STUDY ON HEART RATE VISUALISATION USING COMBINATION OF REAL TIME HEART RATE DETECTION AND AUGMENTED REALITY

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Abstract

Heartbeat is a natural process which the heart continuously beating without any control from the living thing while heart rate is the speed of the heartbeat measured by the number of contractions of the heart per minute (BPM). There are few methods that can be used to check heart rate. Traditionally, heart rate is check by placing a finger on wrist or temple area and the pulse is counted in one minute. There are few devices that can be used to check the heart rate such as a stethoscope, electrocardiogram (ECG) and chest strap. This paper presents the study on the comparison of these devices that are commonly used nowadays. As analysis being done, none of the existing devices provide visualization features that enable user to see how the heart beating process happen in a human's body. This paper also presents the study on providing visualization of heart beating process by using Augmented Reality in delivering health information to improve the understanding on user heart condition whiles getting their real-time heart rate. Since AR is one of the new emerging technologies, it can be used to visualize the user heart beat in real time and user can interact with the application to get details of their heart condition. This project also aimed to encourage the user to do frequent heart rate checkup in order to let them monitor their health by providing interactive features of 'Lean Touch' where heart model can be scaled, moved, and zoomed.

Keywords:*Augmented Reality; Beats per minute (BPM); Heartbeat; Interactive; Visualization;*

1. Introduction

Heart rate is the speed of the heartbeat measured by the number of contractions of the heart per minute (BPM). Every living thing need heart beat to pump blood and supply oxygen to whole body. Traditionally, heart beat measurement usually taken at pulse point of the body. The measurement is count based on how many beats per minute. There is few point from our body that enable us to take detect heart rate such as wrist, inside of your elbow, side of neck or top of your foot. Pulse is rhythmical throbbing of the arteries as blood is propelled through them and it used to help us get a picture of our health. Very low or fast heart beat is a signal of few diseases that need further check up with doctor. The problem raised when it comes to visualization part as patient and doctor cannot see the heart pumping. As the doctor used statoscope, doctor can only hear and count the heart rate. As for patient, they just get the result from doctor observation as we as person with normal hearing, when it comes to pitch the human hearing range starts low at about 20 Hz and ability to hear it is different for each individual. This project goal is to solve the current limitation of visualization of the heart rate for the patient. Augmented reality technology will be used to develop this application in order to produce a functional heart beating model associated with the real time heart rate reading.

2. Literature Review

Heart rate or pulse is a vital signed used to measure basic function of human body. Heart rate is measure on how much beating in a minute. Heart rate is taken to check rhythm and strength of the heartbeat. This is due to uneven rhythm or weak pulse might be a sign of a heart problem [3]. Heart rate usually measured by using your index finger any pulse point on your body and count the beats for set period of time. Example of pulse area include wrist, neck, temple area, groin, behind the knee, or top of the foot [2]. Although this traditional method of counting the beats in second and then multiply the result by two is simple, it is not accurate and it could lead to error in counting when the heart rate is high. Other sophisticated method is created like a smartwatch for pulse detection, digital pulse reader and etc. By using all this new device or technology, the accuracy of the heart rate reading is higher and the risk of error can be reduced [4].

The latest technology has used mobile phone as the heart rate reader. The camera flash from mobile phone will get the measurement of the heart rate and give result to the user less than 10 second. The main idea of how the heart rate is measured is by detecting the change of skin colour and brightness of the surface of skin due to blood pulsation. However, this raw signal cannot be simply taken as it may contain noise or fake peaks or data loss due to movement of the finger during the reading is taken [1].

In medical sector, the most crucial instrument for checking the heart beat is a stethoscope. Stethoscope is a medical instrument that is used to check the performance of the heart and the lung. If there is any murmur; a condition where the heart sound is unusual that may reflect disease or malformation of the heart, further check-up is needed by using other instrument. There are many forms of murmurs and each of them represent a variety of heart condition [6].

Other example in medical sector is the Electrocardiograms (ECG). Electrocardiograms (ECG) is a test that is used to identify the underlying heart condition by measuring the electrical activity of the heart. Condition that may be diagnosed an ECG test are abnormal heart rhythms whether the heart pumps too fast or too slow, abnormal conduction of cardiac impulses that may indicate metabolic disorder, presence of a prior heart attack, occurrence of abnormal blood electrolytes such as potassium, magnesium and calcium [8].

Other than all stated above, there also few wearable gadgets that have been invented to fulfil the needs of our modern culture. This

wearable device includes wristband heart tracker, chest strap and also fitness tracker. Other than that, there is also heart rate monitor integrated with headphones which allow the user to listen to their favourite music while doing physical activity. This headphone is connected to the user smartphone via Bluetooth and the heartbeat of the user is send to the smartphone during the activity [7].

Augmented reality (AR) is one of the technology that allows a level of immersion for user but the immersion level is not a fully immersion like the virtual technology provide. Augmented reality objective usually is simplifying the user's life by providing virtual information immediately in the user's real world surrounding [9]. Augmented reality technology have been used in many sector or applications such as surgery, inspection of hazardous environments, and engineering. Currently the augmented reality technology basically covers for indoor activity within small areas. However, with the advances of the computer, and present of wireless technology, development of wireless augmented reality for outdoor application could be made [13]. There are six different types of augmented reality that fall under two basic categories which is marker based and markerless based augmented reality. Marker based augmented reality are one that use marker or object to initiate the augmentation. Marker Based Augmented Reality can be easily recognized and does not require a lot of processing power to read [10]. The other types of augmented reality are markerless based AR; these types of AR allow the user to experience augmentations without marker. Markerless Based Augmented Reality also known as location-based or position-based or GPS. Wide availability of smartphones and location detection enhance the Markerless Based Augmented Reality [5]. This technology used detection technology to recognize something or pattern before the scene is display [14].

As the Internet of Things (IoT) rapidly develop, this project is one of a IoT project that used Particle Photon as one of the hardware. Every Photon can easily be connected to the cloud by claiming each device in the Particle Cloud. With this Particle Cloud, developer can know the last time that the Photon active, and even to test the functionality of the photon by flashing LED on photon using flash function available in the web IDE [15]. Other than Particle Photon, pulse sensor also used in this project in order to detect the pulse of the user hence getting the heart rate of the user. Pulse sensor is a plug-and-play heartrate sensor for Particle Photon compatibles. Pulse sensor usually used with Arduino to get the heartrate of the user [16].

3. Existing System

There are three existing systems that can be used to get heartrate which are stethoscope, electrocardiogram and chest strap. In medical sector, stethoscope is the most crucial device which doctor will use to check the patient's heartbeat. Listening to the heart and lung need different listening skill to distinguish one another. Uses of stethoscope is painless and it give information on how the body function and if there is any further treatment to be done [11].

ECG is an ambulatory electrocardiogram monitors if the heart in normal state. It helps to detect abnormal heart rates or rhythms of the patient. ECG can detect if there is previous mild heart attack that did not show any symptoms or demonstrating heart disease that has not been suspected [12].

Chest strap should be worn directly under the breast and strap need to be adjust as tight enough to ensure constant contact with your skin. Although the uses of chest strap may cause uncomfortable affect, somehow the chest strap have the highest accuracy compare to other heart monitor device as it implements the ECG-style sensor where the sensor detect the electrical impulse in the heart and the result is shown in beat per minute(BPM). The algorithm and improvement are made to ensure that interference is reduce to improve the accuracy [8].

3.1 Comparison of existing system

Table 1: Comparison of existing system

Device / Aspect	Stetho-scope	Electrocardio-gram	Chest Strap
Unit of Measure-ment	BPM	Millivolt versus time	BPM
Accuracy	High	High for normal condition	High
Price range	RM 20 – RM 400	RM 3000 – RM 7000	RM 150 - RM 500
Advantage	It allows doctors to listen to sound that is produce by the lung, heart and abdomen. Any ab-normal activities in body can be easily de-tected by using steth-oscope.	Non-invasive Continuous moni-toring Diagnostic tool for arrhythmias	Provide most accurate heart rate among other non-medical de-vice.
Disad-vantage	Air leaks may occur and cause the hearing process during heart rate monitor affected.	Only assesses electrical activity of the heart	Uncomforta-ble to be wear in certain activity.
What It Can Detect or Diagnosed	It can de-tect sound in the body of patient and any murmurs also can be heard and detect if any further investiga-tion need to be done.	Abnormally fast/slow or irreg-ular heart rhythms. Abnormal conduc-tion of cardiac impulses.	Chest strap can only de-tect the heart rate but can-not diagnose any heart condition.

4. Hardware Requirement

The devices used in this project were Particle Photon, Pulse Sensor, USB 2.0 Micro-B 5 Pin, and Solderless Breadboard.

4.1 Particle Photon (Header)

Particle's IoT (Internet of Things) hardware development board, the Photon, use to build a connected project. Particle has combined a powerful 120MHz ARM Cortex M3 microcontroller with a Broadcom WiFi chip in a tiny thumbnail-sized module called the PØ (P-Zero).
These specific Photons come with headers, making prototyping easy as each board can plug directly into standard breadboards and perfboards, and may also be mounted with 0.1" pitch female headers on a PCB. The small form factor is ideal for IoT projects with cloud-connectivity. To get you started quickly, Particle has added a rock solid 3.3VDC SMPS power supply, RF and user interface components to the PØ all on a small single-sided PCB.

4.2 Pulse Sensor

The Pulse Sensor Amped is a plug-and-play heart-rate sensor usually used for Arduino. It essentially combines a simple optical heart rate sensor with amplification and noise cancellation circuitry making it fast and easy to get reliable pulse readings. Also, it sips power with just 4mA current draw at 5V so it's great for mobile applications. Simply clip the Pulse Sensor to your earlobe or fingertip and plug it into your 3 or 5 Volt Particle and it will read the heart rate.

4.3 Solderless Breadboard

Solderless breadboard is a construction base for prototyping of electronics and used to connect two electronic components which is Particle Photon and Pulse Sensor. Solderless breadboard has 400 tie-point, 2 power lanes with tie-point 100 and 1 double strip with tie-point 300. It size is 8.2x5.5x0.85 CM. It made up from plastic housing associated with metal contact clips. It accepts wire with diameter 20-29AWG. Voltage/Current: 300V/ 3-5A.

4.4 USB 2.0 Micro-B 5 Pin

USB 2.0 Micro-B 5 Pin is a connector cable with type A end that connect Particle Photon with to the power supply in order to make the particle photon work and able to link to application.

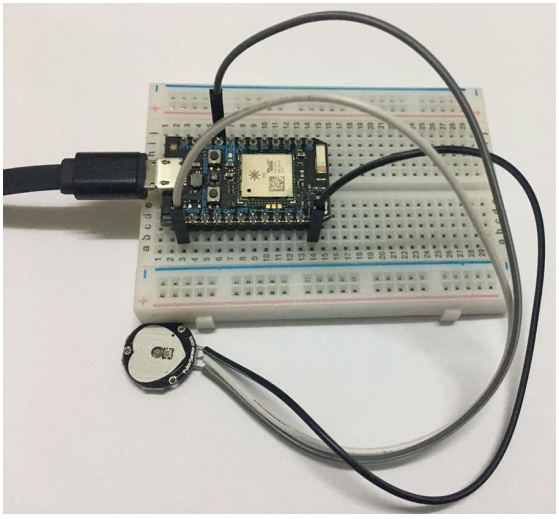

Fig. 1: Combination of all hardware.

5. Software Requirement

Unity and Vuforia are the main platform of building application for this project. In addition, particle application also used to monitor the particle photon.

5.1 Unity

Unity is a cross-platform game engine developed by Unity Technologies, which is primarily used to develop both three-dimensional and two-dimensional video games and simulations for computers, consoles, and mobile devices. In this project, Unity version 2017.3 has been used to develop the application.

5.2 Vuforia

Vuforia is an Augmented Reality Software Development Kit (SDK) for mobile devices that enables the creation of Augmented Reality applications. It uses Computer Vision technology to recognize and track planar images (Image Targets) and simple 3D objects, such as boxes, in real-time. In this project, Vuforia 7 has been used to develop the project.

5.3 Particle

Particle is an application to setup the particle photon to the Wi-Fi. The application allows us monitor our particle photon and provide information of the device such as ID of the device, IP address of the device and the time of the last activity is recorded. It also provides action for user to flash thinker and refresh the data.

6. Project Design

The main menu of this application consist of four option which are PLAY, HELP, TIPS, and QUIT. Refer to Fig 2 to see the flow of application.

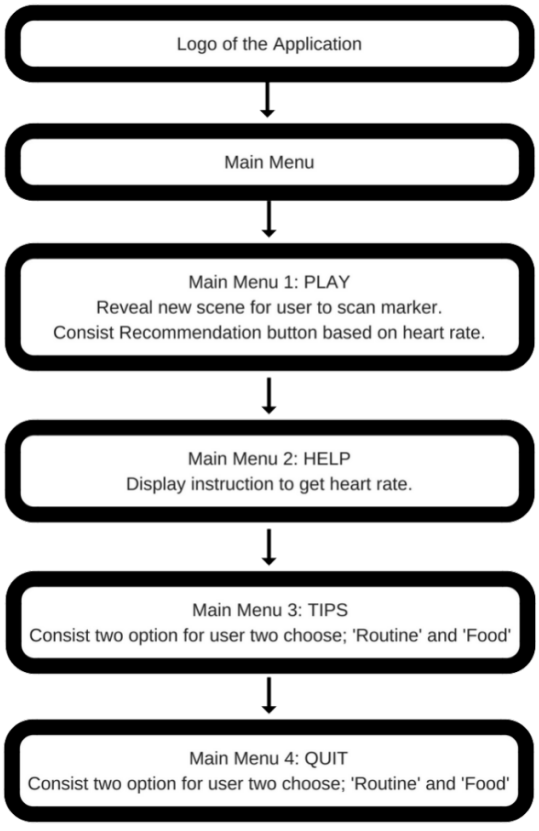

Fig.2: Flow of Application

7. System Architecture

In the system architecture, there is four main parts which is User, Hardware, Software and the Output of the system. For user part, the most crucial element is to get the input from user in term of getting heart rate from the user. In hardware part, there will be three components which is button badge, laptop's camera, and composite device which is combination of pulse sensor and particle photon. In this system, button badge will act as a marker for detection to project the model in the scene. Pulse sensor and particle photon were linked and integrated with coding to make it both of the component works. Laptop's camera is used to produce superimpose effect where the ribcage and the heart will be reflected on user body. The real time heart rate of the user will detect by using the pulse sensor where it uses infrared light to read the heart rate.

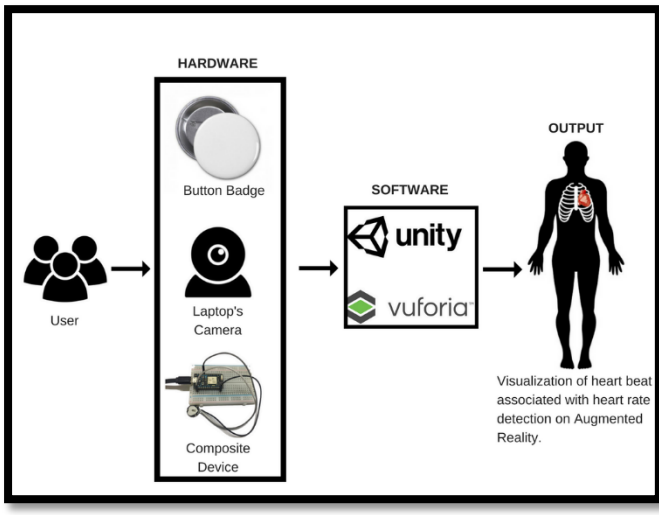

Fig. 3: System Architecture for ARHeartRate application

8. System Flowchart

System flowchart explains the whole process and the probability outcome based on user condition or choice. As different user might have different heart rate, ARHeartRate provides different outcome for each category of heart rate. The system flowchart has one main menu for user to choose from. The Main Menu consist of 'PLAY', 'HELP', 'TIPS' and 'QUIT'. 'PLAY' option will bring user to Augmented Reality scene where user need to scan marker to reveal 3D model and get the heart rate. For 'HELP' option, it provides user guideline to use the application and for 'TIPS' option, it provides user information about routine and food for healthy heart. The overall system flow is summarizing as below.

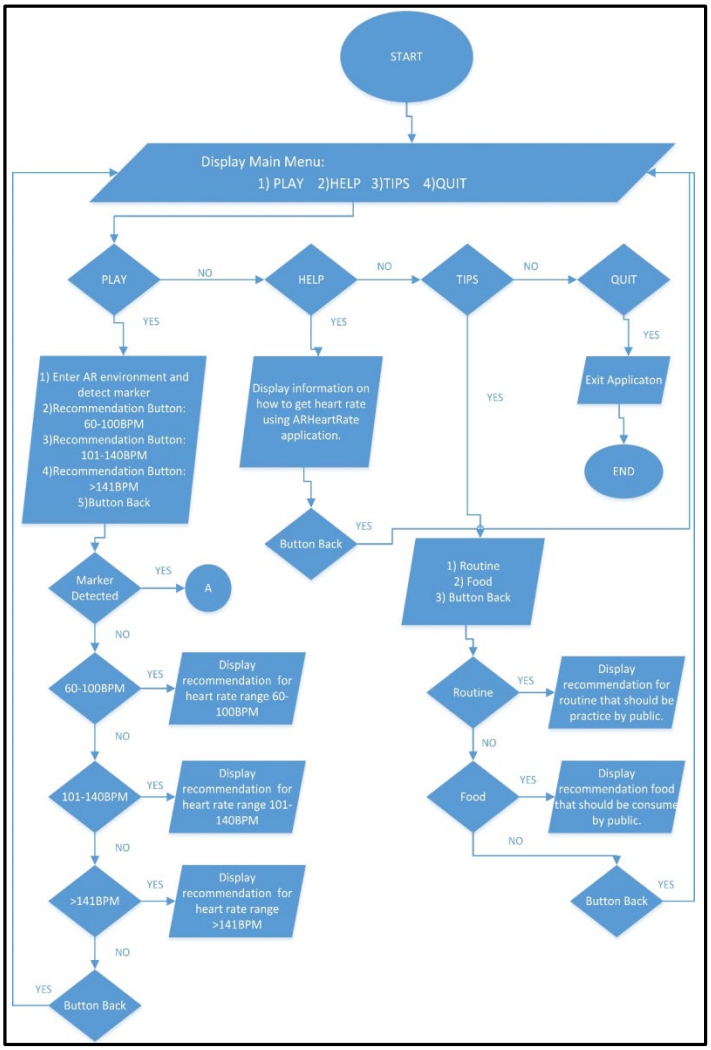

Fig. 4: System Flowchart for ARHeartRate application

9. Advantages and Limitation

The main advantage of this ARHeartRate is provides a visualization of upper part of human body which is ribcage and the heart model. To improve the experience of the user, the ribcage has been set to maps the user body once the marker is scanned. Moreover, the heart has been animate and the user can see and hear the heart beating. To make the application easier to use, the marker of this application has been design in form of button badge, where it allows the user to interact with application without the need to hold the marker.

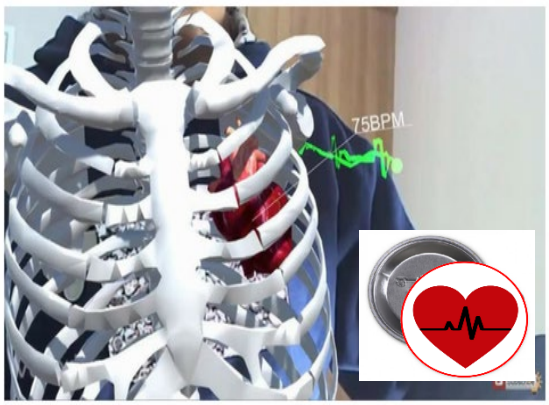

Fig. 5: 3D model maps to user's body and Marker design for ARHeartRate application.

Although the application has its own advantage, this application also has its flaws. The main limitation of this application is the pulse sensor is over sensitive where value of the heart rate often changes during measurement if the pulse sensor is move and expose to noise.

10. Conclusion and Future Work

In conclusion, this project has been successfully developed to achieve certain objective in visualizing heart beating process using real time heart rate detection. By having this project, we hope that user is motivated to do frequent check of their heart rate hence they can monitor their health as well. User can also get information about best practices to ensure their heart is healthy. For future work, the application should include the ability to store history of user heart rate and allow the user or doctor to monitor the heart rate of the user remotely. The proposed model will be further evaluated by using usability evaluation (heuristics evaluation and questionnaire).

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