Biomedical Signal Processing Project
Classifying murmurs

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1 Introduction

In this project you will (hopefully) create a method to classify heartsounds based on if they contain heart murmurs or not. This task was actually given out as an international challenge for researchers, the newly named George B. Moody PhysioNet Challenge [1]. You will work with the same data, but we made your task easier by pre-selecting some of the data. You can use the original complete dataset [2], if you would like, but that is in another format and there are some other differences. All in all it is a bit more complicated to use that, especially based on the varying signal quality.

1.1 Heart murmurs

Heart murmurs are noises which occur in the heart when the flow of blood is turbulent and not smooth. This can be a symptom of heart problems such as valve stiffness (stenosis) or blood-backflow (regurgitation) which can lead to more serious diseases (for more examples see Figure 1 [3]). These noises can be classified with their pitch, timing, and shape. We usually see murmurs starting at some time during the systole or diastole and lasting for different amounts. Based on these the murmurs can be:

- Early-systolic
- Mid-systolic
- Late-systolic
- Holo-systolic
- Early-diastolic
- Mid-diastolic
- Late-diastolic
- Holo-diastolic

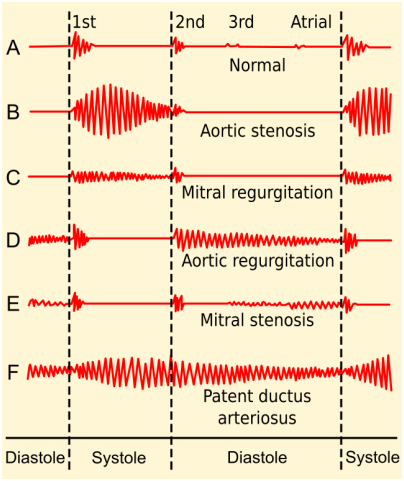

Figure 1: Heart murmurs and their causes

2 Project Description

After downloading the dataset, read in the data. It contains two folders for normal and murmur signals (.wav) and their corresponding heartsound labels (.tsv). In the label files the first and the second column is the start and end of the given event (seconds). Each heartcycle event has a number id: 1-S1, 2-systole, 3-S2, 4-diastole, 0-unknown. You can use anything you learned during the semester to implement your methods. The submission accuracies will be evaluated on a hidden testing dataset, but you can validate your process on the provided data.

2.1 Tasks

1. Research different techniques for PCG processing (spectrum, filtering, features, wavelets, energy, homomorphic envelope etc.)
2. Inspect the database and decide which researched processes can you use.
3. Create a helper function to better visualize the signals and the results.

4. Detect heartsound time locations.
5. Estimate the heartrate for a signal.
6. Separate systole and diastole regions.
7. Show different properties of the signals/segments. Compare regular and abnormal signals. (You can use the features you found during researching)
8. Classify each record as Normal or Murmur. You do not need to differentiate between the murmur types. (PCA, ICA, SVM etc.)
9. Create the documentation and a presentation (∼5 min + questions) for your submission.

Your submission should be in a form of a MATLAB function, which takes the signal in question as input and outputs the final classification as Normal or Abnormal (see the provided template). Please also provide documentation for your submission and some example results as well as the validation accuracy. If your main function calls other functions you made, please also include them in your submission. Your documentation should contain reasons for why you chose given properties for the classification, also it should contain the following table (Table 1) for a schedule and task distribution. Please give us a plan for your work at the start with the same table style. (These two tables do not need to match exactly)

Member	Week 1 (Nov4-Nov10)	Week 2 (Nov11-Nov17)	Week 3 (Nov18-Nov24)	Week 4 (Nov25-Dec1)	Week 5 (Dec2-Dec8)	(Week 6) (Dec9-Dec15)
Name01						
Name02						
(Name03)						

Table 1: Schedule and tasks

2.2 Provided materials

- PCG recording data (sample rate: 4 kHz)
- Heartsound location files
- Measured heartrate (bpm)
- MATLAB function template
- MATLAB runner and evaluator script

Obviously murmur information, heartrate, and the heartsound locations will not be available during testing.

3 Evaluation

Your work will be evaluated based on accuracy, code quality, documentation quality, and your presentation. Since this is a difficult task, we will measure multiple accuracies. Bonus points can be awarded for outstanding accuracy, a well researched method or for extra non-compulsory tasks (e.g. differentiating between systolic and diastolic murmurs). Points will be taken away if the code gives an error during testing, or it is heavily based on other teams' work, and if you use a ready solution without giving a proper reference to it and understanding how it works. We will ask questions about your implementation during your presentation. The accuracies for the results will be calculated as follows:

- Heartsound location: is it between the beginning and the end labels? - Hits/Misses
- Heartrate: what is the error percentage? - $\leq$5% error
- Systole/diastole: what is the overlap percentage to the real one? - $\leq$10% overlap error
- Classification (Normal/Murmur): sensitivity and specificity

The sensitivity and specificity will be calculated as their standard definitions, or to be more exact in the following way:

$$Se = \frac{TP}{TP + FN}, \quad Sp = \frac{TN}{TN + FP}$$

Where each term is defined as in Table 2.

	Murmur	Normal
Murmur Predicted	TP	FP
Normal Predicted	FN	TN

Table 2: Classification terms

References

[1] M. A. Reyna, Y. Kiarashi, A. Elola, J. Oliveira, F. Renna, A. Gu, E. A. Perez Alday, N. Sadr, A. Sharma, S. Mattos, M. T. Coimbra, R. Sameni, A. B. Rad, and G. D. Clifford, "Heart Murmur Detection from Phonocardiogram Recordings: The George B. Moody PhysioNet Challenge 2022," *medRxiv*, 2022. [Online]. Available: https://www.medrxiv.org/content/early/2022/08/16/2022.08.11.22278688

[2] J. Oliveira, F. Renna, P. D. Costa, M. Nogueira, C. Oliveira, C. Ferreira, A. Jorge, S. Mattos, T. Hatem, T. Tavares, A. Elola, A. B. Rad, R. Sameni, G. D. Clifford, and M. T. Coimbra, "The CirCor DigiScope Dataset: From Murmur Detection to Murmur Classification," *IEEE Journal of Biomedical and Health Informatics*, vol. 26, no. 6, pp. 2524–2535, 2022.

[3] "File:Phonocardiograms from normal and abnormal heart sounds.svg," https://commons.wikimedia.org/wiki/File:Phonocardiograms_from_normal_and_abnormal_heart_sounds.svg, accessed: 2022-11-01.