GADNET FOR VIRTUAL REALITY INTERACTION

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By

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GADNET FOR VIRTUAL REALITY INTERACTION

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ABSTRACT

GADNET FOR VIRTUAL REALITY INTERACTION

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Virtual Reality (VR) is a significant technology that has the potential to revolutionize a variety of professions. Virtual reality, often known as immersive multimedia, is a virtual environment simulated by computers that may imitate physical presence of real-world in imaginative environments. Construction of VR setups are available for many new emerging technologies, but we have directed the VR technology, keeping in mind rehabilitation along with entertainment. The setup consists of three smartphones connected via TCP/IP protocol and a Head Mounting Device. The approach considers an individual playing pong game using the host phone as a primary visual component aided by Head Mounting Device (HMD) and the other two phones as left-hand and right-hand controller. The setup requires three smartphones with minimal setup cost and simple implementation. The application is built on Unity and the programing requires key features like computation of speed on the ball, sensor interaction, and connectivity of two secondary smartphones with the UI rackets on either side of the platform to direct the rackets Thus, the project makes for an interesting and rehabilitation product that can be used for future enhancement in medical physical therapy such as hand-eye coordination, shoulder socket movements etc. There is also scope of enhancement on the experience of VR for general people.

Dedicated to my family

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LIST OF ABBREVIATIONS AND NOTATIONS

VR	Virtual Reality
GadNet	Gadget Network
HMD	Head Mounted Device
LAN	Local Area Network
TCP/IP	Transmission Control Protocol/Internet Protocol
PTSD	Post-traumatic stress disorder
RPC	Remote Procedure Call
CAD	Computer-aided Design
UI	User Interface
SYN	Synchronize
ACK	Acknowledgement

CHAPTER I

INTRODUCTION

Versatility of VR gives us the scope to implement the module in multiple application based on user requirement. The application can work from real estate [1][13][14], where architect can virtually analyze and improvise the design through real time to medical therapies for patients to measure the reaction time, muscle contraction and various other test cases[3]. Thus, our major goal is to create an interactive game for individual physical exercise that is easy to interact with in order to counter the repetitive hand movement workout involved.

In today's advanced technological environment, the majority of industrial labor involves sitting in front of the computer and interacting with remote equipment. The desk work results in very low physical movement and exercise of the body, which in-turn gives rise to certain chronic diseases [19]. For example, when we walk, it might be a simple task but, the muscle involvement in this act is a complex mechanism which predominantly involves brain, legs and hands moving synchronously to conclude the task. Walking for few minutes may be tedious and generally been overlooked by normal person as a physical exercise, but it is one of the most important activities for the stroke rehabilitation [20]. This kind of simple day-to-day physical activity like walking, play an essential part in our lives in order to recover from chronic diseases. The physical therapy essentially demands the individual to visit a rehabilitation center, a human therapist, and more tedious repetitive physical activities for long period of time. To counter this high utilization of resources, Virtual Reality provides a solution for all the mentioned task with minimum resource involvement. By merging rehabilitation tactics in an innovative and low-cost way, Virtual Reality (VR) has lately emerged as a legitimate supplement to conventional therapy.

There are multiple applications on VR designed systems where better results on medical therapies and engaging in the virtual world was achieved. Most of the research concludes using low cost [4] but in-turn compromises on the high maintenance accessories, complicated setups or immobile gadgets which doesn't serve the purpose as a flexible user-friendly application. Some of the simulators are cheap, but the accessories provided, or the display used are heavy and costs more than usual price. For this reason, the GadNet is designed to make it a completely mobile setup with three smartphones. As per survey by PEW Research Center, one-third of American household contains more than three smartphones [21]. This means the availability of smartphones in a particular household is enough for the GadNet setup. The smartphones can be easily integrated with each other for therapy session. Smartphone's requirement for GadNet is very low, doesn't need any high-end advance features. Minimum requirement is Wireless connectivity, 200 MB available storage and Gyroscope sensor. The smartphones are readily available at cheap prices from online and offline markets, used markets and recycling stores. This makes our architecture a very low resource utilization module which can be carried to any place and the setup can be built in few minutes for user. Though the architecture involves using three smartphones, it can be considered as a low-cost VR setup.

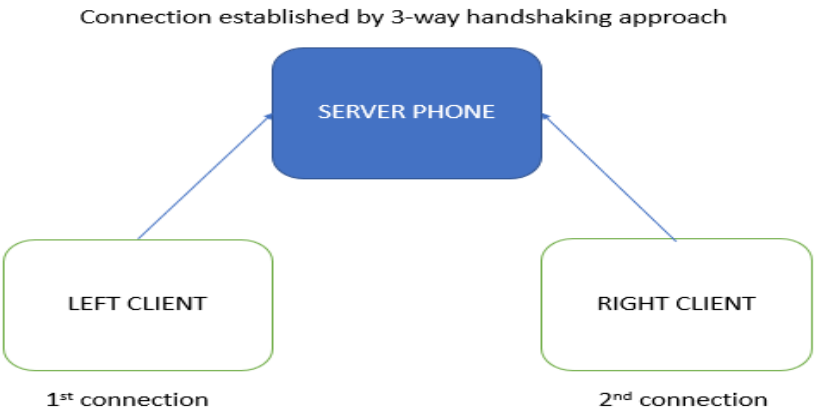

Figure 1: Connection between the client and server through stream socket and secured 3-way handshake.

Gadget Network (GadNet) is a VR interaction setup which may be used as a rehabilitation for individuals engaging in a virtual pong game linking three smart phones through wireless LAN. The player uses the primary mobile phone for visual assistance inserted in an HMD and the other two phones as right-hand and left-hand controller. The game is played using the left-hand and right-hand combination to keep the virtual ball on the platform moving the rackets vertically. The rackets represent the controllers on either side of the platform engaging the ball to bounce back into the platform. The setup is an engaging module which helps in rehabilitation as well as entertainment for the player involved.

The proposed GadNet works on Unity based module consisting of wireless connections between the phones, user interface and motion sensors for the smartphones.

The smartphones are connected through stream socket connection. In this design as shown in Figure 1, we have a goggle phone which is considered as a primary phone, connected to secondary or client phones. The interaction in stream socket is used mostly for multiuser data transfer which we have utilized for our module to interact between the phones in our pong game. On the Internet, stream sockets are often implemented using TCP to allow applications to operate across any network that supports the TCP/IP protocol. The connection uses 3-way handshaking approach for better reliability.

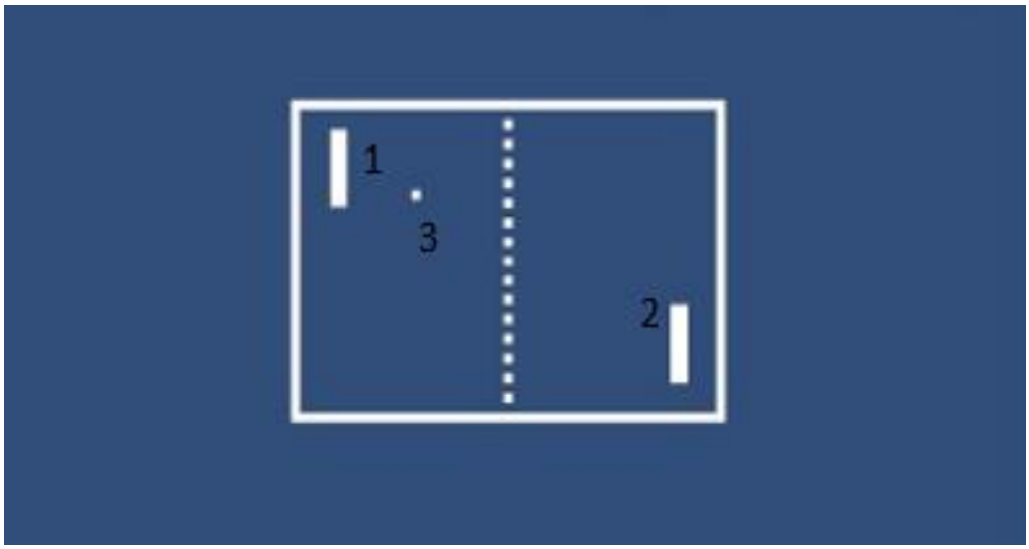

Figure 2: Left client connected to 1, right client connected to 2 and ball object movement 3. The connection is made through gyroscope sensor and ball movement is calculated in Unity by C# programming.

The connection is established by 3-way handshake. The first client connected is automatically assigned to left-hand controller and the next client as right-hand controller. The interface on the client module is built in Unity to start the game after the connection is established. This enables the clients to send an RPC call to the server for response and real time interaction is established. Thus, the pong game is started on the primary or server phone to be viewed by HMD.

The game play used the left rackets synchronized to the left client and the right rackets to right client by gyroscope sensors. The pong game platform is shown in above figure 2. This rackets on both sides are used to keep the ball on the platform. The movement of the ball is taken by transform position vectors. The collision with the rackets helps in movement of the ball in opposite directions. The calculation is done capturing the hit value, normalizing it, and then replacing the coordinates of the ball to get the direction of the movement. This direction of the movement is then multiplied with the constant speed value compute the total movement of the ball.

The labels are introduced into the User Interface where if the user misses the ball, the count in right upper corner decreases. If it reaches 0 from 12 the game gets over. Also, the highest score and timer is found in upper left corner which indicates the player who has maximum time score of the

gameplay and the current game play time. With this functionality the game keeps track of all the actions taking place of the current and previous highest gameplays.

In this project we have successfully implemented a VR interaction module using three smartphones connected with each other for a pong game. The smartphones do have only basic computational requirement for connectivity. The approach can be considered novel due to the fact that three smartphones synchronized and connected to each other has not been performed yet on any kind of VR interaction fields. Thus, making our thesis topic a unique step forward towards multi-phone connectivity on a single application for individual control.

We are also planning to take a further step of connecting more phones which can also help in movement of the legs and can sense the whole-body motion in a VR environment designed from real world scenarios.

CHAPTER II

LITERATURE REVIEW

Virtual Reality has been implemented in many applications from gaming console to 3D models for better experience. VR was first introduced by SEGA as VR glasses, followed by Nintendo called Virtual Boy. Soon after, Georgia Tech et. al came up with an idea for treating PTSD in war veterans using controlled exposure and traumatic triggers. In 2007, VR kit design took a huge step forward by creating a VR headset model which can be made easily transforming it into "Oculus Rift". Further, Facebook took over the oculus technology and SONY launched its first gaming headset for PlayStation console. Nearly a decade after revolution in VR design, the Head Mounted Display took a certain step to cut the prices on the manufactured products [6].

Figure 3: (a) SEGA VR kit introduced in 1994, (b) Georgia Tech and Emory University device for treating PTSD in war veterans (c) HTC Vive, first known HMD for true VR experience.

As of today, the devices are getting much cheaper to afford, where the VR setup instead of a large area to accommodate all the instruments and sensors. HMD is one of the examples. The HMD

is ready to use device, integrating with smartphone for VR experience. There are multiple HMD products available for our use, but we concluded not to limit the user to specific setup so made it available for all the HMDs readily available in the market.

Human Computer Interaction aided by VR started as a research topic in late 1990s and continued early 2000s where some of the two-dimensional images were transformed into 3D environment for real world experiences. Such early example was a CAD system [2] for designer to precisely look at the designs, study them from different viewpoint, rotate and translate the objects as per their requirements.

Figure 4: From left to right, one of the first implementation of low-cost VR, low-cost car simulator in the middle, lastly the medical science training through computer and VR equipment.

In gaming industry, VR has already been subject to much of research and implementation for low-cost perspective, where in 1996 Wells et. al introduced VR connectivity with sensors made out of a huge curving platform with four pressure sensors that looks a lot like a balancing board was modified by Gerwin de Haan et al in 2008 [7], with sensor in VR foot paddles. The sensor connected to Nintendo Wii computes the pressure on the feet for the movement in the gaming environment. It is regarded as one of the first known approach on VR with sensors as a cost-efficient device. Soon after, it was converted into an educational game-based model[15] and the limitation of using it only for a specific gaming console was scrapped. The paper also successfully integrates hardware and software with smooth transition [8]. The sensors were no longer heavy and can be used in

handheld devices. Though making it a complex architecture for implementation, but VR took a step forward in different industry products.

In 2011 Adrian Steinemann et. al, introduced a low-Cost Racing Car Driving Simulators for full body haptic used trigger sensors keeping in mind the impact by the car's velocity, physical behavior, and track features, which gave the user more experience on virtual environment exposing the user to much larger scope of interaction with the VR world [9]. The cost was reduced but the setup with different hardware parts made it complex and bulky as shown in Fig. 4 in the middle and cannot be relocated to other areas easily.

Similar, low-Cost Virtual Reality models started to develop for medical training purposes using the handheld devices making it mobile. The utility of Virtual Reality in rehabilitation, treatment, medical training, and education were being explored. The mobile architecture the module using 'Oculus Rift' and 'Razer Hydra' devices for medical training purpose using handheld device was successful. This made a breakthrough on the medical industry, one of the examples is a paper where the individual can operate on a virtual patient with high accuracy and precision for training purposes [10]. This adds to whole new level of VR interactivity with medical students, enabling them to study the anatomy. Hand tracking added a new feature in three-dimensional interactivity. The setup can only be used within computer-based platform thus making it standstill product. Fig. 4 right most image represents the setup.

In medical industry, therapy-based applications, first VR was implemented by George Town University two decades earlier. Many research has been done on therapy-based applications assisted by VR is still being conducted and available to individuals. These therapies include anxiety, chronic pain, alzheimer's disease, pain management and various others [11]. For example, a paper published on low-cost device for exposure therapy [4] to cure any phobia regarding real world environment. This includes fear of heights, water etc. The VR application requires an HMD,

which builds and environment for the individual replicating a real-world place, gradually helping the individual to adjust to the respective phobia.

Much research work has been present and developing for psychological distress where VR equipment with low cost and mobile setup has been used to assist in the cure for the patients. As VR modules are much better in engaging people, the distraction helps the person in mental stability during procedures such as chemotherapy [12]. Thus, contributing with many successful results in complicated procedures.

Despite this advancement, VR has limited availability to the patients in for medical applications for physical therapy. We wanted to perform some research on assistance on medical industry involvement by VR setups. Thus, our goal is to introduce a project which will help people with the physical therapies, engaging the person in some VR game aiding the physical rehabilitation of the hands for medical purposes. Most physical therapies are monotonous, repetitive procedures where the patient can easily get distracted and can lose the intensity. This may cost or increase healing time of the patient. The project concentrates on the movement of the hands and shoulders sockets for rehabilitation engaging the individual in an interesting single player pong-game.

The pong-game is developed in Unity module, connecting two smartphones to a primary phone which serves as a server communicator to the other two smartphones as clients. The client phones are used as handheld controllers for left hand and right hand respectively. This connection is done with TCP/IP protocol maintained under stream socket connection. The gyroscope sensors are used for the movement of the rackets on either end of the pong-game platform to keep the ball inside the platform. The client phones are moved vertically up and down which in-turn sends the signal to the application assisting in the movement of the racket on either side. This human computer interaction helps the patient during the rehabilitation, engaging the patient in a interesting game, in the meantime serving the person for physical therapy.

The smartphones do not have any minimum requirement except for the basic connectivity tools and motion sensors. This makes installation of the setup very easy. The visual part is used through a low-cost HMD device, and the server phone placed inside, giving the user a proper view of the pong game platform.

As the setup only requires three smartphones and an HMD, this makes it low-cost lightweight mobile setup which can be accessed from anywhere. Furthermore, this can also be the steppingstone for individuals or kids ignorant on VR experience and want to try a basic interactive game before committing themselves in a full mode complicated VR setup. The installation of the research project is easy and can be set up in few minutes using the required accessories and connection steps. The description of the connection and experience of the game will be discussed in the next section under methodology.

CHAPTER III

METHODOLOGY

As discussed earlier, our proposed approach consists of three parts: Setup modules, real time connectivity and UI for gameplay integrated to sensors. The setup modules consist of four hardware namely one HMD and three smartphones connected together. Real time connectivity is done under stream socket based [17] on TCP/IP protocol engaged in 3-way handshake for more reliability. Using gyroscope motion sensor [18] and UI interface, the gameplay is built in Unity and C# programming for deployment on the smartphones like Android and iOS.

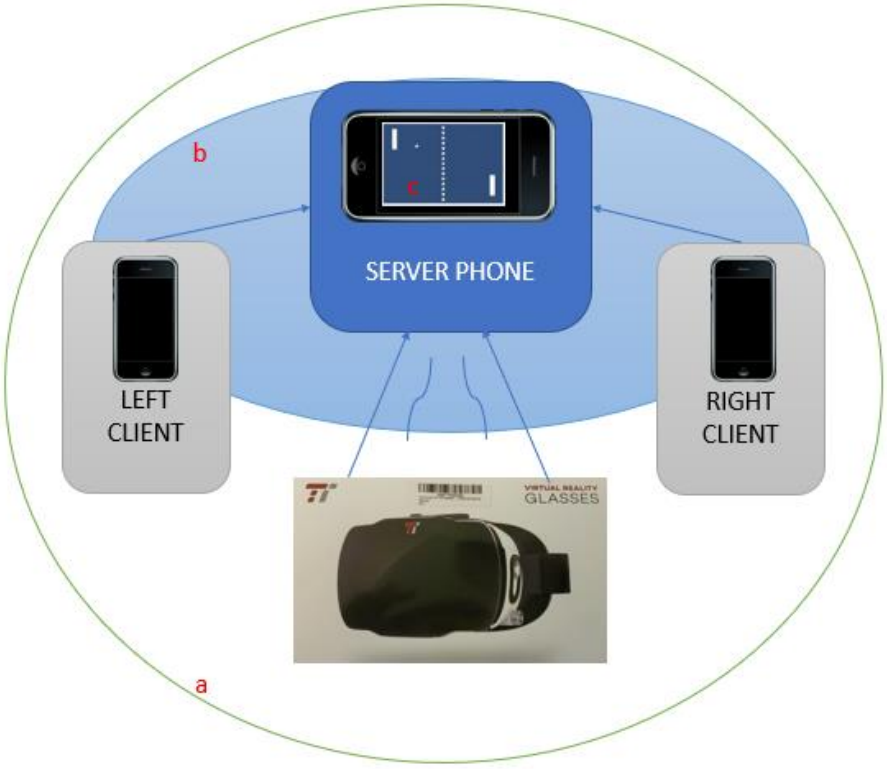

Figure 5: The project high level architecture (a) the experimental setup resources required, (b) Connectivity of the systems for real time experience, (c) User Interface build in Unity and deployed on the smartphone.

3.1 Resources

In Fig 5. we can refer the hardware requirement for the complete setup. The minimum low-cost setup consists of one Head Mounted Device (HMD) module for the human interaction through which the user experiences the pong game.

HMD is a tiny display optic in front of one (monocular HMD) or both eyes (binocular HMD). Gaming, aviation, engineering, and medical are just a few of the applications for a head-mounted display. Fig. 5 shows an HMD device for smartphones. One or two small screens embedded in eyeglasses, a visor, or a helmet, as well as lenses and semi-transparent mirrors, make up a standard HMD. The module in this project used can be of any manufacturer but should have the capacity of integrating smartphones into it. The smartphone integration is a basic setup for HMD where-in the smart phone is attached to the end and from the other end it can be visualized with true gaming experience. The only noticeable factor is the phone screen size compatibility with the HMD case. The screen size of the smartphone should be equal or smaller than the screen size to perfectly fit into the HMD device. Since there are varying screen size for smartphones in the market, choosing the right HMD device is very important for the setup build.

The setup uses three smartphones. As we can refer from Fig 5. the primary or sever smartphone is mounted on the HMD. The basic feature requirement for the smartphone is a wireless network and capability to host a server along with gyroscope sensor. A basic smartphone has gyroscope sensors which enables the phone to be used in vertical and lateral display modification. We utilize this sensor for movement of the handset.

The client servers also have a minimum requirement of smartphones for motion sensors, and server phone connectivity. Pairing of the smartphone decides the priority of left-hand and right-hand controller request. i.e., if the client smartphone pairs first, it automatically is given the high priority and assigned to left hand controller and the next pairing is assigned as a right-

hand controller. The controller motion can then be verified by moving the client phones and server phone module by placing the server phone on the HMD and viewing the rackets position.

3.2 Connectivity Protocol and Sensors

The connection between three smartphones can be done with widely used TCP/IP protocol for better communication, reliability, and stability of the network. This enables us to interact with client and server using two-way communication. The bi-directional communication uses stream socket under TCP connectivity. This is a reliable socket connection for communication and security. This enhances the communication between multiple devices without loss of data. The read and write functionality of the data is done with byte stream.

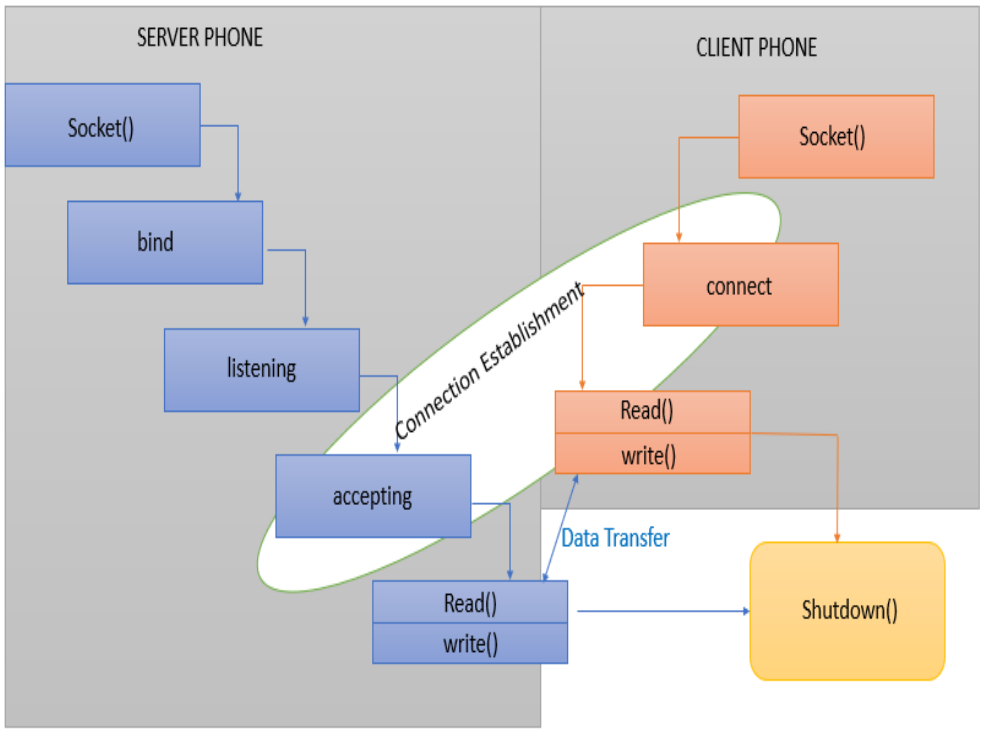

Figure 6: Represents the stream socket flowchart connections which is used in our approach for connecting server and client smartphones.

Stream socket connection uses socket binding followed by listener and connection accept and read-write capability on the server side. On the client side it uses socket connection with server and read write method from the server for data transfer. Both the connection duration shuts off after the either of the client or server is closed. The connection is reliable and bi-directional, which enhances our communication from server to client and vice versa.

Socket connection is enabled and transferred to next phase of binding the name of the socket. The socket then calls the listen() method to indicate a signal that the server is waiting for a client to establish a connection and initialize the data transfer queue for request acceptance. The client phone creates a stream socket, calls the connect method and searches for the target server. If it receives the request for target server, accepts the request and establishes the connection with the server. The data transfer begins in a bi-directional way for communication. The communication is then goes into an infinite loop for the client and server to send and receive data. This interaction helps us in getting the two client phones interacting with the server phone for movement of the rackets on the pong game application. The data transfer between the phones uses byte stream. The connection is limited to three phones hence we are able to use the stream socket connectivity without any major loss of data.

The stream socket connection in the smartphones uses C# on Unity built-in TCP/IP methods for connecting the multiple smartphones together found in TCP Client class. An object of the class is instantiated as a socket connection. Once the wireless connection is enabled on all devices the TCP server/listener waits for clients to interact once provided the address and port of the other device who wish to communicate with it. To begin, it turns off the listener and begins listening when it starts up. If a client is already attempting to connect, it is accepted, and the connection is established. The accepting block as shown in Fig. 6 updates a loop connection to check if there is a client to establish the network. If a client is found and requesting connection, it connects and moves on. If there isn't, the update loop is terminated, and all attempts to read from a client are skipped. When it connects to a client, it obtains new data

from every update frame and reads the stream. The verification of IP address, and connection establishment is a fast process connecting to multiple devices at the same time from the server phone. Thus, the name socket stream, stream is the data flow between the client and the server, and the socket is your actual connection.

Furthermore, for more reliability we use a 3-way TCP handshake process to get more reliability and less data loss. The TCP handshake uses SYN-ACK technique. In this procedure the server sends a sequence number to the client, which in-turn responds with sequence number and acknowledgement. When the acknowledgement is received the server sends back the acknowledgement of the sequence number sent from the client. This indicates the successful transfer of data to back and forth. If any of the acknowledgment not found, the other party continuously sends the signal and data until the confirmation is received. This process helps in reliable communication and minimum data loss in the connection.

For this handshake, we use NetworkDiscovery class in Unity. In this class broadcastData is set for the listener to broadcast the data from the server phone. After the successful broadcast, the method OnRecievedBroadcast is called on the listener. This method is called whenever the client successfully listens to broadcastData from the host/server. The OnRecievedBroadcast uses two parameters, first one is the IP which the user has entered for establishing connection and the second is the broadcast SYN data received from the preliminary communication. After OnRecievedBroadcast's successful listening and communication of SYN and ACK triggers. After this connection, it waits for the ACK from the serverphone to start sending the data from the client phones of the motion detector to the server phone. The client phone will continuously send data to the server after the OnRecievedBroadcast is called until it receives an ACK request from the server phone. In this application the data send from the client phone is the motion detector data. In particular, Gyroscope sensor is used for motion data feed for moving the gameObjects rackets, up and down vertically in the server phone.

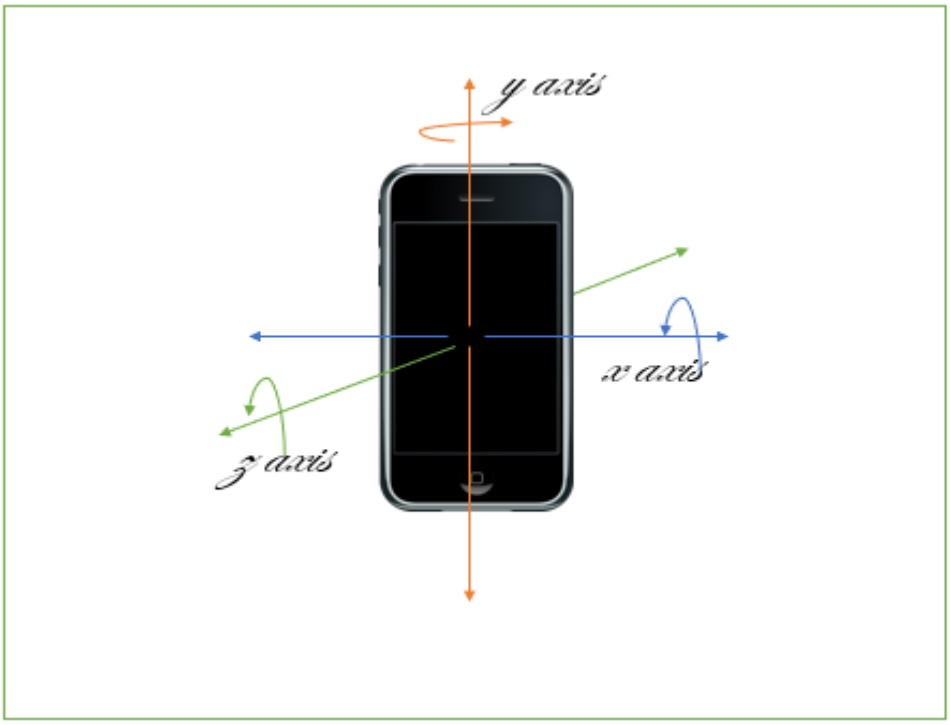

Figure 7: Gyroscope sensor 6-dimensional functionality in mobile phones.

Gyroscope sensor can be used for multiple technologies such as: cell phones, balance control, digital camera, car-navigation, mobile games and so-on. In smartphones is in-built hardware incorporating for more precise movement recognition in 3D space. The use of gyroscope in smartphones are pre-dominantly used for rotation of the screen when the phone is turned on either side. It also helps in commands 3D motion gaming by sensor triggered when a particular directional motion is triggered. Gyroscope can identify 6-dimensional motion which helps in much alluring user experience. We utilize this feature to track the motion of the left-hand and right-hand controllers. The client controller motion is transmitted to the server phone for the movement of the rackets enabling a synchronized gaming experience.

3.3 User Interface and Gameplay

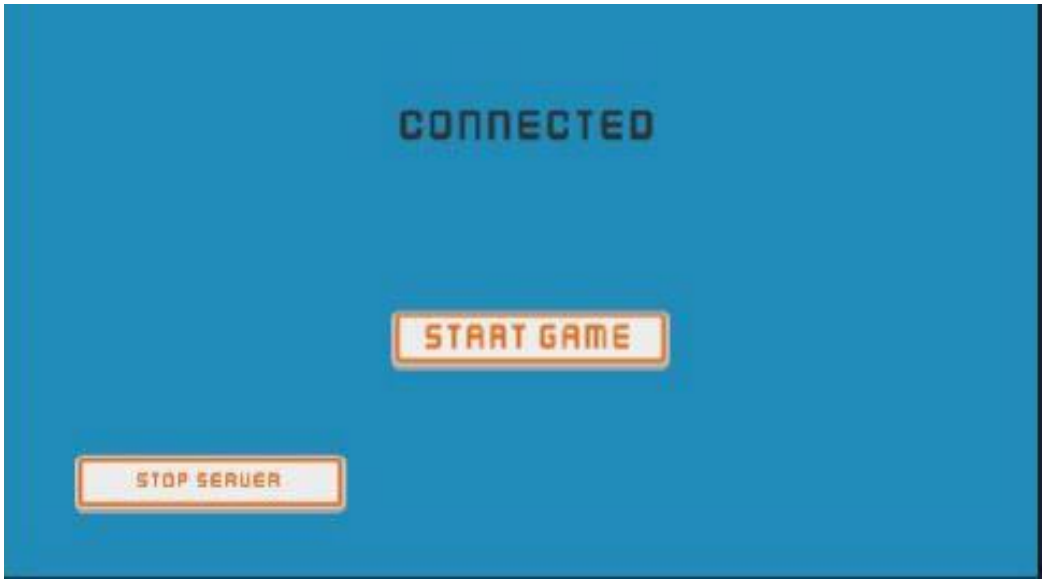

Figure 8: User Interface on client phone for starting the game built in Unity Hub

The User Interface and gameplay is built on Unity. The program triggers and identifies as soon as both the client is added to the server phones as shown in Fig 8. The IP address of the server phone is captured, and signal is sent to the client phone to interact in the game. The execution of the program starts after the user interacts with the interface by pressing the "START GAME" button in the display screen of the client. This triggers the start of the game as shown in Fig 2. The display screen splits into two halves for HMD support. Game objects built the Unity are two rackets on either side of the screen, ball in motion from left to right and vice versa.

After the two clients are connected, the server sends an RPC call to both the clients to start the game. This initiates the game, and the ball starts its motion. The motion of the ball is calculated by the specific speed value after normalizing it which results in the new coordinates of x and y. The motion detected from gyroscope sensor is then transmitted to the application via stream socket data transfer. The collision of the ball with racket is calculated by comparing the coordinates of ball and rackets to direct the ball in opposite direction. Whenever the ball

collides with the racket, we initiate a change in direction of the ball's next probable coordinates. The initiation of the new coordinates and direction of the ball is computed with collision racket, calculating the hit factor from the previous speed value, normalizing the present coordinates (x , y) values, and multiplying it with the required speed value. Thus, the ball motion is identified at colliding step and sent to opposite direction. This continuous computation of ball coordinates, racket coordinates, and motion data for ball through computation and rackets through gyroscope sensor helps in making the pong game a smooth interactive rehabilitation game for the user.

Experimental setup for GadNet requires installation of same Unity application build in all the involved smartphones. The application when opened in the server phone triggers a connection request to the client phone requesting the TCP/IP setup. When the client phone is connected to server phone, the display screen awaits user interaction as seen in Fig. 7. The server phone is then placed inside the HMD module on visual display. The right hand and left-hand controller which acts like clients are already connected to server and start transmitting motion data through gyroscope sensors. The gyroscope sensors help synchronize the rackets in the server phone and positioning of rackets are captured in the executable application program in Unity application. The ball moves from left to right and our aim is to divert the ball back to platform. The controllers are moved vertically up and down using the gyroscope sensors making it a interactive procedure to conduct physical hand therapy, hand eye coordination tasks etc.

The programming is done with visual studio compatible on Unity and C# as the primary programming language. The Game Objects defined in Unity can be controlled by different methods such as, ball motion, ball collision direction, racket and ball collision and racket motion. If the ball collides with the racket a variable is used to hold the coordinate values, the coordinate values are captured from the racket coordinates, and a function is defined as the collider for necessary computational inputs. The ball collision uses transform method to

calculate the motion. The conditions are placed so that only local player can control the racket on both ends. The racket motion from the sensor is feed into the application variable as a floating-point value.

The setup is a mobile one and can be carried to anyplace as per requirement. As discussed earlier the three smartphones along with an HMD module is a simple and engaging technique we have used in GadNet. Thus, low-cost setup with high standard of user experience is the primary motivation for our research topic.

CHAPTER IV

EVALUATION

In this section, we evaluate the proposed approach with experience on gameplay from the different age group human users. We have evaluated through 20 users ages range from 22 to 55 (μ = 27) and the results are as follows.

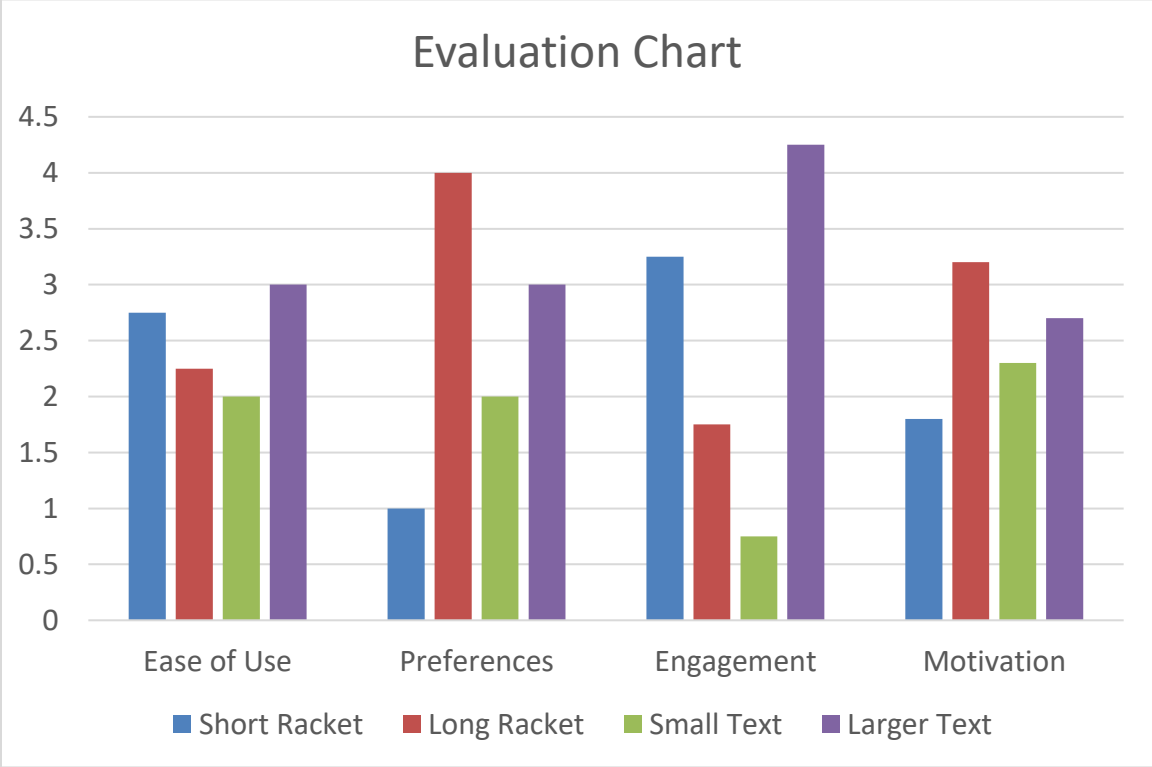

Figure 9: Chart for evaluation of user experience over the gameplay and on-screen view.

As shown in Figure 9, larger text is preferred in terms of ease of use and engagement. Meanwhile, long racket is appreciated for motivation. The main reason is that the users do not

perform well with the small rackets, ending up with a lot of errors and early game finish. Therefore, the long racket helps the user well catch the virtual object.

In the below table, we evaluate and compare the VR technologies of different manufacturer.

Table 1: VR technology comparison. ✓: support, ✗: non-support.

VR Technologies	**GadNet**	**Oculus Rift**	**HTC Vive**	**Microsoft HoloLens**
Low-Cost	✔	✗	✗	✗
Multi-Controller Support	✔	✗	✗	✗
Phone Support	✔	✗	✗	✗

The table represents the comparison of GadNet over high-cost VR technologies such as Oculus Rift, HTC Vive and Microsoft HoloLens. GadNet supports any smartphone user, with multi-controller output to increase the number of communicating devices and comes with much lower cost than the other VR glasses.

We also compare our work with Zhe Huang (2017) where the same type of VR interactive gaming was introduced with Maze game. In that work, the game was played through Google daydream, using one smart phone for display through HMD and other smartphone to balance and

roll the ball against in the maze. We have successfully connected to smartphones to build a pong-game with HMD headset with Unity application. The motion sensor we used is gyroscope is the same as the maze game implementation.

Pong Game

Maze Game

Figure 10: Left image is of Unity Pong Game; right image is of Maze Game.

In accordance with the maze game, pong game is more physically involved with the user. Though the smartphones requirement increases for pong-game, it gives a certain benefit over previously developed games with better user engagement and higher body part interaction.

The connectivity used for maze game is through installation of emulator and Bluetooth connectivity and we have upgraded the same for multi-user connection to TCP/IP stream socket connection. Bluetooth connectivity compromises on the connectivity as it has low bandwidth, greater loss of data and reliability. The TCP/IP reliability and security features as discuss in methodology section has an upper hand on the other means of connections available. Multi-user

connectivity also a key feature for stream socket which can be utilized for enhancement of VR connected equipment.

Thus, the pong-game has better user experience and flexibility on different platforms with irrespective of hardware and software diversity.

CHAPTER V

CONCLUSION

In this thesis, the proposed approach is a low cost VR wherein three smartphones are connected as multi-controller application. The pong game, developed in Unity hub can be build and installed in all the smartphones. The installation process is same for all the three smartphones involved. The application has the flexibility to decide the server phone and the client phones. The client phones are connected to server phone using stream socket connectivity and the motion sensor help in movement of the rackets in the pong game. This is a novel approach of using two client phones as controllers for left-hand and right-hand respectively. The server phone is used for visual display and is inserted into the HMD for gaming experience. The gaming application is built in Unity hub and it can be installed in any smartphones irrespective of the operating system and HMD module. The HMD module can any generic low cost module keeping in mind the size of the smartphone which needs to be integrated. Thus, the module has ease of implementation, readily accessible equipments and better user engagement.

This can be used for rehabilitation process for physical therapy engaging the user into a game where the monotonous therapy practices can be excluded. This results in more engagement of the patients and can yield better rehabilitation results from the patient perspective. The application can also be a stepping stone for individuals with no VR interaction knowledge and want to experience VR setup for entertainment.

CHAPTER VI

FUTURE WORKS

In near future, we would like to integrate more equipments into the same application for better entertainment and more rehabilitation procedures. We are planning to implement a multi-controller using more smartphones which could also detect the motion of the legs and use it as an input for the VR iteractive application. This could further enhance the setup model and can engage all parts of the body rather than the hand and eye control.

We can also build a VR environment increasing to pong game structure to gaming hub, where other games can also be included. This will magnify the options available for the user, choosing from multiple games in the virtual environment as per requirement of entertainment or rehabilitation. Furthermore, we can also develop multi user gaming environment which could integrate two or more users in the same environment competing against each other.

The use of VR in the medical therapies has been limited to mental therapies and doctor training purposes. We would like to explore more areas to integrate VR technologies, which could serve as a benchmark for future research.

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APPENDIX A

TCP 3-way handshake.

3-way handshake uses SYN-ACK steps where SYN is send and ACK is received along with SYN and in completion of the process a ACK communication is send to response SYN.

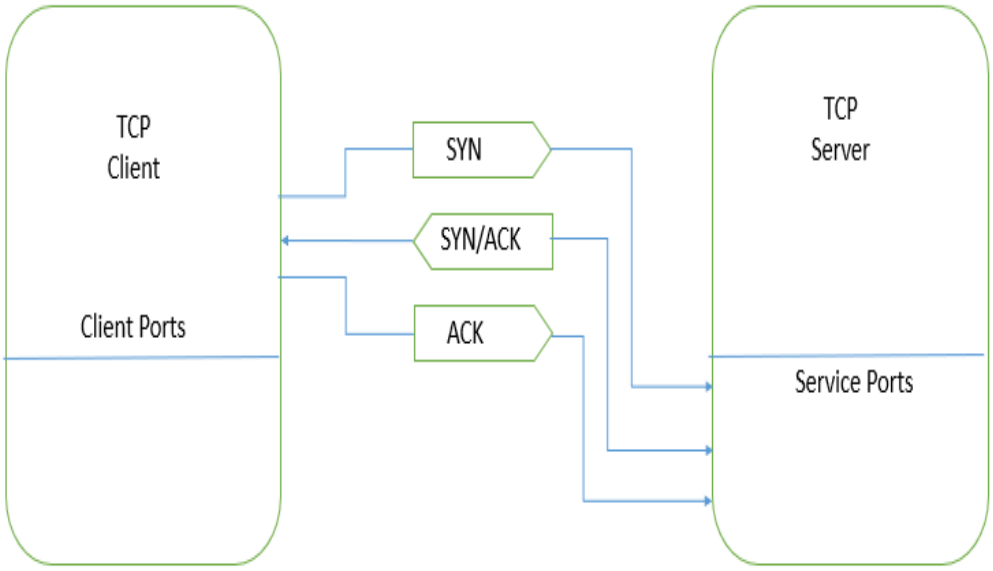
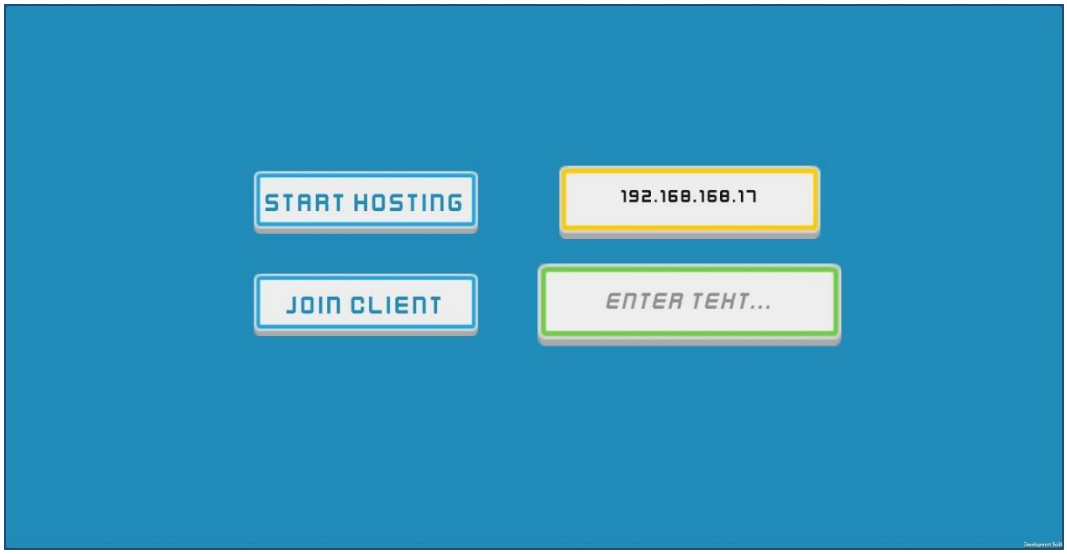


Figure 11: 3-way handshake connection in TCP.

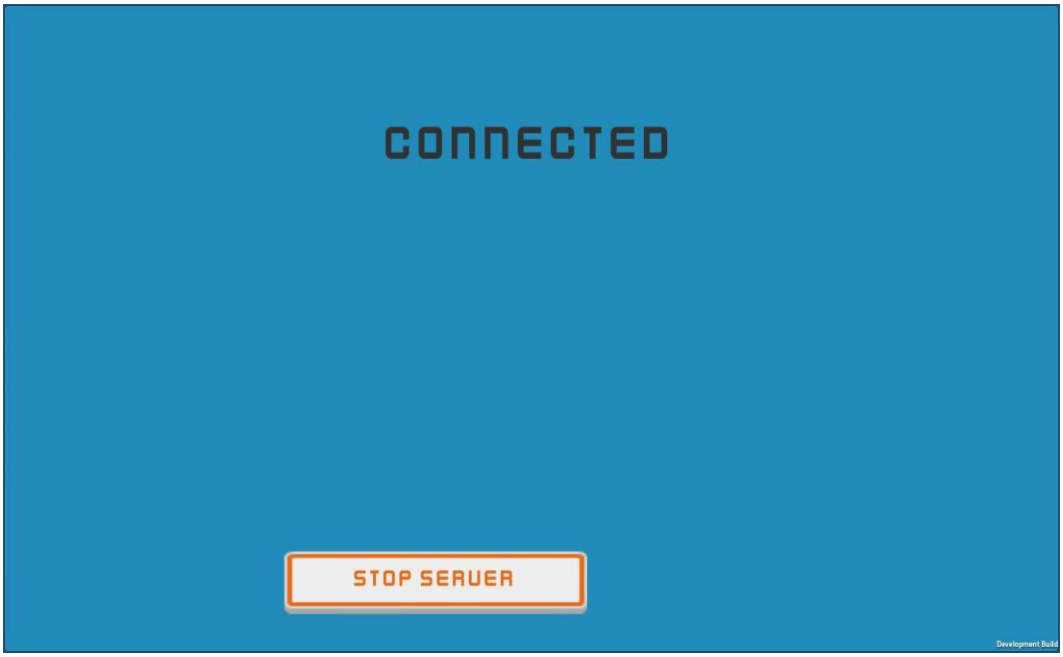
APPENDIX B

Snippets and steps for user interaction with the pong game

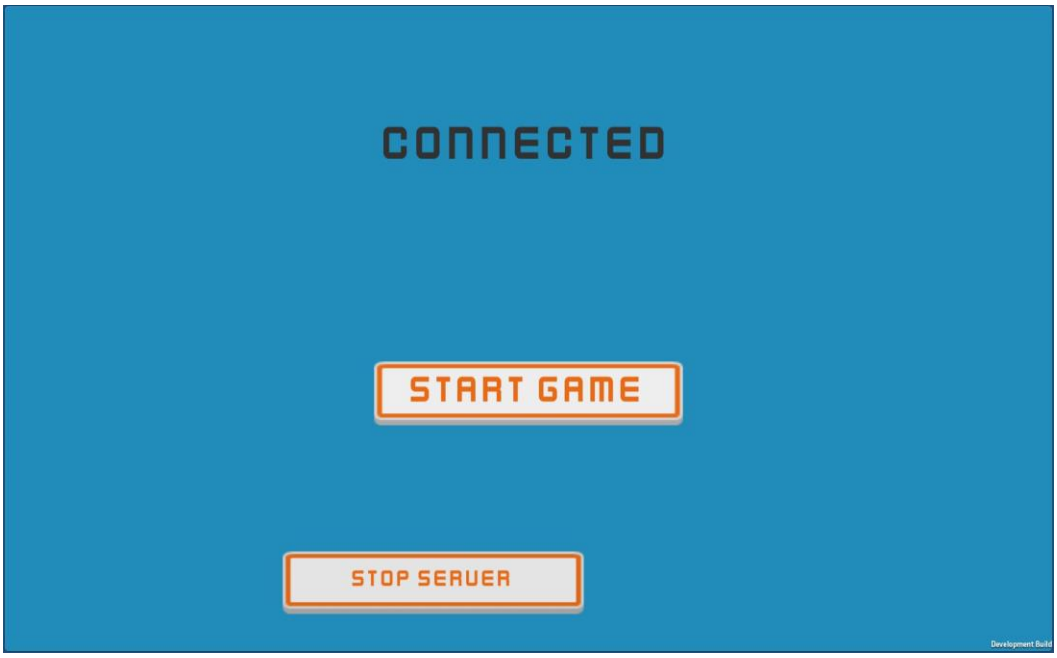
1. Screen on all device before establishing the connection



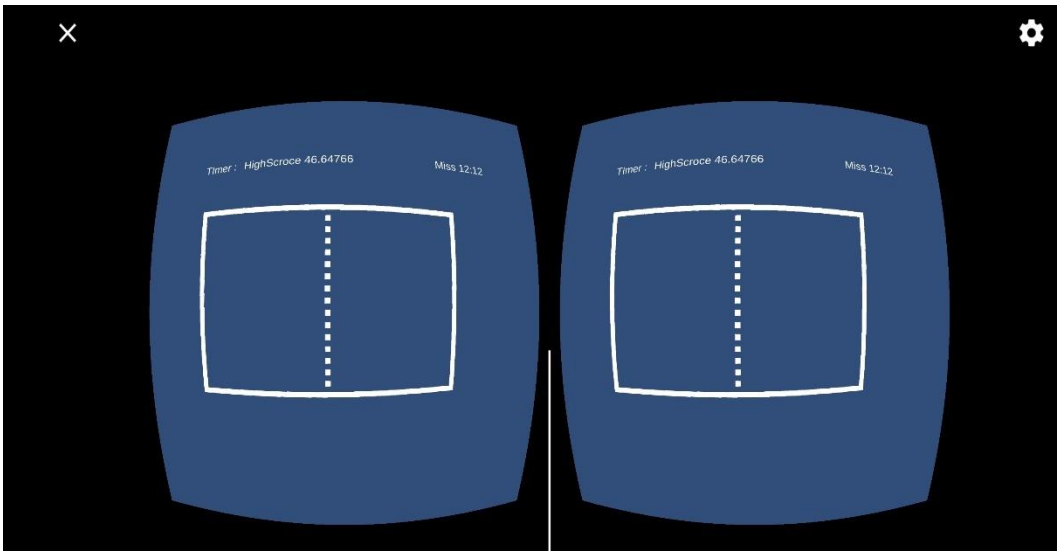
2. Screen on controller phone which is connected.



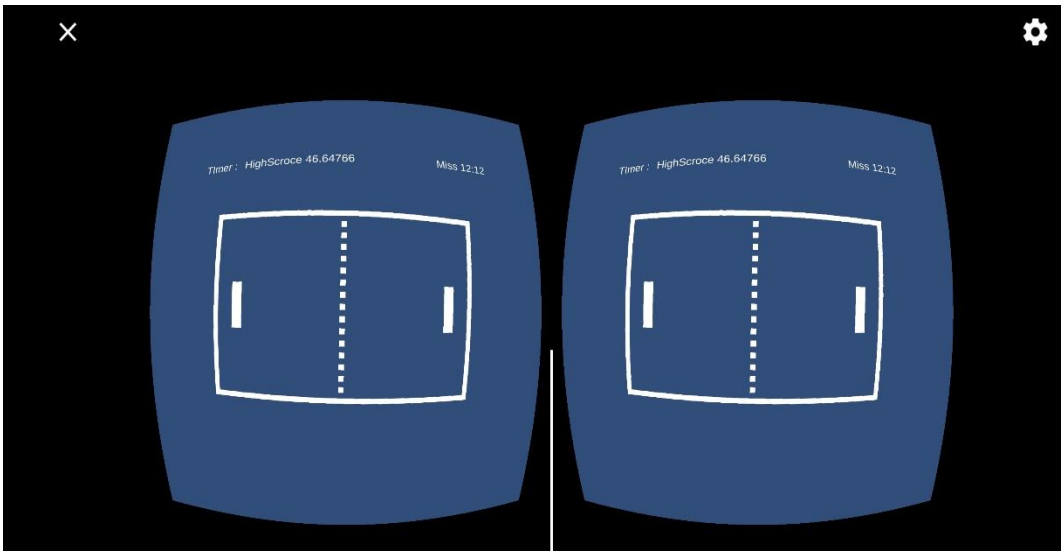
3. Screen on the controller phone when both all the phones are connected.



4. Screen on goggle phone after hosting the connection.



5. Screen on goggle phone after all phones are connected.



6. Screen on goggle phone after starting the game, with the rackets communicating with controllers in both hands.