and reducing transmission rates on an individual scale. With the game of COVID-19 Social Distancing, it can help the community how the social distancing process and based on valid information will get a real simulation with additional information such as the distance between individuals and the level of symptoms that arise and within a certain period of time. So that in subsequent studies it can be developed further with many additional features not only limited to social distancing simulations but also to include a quarantine simulation processes carried out during the pandemic.

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