H7128 Smart interactive sensing systems and applications

Coursework retake 2024

Please refer to your own Assessment Deadlines & Exam Timetable in Sussex Direct/canvas for all submission details.

Exercise brief - This exercise assignment requires you to develop a simulated heart rate monitoring device using LabVIEW.

The use of LabVIEW was covered in the module laboratory sessions and all information about how to use and install the software, are available on the module canvas website.

You should submit your assignment using a word processor along with printouts of the LabVIEW block diagrams and front panels developed as part of this coursework.

Remember to include all the obtained results, and any calculations required for the sub-systems and the complete integrated system.

- ✓ Include all necessary calculations and designs, including a discussion about these.
- ✓ Explain and discus the choice off all involved components referring to the datasheets used for the work developed. Show all relevant simulation results in and professional and understandable way.
- ✓ Discuss your results referring to the concepts involved in each step of your work.
- ✓ Conclude about the overall performance of your system.
- ✓ Include high quality references (books, journal articles, data sheets, lecture notes) as needed.

Task description

This CW aims on developing a heart rate (HR) monitor similar to those found in smart watches.

This consists of three fundamental parts:

- Simulated Heart rate signal design
- Signal acquisition.
- Signal processing, GUI development and output.

1. Physiological and Biomedical Aspects

This coursework aims to build a smart-interactive device that can measure a person's heart. When your heart beats, blood is pushed into your arteries and this pulse propagates throughout the body to your extremities, which can be detected as a momentary increase in the volume of blood in your finger. A single heartbeat has two phases, the systole and the diastole, contributing to the peaks that can be seen on a heart rate monitor. The systole occurs as blood is pushed from the heart through the aorta into the rest of the body, and it is responsible for a larger peak seen on a heart rate monitor. The diastole occurs when blood flows from the body into the right atrium, causing a smaller but distinct peak.

You will apply what you have learnt about data acquisition and processing within a LabVIEW project. Your work will mainly cover the steps that we have already been working in the module (H7128) such as: data collection, processing (i.e. digital filtering), and display. For the data collection, you will be simulating a real world parameter (i.e. Heart rate). In the data processing part, you will require implementing an algorithm for calculating your Beats per Minute (BPM) based on a person's heartbeat frequency. Finally, you will require developing a GUI to display this information in a clear and concise manner as well as adding an audible indicator that produces a beep on every pulse detected.

2. Heart signal simulation

You will have to simulate the HR signal typically acquired using a HR sensor.

Consider the exercises developed during the module and use a suitable LabVIEW function to simulate a HR signal.

a) Produce a sinusoidal waveform within the frequency ranges for averages person heart rate (see step 3). Then select a suitable amplitude considering that this will be simulating the signal representing the data collected through your sensor. Justify your choice.

b) Add the noise present on a real recording (i.e. those produced by external factors). Hint: inverse F noise with an amplitude of 0.005 can be used for such purposes. The signal should look similar to the trace below:

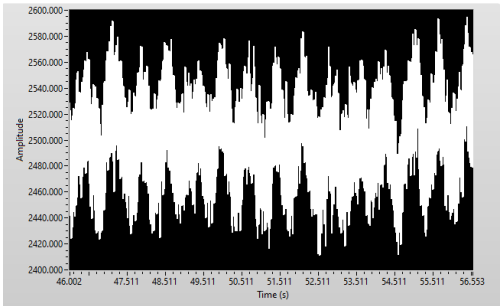

Fig1. Simulated HR signal containing nose

c) Choose an appropriate number of samples and a suitable frequency.

3. Digital Filter design.

We know from our course that the raw data to be acquired using our sensor has inherent noise due to the low magnitude of the signal. Filtering must be performed in order to achieve a useable signal that represents your heart rate. The raw signal has an abundance of high frequency noise which can be

observed in the raw signal as well as in its DC offset causing it to fluctuate. To eliminate this high frequency noise and the DC offset, it is necessary to determine where the desired signal lies on the frequency spectrum. First, assume that an average person's BPM lies between 60 BPM and 120 BPM. The frequency of this BPM signal would then be around 1 Hz when you are at rest and may raise up to 3.5 Hz if you were doing exercise.

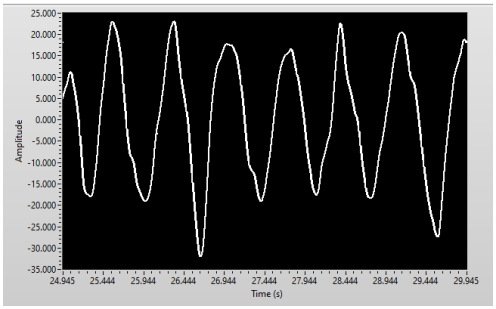

Fig2.Noise Filtered HR signal

a) Based on the information above design a suitable filter that can be used to remove any frequency components outside the signal frequency. You will need to consider the explanation above to set your lower and higher thresholds. The signal should look similar to the trace presented above:

b) The signal will have to be filtered until the heartbeat peaks are reliable enough to be counted by a software algorithm. Present the results including both the block diagram and GUI and justify the choices made.

4. Simulated HR detection and display

The software for the Heart Rate monitor project will require you to perform the following:

Data Processing - Use a threshold value that determines the cut-off for peak detection; peaks that are below the threshold are ignored during calculation and peaks that are above the threshold are included. Determining a good value for the threshold is dependent on several factors such as noise in the environment, the baseline of signal, the peak signal amplitude, etc.

Displaying the data to the user - data is displayed to the user in the form of a flashing LED control and a graph that shows the collected signal and the peak detection threshold. For the audible indicator when detecting every heart rate (consider exploring the palates to find the suitable function i.e. graphics and sound). **Include a short video in your submission together with your document**. (Hint – You can add both files in a zip folder)

The user interface should look similar to the one shown below:

Fig 3. CW graphical user interface

5. Course Work Submission guidelines:

You will submit an individual report which describes your CW project. Please refer to your own Assessment Deadlines & Exam Timetable in Sussex Direct/canvas for all submission details.

Word length – 2500 words (does not include equations, tables and figure captions).

Report structure.

The report must include the following pages and sections. Number the major sections and sub-sections.

Title page – showing the title of the report, your candidate number (not name) and word count.
Summary - describing briefly, but clearly, the objectives of the project and the basic techniques involved; states the principal results and conclusions; omits all inessential detail; stands alone i.e. must make sense without reading any other part except the title; is on a single page.
List of contents - with page numbers.
Introduction – introduces the project and its objectives; describes the technical background and equations to be used.
HR signal simulation and digital filter design – including the design considerations and block diagram.
Simulated HR detection and display – demonstrating your understanding while explaining the code. Include screenshots of the block diagram.
Test results – describing the method of the VI development, including any problems encountered. Include a critical evaluation of all of the test results, with reference to the system design requirements.
Conclusions – a brief summary of how the objectives of the CW project have been achieved and why; consider what could have be done in addition, or differently.
List of references – a numbered list of the sources of information used in the report, correctly formatted according to the Numerical referencing system and cross-referenced in the main text by number.

Report presentation

- Use a clear font of at least 11 point;
- number all pages;
- number all equations;
- number all figures and tables and include figure and table captions;
- refer to all equations, figures and tables in the text;
- Only include images which are essential to understand the information you are providing;
- make sure that all images, figures and diagrams are clear and easy to view;
- write in accurate, grammatical, technical language as explained in lectures;

- use the Numerical referencing system;
- save your document in one of the supported file formats for e-submission;
- name the document file “H7128 Report and your candidate number”.