UNMANNED AERIAL VEHICLE (UAV) SAFETY SYSTEM USING ANDROID APP

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ABSTRACT

The paper discuss about recording UAV's behavior using an android application. It focuses on detecting the anomalies of UAV using multiple sensors such as motion sensors (Accelerometer, gyroscope), environmental sensors (light sensor, sound sensor, pressure sensor and temperature sensors) and position sensors (magnetic sensors, orientation sensors) which are inbuilt in an android phones. The anomalies are displayed using run time graph in mobile phones and can be transmitted to ground station to make UAV user controllable.

Keywords— *Android operating system, mobile phone, sensors.*

I. INTRODUCTION

According to Peter van Blyenburgh [1], UAVs are defined as uninhabited and reusable motorized aerial vehicles, which are remotely controlled, semi-autonomous, autonomous, or have a combination of these capabilities, and that can carry various types of payloads, making them capable of performing specific tasks within the earth's atmosphere, or beyond, for a duration. In reality, UAVs are used widely by the military for missions that are long, tiring, and dangerous for aircraft pilots. Consequently, the military has increased funding for the development of UAVs, which has caused the appearance of generations of UAVs with different capabilities related to their missions.

In recent years, there has been tremendous growth in smartphones embedded with numerous sensors such as accelerometers, magnetometers, multiple microphones, and even cameras [2]–[4].The scope of sensor networks has expanded into many application domains that can provide users with new functionalities previously unheard of [5].

Currently the android is popular and widespread used operating system. Designing a portable android application and combining it with the small UAV machine is great idea all of time that is provide forend users wide operating space and convenient carrying functions.

This paper is organized as follows: In section 2, we present the related research. Section 3 explains the proposed set up of the experiments in which we use our mobile phones as a measuring device to detect UAV's anomalies. In Section 4, we reveal results that have the potential to aid in ground station assist.

II RELATED WORK

Anomaly detection has generated substantial research over past years. Applications include instruction and fraud detection, medical application, robot behavior novelty detection etc. (see [6] for a comprehensive survey). We focus on anomaly detection in unmanned aerial vehicle. This domain in categorized by a large amount of data from many sensors and measurements, that is typically noisy and streamed online, and requires an anomaly to be discovered quickly, to prevent threats to the safety of unmanned aerial vehicle.
In this paper we determined all the anomalies with the help of an android application which is cost effective and gives quick run time response for every anomaly calculated.

2.1 Sensors in Android

There are three major types of sensors that Android supports. The first type is motion sensors that measure the acceleration and rotation of a device, e.g., accelerometers and gyroscopes. The second type is environmental sensors that give the information about the surrounding environment of a device. Examples include barometers, thermometers, and photometers. The third type is position sensors that provide positional information for a device, such as orientation. These include orientation sensors and magnetometers.
The sensors can also be categorized into hardware sensors and software sensors. Hardware sensors correspond to physical hardware. Software sensors are those that exist purely in software and fuse sensor readings from hardware sensors. On Moto G (our experimental device), there are 6 hardware sensors and 7 software sensors provided by Android 5.0

III. EXPERIMENTAL SETUP

Using a mobile phone for these purposes creates numerous variables that must be accounted for as measurements can be misleading in certain situations. Phone location and orientation inside the UAV should be configured to achieve accurate measurements. Likewise, flying behaviors vary from time to time based on the environmental conditions, and performance may be exhibited as unsafe at certain places and safe at others. Providing quantitative data can help define a baseline in these instances. All data recognized by the mobile is stored on the phone and can be transmitted to ground station to take appropriate actions. We factor in all of these ideas during our measurement analysis to provide a secure and accurate technique that is most applicable for a wide range of operators and vehicles.

3.1 Device Background

The device used was an Android-based smartphone: Moto G. This Google phone made it relatively easy to acquire data to be thoroughly analyzed. Given its mobility and rise in popularity the past few years, a smartphone-based measuring device makes these findings unique and applicable for future implementations. The sensors used are:

3.1.1 Accelerometer

One of the most common inertial sensors is the accelerometer, a dynamic sensor capable of a vast range of sensing. Accelerometers are available that can measure acceleration in one, two, or three orthogonal axes. They are typically used in one of three modes:

- As an intertial measurement of velocity and position;
- As a sensor of inclination, tilt, or orientation in 2 or 3 dimensions, as referenced from the acceleration of gravity (1 g = 9.8m/s^2);
- As a vibration or impact (shock) sensor.

There are considerable advantages to using an analog accelerometer as opposed to an inclinometer such as a liquid tilt sensor – inclinometers tend to output binary information (indicating a state of on or off), thus it is only possible to detect when the tilt has exceeded some thresholding angle.

The phone contains a LIS3DH three-axis accelerometer [7] that is capable of detecting multiple motions triggered by a vehicle. For example acceleration in upward, downward, forward, backward, left and right directions. Fig. 1 shows the moto G and its relevant axes. If any movement is detected, it is numerically analyzed and expressed in these directions.

Fig.1: Moto G and Three-axis diagram of the accelerometer. It employs a LIS3DH 3-axis accelerometer, which is capable of detecting movement in any direction. This movement may be the slightest deviation or a disturbance caused by a external environment

TABLE-I

Axis	Direction	Typical Driving
X	Right/Left	Turning
Y	Front/Back	Acceleration/braking
Z	Up/Down	Vibration/Air Anomalies

Table.1: Triaxial Measurements

Different driving measures are found and differentiated by using each individual axis of the accelerometer. Table 1 refers to each axis of the accelerometer of the phone, as well as the directions and relevant driving maneuver performed. Examples of possible causes of these axial movements are shown, such as movement in the y-axis, which may signify a sudden change in acceleration or a jerk experienced when shifting gears.

We test the accuracy of the device by experimental comparison of calculated data and observed data recorded by the phone. For the test, we utilized dynamics equations such as centripetal acceleration and compared that with the measurements recorded by the Moto G. Comparison results, as shown in Fig. 2-4, show the accelerometer to be very accurate , making it a reliable device to be used in these manners.

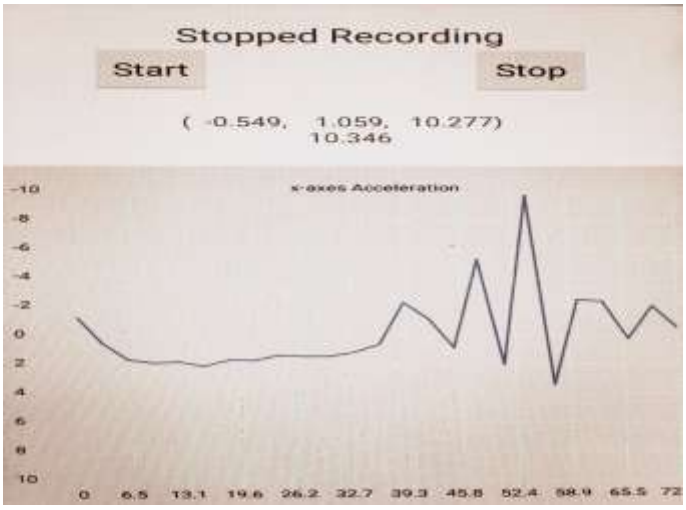

Fig.2: Run time graph of x-axis, motion of UAV in front and back.

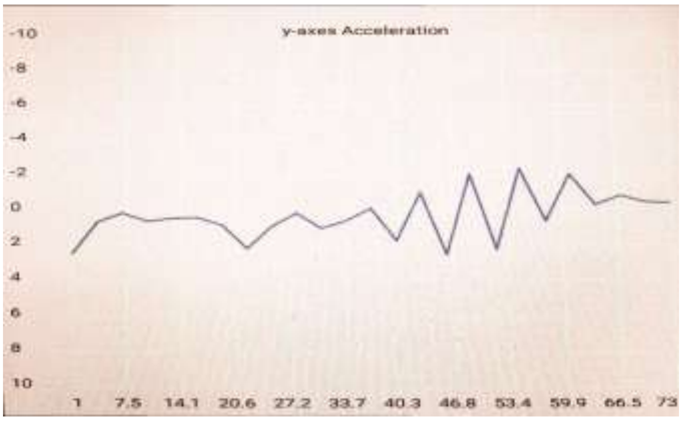

Fig.3: Run time graph of y-axis, motion of UAV in right and left.

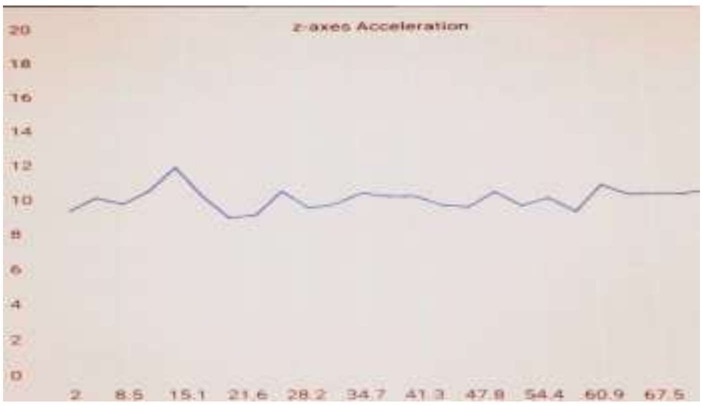

Fig.4: Run time graph of z-axis, motion of UAV in up and down.

This experiment was performed multiple times for different time lengths, conveying similar results each time. The graphs show the acceleration of the UAV based on the event movement. Horizontal axis shows event movement and Vertical axis shows acceleration based on its movement.

3.1.2 Light Sensor

Our phone contains CT406 light sensor [8] which detects the light changes around UAV and record the values in "luxes". These values can be transmitted to ground station for further operation. Most light sensor are photodiodes. When exposed to light, they create current. The brighter the light, the higher the current. This current is then converted to a sequence of bits.

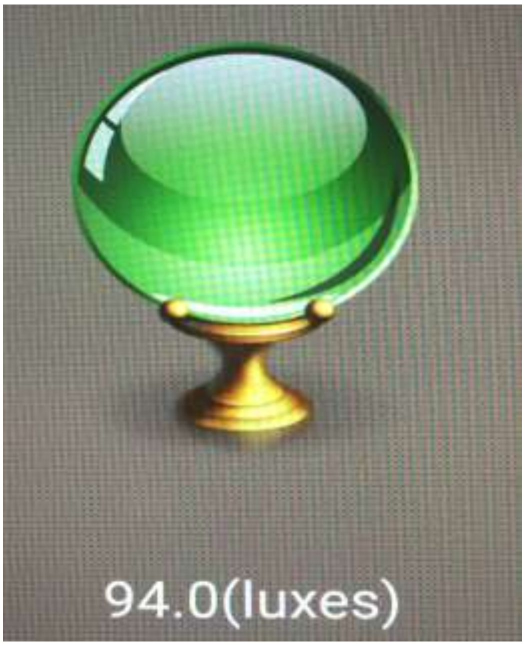

Fig.5: Screen shot of light sensor in android mobile

3.1.3 Sound Sensor

A sound sensor (micro phone) is an acoustic-to-electric transducer or sensor that converts sound in air into an electric signal. It produces an electric signal from air pressure variation. The inner element of microphone are the primary source of differences in directivity. There are lots of ways to use microphone data beyond voice recording: baby monitor, inaudible sounds detectable only by apps.

We are using a pressure based sound sensor to sense the sound in and around UAV and represent it in graphical manner. This sensor uses a diaphragm between a fixed internal volume of air and the environment, and respond uniformly to pressure from all directions, so it is said to be Omni directional. It detects the surrounding sound intensity of the environment and the volume of surrounding in the form of decibel dB. It is carefully calibrated with the knowledge of sound engineering to get actual precise sound level value of surrounding environment with precision of peak value and rms values.

Fig.6: Sound sensor with its run lime graph measured in dB.

3.1.4 Magnetic Sensor

Sophisticated smart phone applications such as maps or augmented reality use measurements of the Earth's magnetic and gravity fields to work out the orientation of the phone.A typical smart phone has three magnetic field sensors, fixed perpendicular to each other, which are used to work out the local direction of Magnetic North.

The phone contains AK8963 [9] 3-axis electronic compass IC with high sensitive Hall sensor technology. Small package of AK8963 incorporates magnetic sensors for detecting terrestrial magnetism in the X-axis, Y-axis, and Z-axis, a sensor driving circuit, signal amplifier chain, and an arithmetic circuit for processing the signal from each sensor. Self-test function is also incorporated. From its compact foot print and thin package feature, it is suitable for map heading up purpose in GPS-equipped cell phone to realize UAV navigation function.

A magnetic field sensor (also known as magnetometer) reports the ambient magnetic field, as measured along the 3 sensor axes.

The application software uses the location of the phone from the mobile phone's nearest base-station or from a GPS reading along with a map of the declination of the magnetic field to work out the direction of True North at the user's location. These are used for speed, rotational speed, linear position, linear angle and position measurement in automotive, industrial, military and consumer applications whose results are stored in android mobile.

Hall Effect

When a beam of charged particles passes through a magnetic field, forces act on the particles and the beam is deflected from its straight path. The flowing electrons through a conductor is known as beam of charged carriers. When a conductor is placed in a

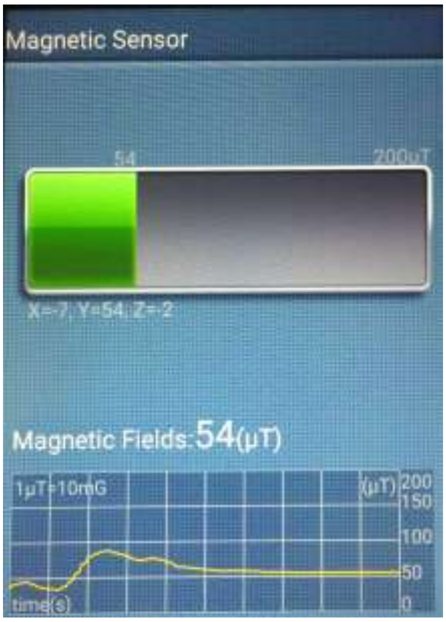

Fig.7: Representation of 3-axis magnetic sensor and its graph.

magnetic field vertical to the way of the electrons, they will be deflected from its straight movement. As a consequence, one plane of the conductor will be negative portion and the contrary side becomes positive one. This paralleled voltage is called Hall Voltage. [10]. When the force on the charged particles from the electric field balances the force produced by magnetic field, the separation of them will stop. If the current is not changing, then the Hall voltage is a measure of the magnetic flux density.

IV. CONCLUSION

Using a mobile smartphone, we have demonstrated some innovative applications that are integrated inside an automobile to evaluate a vehicle's condition, such as vehicle's shifting and overall UAV anomaly, including directions, magnetic field, light and sound. Our application resulted in high accuracy, making it possible to conclude on the state of a particular UAV. Along with these findings, an analysis of a flying behavior for safe and sudden maneuvers, such as vehicle accelerations and orientation changes, has been identified. Using a multiple-axis classification method for directions increased the accuracy, resulting in a better flying anomaly detection system. Being fueled by demand, future advancements in embedded hardware will yield the smartphone and its sensors to be more powerful devices in terms of processing, sensitivity, and accuracy, paving the way for many more innovative applications. Unlocking its potential in intelligent transportation systems seems only logical as there are conceivably numerous of applications that can help reduce safety concerns on the air.

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