Smartphone Based Nano-device for Human Breath Sensing

PROJECT PLAN

Team Number: 22
Client: Prof. Long Que
Adviser: Prof Long Que

Team Members/Roles:
Jared Smiley-Team Leader
Zhaobo Huang-Webmaster
Mengzhou Sha-Communication Leader
Xin Chen-Concept Holder
Team Email: jcsmiley@iastate.edu
Team Website: http://smartphonespectrometer.weebly.com

Revised: 11/19/2016 V2

Contents

1 Introduction

1.1 PROJECT STATEMENT

The goal of this project is to provide a non-invasive test for diagnosing diseases in a portable, cheap, user-friendly package. Our project utilizes the capabilities of an optical spectrometer developed by our mentor to intake a patient's breath and determine the bacteria or virus causing a patient's illness using spectral analysis. Our goal is to attach the spectrometer to a smartphone and develop an app to allow the capabilities of the spectrometer to be utilized in a portable, cheap, user friendly package.

1.2 PURPOSE

This project will benefit society because it could replace more invasive forms of medical diagnostic testing such as blood tests. This means lower cost to diagnose, greater portability, greater patient comfort, more efficient use of doctor's time, and puts greater information into the hands of patients by allowing for self-diagnosis. All these factors give patients a better option for diagnosis than is widely used now. It could also allow third world countries with poor health care access to accurate diagnoses that had previously been too expensive or logistically impossible to achieve. This could save countless lives.

1.3 GOALS

Our goals for this project include becoming better at teamwork as well as improving our technical skills in several areas. Additionally, we have goals for the performance of the product of our project. Below is a listing of specific things we would like to learn and product capabilities we would like to achieve:

-learning to use 3D printer and develop 3D cad designs
-learn how to plan software (Android app) project to make sure all components work together at the end
-determine best places to research android code implementation
-learn how to build a user interface that is user-friendly and can be understood by people with very little technological experience
-learn how to give presentation in a convincing manner and effectively explain project
-learn how to effectively work in a team, delegate tasks, develop schedule, and bring product pieces together in working unit
-learn how to ensure whole team is understanding the project and how their tasks fit into the project
-develop a product that is much easier to use to diagnose diseases than is currently available
-build a product that is cheaper than current testing methods and durable enough to be used in third world countries
-build a product that always diagnoses correctly

2 Deliverables

-3D Design for spectrometer housing phone case
-3D printed spectrometer housing phone case for spectrometer that our mentor will develop: should be durable, portable, fairly cheap to build
-Android app that can determine frequencies and intensities of light that is focused on the camera by the spectrometer
-App must determine which diseases emit these light frequencies
-App must have easy to use user interface

-App must communicate with user steps to use the app and clearly display what disease is present

3 Design

3.1 PREVIOUS WORK/LITERATURE

There are many commercial spectrometers on the market that provide similar functionality as our design although most are much more expensive, less portable, and less user friendly. One example is the Avio 200 ICP Optical Emission Spectrometer.

Several other people have done similar projects. The first was created by several professors in Australia and was shown to us by our professor to base our project on. They created a smartphone spectrometer using optical fiber to carry light and a diffraction grating to shine it on a smartphone camera. Additionally, they designed an app capable of determining specific nucleic acid sequences based on the light spectrum shone on the camera by the spectrometer.[2]

Additionally, several professors at the University of Illinois developed a smartphone spectrometer. They included their software for determining the intensity vs frequency graph that could run on a smartphone as well as their CAD design for the spectrometer. There are some differences between their design and ours. For instance, their spectrometer doesn't look very portable and their software doesn't determine which disease maps to the given spectrum the smartphone senses. They do however give good explanations on the basis of spectrometers that will be helpful in our design.[3]

Consumer Physics has developed a $150 spectrometer that pairs with your smartphone via Bluetooth and sends spectrum pictures via the internet to their servers to be evaluated to determine what the substance is. So far the product can identify medicine and food but there is no mention of determining diseases unlike our design.[1]

1. "Consumer Physics." *Consumer Physics*. N.p., n.d. Web. 19 Oct. 2016. <https://www.consumerphysics.com/myscio/scio/>.
2. Md Arafat Hossain, John Canning, Kevin Cook, and Abbas Jamalipour, "Optical fiber smartphone spectrometer," Opt. Lett. 41, 2237-2240 (2016)
3. Scheeline, Alexander, and Kathleen Kelley. "Cell Phone Spectrophotometer."*Cell Phone Spectrometer*. N.p., n.d. Web. 19 Oct. 2016. <http://www.asdlib.org/onlineArticles/elabware/Scheeline_Kelly_Spectrophotometer/>.

3.2 PROPOSED SYSTEM BLOCK DIAGRAM

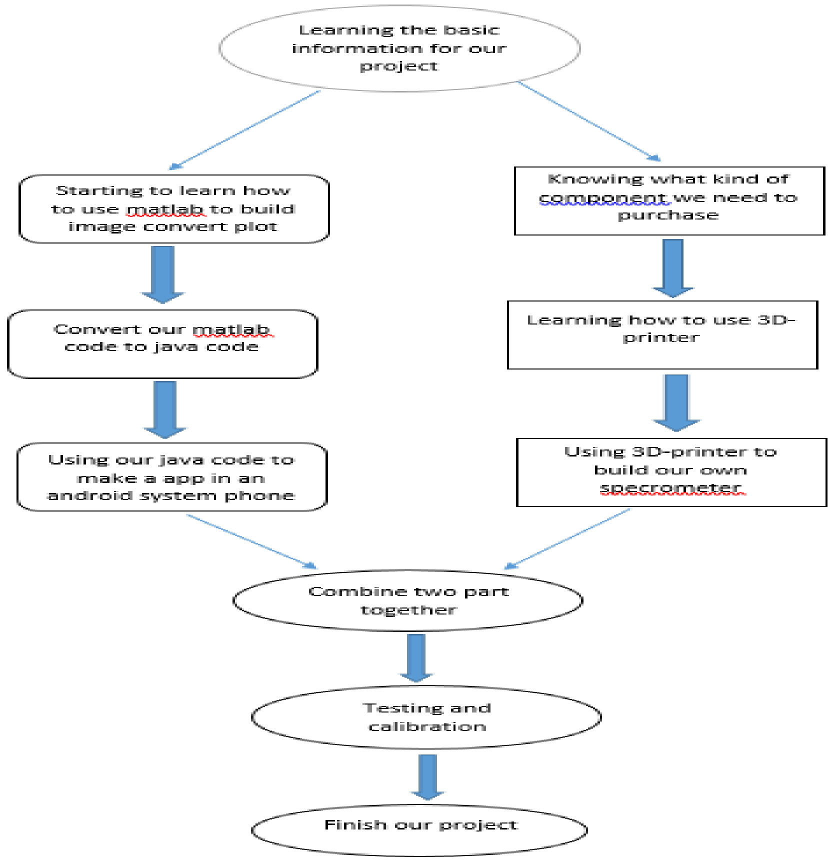


Fig. 1 - Process Block Diagram

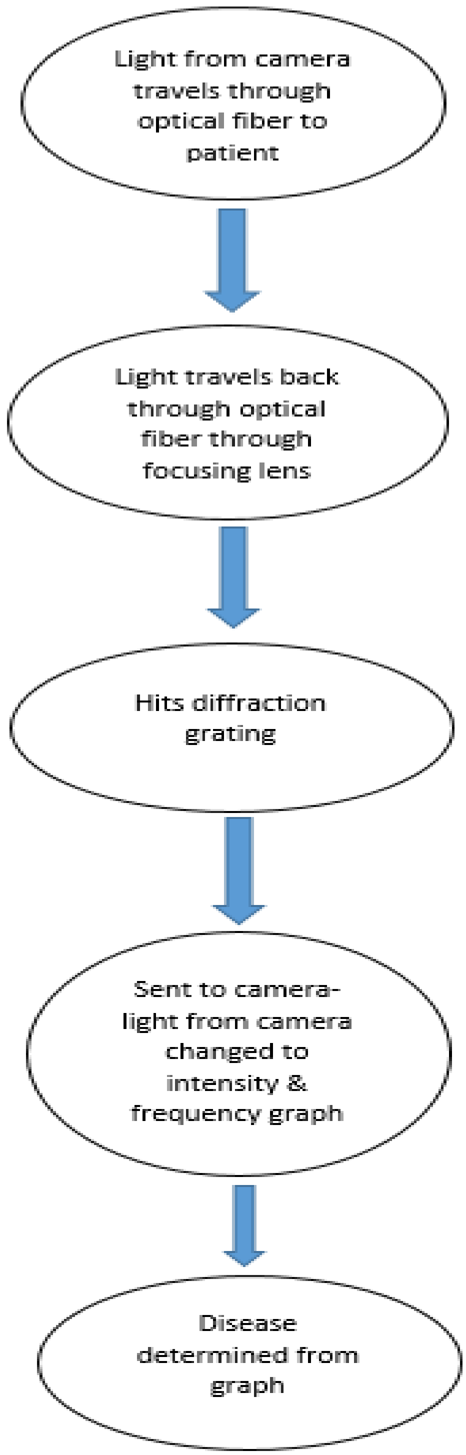


Fig. 2 – Project Block Diagram

3.3 ASSESSMENT OF PROPOSED METHODS

Several different aspects of the project present a choice between several options. The first choice is whether we want to develop an Android or iOS app. Another choice is how we want to determine the frequencies of light shown on the camera. The first option used by most commercial spectrometers is to determine what frequency is diffracted to different locations on the camera based on the angle different frequencies of light diffract at. The other method is to determine the frequency of the light based on the color value provided by the camera. Another choice we can envision at this point is whether to send the image data over the internet to be analyzed on a server with more computer power and memory or to do all the analysis on the phone. A new challenge we have found is how to create a spectrometer that can be adapted to different android phones each consisting of different sized photo-detectors and different lenses on the camera.

Our preliminary decision is to create an android app because there are fewer licenses required and that is the platform that we have the most experience coding in. Additionally, we plan to determine the frequencies by plugging in the angle of diffraction into our app so that it will know where on the camera different frequencies always shine. We believe that if we base the frequency determination on camera color, our answers will change for every smartphone we use the spectrometer on due to different camera designs and color variations. Lastly we plan to do the frequency vs intensity plot and the disease determination on the phone. We believe that the plot will take very little computing power and that many different disease spectrum plots can be saved with very little memory. These plots can then be used to match our plot with and find a disease. In order to make the spectrometer adaptable, we thought about making the spectrometer adjustable so that you can change the distance from the diffuser panel to the camera so that the size of the diffused image can be adjusted to fit the size of the camera. The app will also have to be customized based on the size of the camera to determine what frequency corresponds to what pixel on the image. We can do this in a setup potion of the app.

3.4 VALIDATION

In order to determine if using the diffraction equations provides a correct spectrum image, we will use java code to make a app. After that, we combine our 3D-printed spectrometer with an android system phone to test it. If it creates a frequency vs intensity plot very similar to a commercial spectrometer pointed at the same substance, we know this solution works. If, however it is off due to unpredictability of the distance to the camera when you attach the spectrometer to your phone, we will have to use color to detect frequency.

To determine if we can successfully identify diseases, we may have to find a lab on campus with access to microscope slides of diseases and determine if we can successfully identify them using only the phone processor and memory of if we must use a central server for the calculations.

We must extensively test our product to ensure that it correctly diagnoses patients. Durability can be tested by repeatedly dropping device on floor and then testing to make sure it still can diagnose. Additionally, we believe that Android is the best solution because it is much more prevalent worldwide than iOS. If we have extra time, we may work on an iOS app.

4 Project Requirements/Specifications

4.1 FUNCTIONAL

-Android application must include capability to determine all frequencies of light entering camera
-Android application must include capability to determine the intensity of each of these frequencies
-Android application must include capability to graph frequency vs intensity spectra
-Android application must include capability to determine what bacteria or virus would make that intensity spectra
-Android application must include user friendly UI for clearly describing how to run app and clearly displaying results
-Capable of adjusting to installation on different android platforms with different camera's and resolution

4.2 NON-FUNCTIONAL

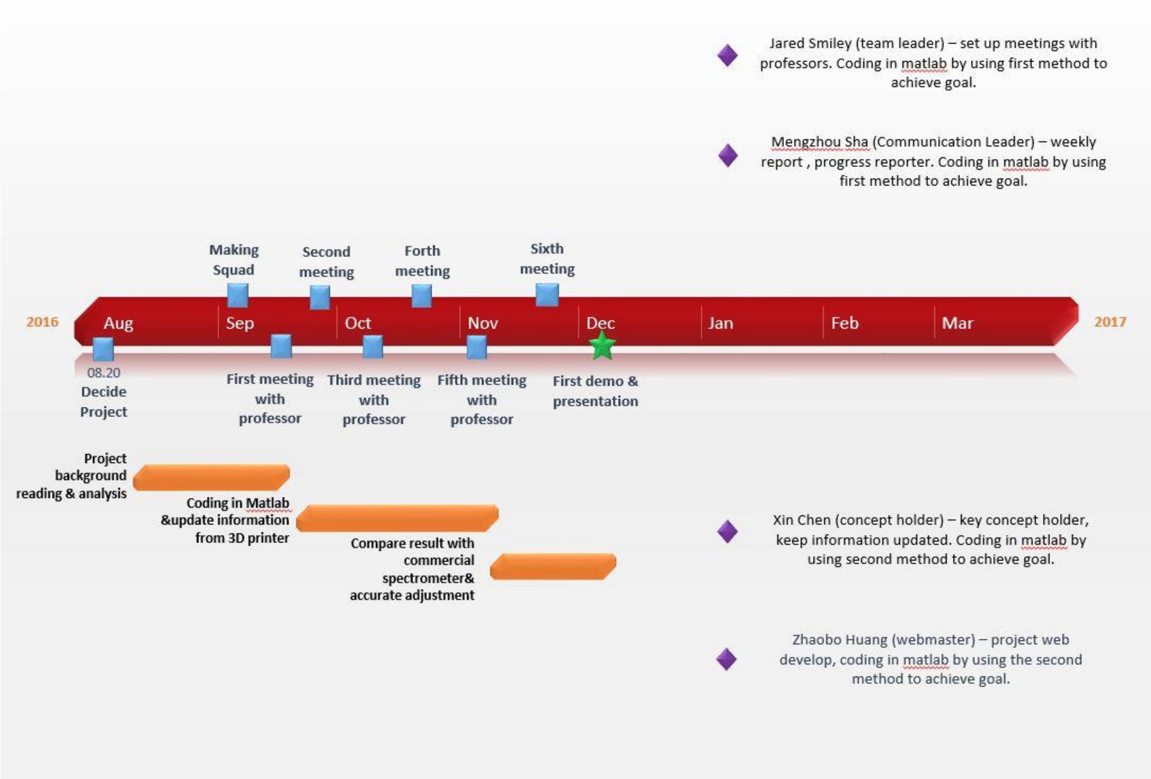
-An app that can run on any Android capable device
-A 3D model and case for the spectrometer to fit over a phone
-Associated 3D CAD model and app design documentation

5 Challenges

-None of us have a lot of experience with writing an app so it will take a lot of debugging time
-None of us has experience using the 3D printer. It is a new thing that we need to learn.
-None of us have a lot of experience with 3D CAD design so it will take a lot of time to learn
-Need to purchase some parts of the Spectrometer-Roughly $400 cost
-It may be hard to find slides of diseases, viruses, or bacteria to test our device on
-It could be tough getting the spectrometer to work on different phones with different cameras, resolutions, color coding schemes, and distance from spectrometer to camera image detector

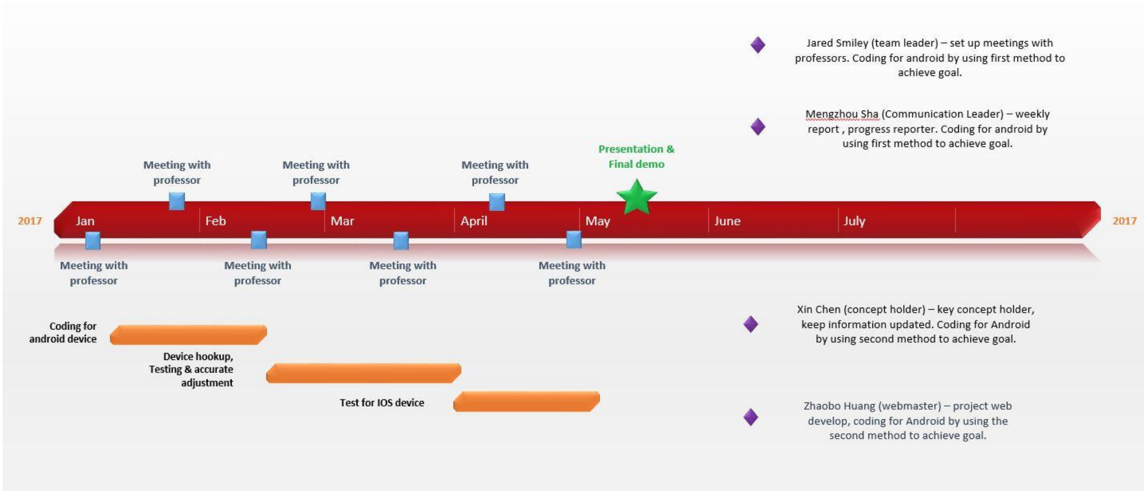
6 Timeline

6.1 FIRST SEMESTER



So far, our team has completed the Matlab code and has gotten a similar frequency vs intensity graph from what they obtained in the academic paper we are basing our design on. Before our presentation, we would like to obtain a new picture using the commercial lab spectrometer and run it through our matlab code at the same time the commercial spectrometer creates an intensity vs spectra graph. We can then compare the two to ensure our code works correctly. We can do this several times with different substances in the spectrometer to ensure that our code does not have trouble handling several different situations. Additionally we have developed an app that can take pictures and display them on screen. Before our presentation, we hope to develop the app further so that it can determine the intensity and frequency spectra of the picture in a similar way to the matlab code and plot the graph on screen.

6.2 SECOND SEMESTER



After completing the app to plot intensity vs frequency of an image, in the spring semester we need to further develop the app to match the spectrum with the spectrums that occur with different diseases. After this, a significant amount of testing needs to occur to determine if it can correctly identify most common diseases by utilizing our app with microscope slides of the disease. Additionally we need to develop a 3d design and a 3d printed case to fit the spectrometer that fits over a phone.

Zhaobo and Jared will primarily be working to develop the app as they have the most android development experience and Xin and Mengzhou will be working to design and 3d print the case.

7 Conclusions

Our project plan is to build a spectrometer that a patient can breathe into and an app capable of analyzing spectrum data from the spectrometer and shown on the camera. The app should be able to graph the intensity vs spectrum and determine what virus/bacteria gives off this spectrum. We have broken this problem down into several manageable portions that we can incrementally develop and then combine to form the final working project. Additionally, we hope to develop good teamwork and project management skills. So far, we have made good progress and have a good plan toward completing the project.

8 References

1 "Consumer Physics." *Consumer Physics*. N.p., n.d. Web. 19 Oct. 2016. <https://www.consumerphysics.com/myscio/scio/>.

2 Md Arafat Hossain, John Canning, Kevin Cook, and Abbas Jamalipour, "Optical fiber smartphone spectrometer," Opt. Lett. 41, 2237-2240 (2016)

3 Scheeline, Alexander, and Kathleen Kelley. "Cell Phone Spectrophotometer."*Cell Phone Spectrometer*. N.p., n.d. Web. 19 Oct. 2016. <http://www.asdlib.org/onlineArticles/elabware/Scheeline_Kelly_Spectrophotometer/>.

9 Appendices

If you have any large graphs, tables, or similar that does not directly pertain to the problem but helps support it, include that here. You may also include your Gantt chart over.