

Immersive Reality Exercise Bike

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Abstract- Despite the diversity of lifestyles, health and fitness has always been an important part of the lives of any individual. And as technology has grown and improved, the need for exercise has only increased exponentially. The change in the components used in foods, as well as technology focussed toward providing the user with a comfortable user experience, has all led to the development of unhealthy body conditions. Moreover, exercise has always been an activity that demanded that the individual partaking in it would have to be genuinely motivated or interested, as in most cases, exercise involved repetitive actions without any real interesting aspects. Multiple efforts have been made, over the course of the past few years, even the past decade, to make exercise an interesting activity, and have seen success to a very little extent.

One such piece of exercise equipment is the common workout cycle. With the application of IOT and VR, this same simple workout cycle can be transformed into a simulated reality with custom experiences, enabling the user to feel as though he or she is actually travelling or cycling somewhere, as opposed to being stuck in one single place. A custom made exercise bike is used, along with multiple sensors that are connected to the bike, to detect and analyze the user input, and pass the digitized data to the VR device, thus allowing the user to interact with the environment in real time. A Virtual Reality viewing device is used along with the cycle, to enable the user to view the environment in which the user is cycling in. Using unity, a completely realistic and natural map will be created, complete with trees and other objects depending on the nature of the environment. Utilizing the input from the exercise bike's sensors, a 3d model of the bike, on which the user is seated in the virtual environment, will interact with the user's surroundings. In this manner, unity will be used to build a number of environments that will be presented to the user as map options, such as a dessert, a city or even a forest. Irrespective of the manner in which the user views the VR environment, the user will be presented with a HuD (ie, Head up Display), where the user can view information about how fast the user is moving, the distance travelled by the user, etc. This, and the other features such as ability to get news notifications, and to possibly compete against friends using the same cycle elsewhere, would make the otherwise boring workout cycle, an interesting piece of fitness equipment, which would prove to be instrumental in improving the fitness of individuals in all areas of life, from all ages.

Index Terms- Arduino, Exercise, Unity, Virtual Reality.

I. INTRODUCTION

In this modern age, where people are more aware about their physical condition, science has proven that genetics aside, an individual's lifestyle and habits have a considerable influence on their health and physical condition. This link between lifestyle and health can be clearly seen in society, where the individuals that lead healthy lifestyles, are in better health, while those that lead unhealthy lifestyles, are suffering from diseases due to bad physical condition. Recent advancements in technology don't seem to be bettering the situation either. Technology has always been geared towards improving the quality of lifestyle of humanity, by simplifying and handling difficult tasks, while providing people with degrees of comfort and luxury. This however, has made it easier for individuals in modern society, to lead an unhealthy lifestyle. A clear decline in the level of health can be seen across the generations, where the younger generations seem to be the ones that are less healthy. This is accompanied by an alarming increase in the number of cases of diabetes, heart attacks, and other conditions that arise from poor health, in the younger generations.

Exercise is the main solution that is constantly advised, to better one's physical condition and health, yet many individuals prefer not to exercise. The main reason behind this being that exercise is a long term process, is repetitive and requires dedication. And the equipment being used is yet to catch up with the current level of technology. But if exercise were to be made more entertaining, more modernised, more rewarding, then more individuals would take an interest in exercising, thus bettering their physical condition. By utilizing the available level of modern technology, we can achieve this.

II. LITERATURE REVIEW

The origins of VR can be traced back to the artists of Europe during the Renaissance, where they created work that caused viewers to perceive things that did not exist. Since then, many breakthroughs were made in the area of Virtual Reality, ranging from flight simulators to implementations in the medical field. As the years went by, the focus shifted to the public sector, and VR technology became available to the masses. Applications were

developed in the areas of entertainment and education, which led to the popularization of Virtual Reality.

Research exploring the potential of Virtual Reality, and especially the ones focussing on human response to Virtual Reality, had discovered that the human response was largely positive, as most activities became more engaging and entertaining, when coupled with a VR element. One experiment had made a comparison between test subjects exercising on a cycle with just a mounted display, while the other subjects were making use of a VR headset. They were provided the same visuals and conditions, to minimalism or eliminate other factors. The results showed that the subjects that had used a VR headset, had cycled longer than the subjects that had just used a mounted display, and that they had found the experience more engaging and entertaining than the other test subjects. This indicated that VR could be utilized to enhance an individual's experience in any activity.

Attempts were made to integrate Virtual Reality elements into activities such as exercising but most of them had involved a pre recorded video clips or experiences being played on a viewer's headset, as the viewer took part in that particular activity, which was observed to not have a considerable impact in the user experience or performance, which was the main drawback of such applications.

III. PROPOSED APPROACH

Previous attempts at integrating VR and exercise had employed pre-recorded media for providing the individual with a VR experience, which had unsatisfactory results as it had resulted in a lack of immersion. The implementation of the interfacing between the user's inputs and the Virtual Environment or media, had to also be such that no delay was present between the user's actions and the required response from the system. By interfacing the inputs of many sensors with a Virtual Environment, a higher level of immersion can be achieved.

A custom made exercise bike is used, along with multiple sensors that are connected to the bike, to detect and analyze the user input, and pass the digitized data to the VR device, thus allowing the user to interact with the environment in real time. The entire hardware setup interacts with an arduino, which is used to get the user input from the exercise bike. A potentiometer is used to detect the angle at which the handlebar has been turned (left or right), and passes this input to the arduino. A Hall sensor is used to measure the speed at which the user is pedaling, at any given time by determining the number of rotations made by the pedals. The arduino puts the steering input and the speed input in unity, thus interacting with the unity environment, using the entire cycle as a controller. A Virtual Reality viewing device is used along with the cycle, to enable the user to view the environment in which the user is cycling in. The environment is preferably

viewed through a VR headset, but since the cost of a VR headset is high, and most users would not be able to afford one, the environment can be viewed through an ordinary display device.

IV. DESIGN

1. Arduino

Arduino is a company that produces hardware and software which are open source, that primarily produces the microcontrollers and microcontroller kits which are used for building digital devices. These boards are provided with digital and analog IO pins that can be used to interface with many other circuits and components. The boards feature serial communications interface and also support communication over USB(Universal Serial Bus) in some models for loading programs from a personal computer. The programming of the microcontrollers can be done using C/C++ programming languages. The Arduino has an open source hardware meaning that it can be manufactured by third party manufacturers legally. This allows for the arduino to be available very cheaply anywhere in the world. Most boards consist of an Atmel 8-bit AVR microcontroller with different pins, flash memory and features depending on the model. Most boards feature a 5V linear regulator and a 16Mhz crystal oscillator or ceramic resonator.

The arduino microcontroller boards comes with a pre-installed bootloader that helps with the upload of a program from a native personal computer onto the board's flash memory. The Arduino UNO is chosen as it offers ample performance at a much affordable price. It has an Optiboot bootloader. The program is loaded onto the board via USB from another computer. This is performed using USB to serial adapter chips(such as Atmega16U2).



1.1 ARDUINO-IDE

The Arduino Integrated Development Environment (IDE) is an application available across different platforms(Windows, Mac and linux), and is programmed in Java. It includes a text editor that has automatic indenting, brace matching, syntax highlighting and so on. This makes programming in the IDE much efficient and simple. It also features a one click compile and upload button making it easy to upload programs onto the microcontroller board. It supports C and C++ using unique rules for code structuring. The arduino library offers many Input Output procedures. A custom code written by a user, only requires the following two functions: for starting the sketch (setup()) and the main program which is loop (loop()). Which are then automatically linked with the main() program. A Serial monitor is used to obtain any output from the microcontroller board, as it offers a quick and easy way to establish a connection with the board. Arduino is used to obtain the speed and direction of the cycle in real time. It gets the data in the form of electrical signals which are then converted to more meaningful values which are then sent to a serial monitor which can later be intercepted by the unity program.

2. Potentiometer

A potentiometer is a resistor with three terminals, with a rotating contact that forms an adjustable voltage divider. The potentiometer used in the build sends out current having voltage between 0 and +5v. The variable resistance can be regulated using the control shaft of the potentiometer. The potentiometer output is read as analog signals by the arduino. The handlebar is connected to the shaft of the potentiometer. This is done so as to obtain an analog input for the direction. The output of the potentiometer is mapped between values of -180 and 180 by the arduino. That is, when a voltage of 5v is provided as input to the arduino from the potentiometer the signal is read and a value of 180 is passed to unity, similarly when the voltage is 0 the value passed would be -180. This is used as direction input in unity. The directions will be mapped such that 180 is hard right and -180 is hard left.



3. Hall Effect Sensor

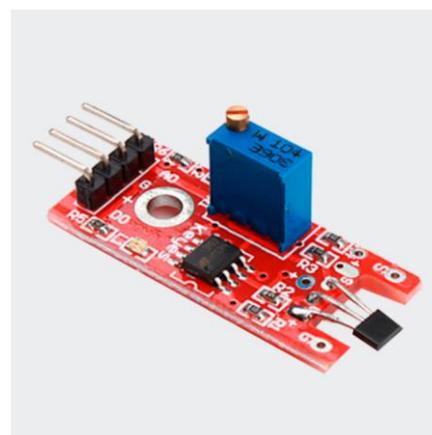
A Hall effect sensor is used to measure the intensity of a magnetic field. Its voltage output is directly proportional to the intensity of the magnetic field. It has a thin metal strip to which current is applied along it. This causes the electrons in the metal strip to flow from one region to another. During the presence of magnetic field, the path of the electrons will become deflected from a straight line. As a result one region of the conductor will be positively charged and the other negative. Hence a new voltage will be produced which is known as Hall voltage. This is better than a conventional inductive sensor as inductive sensors require moving or changing magnetic fields whereas hall effect sensors can detect stationary or non moving magnetic fields.

The advantages of using hall effect sensor are: It requires no contact to work, that is the magnetic field detection does not require the sensor to touch the magnet.

The sensor can be placed in a sealed container so that external contamination will not occur. It can operate at much higher frequencies as compared to a mechanical counterparts. The only disadvantage is that the accuracy in reading the strength of the magnetic field can vary. This is not an issue as the primary use for the sensor in the project is to detect the presence of magnetic fields. The hall effect sensor is a sensor when applied current can detect the presence of magnetic fields. The hall sensor is attached to the frame of the cycle pointed to the outer edge of the driven wheel.

A magnet is attached to the outer edge of the driven wheel. Hence, when the drive wheel rotates the driven wheel, each rotation of the driven wheel can be detected by the hall sensor. Every rotation made by the driven wheel is detected by the hall sensor when the signal is sent continuously, the speed of the driven wheel is calculated in rotations per minute in the arduino

The rotations per minute can be converted to meter/minute by, $speed = 2\pi r * rpm$, where r is the radius of the driven wheel



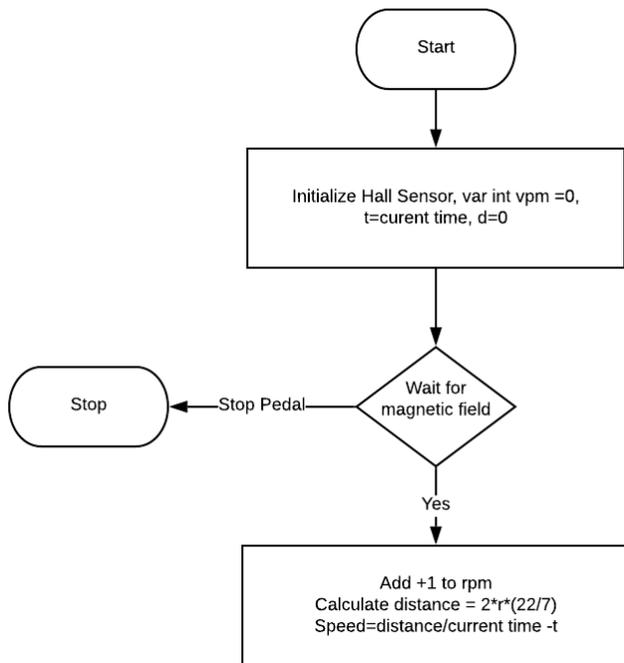


Figure 1 . Hall sensor speed calculation

4. Virtual Reality

The essence of Virtual Reality is derived from the meanings of the words ‘virtual’ and ‘reality’ . Therefore the term Virtual Reality, means anything that is close to being a reality. This being a broad definition, could literally mean anything, including a type of recreation of reality. Our perception of the world is generated by our brain, through the analysis of the data received through our many faculties. The base faculties being the five senses : touch, taste, sight, smell, and hearing. In reality, human beings possess many more faculties than these, like a sense of balance. And since the reality we perceive is actually a blend of tactile data obtained through our faculties, it would make sense that if one were to feed his or her faculties, made up data, that person’s very perception of reality would change in the light of it. The individual would have perceived a version of reality that did not exist, but they would perceive it as genuine. This is the very essence of a VR experience. VR is usually implemented using PC innovation. There are many frameworks that are used to implement Virtual Reality, but they all achieve the same thing, allowing the user to experience the Virtual Environment. The VR environment should produce the proper responses to the individual’s investigative actions, as they explore the environment. If there were to be a delay in the response to a user’s action, from the VR environment, the individual’s experience would be largely affected as they will easily perceive that the reality is counterfeit, and they begin to react in an unnatural manner.

4.1 Virtual Reality Devices

The most significant bit of a computer generated simulation unit is the headset, a gadget like a thick pair of goggles that goes over one’s eyes. The more costly, better headsets should be associated with a PC to run applications and games, while some less expensive ones utilize a mobile phone attached to the front of the headset. All headsets should be utilized close by a decent quality pair of earphones, and there are other discretionary frills from hand controllers to treadmills that are completely intended to upgrade one’s reproduced understanding of being in a different universe. Hand controllers decipher one’s true motions into whatever game or application the person is utilizing, albeit standard gaming joypads can likewise be utilized.

The following constraints are present for virtual devices :-

- Latency - The whole system must respond almost immediately, to user movement, or the user may end up suffering from virtual reality sickness. A high refresh rate and a powerful GPU to render the required number of frame rates.
- Lenses - The focal points of the headset are liable for identifying the very near presentation to a wide field of vision, while likewise giving a progressively agreeable far off purpose of core interest. One test with this is giving consistency of center: since the eyes are allowed to turn inside the headset, it's critical to abstain from pulling together to forestall eye strain.
- Resolution and Display quality - There are various optics and visual characteristics that will influence how the individual sees the picture quality and their experience of the virtual world. The picture lucidity relies upon the presentation goals, optic quality, refresh rate, and the field of view.

Most Virtual reality devices have high quality hardware, but are equally costly.

Enforcing the use of such a virtual reality device, would create a barrier to entry for most users, who are unable to purchase such hardware. An economic approach to this problem would be the use of Google Cardboard. Google Cardboard is simply built from low cost materials such as cardboard, and it has a provision where a smartphone can be placed, as the device providing the visual output. This device was developed to encourage the growth in VR development.

A user is given the choice between building their own viewing device, and purchasing a pre-made device. In order to convert a smartphone to a VR viewing device, the user will run a Cardboard compatible mobile app on their phone, insert it into the Google Cardboard viewer and then view the content through the lenses in the device.

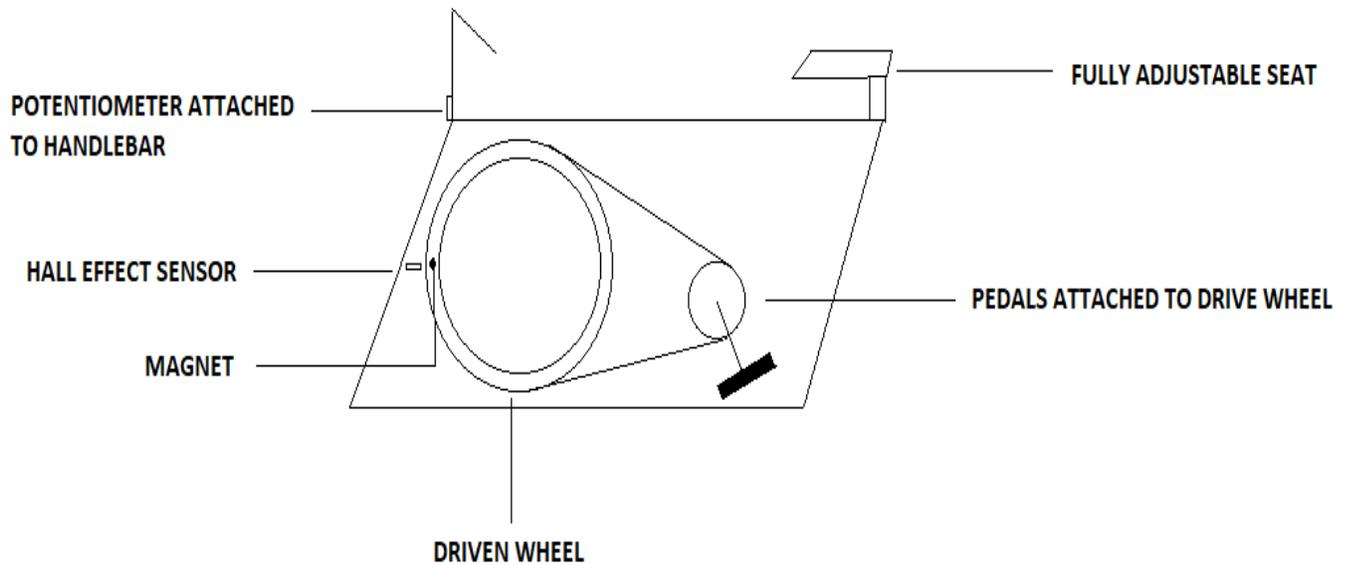
The parts that make up a Cardboard viewer are a bit of cardboard cut into an exact shape, 45 mm central length focal

points, magnets or capacitive tape, a snare and circle latch, an elastic band, and an optional near-field correspondence tag. When the unit is gathered, a cell phone is embedded in the rear of the gadget and held set up by the chosen affixing gadget. A Google Cardboard—good application parts the cell phone represents a picture into two, one for each eye, while additionally applying barrel contortion to each picture to counter pincushion twisting from the focal points. The outcome is a stereoscopic picture with a wide field of view.

5. Unity

Unity is a development platform that utilizes assets and tools to develop 2D and 3D environments, in real time. It's ability to

create whole virtual environments, with custom specified physics rules, various types of objects with a wide range of texture quality, makes it a tool often used by game developers and VR developers. Unity has tools that enable the custom alignment and placing of various objects and assets throughout the environment. These assets can be user made assets or assets available on the asset store. The various tools and editing options provided by unity's editor, allows a developer to craft realistic looking virtual environments.



6. The Virtual Environment

In order to create the environment, we first created a terrain layer and sculpted it using tools provided by unity. By utilizing assets from the asset store, the road was added as a separate element of the environment, with its own high quality texture file, to provide a realistic appearance. Objects, such as buildings, ruins, trees, rocks and boulders, were added to the environment in appropriate locations, with collision enabled, to simulate a realistic scenario. Further effects, such as the movement of the trees in the wind, and the movement of the surface of water, were also implemented by setting parameters in the unity editor. An artificial sky is provided by means of a skybox, which brings to the table, the option for the user to have control over the weather and time of day, especially since the sun is actually a light source that can also be subjected to the user's preferences. Since real life environments appear less clear and more organic than computer generated environments, we applied a visual filter to the user's perspective that further stimulates the different times of day, and also makes the distant objects appear less clear and foggy.

7. Interfacing Unity and Arduino

The user's perspective is through the first person camera, which is provided by unity. By means of custom scripts in C#, we have been able to modify the operation of this first person camera, to accept inputs from the arduino, and interact with the environment accordingly. The input from the arduino is received as a tuple of degree, which indicates the direction of rotation, and the speed of motion. These inputs are processed and then passed as values to functions that rotate and translate the first person camera in the required manner. Because the inputs are received as a constant stream of information, from the arduino, there is near to no lag between when an input is given and the motion of the camera. A 3 dimensional model of a cycle will also be connected to the first person camera, to provide an immersive experience to the user. All these elements come together in the unity engine, to provide the user with an immersive cycling experience. Even though the main focus of the environment will be the path through which the user is cycling, the whole environment will be made as immersive and realistic as possible, to make the user feel less like it's a simulation, and make the experience more

engaging. In this manner, unity will be used to build a number of environments that will be presented to the user as map options, such as a dessert, a city or even a forest. Irrespective of the manner in which the user views the VR environment, the user will be presented with a HuD (ie, Head up Display), where the user can view information about how fast the user is moving, the distance travelled by the user, etc.

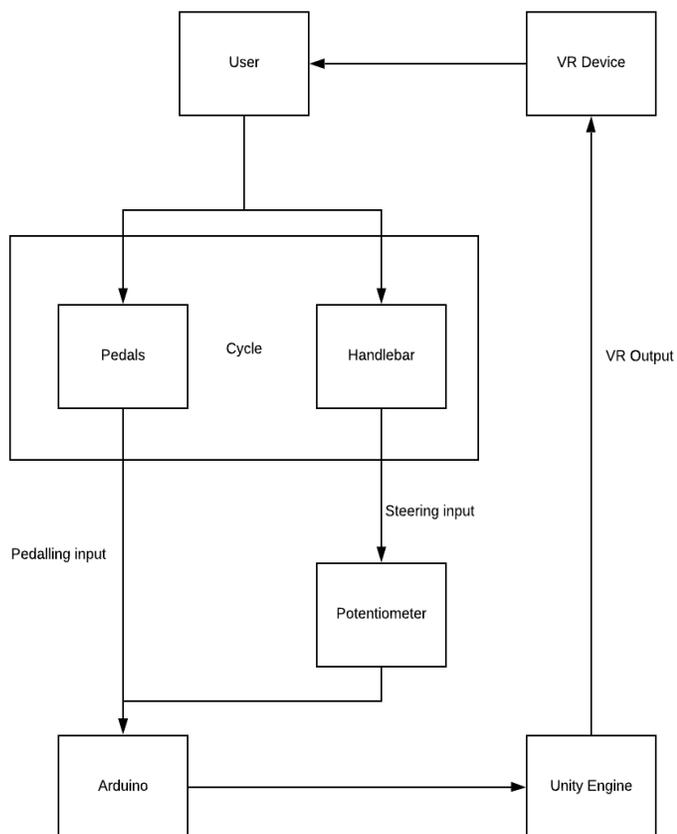


Figure 2. Exercise bike working with VR device

Figure 3. Circuit integration in hardware

VI. CONCLUSION

By this project, we aim to provide the user the experience of cycling through a whole new realistic environment, from the comfort of one's room. And by making this experience as entertaining and engaging as possible, we aim to motivate individuals of all ages to exercise and better their physical health level. We are observing trends in VR environments and fitness, with the intention of ensuring that the user experience we provide, will be found satisfactory by our end users.

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