Serious game to simulate and raise awareness about accessibility problems in the urban context

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Abstract. *The lack of accessibility in urban areas reinforces the need to develop solutions that contribute to understanding the difficulties faced by people in wheelchairs. Many existing solutions present concepts related to the topic in a non-intuitive way, without worrying about user involvement and immersion. This work is a serious game developed to simulate and expose these main challenges through the use of concepts of immersion, simulation, and player experience. Aimed at teenagers and young adults who have access to a mobile device, the objective is to improve the user's understanding by subjecting them to a three-dimensional environment close to reality. WheelChair Simulator was developed to be used as a complementary tool in various use cases, such as schools and environments that encourage this type of theme, in a practical and accessible way. Finally, it is expected that the game will be evaluated in the future by potential users.*

Keywords *Serious games, Acessibility, Simulation, Mobile.*

1. Introduction

Serious games are tools created to entertain, but also train, teach, and guide the player on a specific topic [Loh et al. 2015]. One of the main characteristics of these games is to attract and provide immersion to the player, while a clear and objective message is transmitted.

Studies on the use of serious games to raise awareness of urban problems have become relevant in recent years [Ampatzidou 2020]. Furthermore, serious games are seen as an instrument to help understand accessibility problems involving people with disabilities. Such applications aim to efficiently raise awareness among the population about the difficulties encountered in the daily lives of those with reduced mobility, including allowing participation in urban planning [Aguilar et al. 2021].

This work aims to present the serious game WheelChair Simulator developed to raise awareness about the difficulties encountered in large urban centers by people dependent on wheelchairs. The game was developed to simulate everyday situations that are common and impair the mobility of wheelchair users, such as the presence of stairs, sidewalks, and uneven floors. Aimed at teenagers and adults who use mobile devices, WheelChair Simulator is a third-person game developed in Unity and can be used in educational environments or discussions about accessibility and urban mobility.

2. Related Work

The serious game *Incrusive* [Barbosa et al. 2022] addresses the issue of lack of accessibility and the challenges involving real environments not prepared for the mobility of people with physical disabilities. The 2D game was developed on the Unity platform and has as its main character a wheelchair user, whose mobility problems are presented throughout the game. These challenges were developed in the form of questions, the user of which has three alternative answers. With each correct answer, alternative paths are released for the character's movement.

The authors of the game *Metropolis* [Aguilar et al. 2021] focused on simulating the construction of a smart city, the objective of which is for the user to collectively plan the successful growth of a city's communities. All players have equal importance in the construction and administration of the metropolis, allowing the player to learn to think collectively and make decisions based on this learning.

SmartWheels [Mascetti et al. 2020] is a tool whose objective is to detect urban characteristics based on the analysis of sensor data produced by wheelchair movements. Based on the data collected, this application aims to use the information generated by the sensors to complement the calculation of navigation routes for other users. Therefore, detection is carried out automatically and without human intervention.

3. Metodologia

For the development and execution of the WheelChair Simulator, the Unity game engine [1] was used, which was considered as a platform for the development of all modules that make up the game. Furthermore, the scripts for the modules and objects to function were created in C# language. The justification for this choice is that both the graphics engine and the language have extensive documentation for the development of complex three-dimensional environments aimed at mobile devices. Finally, all 3D models used were made available by the Unity Asset Store [2], a store of exclusive resources and tools for the selected graphics engine.

For better understanding, the development phases were separated into four parts. They are: User Interface (UI) Module, Control Module, 3D Environment Module, and Progression Module. Each of the modules is described and explained below

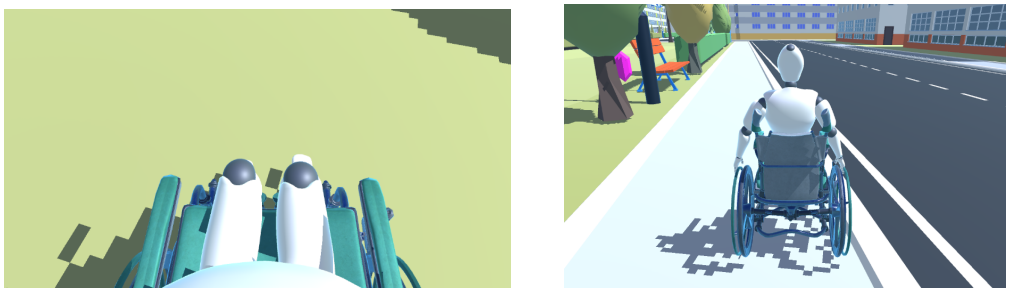
The UI Module is responsible for displaying all the necessary information so that the player can interact with the system and understand the proposed theme. It is also responsible for navigation between all created scenes, and the first scene presented to the player is the Main Menu, whose objective is to provide the user with the following options: start, access the tutorial, or close the application.

The Control Module is the main component of the game, as it is mainly responsible for controlling the character during his adventure in the main scene. Furthermore, two camera options can be used when developing a game: first-person and third-person. When using first-person cameras (Figure 1a), a much greater degree of immersion is obtained, as the objective is to simulate human perception according to the real view of the environment. However, due to the large amount of details present in

[1]Unity: https://unity.com/pt

[2]Unity Asset Store: https://assetstore.unity.com/

the game, as well as the correct perception of the functioning of the wheelchair, it was decided to use the third-person camera (Figure 1b).



(a) First-person. (b) Third-person.

Figura 1. Cameras to the character.

The main concept of the game is to simulate the real difficulties and challenges that people who use this type of device encounter daily. Therefore, Unity components called Wheel Colliders were added to the 3D model of the chair. Such components are commonly used to simulate the physics behind racing, and therefore, for the present serious game, it was possible to simulate the behavior of wheels using the graphics engine itself. Furthermore, these components are extremely customizable, which helps to move the wheelchair as close to reality as possible.

To further improve immersion, the 3D Environment Module contains a virtual environment that simulates a real urban center, as seen in Figure 2. To compose the environment, three-dimensional models were used that represent buildings, trees, and other elements that simulate a city. Therefore, the challenge of the game is to move the character with his wheelchair around the urban center, without having any accessibility infrastructure.

Figura 2. Virtual urban environment developed for this serious game.

The Progression Module is responsible for creating consumable objects positioned throughout the scenario, for the player to collect and explore the virtual environment while earning points. Although the player has a complete scenario at their disposal for exploration, during movement, challenges related to lack of accessibility are faced. Finally, it was necessary to find a balance in executing these challenges so that the player's motivation remained high [Vorderer et al. 2013].

For each object collected, ten points are added to the player's score. Furthermore, to encourage the execution of the various challenges while exploring the city, some collectibles are worth double, or even triple, points, depending on where they are positioned. For example, objects positioned at the top of stairs, on paths with uneven surfaces, or in places with intense vehicle traffic, when collected, are worth more points than objects located in easily accessible areas. Such strategies allow the player to develop a sense of risk and reward, making decisions that can easily be compared to decisions in the real world, where the same problems of urban accessibility are presented. Figure 3 presents an example of a collectible object that can be collected during the game.

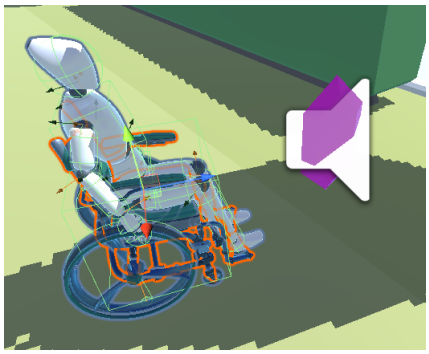


Figura 3. Example of a collectible object.

4. The game

The WheelChair Simulator aims to highlight and report urban accessibility problems through a simulation. It was developed for a target audience of young people and teenagers between 14 and 25 years old. This choice was made due to the ease that this age group has in handling mobile devices, as well as the high probability of this audience being inserted in educational institutions, facilitating the reach and dissemination of the game.

The game was developed based on the simulation genre, whose aim is to subject the player to situations consistent with reality, and which require decision-making for various events related to the real world. To run the game, the platform was chosen for mobile devices, with the Android operating system being chosen. The motivation for this choice lies in the high use of these devices in people's daily lives, as well as the possibility of accessing the game as complementary material for classrooms, lectures, and discussion groups.

Character control is done using buttons at the bottom of the screen (Figure 4), which are:

- Upper arrows: the character exerts forward force depending on the side on which the button was pressed;
- Lower arrows: the character exerts force backwards depending on the side on which the button was pressed; and
- Central bar: whose braking system is activated, allowing the player better control.

It is worth mentioning that the combination of pressed arrows can result in the application of real physical laws, which guarantees the character's movement in

Figura 4. City and UI.

accordance with the movement of a wheelchair user in the real world. This approach allows the player to be introduced to real consequences resulting from a lack of urban accessibility.

The main character in the game has a physical disability that limits his movement, relying on a wheelchair for mobility. The character's animations are aimed at realistically portraying wheelchair movement, focusing on arm movement to control the chair. The design of the character emphasizes the challenges faced by individuals with limited mobility. Therefore, appearance, and dialogues were not the primary focus of the game, which aims to showcase the character's movement in a virtual urban setting.

5. Conclusions and Future Works

The present work sought to present the development of a serious game whose objective was to highlight the lack of accessibility in the basic infrastructure of urban centers, as well as to make the player aware of the importance of the topic. The WheelChair Simulator game features a character in a wheelchair who is controlled using buttons that allow him to move around the virtual environment. Thus, the player needs to move the character without relying on access ramps or any other type of tool that facilitates locomotion.

The development of the game was characterized by the use of important technologies, such as the Unity platform combined with AI. The game has resources that allow the player to understand in an immersive way the difficulties encountered by people with physical disabilities, fulfilling the objective of disseminating reliable information about this problem.

For future work, it is suggested that the game be applied to teenagers in a school environment, as well as to young adults during lectures and discussion groups on the topic. The game would be evaluated and changes would be made according to observations made during application. It is also suggested that the game be applied to Virtual Reality (VR) devices, whose objective is to achieve immersion, involvement, and interaction between the player and the environment. Finally, it is possible to apply other scenarios to simulate different situations in which a lack of accessibility is unfortunately common.

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