



# A Novel Binaural Audio Device for Cross-Platform Situational Awareness and Recall

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## Introduction

The Binaural Audio Capstone Project is a new, self-contained, product aimed at a wide consumer base. This product will capture, record, and transmit audio and video experienced firsthand by the user in addition to relevant data including GPS location and head orientation. This data will be used for near-real-time streaming as well as playback from long-term storage. The recorded data will be processed in a way such that it can be used to recreate the event that was recorded in the most realistic way possible. By using binaural audio recordings and head orientation data the event at hand can be accurately represented and saved.

This product aims to outperform current mobile recording systems by exceeding the shortcomings in terms of binaural audio and head tracking. The combination of these two products yield a large improvement in the capabilities of accurately recreating an event as it was experienced. There are many possible applications for such a device in recreational, military, medical, and hobbyist domains.

The Binaural Audio Capstone Project is being developed as a Senior Design Project at Embry-Riddle Aeronautical University in Daytona Beach Florida. The customer for this project is Dr. Timothy A. Wilson, the chair of the ECSSE department, hereafter referred to as the customer. This design has a maximum schedule of 9 months with a monetary budget of approximately \$1,200. The product that will be designed is an inexpensive, rapid development prototype used as a proof of concept.

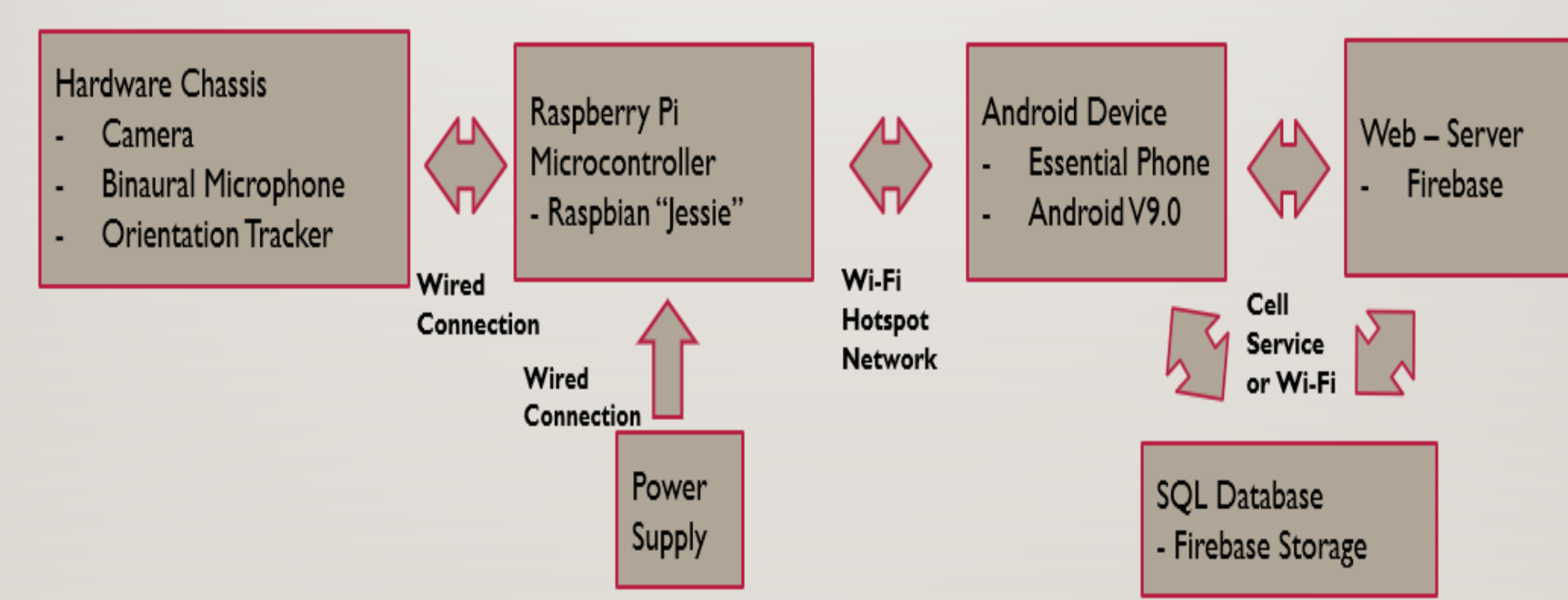


Figure 1: High-Level System Architecture highlighting the main components of the system

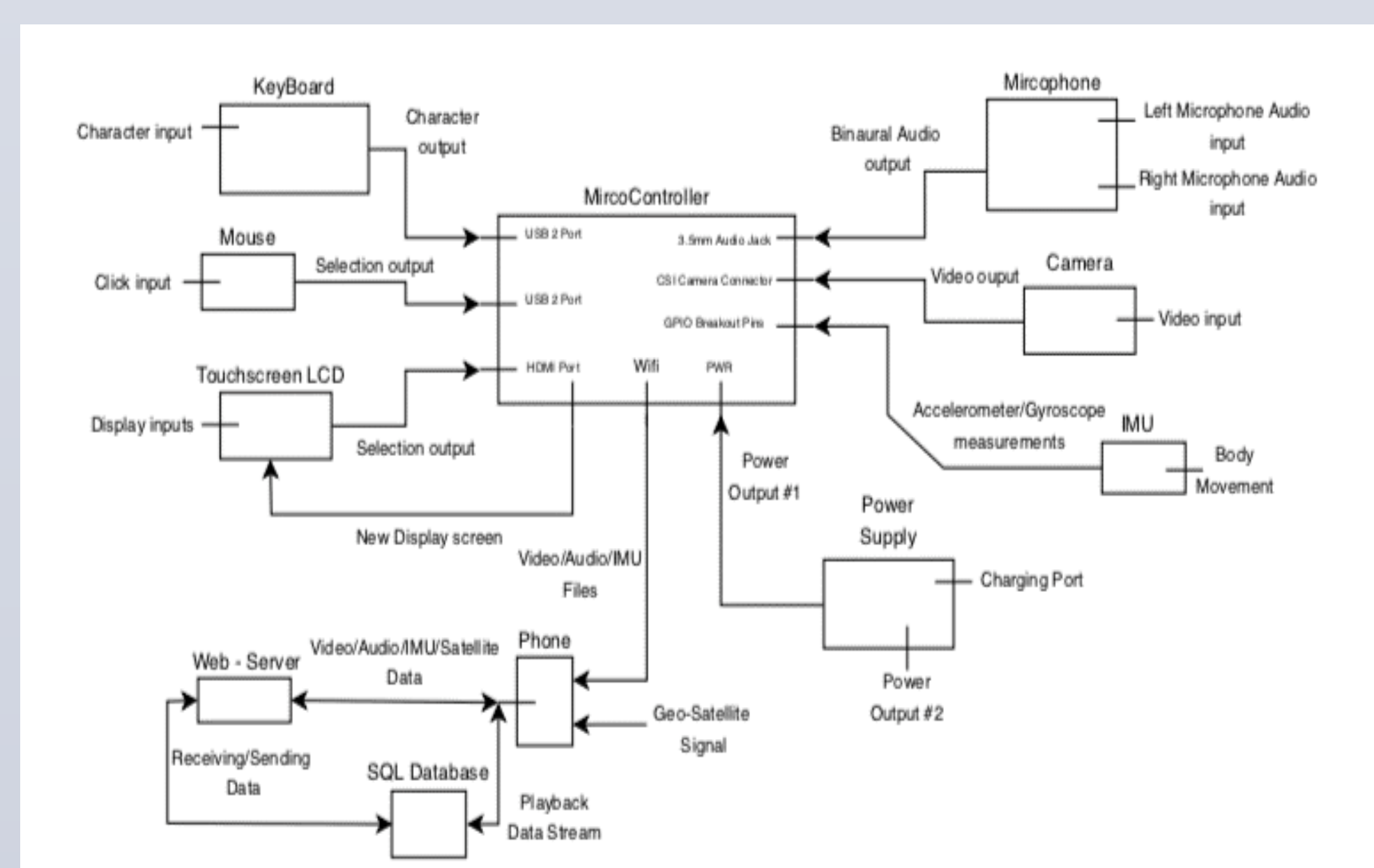


Figure 2: High-Level System Context Diagram for the Binaural Audio Capstone Project

## Methods and Current Work

The System Architecture for the Binaural Audio Capstone project can be decomposed into a hardware-based, and software-based section. The hardware side of the project encompasses the various data recording devices, microcontroller, and the power supply. The recording devices are mounted onto a hardware chassis that will be worn by the user on a pair of glasses. This chassis is directly wired to the microcontroller, which acts as the processor of the data. The microcontroller is powered through a rechargeable external battery to increase the portability of the project. The recorded data is streamed to the users' smartphone using a Wi-Fi Real-Time-Stream.

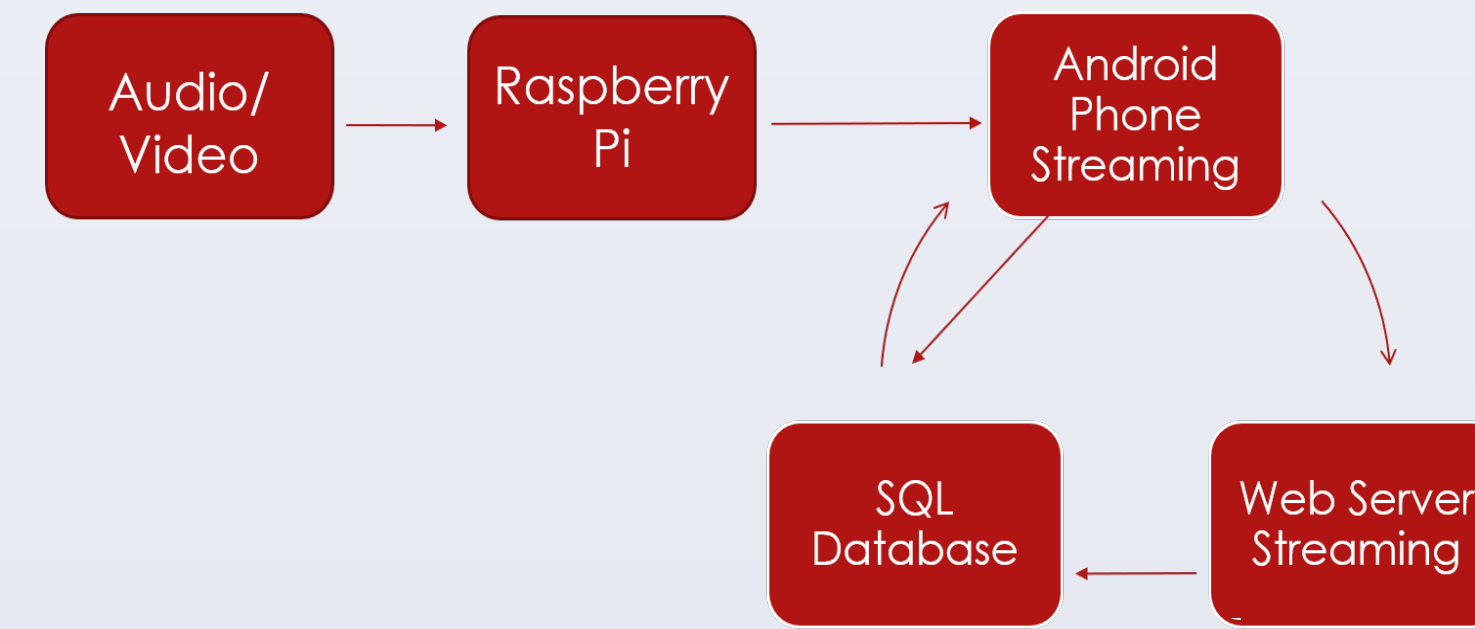


Figure 3: High-level overview of the Software System Architecture with peer interconnections between the Android application, the Web Server, and a SQL Database

Once the data has been received by the smartphone, it transitions through to the software side of the project. The software architecture is comprised of an Android Application installed onto the users' smartphone, an online firebase database, and a webserver. The Android App will be used to start and stop recording as well as to play the recordings in both near-real-time and later. The Android App also streams the data to the firebase database for long-term storage. The software side of the project all interface via internet connections through cell service or Wi-Fi networks.

In the far-left, the home page is where the users will be able to login to their accounts keeping the data safe and secure. The next page is used for prototyping and testing for a stream to be initiated using the built-in camera or with the streaming of the hardware. The third page illustrates the view when streaming. They can type in the address of the stream in the RTSP bar and the stream displays below in near-real-time. The fourth page illustrates the various tab options for the user, so they can navigate in the app. The final page to the right shows where the videos are saved and can be watched when the user wishes to.

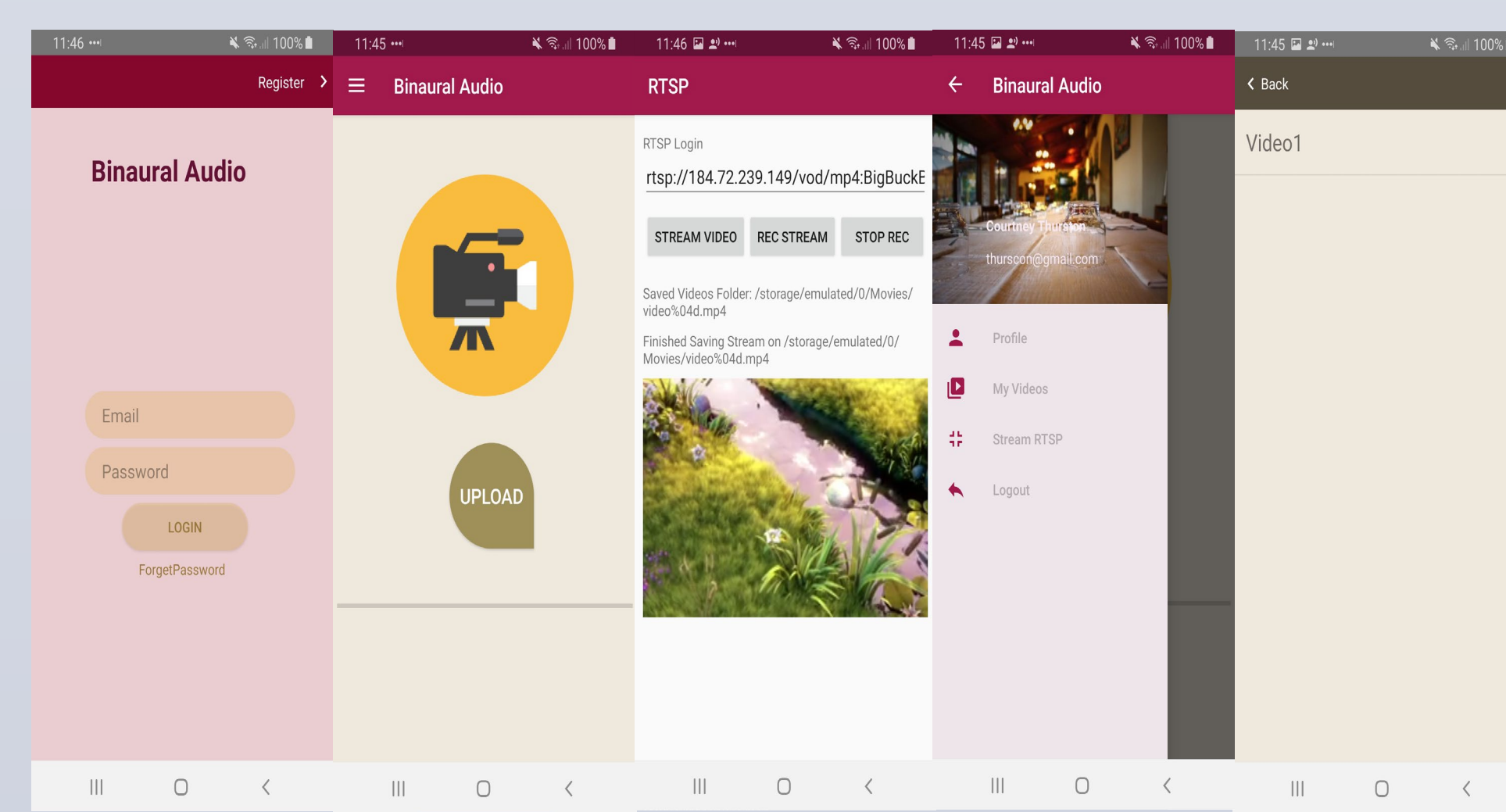


Figure 4: Binaural Audio Android Application Use Pages

The hardware unit for this device contains the relevant sensors and equipment for recording audio, video, IMU, and GPS data. Each of these pieces of equipment was selected, integrated, and tested to prove functionality to meet the requirements.

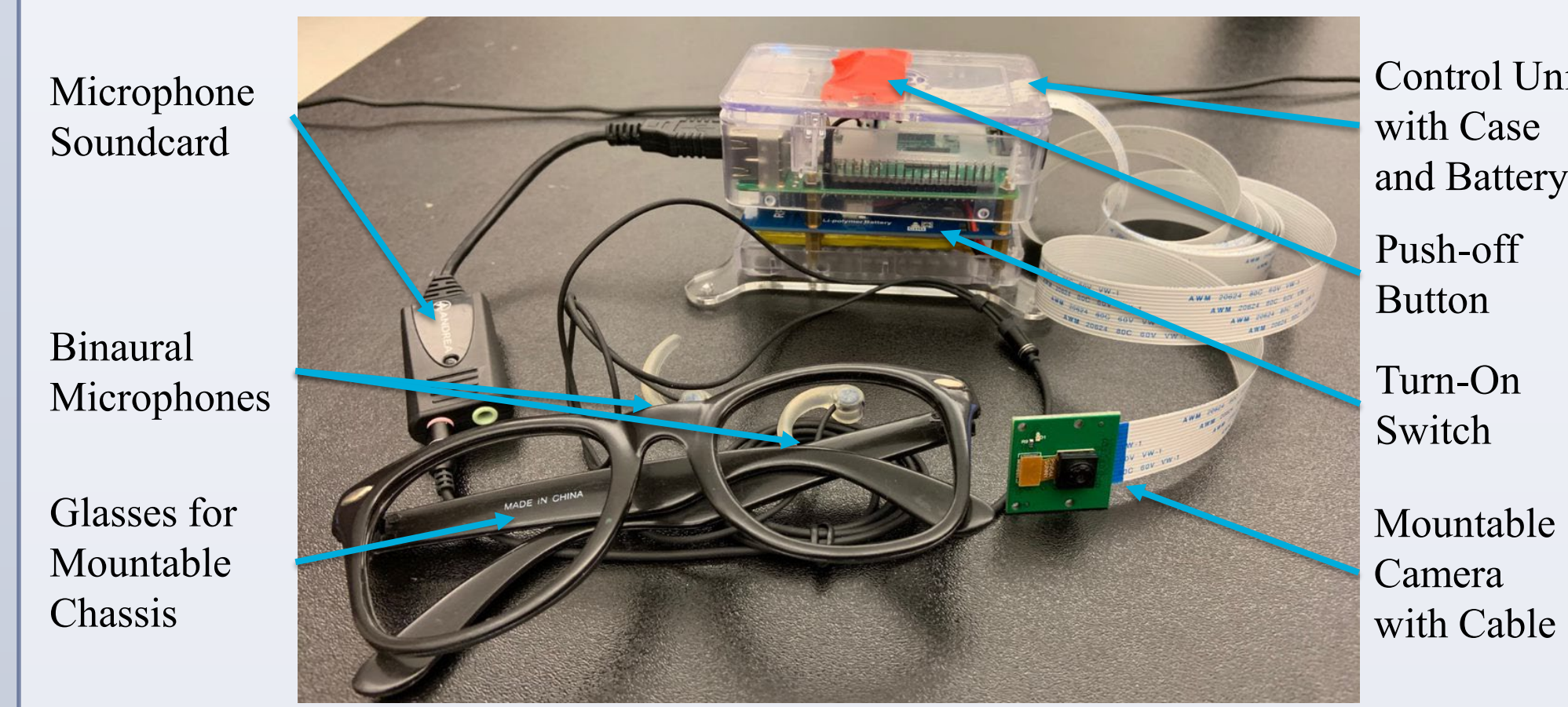


Figure 5: Binaural Audio Prototype Control Unit with attached hardware components for functionality and testing

- **Low Profile Camera** – An Arducam Camera Module will be utilized for video recording purposes. A Raspberry Pi based camera will be used for quick and effective integration with the supported libraries in Raspbian. This camera can capture and stream HD video at 1080p resolution in near-real-time to the Raspberry Pi.
- **Low Profile Binaural Microphones** – Sound Professionals Low Noise Microphones will be utilized to capture audio inside the ear canal after natural filtering by the shape of the users' ear. This audio is the most realistic representation of the sound that the user hears when experiencing an event directly. Capturing this type of audio allows for the accurate recreation of events.
- **Smartphone GPS** – A built-in GPS unit in the Essential Android Phone will be used to capture real-time GPS coordinates of the user. The GPS data that is captured by this unit will be compiled by the phone CPU and synchronized with the audio and video streams when streamed to the database.
- **Inertial Measurement Unit** – An Adafruit 9-DOF Absolute Orientation IMU will be attached to the mounted chassis on the user. It will measure the head orientation of the user in a three-dimensional space. The data output from accelerometers, gyroscopes, and magnetometers will be used by the microcontroller for accurate calculation accounting for linear and angular acceleration. This data is recorded and stored with the audio and video. This further enhances the realistic and accurate representation of the recreated event.
- **Raspberry Pi Power Source** – A Raspberry Pi Lithium Battery Pack Expansion Board for the Raspberry Pi containing an external, rechargeable battery pack will be attached. This device has a 2770 mAh charge capacity, though as it is a standard Lithium battery pack, it may be exchanged for larger or smaller capacity. As the device must be portable, a battery must be attached and integrated to the microcontroller directly.

## Applications and Future Work

The device will allow the user to capture events in the same manner that they were experienced organically for realistic playback.

Figure 6: Executive summary abstract of the Binaural Project

There are many applications and uses for such a device. It could be used in military settings for both training and combat scenarios. In training situations, realistic audio and video captured from a first-person perspective can be used to create the best training simulations where the recorded data could be played back during training. This methodology would provide the most realistic scenarios as each person would hear and see the video exactly as if they experienced it firsthand. In a combat scenario, the recorded audio could be transmitted between soldiers so that each soldier knows the relative position and environment of every other soldier. This would assist a team in identifying threats and ensuring that everyone remained coordinated and safe. Further, the device can assist users that struggle with short-term memory loss, a common side-effect of a large swath of medical conditions. If the user is having difficulties remembering a situation that happened, they can use their Android Device to easily playback the recorded environment to assist them in remembering the details. For hobbyists, this would allow them the best method to capture and record their experiences such that they could reexperience them. Regardless of the hobby, using this product would give someone a versatile way to capture the highlights.



Figure 7: Potential areas of application for the device.

## Acknowledgements and Contact

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