MetaChess: Close to reality chess in metaverse

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We declare that this project titled "*MetaChess: Close to reality chess in metaverse*", submitted as requirement for the award of degree of Bachelors in Computer Science, does not contain any material previously submitted for a degree in any university; and that to the best of our knowledge, it does not contain any materials previously published or written by another person except where due reference is made in the text.

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The Department of Computer Science, National University of Computer and Emerging Sciences, accepts this thesis titled *MetaChess: Close to reality chess in metaverse*, submitted by Muhammad Abdullah (p19-0036), Nauman Tasawar (p19-0073), and Abdullah Tahir (p19-0067), in its current form, and it is satisfying the dissertation requirements for the award of Bachelors Degree in Computer Science.

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Abstract

The Metaverse is an emerging Internet paradigm that aims to create a completely immersive, hyper-spatiotemporal, self-sustaining virtual shared place for people to play, work, and interact. Recent advancements in cutting-edge technology like extended reality, artificial intelligence, and blockchain have helped the metaverse transition from science fiction to a future reality. Making a chess game for the Metaverse is the goal of this project. Using Oculus VR equipment, players will be able to interact with the chess board and pieces while playing the game. The users will be able to play the game with one another from the comfort of their own home thanks to this. The game would be played in a way that makes it appear as though the user is doing it in real time.The player will have an option to choose from different rooms to play in. In each room user will have different themes to enhance user experience e.g. There will be a room in which user can select medieval style structure.

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Chapter 1

Introduction

The Metaverse is a virtual reality world where users can interact with each other and their surroundings using customized avatars. It resembles the real world, allowing users to buy, sell, and trade digital assets like land and buildings.[3] Avatars in the Metaverse represent users and can perform various actions just like humans in reality. They can explore the virtual space, socialize, attend events, play games, and conduct business. Digital assets hold value within the Metaverse's economy, and avatars serve as the users' digital personas, enabling them to interact with the virtual world and other users. The concept and implementation of the Metaverse are still evolving, with different platforms and technologies contributing to its development [19].

This project is about making chess game in Metaverse. The users will be able to play the game using Oculus VR gear and can interact with the chess board and chess pieces using the said VR set. This will enable the users to play the game with each other from comfort of their liking. The gameplay would simulate the experience as if the user is playing the game in real-time. The player will have an option to choose from different rooms to play in. In each room user will have different themes to enhance user experience e.g. There will be a room in which user can select medieval style structure.

Chess, a game with a rich history spanning centuries, has held a significant position in Western culture since the Middle Ages (Adams 2) [5]. It continues to be a popular choice for millions of players worldwide. Chess requires strategic thinking, patience, and, most

importantly, the ability to solve problems. While it possesses considerable complexity, the game's objective remains elegantly straightforward.[10]

1.1 Chess Logic

Chess is a game played on a square board consisting of 64 smaller squares, with half of them black and the other half white, forming a checkered pattern. At the start, there are 32 pieces, 16 black and 16 white, including pawns, rooks (also known as castles), knights, bishops, queens, and kings.

The pawn is often considered the weakest piece, capable of moving forward two squares on its first move and one square thereafter. It can only move straight ahead unless attacking, which involves moving to an adjacent forward diagonal square. The pawn possesses a significant characteristic: if it reaches the opposite end of the board, it is promoted to any other piece except a king. It cannot remain a pawn, offering the potential for a weak piece to become powerful.

The rook, also known as the castle, can move horizontally or vertically across the board until it encounters another piece. It can attack from a distance, contributing to its strategic value.

The knight is a unique piece that moves two squares in one direction (forward, backward, left, or right) and then one square in a perpendicular direction. It is the only piece that can jump over other pieces.

The bishop has the ability to move any number of squares diagonally. Its starting position on either a black or white square remains consistent throughout the game.

The queen is widely regarded as the most powerful piece, combining the movement abilities of the rook and bishop. It can move freely in any direction—forward, backward, sideways, or diagonally—until it encounters another piece.

The king, although not inherently powerful, is the most important piece in the game. It can move one square in any direction. Losing the king results in losing the game.

The objective of chess is to capture the opponent's king. When a king is threatened with capture, it is in "check." The player whose king is in check must make a move in the

subsequent turn to remove the king from check, either by moving the king, blocking the check with another piece, or capturing the threatening piece. If a king is in check and no move can resolve the check, it is considered "checkmate," and the game concludes. The player who achieves checkmate emerges as the winner.

Chess notations are often used in writing about the game. Each piece is represented by a letter, and each square on the board is denoted by a combination of a letter and a number. These notations facilitate communication and analysis of chess moves.

These notations are demonstrated in the following table and image [22]

Piece	**Notation**	**Symbol**
King	K	♔
Queen	Q	♕
Rook	R	♖
Knight	N	♘
Bishop	B	♗
Pawn	P	♙

Table 1.1: Notations

Chapter 2

Literature Review

The concept of the metaverse gained significant attention in 2021-2022, driven in part by Facebook's rebranding as "Meta." The term was originally coined by science fiction author Neal Stephenson in his 1992 novel "Snow Crash" [24]. In modern terms, the metaverse refers to a computer-generated, networked realm of extended reality (XR), encompassing augmented reality (AR), mixed reality (MR), and virtual reality (VR). Currently, the metaverse primarily consists of partially immersive XR spaces where interactions occur between humans and automated entities. These interactions range from everyday experiences with AR apps on computers and phones to more immersive interactions in gaming or fantasy worlds. Additionally, there are "mirror worlds" that replicate real-life environments [13].

2.1 Chess.com

This literature review aims to investigate whether existing research on chess interventions demonstrates any effects on student outcomes. For a study to measure the impact of chess, it needs to establish a clear link between the outcomes observed and the participants' engagement in the chess program. The studies considered varied in their research design quality, which affected their ability to establish this connection between outcomes and chess participation. A significant portion of the studies did not adequately control for group equivalence when comparing chess participants and non-participants. Consequently, it is important to approach the findings of these studies with caution since the

observed differences in outcomes may be attributed to individual student characteristics rather than the impact of the chess intervention [8].

2.2 A survey on metaverse

The Metaverse represents a novel form of internet application and social structure that incorporates various emerging technologies. By utilizing augmented reality, it offers an immersive experience, creating a digital twin of the real world. [17]It integrates blockchain technology to establish an economic system and seamlessly connects the virtual and real worlds within this economic system, along with the social and identity systems. Users have the ability to generate content and shape the Metaverse. It is important to note that the concept of the Metaverse is continuously evolving, with different participants contributing to its definition and enhancing its features in their own unique ways [20].

2.3 3D virtual world in metaverse

This article examines the current state of computing in relation to 3D virtual spaces and discusses the necessary steps to transition from independent virtual worlds to a connected network of 3D virtual worlds known as the Metaverse. The focus is on four essential aspects that are considered vital components of a functional Metaverse.[26]

Firstly, realism is evaluated to determine if the virtual space is immersive enough to elicit psychological and emotional engagement from users, allowing them to feel fully present in the alternative realm.

Secondly, ubiquity is addressed, considering whether the virtual spaces within the Metaverse are accessible through various digital devices, such as desktops, tablets, and mobile devices. Additionally, the continuity of the user's virtual identity or collective persona throughout transitions within the Metaverse is emphasized.

Next, interoperability is explored, examining whether the virtual spaces adhere to standards that enable seamless interchangeability of digital assets used in constructing or rendering virtual environments. It also investigates whether users can transition smoothly between locations without interruptions to their immersive experience.

Lastly, scalability is analyzed, focusing on the server architecture's ability to handle a

large number of users occupying the Metaverse without compromising system efficiency and user experience.

To provide a contextual background for the discussion on 3D virtual spaces, the article delves into the historical development of virtual worlds and the conceptualization of the Metaverse. This historical overview encompasses literary and gaming influences on virtual world advancements, as these precursors often played a significant role in shaping later achievements in virtual world technology [6].

2.4 Cloud gaming on vr headset

Cloud Gaming is an emerging gaming service that offers a new and easily accessible gaming experience to millions of users. It utilizes powerful and flexible computing resources to shift the resource-intensive game processing tasks from the user's device to a robust Cloud Server. In this setup, the interactive gaming application is stored on the Cloud Server and executed upon user request. The rendered game scenes are then transmitted back to the user over a broadband network as a sequence of encoded video. The user's inputs from devices like a mouse, keyboard, or joystick are recorded and sent back to the Cloud Server for game logic manipulation. This allows players to enjoy high-quality games without the need for expensive gaming hardware, as they can play on any device.

While Cloud Gaming shows promise as a means to enhance the accessibility of VR gaming, there are several challenges that must be addressed before it can be considered practical. It is important to note that this technology is still a work in progress and lacks comprehensive evaluations at this stage [4].

Year	Title	Achievement	Limitation
2020	Decentraland [11]	Decentraland is a **3D virtual world** browser-based platform. Users can buy/sell virtual plots of land in the platform.	Not accessible on VR headset. Users have to **create** their own virtual worlds which are quite expensive too.
2015	Virtual sandbox [21]	The Sandbox is a virtual world where players can **build, own, and monetize** their gaming experiences in the Ethereum blockchain.	Not available on VR headset.
2018	Axie Infiity [18]	Axie Infinity is a non-fungible token-based online video game. Players of Axie Infinity **collect and mint NFTs**	User can't create their own maps, **exploring** the maps are really limited
2020	Chain of Alliance [23]	Is a role-playing fantasy game involving **customizable monsters** with NFT value.	Only available on android.
2020	Population:One [2]	Population: One is a multiplayer, **First Person Shooter**, Battle Royale.	Not free. Can't **digitally** trade assets.
2019	Beat Saber [25]	Beat Saber is a virtual reality rhythm game. It takes place in a surrealistic neon environment and features the player **slicing blocks representing musical beats** with a pair of contrasting-colored sabers.	N\A
2009	Chess.com [8]	Chess.com is an internet **online chess server game**, news website and social networking website.	Not available on any VR headset. Doesn't provide and **immersive** close to reality feel.
2022	A Survey on Metaverse: Fundamentals, Security, and Privacy [27]	A comprehensive survey of the fundamentals, security, and privacy of metaverse. This also present the critical **challenges** of metaverse systems.	N\A
2022	The Metaverse in 2040 [1]	Conducted **survey** to gather expert views about metaverse's future.	N\A
2013	3D Virtual worlds and the metaverse: Current status and future possibilities [7]	Achievements surveys the **current status** of computing as it applies to 3D virtual spaces and outlines what is needed to move from a set of independent virtual worlds to an integrated network of 3D virtual worlds or Metaverse	N\A
2022	Opportunities in the metaverse . How businesses can explore the metaverse and navigate the hype vs. reality [9]	**Success** of metaverse lies on a robust and **flexible financial** ecosystem that will allow users to seamlessly connect between the physical and virtual worlds.	N\A
2017	Cloud-Based VR Gaming: Our Vision on Improving the Accessibility of VR Gaming [4]	Cloud Gaming for **improving** the accessibility of **VR gaming** which is based on the more compact and affordable HMDs.	N\A
2016	Tilt Brush [12]	A 3D virtual-reality **drawing experience** for Oculus that lets you paint in the air simply by waving your hands.	N\A

Table 2.1: Literature review summary

Chapter 3

Methodology

3.1 Metachess

To solve the problem of currently available chess games not been able to provide an immersive chess environment where users can interact with each other whilst experiencing close to reality game. Hence we thought to introduce a chess game in metaverse. Here users will interact with our game through Oculus headset.In metachess users will have an option to explore different maps, rooms where they can play chess with their friends and family members whilst having a close to reality feel.

3.1.1 Motivation

The motivation behind choosing this project is the scope of the metaverse industry as it continues to grow every year and the power of VR gaming. It is interesting how technology can impact our lives, so we can explore, interact with virtual worlds from the comfort of our liking. Metaverse will surely paved the way how humans will socially interact with each others.As well as how they do their daily business because metaverse will not only revolutionize the gaming industry it will have a major impact on banking, education, tourism.

3.1.2 Problem Statement

- The current problem while playing chess is all the available chess games lack the feel of 3D chess environment, hence they also lack the interactivity between the players and the environment.
- We purposed a solution by building a chess game in Metaverse. So the players can have close to reality experience, and allow the players to interact with the environment.
- This will also ensures that the players are sitting close to each other in virtual space where as in real world they may be miles apart.

3.2 Business Opportunity

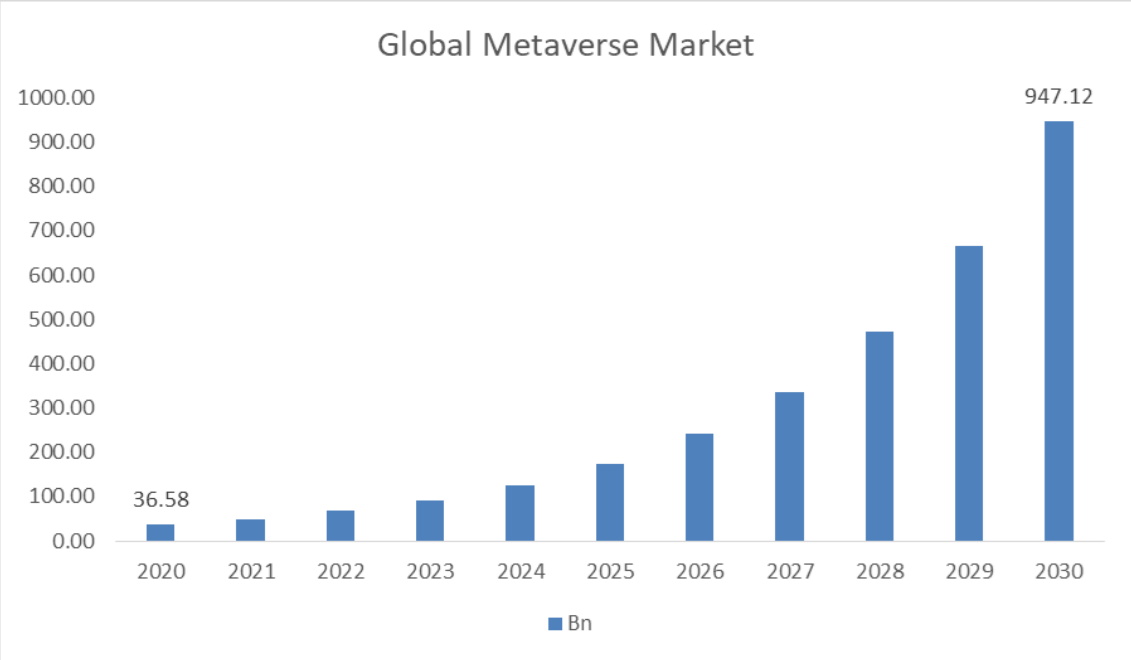

Figure 3.1: Global Metaverse market.

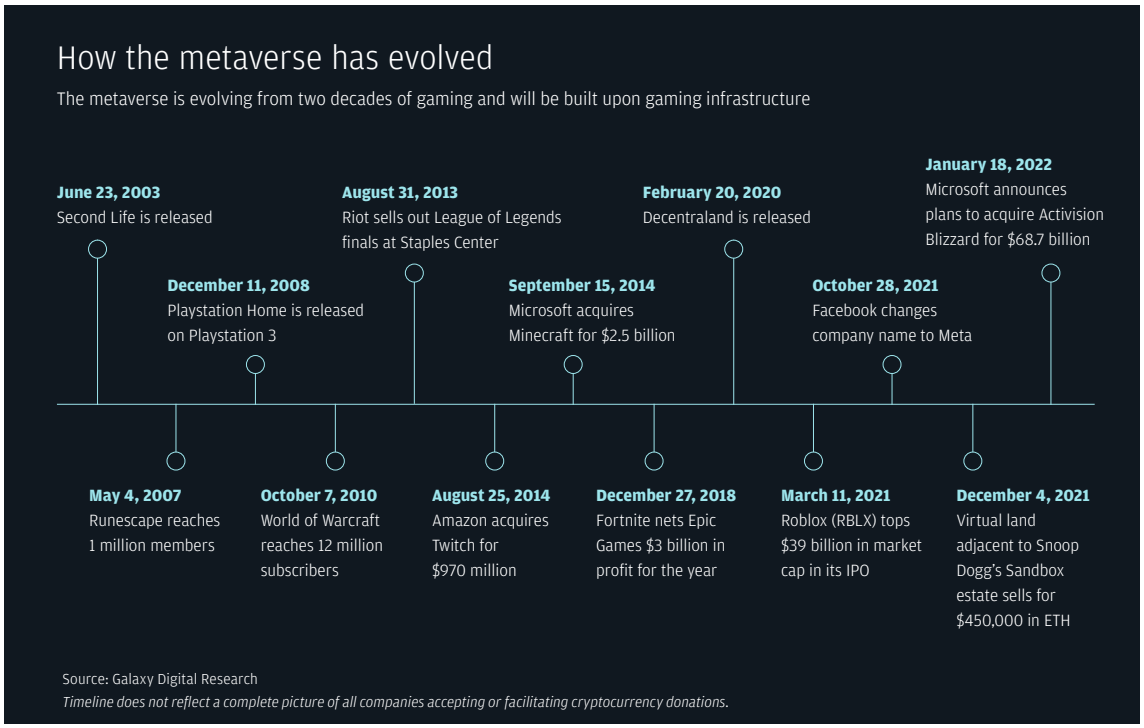

Figure 3.2: Metaverse Evolvement

3.3 Objectives

1. Provide users the most authentic or close to reality chess game-play experience in Metaverse from the comfort of their liking.

2. Providing a night city themed verse where users can explore the environment and interact with it. So they can experience something surreal, yet imaginative.

3. Players can invite their social media friends, interact with other players inside the Metaverse, and collaborate to enjoy the games together.

3.4 Project Scope

MetaChess is a versatile application that enables players to engage in real-time chess games within the metaverse, regardless of their platform. The main objective is to offer an intuitive and enjoyable chess experience for players of varying skill levels. The game incorporates additional features, including the option to explore and interact with the virtual environment. Overall, MetaChess prioritizes delivering a user-friendly and seamless gameplay experience.

3.5 Stakeholders Description

1. Virtual reality and metaverse is a high emerging field. In recent times there have been a lot of development happening in this field.[16] MetaChess main target group are the users who play games in VR. We focus on providing users the most authentic or close to reality chess game-play experience in Metaverse from the comfort of their liking.[15]

2. As chess is played by millions of users everyday throughout the world we have a future plan where companies like chess.com can hold their virtual game events/matches in our game we would like to facilitate them.[14]

Chapter 4

Software Requirements Specifications

4.1 Functional Requirements

Priority	Description
Level 1	The topmost priority level requires complete fulfillment and ensuring that the software meets all necessary criteria.
Level 2	The requirements at this level do not necessarily have to be implemented for the software to remain viable.
Level 3	The lowest priority requirements are not anticipated to be implemented in the current release.

Table 4.1: Priority

4.1.1 Movement

0100 Pawn The pawns are allowed to move one space forward by default, and they have the option to move two spaces forward during their opening move. **Priority 1**

0110 Rook The rooks have the ability to move vertically or horizontally across any number of spaces, unless their movement is obstructed by another piece. **Priority 1**

0120 Knight The knights are capable of moving two spaces either vertically or horizontally, followed by one space in a perpendicular direction. **Priority 1**

0130 Bishop The bishops are allowed to move diagonally across any number of spaces, unless their movement is hindered by another piece. **Priority 1**

0140 Queen The queens have the flexibility to move vertically, horizontally, or diagonally across any number of spaces, unless their movement is obstructed by another piece. **Priority 1**

0150 King The kings are capable of moving one space in any direction. **Priority 1**

0160 Castling When the necessary conditions for castling are fulfilled (as defined), the kings have the ability to move two spaces towards a rook, while the rook simultaneously moves onto the space that the king crossed over during the castling maneuver. **Priority 1**

0170 When a piece is chosen, all the permissible moves for that specific piece are visually emphasized or highlighted. **Priority 2**

0180 The current player is required to choose a game piece by clicking on it. **Priority 1**

0190 The player controlling the white pieces has the first opportunity to make a move. **Priority 1**

0200 Once a piece has been chosen, the player in control can continue selecting other pieces by clicking on them. **Priority 1**

0210 A piece can only be captured by the active player when it is placed on a legal square of opponent piece. **Priority 1**

4.1.2 Capturing

0250 If a chess piece, excluding pawns, moves according to its usual movement rules and lands on a square occupied by an opponent's piece, the friendly piece has the ability to capture and remove the opposing piece from the board. **Priority 1**

0260 Pawns have the ability to capture opposing pieces by moving one space diagonally forward into the occupied square of the opponent's piece. **Priority 1**

0270 In the case of meeting specific requirements for en passant capture, a pawn has the opportunity to capture as described earlier, but this time into a square that was previously occupied by the opponent's pawn but is now empty. **Priority 1**

4.1.3 Promotion

0300 When a pawn reaches the opposite end of the board from where it initially started, it is eligible for promotion. T **Priority 1**

4.1.4 Move Legality

0400 A move in chess will be considered illegal if it violates the aforementioned rules or if it would result in the moving player's king being placed in check. **Priority 1 0410** The users will have the option to choose which player controls the black pieces and which player controls the white pieces. **Priority 1**

0420 On each user's display, their respective pieces will be positioned at the bottom of the board. **Priority 1**

4.1.5 Game Saving/Loading

0500 Players will have the capability to save their game progress to a .sav file. **Priority 2**

0510 Players will have the ability to load their game from a .sav file, even if they are using a different computer than the one where the game was initially saved. **Priority 2**

0520 The .sav format for game saves will be in plain text, without any encryption. **Priority 2**

4.1.6 Network

0600 Connection **Priority 1**

0610 The connection between two computers for gameplay in MetaChess shall be established. **Priority 1**

0620 The connections between computers in MetaChess shall be determined using IP (v4) addresses. Each computer participating in the multiplayer game will have its unique IP address assigned to it.**Priority 1**

0630 When two computers running MetaChess have successfully established a connection, they shall send a "ready" message to each other, indicating the readiness to start the game. **Priority 1**

4.2 Non-Functional Requirements

4.2.1 Network

0800 There shall be an adequate amount of bandwidth available to handle game messages in MetaChess. **Priority 1**

0810 The network availability is a requirement for MetaChess to function properly. **Priority 1**

4.3 Use Cases/ Use Case Diagram

A use case diagram represents the main use case activities and the interaction of actors and the system that is under development process. It helps to identify all the main processes of the system which are then visualized in ovals, known as a use case. A use case diagram is drawn from a scenario that explains the working of the system.

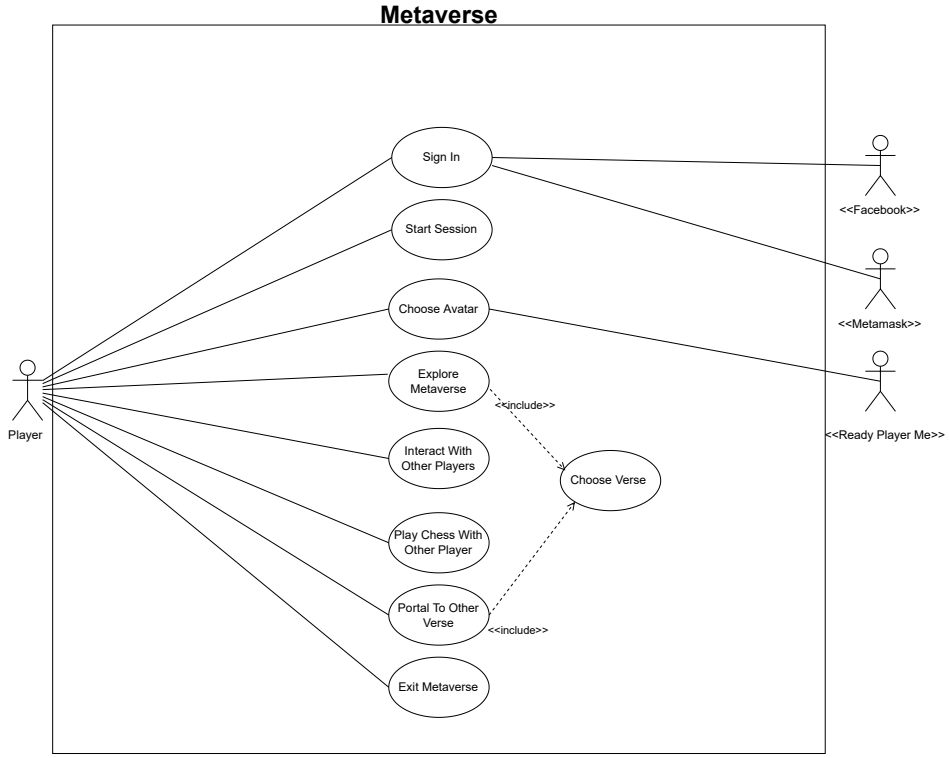

Figure 4.1: Use Case Diagram

4.4 Swimlane

The Swimlane diagram is shown in 4.2, it represents the flow of the activities in a specific order and it explains the details and conditions at every step. This UML diagram helps in understanding the flow of activities and it can help to identify those activities that can be run parallel to make an efficient system. The given diagram represents the flow of activities in Metaverse, it also explains which activity is initiated by which actor, since the activities are separated by swim lanes.

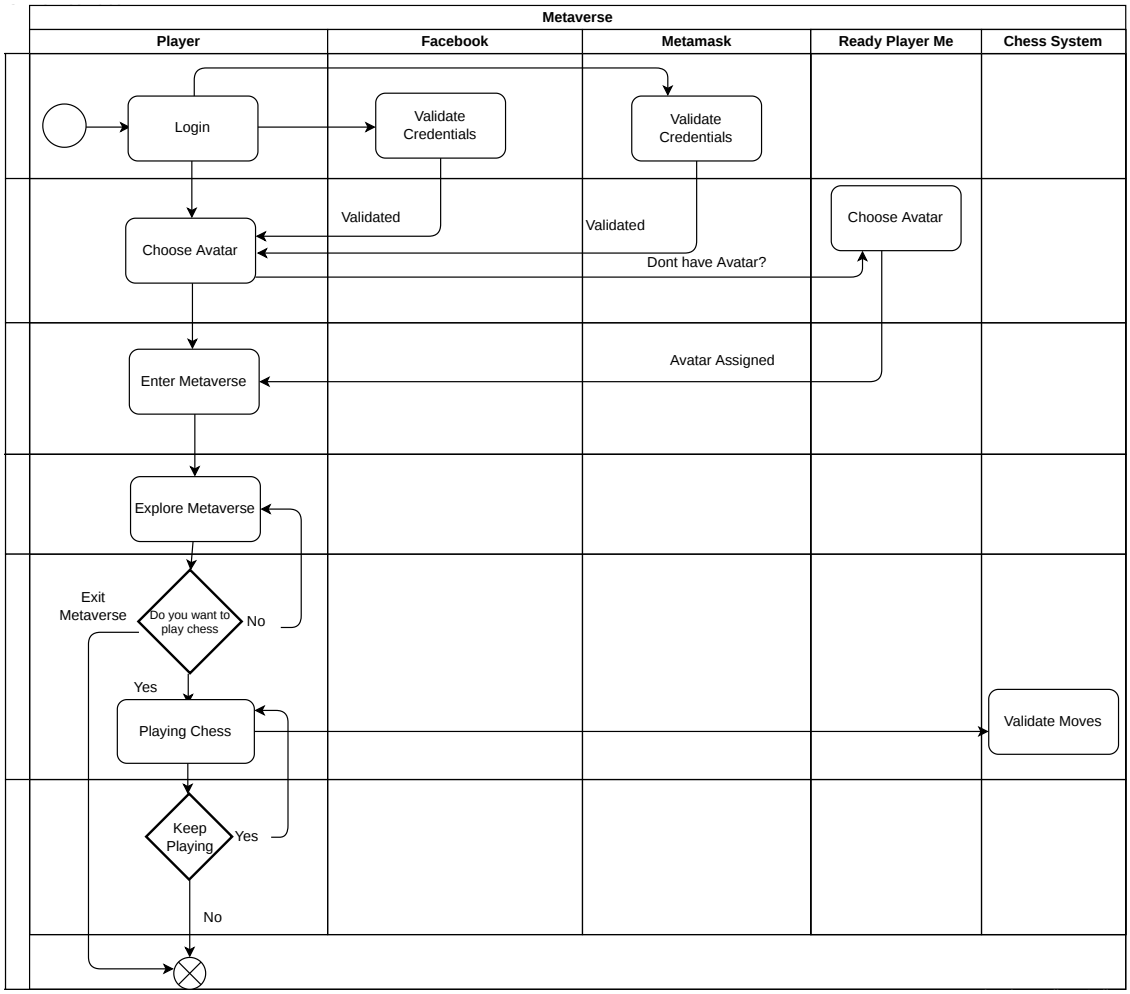

Figure 4.2: Swimlane Diagram

4.5 Flowchart

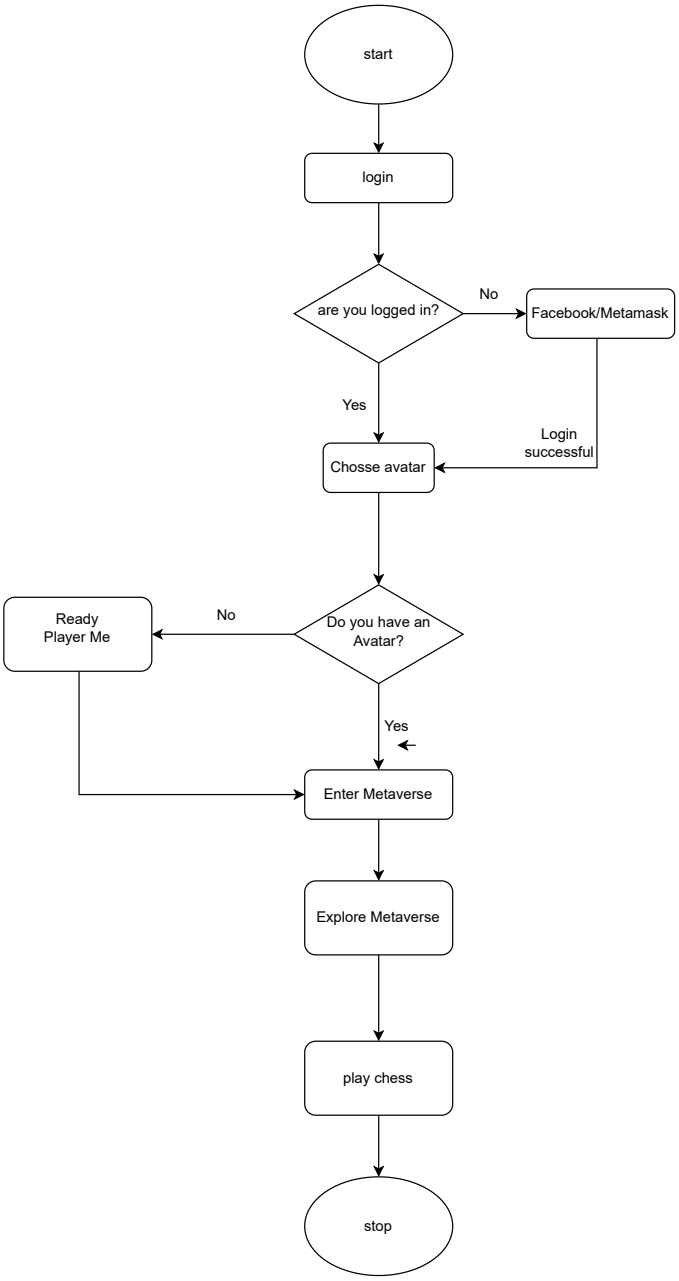

Figure 4.3: flowchart

4.6 Software Development Plan

- Sketch of a scenario:

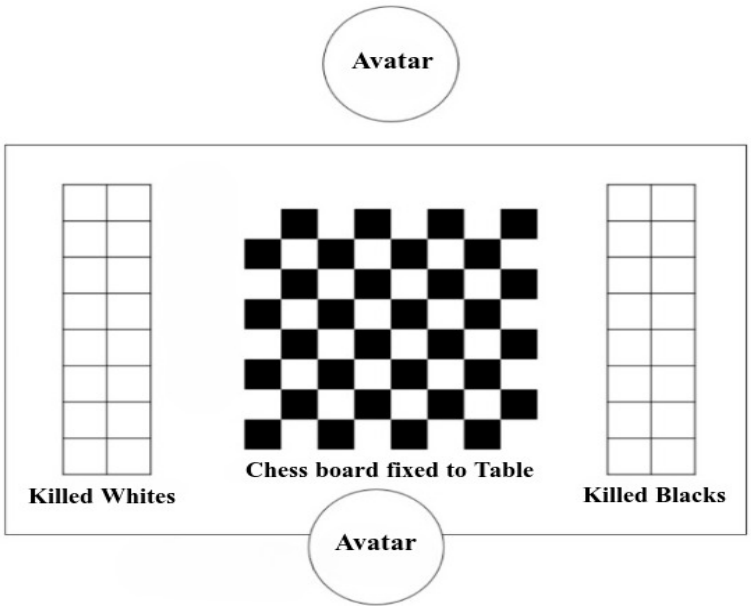

Figure 4.4: Sketch of chess

- Flow chart of the sequence:
  - Starting the game
  - Spawing the avatar
  - Moving of the avatar
  - Exploring metaverse.
  - Initiating chess game
- Starting of chess game
  - Set up game pieces
- Playing the game
  - Completing a move
  - Validating the move.
  - Removing pieces
  - Replacing pieces

- Ending the game

  - Relocating pieces to initial positions

- Back to exploring metaverse

  - Enter the portal to different map.

- Resources

  - VR Headset

  - PC

- Work Breakdown Structure

  - Each person's key areas of interest and work division and summarized in the table below

Task Name	Duration	Start	Finish	complete	Assigned To
Start of FYP 1	1d	08/22/22	08/22/22		
Project Proposal	5d	09/01/22	09/07/22	100%	M.Abdullah, Nauman Tasawar, Abullah Tahir
Project Defence	6d	09/05/22	09/12/22	100%	M.Abdullah, Nauman Tasawar, Abullah Tahir
Literature review	46d	09/01/22	11/03/22	80%	M.Abdullah, Abullah Tahir
3D model of environment and chess	46d	09/09/22	11/11/22	60%	Nauman Tasawar, Abullah Tahir
Developing basic animations.	36d	10/01/22	11/18/22	40%	M.Abdullah, Nauman Tasawar, Abullah Tahir
Prototype of chess game environment in oculus.	24d	10/25/22	11/25/22	0%	M.Abdullah, Nauman Tasawar, Abullah Tahir
Setting up game server	11d	11/15/22	11/29/22	0%	M.Abdullah, Abullah Tahir
Allow multiple user to login	13d	11/23/22	12/09/22	0%	Nauman Tasawar
Testing all functionalities	40d	10/21/22	12/15/22	10%	M.Abdullah, Nauman Tasawar
Documentation	56d	10/01/22	12/16/22	25%	M.Abdullah
End of FYP 1	1d	12/20/22	12/20/22		

Figure 4.5: Teamwork Distribution

- Gantt chart

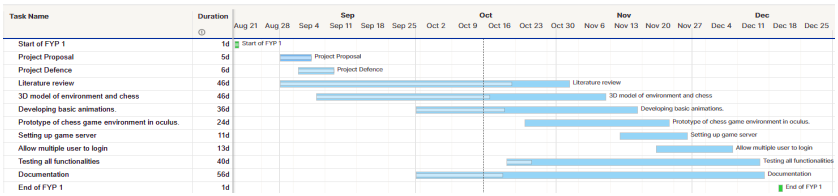

Figure 4.6: FYP-1 Gantt Chart

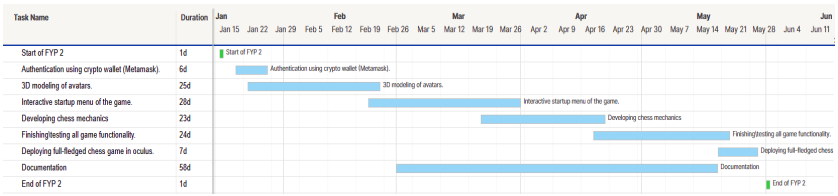

Figure 4.7: FYP-2 Gantt Chart

- Expected Difficulties

Difficulty	**Mitigation strategy**
Accurate use of VR Headset	Provide a user manual for basic instructions.
Integrating the chess mechanics	Implementing standardized chess moves.
Quality of 3D environment Assets	Making assets with high quality on a high-end rig.
Server performance	Using optimized settings for the server for smooth operation.
Avatar functionality	Adding general animations for an avatar.

Table 4.2: Expected Difficulties

Chapter 5

Iteration Plan

5.1 Midterm FYP 1

During the project, a significant milestone was achieved with the delivery of the first demo of the environment. This milestone involved showcasing the progress made in developing the project's environment and presenting a chess asset that was created using Blender.

The purpose of this demo was to provide stakeholders, such as the project supervisor, with a visual representation of the project's environment and the assets that have been created so far. It served as an opportunity to gather feedback, validate the direction of the project, and ensure that it aligns with the desired vision.

In the demo, we presented the environment in which the chess game takes place. This included the chessboard, the surrounding elements. Our focus was on demonstrating the aesthetics, functionality, and overall user experience of the environment.

Additionally, we showcased the chess asset created using Blender. This asset was a 3D model of the chess pieces, each with its unique design and characteristics. The demo highlighted the details, textures, and animations of the chess pieces, giving stakeholders a glimpse of the visual quality and realism achieved.

The delivery of the first demo and the presentation of the chess asset in Blender marked an important milestone in the project's progress. It allowed stakeholders to assess the development status, provide feedback, and make necessary adjustments or enhancements.

5.2 Final FYP 1

Delivering an improved demo of the environment was an important milestone in the project. It signifies progress and showcases enhancements made since the initial demo. The improved demo can included updates, refinements, and additional features based on feedback received from supervisor and users. It provides an opportunity to demonstrate the advancements and improvements made to the environment. By delivering an improved demo, we demonstrated the evolution of the project and the dedication to continuous improvement. It allows stakeholders and users to see the progress made and provide further input or suggestions for further refinement.

The implementation of working chess machines that allowed players to interact with chess pieces and perform logical moves is a significant achievement. This feature enhances the overall experience by combining the traditional gameplay of chess with a tangible and interactive element.

Players being able to grab chess pieces adds a new level of engagement and realism to the game. It allows for a more immersive experience as players can virtually move the pieces on the board. The logical move functionality ensures that the gameplay adheres to the rules of chess, enabling players to make valid moves based on the piece's characteristics and the current board state.

While special moves is not included in this implementation, the core functionality of capturing opponent pieces, moving pieces within their allowed range, and following the standard rules of chess are essential aspects that provide a solid foundation for enjoyable gameplay.

The working chess machines not only cater to experienced chess players but also create an accessible and interactive platform for beginners to learn and practice the game. The combination of manipulation and logical moves encourages strategic thinking and decision-making skills.

Overall, the implementation of working chess machines with the ability to grab chess pieces and perform logical moves contributes to an immersive and engaging chess playing experience. It brings the traditional game into a more interactive and dynamic realm,

appealing to both chess enthusiasts and casual players alike.

5.3 Midterm FYP 2

The integration of avatars in the metaverse environment adds a new dimension to user interaction and exploration. Avatars serve as virtual representations of users, allowing them to navigate and engage with the metaverse in a personalized way.

By incorporating avatar integration, users can create their unique virtual personas, customizing their appearance, characteristics, and even abilities within the metaverse. Avatars act as the bridge between the real world and the virtual environment, enabling users to express themselves and immerse in the metaverse experience.

With avatars, users have the freedom to explore the virtual world, moving through different spaces, environments, and interacting with various elements. They can engage in social interactions with other users, communicate, collaborate, and participate in activities or events within the metaverse.

Avatars also play a crucial role in facilitating user interaction with the environment. Users can interact with objects, manipulate virtual elements, and even perform actions or gestures through their avatars. This interactivity enhances the sense of presence and agency within the metaverse, making the experience more engaging and immersive.

In summary, avatar integration in the metaverse allowed users to explore and interact with the virtual world using their virtual representations. It offers a personalized and interactive experience, enabling users to navigate, socialize, and engage with the metaverse in a more immersive and meaningful way.

User authentication is a crucial aspect of ensuring a secure and controlled environment within the metaverse game. By implementing user authentication, you can verify the identity and credentials of players before allowing them to join the game. This helps maintain the integrity of the gaming experience and protects against unauthorized access. Users will need to create an account by providing their necessary information, such as username, password, and potentially additional details depending on the desired level of authentication.

Once registered, users can authenticate themselves by logging into their account using their credentials. The login process verifies the provided username and password against the stored user data to grant access.

Users should have the option to log out, which invalidates their authentication token and ends their session. Additionally, sessions should have an expiration time to automatically log out inactive users to enhance security.

By implementing user authentication before joining the game, you can establish a trusted environment where only authorized users can participate. This helps protect user accounts, prevent unauthorized access, and ensure fair gameplay within the metaverse.

5.4 Final FYP 2

Developing a multiplayer chess game with improved UI screens enhanced the overall user experience and facilitates smooth gameplay.
Enhancing the UI screens provided a visually appealing and intuitive interface for players. This includes screens such as the main menu, game lobby, player profile, game settings, and in-game UI elements.

Implemented real-time multiplayer functionality that allows players to connect and play against each other over the internet. This involves establishing network communication, handling player matchmaking, and synchronizing game states between all connected players.

Implementing multiple maps in a game adds variety and expands the gameplay experience. We Provided players with the ability to select a map before starting a game. This can be done through a map selection screen or as part of the game setup process. Offer a variety of maps with different themes, designs, and layouts to cater to different player preferences.
Created a unique and visually appealing map designs that reflect various environments or settings. For example, you can select a map set in different landscapes such as forests, castles, beaches, or futuristic cities. Each map can have its own distinct visual elements, colors, and overall atmosphere.

By incorporating multiple maps into your multiplayer chess game, we enhanced replayability, offer diverse gameplay experiences, and provide players with a range of strategic challenges.

Chapter 6

Iteration 1

6.1 Use Cases/ Use Case Diagram

A use case diagram represents the main use case activities and the interaction of actors and the system that is under development process. It helps to identify all the main processes of the system which are then visualized in ovals, known as a use case. A use case diagram is drawn from a scenario that explains the working of the system.

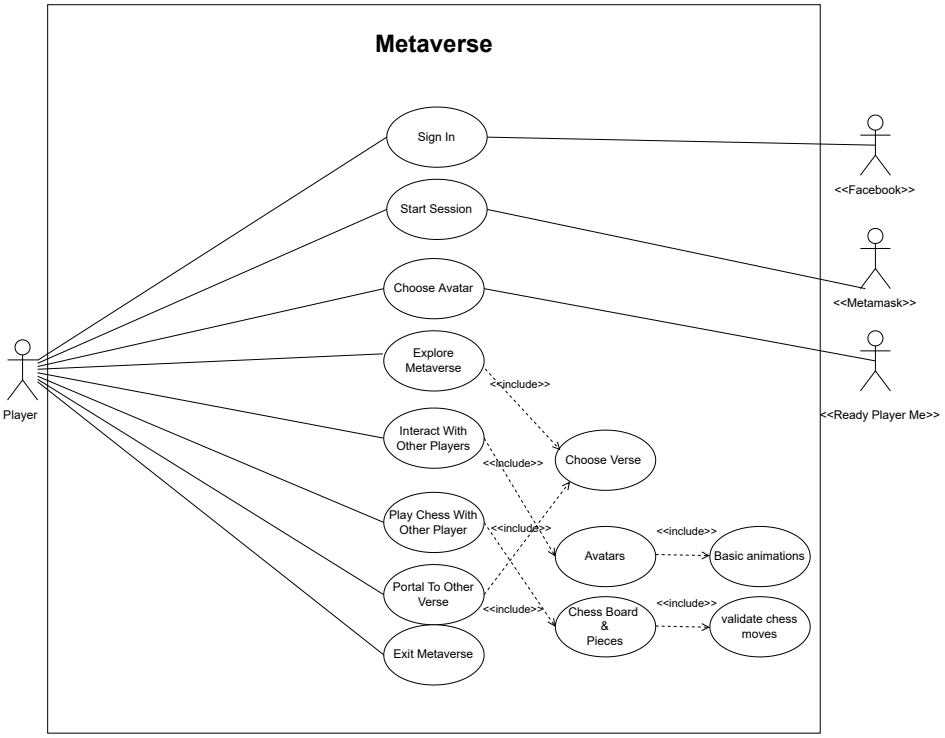

Figure 6.1: Use Case Diagram

6.2 Swimlane

The Swimlane diagram is shown in 4.2, it represents the flow of the activities in a specific order and it explains the details and conditions at every step. This UML diagram helps in understanding the flow of activities and it can help to identify those activities that can be run parallel to make an efficient system. The given diagram represents the flow of activities in Metaverse, it also explains which activity is initiated by which actor, since the activities are separated by swim lanes.

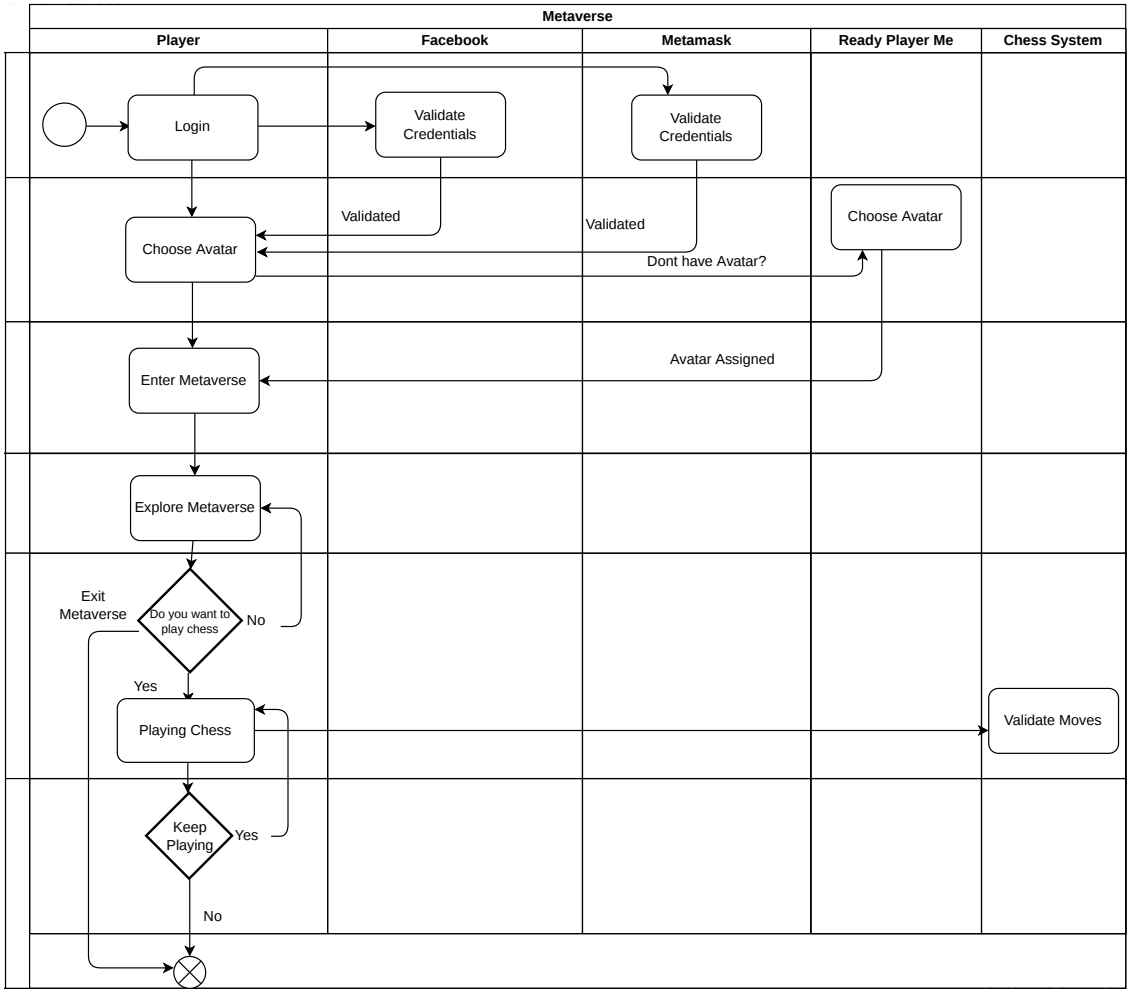

Figure 6.2: Swimlane Diagram

6.3 Flowchart

The flowchart for the MetaChess metaverse project starts with the user logging in or registering if not already logged in. After successful login/registration, the user is assigned an avatar and enters the metaverse. From there, they can explore the metaverse, play chess, and have the option to stop when they desire, providing a clear endpoint to their session. The flowchart outlines a streamlined user journey, ensuring a seamless transition from login to metaverse exploration, chess gameplay, and eventual session conclusion.

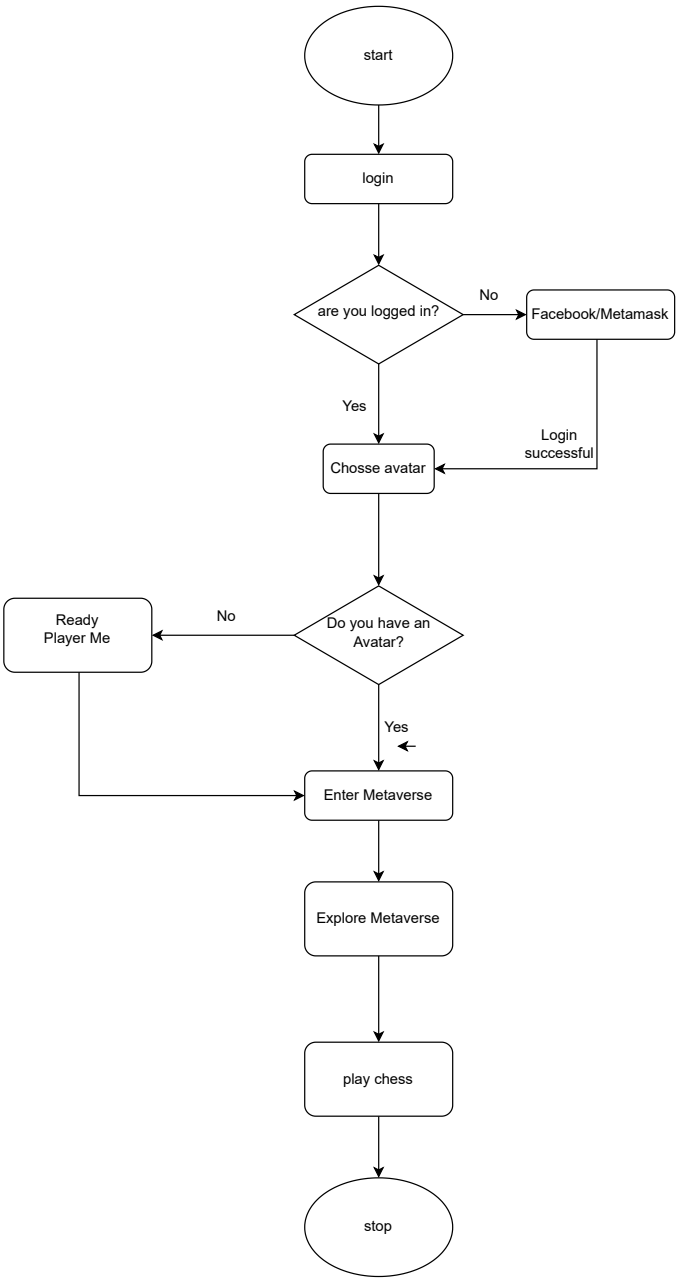

Figure 6.3: flowchart

6.4 Activity diagrams

6.4.1 Activity diagram for the movement of chess piece

The activity diagram for moving a chess piece in MetaChess begins with the player selecting a piece, followed by making a move. If the move results in capturing an opponent's piece, the board is updated accordingly. The diagram then checks for a checkmate condition. If checkmate is not detected, the process loops back to the selection of another piece. However, if a checkmate is found, the game ends. This concise diagram illustrates the flow of activities involved in moving chess pieces, capturing opponents, and evaluating the game state for checkmate, ensuring an engaging and immersive metaverse chess experience.

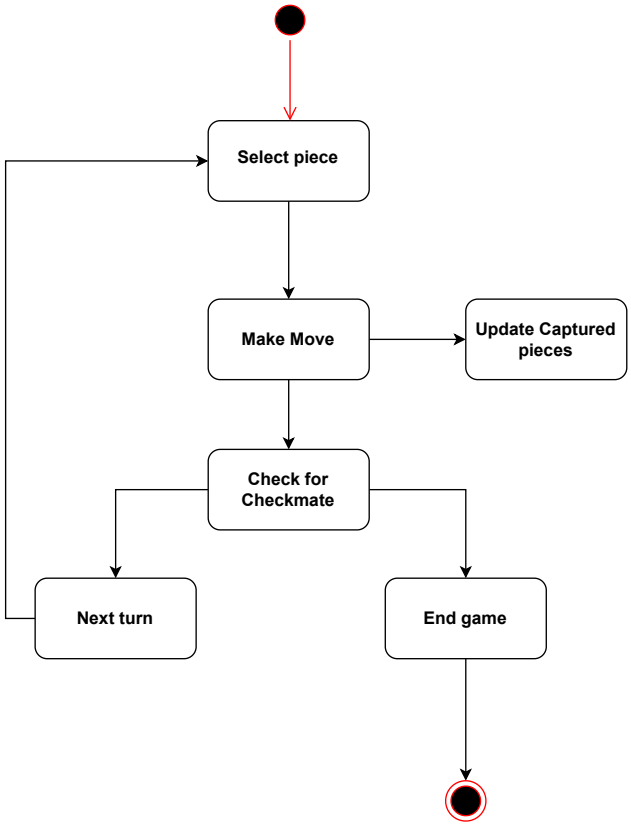

Figure 6.4: Activity diagram for the movement of chess piece

Chapter 7

Iteration 2

7.1 Activity diagrams

7.1.1 Activity diagram for the movement of chess piece

The activity diagram for moving a chess piece in MetaChess begins with the player selecting a piece, followed by making a move. If the move results in capturing an opponent's piece, the board is updated accordingly. The diagram then checks for a checkmate condition.

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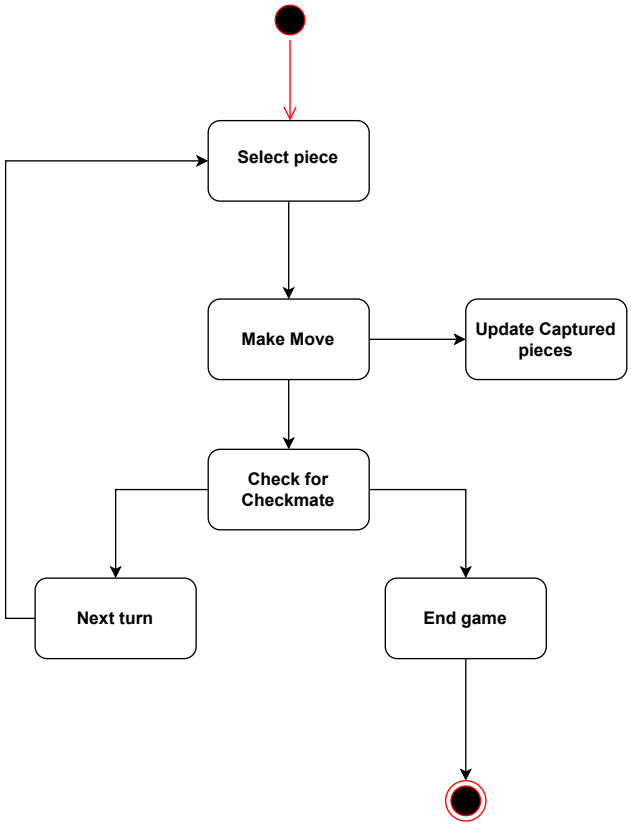

Figure 7.1: Activity diagram for the movement of chess piece

7.1.2 Activity diagram for Avatar

The activity diagram for the MetaChess metaverse project depicts the streamlined process of assigning an avatar to the user and their subsequent entry into the virtual reality world. The diagram begins with the automatic assignment of an avatar to the user, followed by displaying the assigned avatar for the user's review.

The diagram then represents the user's entry into the metaverse, equipped with their avatar, and concludes with the completion of the assignment and entry process. By visualizing the sequential activities, the diagram provides a concise overview of the steps involved in seamlessly assigning an avatar and enabling the user's entry into the immersive metaverse environment of MetaChess

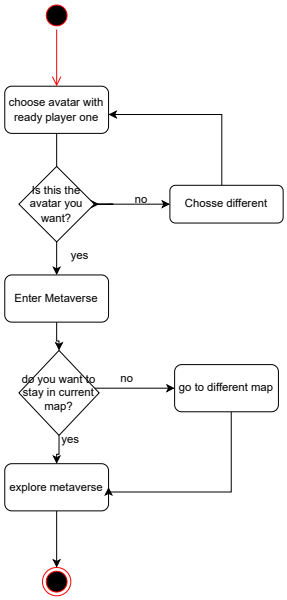

Figure 7.2: Activity diagram for Avatar

7.1.3 Activity diagram for login

The activity diagram for the login process in MetaChess illustrates the sequence of steps involved in logging in to the game within the metaverse environment. The diagram showcases the parallel activities of the user entering their login credentials and the system interacting with Firebase for authentication. The user enters their username and password, which are then verified by the system.

Simultaneously, the system establishes a connection with Firebase, sends the credentials for authentication, and awaits a response. If the credentials are valid, the user is granted access to the game. However, if the credentials are invalid or the authentication fails, the

user is denied access, and appropriate action may be taken based on the error message received. The activity diagram provides a clear visualization of the login process, ensuring a smooth and secure user experience in MetaChess.

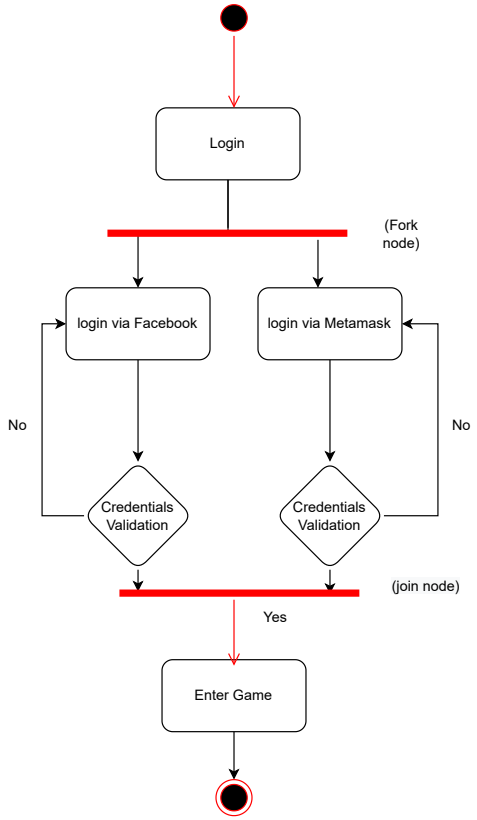

Figure 7.3: Activity diagram for login

7.2 Class Diagram

In the design of MetaChess, a virtual reality chess game set in the metaverse, a class diagram was created to represent the structure and relationships between different classes. The class diagram encompasses several classes, including "Chessboard" and "ChessPiece," along with separate classes for each individual chess piece, all of which inherit from the base "ChessPiece" class.

The "Chessboard" class serves as the central entity that represents the game board. It contains attributes and functions that facilitate the management and manipulation of the chess pieces on the board. Functions within the "Chessboard" class include initializing the board, tracking the current state of the game, validating moves, and updating the positions of the pieces.

The "ChessPiece" class forms the foundation for all chess pieces in the game. It contains common attributes and functions that are shared among different pieces. Functions within the "ChessPiece" class include determining the legal moves for a specific piece, validating moves, and updating the position of the piece on the board. It serves as a blueprint for the specialized classes representing each type of chess piece.

For each individual chess piece (such as "Queen," "King," "Rook," etc.), a separate class is created that inherits from the base "ChessPiece" class. These specialized classes inherit the attributes and functions from the base class and add specific functionalities unique to each piece. For example, the "Queen" class may have additional functions to calculate its specialized moves, while the "Rook" class may have its own move validation logic.

By employing inheritance, the class diagram ensures code reusability and promotes a modular and scalable design. It allows for the customization of each chess piece's behavior while maintaining a consistent structure and interface through the base "ChessPiece" class.

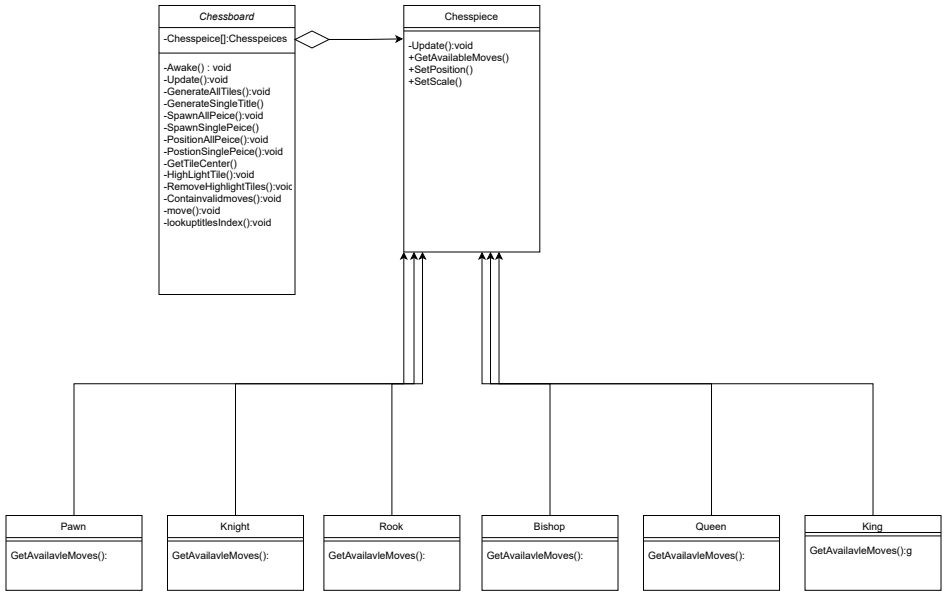

Figure 7.4: Partial class Diagram of chess system

7.3 Component diagram

In the architecture of MetaChess, a captivating chess game set in the metaverse, a component diagram has been carefully designed to illustrate the organization and interactions of the system's major components. The diagram highlights four key components: Chess System, Metaverse, Avatar, and Login, each playing a crucial role in the overall functionality of the game. "chess system" which has all the chess mechanics including ,chess legal moves, spawning of the pieces and placing them in their specific locations.

"Metaverse" which is the main part of the project this is where the user is spawned and allowed to explore the metaverse, There are two different Metaverse in this game so. User can explore both of them, and can easily switch between both metaverses.

"Avatar" where the user is getting their avatar, they are given a default avatar by out "avatar Componet" "login" is where the user can first register ,after that the user can login

into game after successfully putting their correct credentials.

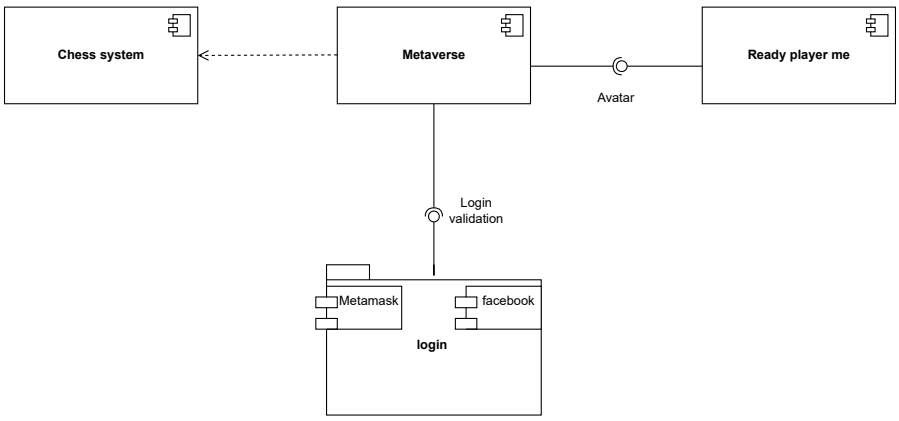

Figure 7.5: Component diagram of the game

Chapter 8

Iteration 3

8.1 User Interface Screens

8.1.1 Login

The login screen for MetaChess is designed to provide users with a seamless entry into the immersive world of virtual reality chess. Upon launching the application, users are greeted with an engaging and visually appealing login interface. The design emphasizes both functionality and aesthetics, ensuring an intuitive and captivating experience.
The login screen features a captivating background that sets the tone for the virtual chess environment. The use of high-quality graphics and immersive visuals instantly immerses users into the metaverse. The login form is strategically placed at the center of the screen, allowing users to easily access the necessary fields to log in to their accounts.

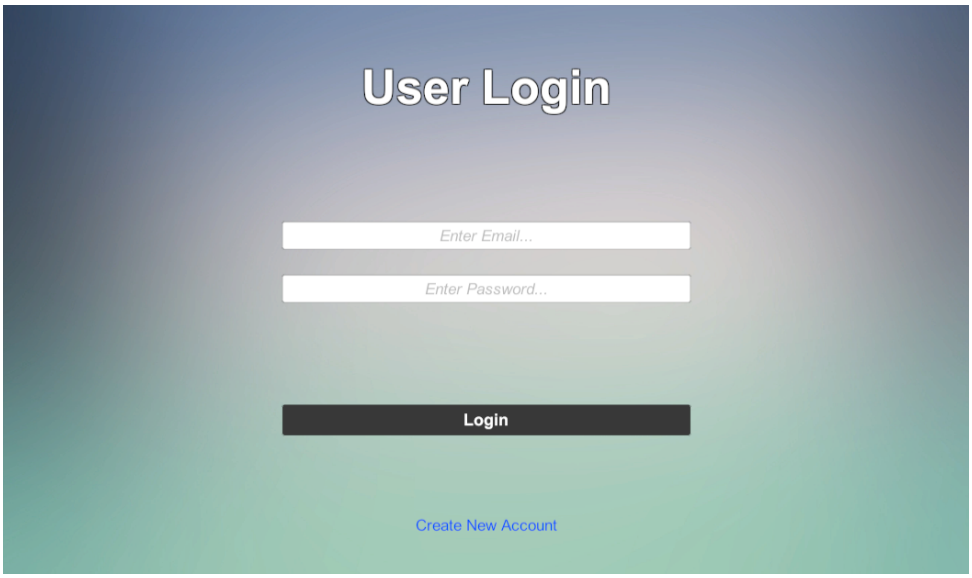

Figure 8.1: Login

8.1.2 Register

The "Register" interface plays a vital role in allowing new players to create their accounts within the game. The Register screen is thoughtfully organized into four distinct columns, each serving a specific purpose

. In the first column, labeled "Enter Name," users are prompted to input their preferred username or display name for their MetaChess account. This feature enables players to personalize their identities within the game and fosters recognition and interaction among other players.

Transitioning to the second column, labeled "Enter Email," players are required to provide a valid email address. This information serves as a unique identifier for the user's account, ensuring secure communication channels and efficient account management.

Moving on to the third column, labeled "Enter Password," users are prompted to create a password for their MetaChess account. To ensure the security of player accounts, this field enforces specific requirements for the password, safeguarding against unauthorized access.

Lastly, in the fourth column labeled "Confirm Password," players are asked to re-enter the password they previously created. This step serves as a verification process to eliminate any potential errors and maintain password accuracy.

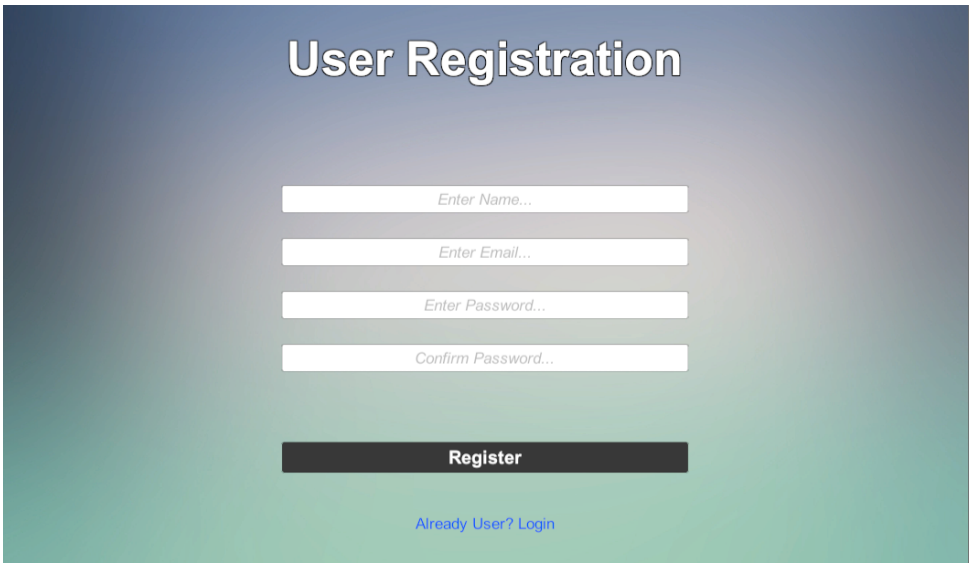

Figure 8.2: Registration

8.1.3 Menu

This menu acts as a central hub for various game options and settings. It presents an immersive environment that sets the tone for an engaging chess experience within different metaverse worlds.

The menu screen features a prominent title, "MetaChess," which appears at the top, establishing the game's identity. Below the title, four columns are displayed, providing different options to the user. The first column, labeled "Reset," includes a button that allows players to reset the chess game at any point, reverting the board and pieces to their initial state. This provides a convenient way to start fresh or undo any erroneous moves.

The second column contains the "Quit" button, which offers a quick exit from the game, allowing users to gracefully leave the metaverse chess experience and return to their VR environment. By incorporating this button, players can seamlessly transition between MetaChess and other activities in the metaverse.

The third column hosts the "Restart" button, which enables players to restart the chess game while maintaining their current metaverse world selection. It resets the board and clears any move history, allowing users to replay the game from scratch without changing their chosen metaverse environment.

The fourth and final column showcases the "Change Metaverse" button. Upon pressing this button, players are transported to a new metaverse world, offering diverse settings and

visual themes. In the case of MetaChess, two metaverse worlds are available: "Medieval" and "Cyberpunk." By selecting either world, users can immerse themselves in a unique atmosphere and backdrop, enhancing their chess experience with an additional layer of aesthetic and thematic appeal.

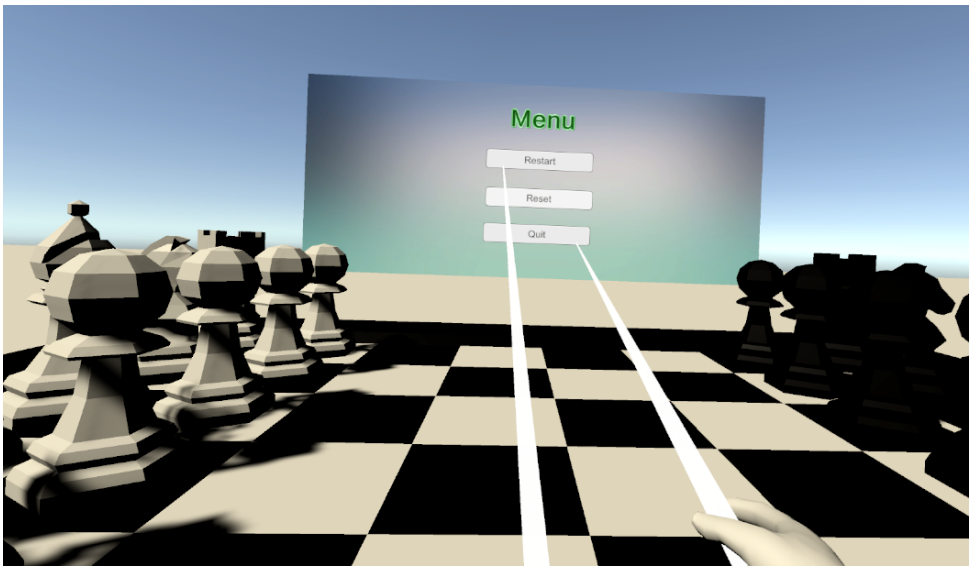

Figure 8.3: Menu options

8.2 Grabbing Chesspieces

8.2.1 Pawn

The grabbing mechanics for the pawn piece have been implemented to provide an immersive and intuitive gameplay experience. When the user interacts with the pawn using their VR controller (specifically the Oculus controller without haptic sensors), the game mechanics respond accordingly to mimic the behavior of a traditional pawn in chess.

As the user reaches out and grabs the pawn with their VR controller, the game registers the interaction and triggers the highlighting of legal moves for that specific pawn. The highlighting is visualized through a clear and distinguishable indicator that appears on the chessboard, indicating the squares where the pawn can legally move.

To ensure a seamless and accurate experience, the grabbing mechanics have been fine-tuned to provide smooth control and precise positioning of the pawn. The user's hand movements and controller input are translated into real-time interactions with the virtual

pawn, simulating the feeling of physically holding and manipulating the chess piece.
The implementation of the grabbing mechanics takes into account the limitations of the Oculus controller without haptic sensors. While haptic feedback is not available, the focus is on providing responsive and visually informative cues to guide the player's actions. The highlighted legal moves serve as a valuable aid in strategic decision-making, allowing the player to plan their next move based on the available options.

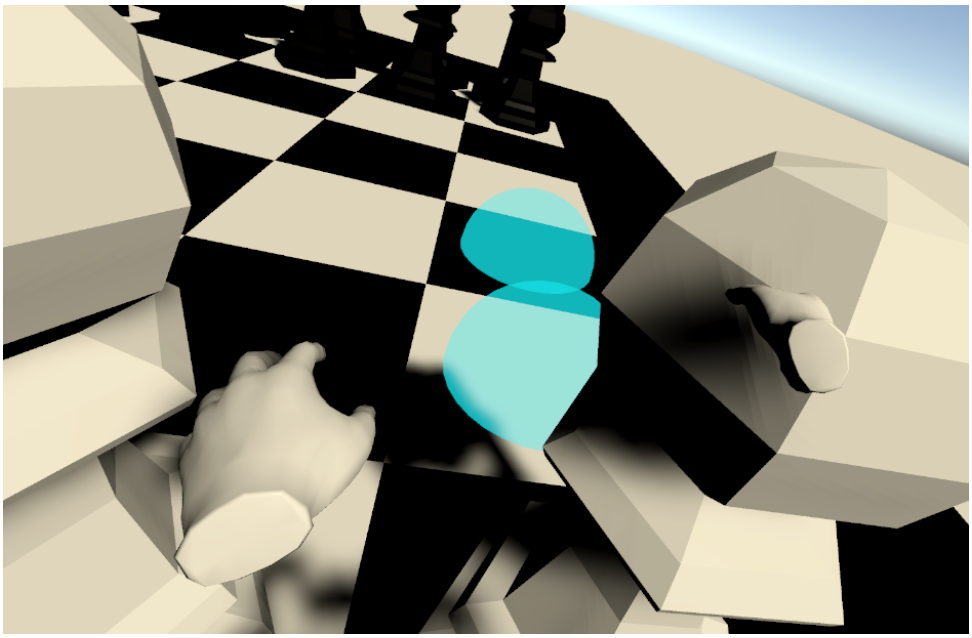

Figure 8.4: Pawn grabbing

8.2.2 Knight

When the user grabs the knight piece using the Oculus controller, a carefully designed algorithm immediately recognizes the action and triggers a response. Although the Oculus controller lacks haptic sensors, the game compensates for this limitation by providing visual cues and feedback. As the player's hand wraps around the virtual knight, a gentle vibration is simulated to create a sense of touch and enhance the feeling of grasping the piece.
One of the standout features of the grabbing mechanics in MetaChess is the highlighting of legal moves. As the player firmly grasps the knight piece, the game instantly evaluates the available legal moves based on the knight's unique movement pattern. These legal

moves are then visually highlighted on the chessboard, providing the player with a clear and intuitive understanding of the knight's potential trajectory.

The highlighting effect is carefully implemented, utilizing a contrasting color scheme or a glowing effect to differentiate the legal moves from the rest of the board. This visual feedback guides the player's decision-making process, allowing for strategic planning and thoughtful gameplay.

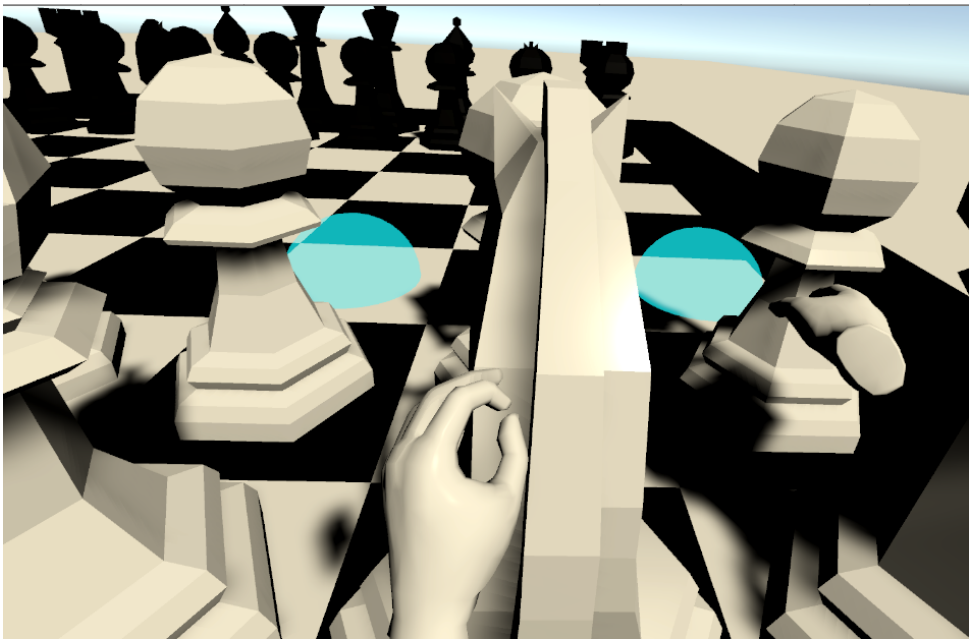

Figure 8.5: Horse grabbing

8.2.3 Queen

As the user's hand closes around the Queen, the virtual representation of the piece responds with a realistic sense of weight and resistance, creating a tactile connection between the player and the game. Although lacking haptic feedback, the controller's motion tracking accurately captures the user's movements, ensuring a seamless and immersive interaction.

Upon grabbing the Queen, a visually striking effect occurs, with the piece subtly glowing or emanating an aura. This highlighting effect is strategically designed to convey to the player the significance and power associated with the Queen in the game of chess. It serves as a visual cue, drawing the player's attention and signifying that they have suc-

cessfully grasped the powerful piece.

Furthermore, as the user holds the Queen, the game intelligently identifies and displays the legal moves available for that specific piece. Using sophisticated algorithms and advanced virtual reality techniques, the metaverse environment dynamically showcases the potential paths and destinations to which the Queen can be moved. The highlighted legal moves provide the player with valuable insights and strategic possibilities, empowering them to make informed decisions during gameplay.

This combination of realistic grabbing mechanics, visual cues, and informative move highlighting adds a layer of immersion and interactivity to the MetaChess experience.[26]

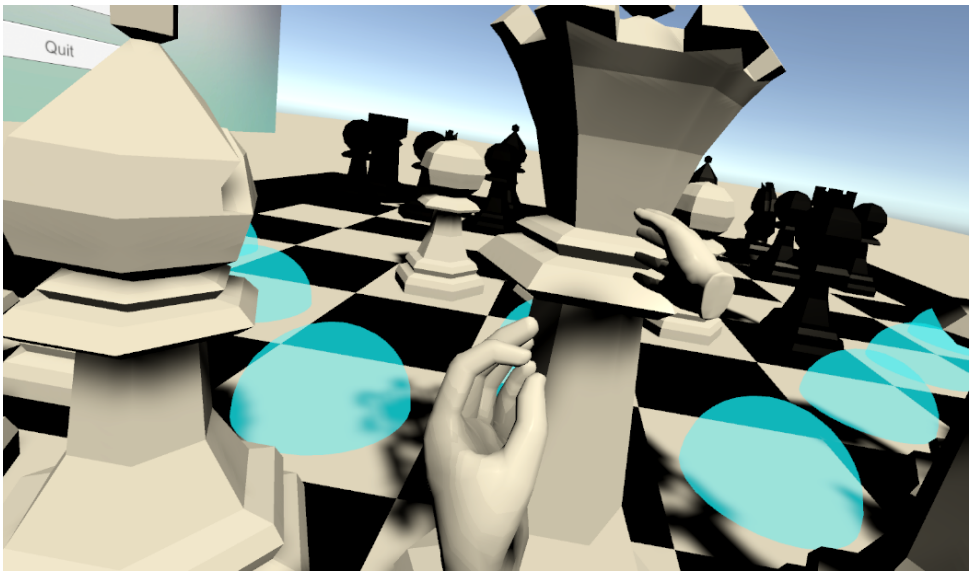

Figure 8.6: Queen grabbing

Chapter 9

Results

The multiplayer chess game in the metaverse, developed using Oculus VR technology, aimed to provide an immersive and interactive chess gaming experience for players. This chapter presents the results of the project, highlighting the key achievements, challenges faced, and user feedback.

9.1 Immersive Gameplay

The integration of Oculus VR technology allowed players to engage in the chess game within a virtual environment, enhancing the overall gaming experience. The use of virtual reality provided a sense of presence and realism, making players feel as if they were physically present in the game.

9.2 Seamless Multiplayer Experience

The multiplayer functionality enabled players to compete against each other in real-time, regardless of their physical location. Through the metaverse platform, players could connect, challenge opponents, and engage in competitive chess matches, fostering a vibrant and dynamic gaming community.

9.3 Intuitive User Interface

The user interface was designed with a focus on simplicity and ease of use. Players could navigate the virtual chessboard, select and move pieces using intuitive gestures and controls. The interface also provided visual cues and feedback to enhance understanding and gameplay.

9.4 Social Interaction

The metaverse integration facilitated social interaction among players. They could communicate with opponents through voice chat, engage in friendly banter, and build connections within the virtual chess community. The social aspect added depth and enjoyment to the gaming experience.

9.5 Challenges Faced

9.5.1 Technical Complexity

Implementing virtual reality and multiplayer functionality posed technical challenges. Integration of Oculus VR required expertise in 3D graphics, motion tracking, and optimization to ensure smooth performance. Managing network synchronization and latency issues for multiplayer interactions was also a significant challenge.

9.5.2 User Adaptation

While virtual reality added immersion, some players needed time to adapt to the new gaming environment. Familiarizing themselves with the VR controls and navigating the virtual chessboard required a learning curve for some users. However, proper tutorials and guidance helped mitigate this challenge.

9.6 User Feedback

User feedback played a crucial role in evaluating the multiplayer chess game in the metaverse. The following feedback was collected from players.

9.6.1 Immersive Experience

Players appreciated the immersive nature of the game, noting that it enhanced their engagement and made the chess matches more exciting and lifelike.

9.6.2 Social Interaction

The ability to interact with opponents and other players within the metaverse was highly valued. Users enjoyed the opportunity to meet new people, discuss strategies, and participate in friendly competitions.

9.6.3 Learning and Skill Development

Players expressed that the multiplayer chess game helped them improve their chess skills. The ability to compete against skilled opponents and observe different gameplay styles provided a valuable learning experience.

9.6.4 Technical Performance

Users appreciated the smooth performance of the game, especially in terms of graphics and motion tracking. However, a few players reported occasional latency issues during multiplayer matches, which impacted the overall experience.

9.6.5 Conclusion

The multiplayer chess game in the metaverse using Oculus VR successfully provided an immersive and interactive gaming experience. The integration of virtual reality, multiplayer functionality, and social interaction created a vibrant and engaging chess community. While technical challenges were encountered, user feedback indicated a positive response to the immersive gameplay, social features, and learning opportunities provided by the game. Further refinements and optimizations based on user feedback will continue to enhance the multiplayer chess game in the metaverse, offering an enjoyable and competitive gaming experience for chess enthusiasts.

Chapter 10

Discussions

This chapter delves into the discussions surrounding the challenges encountered during the development and implementation of the multiplayer chess game in the metaverse using Oculus VR technology. It highlights the various problems faced by the development team and presents the strategies and solutions employed to address them effectively.

10.1 Immersive Gameplay Experience:

One of the primary challenges was to create an immersive gameplay experience that seamlessly blended the traditional game of chess with the immersive capabilities of Oculus VR. The team recognized the importance of maintaining the strategic essence of chess while leveraging the immersive virtual reality environment to enhance player engagement.
To address this challenge, the team focused on optimizing the virtual reality experience by designing visually stunning and interactive virtual chessboards. They leveraged Oculus VR's advanced rendering capabilities and spatial audio to create a sense of presence for the players, making them feel as if they were physically present in the game. The incorporation of realistic hand-tracking and intuitive gesture controls allowed players to interact with the virtual chess pieces naturally, enhancing the overall immersion.

10.2 Networking and Multiplayer Integration

Implementing seamless networking and multiplayer functionality presented another significant challenge. Ensuring that players could seamlessly connect, challenge each other, and engage in real-time chess matches across the metaverse required robust networking infrastructure and efficient synchronization.

To address this challenge, the team employed scalable networking solutions and optimized server architecture. They implemented a reliable and low-latency communication protocol to ensure smooth and synchronized gameplay experiences for players located in different parts of the metaverse. Extensive testing and optimization were performed to minimize network latency and provide a seamless multiplayer experience.

10.3 Interface and Interaction Design

Designing an intuitive and user-friendly interface that effectively translated real-world chess mechanics into the virtual reality environment was a crucial challenge. The team needed to strike a balance between providing a visually appealing interface and ensuring ease of use and accessibility for players of all skill levels.

To address this challenge, the team conducted thorough user testing and iterative design iterations. They focused on simplifying complex chess actions, such as selecting and moving pieces, through intuitive gestures and visual cues. The user interface was carefully designed to provide clear information and guidance, enabling players to make informed decisions during gameplay. Regular feedback sessions with users helped identify areas of improvement and refine the user interface and interaction design.

10.4 Performance Optimization

Achieving optimal performance in the metaverse environment, where the game had to run smoothly on various Oculus VR devices, presented a technical challenge. Maintaining a high frame rate, minimizing motion sickness, and optimizing resource utilization were crucial aspects to address.

To tackle this challenge, the team employed performance profiling and optimization tech-

niques. They fine-tuned rendering settings, employed level-of-detail techniques, and optimized code to ensure a consistent and smooth gameplay experience across different Oculus VR devices. Continuous performance testing and optimization were conducted to address any potential performance bottlenecks and ensure optimal performance for players.

10.5 Conclusion

The discussions and strategies presented in this chapter demonstrate the proactive approach taken to address the challenges encountered during the development of the multiplayer chess game in the metaverse using Oculus VR. By focusing on creating an immersive gameplay experience, seamless networking, intuitive user interface, and performance optimization, the development team successfully overcame these challenges, resulting in a captivating and enjoyable chess experience for players in the metaverse. The lessons learned from these discussions will serve as valuable insights for future projects aiming to combine traditional games with immersive virtual reality technologies.

Chapter 11

Conclusions and Future Work

11.1 Conclusion

The development and implementation of the multiplayer chess game in the metaverse using Oculus VR have brought forth a unique and immersive experience for chess enthusiasts. Through the integration of virtual reality technology, players have been able to engage in chess matches that go beyond the traditional boundaries, allowing for a heightened sense of presence and interaction. The project has successfully addressed various challenges related to immersive gameplay, networking, user interface design, and performance optimization, resulting in a captivating and enjoyable chess experience.

The discussions in this chapter have highlighted the strategies and solutions employed to address these challenges. The focus on creating an immersive gameplay experience, seamless networking, intuitive user interface, and performance optimization has laid the foundation for a compelling multiplayer chess game in the metaverse. By leveraging the capabilities of Oculus VR, players have been able to truly immerse themselves in the world of chess, enhancing their strategic thinking and engagement.

The project's success lies in the collaborative efforts of the development team, who diligently worked on designing and implementing features that brought the game to life. Extensive user testing and feedback sessions ensured that the game met the expectations of players, providing them with an engaging and enjoyable experience. The project showcased the potential of combining traditional games with cutting-edge technologies to cre-

ate unique and immersive gaming experiences.

11.2 Future Work

While the multiplayer chess game in the metaverse using Oculus VR has achieved significant milestones, there are several avenues for future exploration and enhancement. Some potential areas for future work include:

1. Expansion of Gameplay Features: Further enriching the gameplay experience by introducing additional features such as different chess variants, customizable chessboards, and interactive environments can add depth and variety to the game. Exploring innovative ways to incorporate virtual reality mechanics into chess gameplay, such as gesture-based spellcasting or dynamic game modes, can bring new dimensions to the metaverse chess experience.

2. Social and Community Integration: Enhancing the social aspect of the multiplayer chess game by integrating community features, leaderboards, tournaments, and spectator modes can foster a sense of competition and engagement among players. Enabling players to interact, chat, and form communities within the metaverse can create a vibrant and dynamic chess ecosystem.

3. AI Integration and Training: Integrating artificial intelligence (AI) opponents of varying skill levels can provide players with challenging gameplay experiences. Developing AI algorithms specifically designed for virtual reality chess can further elevate the game's strategic depth and provide opportunities for players to improve their skills through training modules and adaptive AI opponents.

4. Cross-Platform Compatibility: Expanding the compatibility of the game to support cross-platform play across different virtual reality platforms and devices can increase accessibility and widen the player base. Enabling players to connect and compete regardless of their VR hardware or platform choice can enhance the multiplayer experience and foster a more inclusive community.

In conclusion, the multiplayer chess game in the metaverse using Oculus VR has show-

cased the potential of merging traditional board games with immersive virtual reality technology. The project has successfully addressed various challenges and provided a captivating chess experience for players. The future work discussed opens up exciting possibilities for further enhancement, innovation, and community engagement in the metaverse chess realm. By continually pushing the boundaries of technology and gameplay, the multiplayer chess game in the metaverse has the potential to become a staple in the realm of virtual reality gaming and chess enthusiasts alike.

Appendix A

Definitions

Bishop: Bishops are chess pieces that can move unlimited squares diagonally as long as no other pieces obstruct their path. Each player has one bishop on white squares and one on black squares, creating a distinct positioning for these powerful pieces.

Castling: Castling is a move in chess where the king moves two squares horizontally, and the corresponding rook is placed next to it.

Check: Check is a move in chess that directly threatens the opponent's king, creating a potential capture opportunity.

Checkmate: Checkmate occurs when the opponent's king is in check and there is no legal move to escape capture, resulting in the end of the game with a victory.

Chess Board: The chess board consists of 64 alternating black and white squares, providing the playing surface for the game. **Chess**: Chess is a two-player game that takes place on a 64-square chessboard, with each player having 16 pieces at the beginning of the game.

En Passant: En passant is a special chess move where an opponent's pawn can capture a pawn that has moved two squares forward, occupying the square it passed through.

King:The king is the central piece in the game, and the objective is to checkmate the opponent's king. It has the ability to move one square in any direction.

Knight: The knight, a unique piece resembling a horse, can move in an L-shape pattern: 1 space vertically and 2 spaces horizontally, or 2 spaces vertically and 1 space horizontally. It has the ability to jump over other pieces on the board.

Pawn: The pawn, the lowest-value piece of one color, typically moves one square vertically at a time and captures diagonally. It is one of eight pawns in the game.

Player or user: A user or player refers to the individual actively participating in the chess game, making moves and decisions during gameplay.

Queen: This piece has unrestricted movement and can traverse any number of spaces in any direction, provided there are no obstructions along its path.

Rook: These pieces, both of the same color, have the ability to move horizontally or vertically for any number of squares, as long as their path is unobstructed by other pieces.

Stalemate: A stalemate occurs when a player's king is not in check, but they have no legal moves available. This situation results in a draw.

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