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# The Heart of the Matter: Proposal

## 1. Introduction

Cardiomyopathy, enlarged heart syndrome, causes the walls of the heart to thicken to an abnormal degree. While several types of cardiomyopathy are common among people, hypertrophic cardiomyopathy is one of the most common among young people, especially athletes, who suffer from unexpected cardiac arrest. As the walls of the heart thicken, blood is unable to get through the ventricle. While symptoms of the disease do not exist for many carriers of cardiomyopathy, this obstruction often presents itself as heart arrhythmias. Young athletes who participate in rigorous physical activities are more likely to suffer from heart arrhythmias, and more severely, cardiac arrest, due to cardiomyopathy. Tests for cardiomyopathy are not integrated into standard physicals, so the disease is difficult to catch until severe problems arise. The purpose of our Senior Design project is to create a device that looks for signs of this disease.

## 2. Problem Description

Physicians usually do not specifically test for cardiomyopathy due to the rarity of the disease and because ultrasounds and x-rays, the only completely accurate tests to determine enlarged hearts, are expensive. Our senior design project aims at looking for symptoms of the disease, specifically abnormal pulses (arrhythmia) and blood oxygenation levels. People with cardiomyopathy often have pulses with a “twice beating” rhythm, which are occasionally difficult to detect with a standard touch or stethoscope testing. Oxygen level testing is absent entirely from most standard check-ups. However, abnormalities in both pulses and oxygen levels may point to larger problems in the heart. The device we create will be able to show abnormalities that would prompt the patient to get further testing.

## 3. Proposed Solution

We plan to create a photoplethysmography (PPG) instrument to observe blood oxygenation levels and heartbeat regularity. Photoplethysmography is an optical method of measuring an organ’s volume by way of infrared and red light. The change in volume caused by the pressure pulse is measured according to the amount of light transmitted to a photodiode. The microcontroller at the center of the device will determine the alternating flash rate of the infrared and red lights, and to process the data collected by the photodiode. Our device will connect to a computer to show the measured waveform of the heart’s cycles (displaying any recordable arrhythmia), as well as outputting to the terminal an actual pulse rate and oxygen absorption levels within the blood. The high level diagram of the proposed device is displayed below in Figure 1.

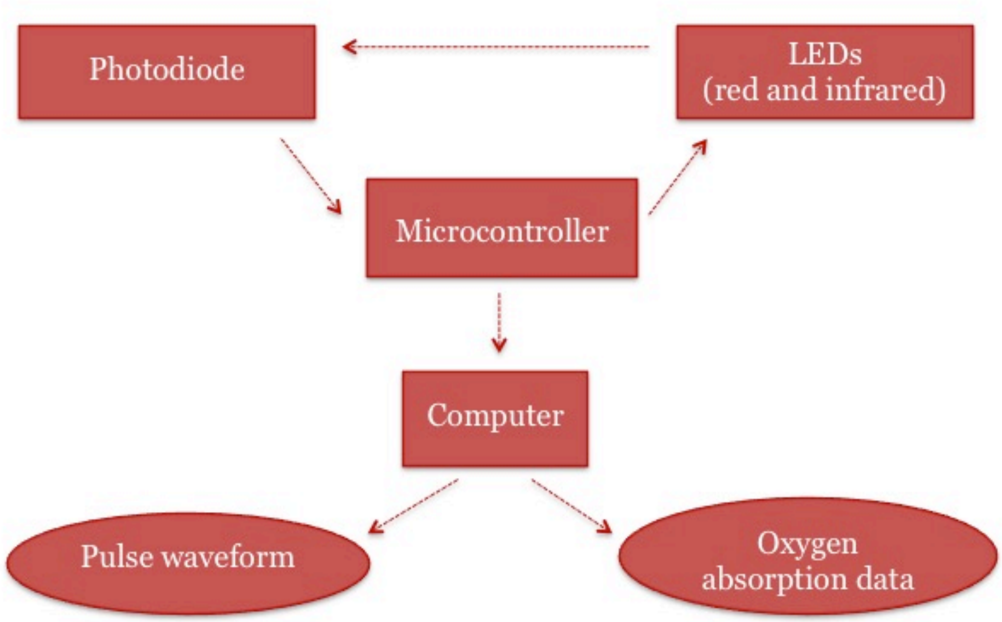


**Figure 1. High Level Diagram**

## 4. Demonstrated Features

First, we will demonstrate communication between the microcontroller and LEDs. The microcontroller will power the LEDs and control the alternate blinking of the red and infrared LEDs. Additionally, the microcontroller determines the rate at which the LEDs blink. Next, we will demonstrate the photodiode's ability to capture the light signal and allow the current to pass through. Then, an amplifier circuit will boost the amplitude of the signal before passing it back into the microcontroller. After the signal is amplified, it will be run through the microcontroller to be sent to the computer display. The computer display will output the collected data and plot the resulting oxygenation level and pulse waveforms. We plan on using MatLab to process and display the data.

**5. Available Technologies**

The following provides a list of the available technologies we plan to use for our project:

Making circuit board ~ $50

Microcontroller ~ $20

IR LED (940 nm) ~ $.75 each

Red LED (660 nm) ~ $.50 each

Plastic for finger clip ~ $10

Spring ~ $1

Photodiode ~ $1 each

Op amp ~ $5

**6. Engineering Content**

The project will focus on the following functional blocks:

1. Microcontroller communication to LEDs
2. Photodiode's light absorption
3. Photodiode's output back to microcontroller
4. Data from microcontroller to MatLab
5. Creating a program that takes the data and displays relevant waveforms

First, the microcontroller must properly communicate with the LEDs to power, control, and regulate the light output. Next, the light will shine through the finger (blood) and the photodiode will capture the transmitted light--the light not absorbed by the blood. The photodiode takes the light and outputs current, which will then be communicated back to the microcontroller. The data must be properly sent to the computer. Finally, we will create a MatLab program to interpret the data from the microcontroller. The data will be presented in waveforms and then analyzed to determine if the oxygenation and pulse readings are abnormal.

## 7. Conclusion

Our senior design project aims at creating a photoplethysmography device to analyze oxygenation levels and pulse rhythm. Many people suffer from hypertrophic cardiomyopathy, the disease of an enlarged heart, which often goes unnoticed as there are few methods of identifying this condition short of a full ultrasound of the heart--a lengthy procedure produced by an extremely expensive device. While many people never show severe symptoms, even minor arrhythmia and abnormalities in blood oxygenation levels can point to greater problems in the heart. Our photoplethysmography device would act as a topical test searching for these smaller symptoms as red flags necessitating further and more extensive testing for cardiomyopathy or other heart conditions if results are irregular.