MPHY0002: Cardiac Engineering

ECG Assignment

(set by Eve Hatten, designed by Rebecca Yerworth)

Electronic submission via Moodle MPHY0002 course page

Deadline: 4pm Monday 9th December 2017

Introduction:

Electrocardiography (ECG) uses electrodes attached to the surface of a patient to measure the electrical activity of the heart. Clinically, several different combinations of electrodes are used so as to 'look' at the heart from different angles. In this assignment, the filtering requirements of a single, bi-polar measurement channel is investigated. The effectiveness of different filtering strategies will be tested using pre-recorded data from patients suspected of having first degree heart block.

First degree heart block (FDHB) is a clinical condition which shows on the ECG as a prolonged P-R interval, defined as ≥200ms between the start of the P wave and the beginning of the QRS complex (1).

The myDAQ serves as the 'patient', and is also used to collect and digitise the data. These instructions should be read in conjunction with the assessment rubric below.

Brief:

1. Research the filter settings used in routine diagnostic ECG recordings.
2. Design and prototype (breadboard) analogue filters for use in an ECG machine (You may use up to 3 filters, the output of one connected to the input of the next, each one consisting of a single circuit from M.Fry's Passive Filter's datasheet.[1]).
3. Characterise the filters, separately and together. The filters should have cut-offs compatible with standard clinical settings.
4. Use these filters on the provided raw patient data to obtain a cleaned signal for analysis in step 4: Download the sample ECQ waveforms (QTDB.mat), matlab programme ('ECG_prac.m') and reference data ('gold.mat') from Moodle, and place in the Matlab file path. QTDB consists of 30 waveforms from patients, which can be played through myDAQ ports (AO0-AO1) using 'ECG_prac.m', which simultaneously records from both AI ports. Do not change any of the settings in this Matlab function. Usage: *[data, time]=ECG_prac(patient_no)* where 'data': n by 2 matrix, one column per AI channel, one row per time point; 'time': n by 1 matrix and 'patient_no' is an integer from 1-30, selecting which patient's waveform to play.
5. For each patient, plot the data in matlab, measure the PR interval for 3 consecutive heart beats and average.

[1] Note: It is not good practice to string multiple filters together like this, due to 'load' issues, which you will learn about next term. However we expect you to do so for this practical, but in order for this deliberate simplification to be valid, you must use the same value of capacitor in all your filters.

6. Classify each patient as ‘normal’ or ‘PR≥200ms’
7. Calculate the sensitivity and specificity of your results vs the clinical interpretation (gold.mat from moodle: logical 1 if PR≥200)
8. Discuss the clinical and ethical implications of your sensitivity & specificity results and the advantages/disadvantages of analogue and digital filter approaches. Remember that your input signal has been artificially constrained by the myDAQ’s Digital-Analogue Converter characteristics.

Your report should include all PR values and classifications, and example waveforms.

Equipment

You should design your filters using a selection of the following passive components which will be available in the lab:

Resistors: E6 series, 1% tolerance; from 10ohms to 1.0MegOhms (39 different values)

Capacitors: 1nF, 2.2nF, 4.7nF, 10nF, 47nF, 0.1uF, 0.47uF, 1uF, 4.7uF, 10uF, 47uF, 100uF, 470uF, 1000uF.

Inductors: 1µH, 10µH, 1mH

References

1.Pocock G, Richards C, D., Richards D, A. Human Physiology. 4th ed: Oxford university Press; 2013.

Assessment Rubric:

1) Filter specification & characterisation	a) Appropriate Filter cut-offs chosen, referenced b)Evidence of calculations used to select appropriate components for each filter c) Frequency vs amplitude plots which confirm filters match specification, for each filter individually, and the combination.	1 8 4
2) data collection	Example of filtered waveform	1
3) PR measurements	Average PR interval for each waveform	2
4) Waveform classification	Normal or FDHB, for each waveform	1
5) Sense & Spec	Calculations and results	4
8) Discussion	Clinical and ethical implications of your sensitivity & specificity results and the advantages/disadvantages of analogue and digital filter approaches	5

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Also note the penalties for late submission: https://www.ucl.ac.uk/silva/srs/academic-manual/c4/module-assessment#3.11, section 3.11.5 will apply from 9am on 10th December.