Analysis of heart murmur and its classification using Image-Based Heart Sound Signal with Augmented Reality

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Abstract: In this paper, a heart sound signal is obtained from a stethoscope and converted into a wave pattern using a phonocardiograph (PCG). Various cardiac sound signal wave patterns obtained from PCG may have normal and abnormal sound signals. Abnormal sound signals are called heart murmurs. These sound signal wave patterns are to be made available in the form of a JPEG image which is in detecting heart abnormalities. Augmented Reality (AR) is a new technology in which computer-generated material such as graphics, text, audio, and objects are superimposed over a display screen to increase one's view of the real-time world. The proposed framework is a mobile-based Android application that would work for all current and future versions of the operating system. In a marker-based augmented reality device, this approach allows the user to see the simulated object in the physical world. Image of the entity that is registered wave patterns of PCG signal could be provided by the consumer. The device is designed to detect the captured JPEG image pattern of the cardiac murmur signal and identify it using the hamming distance technique in this study. A new image pattern is formed as a result of the combination of the real world and generated objects, and it appears as if the real-world object and virtual object coexist within the environment. This is accomplished by the use of an Android-based handset. It is convenient and affordable since the consumer does not need to invest in costly and costly equipment such as an ECG machine, a treadmill, or an echo machine, among other options.

Keywords: JPEG image, Augmented reality, Hamming distance, Heart murmur, and Vuforia.

1. Introduction

Heart abnormality is detected based on cardiac murmurs[7] heard using a stethoscope. Cardiac murmurs are vibrations caused by blood turbulence flowing into a narrow tunnel. In a natural cardiac rhythm, the heart tones S1 and S2 are present. When the tricuspid and mitral valves are all closed, S1 occurs during isochoric contraction. When the aortic and pulmonary valves are closed, an S2 sound is produced. S3 and S4 are the other two lower-intensity heart sounds[4] that can also bear clinical detail. The standard heart sound signal is seen in Figure 1Cardiovascular diseases, aberrations, and faulty valve structure all induce cardiac murmurs. Low frequency, time and length of incidence of heart sounds, noise, signal amplitudes, and extremely useful health knowledge are all features of a PCG signal.

The different forms of Phonocardiogram signals recorded by this device are detected using an integrated reality technique in this study. This is the simplest approach for classifying heart sound signals and analyzing irregularities in the heart.

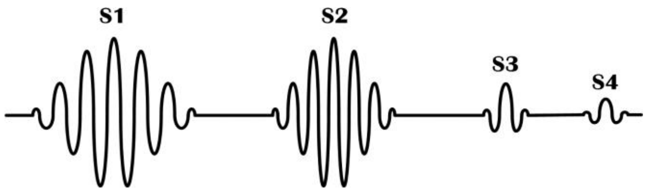


Figure. 1: Normal heart sound signal

2. PHONOCARDIOGRAPH SYSTEM

A phonocardiograph is a device that records heart sounds as well as murmurs produced by the heart. These sound[13] signals can be used to determine heart rate, rhythmicity, and details about blood-pumping efficiency and valve operation.

A phonocardiogram is a schematic representation of the waveform of cardiac signals, and phonocardiography is the method used to record the signal. This methodology allows for a more in-depth analysis of temporal dependencies between mechanical processes that produce heart sounds by allowing for a visual interpretation of heart sounds. Other heart-related measures including the ECG, carotid arterial pulse, jugular venous pulse, and apex cardiogram are also recorded at the same time as the phonocardiograms. Clinicians may use this information to evaluate a patient's heart sounds in terms of electrical and mechanical cardiac cycle operations. Figures 2 and 3 show a block diagram of a phonocardiograph, respectively. The above are the units that make up the whole structure.

- Transducer/Microphone
- Preamplifier
- Second-order low pass filter
- Volume controller
- Audio amplifier (Negative feedback non inverting amplifier)
- Power supply

With the aid of the audacity app, the experimental setup is seen in Fig. 4 for observing heart sound and analyzing different heart irregularities.

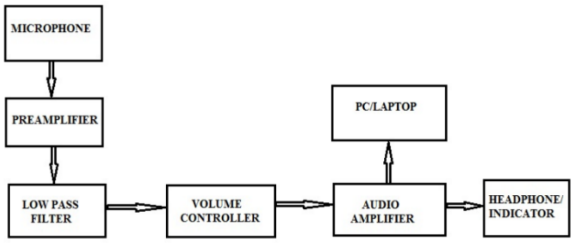


Figure. 2: Block diagram of Phonocardiograph system

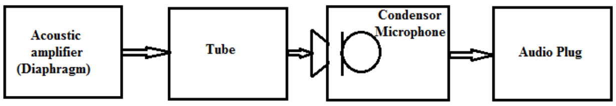


Figure. 3: Sensor coupled microphone in a stethoscope

3. AUDACITY SOFTWARE

Audacity is a free and easy-to-use multi-track audio editor and recorder for Windows, Mac OS X, GNU/Linux, and other operating systems. The user interface can be used in several different languages. Audacity is distributed under the GNU General Public License by all volunteers (GPL). These applications are classified as open-source software and the source code can be used by anybody for whatever reason.

Figure. 4: Experimental set up for PCG

The heart sound waveform is seen in Figure. 5 using the audacity software.

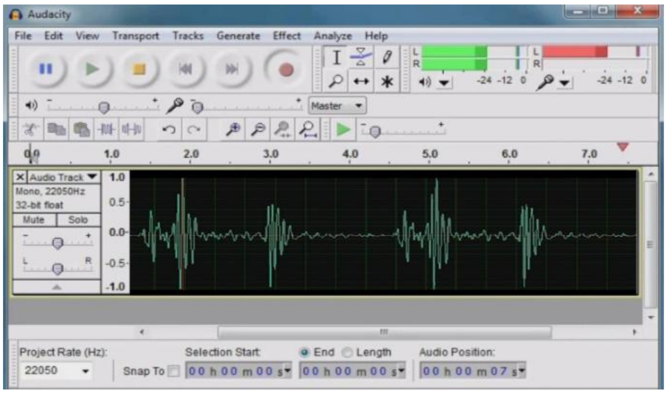


Figure. 5: PCG waveform observed using Audacity software.

Heart sound and murmur measurement analysis can diagnose a variety of heart irregularities. Table 1 shows murmurs and their psychoacoustic characteristics.

Table 1: Murmurs and their psychoacoustic or perceptual features.

Types of Murmurs	Psychoacoustic features
Heart Sound or Murmurs	Sound/Acoustic Properties
Aortic Stenosis	High pitch, high energy envelope
Mitral Regurgitation	High pitch, high energy envelope
Pulmonic Regurgitation	High pitch, high energy envelope
Third Heart Sound	Faint heart sound after second heart sound.
Fourth Heart Sound	Faint heart sound after third heart sound.
Early Systolic Murmur	Systolic, early cycle of S1, high pitch, high frequency.
Late Systolic Murmur	Systolic, late cycle of S1 or S2, high pitch, high frequency.
Ejection Click	High energy pulse of 2-5 ms duration
Diastolic Rumble	Rubbing sound
Atrial Septal Defect	Gushing sound with high pitch
Patent Ductus Arteriosus	Gushing sound with low pitch and inaudible
II Heart Sound Split	Clear split sound of duration 2- 48 ms after S1.
III Heart Sound Split	Clear split sound of duration 5 - 50 ms after S2.
Diastolic Tricuspid Stenosis	High pitch and rhythmic
Diastolic Ventricular Gallop	Galloping with high intensity &reducing with time.

4. AUGMENTED REALITY

4.1 Concepts of Augmented Reality

A live, direct or indirect view of a physical environment in which real-world elements such as video, sound, photographs, or GPS data are supplemented by electronically generated sensory input is known as augmented perception [1][2]. Augmented reality refers to the combination of sensory knowledge and the user's surroundings in real-time. In virtual reality, the original universe is used to layer new content on top of it. This is used in this analysis to differentiate between the various types of PCG (Phonocardiogram) signals recorded by this system. This is the most basic method for classifying heart rhythm signals and analyzing heart rhythms. The strategies used in augmented reality [3] are described below.

4.1.1 Projection

In this technique, virtual photography is used to supplement live snapshots, which can record movements and sounds with a camera and then react.

*4.1.2*Recognition

AR identifies shapes, faces, or other real-world objects in this approach and gives real-time virtual information to the user.

*4.1.3*Location.

AR makes use of GPS technology to provide accurate, real-time directional information. A smartphone with GPS will usually assist in deciding the location, during which the user's foreground image can be sensed and the direction of travel determined using superimposed onscreen arrows (over a live image).

*4.1.4*Outline.

AR combines the outline of the human body or a part of it with abstract items, allowing the user to pick up and manipulate objects that do not exist in the real world.

Augmented reality[6] system must have the following characteristics:

- It combines the physical and virtual worlds.
- It is real-time interactive.
- Registered in three dimensions

4.2 Classifications of Augmented reality

Simple augmented reality is divided into two types: marker-based (which uses sensors and visual cues) and markerless (which uses spatial details like a smartphone's GPS and compass).

4.2.1 Marker-based AR

Markers are images that can be detected by a camera and used by the software to locate virtual assets installed in a scene. It's just a collection of black and white stickers. Digital reality in its most basic form [eight] Easy shapes composed of black squares on white background may be used to create [10] labels. Simple images that can also be read by a camera can be used to create more intricate markers, which can also be tattooed.

4.2.2 Markerless AR

The image is taken from the internet and projected in markerless virtual reality on a particular site (gathered using GPS). In this program, the content is shown without the use of a marker. It is more immersive than marker-based augmentation.

4.3 AR-based approach

As seen in Table 2, Vuforia [web-based tool] is a feature of the program system that helps you to simulate applications.

Table 2: Vuforia, a web-based tool, has the following features.

Capabilities	Type	Examples
To recognize images and objects	Flat images	Print media and product packaging
Supports geometric shapes classification	Multi Targets of JPG/PNG/RGB/ Gray-scale	Cascaded Images
Mapping physical environment	Smart Terrain	3D Mesh Creation

4.3.1Extended features

(1) Create devices and cloud databases
(2) Assign databases to license keys
(3) Add targets to databases
(4) Edit and remove targets
(5) Manage databases
(6) Download Device Databases

4.3.2 Attributes of an Ideal image target.

The Vuforia SDK can have the highest identification and tracking value if image targets have the following attributes.

Table 3: Related Work Attributes of an Ideal Image Target

Attribute	Example
Rich in detail	PCG scene, group of features, Mixtures of hidden acoustic signals and murmurs
Good contrast	Bright and dark regions, and well-lit
No repetitive patterns	Abnormalities may be multiple and random.
Format	Must be 8- or 24-bit PNG and JPG formats; less than 2 MB in size; JPGs must be RGB or gray-scale (no CMYK)

4.3.3 Applications

i). The use of an expression language to help with text comprehension.

ii). Object recognition by scanning: This software is used to identify and recognize PCG wave images in this study. This method can be used to build apps that recognize and track complex rigid scans.

iii). The PCG wave material communicates with the history classification algorithm in this analysis, resulting in content interaction (without the need for feature extraction).

4.3.4 Advantages

(1) The drawback of a standalone ‘app' is that query times for computer databases are shorter than query times for cloud databases.

(2) Data in the Standalone ‘app’ support tracking of multiple targets simultaneously, while cloud databases support tracking of only one target at a time.

(3) Large Device Databases can take a few seconds to load, while Cloud Databases can be queried immediately after the software launches.

5 HAMMING DISTANCE

5.1Hamming distance method

Using the Hamming distance between two photographs, this technique is used to detect heart irregularities. The number of points in the string where the two strings have separate characters, or the least number of errors in one string that might have converted it into the other, is the Hamming distance between two identical strings.

The number of gaps between matching bits is the Hamming distance between two terms.

1). Measure the obtained frame's hamming gap about the reference frame.

2). Calculate the minimum Hamming distances in ed1 and ed2 and make a decision.

$$ed_1 = \sum_{i=1}^{3}\sum_{j=1}^{3}[P_{i/p}(i,j) - P_{ref_1}(i,j]$$

And

$$ed_2 = \sum_{i=1}^{3}\sum_{j=1}^{3}[P_{i/p}(i,j) - P_{ref_2}(i,j]$$

Min (ed1, ed2) of sub-blocks determines the nearest fit between the caught frame and the individual reference frames.

*5.2*Hamming distance algorithm

For a k^{th} scanned image of some size

(1) A glance at the values in the i^{th} block.
(2) Calculate the Hamming interval for a string of length ‘l’.
(3) Determine the shortest Hamming distance (2)
(4) For the $(i+1)^{th}$ block, repeat steps 1–3 to cover all sub-blocks of the scanned image.
(5) Get the vector that represents the k^{th} scanned image's minimum Hamming distance for all NxN sub-blocks.
(6) Repeat steps 1–5 for additional photographs depicting the same background.

5.3 Methodology

Step1: Determine/providing Frame markers that are independent of the scene.

Step2: Detect and monitor (hidden) features in a picture at the pixel level.

Step3: After the feature vector has been treated, keep an eye on the image and see if it matches the

reference database.

5.3 Algorithm for Classifying Heart Murmurs

Let's call the Median String's length "L" and the height of the selected sub-block "M". The coordinates of the elements in the sub-block are M0 and M1.

(1) Calculate the Hamming distance between the median string size of 'L' and the elements of 'M', starting with M0.
(2) Repeat step (1) for elements beginning with the letter 'M,' but for M1 as the first element. Rep the steps above for each new letter 'M' starting spot.
(3) From the above, find the place value that corresponds to the shortest Hamming time.

6 WORKFLOW OF AR APPLICATIONS

All marker-based AR applications [9] follow the same general workflow, which is depicted in Fig 6. The marker must be removed from the remainder of the picture after it has been captured by the sensor. After that, the marker's contour is extracted. The simulated object's localization matrix is determined using the four corner points (or contour). The object must then be shown above the image obtained in the first move using the matrix. PCG signals are analyzed, and different forms of cardiac disorders are classified using AR applications.

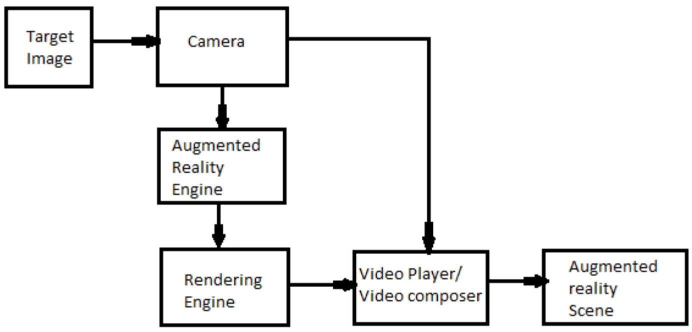


Figure. 6: Workflow of AR applications

7 RESULTS AND DISCUSSION

The Hamming distance is calculated in virtual reality, and the results are compared to the minimum non-matching values. Figure 7 depicts this for three separate blocks in the graphic. The best match murmur group is described as the murmur with the shortest

Hamming distance.

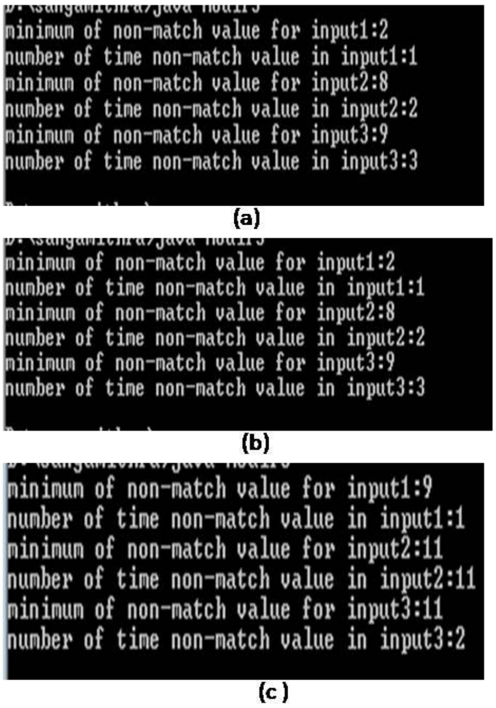


Figure. 7: Hamming distance evaluation

For multiple heart rhythms, an augmented reality-based technology has been developed and tested. The steps involved in testing heart signals by recording them first using a smartphone and then the forms of murmur shown on the screen are described in Fig. 8, Fig. 9, and Fig. 10.

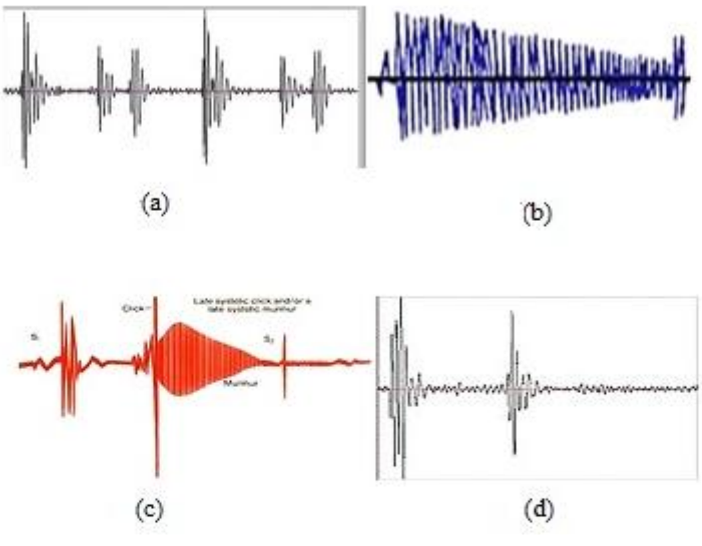
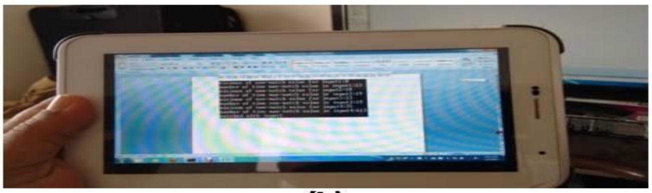


Figure. 8: Heart signals under test

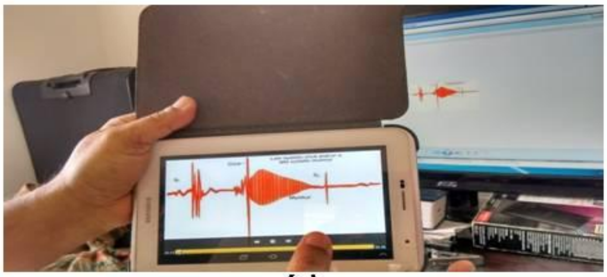
(a)



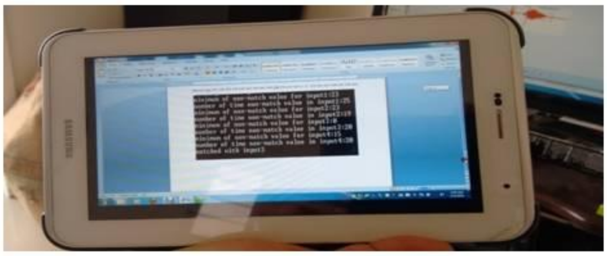
(b)

(c)

Figure. 9: Heart signals captured using AR concept and classified and displayed on the mobile device



(a)



(b)

(c)

Figure. 10: Detection of machinery murmur

8 CONCLUSION

The phonocardiogram-based study of heart murmurs and classification of different heart disorders is discussed in this article, as well as the identification of heart abnormalities using an Augmented Reality-based PCG signal classifier on Android smartphones. The Android interface was launched, and its features were demonstrated. Also, the limitations that can be seen on mobile devices have been identified. Aside from that, interface requirements for AR apps on mobile devices were addressed. The AR platform, which is capable of rendering complicated 3D models on AR markers, may be used to investigate future research directions. In the clinical sector, using software to monitor a handheld computer to classify murmurs is critical. This strategy is straightforward, easy to produce results, and much less difficult than other approaches. In the future, superimposing an MRI image onto a patient's body could enable surgeons to pinpoint a tumor that needs to be removed.

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