M.A.V
Medical Analyzer In AR

Dissertation submitted to
Shri Ramdeobaba College of Engineering & Management, Nagpur
in partial fulfilment of requirement for the award of
degree of

Bachelor of Engineering
In
Computer Science and Engineering

By

Isha Bahendwar
Nandini Jain
Riya Khandelwal
Ruchit Bhardwaj
Saburi Hindaria

Guide
Prof. V. Rathod

Computer Science and Engineering
Shri Ramdeobaba College of Engineering & Management,
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Department of Computer Science and Engineering

CERTIFICATE

This is to certify that the Thesis on **"M.A.V : A Medical Analyzer in AR"** is a bonafide work of **Isha Bahendwar, Nandini Jain, Riya Khandelwal, Ruchit Bhardwaj, Saburi Hindaria** submitted to the Rashtrasant Tukdoji Maharaj Nagpur University, Nagpur in partial fulfilment of the award of a Bachelor of Engineering , in Computer Science and Engineering has been carried out at the Department of Computer Science and Engineering, Shri Ramdeobaba College of Engineering and Management, Nagpur during the academic year 2017-2018.

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DECLARATION

I, hereby declare that the thesis titled **"M.A.V : A Medical Analyzer in AR"** submitted herein, has been carried out in the Department of Computer Science and Engineering of Shri Ramdeobaba College of Engineering & Management, Nagpur. The work is original and has not been submitted earlier as a whole or part for the award of any degree / diploma at this or any other institution / University.

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This thesis/dissertation/report entitled **"M.A.V : A Medical Analyzer in AR"** by Isha Bahendwar, Nandini Jain, Riya Khandelwal, Ruchit Bhardwaj, Saburi Hindaria is approved for the degree of Bachelor of Engineering in Computer Science and Engineering.

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Name & signature of External. Examiner(s)

Name & signature of HOD

Date:

Place:

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ABSTRACT

Augmented Reality (VR) is what can be termed as one of the three major areas of 'false reality'. It is one amongst – "Augmented Reality, Virtual Reality and Mixed Reality". It is a relatively new branch of computer science and is quite prevalent nowadays. If we go by the actual definition, VR can be described as – "a technology that superimposes a computer-generated image on a user's view of the real world, thus providing a composite view." The number of doctors in our country that graduate every year are a whopping 52,715 in number. So, it is no doubt a food for thought as to where do we bring so many cadavers for practising upon?

Our project aims to reduce that problem along with an aim to reduce some other problems that the medical fraternity faces given the current scenario. According to our project, each patient is given a unique identification pattern based on which s/he will be identified. Once identified, a 3-D projection of his heart and rib cage will appear on the virtual display. This will be accompanied by the live heart rate of the person along with the graphical representation of the same for each and better analysis of the condition. This will also help in reducing a need of the display monitors that will be economical to the hospital and the patient as well.

Also, a separate module for object detection will also be available which will allow amateur doctors to have an insight about the different objects present in an operation theatre. This object detection module has been implemented in Unity i.e. Virtual Reality and is one of its kind.

All in all, this module can be termed as a very effective and efficient way of solving many problems along with a huge scope of improvement.

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CHAPTER 1. INTRODUCTION

According to a recent report, India produces approximately around 50,000 new doctors each year. And with so many doctors trying to practise and achieve expertise in their respective fields, the number of subjects on which they can practise surgery is an alarming low number. Every other day we come across disaster stories of medical frauds that lead to loss of precious human lives. This loss of lives also comes due to the fact that sometimes the monitoring devices used in the hospitals are quite old and don't function properly. This might be disastrous in some situations more than the rest. Our project aims at reducing these problems by providing doctors with an advanced, state of the art mechanism to monitor the patient's bio-signals or vitals as they are called. Also, with machine learning integrated into our VR app for various object detection, focusing primarily on human anatomy, our module would try to provide a way for the amateur doctors to get a first-hand and detailed knowledge of the instruments used in an operating theatre thereby reducing the scope of errors.

1.1 OBJECTIVE

- To design and prototype a device that acts as a "Virtual Monitoring Assistant" by providing customizable information of the patient's vitals.
- To have object detection integrated well inside the application to provide seamless knowledge of the object at first glance.
- Reduce the need for monitoring systems in hospitals replacing them with the VR versions of the same.

1.2 NEED OF YOUR PROJECT

When in a hospital, there is a constant battle between life and death. And in such scenarios, even the slightest of errors can prove to be fatal and can result into death. These errors can be human errors or technical glitches. As for human errors, those are beyond our reach but we can definitely try to reduce technical glitches. Sometimes these technical faults arise due to faulty monitoring devices giving incorrect information. Our project aims at reducing such errors and also proving object detection functionality to amateur doctors regarding various instruments found in an operation theatre.

1.3 FEATURES

- ***Easily Accessible Data*** : Data regarding human body vitals is easily accessible.
- ***Reducing Hardware :*** The hardware used for monitoring a patient's vitals will be significantly reduced and will be replaced by our application.
- ***Smart Object Detection***: With machine learning capabilities present in our application, the amateur doctors will have a better understanding of what is what in an operation theatre.

1.4 BENEFITS

- ***Customizable****:* The current module shows the vitals for heart rate but the application can be used for monitoring any vital that can be specified by the doctor given a appropriate sensor.
- ***Multitasking****:* The doctor in question could in fact do multiple tasks rather than just spending time monitoring the vitals of the patient. With the vitals right in front of his eyes, he could do more than one task at the same time.
- ***User Friendly***: The application is user friendly as it enables user to operate the application to get specific information with ease.
- ***State of the Art*** *:* Augmented Reality is completely new and this will provide an edge to other conventional monitoring systems thereby making the complete process state of the art.

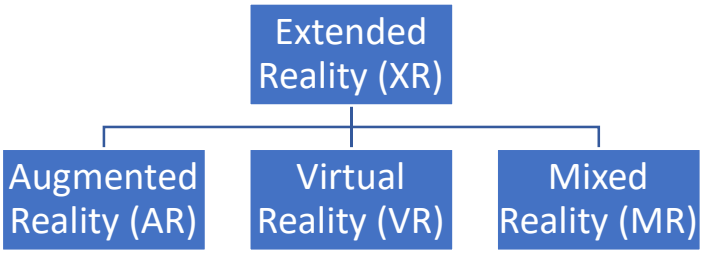
CHAPTER 2. REVIEW OF LITERATURE

2.1 EXISTING SYSTEMS

Many monitoring devices that are used to monitor and take care of the vitals of the patient have become obsolete and can sometimes malfunction. Though this method might seem as the most convenient and fool proof at first but this also has its fair share of disadvantages. The current echocardiogram checks how your heart's chambers and valves are pumping blood through your heart. An echocardiogram uses electrodes to check your heart rhythm and ultrasound technology to see how blood moves through your heart. Conducively, an echocardiogram can help your doctor diagnose heart conditions.

2.2 OVERVIEW ON EXTENDED REALITY PROJECTS

Extended Reality, or XR as it is commonly termed as, is a broader scope that encompasses within it – Virtual Reality (VR), Augmented Reality (AR) and Mixed Reality (MR). Though the distinction between these might seem intimidating but their applications are immense. They have been used in a variety of places ranging from fields as diverse as entertainment, marketing, education, medicine, robotics, social science and psychology, healthcare and clinical therapies and so many more. To explain the difference in them concisely, it is as follows.



In VR, a HMD (Head-Mount Display) is put and the complete perception of the person using the VR Application changes. It immerses the user into a trance and the user can interact with objects that are not even present in the real world. AR, on the other hand provides an overlay on the existing world and superimposes animate objects on the real ones. These objects can be interacted with and follow the same laws of physics as in the real world. Now, as of MR, it is a dodgy term but can be best described as a combination of AR and VR thus providing the user with the best experience possible.

2.3 TECHNOLOGIES USED

1) Arduino Genuino UNO

Arduino Uno is a microprocessor board based on the ATmega328P (datasheet). It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inpurs, a 16 MHz quartz crystal, a USB connection, a power jack, an ICSP header and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable and power it with a AC-to-DC adapter or battery to get started. “Uno” means one in Italian and is chosen to amrk the release of Arduino Software (IDE) 1.0. The Uno board and version 1.0 of Arduino Software IDE were a reference version of Arduino, now evolved to newer releases. The Uno board is the first in a series of USB Arduino Boards, and the reference model for the arduino platform.

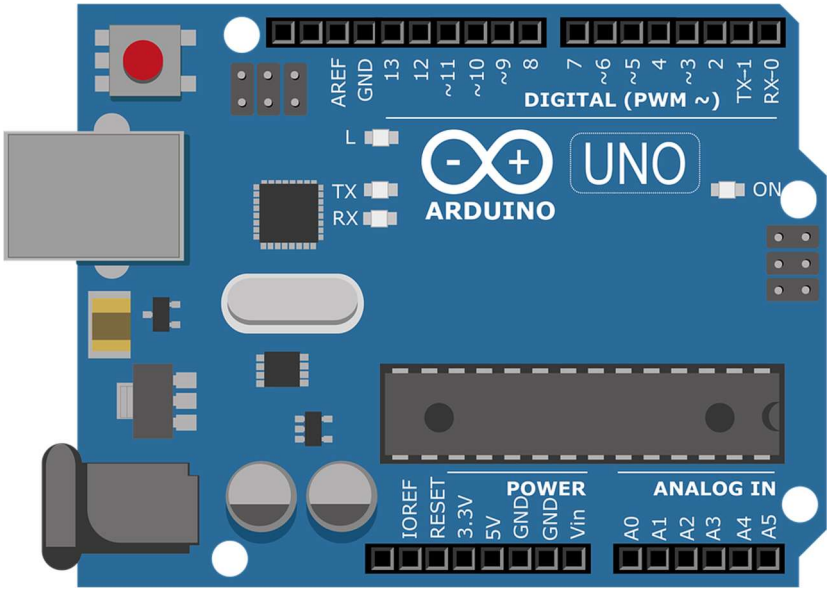


Figure 1 : Arduino Genuino UNO

2) Pulse Sensor

When a heartbeat occurs blood is pumped through the human body and gets squeezed into the capillary tissues. The volume of these capillary tissues increases as a result of the heartbeat. But in between the heartbeats (the time between two consecutive heartbeats,) this volume inside capillary tissues decreases. This change in volume between the heartbeats affects the amount of light that will transmit through these tissues. This change is very small but we can measure it with the help of Arduino. The pulse sensor module has a light which helps in measuring the pulse rate. When we place the finger on the pulse sensor, the light reflected will change based on the volume of blood inside the capillary blood vessels. During a heartbeat, the

volume inside the capillary blood vessels will be high. This affects the reflection of light and the light reflected at the time of a heartbeat will be less compared to that of the time during which there is no heartbeat (during the period of time when there is no heartbeat or the time period in between heartbeats, the volume inside the capillary vessels will be lesser. This will lead higher reflection of light). This variation in light transmission and reflection can be obtained as a pulse from the output of pulse sensor. This pulse can be then conditioned to measure heartbeat and then programmed accordingly to read as heartbeat count.

Figure 2 : Pulse Sensors

3) Unity Game Engine

Unity is a cross-platform game engine developed by Unity Technologies, first announced and released in June 2005 at Apple Inc.'s Worldwide Developers. Unity gives users the ability to create games in both 2D and 3D, and the engine offers a primary scripting API in C#, for both the Unity editor in the form of plugins, and games themselves, as well as drag and drop functionality. Prior to C# being the primary programming language used for the engine, it previously supported Boo, which was removed in the Unity 5 release, and a version of JavaScript called Unity Script, which was deprecated in August 2017 after the release of Unity 2017.1 in favour of C#.

4) Python & OpenCV

Python is an interpreted high-level programming language for general-purpose programming. Created by Guido van Rossum and first released in 1991, Python has a design philosophy that emphasizes code readability, notably using significant whitespace. It provides constructs that enable clear programming on both small and large scales.

Python features a dynamic type system and automatic memory management. It supports multiple programming paradigms, including object-oriented, imperative, functional and procedural, and has a large and comprehensive standard library.

Python interpreters are available for many operating systems. CPython, the reference implementation of Python, is open source software and has a community-based development model, as do nearly all of its variant implementations.

5) TensorFlow Sharp

TensorFlowSharp provides APIs for use in .NET programs, including C# and F#. These APIs are particularly well-suited to loading models created in Python and executing them within a .NET application. TensorFlowSharp itself is a .NET API that calls into the native TensorFlow runtime.

2.4 WHY EXTENDED REALITY?

- **The provision of an unusual experience**. A dive into a radically different reality allows companies to provide their users with the possibility of visiting places of interest or experiment something without leaving the house.
- **Efficient information uptake**. XR provides its users with a more realistic view of their subject matter, which allows them to be trained in a more effective manner.
- **Safe training**. Those who need to practice in high-risk conditions, such as military or chemists, can train safely from conventional classrooms.
- **Seamless data access**. XR removes distance barriers, which is why humans can smoothly access remote data.

These are not just random advantages but they also have promising numbers on papers

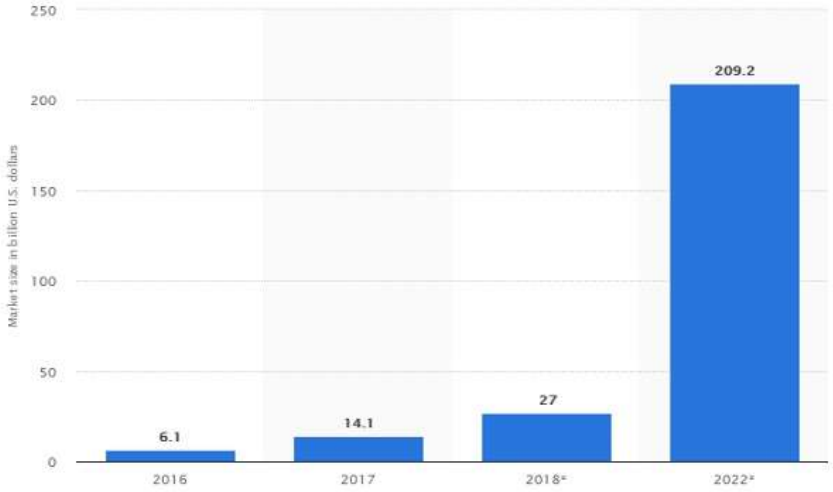


Figure 3 : Rise in AR Applications

As we can see, the need for AR and its uses have been increasing and hence will be quite prevalent in the near future.

CHAPTER 3. SYSTEM ARCHITECTURE AND COMPONENTS

3.1 DATASET

One of the modules of our projects include the functionality of object detection and the dataset that we have used is the COCO dataset. Common Objects and Context (COCO) is a dataset that consists of various objects that can be observed in everyday life such a as person, bike, toilet, sink, computer, laptop and 90 such classes of objects. The model that has been used for training is the Mobile Net V1 model which is an SDD model i.e. the Single Shot Detector model using the TensorFlowSharp plugin for integrating the object detection functionality in the VR Applications. The COCO dataset can classify 90 different classes of objects and is continuously being added to since it is an open source dataset.

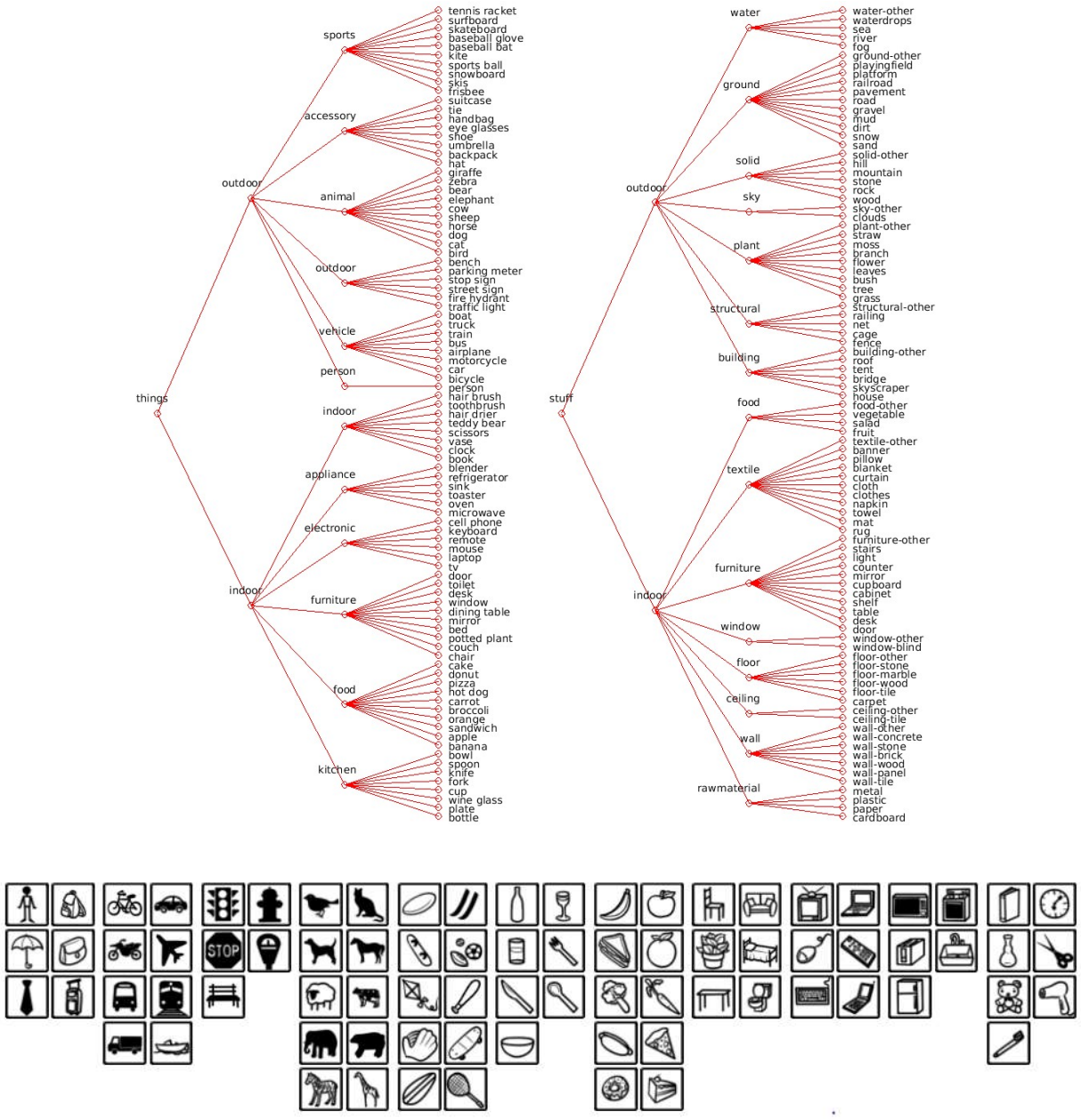


Figure 4 : Dataset Overview

3.2 METHODOLOGY

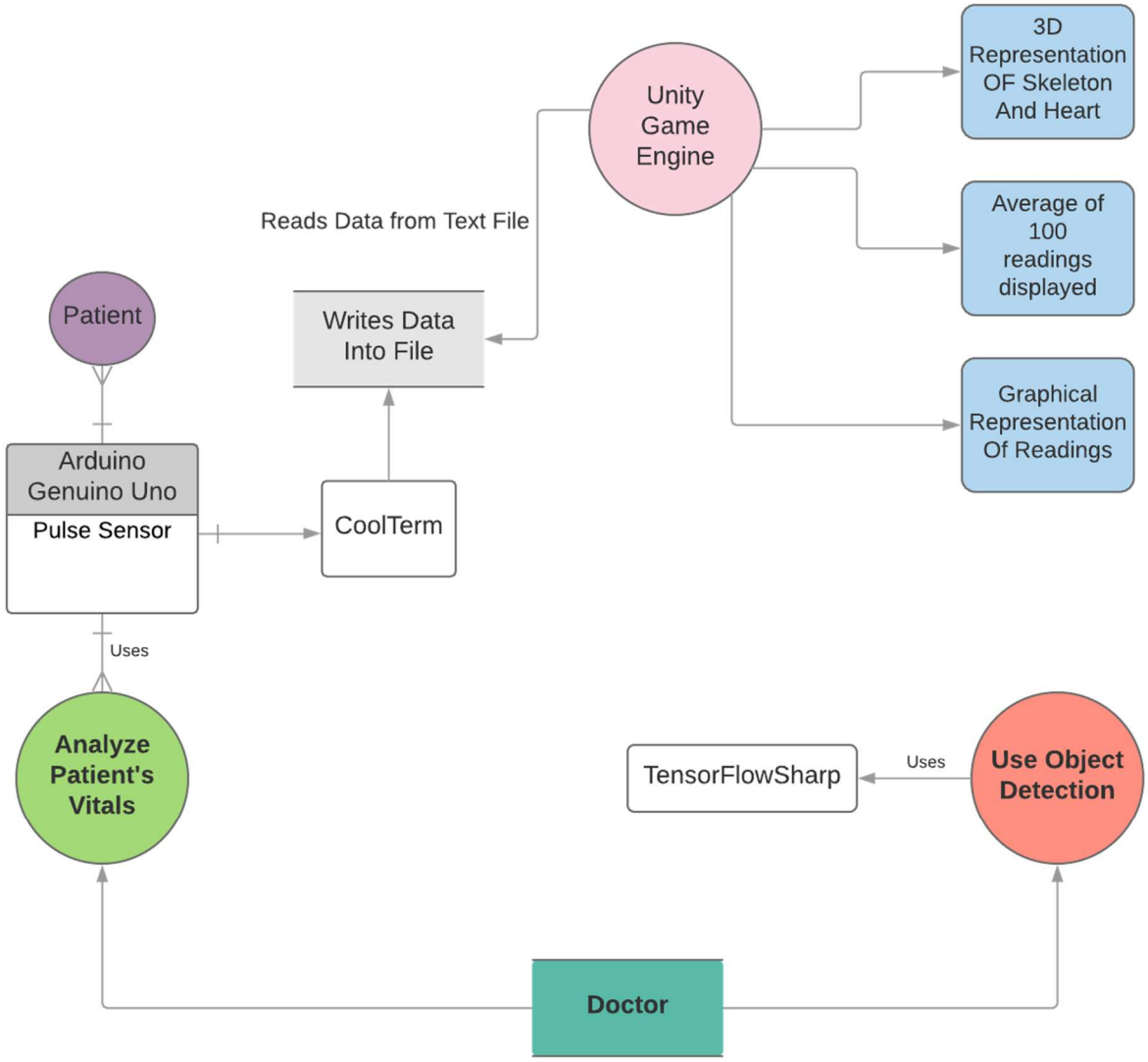


Figure 3 : Methodology

The module consists of the following actors : Doctor, Patient, Unity Game Engine, Arduino Genuino UNO and Pulse Sensor.

3.3 MODULES

- ***Arduino – Pulse Sensor Module***

This module uses the pulse sensor which is connected to the Arduino to give us an analogue reading of the pulse of the person using the sensor at that point of time. As explained in the working of the pulse sensor, it is an analogue sensor and we needed to convert the analogue output into a digital format. We used this formula to get the Beats Per Minute (BPM)–

BPM = (1.0 / PulseInterval) * 60 * 1000

Where PulseInterval is the difference between the first pulse and the consecutive pulse thereafter

In order to convert the analogue output into digital.

- ***Augmented Reality Module***

This module is the most essential part of the project. It uses a marker (which can be replaced by a unique ID for every patient that is admitted to the hospital) to generate a 3D structure of the skeleton and the heart enclosed inside a rib cage. The Beats per minute is shown right next to the heart along with a graphical representation of the reading in real time.

- ***Object Detection Module Using TensorFlowSharp***

This module provides the functionality of object detection using Machine Learning built right inside the Unity Game Engine which can be transferred into a mobile application and having object detection functionality on the go. The dataset that has been used is COCO and SDD model has been used for classification.

- ***Backend***

Once the analogue data of the pulse of the patient is received and has been converted into digital form, this data is can simultaneously written in a normal text file. These readings, ideally have to be processed and converted into a graph so that it can be represented graphically for real time analysis of the data. But as we all know from databases, that concurrent read and write from a file cannot take place due to the ACID (Atomicity, Concurrency, Integrated and Durability). So for demonstration point of view, we have taken 1000 readings which are used to statically show the graphical representation of data. This graph is then imported into the Unity Game Engine and shown to the users along with the 3D representation of the skeleton and heart.

- ***Features***

Our module can provide an augmented visual representation of the heart rate and beats per minute of the patient's heart along with a diagrammatic representation of the same. A separate module for object detection allows amateur doctors to get a first hand glimpse of various objects present in a operation theatre along with their information. The module currently is trained for 6-7 classes of objects but can later be tweaked for classifying specific objects as per the need and requirement of the same.

CHAPTER 4. SYSTEM DESCRIPTION

4.1 WORKING OF THE PROJECT

For starters, the pulse sensor is connected to the Arduino using the given circuit connection.

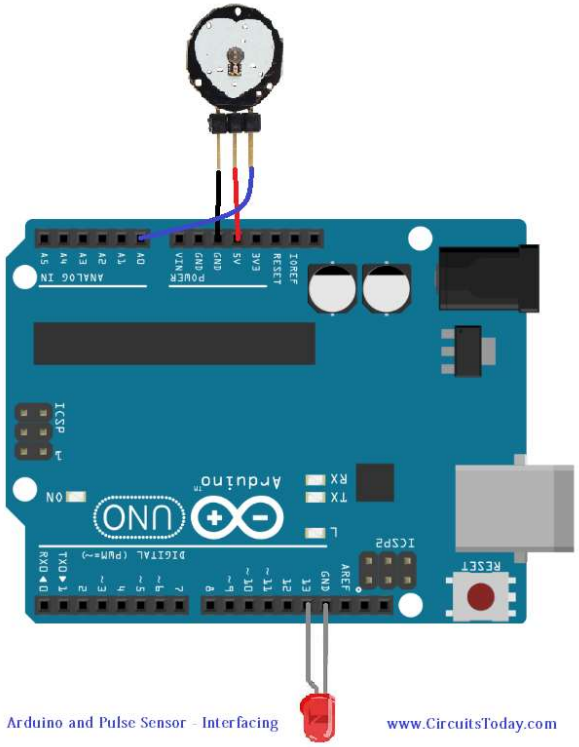


Figure 6 : Circuit Diagram for Pulse Sensor and Arduino Connection

The pulse sensor is an analogue sensor which gives the output in the Arduino's serial plotter. These analogue readings had to be converted into a digital output and this we used a formula to do get the beats per minute - BPM = (1.0 / PulseInterval) * 60 * 1000. Once we get the beats per minute, we use a software named 'CoolTerm'. This allowed us to save the output into a file from where is was read inside of the Unity Game Engine using a C# script. But as we all know from databases, that concurrent read and write from a file cannot take place due to the ACID (Atomicity, Concurrency, Integrated and Durability). So for demonstration point of view, we took 1000 readings which statically show the graphical representation of data. This graph is then imported into the Unity Game Engine and shown to the users along with the 3D representation of the skeleton and heart. Also, as a separate entity of the project, we tried to implement Object Detection using TensorFlowSharp that allowed us to get the object detection functionality inside the Unity Game Engine. This application is activated as soon as the camera scans the marker (which will be unique for every patient that is admitted in the hospital which will allow for unique representation of vitals given a particular marker) to show and demonstrate the vitals (in our case, the heart rate) of the patient under consideration.

4.2 PROJECT FLOW

It starts with the camera looking for the marker (which will be unique for every patient that is admitted in the hospital which will allow for unique representation of vitals given a particular marker) along with the patient holding the pulse sensor in his hand simultaneously. Once it finds the marker, a 3D projection of the patient's skeleton and heart appears. Giving it a minute or two, the heartbeat of the patient along with the graphical representation of the same is shown right next to the heart. Between registering the vitals and display of the same, the following process occurs in the back end –

1. The analogue data is converted into digital readings of BPM using a given formula.
2. These digital readings are then stored inside a text file. This functionality is given to us by the "CoolTerm" software.
3. The data that has been written into the file is then read from it using a C# script into unity.
4. The file is parsed and the average of 100 readings per batch is taken to be displayed on the application.
5. The file is parsed, also making a graph of the readings so give a visual and graphical representation of the reading for easy understanding and better scope of judgement.
6. In parallel, TensorFlowSharp is used for Object Detection to build that inside of the Unity Game Engine.

This then eventually completes a cycle and it is repeated again for the next batch of readings. This culminates one epoch of the project flow.

4.3 USE CASE DIAGRAM

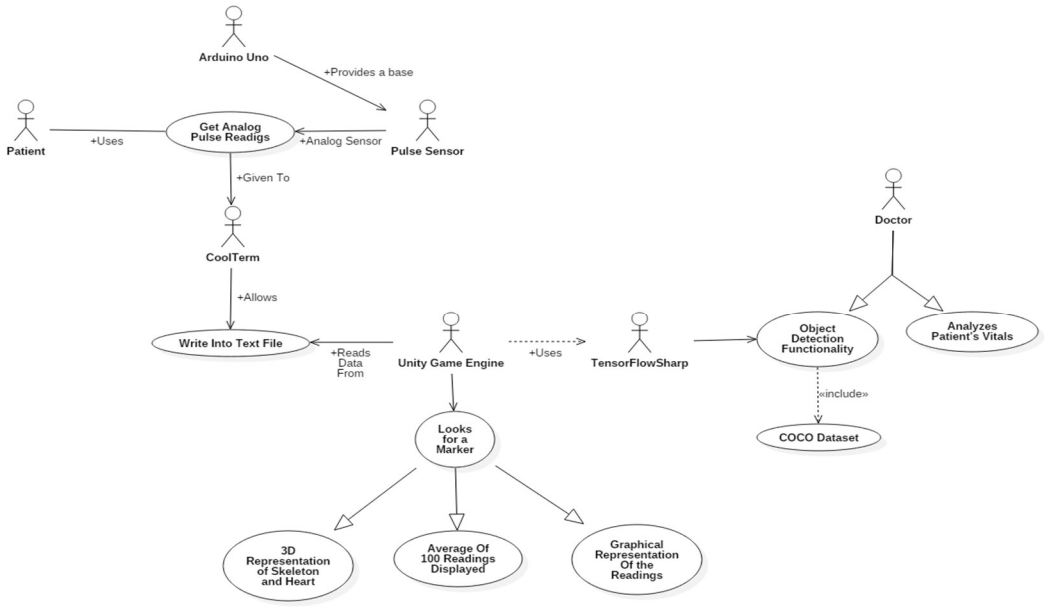


Figure 4 : Use Case Diagram

CHAPTER 5. RESULTS

SCREENSHOTS OF THE PROJECT

Figure 7 : Marker for Initialization

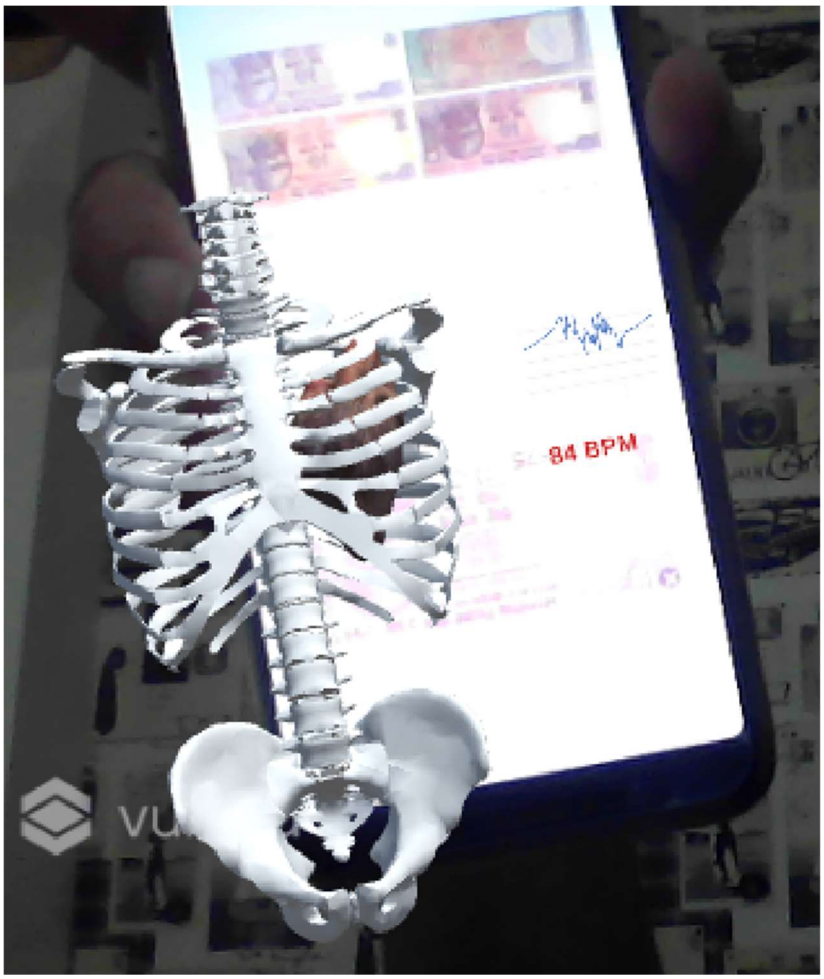


Figure 8 : Depiction of 3D Skeleton & Heart

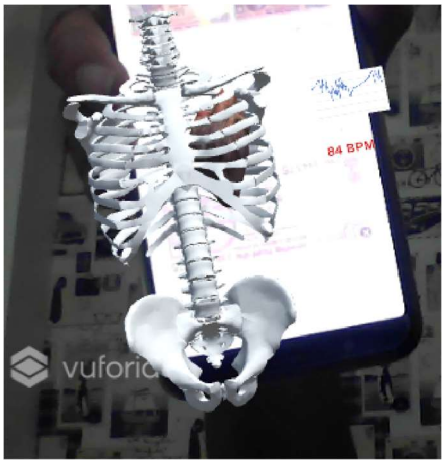


Figure 9 : Graphical Representation of BPM

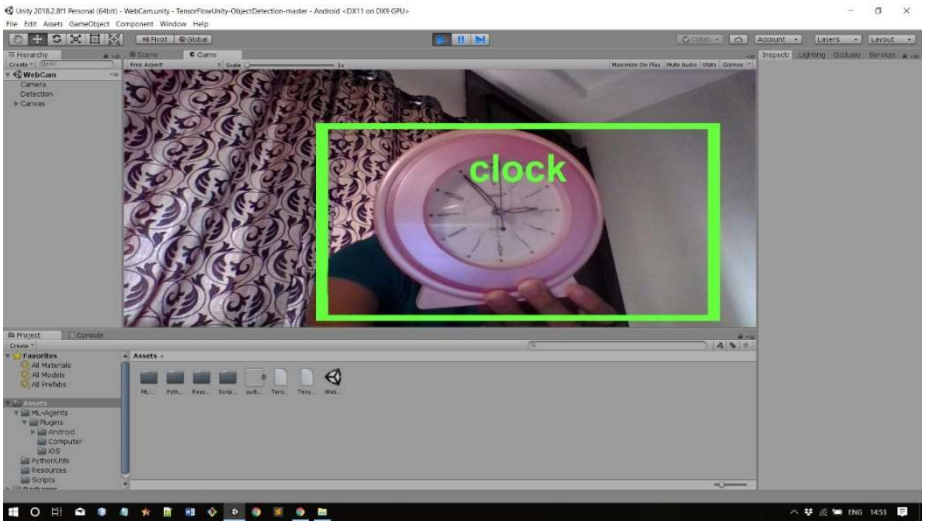


Figure 10 : Object Detection : Clock

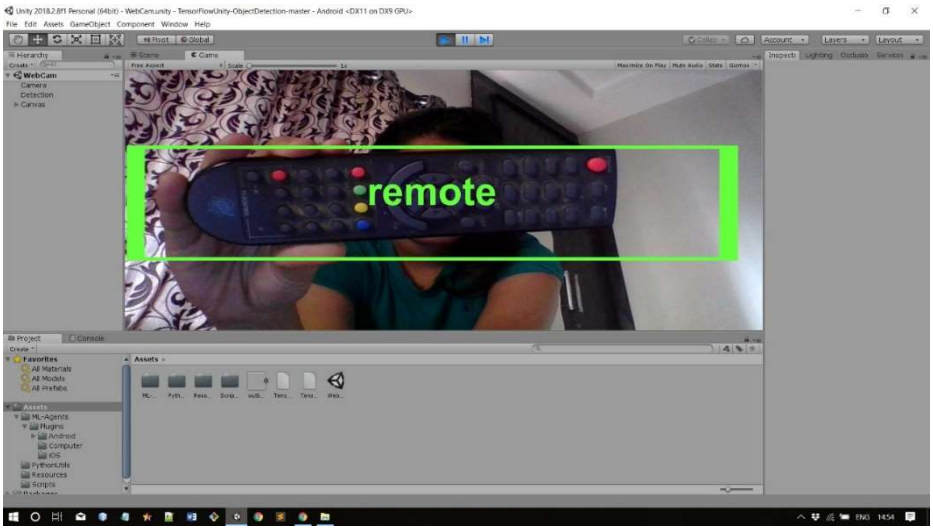


Figure 11 : Object Detection : Remote

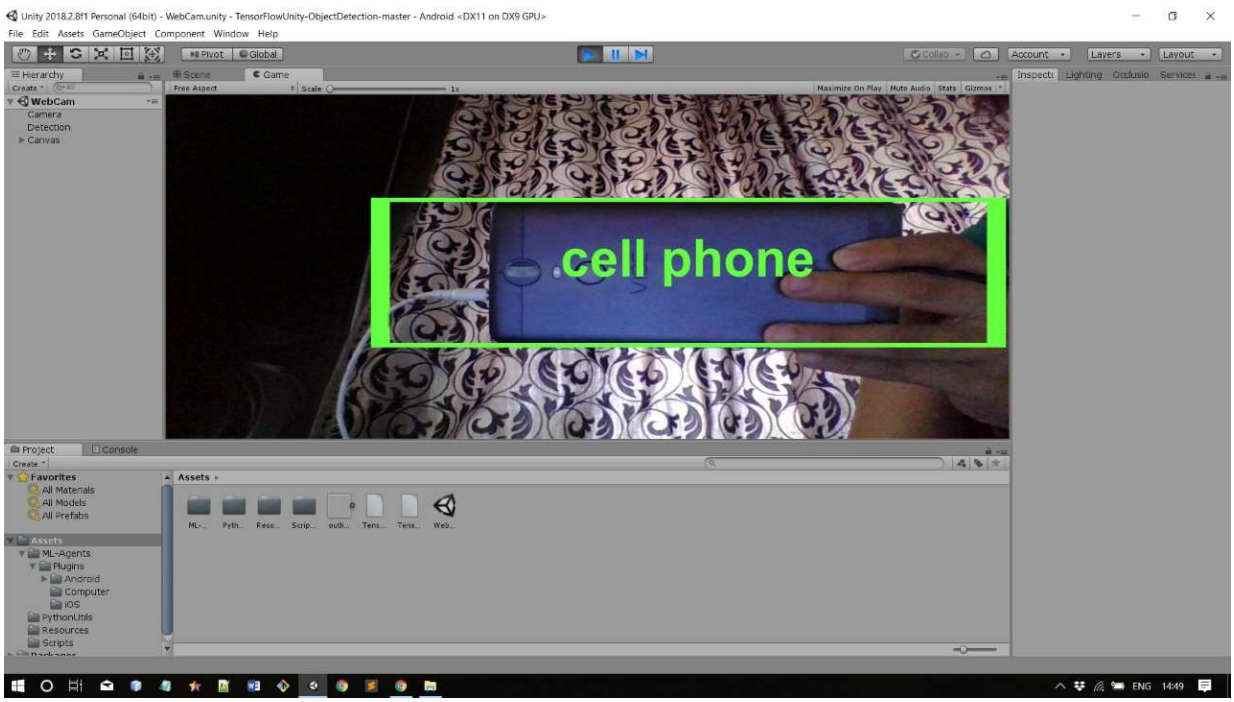


Figure 12 : Object Detection : Cell Phone

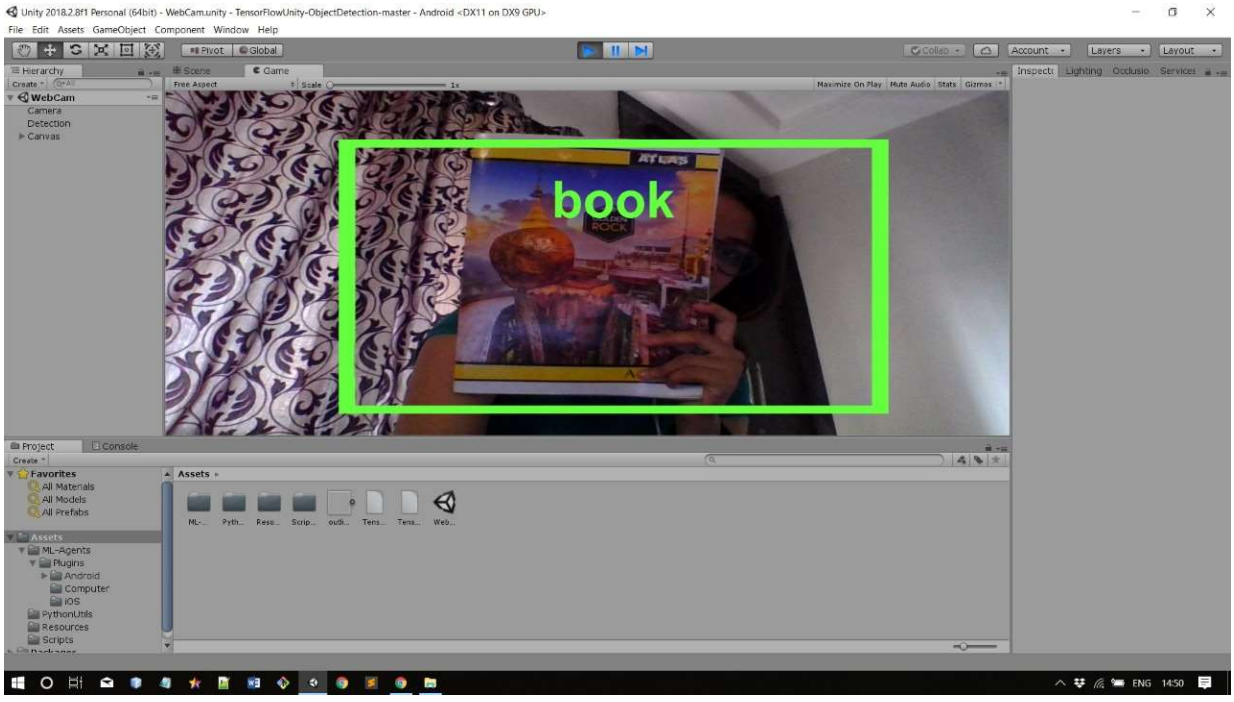


Figure 13 : Object Detection : Book

CHAPTER 6. CONCLUSION AND FUTURE WORK

6.1 FUTURE WORK

The limitation that we have in our project that restricts us in reading and writing simultaneously is a huge one which does not currently allow us to give real time data output. As for future work, we can work on this limitation. There exists a hardware solution to this – Particle Photon which was built specifically for the pulse sensor and stores the reading of the pulse sensor to the cloud directly. If the data is stored in the cloud, t=we can simultaneously read as well as write the data from the cloud thus eliminating the limitation posed by writing data inside a file caused due to the ACID properties in Database Management Systems.

Also, this demonstration is restricted to show only the heartbeat of the patient. It can also be extended to show various other vitals provided we respective sensors.

As for the Object Detection side, the module currently is trained on a broader scope of objects. It can be tweaked and the last layer of the convolutional model can be trained to enable to classifier to identify and classify specific classes of objects.

6.2 CONCLUSION

Hence , in this way we have created a M.A.V (Medical Analyzer in AR) which gives the facility of monitoring the patient's vitals using a state of the art technology. Also it provides an economical way and an error free way of analysing the patient's condition over the conventional methods of vital monitoring currently present.

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- Unity Virtual Reality Projects by Jonathan Linowes
- Practical Augmented Reality: A Guide to the Technologies, Applications, and Human Factors for AR and VR (Usability) by Steve Aukstakalnis
- Machine Learning By Tom Mitchell
- Programming Arduino: Getting Started with Sketches by Simon Monk

Research Papers

- Roopali Garg, Inderdeep K. Aulakh, Nisha Kumari, "A mathematical model to detect hand object from the scene", Advance Computing Conference (IACC) 2014 IEEE International, pp. 1133-1136, 2014.

Hyperlinks

- Information about Arduino Genuino Uno and Pulse Sensor

  https://www.arduino.cc/

  https://www.pulsesensor.com/

- Tutorial files related to Unity Game Engine and TensorFlowSharp

  https://unity3d.com/learn/tutorials/topics/scripting/coding-unity-absolute-beginner

  https://migueldeicaza.github.io/TensorFlowSharp/articles/start.html

- For application development tools and error solving purposes
  - www.w3schools.com
  - stackoverflow.com
  - www.wikipedia.com
  - www.cocodataset.com

GUIDE APPROVAL

Prof. V. Rathod

Project Guide