The Falcon Pack

EE 41430-01

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October 25th, 2016

1. Introduction

Notre Dame undergraduate students William Bloebaum, Alexander Rosner, and Albert Lee in the Senior Design I course (EE 41430-01) will be working with postdoctoral fellow Felix Fu, Assistant Professor Laura Kloepper, and Professor Robert Stevenson on this project to study the flight patterns and communications of Mexican free-tailed bats. Our project focuses on the design of the system used to record and process audio and video signals of the bats.

2. Problem Description

Wireless, high-frequency communication between large numbers of military drones is difficult to manage, but must be accomplished in order to prevent collisions with various obstacles and each other. Mexican free-tailed bats demonstrate swarming flight behavior each night as they undergo mass emergence from their cave in a dense stream at approximately 25 mph, and therefore act as ideal models for investigating swarming behavior. Each bat constantly emits short (1-5 ms) pulses that sweep from high frequencies to low frequencies in order to communicate with each other and avoid collisions. The aforementioned group will be designing and building an electronic rig that will study the communication and flight patterns of these bats in order to understand how acoustic waves control the navigation of the colony.

3. Proposed Solution

Basic Goal: Use a PIC32 microcontroller connected to a high-frequency microphone with adjustable gain to record the high-frequency sonar pulses emitted by bats. The microcontroller will convert the analog signals to digital data, and then dump the information into a microSD card. The whole contraption should weigh less than, or around 25 grams, and will be attached to a hood worn by a falcon.

Stretch Goal: Use two separate microphones to collect stereo-sound data, and simultaneously record video data of the bat colony mid-flight. Synchronization of the audio and video data can be accomplished during or after data collection.

There are several proposed methods of synchronizing the recorded video and audio files. The crudest would be to use a clapperboard, and match up the timestamps of the distinct sound it makes with its visual cues on the audio and video files, respectively. A more elegant method would be to regularly flash an LED on camera, and simultaneously send a signal to the microphone's microSD card. For both methods, synchronization would be done after data collection. Rough diagrams of the systems can be found at the end of the document in Figures 1 and 2.

4. Demonstrated Features

To demonstrate our project, we will use an audio signal of a bat sonar sample and play it near our microphone(s). Our code will process the analog signal in the PIC32 by converting it to digital with the desired bit representation (16-bit) and sampling rate (200 kHz). The PIC32 will then convert the data to the correct file type (wav) and send it to the SD card. We will compare the extracted data in the SD card to the audio file originally played to find the signal to noise ratio (SNR). Additionally, audio files with varying frequencies and volumes can be played to test the filter and adjustable gain so that it is appropriate for the environment that the hawk will be flying in.

To test the video, we will simply take a low-resolution shot with our camera of a high-resolution bat colony video to ensure that we can discern the general movement of the bats and any obstacles that they could face. With simultaneous videos from an iphone and our device, we can judge the accuracy of the synchronization technique. An acceptable SNR when compared to higher resolution test signals, accurate synchronization and correct data in the SD card will demonstrate the success of our project. See figures 1-2 for diagrams of the system to be tested.

5. Available Technologies

-The ‘Knowles Mini SiSonic Ultrasonic Acoustic Sensor’ is the microphone we have right now.
-PIC32MX series should have enough processing power and memory
-Prof. Stevenson is undecided on the proper SOC for the project.
- SanDisk microSD with enough memory to support Dr. Kloepper’s time requirements
-CMOS image sensor (low-res)
-Op-Amp and lumped components for analog bandpass filter and gain unless DSP is necessary.
-Falcon hood designed by specialist

6. Engineering Content

Most of the engineering is in the design of the analog system that processes the sound. The major functional blocks are in two categories: make data and process data. In order to make data we have to design and build the audio processing hardware. To process the data we have to write the code for the PIC to make the analog to digital conversion of the raw data and write that data to a microSD card. If those two blocks are complete, we can move on to another make data block (adding a second microphone) and another data processing block where we write stereo audio data to the microSD and synchronize the audio with the video feed.

7. Conclusions

Our project the design and implementation of a microphone and its associated processing for a falcon. We are in charge of the design and implementation of the audio processing component of the greater project from data collection to data writing. The microphone system will gather data to be used in conjunction with a camera to monitor the flight and communication of Mexican free-tailed bats.

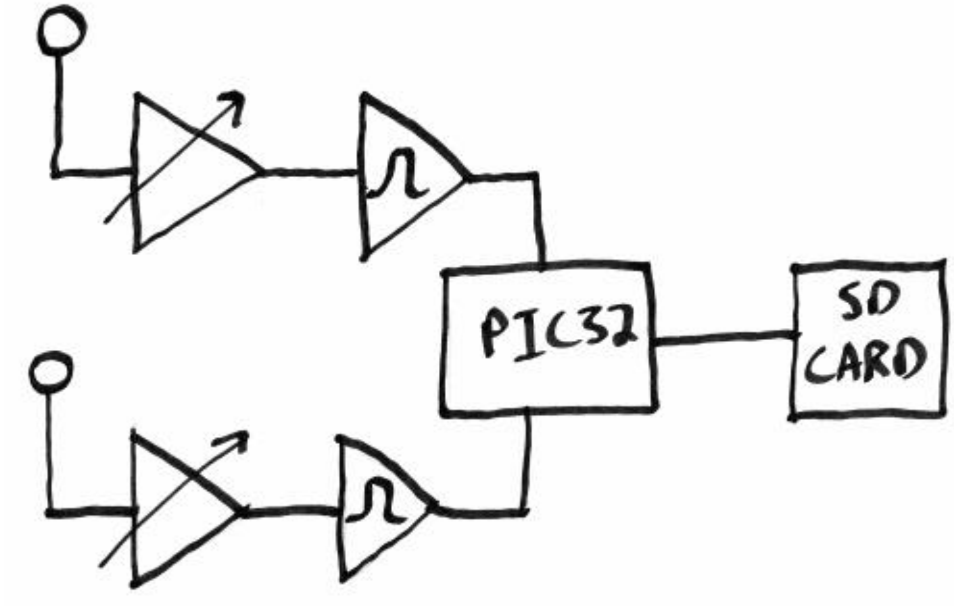

Figure 1. Basic Microphone System Flow Diagram

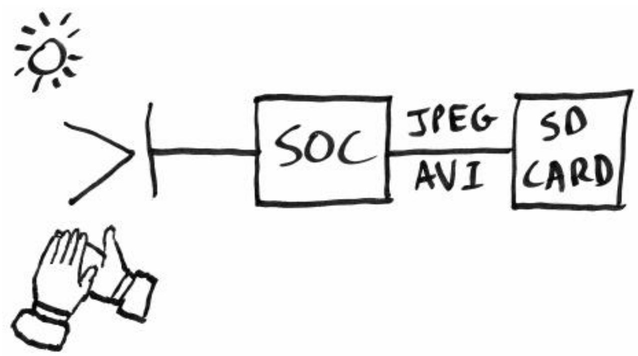

Figure 2. Basic Video System Flow Diagram