Designing A Heart Rate Monitoring System & Exploring Blood Pressure Prediction Using PPG Sensors

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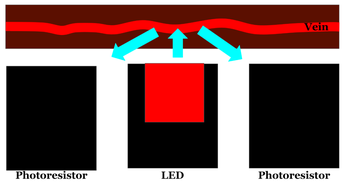
Background

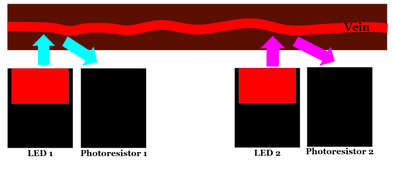
- Cardiovascular disease is approximately responsible for one in four deaths in the United States. An indicator of a heart problem can be revealed through abnormalities in a person's heart rate.
- A common way to measure heart rate is through photoplethysmogram (PPG) which uses light to detect changes in blood volume.
- Current PPG technologies have the capacity to measure the heart rate but the only way to read blood pressure is through cuff based equipment.
- Miscuffing an individual can lead to inaccurate results and a patient with cardiac problems being misdiagnosed.
- Based on this background the research goal is to use the heart rate data generated from two photoplethysmogram (PPG) sensors at different locations along the finger to give a continuous reading of blood pressure.

Methods

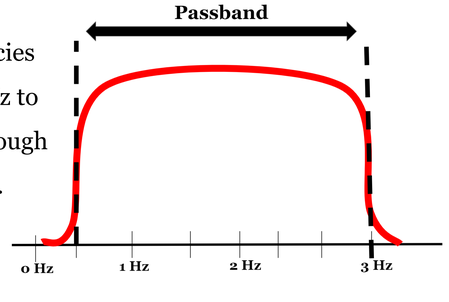
- Tools for collection and analysis were Labview MyDAQ (Data Acquisition Device) and Laboratory Virtual Instrument Engineering Workbench which is a graphical programming language.
- Tested one prototyped sensor using one LED and two photoresistors equally spaced apart to generate data regarding heart rate.



- Tested second prototyped sensor using two LEDs and two photoresistors at different locations along the finger to generate data regarding heart rate.

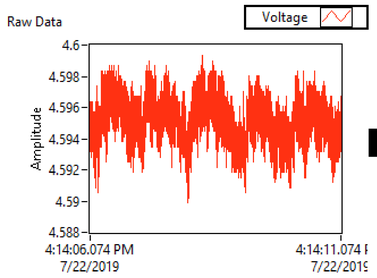


- Previous attempts such as applying an amplifier and a new circuit design failed to eliminate signal interference from both sensors. The best method to overcome signal interference from both sensors is to use two completely separate data acquisition devices.
- Used a bandpass filter to pass frequencies within a certain range of 0.5 Hz to 3 Hz to allow the heartbeat signal to come through and outside signal noise to be rejected.



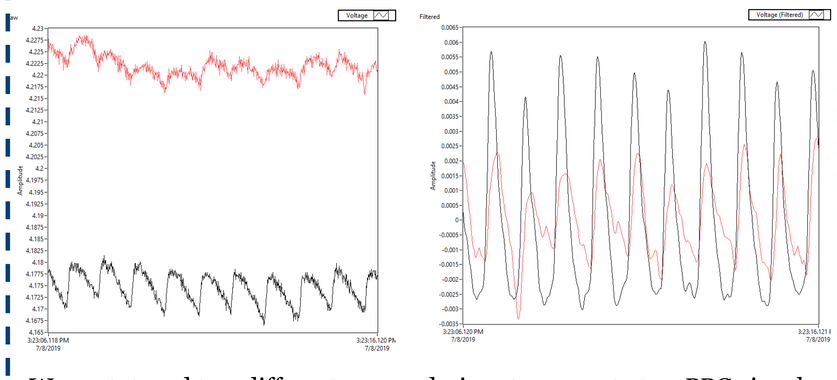
Results

Unfiltered data from using one sensor:

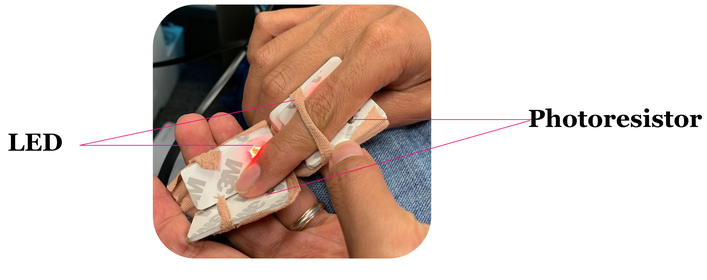


The figure on the left shows the raw data generated from our sensor and the figure on the right shows what that data looks like after it has been passed through the bandpass filter. From this data we were able to program our sensor to give us a readout of the beats per minute made by the heart.

Data from using two sensors:

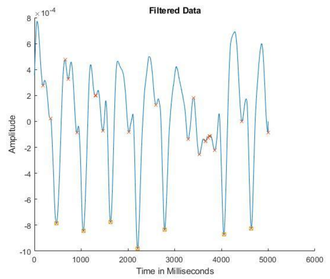


We prototyped two different sensor designs to generate two PPG signals and found that two LEDs and two photoresistors along the finger gave the best signal. Using a bandpass filter for the data generated and adjusting the millisecond differences between the sensors we were able to produce two waves that flow alongside one another.



Shown above is a picture of the device we prototyped. By using two sensors at different distances along the same finger we were able to see heart rate variability from the data produced

Filtered data from using one sensor:



	Our System	Commercial Device
Subject 1	61	61
Subject 2	84	72
Subject 3	80	75

We exported data from the Labview Workbench where we were storing data generated by the sensor and imported it into Matlab to perform peak anaylsis to generate heart beat. From the data we compared our results with a commercial device to see if our results we gathered were in an acceptable range.

References

- National Instruments. *Build Your Own Heart Rate Monitor*. 2012, http://www.ni.com/tutorial/14248/en/.
- Khalid, Syed Ghufran, et al. "Blood Pressure Estimation Using Photoplethysmography Only: Comparison between Different Machine Learning Approaches." *Journal of Healthcare Engineering*, vol. 2018, 2018, doi:10.1155/2018/1548647.

Conclusions

- **We have demonstrated that using a two photoresistors and two LED approach at different lengths along the finger are probable routes to detecting heart rate variability**
- **In the future this approach to generating blood pressure using the heart rate data generated from two different locations along finger has possible medical applications**

Acknowledgements

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