Memorandum

To: Mel Dundas, Wayne Mayes
CC: Joe Benge
From: Bikramjit Singh, Amandeep Singh, Zachary Legg
Date: September 22, 2017
Subject: Motion Synthesizer

SUMMARY

The Motion Synthesizer is a fun device for creating and playing music. It's an electronic instrument that can produce various sound effects. The user will be able to control the pitch of the sounds with motion. We will create a simple human to machine interface so that anyone can use our synthesizer.

BACKGROUND

For our final project, we wanted to make something that everyone could enjoy using. We came up with an idea to make a device that would allow the user to easily control different sound effects with their body movements. The original idea we had for our project was to control pitch by detecting the user's hand motion with two ultrasonic sensors. We really liked this idea, but we found that this approach would restrict the user's range of motion and creativity. We did some research on computer vision, and found that we could base tones on the user's body motion captured using a camera. This second approach would give the user more freedom and creativity. Both the first and the second approach offer different dimensions to our final project, so we decided that we would implement them both.

PURPOSE

The Motion Synthesizer is an electronic musical instrument which will allow anyone to control different sound effects. This device could be used in schools, especially by the low incident students who may not be able to play a musical instrument with the band, but still want to be musically creative. It may also help them to express themselves and communicate in a different form. The Motion Synthesizer can be used as a tool to teach some of the science concepts like sound, tone, pitch, and movements.

FUNCTIONALITY

The Motion Synthesizer can be considered a toy for people of all ages. The user will be able to choose different sound effects and will be able to control the pitch with motion. The device's volume, sound effects, and modes will be controlled with push buttons located on the surface of the enclosure. The Motion Synthesizer will have two modes that a user can choose between. In the first mode, the Motion Synthesizer will change the pitch based only on distance measurements made by two ultrasonic sensors. In the second mode, the Motion Synthesizer will use a USB camera to capture a stream of digital images which will be analyzed to provide external motion data. We will need to learn about the OpenCV programming library so that we can use real time computer vision to track moving objects and generate tones based on the data. There are many algorithms to track moving objects, but we will need to test for which one will render the best results for our project. A simple block diagram of the Motion Synthesizer's functionality can be seen below in Figure 1 (See Appendix A for a more detailed drawing).

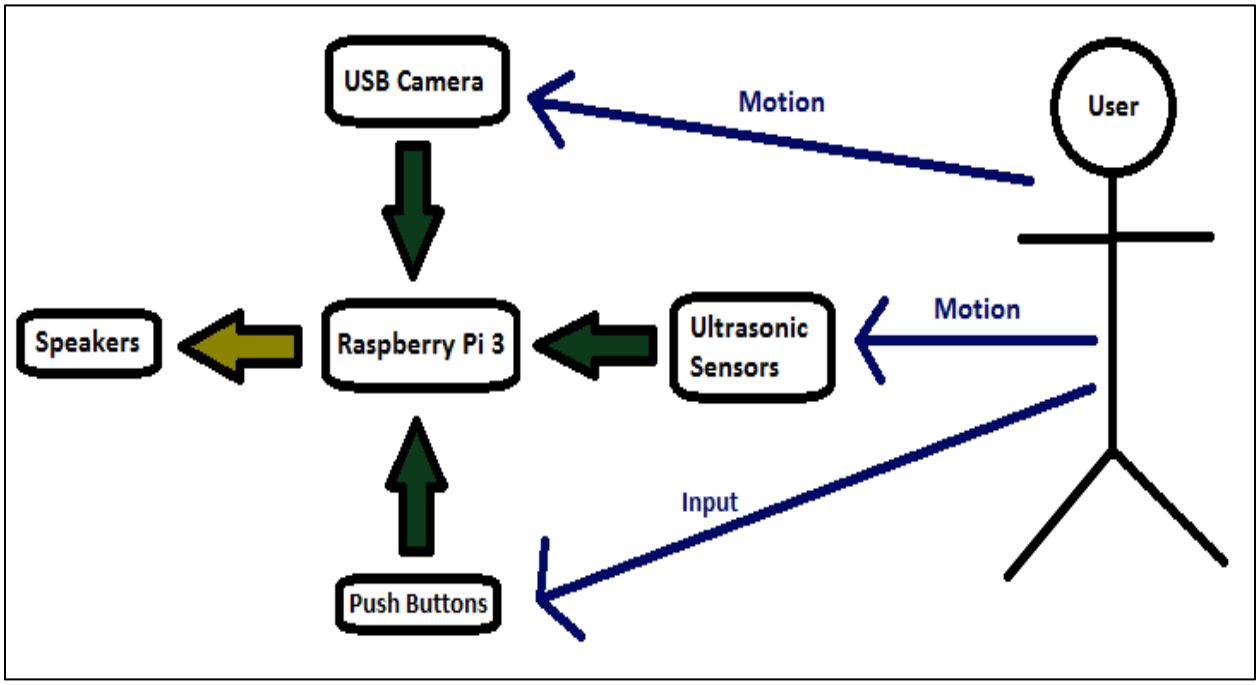

Figure 1: Rudimentary drawing of the Motion Synthesizer's functionality

TECHNICAL

The Motion Synthesizer will use a Raspberry Pi 3 to process all incoming and outgoing data. It will create sounds using the Sonic Pi music software installed on the Raspberry Pi 3. Sonic Pi is a coding environment that uses a synthesis engine to produce a variety of sound effects. We will need to create a way to interface our inputs with Sonic Pi.

The Motion Synthesizer will use two ultrasonic sensors and a USB camera to capture a user's movements to determine the pitch of the sounds being produced. The user will be able to control the synthesizer's music effects using push buttons located on the surface of the enclosure. We will use a Python interface for Sonic Pi to control the synthesizer. Our main challenges for this project are to learn about computer vision, Python, and Sonic Pi so that our system can work seamlessly.

We will interface a USB camera to the Raspberry Pi 3 so that we can use real-time computer vision to detect objects and motion from a stream of digital images. Computer vision is concerned with the automatic extraction, analysis and understanding of useful information from a single image or a sequence of images. We are new to the Open Source Computer Vision (OpenCV) library, and we are finding that there are a lot of different ways to detect motion. We are currently testing different methods to detect objects based on their geometric, and color features.

We will also be interfacing two HC-SR04 Ultrasonic Sensors with the Raspberry Pi 3. The HC-SR04 is a commonly used module that uses sonar to measure distances. We will be using them to measure the user's hand movements to create sounds based on how far their hands are from the sensors. The ultrasonic sensors are rated for 5V. We will need to use a small voltage divider circuit, consisting of two resistors, to lower the sensor's output voltage to something our Raspberry Pi can handle (see Appendix B for a schematic).

FINANCIAL

For our final project, we only need to pay for a USB camera, manufacturing the PCB, and the enclosure. The rest of the materials we already own from previous years in our program. A breakdown of all our project costs can be seen below in Table 1.

Table 1 – Materials and Costs

Part	Quantity	Unit Cost	Cost
Raspberry Pi 3	1	$70	$70
HC-SR04 Ultrasonic Sensor	2	$7	$14
USB Camera	1	$30	$30
Speakers	1	$50	$50
PCB Manufacturing	1	$10	$10
Enclosure	1	$10	$10

MANAGEMENT

Our group has worked together for the last two years in this program. Our good team chemistry will help us manage our project so that we can achieve our goals within the given constraints. We have created a Gantt chart that illustrates our project's schedule (See Appendix C for our Gantt chart). We are very flexible and hardworking; we are committed to meeting the project deadlines.

CONCLUSION

We are excited to bring our idea to life. We expect people to have fun creating music with the Motion Synthesizer. We are keen to learn more about computer vision, and so far, we are having a lot of fun with it. This project will give us experience managing, designing, planning, and manufacturing a product which can be fun to play with and has the capacity to be used in different environments.

CONTACT

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Appendix A

Detailed Drawing of the Motion Synthesizer's Functionality

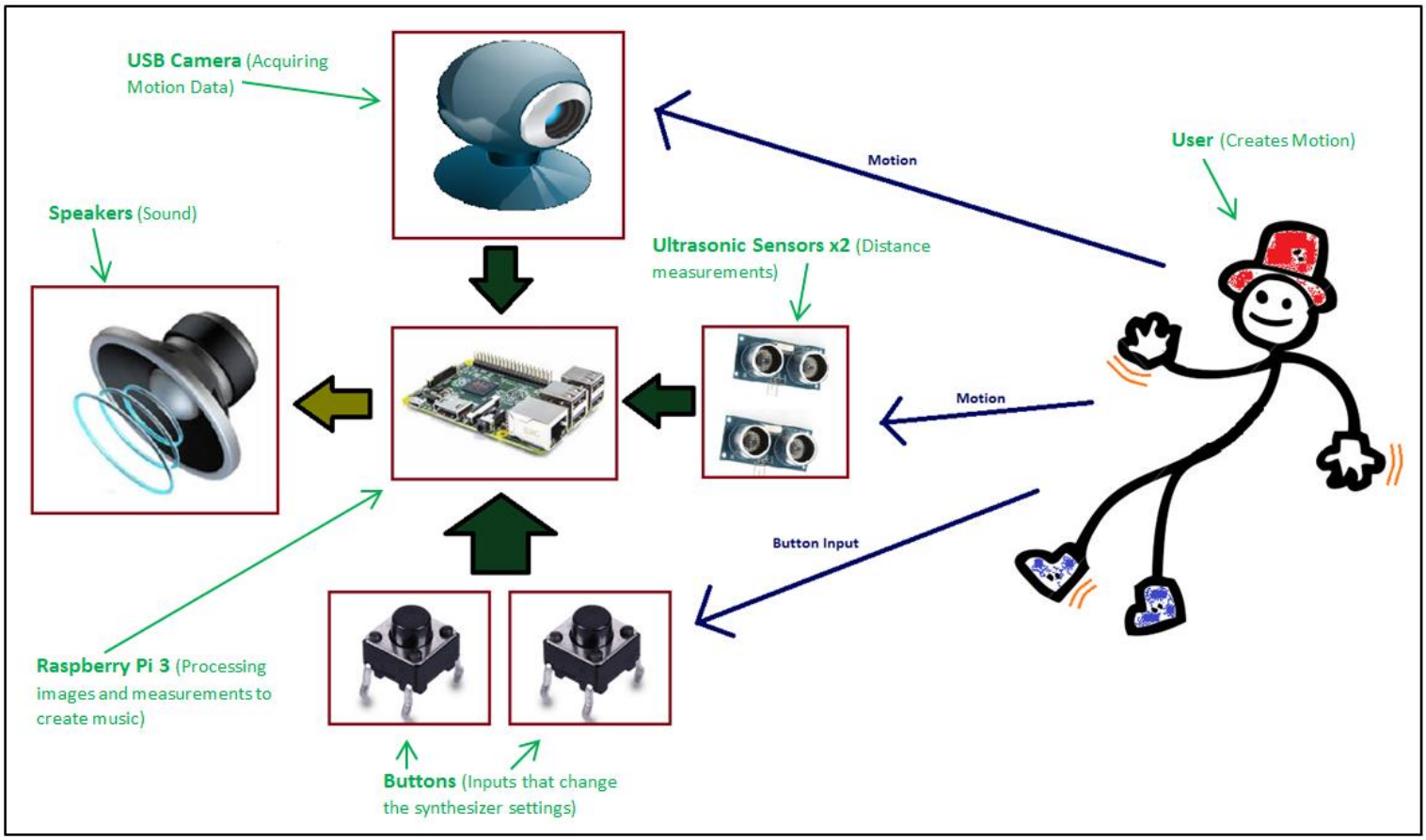

Figure 2: Flow chart detailing the Motion Synthesizer's functionality.

Description of Each Block in Figure 2:

User: The user uses motion to control the pitch of the sound effects created by the Motion Synthesizer.
Buttons: These will be push buttons that will allow a user to control the Motion Synthesizer's sound settings (Volume, synthesizer type ETC).
Ultrasonic Sensors: The Motion Synthesizer has two ultrasonic sensors that take distance measurements which are processed in the Raspberry Pi 3.
USB Camera: The USB camera captures images from the real world and passes them on to be analyzed in the Raspberry Pi 3.
Raspberry Pi 3: The Raspberry Pi 3 is the computer that will be acquiring, processing, analyzing, and understanding the external data to create music and sounds.
Speakers: The speakers are for the output of the music created by the Motion Synthesizer.

Appendix B

Voltage Divider Circuit

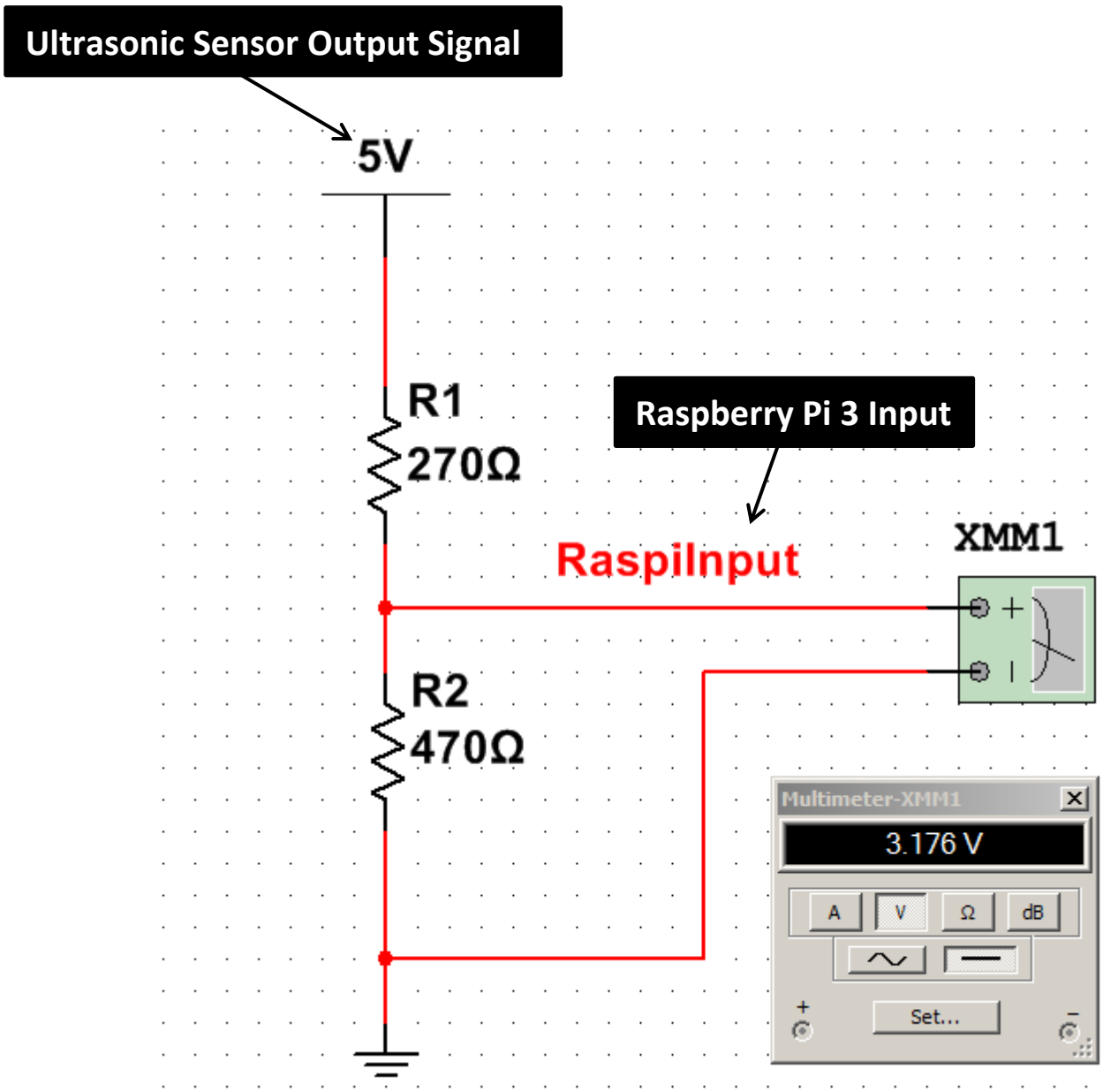

Figure 3: The ultrasonic sensor's output signal needs to be reduced for the Raspberry Pi's unprotected input pin. The sensor's output signal is decreased from 5V to 3.176V.

Appendix C

Gantt Chart

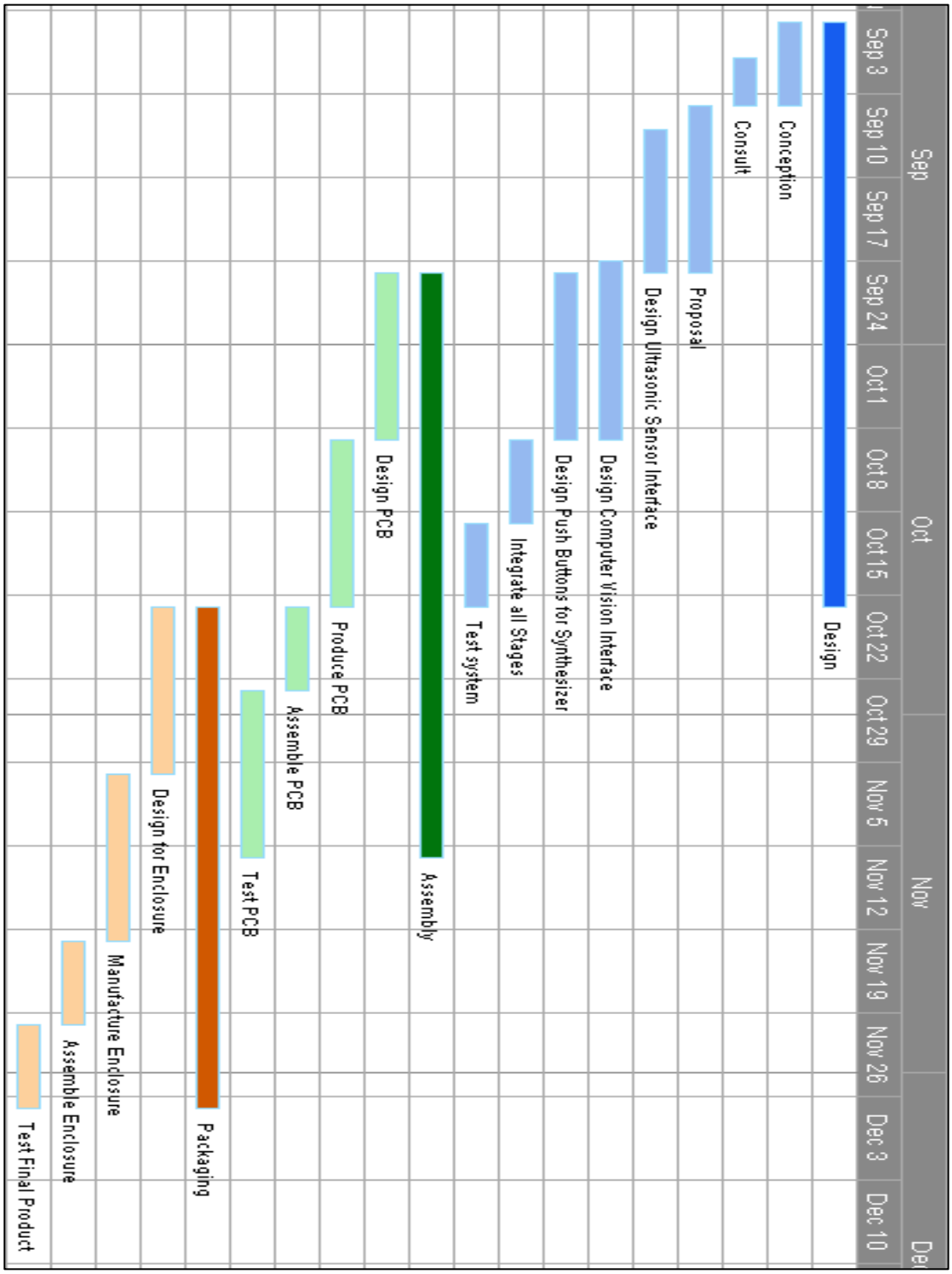

Figure 4: Gantt chart illustrating our project's schedule.