IEEE Signal Processing Cup 2019

Search & Rescue with Drone-Embedded Sound Source Localization

Data Collection

Team Maverick

1 Introduction

The IEEE Signal Processing Cup 2019 has a bonus task in the Open competition stage where participating teams are asked to send their own audio recordings obtained from one or several microphones embedded in a flying unmanned aerial vehicle (UAV). This report contains a detailed description of the data collection process for "Team Maverick".

2 Data Collection

For this task, we have used three microphones embedded in a Quad-copter and collected the motor noise data in different kinds of flight conditions. The whole data collection process has been performed in an acoustic an-echoic room to ensure minimum to no reverberant condition and prevent any unwanted interference.

3 Hardware Details

This section contains a description on the hardware and protocols used to collect the data.

3.1 UAV Details

A quadcopter UAV YH-19HW [1] has been employed to collect the data. This foldable quadcopter is equipped with four brushed motors. This quadcopter supports functions like altitude hold, headless mode, 360-degree flips, return to home, three-speed switch, WIFI operation and many others. It can be remotely controlled by a four channel 2.4GHz wireless remote controller. It is also equipped with a WIFI on board camera. It's advanced barometer along with 6-axis flight control system enables it to achieve a fixed hover mode and flight stability. A more technical details can be found in the following table:

[1] `https://amzn.to/2T1bSl3`

Table 1: Technical details of the UAV used.

General	• Type: Quadcopter • Model: YH - 19HW • Features: Brushed Version • Motor Type: Brushed Motor • Size: Medium • Sensor: Barometer • Built-in Gyro: 6 Axis Gyro
Connectivity	• Remote Control: 2.4GHz Wireless Remote Control • Channel: 4-Channels • Radio Mode: Mode 2 (Left-hand Throttle) • Control Distance: 50-100m • Detailed Control Distance: About 100m • Compatible with Additional Gimbal: No • FPV Distance: About 60m • Transmitter Power: 3 × 1.5V AA battery • Model Power: Built-in rechargeable battery
Battery	• Battery: 3.7V 800mAh lithium-ion • Flying Time: 8-10 mins • Charging Time: About 90 mins
Dimension and Weight	• Weight: 0.1600 kg • Size (L x W x H): 21.00 x 16.50 x 8.00 cm

Figure 1: The quadcopter, YH-19HW.

3.2 Microphones

For audio recording purpose we have used three Yinwei YW-001 mini collar, omni-directional microphones. [2] The technical details of the microphones are listed below:

- Frequency range: 50Hz - 16 KHz
- Impedance: low
- Sensitivity: -60dB $\pm$ 3dB
- Cable length: Up to 2 Meter
- 3.5mm Plug Microphone
- Size: 26mm $\times$ 15mm $\times$ 12mm
- Weight: 30g

Due to the light weight nature of the UAV, it was not possible to integrate any on board processing unit to collect the recorded audio. To solve this issue, we have used a long-wired connection between the on board microphones and a remote laptop for saving the recorded data on real-time. For proper interfacing between the laptop and the microphones, we have used three 5.1 Channel USB External Sound Card Audio Adapters[3].

4 Array Geometry

For the sound recordings, three microphones were arranged in a triangular shaped structure under the UAV. This placing was motivated because this location partially protects the microphone array from possible shocks and from the wind generated by the rotors. The microphones are attached to the UAV's base with the help of durable insulating tape and glue gun.

[2] https://amzn.to/2CehBOS
[3] http://bit.ly/2VS6su6

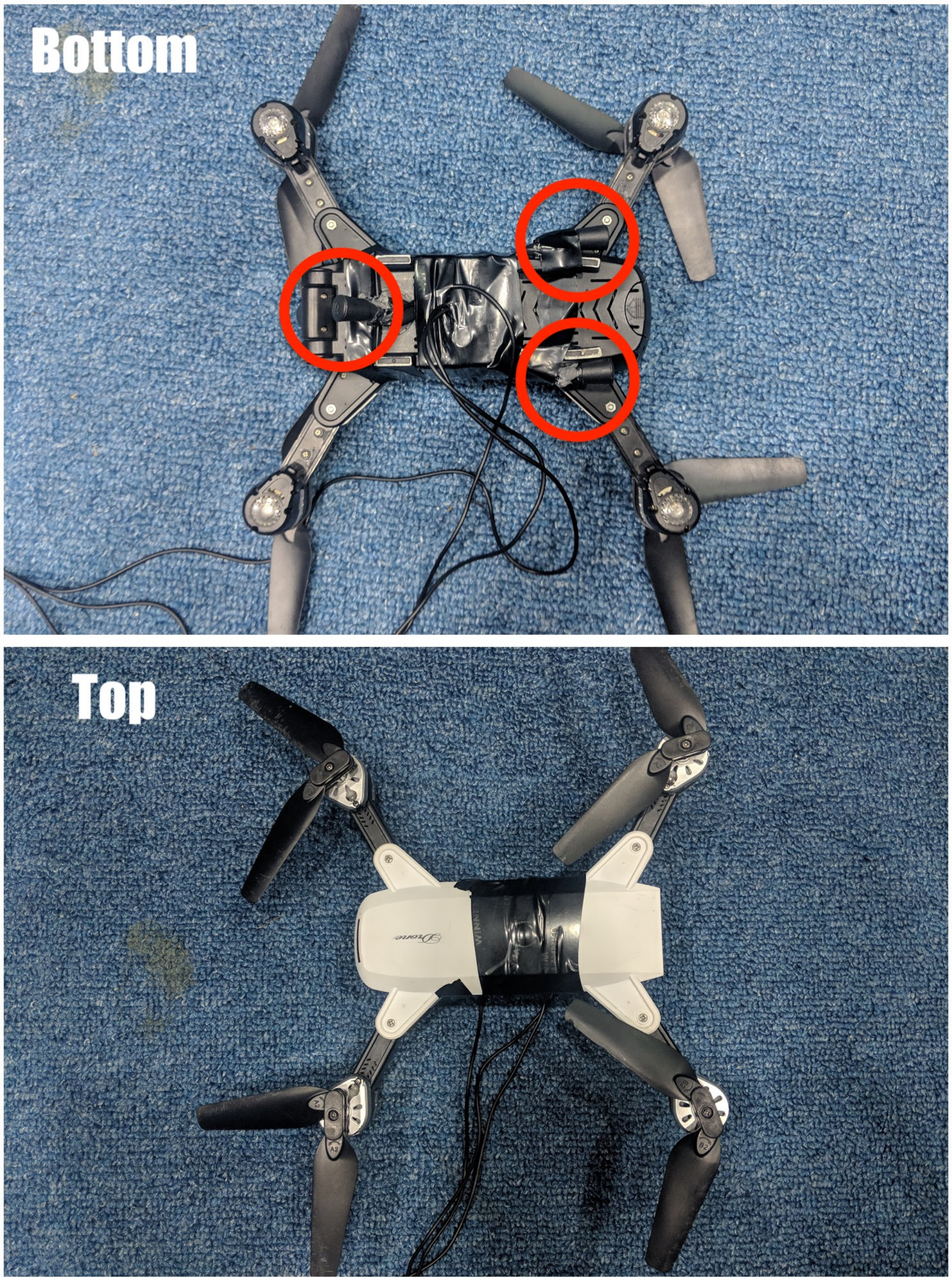

Figure 2: Top and bottom view of the quadcopter with three embedded microphones used to collect the data. The red circles highlight the microphones.

In the following figure, x, y and z axes are marked. Co-ordinates of the microphones (marked red) are also labelled (in cm) unit in the bottom of the figure.

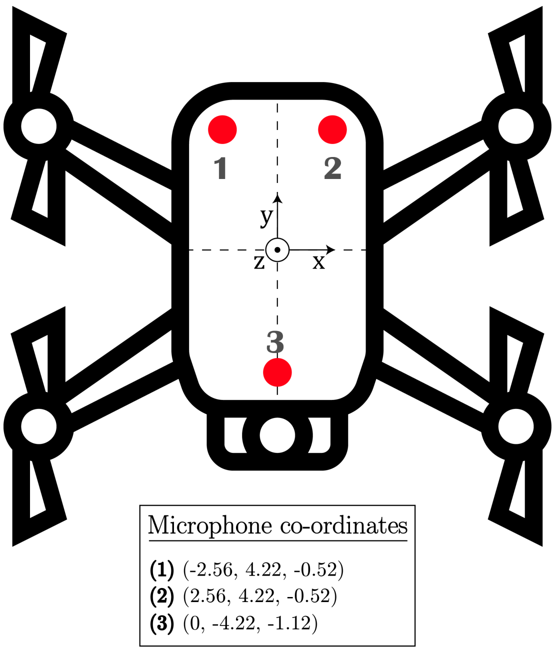

Figure 3: Array geometry, the defined axis and co-ordinates of the microphones.

5 Recording Environment

All the audio recordings have been performed in a controlled setup to prevent any interference from external audio source. The UAV was flown inside our Speech and Hearing Laboratory, Department of Biomedical Engineering, BUET which is an acoustic anechoic chamber to completely eliminate any unwanted reflection of sound and and external noise caused by electromagnetic waves.

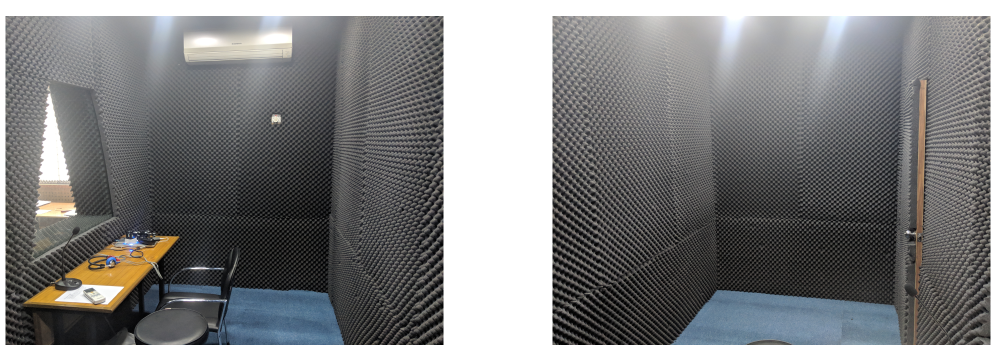

Figure 4: Inside of the acoustic anechoic chamber used for our data collection.

6 In-flight Audio Recordings

All audio recordings have a sampling frequency of 44.1 KHz witch 16 bit encoding and the total weight of the equipped system is 0.88 kg. The propellers' speed ranges from 10 turns/s when they start, up to around 75 turns/s at maximum.

Total six in-flight recordings of the motor sound were performed to make the dataset. Among them, during the 2nd, 3rd and 6th recording, the UAV was tele-operated by a human and was performing free-flights combining sequences of take-off, landing, stabilization, hovering, circles and spinning in a realistic way. During the other recording (numbered as 4), the motors were turned on and a human operator carried the UAV to simulate motion. In this case the UAV was moved in a circular path and its yaw and pitch were varied. The details of each recordings are listed below:

Audio 1 The UAV motors were turned on and a human operator carried the it to simulate motion.

Audio 2 the UAV was tele-operated by a human and was performing free-flights combining sequences of take-off, stabilization, hovering, and landing.

Audio 3 the UAV was tele-operated by a human and was performing free-flights combining sequences of take-off, stabilization, spinning, and landing.

Audio 4 The UAV motors were turned on and rotated at a constant speed but the drone did not take any flight rather it was stationary.

Audio 5 The UAV motors were turned on and a human operator carried the it to simulate motion. In this case, the human operator manually moved the UAV in a circular path and its yaw and pitch were varied.

Audio 6 The UAV was tele-operated by a human and was performing free-flights combining sequences of take-off, stabilization, hovering, and landing.

7 Frequency Domain Analysis of the Recorded Audio

We performed some frequency domain analysis to get a clear view of the nature of our collected ego noise data. The motor ego noise has an inherent property of containing several spectral harmonic components centered to its instantaneous speed. To validate this, we have performed frequency domain analysis of the 4th recordings where the UAV was stationary, but all the four motors were turned on.

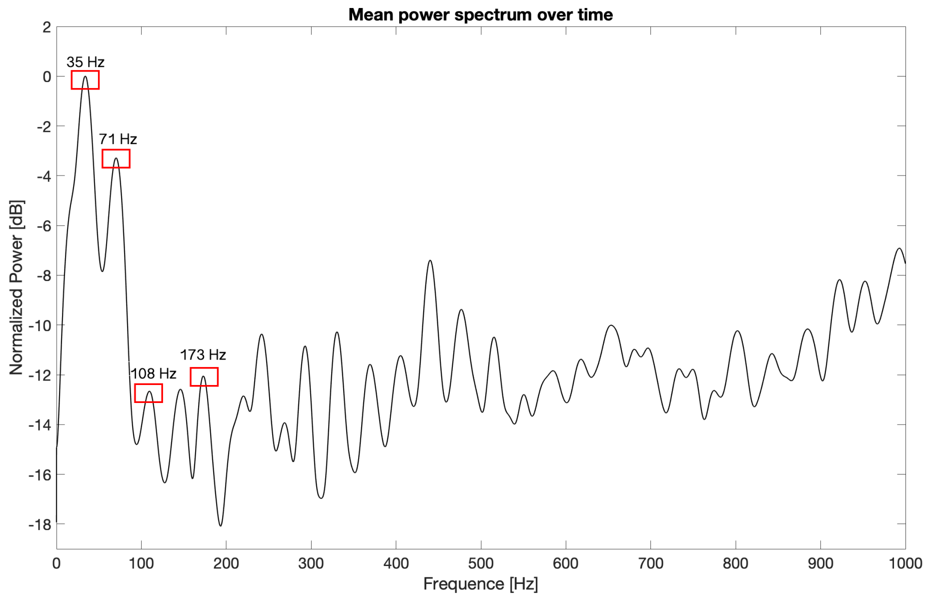

Figure 5: Mean power spectrum of the sound generated by the 4th recordings where the UAV was stationary, and the motors rotating at a constant speed. Peaks at harmonics proportional to 35 Hz can clearly be identified.

From the figure, it is evident that the motor ego noise contains the spectral harmonics proportional to its original speed.