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Virtual Reality Skateboard Extending Metaverse

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***Abstract* – Implementing a virtual reality skateboard which would be further expanded into the Metaverse, a cyberspace where multiple people can come together and interact virtually. Further implementation of this VR experience into the Metaverse will be conceptualized in the research paper published along with the project. The motive behind the project was to let people experience certain activities which are hard to realize in the physical world. Our project consists of 2 parts, hardware, and software. The hardware consists of a skateboard, Arduino, VR headset, jumper wires, mini breadboard, an HC-06 Bluetooth module, an MPU-6050 accelerometer or gyro, and a 9V battery with a battery box that has an on/off switch and a barrel plug (to power the Arduino board). Software is a mobile application that is developed using the Unreal Engine, on which the terrain is built and the user wearing the VR headset can experience the virtual world thus created. The software and hardware will be connected using the plugins which are available in Unreal.**

***Keywords* – Metaverse, augmented reality, IoT, VR headset, Game Based Learning (GBL), Arduino, Unreal, Virtual Reality**

I. INTRODUCTION

VR (Virtual Reality) is an artificial experience where the user can interact in a 3-Dimensional space making them feel the surroundings real. The environment is created artificially through sounds, images, and objects. The environment can be perceived through a virtual reality helmet or headset. VR is one of the most strongly emerging technologies capable of holding much of the advancements and growth in technology [1]. Nowadays a keen usage of VR is seen in gaming where the creators are getting real-world gaming experience for the players by providing them with virtual objects with cutting-edge capabilities increasing players' engagement and interest in the game [2]. Virtual Reality can be in form when the objects (the physical entities in the real world can thus be created virtually in virtual reality space) and avatars (virtual representation of the user with which it interacts with the virtual world controlling its movements) remain in synchronization with each other. Whether it be object-object, avatar-avatar, or avatar-object, harmonized space is essential [3].

Coming to one such VR-operated game called Virtual Reality Skateboard in which a player plays the skateboard game with the help of a VR headset, skateboard. The game terrain is created using the Unreal Engine, with which the player can experience a virtual world having different virtual objects necessary for the playing of the game. This is the frontend part which is connected to the hardware part (IoT is responsible for the hardware simulation which helps in noting the speed, direction, and movement of the player), the VR headset, skateboard, Arduino, and Bluetooth module. The connection between the front end and the hardware part is done by converting the game to an APK file and connecting it to the Arduino code [4].

Virtual Reality is a boon where people can cherish a new world where they interact with objects without the actual presence of those objects [3].

Adding to the scope of virtual reality lies Metaverse which is a cyberspace that is a world in which many virtual, augmented reality small worlds can interact creating a mass environment that is connected through the internet. It is concentrated on social connection, it is the near future where multiple users can interact sitting in different parts of the country [5]. The different virtual worlds comprising the Metaverse should be working in harmony that is in complete synchronization with each other. It is crucial to remember that users in a virtual environment, or a portion of the Metaverse, should view the same information as other users do. Additionally, users may communicate with one another in a regular and timely manner. In other words, how users should perceive virtual items and user participation in a shared virtual environment would be crucial. The simultaneous activities of all the objects, avatars that represent their users, and their interactions, such as those between object-avatars, object-objects, and avatar-avatar, must be merged at the center of creating the Metaverse through the composition of various virtual shared spaces. The dynamic states and events of the virtual spaces should be synchronized by and reflected in all participating processes in virtual environments [1].

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This is what if applied to the skateboard can make multiple players in different locations play together in the environment of Metaverse making the playing more efficient without the actual interaction of the players, they can play whenever and wherever they want just need to be connected through the internet to create cyberspace [2].

The paper is organized as follows: Section 2 gives a thorough description of all the papers that define Metaverse and how it is implemented with IoT. Section 3 gives a detailed description of the project implementation which includes the hardware implementation, frontend implementation, and packaging of the frontend into an Android application. In Section 4 we conclude by giving the results and the future scope of the project.

II. Literature Review

The paper stated the real meaning of Metaverse where they featured it to be an internet application. It describes Metaverse from five aspects which are network infrastructure, management technology, basic common technology, virtual reality object creation, virtual reality convergence, and showcasing the technical infrastructure of Metaverse. The paper mentioned the characteristics of Metaverse to be multi-technology, sociality, and hyper spatiotemporality along with its different applications along with the challenges [6].

The paper tried to obtain real insight into the actual meaning of what is Metaverse. He states that there is no absolute definition of Metaverse even though multiple phrases and acronyms have been suggested. Without a clear concept, a debate breaks out, and creating a structure for a virtual world becomes difficult. A definition was offered by several scholars, however, there are still issues with each definition and it is simply impossible to apply it to modern technology. The main aim was to define a "virtual world" that is specially aligned with technology by using the basic theories to sample technologies. The resultant outcome is compared to other similar work and it is used to categorize technologies like virtual and mixed reality, Metaverse, pseudo-persistent video games, and MANets. It breaks down the characteristics of different technologies, a comparison of the definitions, an ontology showing relationships between various terms and definitions, and the use of pseudo-persistence to classify technologies that simulate persistence [2].

The paper presented that Metaverses are examined as a platform for game-based learning. A relatively new class of Internet applications is Metaverses like Second Life. Their functionality is comparable to that of an online 3-dimensional multi-player game but is different in a way that the users can create their avatars and are not restricted by predetermined goals of any kind by the game. Metaverses demand more host server systems and network traffic as compared to games. This paper contributes to the understanding of the Metaverse by presenting the case study of Game-Based Learning (GBL) in the Metaverse environment and analyzing the Quality of Service provided by the Metaverse under a variety of evaluator-induced network conditions [7].

The paper stated that progress in areas like immersive realism, ubiquitous access, identification, interoperability, and scalability is necessary to transform a collection of separate virtual worlds into Metaverse. The present state and improvements required for the creation of a usable Metaverse are discussed for each sector. The development of Metaverse is dependent on multiple factors like institutional and public interests, ongoing hardware performance improvements, and factors that limit the realization of the goal such as the computational limitations and the collaboration between virtual world stakeholders and developers [5].

The paper is about the design and implementation plans for an IT convergence framework for games as IoT services. First, he examined the factors to take into account while designing and implementing an IT convergence framework for games that leverage user mobile devices and a variety of sensors in an Internet of Things environment, along with the associated solutions. Then, by developing games and tracking user interactions in the IoT environment, they demonstrated the potential of games in the IoT ecosystem. By this, they showcased the amalgamation of IoT and gaming which is an important stage of developing hardware games [8].

The complex term, "the Metaverse", is defined as a broad shift of interaction between the users and the technology. The companies refer it to as persistent virtual worlds that exist even when the player is not playing. Many companies envision the Metaverse as a virtual world with a digital economy, a place where users can create, buy and sell goods. Companies like Meta, Microsoft, and so on are defining and developing Metaverse in their own words. Meta defines the Metaverse as a place with virtual houses where avatars of individual people can interact. Microsoft defines it as a virtual room for individuals to chat with their remote workers or train their new hires [9].

Metaverse lets us perform social gaming which allows interaction with other players, earning money by creating and selling assets virtually, adding more players in the virtual world, and allowing mixed reality experience. AR, VR technology, blockchain, cryptocurrency, IoT, and artificial intelligence are the few technologies that empower metaverse development. Data security, child control services, and incorporation of NFTs are still some of the challenges faced for the development of gaming in the Metaverse [10].

The Metaverse, which was first featured in video games, has drawn interest from a variety of industries, including literature, the arts, music, and education. The Web of Science database's 40 journal articles with the term "Metaverse" are the subject of this review article. Daily tasks like working, traveling, shopping, and attending school will be made possible by the Metaverse, giving users a stronger sense of identity and continuity in their experiences. These modifications' socio-cultural and psychological implications will also be investigated. Big data, data science, and artificial intelligence

researchers can use the Metaverse as a working platform because it will assist current study themes and expose new ones. The Metaverse will see more scientific studies and richer material emerge as technical infrastructure advances and academics' interest grows [11].

This study analyzes Metaverse research, including avatars, XR, and the necessary components (hardware, software, and contents). It reviews trends in user interaction, implementation, and application, and discusses the importance of interaction in storytelling. The study also examines Metaverse domains like Ready Player One, Roblox, and Facebook Research. The study highlights the potential for social influence, limitations, and open challenges in the future [12].

This exploratory study investigates the multi-dimensional features of pre-service teachers' readiness to build technology-enhanced learning environments. It examines pre-service English teachers' VR-making and Metaverse-linking experiences, highlighting the importance of instructional VR content design in the language classroom. The study also highlights the role of the Metaverse in transforming one-way interaction between digital content knowledge and student learning to meta-modal learning extended through social connection and interaction with a teacher. This Metaverse design benefits teachers and students in terms of learning adaptivity and sustainable education. The findings can provide insights into future professional development and support preservice teachers' dispositions toward teaching with emerging technologies for sustainable education. Future research should validate the theoretical and pedagogical benefits of VR and document trajectories of VRM in pre-service teachers' professional development to provide a wider audience and message [13].

This paper proposes an approach for integrating social interactions into games while maintaining immersion. Due to VR, social interactions might become unimportant as it destroys the illusions of the happenings in the real world. But some authors contradict this point of view and suggest that it gives a joyful gaming experience. Some participants experienced cognitive immersion while playing with other players. Expansion of the game space means integrating immersion as well gaming. Some design techniques are unification (where every detail, like the game theme, surroundings, and the music is designed to facilitate the immersion), storytelling (to help players bond with the virtual world), stimulating communication (with other players there is a chat section), and assigning roles and responsibilities to all the players. The authors conducted a case study on Lunar Escape which is a collocated multiplatform VR game and explained the different roles and tasks available for each of the roles. Thus, with this case study, the authors were able to explain the design approach for a VR game which includes both social interaction and game features [14].

Conclusively the paper provides us with statistical and definition-oriented information where no directives for the doing and working of the virtual reality skateboard are provided, moreover, the implementation of Metaverse through virtual reality skateboard is also not provided. The papers are related peripherally to the main aim.

After the comprehensive study of the above papers, much understanding of the subjects like Virtual Reality and Metaverse can be made. Their impact on the technology and their uses are greatly mentioned and through this one such utility of creating Virtual Reality Skateboard embarked through which virtual reality can be experienced by creating a skateboard game in which the player is signified as a character in the game developed using Unreal Engine. It doesn't cease here but the concept can further be extended into Metaverse where multiple users in their own virtual reality environments can come together by interacting with each other in virtual reality environments forming the Metaverse.

III. Materials and Methods

In this paper, we designed a prototype of the Metaverse implementation of a virtual reality skateboard. It is a single-player game, where the player will be standing on the skateboard, which has an Arduino connected to it capturing all the player movements, and will be wearing a VR headset, which will show the terrain on which the player is playing [7].

The entire implementation is divided into two parts, one is the hardware part and the other is the frontend part (the Skateboard Game developed Using Unreal Engine). The hardware part captures all the player's movement and is connected to the frontend part.

The hardware and frontend parts are connected using the plugins available in Unreal Engine.

Fig.1 shows the activity diagram which shows the interaction between the player and the game.

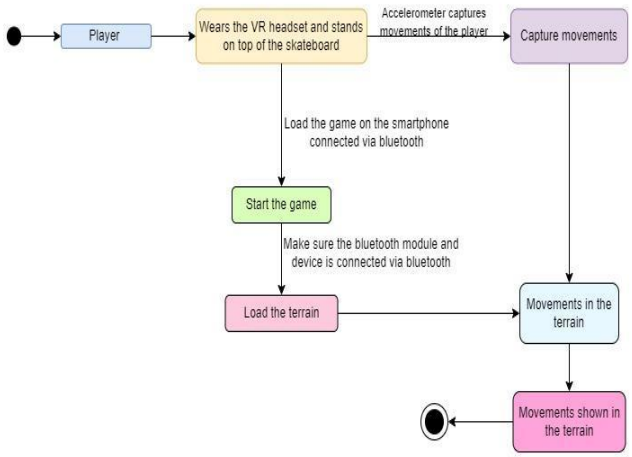


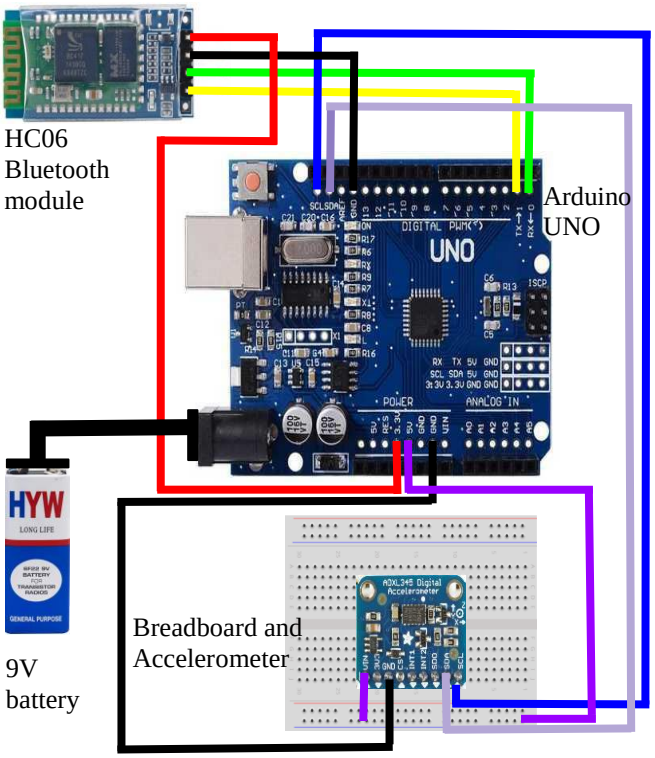
Fig. 1. Activity diagram showcasing the directives required for implementing the Virtual Reality skateboard

A. Hardware requirements

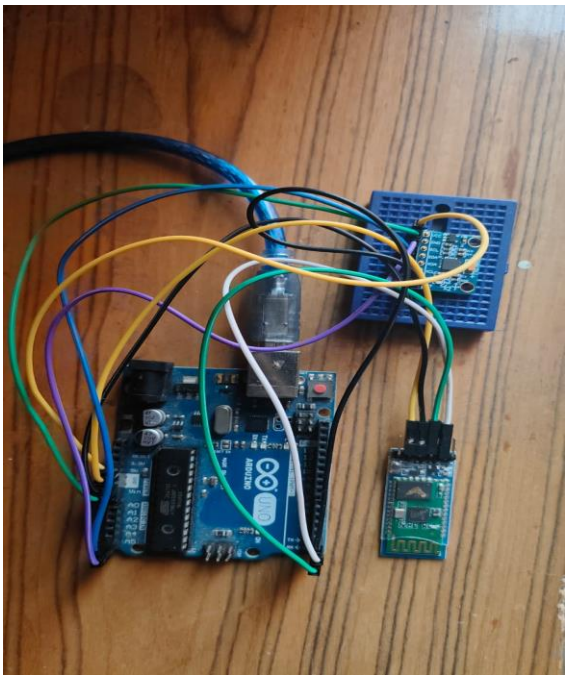
- Arduino UNO [15]: It is an ATmega328P-based microcontroller board with 6 PWM outputs, 14 digital

input/output pins, 6 analog inputs, a 16 MHz ceramic resonator, a USB port, a power jack, an ICSP header, and a reset button. It already has everything needed to support the microcontroller, so all that is required to get it going is a USB connection to a computer, AC-to-DC power converter, or battery.

- HC06 Bluetooth module [16]: For transparent wireless serial communication, the HC-06 is a class two slave Bluetooth module. The user can operate it with complete transparency once it has been associated with a master Bluetooth device, such as a computer, smartphone, or tablet. All information received via the serial input is immediately broadcast over the radio.
- MPU6050 - Triple Axis Gyro Accelerometer Module [17, 18]**:** The MPU6050 module makes use of the well-liked MPU6050 Sensor, which combines a three-axis gyroscope and an accelerometer into a single unit. A sensor and microcontroller can easily and directly communicate with one another thanks to an I2C connection.
- VR headset [19]: Virtual reality headsets allow users to experience information in a 360-degree environment that allows them to turn and gaze about just like they would in the real world. This replaces the player's natural environment.
- Skateboard [20]**:** The skateboard has IoT technology installed on it, which will provide a virtual reality experience of the metaverse.

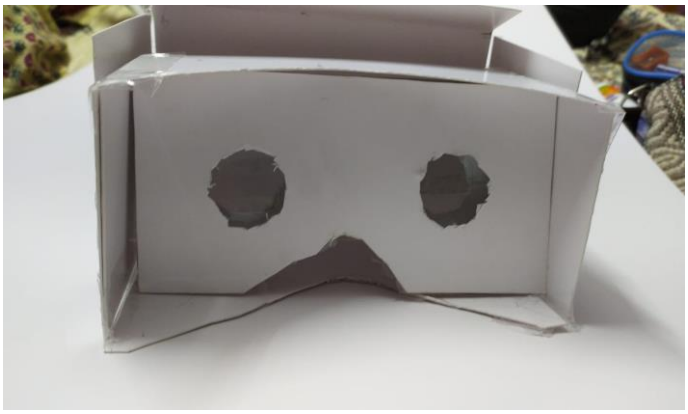


(a)



(b)

(c)



(d)

Fig. 2. (a) Circuit diagram (b) Hardware connection (c) Hardware connection connected to the skateboard (d) VR headset made at home

The circuit diagram is shown in Fig.2. (a) and the implementation of the circuit diagram is shown in Fig.2. (b). MPU6050 module should be positioned correctly with the yarrow pointing upwards, aligning it with the nose of the board. The VCC, GND, SDA, and SCL pins of MPU6050 should be connected to the 5V, GND, A4 (SDA), and A5 (SCL) pins of Arduino respectively. The VCC, GND, TXD, and RXD pins of the HC06 Bluetooth module are connected to the 5V, GND, RX (pin 0), and TX (pin 1) pins of Arduino respectively. Fig.2. (c) shows that the hardware connection is placed under the skateboard. The hardware connection was screwed to the skateboard.

Fig.2. (d) shows the VR headset made at home. The VR headset, Fig.2. (d), was made out of thick paper and two convex lenses of 45mm focal length. The thick paper is cut into rectangles of different sizes, two rectangles with two holes to fit the convex lenses, three rectangles to cover the sides, one rectangle to form the base, and another rectangle to support the phone that will be kept inside the VR [21].

B. Frontend

The frontend part of the implementation is done on Unreal Engine 4.27.2. Unreal is an open-source game engine that consists of components that are shared by many video games. It can be easily used to create 3D models and realistic images. It consists of tools to integrate with other commercial software and provides tools to document the virtual world created by the developer [22].

The terrain is created by downloading the already available free assets in Unreal.

The asset provides props that can be edited according to the developer's requirements. The road prop provided has to be duplicated, rotated, and grouped to form a block of the road. This block of the road has to be duplicated and grouped multiple times to form the basic road structure of the terrain.

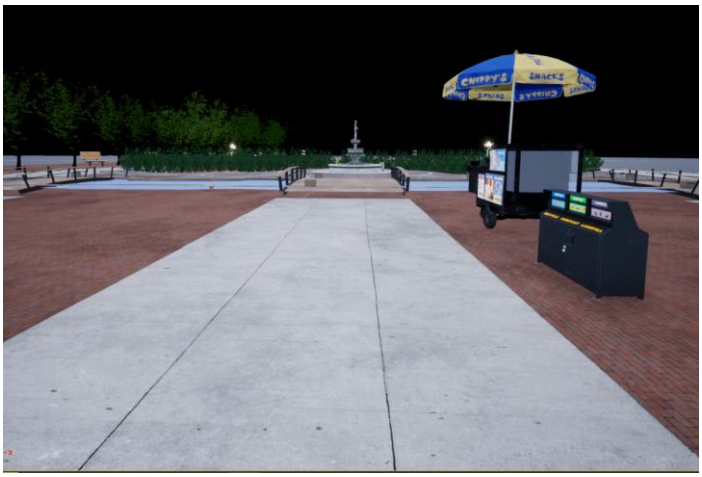
The brick ground prop provided, in a similar way as the road mesh, needs to be duplicated and grouped together to form the base of the park structure of the terrain. A pavement prop is already available in the asset which can be placed over the park structure. To add details to the terrain, the tree mesh along with the leaves VFX can be added along the road structure, bush mesh along with the bush VFX can be added along the pavements, and bench prop and switched-on street light can be added along the road structure. A fountain VFX can be added on top of the pavement and a bridge, a river body, a food truck, and a couple of chairs are already available props that can be added on top of the parking structure [4].

The character mesh, an FBX file, is downloaded from a third-party website. After loading the file as a component into the Unreal Engine, a blueprint is created for the character, which helps in the movement and speed of the movement of the character [20]. The axes of the character are adjusted and the controls are added. In Unreal Engine, the controls for the character can easily be built using the existing controls like moving forward, backward, rotating, and controlling the speed. The controls are defined using a flow graph, hence it is easy for the user to understand the movement of the character [4, 21].

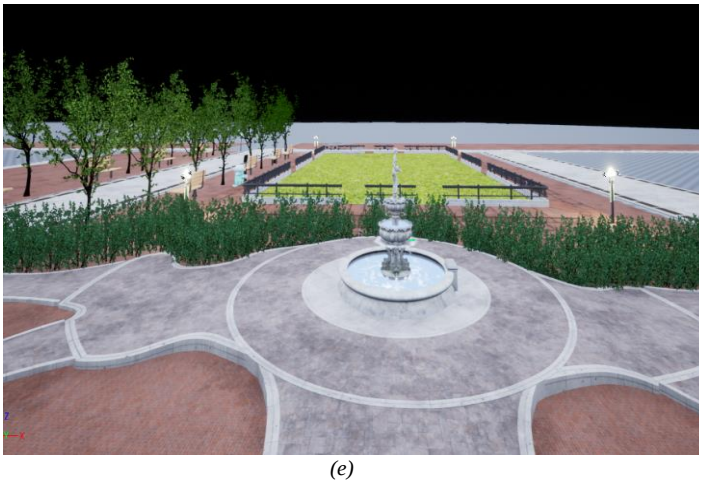
(a)

(b)

(c)



(d)



(e)

Fig. 3. (a) Top view of the terrain (b)The starting position of the player (c) Ground (d) Pavement to the fountain (e) The fountain

Fig. 3 shows the terrain created using the Unreal Engine. Fig.3. (a) shows an overall view of the terrain, Fig.3. (b) shows the starting point of the player, Fig.3. (c) shows the ground, Fig.3. (d) shows that pavement to the fountain and Fig.3. (e) shows the fountain area from which the pavements are connected to the roads.

The various poses of the character are shown in Fig.4. (a) and (b).

(a)

(b)

Fig. 4. Character animation in the skateboarding state (a) Standing on the skateboard pose (b) Pushing the ground pose

C. Packaging for Android

The frontend application is loaded into an Android device, hence the necessary APK files are needed to be downloaded and uploaded to the IoT application [11].

Android SDK, NDK, and JDK files are required to convert the game created into an Android application. All these files are downloaded from the links available on the Unreal Engine website. For loading the files into the Unreal Engine, the system variables need to be edited and the path where these files are stored is copied into the Android Platform option [4,11,22].

IV. Conclusion

The terrain built using the Unreal Engine gives the virtual reality experience of riding a skateboard. This is created using the assets and props provided by the Engine. By simple drag, drop, and resize the virtual world for the player to ride the skateboard is created. The collision option allows the props to become opaque so that the player does not go through it.

The character with the game is created by downloading the required FBX file, which contains the character mesh, and the animation mesh required is also downloaded as the FBX file. These files are loaded into the Engine, the character axes are adjusted to the terrain mesh, speed and movements are adjusted and finally, the character can move according to the player's movements.

The front end is exported as an APK file to be loaded into the Android platform and using the VR headset the player is able to ride the skateboard virtually [11].

The hardware consists of an Arduino with an accelerometer and Bluetooth module connected to it. All these components are connected to the skateboard. The Bluetooth module is used to connect it to the mobile phone connected to the VR. The accelerometer is used to detect the motion of the player and the Arudino, a microcontroller controls the Bluetooth module and the accelerometer [7].

Since this game is created virtually, it can be further expanded into Metaverse, where multiple players can play virtually in their own virtual world connected through the internet where they can experience the leisure of gaming even when they are geographically separated [5].

This paper acts as a testimony to the creation of a virtual reality skateboard through which the Metaverse Environment can be perceived. It provides structured directives for the implementation of the virtual reality skateboard. All the papers presented are peripherally related to the objective whereas this paper provides in-depth knowledge leading to the formation of Metaverse through Virtual Reality games (here in skateboard riding). With more technologies like Artificial Intelligence and Spatial and edge computing, the response time to the user's action can be reduced, which further enhances the user's interest in using this system [23].

V. Future Scope

This prototype opens up a plethora of ideas that can be further implemented into the Metaverse. The games which require multiple body movements like badminton, tennis, and so on, can also be implemented into the Metaverse. Multiple players from different parts of the world can play together in the Metaverse. There can be multiple championships that can be held in the Metaverse as it breaks the geographic barrier for the players to play together.

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Author Contributions

KK- Kanishka Kataria, JC- J Chandana, AR- Athira Raghumadhavan, KG- Komal Gandhi, KR- Kartik Raja, SG- Shilpa Gite.

KK brainstormed and structured the project outline. KK was also involved in the planning of the project. KK defined the project scope and documentation, was involved in the hardware and software requirements, terrain building of the skateboard game, implementation of the project, wrote the black book for the same, and was a major contributor in writing the manuscript.

JC brainstormed and structured the project outline. JC was also involved in the planning of the project. JC defined the project scope and documentation, was involved in the hardware and software requirements, terrain building of the skateboard game, implementation of the project, wrote the black book, and was a major contributor to writing the manuscript.

AR brainstormed and structured the project outline. AR was also involved in the planning of the project. AR was involved in building the terrain, character placement, testing and debugging the game, implementation of the project, and was involved in writing the black book.

KG brainstormed and structured the project outline. KG was also involved in the planning of the project. KG was involved in building the terrain, character placement, testing and debugging the game, implementation of the project, and was involved in writing the black book.

KR brainstormed and structured the project outline. KR was also involved in the planning of the project. KR was involved in

the hardware requirements, testing, and debugging of the game, implementation of the project, and was involved in writing the black book.

SG helped by guiding us throughout the project. All authors read and approved the final manuscript.

CONFLICTING INTERESTS

The authors declare that they have no conflicting interests.

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