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3D Avatar Customizer for Multiplayer Endless Runner Game

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***Abstract*—This study investigates the integration of a 3D avatar customizer within a multiplayer endless runner game, focusing on the designing and integration process. Utilizing the Ready Player Me SDK, players can create avatars based on their photographs, potentially can foster a deeper connection between players and their in-game representations. The game is developed using the Unity engine, with the Mirror library implemented to facilitate real-time multiplayer interactions. The study outlines the design and functionality of the game, including features such as avatar customization, single-player and multiplayer modes, and user interfaces (UI). Results show effective integration and functionality demonstrating successful integration of the 3D avatar customizer and multiplayer elements, as well as the smooth operation of the game mechanics and user interface.**

***Keywords*—3D Avatar, Avatar Customizer, Endless Runner Game, Multiplayer**

I. INTRODUCTION

The development of a 3D Avatar Customizer for a multiplayer endless runner game represents a significant advancement in the realm of interactive gaming, particularly in enhancing player engagement and personalization. Avatars serve as crucial extensions of players' identities within virtual environments, allowing for self-expression and emotional connection. Research indicates that customized avatars can lead to increased physiological arousal and a sense of affinity, thereby enhancing the overall gaming experience [1]. The ability to create and modify avatars not only fosters a deeper connection between players and their in-game representations but also impacts their enjoyment and identification with the game [2], [3].

Recent advancements in artificial intelligence and machine learning have paved the way for sophisticated avatar creation systems. For instance, AvatarCLIP [4] utilizes a vision-language model to enable users to generate 3D avatars based on natural language descriptions, making the customization process accessible to non-experts. This democratization of avatar creation is crucial in multiplayer settings, where diverse player backgrounds and preferences can be accommodated, thus enriching the gaming community [5]. Moreover, the integration of 3D modeling techniques allows for high-quality, expressive avatars that can adapt to various gameplay scenarios, enhancing the immersive experience [6], [7].

The psychological implications of avatar customization are profound. Studies have shown that players who engage in avatar personalization report higher levels of identification with their avatars, which can lead to increased loyalty and sustained engagement with the game [3], [8]. Furthermore, the customization process itself can serve as a form of self-affirmation, allowing players to explore and express aspects of their identity that may not be as easily conveyed in the real world [9], [10]. This aspect is particularly relevant in multiplayer games, where social interactions are integral to the gameplay experience [11].

Therefore, the introduction of a 3D Avatar Customizer for a multiplayer endless runner game not only enhances player engagement through personalization but also leverages cutting-edge technology to create a more inclusive and dynamic

gaming environment. By allowing players to craft avatars that resonate with their identities, the game can foster deeper connections among players, ultimately enriching the overall gaming experience.

The paper is organized with an overview of background on avatar customization and multiplayer game development. This is followed by the game design details, including mechanics and flow. The integration of 3D avatar customizer with the multiplayer game components is then explained. The results highlight the graphical interfaces and multiplayer features. The paper concludes with a summary of the findings.

II. BACKGROUND

The digital entertainment landscape has evolved rapidly, with video games and virtual environments becoming central to leisure activities. Avatars, as digital representations of players within these spaces, have a significant impact on game enjoyment and immersion [12]. They shape user experiences and influence engagement levels, often serving as a medium for players to project aspects of their identity [13], [14]. The customization of these avatars is crucial, as it allows players to personalize their in-game representation, enhancing emotional investment and immersion [15], [16].

Multiplayer gaming, in particular, has expanded opportunities for real-time interactions and competitive experiences. Research highlights the importance of these dynamics in shaping player engagement and social interactions [17]. Multiplayer games foster positive social connections and cooperative experiences, promoting teamwork and friendly competition [18], [19]. However, implementing seamless real-time interactions, especially in fast-paced competitive scenarios like racing and endless runner games, presents ongoing technical and design challenges [20], [21].

Managing various game elements such as audio, visual effects, animations, and user feedback is a crucial task for developers, as these components significantly impact player experience [22]. Studies emphasize that maintaining thematic consistency and coherence among these elements enhances immersion, motivation, and overall player engagement [23] [24]. For endless runner games, these factors must be strategically integrated to deliver a visually appealing and engaging experience, particularly when coupled with a customizable avatar system that allows players to personalize their in-game characters, thus enhancing their emotional connection to the game [25], [26].

III. DESIGNING ENDLESS RUNNER GAME

The design and development of the endless runner game focus on creating an immersive environment and a smooth gameplay experience, with particular attention to integrating customizable 3D avatars for a multiplayer setting. This section outlines the processes involved in crafting the game scene environment, integrating assets, and building the core game mechanics using the Unity Engine.

First, the game scene environment design is undertaken to establish the visual style and interactive elements of the game. This includes the creation of 3D environment models such as obstacles, world backgrounds, and terrains, all of which contribute to the immersive experience and functionality of the game. Where available, assets will be sourced from online repositories, including free-source websites and the Unity Asset Store, to ensure resource efficiency. If suitable models are not found, 3D modeling software like Blender will be used to create custom assets, ensuring they meet the game's design and thematic requirements.

The player avatar animations are sourced from Mixamo [27], an online platform offering a library of free animations compatible with Unity. Utilizing Mixamo allows for quick integration of high-quality animations, ensuring fluid and realistic movements for the avatars, which is essential for enhancing player engagement and immersion. These animations will be integrated with the 3D avatar customizer to support various player-driven customization options.

Next, the base game development takes place using the Unity Engine. All the designed scenes, assets, and interfaces will be integrated into the Unity project to form the core structure of the endless runner gameplay. This process involves building a functional single-player endless runner game as the initial foundation, which will later be expanded into a multiplayer format. The basic game flow, which includes continuous player movement, obstacle navigation, and point collection, follows the established mechanics of the endless runner genre. Fig. 1 below illustrates the initial game flow structure, highlighting the sequential and repetitive nature typical of endless runner games.

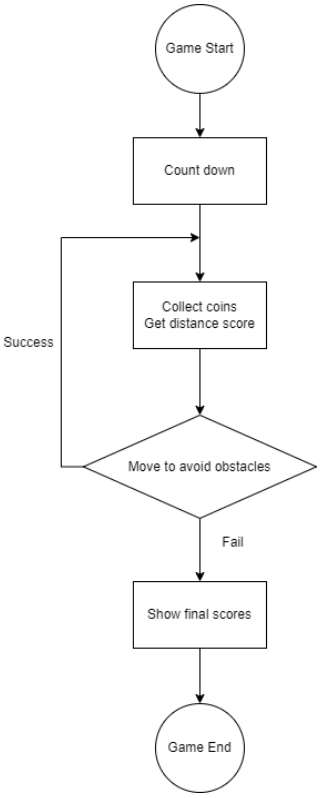


Fig. 1. Flowchart of one round gameplay of single player mode

Fig. 2 illustrates the Entity-Relationship Diagram (ERD) for the database structure used in this project. The database has been designed to efficiently manage and store data for both the Player and the Endless Runner Game, facilitating real-time updates and enhancing the overall gameplay experience, especially in the multiplayer context.

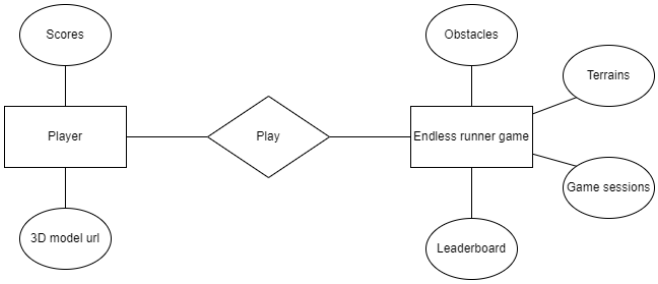


Fig. 2. ERD illustrates the database structure for endless runner game

The Player entity represents each individual who participates in the game. This entity includes several key attributes, such as the player's unique ID, score, and the Uniform Resource Locator (URL) for the 3D model representing their customized avatar. The score attribute tracks the player's performance, updating automatically after each game session. This dynamic updating mechanism allows for precise tracking of player progress over time, providing insights into their improvement and engagement with the game.

The 3D model URL attribute is particularly important for the customization aspect of the game, which is a core feature. This attribute stores the link to the player's current avatar design. Each time a player customizes or modifies their avatar through the avatar customization interface, this URL is updated to reflect the latest version. By storing this information in the database, the system ensures that the player's personalized avatar is accessible and can be loaded seamlessly in-game, providing consistent and immersive experience tailored to each player's preferences.

The Endless Runner Game entity encompasses the game's structure and its components, including various obstacles, terrain types, and other in-game assets. This entity manages data related to the game environment, ensuring that different combinations of obstacles and terrains can be dynamically generated during gameplay to maintain variety and challenge for the players. The asset data stored within this entity allows the game engine to access and render these elements efficiently, contributing to a smooth and visually engaging gaming experience.

In addition, the Endless Runner Game entity tracks multiplayer game sessions, which are essential for supporting the multiplayer mode of the game. For each session, relevant information such as the players involved, their scores, and their interactions during the session are recorded. This session data is crucial for managing the state of the game in real time, allowing players to join, leave, or continue sessions without disrupting the overall gameplay.

The database also supports a leaderboard system, which is designed to update dynamically based on the outcomes of each game session. The leaderboard ranks players based on their performance metrics, such as high scores and win rates. This functionality enhances the competitive aspect of the game, motivating players to improve their skills and engage more actively with the multiplayer features. The leaderboard information is stored and retrieved efficiently, ensuring that players can view the latest rankings immediately after each session.

IV. INTEGRATE 3D AVATAR CUSTOMIZER FOR MULTIPLAYER RUNNER GAME

In this section, the integration of a 3D avatar customizer into the multiplayer endless runner game is detailed. This process involves combining multiplayer functionality with a personalized avatar system, enhancing the overall gaming experience by allowing players to interact with avatars that resemble their own likeness. The implementation of the multiplayer competitive feature uses the Unity library called Mirror, which simplifies the development of real-time multiplayer games by providing built-in functionalities for managing player connections and synchronizing game states. The first step involves installing the Mirror package from the Unity Asset Store, enabling multiplayer support within the Unity project. Next, a *NetworkManager* script is created to manage network communication, player connections, and disconnections. This script acts as the core component for handling multiplayer sessions, ensuring smooth communication between all players. The networked logic of the game is then implemented, synchronizing player avatars, movement, and scores across all connected players. Events such as when a player joins or leaves a game session are managed within this setup. The game flow for the multiplayer mode of the endless runner game, shown in Fig. 3, illustrates how players interact and compete in real-time.

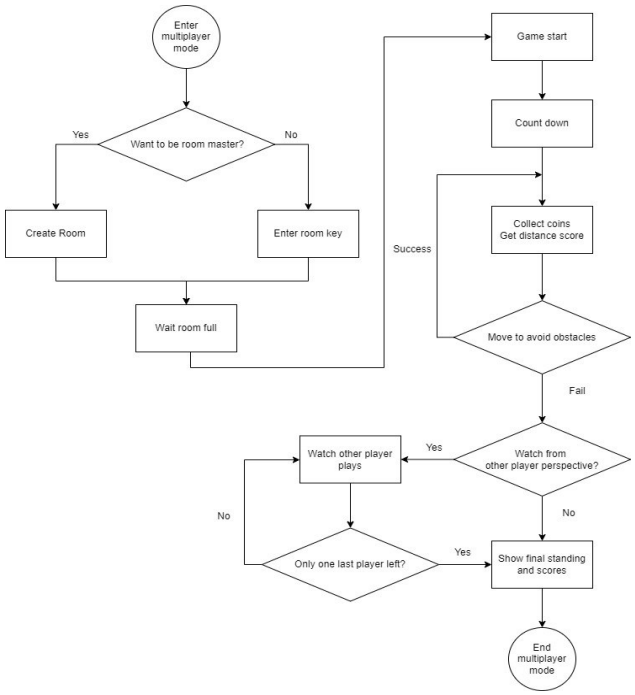


Fig. 3. Flowchart of one round gameplay of multiplayer mode

The 3D avatar customization uses a software development kit (SDK) called Ready Player Me [28], which provides tools for generating personalized 3D avatars based on the player's face. Upon accessing the avatar customization feature, the player is prompted to take a selfie using their phone camera, and the system, after receiving the player's permission, sends this image to the Ready Player Me API. The API processes the picture to generate a 3D avatar that closely resembles the player's facial features. This avatar is then integrated into the game, allowing players to see a digital representation of themselves as they navigate the endless runner environment. Once both the avatar customization module and the game module are complete, the integration phase begins. This phase involves combining both modules to create a unified experience, with additional interfaces introduced to accommodate the avatar customization feature, ensuring a seamless transition between gameplay and avatar personalization. The updated user interface flow, outlined in Fig. 4, shows how the game's menu system guides players through different options and gameplay modes.

At the start, the game presents the main menu, where players can navigate through various options, including instructions on gameplay, avatar customization using a selfie to generate and modify a 3D avatar, and settings for audio and graphics. For gameplay, players can choose between single-player and multiplayer modes. In single-player mode, players aim to navigate obstacles and achieve high scores, which are displayed at the end of the session before returning to the main menu. In multiplayer mode, players can either create a room or join an existing one using a room number, leading to a real-time competitive session. At the end of the multiplayer session, all players' scores are displayed, and they return to the main menu. The interface structure, which also includes an exit option to close the game, ensures that players can easily access instructions, customize avatars, adjust settings, and choose gameplay modes, creating a user-friendly environment tailored to their preferences.

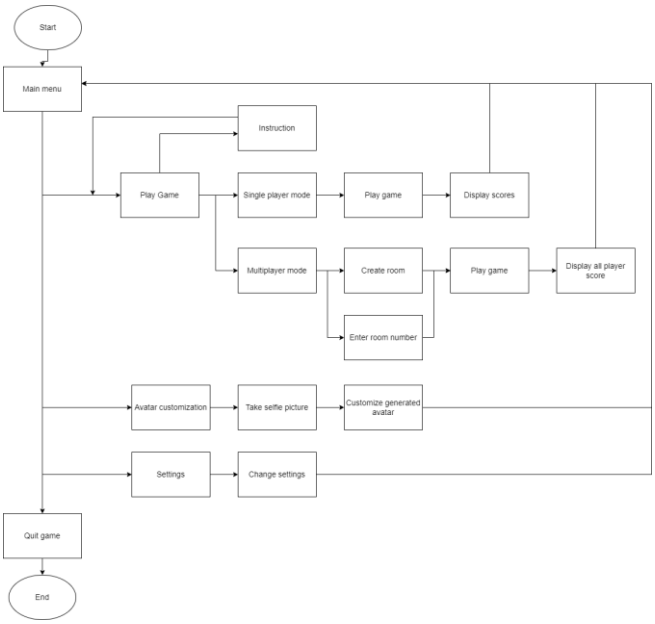


Fig. 4. Flowchart of user interfaces

V. RESULT

This section presents the outcomes of integrating the 3D avatar customizer and multiplayer functionalities into the endless runner game. The results demonstrate the effectiveness of the game interface in supporting player interactions and avatar customization, confirming the functionality and user flow as designed.

The start screen, shown in Fig. 5, displays the implemented game title and buttons such as Play Game, Avatar, Settings, and Quit Game. Each button will successfully lead to its respective function, confirming that the interface correctly navigates the player through various options. The Play Game button leads to the Game Mode Screen (Fig. 6), allowing the player to choose their play mode. The interface's responsiveness to these selections verify that the navigation and options operate as intended.

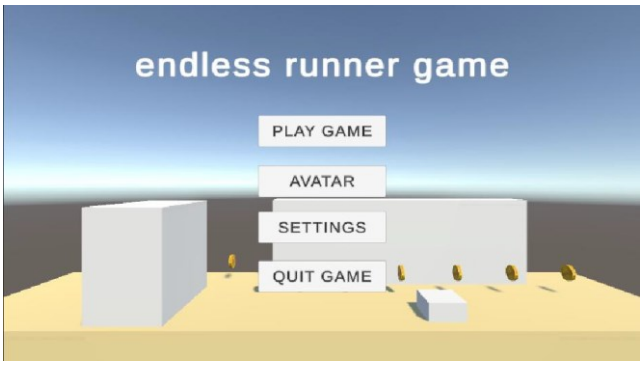


Fig. 5. Start screen interface

Fig. 6. Setting screen interface

In Fig. 7, the Game Mode Screen provides three functional buttons: Instruction, Single Player, and Multiplayer. Each button performs its intended task, with the Instruction button displaying gameplay information, the Single Player button starting a single-player session, and the Multiplayer button offering room creation or entry based on a code. These interactions ensure that players can access and switch between modes seamlessly.

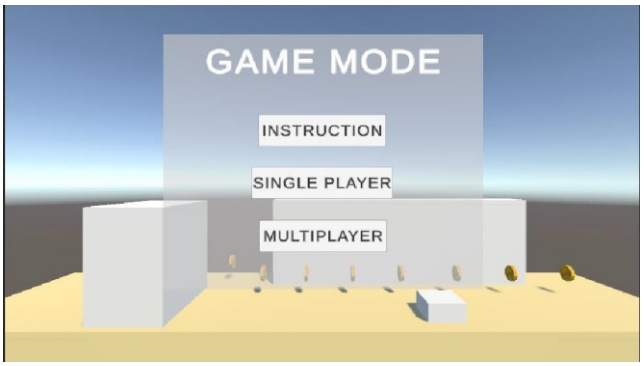


Fig. 7. Game Mode screen interface

Fig. 8 depicts the avatar creation screen, where players can upload a photo or take one via the device camera. This feature successfully integrates with the Ready Player Me SDK, generating avatars that match the player's appearance based on the uploaded image. Subsequent customization options allow players to modify the avatar as shown in Fig. 9, verifying the customizer's ability to provide an interactive and user-friendly experience. Once completed, the avatar is saved and set as the main character for the gameplay sessions.

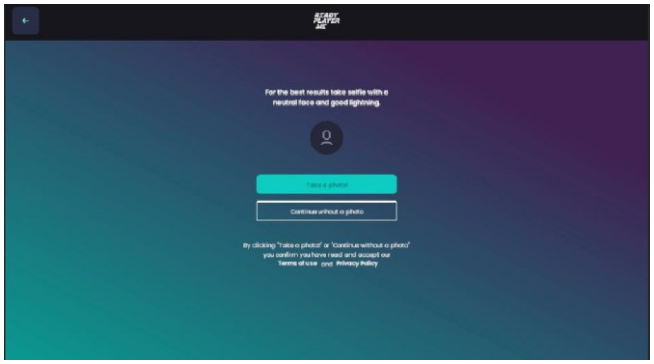


Fig. 8. Avatar Creation Screen

Fig. 9. Generated Avatar and Customization Screen.

The single-player mode and its game loop, as outlined in Fig. 1, function as designed, providing consistent feedback and score tracking during gameplay. This demonstrates the effectiveness of the mechanics in maintaining a coherent and engaging game cycle.

In Fig. 10, the player performs a swipe-up gesture to make the avatar jump over obstacles within the game environment, showcasing the responsiveness of the controls and the dynamic interaction between the player's input and the avatar's movement. This demonstrates the game's ability to recognize and respond to player commands accurately, enhancing the immersive experience.

Fig. 10. Player swipe up to jump over obstacles

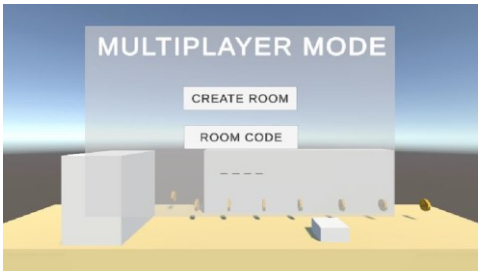
Fig. 11(a) shows the scenario where the player fails to avoid obstacles, resulting in a collision that affects gameplay, indicating the consequences of in-game actions and the importance of timing and precision. Fig. 11(b) displays the scores screen, where the player's performance is evaluated and presented based on their progress and achievements, ensuring that feedback is provided in a clear and structured manner.

(a)

(b)

Fig. 11. Player (a) failed to avoid obstacles. (b) game over and show scores

The functionality of the multiplayer room creation and joining processes is confirmed in Figs. 12. Players can create rooms or join existing ones using room codes as shown in Figs. 12(a), and the room owner can effectively manage the session by starting the game once all participants are ready as in Figs. 12(b). These results verify that the multiplayer infrastructure supports real-time interactions and player management, which are critical for competitive play.



(a)

(b)

Fig. 12. Player swipe up to jump over obstacles

The multiplayer in-game screen, shown in Fig. 13, depicts avatars interacting within the game environment, validating the synchronization of player avatars in real time. The final screen in Fig. 13 displays player rankings and scores accurately after the multiplayer session ends, confirming that the leaderboard updates and game session management function as expected.

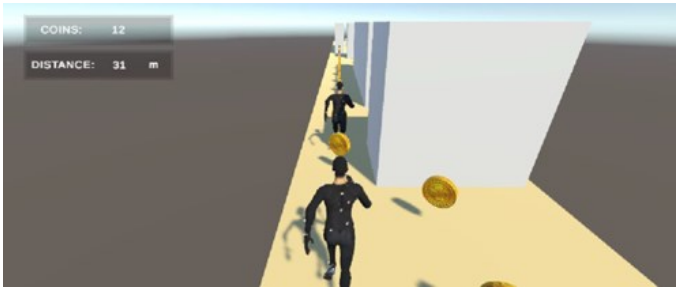


Fig. 13. Multiplayer in-game screen

Fig. 14. Leaderboard score in multiplayer mode

Overall, the results confirm that the avatar customizer and multiplayer functionalities are effectively integrated into the endless runner game, providing a cohesive and engaging user experience across both modes.

VI. CONCLUSION

This study successfully integrated a 3D avatar customizer and multiplayer functionalities into an endless runner game, demonstrating the feasibility of combining personalized avatars with competitive gaming environments. The implementation of features like real-time multiplayer interaction, avatar creation based on player photos, and customizable game interfaces provides players with immersive and engaging experience. The results confirm that the designed mechanics, navigation options, and interface components operate as intended, offering cohesive gameplay experience.

For future work, conducting a comprehensive evaluation of the game's user experience (UX) and user interface (UI) design is recommended. This could involve usability testing and collecting player feedback to identify areas for improvement. Refining the UI elements and interactions based on these insights would enhance player engagement and study the effect of how avatar customization can affect players psychologically hopefully can be a meaningful dimension and can be further explored., optimize the customization process, and ensure a more seamless and enjoyable gaming experience.

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CONFLICTS OF INTEREST

The author(s) declare(s) that there is no conflict of interest regarding the publication of this paper.

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