HEARTBEAT SOUND SEGMENTATION AND CLASSIFICATION

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Abstract: A heartbeat diagnostic system that consists mainly of preprocessing, segmentation and classification has been developed. Wavelet analysis is used for denoising and Shannon energy is used to find envelopes. For classification, ANN, SVM and XGBoost models were used. The system presented an accuracy of 80% and 89% for classifying normal heart sounds with SVM and XGBoost respectively. It is suggested that improving recording techniques and location of S1 and S2 will improve system performance.

Key words: Denoising, Segmentation, PCG (Phonocardiogram), Wavelet Analysis,

1. INTRODUCTION

Cardiac auscultation remains to be the most popular yet challenging technique used by physicians to diagnose cardiovascular diseases (CVD's). Studies have shown that 22%, 26% and 20% of patients in the United States, Canada and England respectively were correctly diagnosed through auscultation [1]. This technique has proven to be insufficient in diagnosing heart diseases since physicians still request unnecessary echocardiograms for reassurance [2], [3]. Echocardiograms are expensive and are normally done to avoid type II errors [2]. Type II errors occur when a patient who has a CVD is sent home without any medical treatment.

A heartbeat diagnostic system able to classify heart sounds into normal and diseased categories would help reduce the costs spent on unnecessary echocardiograms and also assist physicians to make well informed decisions during auscultation. This type of system would also be useful for home use by the general public by providing preliminary screening for CVD's. People would benefit from such a system as it will save them costs spent on unnecessary medical consultations.

This report presents a heartbeat sound segmentation and classification system capable of locating and segmenting heart sounds, primarily known as (lub and dub) or (S1 and S2) sounds from real-life recorded heart sounds. Segmentation is implemented in MATLAB using wavelet transforms amongst other methods for denoising. To detect peaks, Shannon energy is used. Machine learning models for classification and a user-interface are implemented in python.

Section 2 presents the background which outlines the project framework and Section 3 details the design methodology used. This is followed by implementation,test results, critical analysis of results and future recommendations respectively.

2. BACKGROUND

As mentioned above, this project aims to provide preliminary screening of heart diseases for both physicians and the general public for home use. This implies that the system should be applicable in real world surroundings with various background noises, some excessive depending on the environment.

According to literature [4], [5], the most common challenge with heart sounds that contain noise is segmentation and location of S1 and S2 sounds. Segmentation is considered a crucial step in the process of classifying heart sounds. It is therefore vital that heart sounds are detected as accurately as possible.

2.1 Dataset

Only two datasets are used in this project, namely; Dataset-A and Dataset-B. Dataset-A is collected from the general public using an iStethoscope Pro iPhone app and Dataset-B was collected at a hospital using a digital stethoscope [6]. Dataset-A contains 124 recordings, each with a sampling frequency of 44100Hz and grouped into four categories: Normal, Murmur, Extra Heart Sound and Artifact. Dataset-B on the other hand contains 310 recordings, each with a sampling frequency of 4000Hz and grouped into three categories: Normal, Murmur and Extrasystole. Table 1 illustrates the distribution of data amongst the categories mentioned in each dataset.

Table 1 : Dataset Distribution

Dataset	**& Categories**	**Count**
Dataset-A	Normal	31
	Murmur	34
	Extra Hear Sound	19
	Artifact	40
Dataset-B	Normal	200
	Murmur	66
	Extrasystole	44

2.2 Project Specifications and Requirements

A method that can successfully locate and segment S1 and S2 sounds from audio data must be implemented. This must be followed by a method to classify the heart sounds into normal and diseased categories. It is required that the project be carried out with only the audio data from Dataset-A and Dataset-B as stated above.

2.3 Assumptions

The project is executed with the assumption that the length of the audio recordings will be 30 seconds or less. It is also assumed that both Dataset-A and Dataset-B have integrity, in other words the audio data has been correctly placed within corresponding categories.

2.4 Constraints

The following constraints are to be considered when executing the project:

- Segmentation must solely be based on the first and second heart sounds, *S1(lub)* and *S2(dub)*.
- All audio data must be segmented on the basis of Normal heart sounds only.
- Only data from reference [6] can be used to execute the project due to ethics clearance.
- Audio heart sounds may only be in *.wav* or *.aif* format.

2.5 Success Criteria

For the project to be deemed successful, it must fulfill all requirements stipulated in Section 2.2 and conform to all constraints stipulated in section 2.4. A normal classification accuracy of equal to or higher than 77% for Dataset-A and 46% for Dataset-B will be highly desirable considering that existing solutions have an accuracy of up to 77% and 46% for the individual datasets.

2.6 Related Works

As part of prepossessing, Angela *et al.* and Iwata *et al.* both downsample the signals down to 2000Hz to reduce noise [7], [8]. Angela *et al.* further uses wavelet decomposition with a fourth-level order six Daubechies filter to curb the remaining noisy components [8]. The signal is then normalised to enable representation of data within a common scale, allowing effective analysis of feature relations.

Liang *et al.* uses an eighth order Chebyshev Type I lowpass filter with a cutoff frequency of 882Hz to get rid of noise [9]. The segmentation algorithm is based on a second-degree normalised Shannon energy which finds the envelope of the signal [9]. Peaks are identified using a threshold to avoid detecting very-low frequency signals. Incorrectly detected peaks are rejected using intervals between adjacent peaks as well as the energy of the peaks [9]. S1 and S2 sounds are identified by exploiting the fact that the diastolic period is larger than the systolic period. This method presents a segmentation accuracy of 93%.

Majority of recent literature use wavelet transform and spectrogram to segment heart sounds [3], [4],[9], [10]. It is suggested that wavelet analysis, in particular Discrete Wavelet Transform (DWT) yields better accuracy and is efficient in denoising heart sounds [2]. The spectrogram on the other hand is mostly used to extract frequencies below 195Hz. This is a result of heart sounds generally being low frequency signals [10].

As part of classification, Bentley constructs features based on the systolic and diastolic periods of the the heart sounds [10]. Gomes uses similar features to train machine learning models and classifies the heart sounds with J48 (Decision Trees) and MLP (Multi Layer Perceptron) [5]. Strunic *et al.* uses Artificial Neural Networks (ANN) to classify heart sounds which presents an accuracy of $85 \pm 7.4\%$ for simulated heart sounds [2]. The accuracy decreases to $48 \pm 12.7\%$ when tested with recorded heart sounds. The drop in accuracy is caused by inaccurate detection and location of S1 and S2 sounds in recorded heart sounds.

3. SYSTEM OVERVIEW

The project is divided into 3 subsystems: Preprocessing, Segmentation and Classification respectively. Figure 1 below illustrates the flow diagram which highlights the system overview. The input to the system is raw PCG signals from Dataset-A and Dataset-B.

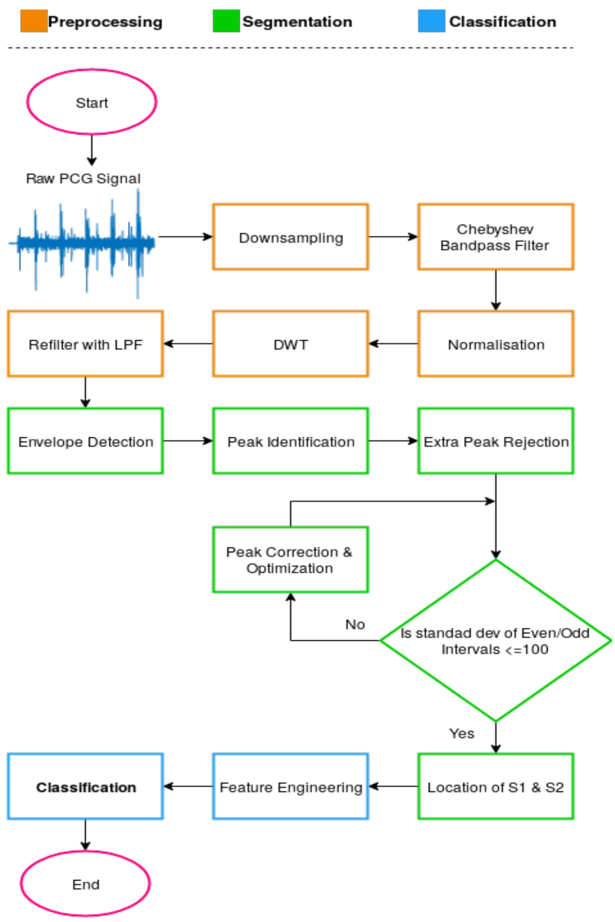

Figure 1 : System Flow Diagram

Preprocessing largely covers removing excessive noise from the PCG signals in order to condition the signals for segmentation. When the denoising process is completed, peaks are detected together with the location of S1 and S2 heart sounds. This is followed by construction of features important for classification, training of machine learning models and lastly classification of heart sounds into normal or diseased categories.

This paper will mainly focus on Preprocessing and Segmentation. Refer to [11] for a detailed explanation on Feature Extraction and Classification.

4. IMPLEMENTATION

4.1 Preprocessing

In Section 2.1 it is mentioned that the PCG signals are recorded in real-world situations, therefore there is a high possibility that the signals will contain artefacts and background noises. Noise can be caused by breathing sounds or fiddling with the stethoscope. Noisy signals make it impossible to analyse PCG signals, therefore, it is necessary to denoise the signals.

The first step to denoising the raw PCG signals is downsampling both datasets to 2000Hz. Downsampling compresses the data whilst retaining all the important information within the signal [12]. It also helps reduce high frequency components in the signal. The choice for 2000Hz sampling frequency abides by Nyquist Criterion and allows aliasing errors to be avoided.

Additionally a low bandpass Chebyshev filter of order 5 with a cut-off frequencies of 30Hz and 195Hz is applied to the downsampled signal. The filter is applied to further eliminate high frequency signals. Multiple researchers have chosen to apply filters with cut-off frequencies up to 600Hz [8], [10], [13]. They choose this band on the basis that murmurs contain frequencies up to 600Hz. The reason for choosing 195Hz as the upper cutoff frequency will be can be seen in Appendx E.

Before wavelet analysis can take place the PCG signal is normalised to obtain amplitudes ranging between -1 and 1 using Equation 1:

$$x_{norm}(i) = \frac{x_{f_{ds}}(i)}{max_j(|x_{f_{ds}}(j)|)} \tag{1}$$

where $x_{f_{ds}}$ is the signal obtained from applying the Chebyshev filter.

4.1.1 Wavelet Analysis

Denoising with only a bandpass filter is considered ineffective since some of the noisy signals overlap with some parts of the PCG signal [14]. This creates a need to decompose the signal for analysis. Decomposition is implemented with a Discrete Wavelet Transform (DWT) which allows the analysis of the PCG signal in multiple frequency bands also known as multiresolution analysis [15]. In this project, a fifth-level DWT with a 7^{th} order Daubechies filter using a soft threshold is adopted. This wavelet is known as the mother wavelet.

The mother wavelet goes through various scaling and translation computations which yields a set of coefficients and functions called wavelets [3], [4]. Equation 2 below shows the the DWT formula:

$$\psi_{(a,b)}(t) = \frac{1}{\sqrt{a}}\psi(\frac{t-b}{a}) \tag{2}$$

where $\psi(t)$ is the mother wavelet and a and b are translation coefficients. After decomposition and wavelet analysis the signals in the different bands are reconstructed using the coefficients. Coefficients found to have a value greater than the soft threshold are removed. Figure 2 illustrates the different levels (d_1-d_5) of the signals at different frequency bands as well as the approximated denoised signal (a_5).

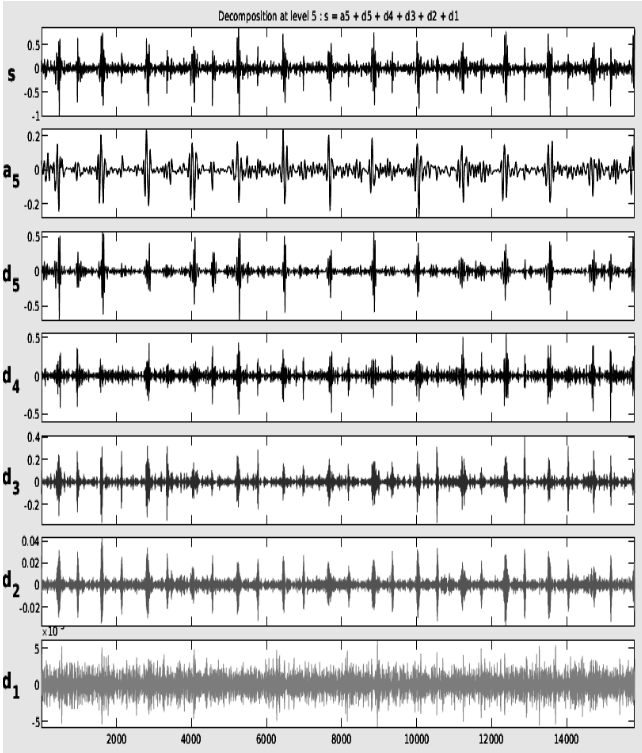

Figure 2 : Level 5 DWT with 7^{th} order Daubechies Filter

The resultant denoised signal (s) is obtained by combining all the levels and approximation in Figure 2. Equation 3 shows how to generate the denoised signal.

$$s = a5 + d5 + d4 + d3 + d2 + d1 \tag{3}$$

To avoid unwanted frequency components after denoising with DWT, a low pass filter with a cutoff frequency of 195Hz is applied for refiltering. Figure 3 and 4 show the raw PCG signal and its FFT before and after preprocessing is applied.

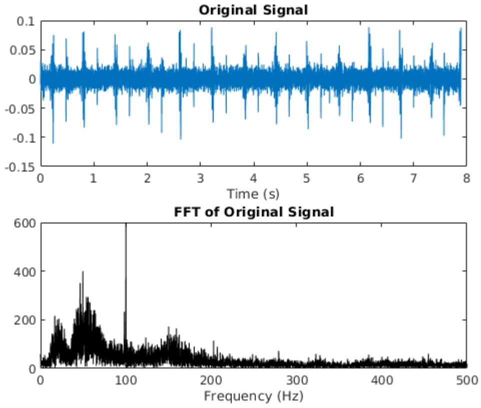

Figure 3 : Raw PCG signal

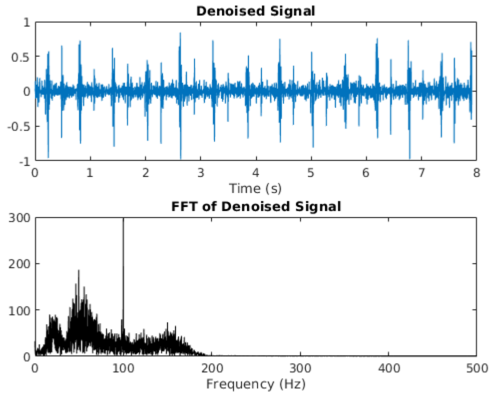

Figure 4 : PCG Signal after Preprocessing

4.2 Segmentation

4.2.1 Envelope

After extensively denoising the PCG signal, a method to outline the envelope of the signal is implemented. Envelopes are smooth, continuous functions that outline the extreme points of a signal [16]. The continuous functions make it relatively easy to identify peaks in a signal. The envelope is found using Shannon energy. Shannon energy is a popular method for threshold-based peak identification methods [17]. It is mostly preferred for heartbeat sounds segmentation over other methods because of its exceptional performance. Shannon energy was adopted it can attenuate low-amplitude noises and makes it easier to identify low-intensity signals [18]. The envelope of the signal was computed with Equation 4 as follows:

$$E = -x^2 log(x^2) \tag{4}$$

4.2.2 Peak Identification

Peaks are detected with a gradient method were derivatives of each point on the smooth signal is calculated. The points with derivatives that change from positive to negative are marked as peaks.

4.2.3 Peak Rejection

Even with a substantial amount of denoising, noise is never removed completely. Therefore, some peaks might be wrongfully identified as heart sounds. It is crucial that all components that are not S1 and S2 sounds are removed, failure to do so will compromise the classification results.

To eliminate the wrongfully marked peaks, a threshold based on the third maximum peak is set. The threshold is set to 20% of the third maximum peak. All peaks that are below this threshold are excluded.

4.2.4 Peak Correction and Optimization

To verify if the peaks have been correctly detected, intervals between adjacent peaks are computed. The mean and standard deviation of odd and even intervals are calculated. If the standard deviation for either intervals is above 100 it means that there was an error in peak rejection. Two new thresholds are computed to correct this error, the upper and the lower threshold as seen in equation 1:

$$t_{u,l} = |\mu \pm \sigma| \tag{5}$$

where μ is mean of the even or or odd intervals and σ is the standard deviation of the even or odd intervals.

An interval with a value higher than the upper-threshold suggests that a peak was missed and an interval with a value lower than the lower-threshold suggests that double peaks were detected. A missed peak is found by flagging the peaks between the corrupt interval. The two flagged peaks are used to map to the original signal before peak rejection. The peak with the largest amplitude between the two flagged peaks in the old signal will be now be marked as valid.

As for the double detected peaks, the two peaks before the corrupt interval and the one after are flagged. The distance between the left most flagged peak and the two right most flagged peaks are calculated individually. The peak with a distance closest to the mean is taken and the other is dropped.

When peak correction is completed, the intervals are recalculated and the cycle continues until the condition is met, see Figure 1. Provided that the algorithm does not find any changes in consecutive iterations, it will exit the loop.

4.2.5 Location of S1 and S2 Sounds

Location of S1 and S2 heart sounds is purely based on the fact that the diastolic period is larger than the systolic period. The largest interval is found and if it lies within the even intervals then all even peaks are marked as S1's, odd peaks as S2's and vice versa. The end result of preprocessing stages and segmentation can be seen in Appendix E.

4.3 Feature Engineering and Classification

After preprocessing and segmentation a total of 24 features are extracted. Only 21 features are extracted from Dataset-A and 24 features from Dataset-B. From the located heart sounds, 10 features are extracted. The remaining features are from the frequency, cepstrum and wavelet domains [11]. The features are used to train and classify the heart sounds with the ANN, SVM and XGBoost machine learning models.

4.4 System GUI

The user interface is implemnted in Python with PYQT5 application. It allows the user to see the end results of preprocessing, segmentation and classification results. The user has an option of choosing their desired model, see Appendix G, Figure 12

5. RESULTS

Figure 5 depicts the segmentation accuracy of S1 and S2 heart sounds in the normal category for both Dataset-A and Dataset-B. Segmentation accuracy was calculated by counting the number of PCG signals which have a standard deviation smaller than 100 for both systolic and diastolic periods.

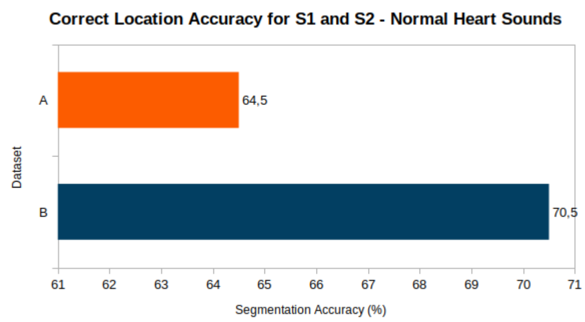

Figure 5 : Segmentation Accuracy of Normal Heart Sounds in Dataset-A and Dataset-B

Table 2 and Table 3 show the performances for each dataset with the respective models as shown:

Table 2 : Classification Performance Dataset-A

Class (A)	**ANN (%)**	**SVM (%)**	**XGB (%)**	**Literature(%)**
Normal	27	80	71	45
Murmur	88	78	86	31
ExtraHS	67	25	57	11
Artifact	100	57	50	58
Overall Accuracy	**81**	**64**	**68**	**46**

Results for feature importance can be seen in figure 11, Appendix F.

Table 3 : Classification Performance Dataset-B

Class (B)	**ANN (%)**	**SVM (%)**	**XGB (%)**	**Literature(%)**
Normal	80	77	89	78
Murmur	90	87	75	37
Extrasys	15	0	17	17
Overall Accuracy	**80**	**78**	**79**	**77**

6. CRITICAL ANALYSIS OF RESULTS

From observation of results, it can be seen that S1 and S2 heart sounds were mostly incorrectly identified in Dataset-A. One of the major reasons for this is the high inclusion of a wide variety of background noises since it was recorded by the general public. This makes it difficult to segment the heart sounds since most noisy components overlap with the heart sounds. Another reason to explain why the segmentation accuracy of both datasets is not high is the high intensity of murmurs which also overlaps with the heart sounds, making it impossible to differentiate between S1 and S2 sounds and murmurs.

The sudden release of the stethoscope from the patient while recording greatly affects the segmentation results since the first and last peaks have to be excluded from analysis. This means that valuable information is lost.

As seen in figure 11, Appendix F, it is shown that out of the top 6 most important features, 4 are computed from segmentation results. This implies that segmentation greatly affects classification, therefore: accurate segmentation results in a high classification accuracy.

The best performing machine learning models for classifying normal heart sounds in Dataset-A and Dataset-B according to Table 2 and 3 is SVM and XGBoost with an accuracy of 89% and 80% respectively. For murmurs, ANN performed best in both datasets with an accuracy of 88% for Dataset-A and 90% for dataset B. One major flaw identified in this project is the inability of all models to classify extrasystole heart sounds in Dataset-B. The reason for obtaining these results is the unequal distribution of data amongst the categories. This means that the models are mostly acquainted with normal heart sounds and murmurs rather than extrasystoles. After careful study of the heart sounds, it was observed that the extrasystole class has similar characteristics to normal heart sounds, making it difficult to distinguish between the two [6].

With the above mentioned, it can be concluded that the system met the success criteria stipulated in Section 2.5.

7. RECOMMENDATIONS FOR FUTURE WORK

To achieve better segmentation results, recording techniques can be improved as well as better segmentation techniques. Classification can also be improved by training models with an equally distributed dataset to avoid having biased models. Better ways of distinguishing extrasystoles and extra heart sounds need to be developed.

8. CONCLUSION

A method to segment and classify heart sounds into normal and diseased categories has been successfully developed and implemented. Wavelet analysis and Shannon energy are used to denoise the PCG signal and generate the envelope respectively. Methods to improve location of S1 and S2 have been proposed. The system presented an segmentation accuracy of 64.5% and 70.5% for Dataset A and B respectively. Machine learning models used for classification include ANN, SVM and XGBoost. SVM and XGBoost presented a classification accuracy of 80% and 89% for normal heart sounds for Dataset A and B respectively.

ACKNOWLEDGEMENTS

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Appendices

A Reflection on Group Work

A1 Introduction

In this document, the work division amongst the members of the group, challenges encountered as well as the author's personal reflection of working in a group is presented.

A2 Work Division

Initially me and my partner, Elias Sepuru preferred to work together to ensure that both team members have a common and solid understanding of the project requirements, specifications and dataset. The initial plan was that both members will try different approaches for the same section and the technique that yields the best results will be chosen. However, due to limited time and complexity of some methods, it was decided that working in parallel will not be feasible. This required us to go back to the drawing board to restructure the work division. The division of tasks can be seen in Table 1 below. This does not strictly suggest that the members mentioned in the respective tasks did all the work alone. The members fairly distributed work amongst themselves and if anyone needed help the other member was always ready to help.

Table 4 : Work Division

Task	**Team Member**
Preprocessing	Boikanyo
Segmentation	Boikanyo
Feature Extraction	Elias
Classification	Elias
GUI Front-end	Boikanyo
GUI Back-end	Elias
GUI Integration	Boikanyo and Elias
Project Poster	Boikanyo and Elias

A3 Challenges Encountered

The only challenges we encounted in the first few weeks was to accurately locate S1 and S2 sounds and machine learning optimization. We realised that if these tasks are not executed well the success of the project will be compromised. We were forced to invest most of our time in perfecting these sections which turned out well in the end.

A4 Personal Reflection on Group Work

Elias Sepuru and I have previously worked together on school projects and labs. We are well aware of each others work ethic, strengths and weaknesses. We worked well together throughout the project because we share a similar work ethic, interests and goals when it comes to academic work. One of the most valuable skills I have learned while working with Elias is to effectively communicate my ideas and thoughts. This enabled both of us to look at things from a different perspective and to also foresee challenges that we might encounter. We are always ready to tackle any work assigned to us which helped with the progress of the project. One strength but mostly a weakness that we both have is that we are perfectionists. We always take more time to complete tasks than anticipated which results in us working close to the deadline. In future this is one of the things I would like to improve about myself. One of the things I enjoyed about working in a group is that I did not have to do all the work alone. Elias's positive attitude always motivated me to work hard despite the challenges we encountered. All in all I am proud of the work we put in this project as well as the quality of work we both produced.

A5 Conclusion

The work was equally divided amongst team members and the project was successfully completed. Communication and being aware of team players work ethic greatly affects the success of the project.

B Project Specification

School of Electrical and Information Engineering
University of the Witwatersrand, Johannesburg
ELEN4002/4012: Project Specification Outline

To be completed by supervisor
Assessment:
☐ Deficient ☐ Acceptable
☐ Good ☐ Excellent

Project Title: Heartbeat Sound Segmentation and Classification

Group Number:	19G11	Supervisor Name:	Ellen De Mello Koch
Student Name A:	Elias Sepuru	Student Name B:	Boikanyo Radiokana
Student Number A:	1427726	Student number B:	1386807

Ethics:

☐ Request for waiver (does not involve human participants or sensitive data)
☐ Copy of ethics application attached (Non-medical) – School Committee
☒ Copy of ethics application attached (Medical) – University Committee

Supervisor Signature

Project Outline: *(give a brief outline such that ethics reviewers understand what will be done, 100 words maximum)*

This project aims to create the first level screening of detecting signs of heart diseases in patients. This will aid medical practitioners in their field and possibly home use by patients. A method to locate lub (S1) and dub (S2) sounds in audio data of patients' heartbeats will be implemented. After location the heartbeat audio data will be segmented based on S1 and S2. Followed by segmentation, a method to classify a heartbeat into normal and diseased categories will be implemented.

Project Specification:

1. Project Objectives:

1.1 Primary Objectives:

- To successfully locate S1 and S2 and segment the audio heartbeat data into the categories S1 and S2.
- To train a machine learning model that is going to classify a heartbeat sound into either diseased or normal

Success criteria: Current existing solutions have an accuracy of less than or equal to 79%, this project aims to obtain an accuracy of 79% or higher.

1.2 Secondary Objectives:

- If time allows, the project aims to create a user-interface, for home use or use by medical practitioners.

2. Project Work Breakdown Structure:

2.1 Heartbeat Segmentation

For location and segmentation of the heartbeat sounds into S1 and S2, the following high-level methodology represented by illustration 1 will be used.

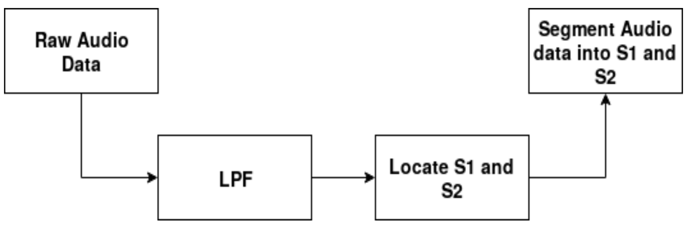

Figure 1: High level methodology to be followed for heartbeat audio segmentation

- The audio data is first filtered using a Low Pass Filter (LPF) to remove high frequency noise components. The prospective filters that might be used are the Discrete Waveform Transform Filter (DWT), Daubechies filter or any other wavelet filter.

- To locate and segment the heartbeat audio data into S1 and S2, the fact that the time from S1 -S2 is shorter than the time from S2-S1 will be exploited.

2.2 Heartbeat Classification

- For heartbeat classification, methods for finding feature importance of the segmented heartbeat audio signal are going to be used.
- After finding the feature importance, numerous machine learning models are going to be trained and tested on the features. The model with the highest accuracy is to be selected.

Milestones:

1. Literature review [0.5 Weeks]
2. Data Cleansing [2.5 weeks]
3. Model Training & Testing [2 weeks]
4. Documentation [1 week]

   (If time permits the user interface will be built on the last week of Model Training and Testing)

Preliminary Budget & Resources:

- MATLAB and Jupyter Notebook for signal processing and building models.
- KNIME and Anaconda building models.
- Two compatible computers for data cleansing, training and testing of the models.
- Internet for research.
- Digital Stethoscope.
- Funds for printing of technical report and the poster for open day.

Risks / Mitigation:

- The two laptops that will be used for testing and training the data might not be able to process the big data which can result in the two machines crashing. This risk will be mitigated by using the machines provided by Professor Otto for running big data simulations.
- Failure to remove all the noise present in the data might compromise the success of the project and reduce the desired accuracy. This will be mitigated by using alternative secondary open source data from MIT. The data from MIT has consistent length and reduced/no noise.
- Mislocation of S1 and S2 sounds in the audio data will lead to misinterpretation, incorrect analysis and unacceptable prediction results. This will be mitigated by using multiple methods of locating S1 and S2 to check for any errors and correspondence of the results.

Project Plan for the Design and Implementation of a Heartbeat Segmentation and Classification Model

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Abstract: This paper presents a plan to design and implement a Heartbeat Segmentation and Classification Model. The model is divided into 3 main sections namely: Preprocessing, Segmentation and Classification. The preprocessing stage involves reducing noise from the hearbeat signals and conditioning it for segmentation. The signal will be downsampled with a factor ranging from 10 - 20. Segmentation will be performed by computing the signals average Shannon energy. Classification is to be be implemented with machine learning methods such as ANN and RNN. Project management concepts such as work-division and risk management are also taken into consideration.

Key words: PCG, Heartbeat-Segmentation, Heartbeat-Classification, ANN, RNN

1. INTRODUCTION

Cardiovascular diseases (CVDs) continue to be one of the leading causes of deaths around the world. More people die annually from CVDs than any other cause. In 2016 alone an estimated 31% of the deaths were due to CVDs [1]. Methods to detect early signs of heart diseases could prove to be very helpful in preventing deaths due to CVDs.

This paper presents the plan of Heartbeat Segmentation and Classification project. The project aims to create a first level screening for individuals in the detection of heart diseases. This will aid medical practitioners in their field and possibly home use by individuals.

In the upcoming sections, the background, system overview, design methodology and project management are discussed.

2. BACKGROUND

2.1 Project Specifications and Requirements

The aim of this project is to create a first level screening to detect signs of heart diseases in individuals. This will be carried out by using audio data sets from two sources, the iStethoscope Pro iPhone app labelled Dataset A and a digital stethoscope labelled Dataset B. The audio data was recorded by the general public and clinical healthcare practitioners respectively [2]. Both data sets A and B each have different categories which all contain various background noises. The audio files vary in length from 1 to 30 seconds as a means of reducing excessive noise [2]. Dataset A is said to consist of the the following categories, namely; Normal, Murmur, Extra Heart Sound and Artifact whilst Dataset B has Normal, Murmur and Extrasystole categories. The above mentioned categories will be used as classifiers at a later stage.

With the excessive noise present in the audio data, it is required that preprocessing methods, capable of removing noise from the data be implemented before execution of further detection methods. Following the denoising process, a method to locate S1 (lub) and S2 (dub) heart sounds as well as segmentation of Normal audio files from the two data sets is required. A machine learning method to classify heartbeat sounds into normal and diseased categories as mentioned above must be implemented.

2.2 Assumptions

The project is to be conducted with the following assumptions:

- The audio data range will be 30 seconds and less.
- Dataset A has only four categories (Normal, Murmur, Extra heart sound and Artifacts) and Dataset B has only three categories (Normal, Murmur and Extrasystole)

2.3 Constrains

The following are the project constraints:

- Constrained to only locating S1 (lub) and S2 (dub) heart sounds
- Only the Normal audio data is to be used for the location of S1 and S2.
- Only the data from here `https://www.kaggle.com/kinguistics/heartbeat-sounds/kernels` can

be used, due to ethics clearance

- Heart sounds are only in `.wav` and `.aif` format

2.4 Success Criteria

For the project to be deemed successful it has to meet all the requirements specified in section 2.1. Since existing solution only have an accuracy of up to 77%, an accuracy of 77% or higher is highly desirable.

2.5 Literature Review

Cardiovascular diseases continue to be one of the leading cause of deaths around the world [1]. With the above mentioned there have been various attempts to accurately distinguish between normal and diseased heartbeat sounds using ECG and PCG. Groch uses a microprocessor controlled Heart-Sound Gate (HSG), which automatically identifies heart sounds from PCG alone, using timing relationships [3]. He amplifies the heart sound and passes it through two bandpass filters, folds the negative portions of the waveform into the positive and the envelopes the whole signal. To locate the peaks he uses a Schmitt trigger which then generates a square wave corresponding to the peaks. To identify S1 and S2, he exploits the fact that the diastolic period is longer than the systolic period.

Karraz *et al.* makes use of data from MIT-BIH Arrhythmia database, to classify the heartbeats into five categories. They use an FIR filter set at (0.05 - 40 Hz) cut-off and a notch filter for denoising the signals, for peak location and S1 and S2 identification they use a QRS detection algorithm. To classify the heartbeat sounds into the different categories they picked, they use the Bayesian Artificial Neural Network (BANN) with the following features: i) P-amplitude, ii) P-wide, iii)R-amplitude, iv) Q-amplitude, v) S-amplitude, vi) QRS-wide, vii)T-amplitude, viii) T-wide, ix) PR-period, and x) RR-period [4]. Kampouri also uses the QRS complex for feature extraction but instead of Neural Networks, he uses Support Vector Machine (SVM) [5].

Stunic *et al.* detects and classifies heart murmurs using segmentation techniques and ANN. This study is conducted using simulated and recorded patient heart sounds. The segmentation algorithm identifies individual heart cycles and an average of all cycles is computed to extract components within 195Hz since this band has the most valuable information [6]. The basis of the segmentation algorithm is the fact that the diastolic period is longer than the systolic period. They used an alignment algorithm to ensure that data is always fed in the same order to the ANN input neurons. The ANN algorithm consists of 3 hidden layers with 25 input neurons each and 1 output neuron. The diagnostic system presented an accuracy of 48,7±12,7% for real life recorded patient records and an accuracy of 85±7,4% for simulated data [6].

To combat the issues of noise in real life recordings of heartbeat sounds Liang *et al.* uses a Chebyshev type I lowpass filter and an algorithm based on the normalised average Shannon energy of a PCG signal. The algorithm is used to find the peak locations and to pick up the locations of S1 and S2. It achieves 93% correct ratio [7]. Debbal *et al.* uses Discrete Wavelet Transform (DWT) to decompose and reconstruct a PCG signal with insignificant loss of information. The error found in reconstructing the signal is considered as an important feature in the classification of diseased categories. It was found that the reconstruction error increases with an increase in murmur intensity [8].

3. SYSTEM OVERVIEW

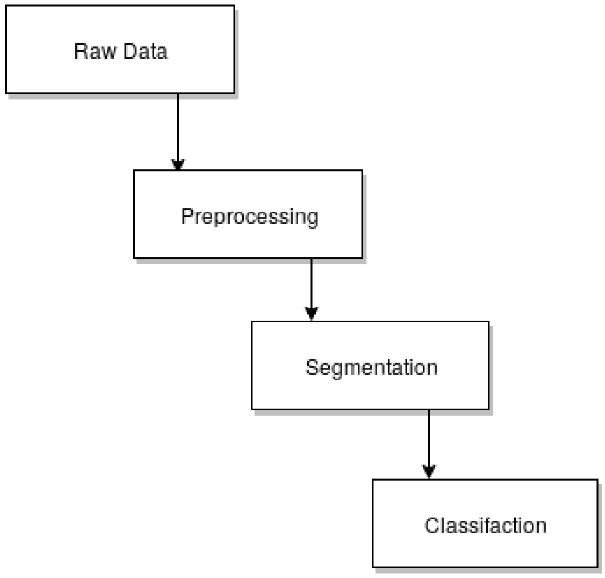

Figure 1 : System Overview

Figure 1 above illustrates an overview of the proposed system. The raw data is read from the two datasets, Dataset A and Dataset B as mentioned in the section 2.1. The audio data can either be in `.wav` or `.aif` format. As mentioned previously, the audio data sets contain excessive noise which requires denoising before segmentation can take place. This denoisong process is performed in the preprocessing phase to ensure that the data is conditioned for segmentation. Once the data is conditioned, it goes through the segmentation phase where S1 and S2 are located. This is done in order to extract important features useful for classification. The features will be fed into a machine learning algorithm in order to classify the heart sounds into normal or diseased categories.

4. DESIGN METHODOLOGY

The project in its entirety mainly consists of two main sections, heartbeat segmentation and heartbeat classification. However, due to the fact that data cleansing forms the bulk of the project, it was decided that it will be suitable to make preprocessing a standalone section as seen in figure 1. This will also help break down the project into manageable tasks.

4.1 Preprocessing

As mentioned earlier the audio data is from real world situations and contains a lot of background noise, in the processing phase, techniques to remove the background noise are applied to the audio data.

The audio data has a sampling frequency of 44.1 kHz. The first stage of denoising the signal involves downsampling the signal with a factor between 10 - 20. Since it is known that the highest desired frequency is that of the murmur which is 600 Hz [9], downsampling by the highest factor, which is 20, will still give a sampling frequency higher than twice that of a murmur. Downsampling helps with cutting high frequency components, exploiting the Nyquist Theorem. The high frequency components are aliased whilst preserving the desired low frequency components. Downsampling also compresses the size of the audio data, allowing for faster processing time [10].

Most of the information of a PCG signal is contained in the lower frequency components of the signal as mentioned in the above paragraph. With that mentioned a low pass filter of 195 Hz will be applied after downsampling to further curb the noise [2].

The final stage of preprocessing involves normalising the signal to the absolute maximum of the signal using equation 1 [7].

$$x_{norm}(i) = \frac{x_{f_{ds}}(i)}{max_j(|x_{f_{ds}}(j)|)} \tag{1}$$

where $x_{f_{ds}}$ is the downsampled signal. Figure 2 summarises the preprocessing phase.

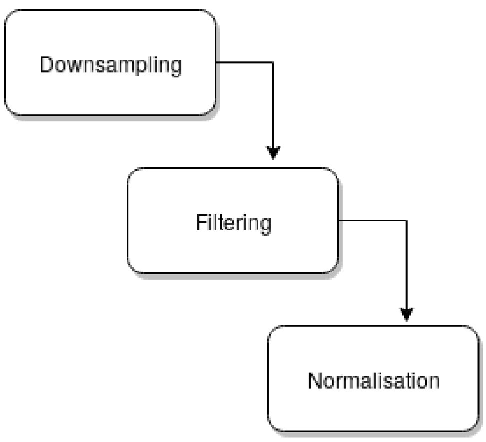

Figure 2 : Flow diagram of the preprocessing phase

4.2 Heartbeat Segmentation

The segmentation phase involves locating S1 and S2 heart sounds, thus determining the diastolic and systolic periods. To segment these heart sounds, the envelope of the normalized signal obtained in the preprocessing phase is computed. The Shannon energy will be used to compute the envelope of the signal with equation [7]:

$$E = -x^2 log(x^2) \tag{2}$$

The reason for choosing this method is the fact that Shannon energy attenuates small spikes in signals much more than large spikes [7]. Furthermore, a triangular smooth function will be applied to smoothen out the signal since the signal will still contain small spikes. Equation 3 below will then be used to determine the average Shannon energy of the entire signal [7]:

$$E_s = -\frac{1}{N}\sum_{i=1}^{N} x_{norm}^2(i) log x_{norm}^2(i) \tag{3}$$

where x_{norm} is the value of the normalized sample signal and N is the signal length. This is followed by the computation of the normalized average Shannon energy using equation 4 below [7]:

$$P_a(t) = \frac{E_s(t) - M(E_s(t))}{S(E_s(t))} \tag{4}$$

where $M(E_s(t))$ is the mean of $E_s(t)$ and $S(E_s(t))$ is the standard deviation of $E_s(t)$.

4.2.1 Peak Identification

The peaks representing the heart sounds S1 and S2 will be identified with a function in Matlab called peakdet [11]. One advantage of using this function is that it is an open source function and therefore allows one to condition it to best suite their needs. S1 and S2 will be located by exploiting the fact that diastolic period is greater than systolic period.

4.3 Heartbeat Classification

The classification phase involves coming up with a model, given a specific audio file, will successfully identify it as either one of the categories in Dataset A or one of the categories in Dataset B. Before training the model, feature construction and selection has to occur first. The features are to be constructed from the locations of S1 and S2.

Table 1 presents the possible features that could be used to train the machine learning models [11].

Table 1 : Potential feature selection

Feature	Description
N	Number of heartbeats per minute
M_1	Mean of diastole period
M_2	Mean of systole period
R_{s1}	Standard deviation of S1 over the standard deviation of the whole signal
R_{s2}	Standard deviation of S2 over the standard deviation of the whole signal
R_{m1}	Mean of S1 over the total mean of the entire signal
R_{m2}	Mean of S2 over the total mean of the entire signal
R_{med}	Ratio of the median of the three largest segments in the sample over the total mean
R_{sq}	Square of the array of the sorted segments of the sample

The features shown in table 1 are to be carefully selected in order to cater and distinguish for the different categories in Dataset A and Dataset B.

For training, two models, ANN and RNN are chosen. ANN is chosen due to its good ability to recognise patterns [12]. The RNN is also chosen for its great pattern recognition and its ability to handle many-to-many predictions problems [13].

5. TESTING

In order to allow for testing the machine learning algorithms will be trained according to 7:3 ratio. This means that 70% of the audio data will be used for training whilst the other 30% will be for testing to generate the F-score, Youdens Index and the Discriminant Power.

6. PROJECT MANAGEMENT

6.1 Work Division

The project will be conducted by a team of two people. Each section in the project as illustrated in figure 1 will be allocated two different techniques. Each team member will then be assigned a technique to follow to solve a particular section. The technique that yields the best accuracy will be the approach chosen for the project. Table 2 below shows a detailed work division amongst the members of the team.

6.2 Project Time-line

The project will officially be started on the 15^{th} July 2019 following extensive research by both team members. The project deadline is on the 6^{th} September 2019. All in all the project is said to run for six weeks. Table 3 shows all the project milestones and completion dates.

Table 2 : Work Division

Task	Technique	Team Member
Environment Setup	-	Both
Preprocessing	1	Elias
	2	Boikanyo
Segmentation	1	Elias
	2	Boikanyo
Classification, Training and Testing	1	Elias
	2	Boikanyo
Documetation	-	Both

Table 3 : Project Milestone Completion

Completion Date	Milestone
15 July 2019	Project Planning
16 July 2019	Environment Setup
31 July 2019	Data Cleansing
09 Aug 2019	Segmentation
30 Aug 2019	Classification(Model Training and Testing)
06 Sep 2019	Documentation (Final Project Report)

6.3 Resource Management

The following resources (hardware and software) will be necessary to successfully carry out the project:

- Two compatible computers for data cleansing, training and testing of the models
- Clusters for processing big data
- MATLAB and Jupyter Notebook for signal processing and building models
- KNIME and Anaconda building models
- Internet for research
- Digital Stethoscope.
- Funds for printing of technical report and the poster for open day.

6.4 Risk Management

Potential risks that can possibly jeopardise the success of the project have been identified. The risk register in table 4 shows the cause of each risk that is identified, its rating, degree of impact as well as the action that should be taken to mitigate the risk.

Table 4 : Project Risk Register

Risk	**Cause**	**Risk Rating**	**Impact**	**Actions**	**Person Responsible**
Machines crashing	Software installation and Processing Big data	H	H	Use clusters provided by Professor Otto for running big data simulations and proper software installations	Both members
Failure to remove noise	Application of incorrect techniques	H	H	Use of alternative secondary open-source data from MIT. Use of predefined methods	Both members
Mislocation of S1 and S2	Using incorrect techniques	M	M	Use of multiple methods of locating S1 and S2 to check for any errors and correspondence of the results.	Both members
Loss of work	Not saving copies of completed work	H	H	Use Github for version control	Both members
Poor milestone estimation and project running behind schedule	Underestimating the complexities of each section	M	M	Work on the project as soon as possible,	Both members

7. CONCLUSION

A plan to design and implement a Heartbeat Segmentation and Classification Model is presented. The model is divided into 3 main sections namely; Preprocessing, Segmentation and Classification. The preprocessing stage involves reducing noise from the hearbeat signals and conditioning it for segmentation. The signal will be downsampled with a factor ranging from 10 - 20. Segmentation will be performed by computing the signals average Shannon energy. Lastly, classification will be implemented with machine learning methods such as ANN and RNN.

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D ETHICS CLEARANCE CERTIFICATE

UNIVERSITY OF THE
WITWATERSRAND
JOHANNESBURG

R14/49 Mr E Sepuru

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)
CLEARANCE CERTIFICATE NO. M190470

NAME: **(Principal Investigator)**	Mr E Sepuru
DEPARTMENT:	School of Electrical and Information Engineering University
PROJECT TITLE:	Heartbeat segmentation and classification
DATE CONSIDERED:	2019/04/26
DECISION:	Approved unconditionally
CONDITIONS:	
SUPERVISOR:	Ms E de Mello Koch
APPROVED BY:	CB Penny Dr CB Penny, Chairperson, HREC (Medical)
DATE OF APPROVAL:	2019/07/10

This clearance certificate is valid for 5 years from date of approval. Extension may be applied for.

DECLARATION OF INVESTIGATORS

To be completed in duplicate and **ONE COPY** returned to the Research Office Secretary on the 3rd Floor, Phillip Tobias Building, Parktown, University of the Witwatersrand, Johannesburg.
I/we fully understand the conditions under which I am/we are authorized to carry out the above-mentioned research and I/we undertake to ensure compliance with these conditions. Should any departure be contemplated, from the research protocol as approved, I/we undertake to submit details to the Committee. **I agree to submit a yearly progress report**. When a funder requires annual re-certification, the application date will be one year after the date when the study was initially reviewed. In this case, the study was initially reviewed in **April** and will therefore reports and re-certification will be due early in the month of **April** each year. Unreported changes to the application may invalidate the clearance given by the HREC (Medical).

Principal Investigator Signature

16/07/2019
Date

PLEASE QUOTE THE CLEARANCE CERTIFICATE NUMBER IN ALL ENQUIRIES

E Preprocessing and segmentation

The following figures show the end result of each an every process in the system, from preprocessing all the way to segmentation.

Figure 6 shows the raw PCG signal before preprocessing. It is evident that most energy is concentrated below 200Hz. No valuable features can be extracted above 200Hz. Therefore filters with cutoff frequencies equal to 195Hz will work.

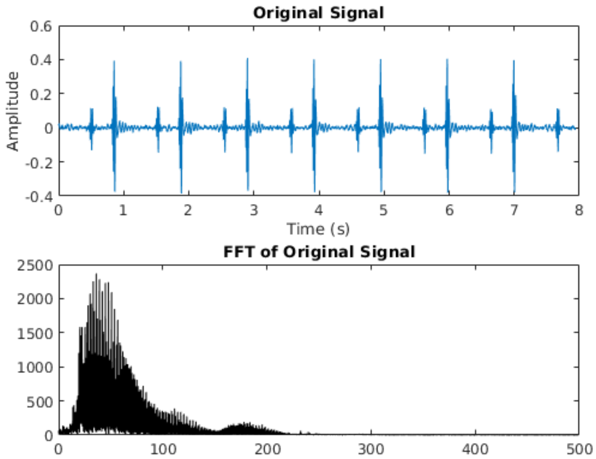

Figure 6 : Raw audio PCG Signal

Figure 7 shows the PCG signal after preprocessing.

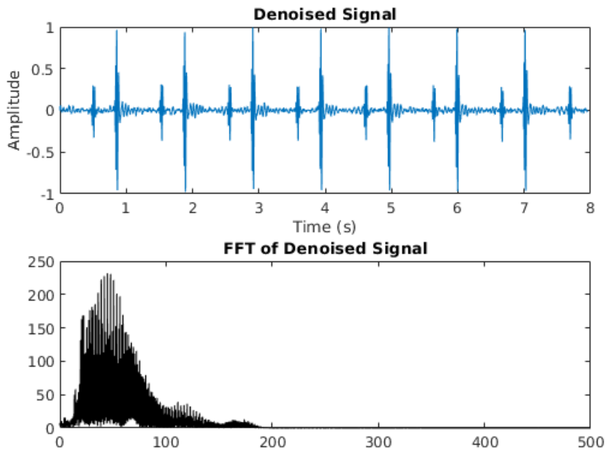

Figure 7 : Denosed Signal

Figure 8 shows the envelope of the signal using Shannon energy.

Figure 9 shows the peaks detected using gradient method. Some of the peaks detected are noisy components.

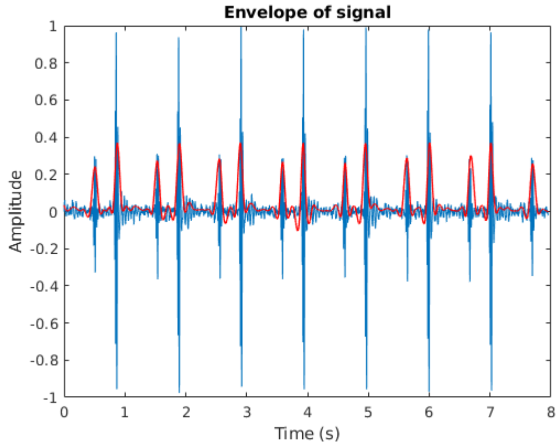

Figure 8 : Envelope of Signal

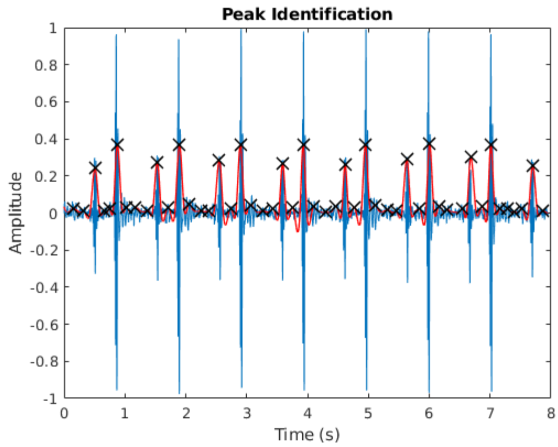

Figure 9 : Peak Identification

Figure 10 shows the PCG signal after peak rejection, correction and optimization.

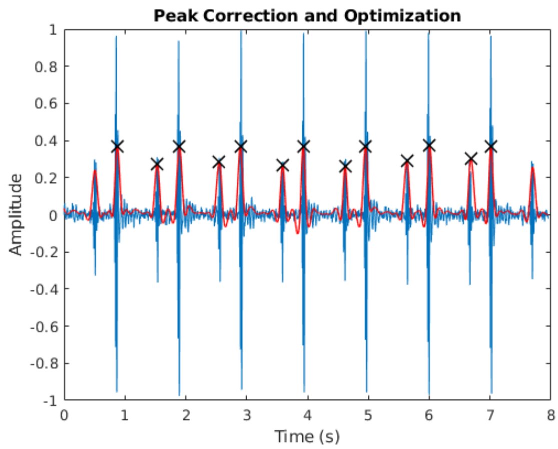

Figure 10 : Peak Correction and Optimization

F Extracted Features

Table 5, 6, 7 and 8 shows all features extracted from the time ,frequency domain, wavelet analysis and cepstrum domain.

Table 5 : Features from the time-domain

Feature	Description
stdS1	Standard deviation of systolic period.
stdS2	Standard deviation of diastolic period.
meanS1	Mean of systolic period.
meanS2	Mean of diastolic period.
maxstdS1	Standard deviation of systolic period after dropping the largest interval.
maxstdS2	Standard deviation of diastolic period after dropping the largest interval.
mmstdS1	Standard deviation of systolic period after dropping the largest and smallest intervals.
mmstdS2	Standard deviation of diastolic period after dropping the largest and smallest intervals.
prRatio	Ratio of the total number of peaks left after Peak Rejection over the length of the audio file
pcRatio	Ratio of the total number of peaks left after Peak Correction over peaks from Peak Rejection.

Table 6 : Features extracted from DWT

Feature	Description
rebuildError	Average difference between the PCG signal before denoising and the PCG signal after denoising.
stdWavelet	Standard deviation of the approximation of a 6^{th} level db6 DWT of the preprocessed PCG signals.
meanWavelet	Mean of the approximation of a 6^{th} level db6 DWT of the preprocessed PCG signals.

Table 7 : Features extracted from the frequency-domain

Feature	Description
stdFFTSHA	Standard deviation of the identified peaks in the [180 190] Hz band.
lenFFTSHA	Count of qualifying peaks identified in the [180 190] Hz band.
stdlen FFTSHA	Ratio of stdFFTSHA over lenFFTSHA.
lenstdFFTSHA	Ratio of lenFFTSHA over stdFFTSHA.
posFFT	Count of peaks from Shannon Energy of FFT.

Table 8 : Features extracted from Cepstrum

Feature	Description
stdPCA1	Standard deviation of the first PCA vector.
meanPCA1	Mean of the first PCA vector.
stdPCA2	Standard deviation of the second PCA vector.
meanPCA2	Mean of the second PCA vector.
stdPCA3	Standard deviation of the third PCA vector.
meanPCA3	Mean of the third PCA vector.

Figure 11 shows the features in all the tables presented above in the order of the most important to the least important. From the top 6, 4 of the features are from the results obtained from segmentation.

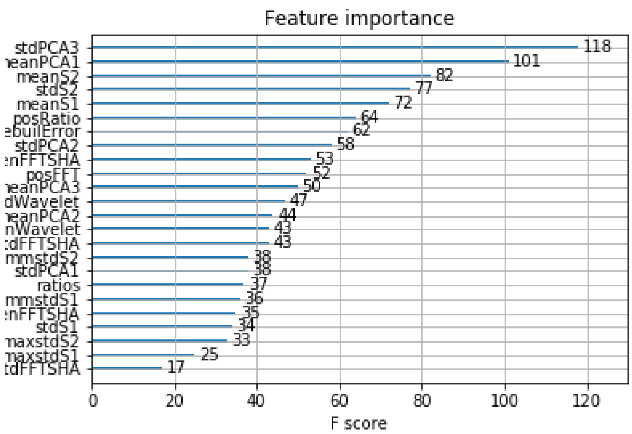

Figure 11 : Feature Importance

G System GUI

The following figure shows the implemented user interface. The user interface is implemented in python using PYQT5. It allows the user to choose their desired model from ANN, SVM or XGBoost. The pictures shown in the interface are raw audio data before preprocessing, after and the end result of segmentation. When a model is evaluated, the classification results are presented together with the confidence of the model.

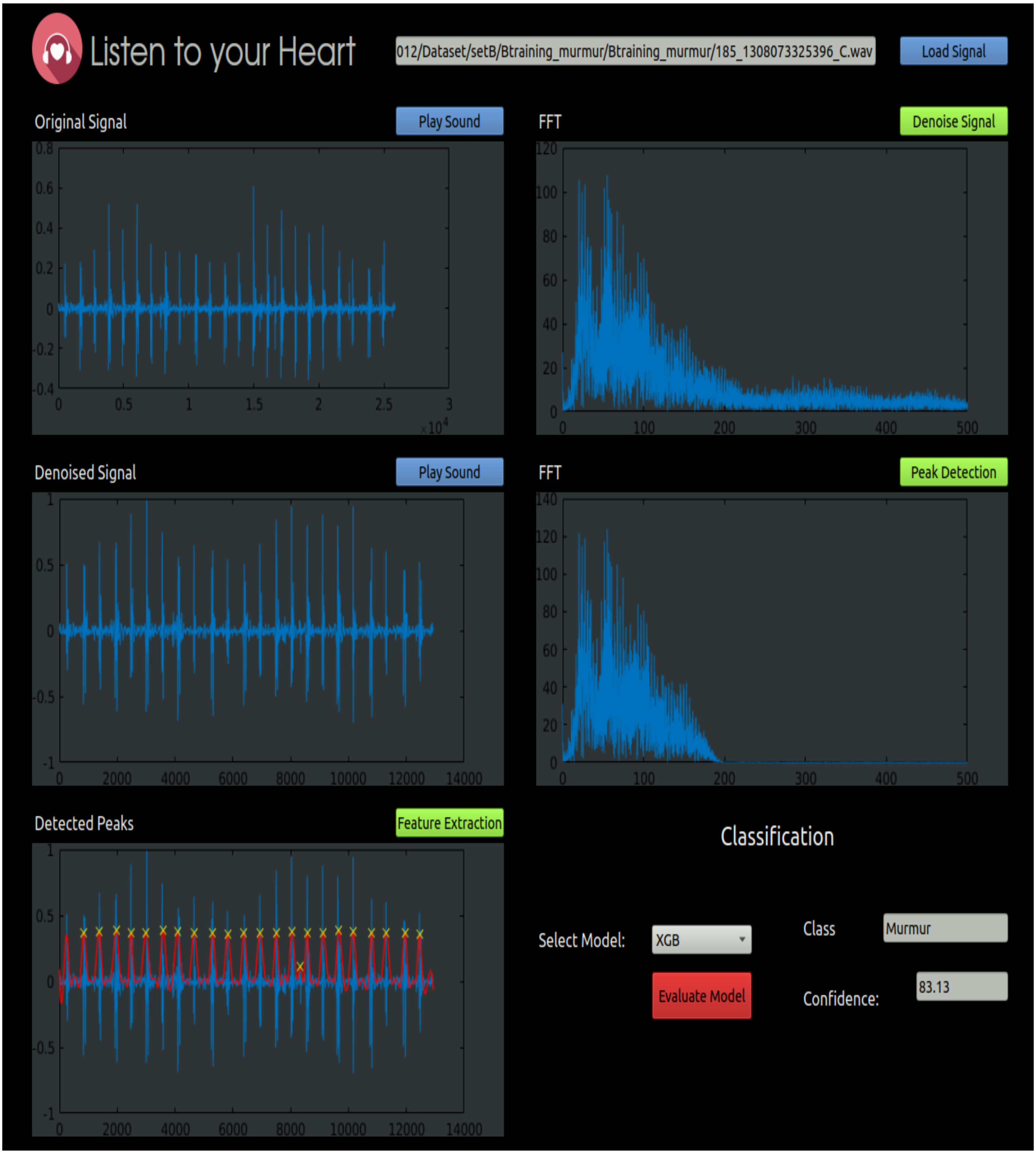

Figure 12 : System User-interface

H MEETINGS MINUTES

RESEARCH GROUP MEETING FOR BIOMEDICAL ENGINEERING TOPICS (WEEK 1)

Date | *time* 15/07/2019|10:30 *Meeting called to order by* Graig Carlson

Current meeting

Chair: Graig Carlson

Minutes taken by: Jesal Chana

In Attendance

*Student Attendees can be found within the attached attendance register.

Supervisors: Mr Graig Carlson

Ms Ellen De Mello Koch

Mr Adam Pantanowitz

Prof. David Rubin

Dr Xriz Richards

Approval of Minutes

Thapelo Chabangu

Key Notes

1. Greeting and Introduction of groups and members and which project each group is undertaking
2. Control lab access would be granted to the relevant groups after the conclusion of this meeting. Forms for access to the Control laboratory handed out by Mr Graig Carlson.
3. Minutes and Chairing of the weekly meetings will alternate each week through the various student groups
4. Google drive folder will be set up by J.Chana, so that the weekly minutes can be shared with all the relevant groups.
5. Budget is allocated by the school and for further information each group is to consult with their supervisors separately.
6. Prof Ruben suggested getting further clarification regarding budget from course coordinators.
7. Wits vendors are preferred for the procurement of parts. It is however possible to use outside vendors but Mr Graig Carlson raised attention to a lengthy process to be reimbursed.
8. Formats for meetings going forward will follow groups discussing three main aspects:
    a. What was done in the previous week?
    b. What will be done in the coming week?
    c. And, what is being worked on currently?

Announcements

1. Meetings will be held weekly at 10:30 on a Monday morning for the duration of the lab project, the venue for meetings will be the EIE meeting room.
2. Attendance to weekly meetings is compulsory.
3. Further clarification regarding budgets should be discussed with supervisor separate from the meetings.
4. Next group to chair meeting and take minutes will be 19G04

Next Meeting

22/07/2019 10:30 EIE meeting room

Student No.	Name	Signature
603 177	Jesal Chang	
1438756	Haroon Rehman	Haroon
1393410	Nicholas Kastanos	
1371116	Anita de Mello Koch	
1038253	Jannes Smit	
1073682	Sean J van Rensburg	
820971	Daniel Kutz	
1046955	Jason Parry	
1099797	Muhammed Rashaad Cassim	
1079587	Alexandra de Nooy	
1036613	Daniel de Barros	
1037502	Matthew Muller	Muller
1094837	Junaid Dawood	
1157717	TEBOHO MATSHEKE	
1122277	Sixolele Toko	
708607	THAPELO CHABANGU	
1427726	ELIAS SEPURU	
1386807	Baikanyo Radiokana	

RESEARCH GROUP MEETING FOR BIOMEDICAL ENGINEERING TOPICS (WEEK 2)

Date | time 22/07/2019|10:30 *Meeting called to order by* Muhammed Rashaad Cassim

Current Meeting

Chair: Muhammed Rashaad Cassim

Minutes taken by: Jason Parry

In Attendance

* Student attendees can be found within the attached attendance register.

Supervisors:	Ms Ellen De Mello Koch
	Mr Adam Pantanowitz
	Prof. David Rubin
	Dr Xriz Richards
	Prof. Michiel Postema
Apologies:	None

Approval of Minutes

Muhammed Rashaad Cassim

Proceedings

1. Cassim called the meeting to order and welcomed all attendees. All groups are requested to sign the attendance register and follow the standard agenda of the meeting.
2. Electronic stethoscope:
    a. J Chana said he is currently working on increasing the sampling frequency used to 8 kHz and plans to record ten seconds of stethoscope data.
    b. Mr Pantanowitz suggested the group may be oversampling and that it may be possible to decrease the filter bandwidth if this is the case.
    c. J Chana and T Chabangu said that the group's research indicated a 2 kHz frequency of internal body sounds.
    d. T Chabangu said he has been working on the amplification circuit for the stethoscope. This circuit has been designed and implemented by soldering it onto Veroboard.
    e. J Chana and T Chabangu stated that the group has no major issues currently.
3. Heartbeat sound segmentation and classification:
    a. E Sepuru said that the group has been working on sampling of the heartbeat signal.
    b. B Radiokana said that the two beats of the heartbeat cycle have different frequencies, however, a sampling frequency of 2 kHz should be sufficient to sample both based on research.
    c. B Radiokana said a low pass filter with a cut-off frequency of 800 Hz will be used to eliminate high frequency noise.
    d. Mr Pantanowitz said this filter is likely to cause attenuation of high frequency components in the heartbeat signal.
    e. B Radiokana and E Sepuru indicated that this behaviour is desirable in the case of the group's application.
    f. Prof. Rubin remarked on the cut-off frequency of 800 Hz being very low.
    g. B Radiokana and E Sepuru said, based on research, this frequency should be sufficient.
    h. B Radiokana and E Sepuru stated that the group has no major issues currently.

4. Monitoring mood changes from daily routine patterns:
    a. N Kastanos said he has been working on gaining access to all necessary sensors for recording of routine data and currently has access to 75% of these sensors. The group plans to obtain other necessary signals from audio components of sensor data.
    b. A De Mello Koch said she has been working on providing sensor input to neural networks and training these networks to predict routine changes. The current accuracy of the routine predictor is 60% when used on small training sets. An anomaly detector is also being developed.
    c. N Kastanos and A De Mello Koch stated that the group has no major issues currently.
5. Detection of depression from speech:
    a. A De Nooy said that the group has selected a set of features to be used in a machine learning algorithm to detect depression. A method to separate the participant's identity from the features used has also been developed.
    b. S Bulkin said that Ionic had been chosen as the application development framework due to its cross-platform capability. A database is required to store the audio data such that MATLAB can easily access it.
    c. Mr Pantanowitz suggested using Python instead of MATLAB since it will most likely be easier to connect various types of databases. An alternative solution may be arranging a different MATLAB licence which will enable the database connection.
    d. A De Nooy and S Bulkin said that MATLAB is preferable since it has all of the audio and speech analysis tools which the group has been using.
    e. A De Nooy and S Bulkin said that the major issue currently faced by the group is the choice between MATLAB and Python.
6. Respiratory disease classification:
    a. S Van Rensburg said that the group is currently working on signal processing of the medical data. This includes conversion of audio data into spectrograms to be used in conjunction with neural networks.
    b. D Katz said that the signal processing stage is mostly complete, however, the group has to redo some parts of it since they did not consider where (in the body) various sounds had been recorded.
    c. Prof. Rubin asked about the size of the data set with which the group is working.
    d. Mr Pantanowitz suggested the use of convolutional networks for large data sets since feature extraction forms part of the convolutional process. This avoids having to manually identify features to be extracted.
    e. S Van Rensburg and D Katz stated that the group has no major issues currently.
7. A cost-effective, portable sign language to speech translator:
    a. M Cassim said he has been working on different flex sensor designs since the group has decided to make their own sensors. The final sensor design has been selected and five sensors have been made which are to be attached to a normal glove. These sensors have been tested and are operating desirably.
    b. J Parry said he has been working on creating mock sensor data to be used when training the various machine learning algorithms which are to be compared. A generic class has been created to generate mock sensor data which allows the group to enter the specific parameters of the sensors being used once they have been determined.
    c. M Cassim and J Parry stated that the group has no major issues currently.
8. Shear-wave generator:
    a. D De Barros said that the group has been working to determine the characteristics of the jelly being used as the medium for the shear-waves. A cheap accelerometer was purchased to be used in an attempt to detect waves in the jelly.
    b. J Smit said that the accelerometer could not accurately measure the signals currently due to the small amplitude of the waves produced by the current speaker. A higher power speaker will be ordered to produce waves with a larger amplitude. Another possible solution is using an accelerometer with a higher sensitivity.
    c. Prof. Postema suggested the use of a different material which is a closer replica of human skin such as pudding or chicken breast.
    d. Mr Pantanowitz asked whether a speaker array would be feasible to generate waves with a larger amplitude.
    e. D De Barros said a speaker array may be a possibility, however, the group would then have to consider radiation patterns in the medium.
    f. Mr Pantanowitz suggested trying an array of cheap speakers first to avoid damaging an expensive speaker by submerging it in jelly.

    g. D De Barros and J Smit said that the major issue currently facing the group is determining the plate material which will be used to transform longitudinal waves into shear waves.

9. Are they breathing:
    a. M Muller said that the current design focuses on using a temperature sensor (thermistor) with a sufficient response rate to detect temperature changes when a person breathes in and out. The circuit to do this has been built and a microcontroller is being used, together with an LCD display, to Soutput the detected breathing rate. This design needs to be tested in different ambient conditions with different breathing rates. Due to the design of the deflection bridge and the (cheap) operational amplifier currently in use, the system may not be able to detect temperatures lower than 10 °C. A possible solution to this is the inclusion of an operational amplifier designed for medical use but it is much more expensive.
    b. Mr Pantanowitz said that one of the main purposes of a lab project is to quantify and characterise measurements, meaning that getting an ideal solution is not always necessary. The group is advised to continue their investigation with the current operational amplifier and possibly switch to the medical operational amplifier at a later stage.
    c. T Chabangu suggested using a DC offset to avoid the undesirable cut-off condition. This would come with an associated loss of resolution.
    d. J Dawood is working on the signal processing aspect and said that the current aim is to perform peak detection of the breath signal. Moving average, gradient and Fast Fourier Transform (FFT) methods have been attempted. The gradient method seems to work best and is the method currently in use. Certain Finite Impulse Response (FIR) filters have been implemented but do not seem necessary based on readings taken.
    e. M Muller said that breath signals are approximated as sinusoids and the gradient method assists in avoiding the issue of the signal “bouncing” across the crossing point.
    f. M Muller and J Dawood said the issue they are currently facing is the possibility of not being able to detect temperatures lower than 10 °C due to the operational amplifier currently being used.
10. Sonic suction:
    a. P Makgobola said that the group has been experimenting with speakers and fine particles in an attempt to get the speaker to move the small particles. However, the issue is that the speakers have not generated sufficient force to move the particles unless the particles are in contact with the speaker. The group is looking into obtaining a higher power speaker to generate more force in an attempt to move the fine particles.
    b. Mr Pantanowitz suggested using the resonant frequency of the particles in question to assist in causing vibration in the particles.
    c. Prof. Postema said that this approach is not viable due to the small size of the particles.
    d. P Makgobola said that the group has also investigated the possibility of using a wedge-shaped chamber to create the desired suction effect.
    e. H Rehman said that the group has been looking at using phase differences in standing waves to manipulate particles, causing them to be drawn towards the speaker.
    f. Prof. Postema indicated that the wavelength may be too long for this approach to work.
    g. H Rehman said that the group would try frequencies in the kilohertz range for this approach.
    h. Prof. Postema suggested using two speakers to create an interference pattern which causes a net movement of particles towards the speaker, however, he suggests working out the geometry of the problem in water before purchasing more speakers.
    i. P Makgobola and H Rehman said that the major issue the group is facing is determining the best approach to create a suction effect.
11. Have a brain tweet:
    a. T Matsheke said the group has been focusing on setting up the previous brain tweet project and obtaining all the necessary equipment. The group has attempted to ensure the LEDs are operating within a safe frequency range to avoid triggering epileptic fits.
    b. S Toko said that the previous project converted letters into binary, segmented them and transmitted them. The group wishes to increase the transmission rate either by using more frequencies (different colours of light) or a compression technique.
    c. Prof. Rubin suggested making use of wavelength division multiplexing to achieve faster transmission speeds.

   d. Mr Pantanowitz said that this approach may not work as the brain may scramble this data. A time division multiplexing approach may be tested experimentally.
   e. T Matsheke and S Toko said the main issue they are currently facing is obtaining all the necessary components.
12. Prof. Postema suggested all groups have some sort of “wow factor” for their presentations on Open Day (29 August 2019).
13. Cassim called the meeting to a close.

Key Notes

1. All groups should ensure the division of work which was suggested in the project plan is still valid and adjust it accordingly if it is not.
2. An official agenda is not necessary for each meeting since each meeting follows the same agenda – each group discusses:
   a. What was done in the previous week.
   b. What will be done in the coming week.
   c. Any issues experienced which may hinder the group.
3. All minutes of all meetings should go into the final report.
4. Final reports should contain all necessary details (down to the part numbers of components) to fully explain to any electrical engineer how to exactly repeat the process of the experiment.

Announcements

1. Students should take additional minutes pertaining to their own project during the weekly meeting.
2. Next group to chair meeting and take minutes will be 19G31 (Alexandra De Nooy and Seth Bulkin).

Next Meeting

29/07/2019 10:30 EIE seminar room

Student no.	Name & Surname	Signature
1036613	Daniel de Barros	
1038253	Joannes Smit	
1037502	Matthew Muller	
1094837	Junaid Dawood	
1078313	Phetole Makgobola	
1438756	HAROON REHMAN	Haroon
1122277	Sixolele Toko	
1157717	TEBOHO MATSHEKE	
1099797	Muhammed Rafael Cassim	
1046955	Jason Parry	
820971	Daniel Katz	
1073692	Sean J van Rensburg	
1079587	Alexandra de Nooy	
1131453	Seth Bulkin	
1393410	Nicholas Kastanos	
1371116	Anita de Mello Koch	
1386807	Boikanyo Radickana	BVRadickana
1427726	ELIAS SEPURU	
603177	Jesal Chana	G34
708607	Thapelo Chabangu	

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RESEARCH GROUP MEETING FOR BIOMEDICAL ENGINEERING TOPICS (WEEK 3)

Date | time 29/07/2019|10:30 *Meeting called to order by* Seth Bulkin

Current Meeting

Chair: Seth Bulkin

Minutes taken by: Alexandra de Nooy

In Attendance

* Student attendees can be found within the attached attendance register.

Supervisors:	Ms Ellen De Mello Koch
	Prof. David Rubin
	Dr Xriz Richards
	Prof. Michiel Postema
	Mr Craig Carlson
Apologies:	None

Approval of Minutes

Seth Bulkin

Proceedings

1. S Bulkin called the meeting to order. All groups are requested to sign the attendance register and follow the agenda.
2. No apologies are recorded
3. Electronic Stethoscope - 19G34
    a. J. Chana said he is currently working on the application to display data from the stethoscope (including working with live data) and is also busy with soldering of components.
    b. T. Chabangu stated that he is busy working on the hardware for the stethoscope.
    c. T. Chabangu stated that the initial plan for the previous week was to work on the filter, however there was a delay in parts. As such, work was done on the audio amplifier and power supply instead. This is noted to be almost completed besides attaching battery holders.
    d. T. Chabangu stated that the intended work for this week is on the filter, while using substitute op amps until the correct parts can be obtained.
    e. The group stated that a current problem being faced is that the signal is being attenuated on the output side (after audio amplifier), the group has decided to perform tests without the filter to properly find bandwidth.
    f. J. Chana stated that the original cut-off frequency obtained from literature is 2000Hz, but that he is looking to reduce this to 1000 Hz as this might allow for easier hardware design by T. Chabangu.
    g. Prof. Rubin noted that he believes the cut-off frequency might be too low, thought that aspects like heart murmurs would be at a much higher frequency.
    h. Mr Carlson queried whether the group had planned to solder the ATMEL chip directly to the board and suggested rather using a socket such that the chip could be replaced.
    i. Using a socket is confirmed as the intended plan for the soldering process by J. Chana.
    j. It was queried by Mr Calson as to what op-amps were to be used and he suggested possibly using a hybrid op-amp as opposed to the intended LM326.
    k. D de Barros suggested using an OPA 551 or OPA 552 op-amp.

4. Heartbeat Sound segmentation and classification - 19G11
   a. E. Sepuru said that in the previous week the group managed to clean the signal using a LPF, as well as performed wavelet consideration so as to get a peak outline. This outline is reviewed to find major peaks.
   b. B. Radiokana stated that they are experiencing issues in locating S1 and S2 as a result of some peaks not being detected as well as extra peaks being detected as a result of noise. B. Radiokana stated that attempts to improve peak location would be made by:
      i. Conditioning for normal situations
      ii. Using intervals to locate S1 and S2 (if interval is much greater than mean a peak is likely to have been missed, if the interval is much smaller than the mean there is likely an extra peak)
   c. The group stated that other intended work for the week would be feature extraction for machine learning.
5. Respiratory Disease Classification – 19G29
   a. D. Katz stated that in the previous week they worked feature extraction and data labelling as well as the production of Mel-cepstral coefficients for the data.
   b. S. van Rensburg stated that in the previous week he had also worked on the GUI to be used to work with the Machine Learning models
   c. The group stated that the intended plan for the week would be to build their machine learning models.
6. Detection of Depression Through Speech Analysis – 19G31
   a. S. Bulkin stated that in the previous week he had worked on building a mobile application to record audio and had begun attempting to connect the application to an external database.
   b. S. Bulkin stated that the intended work for the upcoming week would be to link the application to the database and begin working on some of the machine learning.
   c. A. de Nooy stated that in the previous week work had been done on installing and building a basic TensorFlow model as well as looking at the COVAREP speech processing toolbox.
   d. A. de Nooy noted that COVAREP was found to not work well and is believed to be as a result of compatibility issues (written is MATLAB 2016). This led to a decision to try a new feature processing tool box – OpenSmile.
   e. A. de Nooy also stated some concerns regarding a small data sample available for machine leaning as well as imbalances in data. Possible ways of dealing with this are thought to be using forms of data weighting as well as over/under sampling of data.
7. Monitoring mood changes through daily routine patterns – 19G16
   a. N. Kastanos stated that in the previous week he worked on gaining more access to sensors from the application as worked on putting this data into text files.
   b. N. Kastanos stated that there was difficulty in library compatibility which required a change in strategy for determining MFCCs.
   c. N. Kastanos said that he would looking in to calculating these values on the actual server.
   d. A de Mello Koch said that she was building machine learning models to detect anomalies in routine. The intended idea to test this is noted to be through building a mock routine (to extend data as only a week of data is available for each person).
8. A cost-effective, portable sign language to speech translator:
   a. J. Parry stated that in the previous week they had managed to connect flex sensors to a glove so as to get initial reading for movement of each finger.
   b. J. Parry stated that 1000 data points were collected for each gesture and were used for, k-means clustering. Initial clustering produced low accuracy but changes in the manner of clustering lead to improvements.
   c. M. Cassim stated that a MATLAB GUI had been designed to test for accuracy and different sampling rates.
   d. Prof. Rubin queried how many features are collected for the glove
      i. M. Cassim stated that there is one voltage feature collected for each finger
      ii. Prof. Rubin suggested possibly using a rule-based approach for each person as well as including individual calibration. This approach is also suggested to be used as a comparison to other approaches.
   e. M. Cassim stated that an issue was experienced with respect to different values being dependent on the positioning of sensor wires with respect to the glove. This is noted to be as a result of dealing with a very prototype glove. Accuracy is likely to improve Believe accuracy with a better glove.
   f. M Cassim stated that sensor resistors are very sensitive, and that the group has decided to introduce a filter to remove HF, even though finger gestures are quite different
   g. Group stated that they have been considering the type of ADC to purchase (i.e. a more expensive one with more channels or several ADC).

9. Shear-wave generator – 19G15
    a. D. de Barros said that there had been a delay in obtaining parts which affected the intended work for the previous week.
    b. D. de Barros stated that the work completed while waiting for parts was the building of the DC-DC convertor as well as the amplifier circuit.
    c. D. de Barros stated that for the moment experimentation has still made use of basic speakers and that a speaker array had been attempted (produced mixed results).
    d. J. Smit stated that a new phantom has been used and that is produces better results. J. Smit stated that the audio properties of the new phantom are based on a research paper found (1996).
    e. Prof. Postema queried whether the delay in parts was made part of the risk analysis and said that analysis of whether or not this could have been foreseen should be presented in the final results.
    f. D. de Barros stated that Dr Dinger had suggested that the groups sensor sensitivity might be too low and had consequently provides piezoceramic sensors. It was noted that it is quite difficult to get the sensors fixed in phantom so as to pick up the shear wave
    g. The group stated that research had also been completed into acoustic amplifiers and how they can be designed.
    h. The group believes to be on track besides the delay in parts.
10. Sonic Suction - 19G25
    a. P. Makgobola stated that not all required parts could be obtained from the workshop and that some difficulty has been experienced in sourcing alternatives. It is believed that components may have to be sourced externally.
    b. P. Makgobola stated that parts are likely to be obtained this week and that experimentation with these parts can begin.
    c. P. Makgobola stated that the experiment stated by Prof. Postema in the previous meeting had been attempted and that some movement towards the center had been seen (likely as a result of geometry);
    d. The intention for this week is stated to be replicating the water experiment with two speakers.
    e. Prof. Postema stated that the speakers could be coupled to a plate.
    f. P. Makgobola said that a reflecting surface would need to be used which would be likely to vibrate. Concerns with this are stated that a vibrating wave may be produced rather than the necessary pressure waves.
    g. Prof. Postema suggested that there are equations which can be used to answer this question and stated that as the group did not define what particles would be used, very light ones could be chosen (e.g. paper).
    h. H. Rehman stated that the plan moving forward is to build high power amplifier speaker to get more power out.
    i. H. Rehman stated that previously the group experimented with a 7 W speaker, but that this power was insufficient to push particles.
    j. Prof Postema stated that time may be running out and queried whether the required parts have been ordered by the time of the meeting.
    k. P. Makgobola stated the group is thinking of acquiring the parts themselves and being reimbursed so as to reduce time delays.
    l. Prof. Postema stated that the geometry should be finalized in the meantime such that experimentation can begin as soon as parts are acquired. Prof. Postema queried how the project work is being split.
    m. P. Makgobola stated that results are based on experimentation that was being performed as a group.
    n. Mr Carlson said that groups need to be able to show individual contributions. Effectively two papers describing project.
    o. Prof Postema suggested that one partner focus on HF, and the other LF, as well as consider reflectors (straight vs angles) and with different materials. It is stated that each report needs to be scientifically novel.
11. Are they breathing? – 19G12
    a. M. Muller stated that prior to previous meeting circuit combination on bread board had been tested with suitable initial results.
    b. M. Muller stated that in the previous week the group had transferred the circuit to Veroboard and tested it – results produced are similar to breadboard.
    c. M. Muller stated that in the following week the group would be looking at testing the circuits with different breathing patterns and seeing how it behaves as well as possibly moving the circuit to PCB (to reduce size).
    d. The following points are stated as aspects to still be considered/completed:

i. Packaging for device – possibly strap to someone's arm and then connect to mask (this would have to use PCB as a result of size constraints)
ii. How to fasten sensor to mask and how it can be detached.
iii. Including and On – off switch for the device
iv. Considerations of the type of mask: Nebulizer vs dust mask
v. Inclusion of Bluetooth data logging

e. J. Dawood stated that noise quantification was attempted in previous week that suggested filters may not need to be included. This noise is noted to be background thermal noise. The group intends to test without the filters to record differences.
f. J. Dawood stated that the performance still needs to be recorded for if the sensor is disturbed.
g. J. Dawood said that a MATLAB GUI is being used to plot the input waveform to see when breaths are occurring. This is being used to develop accuracy.

Key Notes

1. Report produced by each partner should be scientifically novel – need good separation of work.

Announcements

1. Next group to chair meeting and take minutes will be 19G15 (Jannes Smit and Daniel de Barros).
2. Following meeting (5/08/2019) to take place in Control Lab

Next Meeting

05/08/2019 10:30 EIE seminar room

Name	Student #	Signature
Daniel Kutz	820971	
Sean J van Rensburg	1073682	
Boikanyo Radiokana	1386807	
ELIAS SEPURU	1427726	
Jesal Chano	603177	
Thapelo Chabangu	708607	
Sarah Bulkin	1131153	
Alexandra De Nooy	1079587	
Nicholas Kastanos	1393410	
Anita de Mello Koch	1371116	
Mohammed Rashaad Cassim	1099797	
Jason Parry	1046955	
Jannes Smit	1038253	
Daniel de Barros	1036613	
Phetole Malgobola	1078313	
HAROON REHMAN	1438756	
Matthew Muller	1037502	
Junaid Dawood	1094837	

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RESEARCH GROUP MEETING FOR BIOMEDICAL ENGINEERING TOPICS (WEEK 4)

Date | time 05/08/2019|10:30 *Meeting called to order by* Daniel De Barros

Current Meeting

Chair: Daniel De Barros

Minutes taken by: Jannes Smit

In Attendance

* Student attendees can be found within the attached attendance register.

Supervisors: Ms. Ellen De Mello Koch

Prof. David Rubin

Dr. Xriz Richards

Mr. Craig Carlson

Dr. Adam Pantanowitz

Apologies: E. Supuru apologized on behalf of his partner, B. Radiokana, not attending the meeting as she was preoccupied with bursary interviews.

Approval of Minutes

Daniel De Barros

Proceedings

1. D. de Barros brought the meeting to order. Groups were requested to sign the attendance register and follow the agenda.
2. B. Radiokana apologized for not being able to attend, as she was preoccupied with bursary interviews.
3. Are they breathing? – 19G12:
    a. J. Dawood stated that the current system was tested under the following conditions:
        i. The system response to fast, slow and shallow breathing conditions were tested by measuring the breathing rates of the two group members and random participants.
        ii. The system response to ambient temperatures at 20^{o}C to 30^{o}C and 6^{o}C to 7^{o}C.
    b. J. Dawood also stated that on the hardware side, that the PCB for the system has been printed.
    c. The group stated that the following activities should be completed in the week:
        i. The components will be soldered onto the PCB.
        ii. To find an efficient method to attach the temperature sensor to the breathing mask.
4. A cost-effective, portable sign language to speech translator – 19G04:
    a. J. Parry stated that he has trained a neural network in Python. However, the accuracy of this network was not sufficient for their application.
    b. J. Perry then suggested that he would shuffle the data to improve the accuracy.
    c. M. R. Cassim stated that on the hardware side that the Atmega based processor was not meeting the required specifications for this project. The MCU was then replaced by a Raspberry Pi unit.
    d. The group stated that the activities for the week will be centered around the following activities:

    i. To improve the accuracy of the neural network using improved K-means clustering and F-scores as metrics.
    ii. To improve the attachment of the sensors on the glove in order to complete the final configuration of the sensing glove.
    iii. To attach an accelerometer sensor to the sensing glove.
    iv. Test the use of a Myo sensor to detect various hand positions.
  e. Mr. Carlson enquired when the group would begin testing the glove on individuals.
    i. The group stated that this should occur at the end of the week.

5. Respiratory Disease Classification – 19G19
  a. D. Katz stated that the group had to segment the data in order to increase the number of samples.
  b. D. Katz stated that a preliminary convolutional neural network has been trained and preliminary tests gave an accuracy of 90%.
  c. S. van Rensburg stated that after segmentation, the group had 7000 sample points.
  d. S. van Rensburg stated that he has applied some pre-processing on the audio data, and this has improved the performance of the neural network to 95%.
  e. Dr. Pantanowitz enquired whether the group is using one- or two-dimensional convolution in their neural network.
    i. D. Katz answered that they are using two-dimensional image of the audio data as an input to the neural network as it allows the neural network to make more accurate predictions based on the input audio data.
    ii. Dr. Pantanowitz suggested that the group train a one-dimensional neural network to compare the performance of the two networks.

6. Detection of Depression Through Speech Analysis – 19G31:
  a. A. de Nooy started using open smile to train the neural network as it allows for greater audio feature extraction.
  b. A. de Nooy said that even though the new platform allows for greater feature extraction, preliminary neural networks still ineffectively classify depression through speech.
  c. A. de Nooy stated that they started to segment the data further to further increase he number of samples to train the neural network.
  d. The group increased the number of samples from 189 to 1000.
  e. A. de Nooy further stated that each segment is different form the next and that this should increase the classification accuracy of the neural network.
  f. The group has also researched into using PHQ8 scores as audio features to be used by the neural network.
  g. The group aims to classify cases of depression from mild to severe.
  h. S. Bulkin stated that due to the low number of samples, that he has been developing a feature extracting algorithm to efficiently extract relevant features from sample audio.
    i. Preliminary testing of this algorithm has shown that it is capable of extracting features, but it does have some stability issues as it is prone to crash.
  i. Dr. Pantanowitz stated that increasing the number of samples should increase the accuracy of the neural network.
    i. A. de Nooy agreed and stated that they are aiming to split the audio data into equal length segments and that they are removing irrelevant sections of the audio data such as the beginning and end of audio recordings.
    ii. Dr. Pantanowitz then enquired which characteristics are present in an audio recording where the person is suffering from depression as this could be used to better segment audio samples.
    iii. A. de Nooy then stated that there are multiple characteristics in a person's speech which could indicate depression.
    iv. Dr. Pantanowitz then stated that if they need to, it might be beneficial to truncate data.

        v. Dr. Pantanowitz then asked whether another person other than the patient speaks during the interviews.
        vi. A. de Nooy then replied that the interviewer does speak in some sections of the recordings, but she has already removed those sections from the sample data previously.
        vii. Dr. Pantanowitz further stated that segmenting the data produces audio breaks. These breaks in the data can further cause high frequency components in the sample audio data. It would thus be beneficial if this data is filtered to reduce these frequency components.
    j. Dr. Richards enquired whether the group was looking into the effects that the length of audio segments and lengths of paragraphs read by subjects have on the accuracy of depression measurements.
        i. A. de Nooy replied that they would look at these factors.
    k. A. de Nooy then asked whether it is a good idea to have a standardized length for each audio sample or if applying a weight to the samples is a better idea.
        i. Dr. Pantanowitz then answered that the data should remain as unaltered as possible and that the audio samples should all be the same length.
        ii. Dr. Pantanowitz further stated that if the majority of patients in the study are diagnosed with depression, for example 70%, that the algorithm doesn't just assume that 70% of people in general have depression.
        iii. The origin of data and how the data was recorded should also be stated in the report.
    l. Mr. Carlson stated that he also thinks that increasing the number of data points should increase the accuracy of the neural network. He further asked the group to think about methods to improve the input data.
7. Monitoring mood changes through daily routine patterns – 19G16:
    a. N. Kastanos completed the following activities in the past week:
        i. The sensors used to capture routine data seem to be fully operational. He just needs to effectively interface with plug-ins.
        ii. N. Kastanos further stated that they are recording data every 15 minutes as opposed to every 1 minute, as the accuracy of the predictive algorithm does not seem to be affected by this change.
    b. A. de Mello Koch stated that she completes the following activities over the last week:
        i. A script which generates a standard user for a set number of weeks was created and it operates as expected.
        ii. The SVM network has shown to be accurate when detecting anomalies when given data which spans over two weeks.
    c. A. de Mello Koch further stated that using an SVM will allows for anomaly detection in a set of data.
        i. Dr. Pantanowitz cautioned the group to ensure that they are training the SVM network with a normal set of data without anomalies.
8. Shear-wave generator – 19G15:
    a. D. de Barros that two different shear-wave generators have been constructed in the past week.
        i. The first generator consists of a solenoid-based system, where the solenoid shaft strikes a coupling plate.
        ii. The second generator consists of a speaker which is closely coupled to the coupling plate.
    b. D. de Barros further stated that the waves generated in the phantom medium is measurable using both a piezo-electric transducer and an accelerometer sensor.
    c. J. Smit stated that the Young's modulus of the tissue mimicking phantom was determined using compression tests.

        i. Prof. Rubin then enquired as to why these tests were conducted.
        ii. D. de Barros answered that these tests were conducted to measure how accurate the wave speed measurements with the accelerometer or piezo-electric sensors are.
    d. D. de Barros then outlined the groups plan for the week as follows:
        i. The circuit components for the two generators will be placed on PCB's to make the testing process easier.
        ii. The speed of sound in the tissue mimicking phantom will be remeasured to ensure that the sensor system produces accurate results.

9. Electronic Stethoscope – 19G34:
    a. J. Chana said that the group is 85% with the amplification circuit.
    b. J. Chana further stated that the developed device can display measured stethoscope audio data in real time. Although the system only needs a 30 second clip to accurately determine the heart rate.
    c. T. Chabangu stated that on the hardware side the signal can be easily displayed on an oscilloscope before and after filtering.
    d. T. Chabangu elaborated that signal does seem to be attenuated after filtering and will thus rebuild the filter to find the root of the attenuation problem.
    e. T. Chabangu said that they also purchased a new microphone and they are waiting for the delivery of a new filter which might solve some of their problems. It was further stated that the delivery of the filter is taking longer than usual.
        i. Mr. Carlson then enquired where the filter was purchased from.
        ii. T. Chabangu stated that the filter was ordered from RS Components and that they should receive this component within the week.
10. Heartbeat Sound segmentation and classification - 19G11
    a. E. Supuru apologized for his partners absence and proceeded to convey his partners completed activities:
        i. B. Radiokana has been able to segment heartbeat data into S1 and S2 sections of normal heatbeat samples.
        ii. B. Radiokana still struggles to segment abnormal data points using the algorithm.
    b. E. Supuru further stated that he has been working on extracting more features from their data and MFCC's.
    c. E. Sepuru then stated that they will attempt to better examine heartbeats using their algorithms.
11. Sonic Suction – 19G25
    a. H. Rehman stated that they received all their components from Communica and that they built a high-power amplifier of 100W.
    b. H. Rehman stated that the system currently operates at a voltage of 10V.
    c. H. Rehman further stated that they have performed some preliminary testing with the speaker system, and they found that operating the speaker in the 50 to 90 Hz range produced the best particle movement. Any frequency outside that range did not operate as well.
    d. P. Makgobola further stated that they would conduct a frequency sweep with the speaker system to measure the frequency response of the system.
    e. P. Makgobola also stated that it is difficult to find a suitable environment to conduct these experiments as they are concerned as to how noise could influence their measurements.
        i. Mr. Carlson stated that the group might be able to conduct experiments in the Biomedical Engineering Laboratory.
    f. P. Makgobola also stated that mechanically coupling produced far better sound transmission into the plate medium.

g. P. Makgobola enquired who to ask for extra equipment such as power supplies and signal generators
    i. Prof. Rubin replied that he should ask his supervisor.

Key Notes

Any additional equipment required by students must be requested through supervisors.

Announcements

1. Next group to chair the meeting will be group 19G16 (A. de Mello Koch and N. Kastanos).
2. The meeting will be held in the Control Laboratory.

Next Meeting

2019/08/12 10:30 Control Laboratory.

Name	Student no.	Signature
Nicholas Kostanos	1393410	
Anita de Mello Koch	1371116	
Seth Bulkin	1131453	
Alexandra de Nooy	1079587	
Daniel Katz	820971	
Sean J. van Ronsburg	1073682	
Jason Parry	1046955	
Muhammed Rashaad Cassim	1099797	
Junaid Dawood	1094837	
Matthew Muller	1037502	
Phetole Makgobola	1078313	
HAROON REHMAN	1438756	Haroon
ELIAS SEPURU	1427726	
Jesol Chang	603177	
Daniel de Barros	1036613	
Jannes Smit	1038253	
THAPELO CHABANGU	708607	

RESEARCH GROUP MEETING FOR BIOMEDICAL ENGINEERING TOPICS (WEEK 5)

Date | time 12/08/2019|10:30 *Meeting called to order by* Nicholas Kastanos

Current Meeting

Chair: Nicholas Kastanos

Minutes taken by: Anita de Mello Koch

In Attendance

* Student attendees can be found within the attached attendance register.

Supervisors:	Ms Ellen De Mello Koch
	Prof. David Rubin
	Dr Xriz Richards
	Mr Craig Carlson
Apologies:	Rashaad Cassim
	Haroon Rehman

Approval of Minutes

Nicholas Kastanos

Proceedings

1. N. Kastanos called the meeting to order.
2. R. Cassim and H. Rehman send their apologies.
3. Detection of Depression Through Speech Analysis – 19G31
    a. S. Bulkin stated in the previous week he managed to get the mobile application to record and upload audio files. The raw audio data can be sent to the feature extraction software used on the server.
    b. S. Bulkin stated that in the upcoming week he will be focusing on creating a good user interface for the application.
    c. A. de Nooy stated that in the previous week she achieved a 75% - 78% accuracy with a binary classification by splitting and normalizing the data.
    d. A. de Nooy stated she is achieving a root mean square error of 6 using a regression algorithm, which agrees with literature, but the error is clustered around specific numbers, resulting in this RMSE of 6. She trained two separate models, one trained on non-depressed data and the other trained on depressed data and sends the data to one of these two models. This improved the RMSE to around 5.5% with a wide-spread error.
    e. A. de Nooy stated she will be looking into improving and differentiating the classification.
    f. Dr Richards enquired what was being compared to obtain the RMSE scores and A de Nooy replied that the model is attempting to predict the PHQ8 scores which are provided in the dataset.
4. Electronic Stethoscope - 19G34
    a. J. Chana stated that in the previous week the group began testing and building each circuit subsystem onto PCB. The group is attempting to sample on the PCB at 4000.
    b. J. Chana stated the components they ordered are surface mounts and hence the decision to move onto PCB.
    c. J. Chana stated the goal for the next week is to finish printing the circuits and complete testing. The filter needs to be printed and the components they ordered are working well.
    d. T. Chabangu stated that the group tested that each circuit subsystem can operate independently.

e. T. Chabangu stated that for the upcoming week, the group needs to test the full system and confirm they are obtaining accurate results.
f. T. Chabangu stated he was obtaining some odd results when compared to the oscilloscope readings. He found the signal was inverted on the y axis which can not be solved with the inclusion of an inverting operational amplifier.
g. The group stated they will begin looking into packaging.

5. Monitoring mood changes through daily routine patterns – 19G16
   a. N. Kastanos stated in the upcoming week he will be working on setting up a server to store the data generated by the user's cellphone and to begin integrating the data with the machine learning algorithms.
   b. A. de Mello Koch stated she worked on improving the accuracy of the machine learning algorithms and managed to improve the accuracies. The upcoming week will be spent integrating the machine learning algorithms and the phone application.
6. Shear-wave generator – 19G15
   a. J. Smit stated in the previous week the group moved the solenoid shear-wave generator onto PCB.
   b. J. Smit stated the group will be working on moving the speaker circuit onto PCB in the upcoming week.
   c. D. de Barros stated he is displaying and filtering the received waves on MatLab. Further processing needs to be done on the signal.
   d. D. de Barros stated the group made a new phantom.
   e. D. de Barros stated in the upcoming week the group will try different sheer and surface wave signal processing.
   f. The group stated they are having issues differentiating between surface and shear-waves. They will attempt to use another accelerometer to improve resolution as they suspect the surface waves are faster than the shear-waves.
7. A cost-effective, portable sign language to speech translator – 19G04
   a. J. Parry stated the group completed the prototype glove in the previous week as well as using SK to create different models for detection.
   b. J. Parry stated the group was achieving very good results, achieving 95% - 100% accuracies after splitting the data into training and validation sets.
   c. The group moved the processing onto the raspberry pi to attempt real-time classification. The prototype glove has a tight stich on one finger which affected the accuracy of the real-time classification.
   d. In the upcoming week, the group will hopefully complete the final glove which should provide standardized results.
   e. Prof Rubin enquired on the progress with the MIYO.
   f. J. Parry stated that R. Cassim is currently working with the MIYO. They will be using the MIYO to train some additional models which can be used for comparison.
   g. Dr Richards asked the group if they have seen the article in the You magazine for a prototype hand capable of signing.
8. Respiratory Disease Classification – 19G29
   a. D. Katz stated the group is currently refining their model.
   b. D. Katz stated in the previous week the group rewrote their model to simplify code and have been validating on different data sets.
   c. S. van Rensburg stated the group does not have more data because they need to obtain data from patients. The group separated 60 samples from their original dataset to be used for testing the models separately.
   d. S. van Rensburg stated the group wants to do more augmentation of the data to prevent the overfitting of their model.
9. Heartbeat Sound segmentation and classification - 19G11
   a. E. Sepuru stated the group is trying to get the features of the datasets.
   b. E.Sepuru stated the group is using two different datasets, A and B. Dataset A was recorded using an iPhone and, therefore, contains noisy signals. Dataset B was recorded using a digital oscilloscope and therefore has very clean signals.
   c. E.Sepuru said the group id having trouble with detecting the location of S1 and S2. The group first attempted using the mean to detect extra peaks, with an accuracy of around 51%. The group moved to using the standard deviation to locate S1 and S2. This led to an improvement resulting in an accuracy of around 61% for A. Detection for dataset B is much better.
   d. E. Sepuru stated he will be focusing on improving the detection of S1 and S2 using the features of the signals.

e. B. Radiokana stated the group is using a Bayesian model to test if the features are being calculated correctly.
f. B. Radiokana stated the model has low accuracy when classifying dataset A.
g. B. Radiokana stated the datasets have different classes.
    i. For dataset A, the accuracy for artifacts is almost 100%, but the other classes have accuracies around 50%.
    ii. Overall, dataset B has an accuracy of 70%, with accuracy for murmur at 71%.
h. The group stated detection of S1 and S2 in dataset A is proving to be problematic but S1 and S2 detection is working well for dataset B.
i. The group is planning to use a neural network to train a model to improve the detection of S1 and S2 on dataset A to balance the accuracy.

10. Are they breathing? – 19G12
    a. M. Muller stated the group has printed their circuit to PCB.
    b. M. Muller stated the group added Bluetooth functionality by including a Bluetooth module.
    c. M. Muller stated the group printed the PCB with the copper tracks on the top layer. However, after attempting to attach the components, decided it would be easier if the copper tracks were on the bottom layer and reprinted the PCB.
    d. The circuit has the same basic functionality after being moved onto the PCB.
    e. M. Muller stated when testing the Bluetooth model, it was found the module draws too much current, drawing 10mA resulting in fluctuations in the voltage provided by the battery. Because the battery is powering the bridge circuit, the model detects these fluctuations as a breathing rate.
    f. M. Muller stated he designed a new circuit to include a separate battery for the Bluetooth module as well as reducing the size as the original circuit size was too large for the circuit casing.
    g. M. Muller stated the circuit can wirelessly send the breath rate.
    h. M. Muller stated the goals for the upcoming week are to improve the packaging as well as improve the placement of the sensor in the breathing mask.
    i. J. Dawood stated he will run extra tests and compare these to other algorithms.
    j. J. Dawood stated inbuilt MatLab tools overestimated the error of the circuit. In the upcoming week he will be writing scripts to detect these peaks manually and improve the accuracy reported.
    k. J. Chana stated he has a similar problem with the Bluetooth module in the electronic stethoscope. He isolated the Bluetooth module from the rest of the circuit using an optocoupler.
11. Sonic Suction - 19G25
    a. P. Makgobola stated the group acoustically coupled the speakers to wood.
    b. P. Makgobola stated the group managed to obtain movement millimeters away from the wood. This movement, depending on the location of the particles from the wood, moved in a circular motion, toward the speaker or away from the speaker. The group is working on understanding these results.
    c. P. Makgobola stated the group found that 6cm away from the source, they find there is no motion.
    d. The group used both saw dust and paper in their tests and found that when the source is coupled there was no difference between these two substances.
    e. Prof Rubin stated this is most likely a power issue.
    f. P. Makgobola stated they tried to increase the power, but this did not affect the movement of the particles.
    g. P. Makgobola stated the group will be focusing on understanding why they are obtaining the results they are getting as well as how to get the desired effect of suction.
    h. P. Makgobola stated the group is considering using a conic structure as seen in a YouTube video in an attempt to increase the distance away from the source at which particles show movement. This will be attempted in the upcoming week.
    i. Dr Richards asked what the group is using to create their signals.
    j. P. Makgobola stated the group is using sig gen at 80 Hz and then adjust the amplitude. The group has found that, due to their speakers, there is no difference, apart from pitch, once the signal is over 200 Hz. As a result, the group has decided to focus on low frequency signals and getting better results.
    k. P. Makgobola stated the group would like to increase the distance in front of the source as which particles are sucked.
    l. P. Makgobola stated the group was having trouble finding a big enough circular pipe. The group can only find pipes with the correct diameter 6m in length.
    m. Prof Rubin recommended asking companies if they have any cutoffs the group can use.
    n. Dr Richards asked what diameter the pipes needed to be.

o. P. Makgobola stated the diameter of the pipes is about 6 inches.
p. Dr Richards suggested looking at Builder's Warehouse, who have pipes of length 1.5m.
q. P.Makgobola stated he has already look at a Builder's Warehouse and did not find any suitable pipes. He stated he will look at some other Builder's Warehouses.

Key Notes

1. No key notes.

Announcements

1. Next group to chair meeting and take minutes will be 19G29 (Daniel Katz and Sean van Rensburg).

Next Meeting

19/08/2019 10:30

Week 5 Attendance

Name	Student Num	Signature
Alexandra de Nooy	1079587	
Seth Balkin	1131453	
Anita deMello Koch	1371116	
Nicholas Kastanos	1393410	
Jason Parry	1046958	
Daniel Katz	820971	
Sean J van Rensburg	1073682	
Junaid Dawood	1094837	
Matthew Muller	1037502	
Phetole Makgobola	1078313	
ELIAS SEPURU	1427726	
Boikanyo Radiokana	1386807	
Jannes Smit	1038253	
Daniel De Barros	1036613	
Jesal Chang	603177	
THAPELO GYABANGU	708607	

Research Group Meeting for Biomedical Engineering Topics (Week 6)

Date | time 19/08/2019|10:30 *Meeting called to order by* Daniel Katz

Current Meeting

Chair: Daniel Katz

Minutes taken by: Sean Janse van Rensburg

In Attendance

* Student attendees can be found within the attached attendance register.

Supervisors: Ms. Ellen De Mello Koch
Prof. David Rubin
Dr. Xriz Richards
Mr. Craig Carlson

Apologies: J. Dawood apologized that his partner, M. Muller, could not attend the meeting.

Approval of Minutes

Daniel Katz

Proceedings

1. D. Katz brought the meeting to order. Groups were requested to sign the attendance register and follow the agenda.
2. Mr. Carlson suggested that groups start preparing their posters

3. Are they breathing? – 19G12:
   a. J. Dawood stated that his partner, M. Muller , could not be present.
   b. J. Dawood stated that in the previous week the group had tried to obtain an appropriate housing for their product and finding a reliable way of placing the sensor in the mask.
   c. J. Dawood stated that the group got components that had been ordered and most of the testing was done under different temperature conditions with these components.
      i. Results appeared to be better but could just be test-to-test variance.
   d. Tasks to be completed this week

i. Analyze the test data more
ii. Prepare the presentation for open day.

e. J. Dawood enquired about where the groups will be allocated on open day.

i. Mr Carlson responded that there would be no allocations and the groups can situate themselves wherever space is available.

4. A cost-effective, portable sign language to speech translator – 19G04:
    a. J. Parry stated that last week the group got the final glove done.
    b. J. Parry further stated that the group was working on the myosensor in order to classify gestures correctly.
    c. J. Perry then stated that further data collection needs to be done for testing and for the report.
    d. J. Perry said that the group has started the poster.
    e. M. R. Cassim stated that he tested full sentences with the myosensor and it was working fairly accurately.
    f. M.R. Cassim stated that he freaked out his parents a bit and the group laughed.
    g. M.R. Cassim further stated that they will take further results this week for the report.

5. Respiratory Disease Classification – 19G29
    a. D. Katz stated that the task for the current week will be to work on more models and train more neural networks with differing parameters.
    b. Extra refinement and debugging will be done and the GUI will be completed.
    c. D. Katz stated that the group is figuring out how to present on open day due to ethical issues involved with recording live data from individuals.
        i. A possible solution would be to generate fake data or use pre-recorded respiratory sounds from a database.
    d. D. Katz stated that the group will start on the poster by the end of the current week.
    e. Dr. Richards enquired if the recorded sounds would be coming from a stethoscope.
        i. D. Katz stated that the sounds would be used from a database and the audio samples in the database had all been recorded with an electronic stethoscope.
    f. S. van Rensburg stated that usable data would need to be filtered out of the database since most of the audio recordings consist of background noise and indistinguishable lung sounds.

6. Detection of Depression Through Speech Analysis – 19G31:
    a. A. de Nooy stated that the group had worked on a second approach to predicting the patient's depression.
    b. A. de Nooy further stated that the second approach worked better than the first approach.
    c. Dr. Richards enquired whether the group was still using voice.
        i. A. de Nooy replied that they are still using voice. A. de Nooy further stated instead of doing a binary classification first and the prediction the regression based on those results, they grouped the PHQ score into classes of about five points in order to predict the class which will be an input to predict the regression.
    d. A. de Nooy stated the group integrated all the models with the app.
    e. A. de Nooy stated that this week the group will try to fully understand the incorrectly classified results.
    f. A. de Nooy stated that this week the group will be working on the poster.
    g. S. Bulkin stated that the group have achieved 95% functionality on the front-end of the application.

7. Monitoring mood changes through daily routine patterns – 19G16:
    a. N. Kastanos stated that from the application side:
        i. Data can be recorded and sent to the server.
        ii. The server performs very basic inference.
        iii. The GUI still needs to be implemented to make the application more user friendly.
        iv. The anomaly detector still needs to be connected to the entire system.
    b. A. de Mello Koch stated that they had settled on a network for both the activity detector and the anomaly detector which gave a 70% accuracy overall for the activity detector and a 70-80% accuracy for the anomaly detector.

8. Shear-wave generator – 19G15:
    a. D. de Barros stated that in the previous week they had obtained an additional accelerometer and all hardware has been moved to a PCB and is in a stable, working condition. Hardware :
        i. Two accelerometers that send data across to MATLAB and is able to record two signals and measure the propagation of the wave through the jelly.
        ii. Cross-correlating the two signals in order to measure the phase difference between the two, and estimate what the shear speeds are.
        iii. Still need to obtain shear amplitudes which will require some additional software.
    b. D. de Barros stated that in the coming week a bracket will be obtained for the solenoid for open day presentation and the solenoid angle will need to be adjusted for testing purposes.
    c. D.de Barros stated that the poster will be started in the week to come.

9. Electronic Stethoscope – 19G34:
    a. T. Chabangu said that the group transferred their breadboard circuit to a PCB and that the PCB board testing didn't go well.
    b. T. Chabangu said that the group spent most of the week testing.
    c. T. Chabangu stated that if the PCB board doesn't work, the group will use Veroboard.
    d. T. Chabangu stated that the group will work on the poster this week.
    e. T. Chabangu suggested that the group will use a TV and speakers on presentation day to present the electronic stethoscope's output.
    f. J. Chana said that he will work on unit testing of the application this week.

10. Heartbeat Sound segmentation and classification - 19G11
    a. E. Supuru stated that in the previous week the group had segmented the S1 and S2 sounds to perform feature extraction. Some additional features were also considered
        i. In the frequency domain, the heart murmurs and normal sounds had different spikes in different frequency ranges, these were used as features for the machine learning model.
    b. B. Radiokana stated that several different supervised models were tested.
        i. It was noticed that a lot of literature does not focus on gradient boost and random forest models although they give good results within the 70-75% range.
        ii. An artificial neural network and support vector machine were the chosen models.
    c. B. Radiokana stated that the Neural Network model with two layers for dataset B training gave a training accuracy of 88% and testing accuracy of 79%.
    d. Dataset A consisted of 3 layers and gave a training accuracy of 91% and testing accuracy 73%.

e. B. Radiokana stated that with dataset A there is an accuracy difference of 20% in terms of overfitting.

f. The Artificial Neural Network will be chosen for dataset B and the Support Vector Machine will be chosen for dataset A since training accuracy was 74% and testing accuracy was 75%.

i. B. Radiokana stated that the K-Nearest Neighbour model gave an accuracy of 68%.

ii. The accuracy of the models was also tested with normalizing and not normalizing the data.

iii. For dataset B the accuracy increased when the data was normalized. For dataset A the accuracy did not increase.

g. It will still be decided which model should be used since they all give good results.

h. B. Radiokana stated that in the following week the group will create an interface as an additional feature to demonstrate on open day.

i. It was then further stated that the poster will be started in the coming week.

j. Dr. Richards asked where the data for the training comes from to which E. Supuru responded that it is all found in a database on Kaggle.com.

11. Sonic Suction – 19G25
    a. H. Rehman stated that they will be working on theoretical models this week.
    b. H. Rehman further stated that they will do testing on the current suction model and use a piezo-electric microphone for suction.
    c. H. Rehman stated that the group will start on the poster this week and use latex for the poster.
    d. P. Makgobola stated that they were able to generate standing waves which can generate suction in one direction.
    e. P. Makgobola further stated that this week they want to work on different models that will give them the same result.

Key Notes

All groups must confirm their project name and location so that the appropriate banners can be made.

Groups must ensure that they choose a spot that is visible so that their presentations are not overlooked.

Announcements

1. Next group to chair the meeting will be group 19G11 (E. Supuru and B. Radiokana).
2. The meeting will be held in the Control Laboratory.

Next Meeting

2019/08/26 10:30 Control Lab

Name	Surname	Student no	Signature
Daniel	de Barros	1036613	
Daniel	Kutz	820971	
Sean	J van Rensburg	1073632	
Boitumelo	Radiokana	1386807	
ELIAS	SEPURU	1427726	
Anita	de Mello Koch	1371116	
Nicholas	Kastanos	1393410	
Junaid	Dawood	1094857	
THAPELO	CHABANGU	708607	
Jesal	Chana	603177	
HAROON	REHMAN	1438756	
Phetole	Makgobola	1078313	
Alexandra	de Nooy	1079587	
Seth	Bulkin	1131653	
Jason	Parry	1046955	
Mahomed Rashad	Cassim	1099797	
Jannes	Smit	1038253	

RESEARCH GROUP MEETING FOR BIOMEDICAL ENGINEERING TOPICS(WEEK 7)

Date | *time* 26/08/2019 | 10h30 | *Meeting called to order by* Elias Sepuru

Current Meeting

Chair: Elias Sepuru

Minutes taken by: Boikanyo Radiokana

In Attendance

* Student attendees can be found within the attached attendance register.

Supervisors: Ms Ellen De Mello Koch

Prof. David Rubin

Dr Xriz Richards

Mr Craig Carlson

Apologies: Thapelo Chabangu

Approval of Minutes

Elias Sepuru

Boikanyo Radiokana

Proceedings

1. E.Sepuru called the meeting to order
2. <u>Are they Breathing : 19G12</u>
   a. M.Muller stated that the past week they were busy with packaging the final product and running final tests.
   b. M.Muller stated that the group was busy preparing for open day, doing the poster and also started with writing the report.
   c. M.Muller stated that they are ready for the open day.
   d. Mr Carlson asked if all the groups are ready for open day.
   e. M.Muller stated that they will need to print out the poster for testing purposes.
   f. M.Muller stated that the group will need spare masks and cleaning detergents for open day.
   g. Dr.. suggested that the group must prepare participant information sheets for open day.
   h. Mr Carlson suggested that all groups must think of potential questions that people would ask on open day and that everyone must prepare thoroughly.
3. <u>Respiratory Disease Classification: 19G29</u>
   a. S. van Renburg stated that the group is done with the GUI.
   b. S. van Renburg stated that they have started with the poster which will be completed by tomorrow.

4. Monitoring Mood Changes from Daily Routines: 19G16
    a. N.Kastanos stated that they are still busy with fixing the placement of pictures on the poster.
    b. N.Kastanos stated that they are still improving the GUI.
5. Shear-wave Generator: 19G15:
    a. D.De Barros stated that the group has completed the GUI.
    b. D.De Barros stated that the group has achieved showing real time plots.
    c. J.Smit asked if it would be allowed to serve people small cups of jelly on open day.
    d. Prof Rubin answered that it will be fine to serve the jelly.
    e. Mr Carlson stated that the group must ensure that there is no food poisoning.
    f. J.Smit stated that he will bring a fridge to keep in jellies.
    g. J.Smit stated that in the past week they were able to pick up frequency shifts when using marbles.
6. A Cost-effective, Portable Sign Language to Speech Translator: 19G04
    a. M.Cassim stated that the group successfully remade the glove and completed final packaging.
    b. M.Cassin stated that with the remade glove, they were able to get a better accuracy.
    c. J.Parry stated that they worked on the poster and they are currently preparing on responses to possible questions that will be asked on open day.
    d. M.Cassin stated that they would like to show real time data on the interface.
    e. M.Muller asked how we should all include the minutes of all meetings of all appendices and what is the preferred structure.
    f. Mr Carlson stated that it is okay that everyone have a common set of minutes in their appendices.
    g. Prof Rubin added that for the personal reflections in the appendices would be better of in first person as it personalises the reflections based on experiences.
    h. Mr Carlson stated that in the personal reflections, the benefits, dislikes, problems encountered and lessons learnt must be included.
    i. M.Muller asked if it will be allowed to add additional data in the appendices.
    j. Mr Carlson stated that the report must follow structure stated in the project brief, since it makes it easy for markers to read and that this structure will be convenient for audit purposes.
    k. Mr Carlson stated that all the groups must consult with their respective supervisors for their preferences of appendices.
7. Detection of Depression from Speech: 19G31
    a. A.De Nooy stated that the group has completed the last testing for their project.
    b. A.De Nooy stated that they were working on the poster and it will be completed by tomorrow.
    c. A.De Nooy stated that their demo for the project is ready.
    d. A.De Nooy asked what kind of paper is preferred for the poster and in what size.
    e. Mr Carlson stated that the normal paper is recommended, however if one wishes to laminate the poster, it must be matte and not glass.
    f. Dr Richards stated that light will be reflected from glass and the poster will not be clearly visible.
    g. Mr Carlson stated that a person must still be able to read the poster 1 and half a meter away from the poster.
    h. Prof Rubin added that all groups must be aware of not adding too much text to the posters.
    i. Prof Rubin added that a picture is worth more than a 10000 words and a poster is better of with graphs than words.

j. A.De Nooy asked if it is allowed to reference a partners report and if so how should it be done.
k. Mr Carlson stated that it must follow the normal report style for referencing.
l. Mr Carlson added that he will send through the format of referencing a partner in a project.

8. Heartbeat Sound Segmentation and Classification: 19G11
    a. E.Sepuru stated that the group managed to do the GUI but it is still in progress.
    b. E.Sepuru stated that they are still busy will the poster and finalizing the features.
9. Electronic Stethoscope - Design, Prototyping and Testing Development with Enhanced Functionality: 19G43
    a. J.Chana stated that the group has completed testing.
    b. J.Chana stated that the group is done with the poster and it has been printed out.
    c. J.Chana stated that they need to fetch the display case from Genmin lab.
    d. J.Chana stated that they are now busy with writing the report.
    e. Prof Rubin asked if any group is considering publishing their reports.
    f. Prof Rubin stated that the report must have a high level of novelty, a new set of results, new set of ideas or findings.
    g. Prof Rubin stated that he and Mr Carlson recently published one of the 4th year reports from previous years .
10. Sonic Suction: 19G25
    a. P.Makgobola stated that they are still busy with final testing.
    b. P.Makgobola stated that the group is still busy working on the poser and preparing for open day.
    c. Prof Rubin stated that those who wish to publish their work, the final report will be a combination of the best elements of both reports and will be co-authored.
    d. Mr Carlson asked if any group has any issues and if there is anything that makes anyone feel uncomfortable about open day.
    e. S. van Renburg asked at what time will the staff inspection and openday will start taking place.
    f. Mr Carlson stated that the staff inspection will start on Wednesday at 14h30 -16h30 and open day will start at 13h15
    g. Mr Carlson stated that the groups must think of staff inspection as a mock open day.
    h. Mr Carlson stated that all projects setups must be finalised.
    i. Dr Richards stated that staff inspections are mainly to assess safety and posters

Key Notes

1. No Key Notes.

Announcements

Staff inspection will be happening on the 29/08/2018 at 14h30. All students must be at their respective stations and fully setup for open day**.**

Next Meetings

End of Group meetings