# Virtual Reality in Gymnasium: Stationary bike using Hall-Effect Sensor and Bluetooth BLE

**Muhammed Ali Akhtar[1], Amna Shabbir [2] ,Najmi G.Haider[3] ,Maria Andleeb[3] ,Syed Abbas Ali[1], Safdar Rizvi [4]**

*[1]Computer and Information System Engineering, NEDUET, Karachi, Pakistan*
*[2]Electronic Engineering Department, NEDUET Karachi, Pakistan*
*[3]Computer Science and Information Technology, NEDUET, Karachi, Pakistan*
*[4] Department of Computer Science, Bahria University Karachi, Pakistan*

**Summary**
Increase in power of Hardware, reduction of cost and extensive media coverage has finally brought Virtual Reality to the masses .The scope of Virtual Reality Technology is in military where it is used for training and re-enact particular scenario to avoid injury, health fitness where it is used in robotic surgery, sports where it is used in football game, entertainment where it is used in interactive exhibitions and theaters and in education fields where it is used for teaching and learning purpose has already been discovered. This paper will highlight an entirely different dimension in which Virtual Realty can be used. This paper presents the revolutionary concept of Virtual Reality cycling on a stationary bike in gymnasium which gives a mesmerizing experience of virtual world that does not physically exist. The need of this product is to provide a fascinating environment to the exercisers and physiotherapy patients for their relaxation Regular exercising poses number of benefits in terms of health and fitness [1]. While the exercises in gyms these days are too generic, , our invention gives diverse vivid conditions for clients to get the best cycling experience than at any time in recent memory. Individuals who need to keep up their wellness in the most astounding way while getting a charge out of themselves, this item is intended for them. It gives totally new degree of human-PC connection [2].

***Keywords***
*virtual reality; virtual environment; immersive; cycling; exercise; head mounted display; human-computer inter- action*

## I. INTRODUCTION

Recently emerging technology of Virtual Reality has been a center of attraction for people because of its reduced cost and powerful hardware. While it was first introduced way back in 1800s by Charles Wheaton, the first product was successfully patented in 1939 [3, 4]. And now virtual reality has not only spread its roots in Video Games, but also in education, sports, military, health and fitness. Virtual Reality experience entails four key elements; virtual world, immersion, sensory feedback and interactivity [5]. The immersive element of virtual reality can now be easily experienced using head mounted displays (HMDs), brilliantly developed by Oculus, HTC and Samsung, etc. We ideate the submersion of virtual reality to assist individuals with making their exercise gamified and carefree in the rec center condition. In the cutting edge life, individuals will, in general, occupy their energies towards diversion. While in a regular gym, individuals, in the end, lose their inspiration and intrigue. They feel tiredness and boredom from this casual tiring routine and ultimately resulting in leaving gym, and this practice in spite of providing those benefits in term of health and fitness, harmful for their heath. Cardiovascular fitness level decline muscular strength decline and weight gain are some of the hazards of leaving gym. The focal point of this Research paper is virtual reality, involvement in cardiac exercises that is actually done with stationary bike and/or treadmill. In previous research (2015), ARPN Journal of Engineering and Applied Sciences states [6], in large no of mobile devices, developed accelerometer and gyroscope sensors detect the product's immediate angular velocity and acceleration. When the structure is formed in a head-mounted display and the user's body is tracked with some movement, this can all be accomplished. Like Google Cardboard by moving users head, walking and rotating. However, the VR game we are trying to create controlled with hand and body movement is the precision and accuracy of virtual reality visualization employing a sensor controller system vary greatly from device to device.

Another piece of research shows development of specialized Omni-directional treadmill. It gives a two-dimensional movement interface work for connecting a symbol in the virtual condition and the client in the genuine condition. Their significant downside is impediment of quick quickening and deceleration, which make them lacking for applications that require high increasing speed and deceleration, for example, preparing of warriors in virtual condition [7]. Omni-

Manuscript received May 5, 2022
Manuscript revised May 20, 2022
https://doi.org/10.22937/IJCSNS.2022.22.5.82

directional treadmills are heavy, complex, exhibits low power transmission and bear high cost.

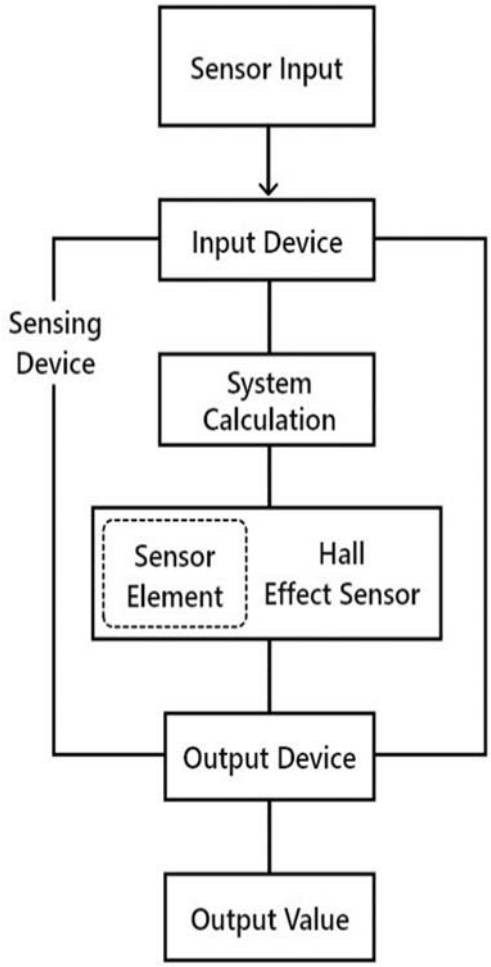



Fig. 1. Transmission cycle in Stationary bike

This research provides a low-cost solution for an immersive virtual reality exercise experience. Using just an extended hardware of the existing stationary bike and/or treadmill, people can have the virtual immersion in their exercise at their home and/or gyms. Since the proposed solution does not depend on sensor data, the accuracy and precision are invariant. Real-time transmission of exercise machine information in to the software module leads to least lag and high accuracy in locomotion of the user in virtual reality environment.

## II. METHODOLOGY

### A. OVERVIEW OF THE HARDWARE MODULE

The equipment created right now a lobby impact sensor (LF-DI12-15B2) combined with Arduino UNO small scale controller, to figure cycles per min (rpm) of stationary bicycles wheel. Hall Effect sensors are triggered by external magnetic field. Magnetic field density around the device is the function of output signal from the sensor. The data is shared using Bluetooth 4.0 Bluetooth Low Energy (BLE) HM-10 that is efficient for real time data transmission.

### B. Detecting RPM of Stationary Bike using Hall-Effect Sensor

The sensing technology of hall-effect sensor is ultimate, taking over the previously used sensors.A thin sheet of conductive material and the output connections are placed perpendicular to the direction of flow of current. The sensor, when exposed to the magnetic field produces an output voltage this output voltage is proportional to the magnetic field strength [8]. Arduino UNO is a micro controller board having 14 input/output pins (digital) [9]. Since we are interested in digital form of data, the next step is to connect the Hall-effect sensor input/output pins with those of the micro controller. A small magnet is attached to the stationary bikes wheel in the proximity of hall-effect sensor. The timer of Arduino is accurately interrupted whenever a significant amount of voltage is produced on the sensing device due to magnetic field strength. The falling type interrupt is attached to the interrupt service routine (ISR) using: attachInterrupt(0,isr,FALLING);

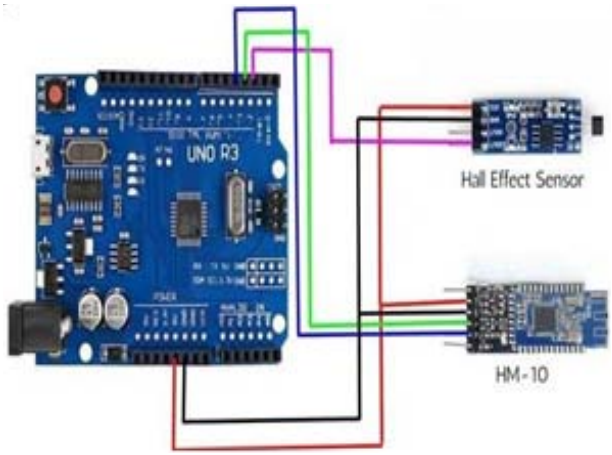



Fig. 2. Hardware simulation containing Arduino, Hall Effect Sensor, Bluetooth Low Energy BLE.

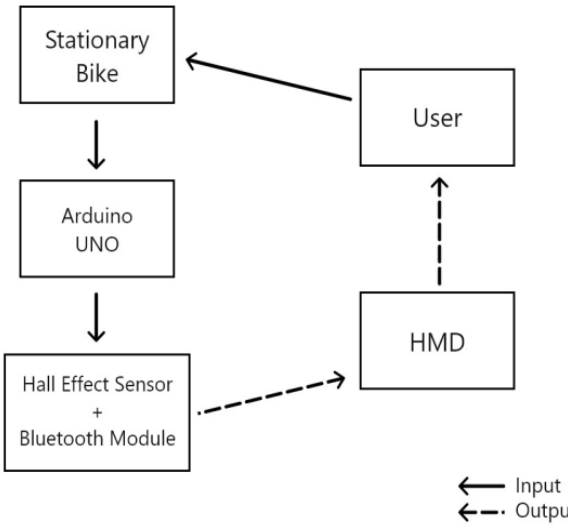



Fig. 3. Hardware simulation containing Arduino, Hall Effect Sensor, Bluetooth Low Energy BLE.

- **THEORY OF HALL EFFECT**

Consider the x direction with the L the length, the width w in the y direction, and let t be the thickness in the z axis of a conducting slab as shown in Fig. 5.
When Ix current is flowing in the x direction, keeping in view the positive x direction only, assume the conductor has a charge carrier of charge q (can be positive or negative or both, but we'll assume it's only one sign here), n the density of charge carriers (number of carriers per unit volume), and $v$x be charge carrier drift velocity.

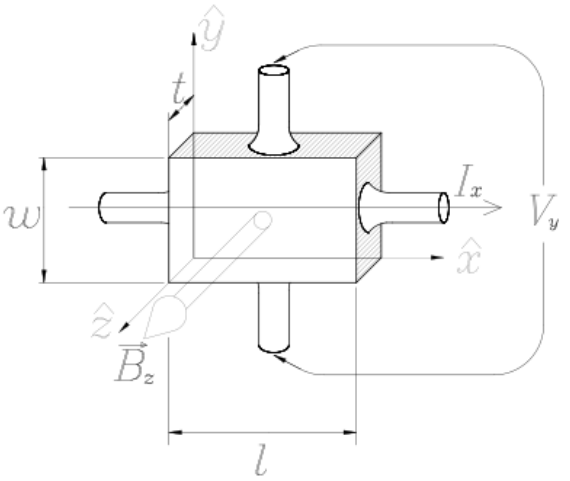



Fig. 4. Geometry of fields and sample in Hall effect experiment.

The drift velocity is indeed the average charge carrier velocity over the conductor's volume; each charge carrier might move in a fairly unrelated manner within the conductor, but due to the influence of applied fields, there will be a net transport of carriers along the conductor's length. The current Ix is equal to the current density Jx multiplied by the conductor's cross-sectional area could be written as:

$$Ix = Jx(wt) = nq(vx)(wt) \quad (1)$$

An electric current is applied along the length of the conductor E that creates the current Ix. Whenever the current is directly proportional to the field, the material is said to obey Ohm's law, which can be written as x.

$$Jx = \sigma Ex \quad (2)$$

Suppose the conductivity is in a perpendicular towards the slab's surface of magnetic field. The charge carriers would be deflected toward one side of the slab due to a Lorentz force $q\vec{v}*\vec{B}$. This deformation causes charges to be accumulated along one particular side of the slab, results in a traverse electric field Ey that neutralizes the magnetic field's power.

Since the electrical and magnetic forces on the charge carriers in that direction must be balanced when steady state is reached, there will be no net flow of charge in the y direction. Accepting these circumstances, it is straightforward to establish that

$$Ey = v(Bz) \quad (3)$$

Here Ey is the electric field in the y - axis, also known as the Hall field, and B is the magnetic field in the z - axis.
We calculate the potential difference across the sample in an analysis using the Hall voltage VH, which is related to the Hall field by:

VH= As a consequence of equations (1), (3), and (4), we get

$$VH = -\left(\frac{1}{nq}\right)\frac{IxBz}{t}$$

The Hall coefficient is the word in parenthesis:

$$RH = \frac{1}{nq}$$

If we have positive charge carriers result would be positive; if they are negative, it would be negative. In practice, the charge carriers' sign is determined by the polarity of VH. The Hall coefficient is calculated in SI units of [m3/C] or, more generally, [m3/A-s].

An equivalent electrical circuit of a Hall effect transducer is shown in Fig 5[10]:

Fig. 5. Basic hall effect sensor assembly

- **TRANSMITTING RPM USING BLUETOOTH**

Real-time data transmission done via Bluetooth module is more efficient than a Wi-Fi module. Bluetooth offers less power consumption, error rate and packet losses, for these reasons we prefer Bluetooth in real time data transmission [11]. There are various Bluetooth modules that have claimed compatibility with the micro controller. The proposed solution however, uses Bluetooth Low Energy (BLE) module HM-10.

According to the specifications mentioned in the datasheet [12], the UART serial connection helps to connect with Arduino micro controller easily. Arduino sketch for this solution writes the data on HM-10 as string, which is then transmitted in to the app.

Bluetooth interface implemented in the software application receives the data and parse it using ASCII Encoding UTF8 to make it further usable or process able

$$VH = -\int_0^w Eyl = -Eyw \quad (4)$$

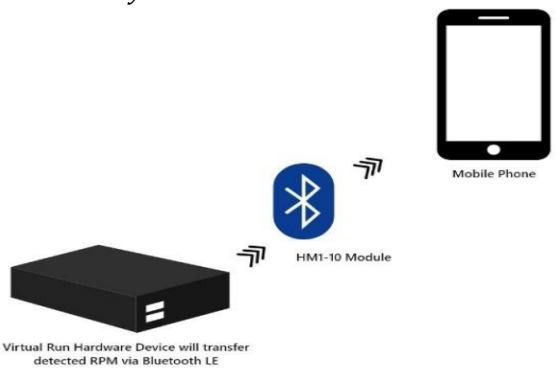



Fig. 6. (a) shows the detection of magnetic field using Hall-effect sensor attached in the device. (b) shows the transmission of real data from device to mobile application via Bluetooth 4.0 BLE HM-10 Module

**A. MOVING THE USER AHEAD IN VIRTUAL ENVIRONMENT**

Linear speed is derived from the data (revolutions per min) received via Bluetooth BLE. Unity3D offers a character controller component for first-person shooter game object. It allows the user to move freely in a 3D environment usually in shooter games [13]. This solution masks the first-person shooter as a person sitting on a stationary bike. The speed at which the person is pedaling on the stationary bike is transmitted in the application at real-time. Taking all the above explanations under consideration, the user can now move ahead in the virtual environment while still having a constant position in real life. Virtual environment has been created using 3D models, lightings and effects in Unity3D framework. This system works with any simple Head Mounted Display (HMD) like Google Cardboard. Users can look around in the virtual environment by moving their head. User is prompted the distance covered in the environment at regular intervals. Formula used for calculating revolutions per minute is given as:

RPM = Number of times the magnetic field detected/Time Interval

## III. OVERVIEW OF THE SOFTWARE

We have released VR Run app for both Android and iOS platforms using Unity3D game engine. Application is developed using Csharp as it is supported on Unity 3D and provides Object Oriented features. Components of Unity 3D used in this project are First person Shooter (creates vision of users own eye) and Camera (a paramount to display the virtual environment to the user) .To make the experience of User while riding stationary bike more interactive , VR Run also provide a feature to view 360 videos controlled by the real time speed.

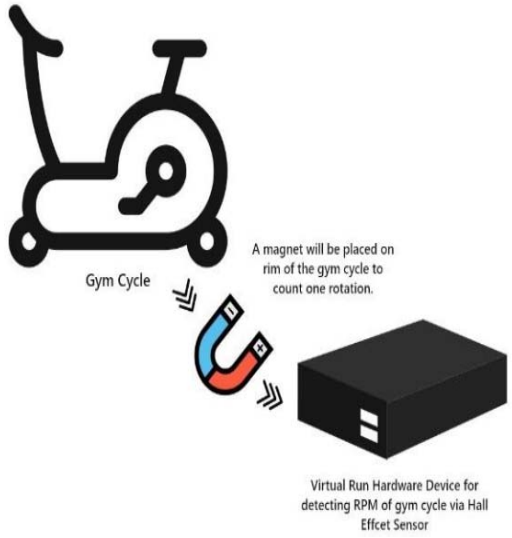
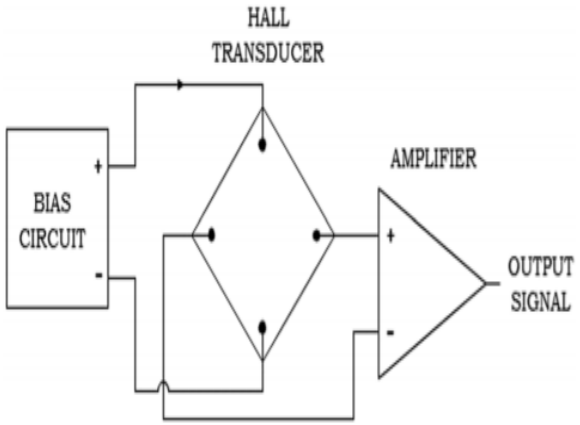



Fig. 7. Hardware interfacing.




### B. APPLICATION CLIENT FLOW AND ARCHITECTURE

- After Log on to the application user will have interface of VR Application for experiencing VR tour it will move directly to splash screen

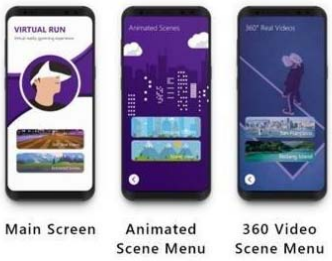



Fig. 8. Applications User interface

- On splash screen multiple scenes would be there user may select the desired one.
- User may have option to view directly animated scenes on VR or experience 360 video environment. Both environments would have their counter screens and response as per selection.
- Purpose of counter screens to give some time to user to get ready to experience the environment.
- User may experience 3D environment with 360 degree view.
- User can play scenes in VR Gear. After connecting with hardware via Bluetooth.
- Elliptical would transmit speed to the hardware and then elliptical would synchronize with the scene and user will feel perfect move in VR.

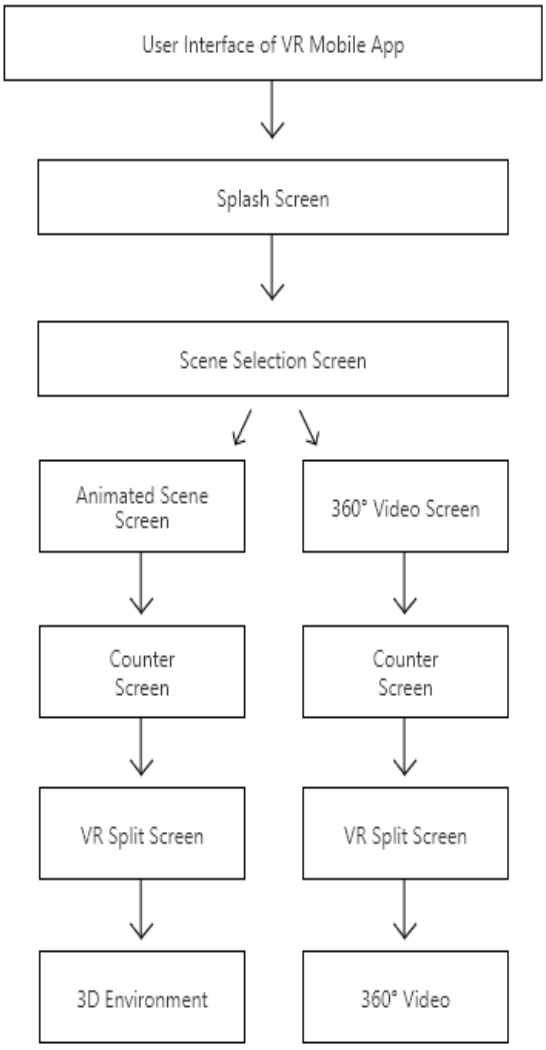



Fig. 9. Display Architecture at Customer End

## IV. ANALYSIS OF DATA AND DISTINCTION OF PROPOSED SOLUTION

Virtual reality has been an attraction since its birth. But despite of being an amazing human-computer interaction technology, it poses great challenges for developers in terms of immersion. Immersion is a feel that a user encounter while experiencing a virtual environment, cannot distinguish between real world and the virtual world. Virtual Reality's popularity is hindered too much extent due to lack of access of 3D Images of high quality to developers. But still from its immersion much work has been done in the evolution of Virtual Reality.

## V. HISTORICAL WORK

Until recently, virtual reality had been something of a fantasy for storytellers and technologists [14]. Virtual reality has beginnings that gone before the time that the idea was originated and formalized. In this focal point of history of virtual reality we take a fleeting look at how innovation has developed and how key pioneers have cleared the way for virtual reality as we probably know it today. Different versions of application that currently exist for cycling purpose are either unintegrated with the hardware or they don't have virtual reality features in it. Existing products in the market uses front camera on your phone or tablet to see your exercise motion thus have lesser accuracy. Another application VZ Fit that is developed by Vir ZOOM, acer and Intel, consist of a Bluetooth gadget, VR bicycle and suite of wellness is currently accessible for Gear VR to use with Galaxy S8 and S8+ handsets.

### A. Distinction Of The Proposed Solution

The previous work that uses built-in accelerometer and gyroscope sensors depicts less accuracy causing motion sickness. While the sensors provide six degrees of freedom (6DOF) that is, right/left, up/down, forward/backward, pitch, yaw and

User body movement or locomotion in the virtual environment. Omni-treadmills however are highly expensive for a home user and it is also not accessible in our country yet. The cost effectiveness that our product can provide is up to 90This paper work proves the solution to be the most accurate and cost effective as compared to the existing ones. A simple yet effective device is just to be attached on the existing stationary bike. The transmission of sensor data in real time through Bluetooth provides the smooth user movement in virtual reality.

## VI. CONCLUSION AND RECOMMENDATION

The paper introduced the progressive idea of Virtual Reality
cycling on a stationary bicycle in exercise center which gives an entrancing knowledge of virtual world that does not physically exist before with the lower cost and accuracy. A complete solution is provided for

user including a mobile app available for both platforms (Android and iOS), a cost effective hardware unit for getting speed of the gym cycle, high quality 3D graphics environments and high definition 360 videos. User can download our android app from Google Play Store and iOS app from Apple play store and Connect hardware unit with mobile app through Bluetooth to experience the virtual reality.

## *VII.* CONCLUSION AND FUTURE RECOMMENDATIONS

A virtual cycling product for a stationary exercise center bicycle has been created. The item permits the cyclers to travel diverse virtual conditions created for excellent submersion. They flawlessly make the most of their ride submerged in the perspectives on the virtual world while as yet having their physical presence in reality. Every one of these advantages is financially savvy when contrasted with the current work, which includes cost-drenching tradeoffs. Now a days indoor cycling has become trendy for getting smarter and healthy, this paper suggested that Computer-generated simulations can help clients avoid the monotony of indoor cycling by offering a valuable product

The practical use of virtual cycling will be expanded in the future by including all the more true ecological elements like a breeze, downpour, daylight and so forth. This application can likewise be changed over into a multi-client game that will give a feeling of rivalry among the clients inside an exercise center. Moreover, we can extend this prototype for other industries as well. Driving school that teaches car driving different to students manually can opt this idea by attaching the hardware module already developed to accelerator. Aviation industry can also adopt this idea for new pilots training before going for the first flight, it will create a virtual environment which will built their confidence to avoid injuries and life loss. Furthermore, virtual reality have a room to target other gym exercise machines with variety of user interactions that are not under consideration yet. Hence, Virtual reality has much more to do it can move the World!

## REFERENCES


[1] "The Effectiveness of Virtual Reality Exercise on Individual's Physiological, Psychological and Rehabilitative Outcomes: A Systematic Review" Internet: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7312871/

[2] "Human-Computer Interaction Experiments Immersive Virtual Reality Applications for the Mining Industry". Internet: https://www.researchgate.net/publication/224142319_HumanComputer_Interaction_Experiments_Immersive_Virtual_Reality_Applications_for_the_Mining_Industry

[3] "History of Virtual Reality". Internet: https://www.fi.edu/virtual_reality/history_of_virtual_reality , [Aug. 19, 2018].

[4] "The History of Virtual Reality: An Escape to Different Worlds". Internet:https://www.colocationamerica.com/blog/history_of_virtual_reality, [Aug. 19, 2018].

[5] "William R. Sherman. (2003, Jan 1). Understanding virtual Reality. (1st edition). [On-line]. Available: https://profs.info.uaic.ro/~avitcu/FII%20_20152016/Animatie%203D_Documentatie/VR.pdf [Sep 8, 2018].

[6] "Herman Tolle, Aryo Pinandito, Eriq Muhammad Adams J. and Kohei Arai. "Virtual Reality Game Controlled with User's Head and Body Movement Detection Using Smartphone Sensors," ARPN Journal of Engineering and Applied Sciences, 2015, pp. 9776-9780.

[7] "Hose Lee, Sangjoon Park, Jungwon Yoon and Sanghun Pyo. "Design of the omni directional treadmill based on an Omni-pulley mechanism," 13th International Conference on Ubiquitous Robots and Ambient Intelligence (URAI), 2016, pp. 1-3

[8] "HoneyWell. Hall Effect Sensing and Application. (1st edition). Internet: https://sensing.honeywell.com/hallbook.pdf, [Sep 8, 2018].

[9] "Arduino Uno Rev3". Internet: https://store.arduino.cc/usa/arduino-uno-rev3, [Sept. 4, 2018].

[10] "Hall effect instruments, evolution, implications, and future prospects" Internet: https://aip.scitation.org/doi/pdf/10.1063/5.0009647

[11] "Dinuka Salwathura. "Embedded Systems —Bluetooth vs WiFi for real time communication". Internet: https://medium.com/@dinukasal/embedded-systems-bluetooth-vs-wifi-for-realtime-communication-3a2013cb2ee3, Sep. 25, 2017

[12] "Bluetooth 4.0 BLE module". Internet: ftp://imall.iteadstudio.com/Modules/IM130614001_Serial_Port_BLE_Module_Master_Slave_HM-10/DS_IM130614001_Serial_Port_BLE_Module_Master_Slave_HM-10.pdf , [Sep. 8, 2018].

[13] "Unity 3D Documentation"-3D Physic Reference Character Controller Internet: https://docs.unity3d.com/Manual/class_CharacterController.html

[14] "Until recently, virtual reality had been something of a fantasy for storytellers and technologists.'' Internet https://www.theguardian.com/technology/2016/nov/10/virtual_reality_guide_headsets_apps_g