SEMINAR PRESENTATION

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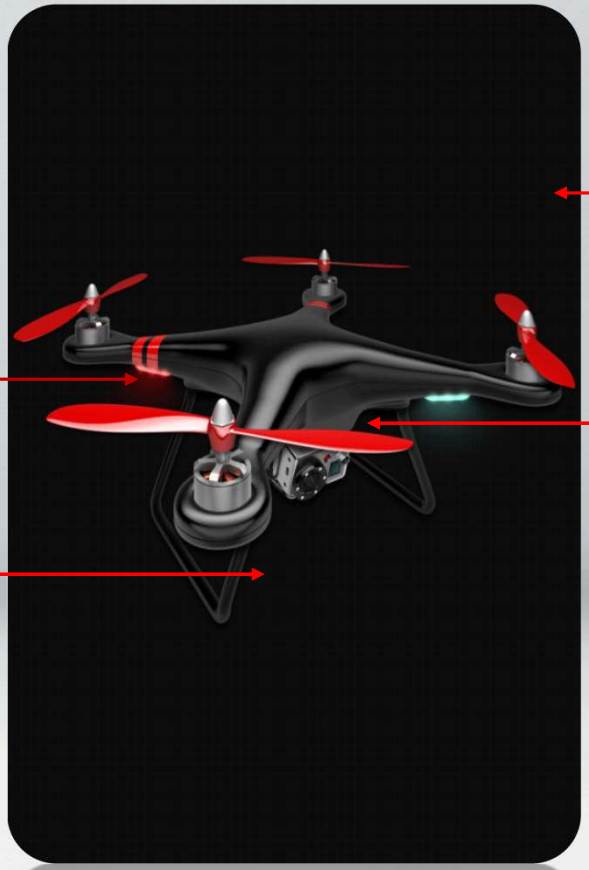
DRONE IMPORTANT PARTS

Quadcopter frame

This is a structure (frame) in which all the other parts fit in. It acts as a skeleton in which different components are placed.



Motors

Motors are essential for the propeller's rotation. This enhances a thrust force for propelling the drone. The number of motors should be the same as the number of propellers.

Camera

For video footage, cameras are attached to the drones. Cameras with the capability of shooting and storing or sending videos

Electronic Speed Controller

This is an electronic control board that varies the motor's speed. It also acts as a dynamic brake.

DRONE IMPORTANT PARTS

Propellers

Propellers are clove like blades structured that helps the drone to fly.

Landing gear

This is a structure meant for safely landing the drone.

VIBRATION-BASED FAULT DECTECTION IN DRONE USING ARTIFICIAL INTELLEGENCE

CONTENTS

INTRODUCTION

01

These days the global market of multirotor is growing and attracting many researchers all over the globe.

02

Multirotor is a type of unmanned aerial vehicle (UAV) or drone that uses more than two motors.

03

One of the most overlooked challenges in the use of multirotor is vibration.

04

If a multirotor collides or crashes, there might be some damages to the propellers or arms. The existence of such damages will produce unwanted vibrations that can significantly affects the performance of the multirotor and eventually lead to a crash.

INTRODUCTION

- Vibration-Based Fault Detection in Drone Using Artificial Intelligence is the proposed system, with a focused on the multirotor arms.
- AI techniques such as fuzzy logic, neuro-fuzzy, and Artificial Neural Networks are used in this system to predict the safety of the multirotor, whether it is safe, partial safe, or not safe.
- User interface via smartphones the users can monitor the status of the multirotor based on the green, yellow, and red colour. whether it is safe, partial safe, or not safe.

LITERATURE REVIEW

1. Verbeke and Debruyne used Experimental modal analysis (EMA) and numerical simulation.

2. The analysis of the random vibrations in multirotor was done by Abdulrahman Al-Mashhadani.

3. A technique for fault detection of physical impairment of UAV rotor blades is proposed by Bondyra et al.

4. Pourpanah et al used a hybrid method of Q-learning Fuzzy ARTMAP classifier (QFAM) and genetic algorithm (GA) to classify between healthy and broken propeller, based on vibration signals.

5. Ghalamchi and Mueller presented a fault detection method

- Most of the studies performed by other researchers are offline methods, where the fault detection or decision-making is done not in real-time.

- The smartphone's application was not incorporated in the previous studies.

METHODOLOGY

- It starts with data acquisition.
- vibration data is collected from vibration sensors and stored in the microcontroller. The AI methods (AI algorithms) then compute the vibration data collected and provide a decision as to whether the multirotor is safe, partially safe, or not safe.

METHODOLOGY

FUZZY LOGIC

- Introduced by Lotfi Zadeh back in 1965
- It utilized for fault detection in many areas such as robotics, machine vision, energy, industries, etc.
- In this study fuzzy logic with four inputs and one output is used.
- The proposed fuzzy logic model, which can be divided into three steps.
  - The first step is fuzzification.
  - Creating the rules for the fuzzy logic system.
  - The last step is defuzzification.

METHODOLOGY

NEURO-FUZZY

- It also known as a fuzzy neural network (FNN)
- A neuro-fuzzy system can be considered as 3-layer
  - Input variables
  - Fuzzy rules
  - Output variables
- The ANFIS network has four inputs (Sensors A, B, C, and D)
- It has Five layers
  - Fuzzification process
  - Fuzzy rules
  - Normalizes the membership functions
  - Conclusive part of fuzzy rules
  - Calculates the network output
- The neuro-fuzzy technique heavily depends on the dataset.

METHODOLOGY

ARTIFICIAL NEURAL NETWORKS

- Artificial neural network (ANN or NN) can be defined as an interconnected assembly of simple processing elements, units, or nodes, whose functionality is inspired by the way that the human brain processes information.
- NN can be divided into single-layer and multilayer NN
- In the single-layer NN there is only one neuron and computes only one output
- There are three different types of layers used in multilayer NN
  - Input Layer
  - Hidden Layer
  - Output layers
- The performance of the NN model depends on the size and quality of the dataset.

METHODOLOGY

- The multirotor's vibration is measured using the SW420 vibration sensors.

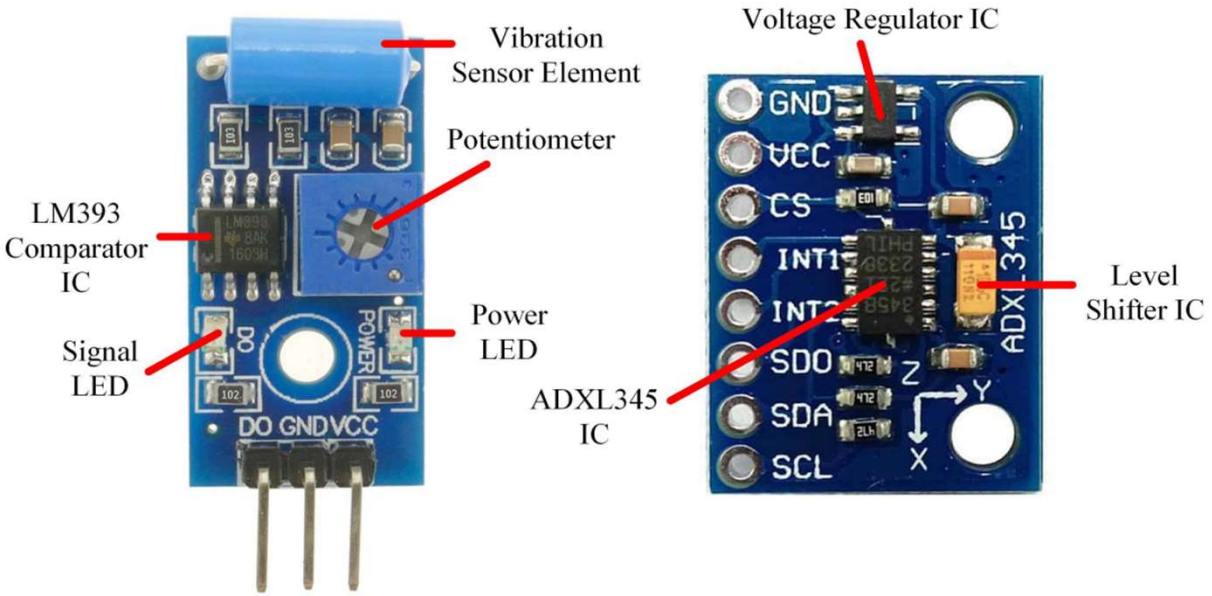


Fig. 2: The SW420 vibration sensor and ADXL345 accelerometer

METHODOLOGY

- The SW420 vibration sensor is chosen for fault detection in multirotors.
- The ADXL345 accelerometer is required to determine the faulty location in the multirotor because frequency information is critical.
- The Arduino UNO microcontroller is used, and four SW420 vibration sensors are attached to the multirotor arms and connected to the microcontroller to record vibration data.
- The proposed framework implemented on the DJI Phantom
- Bluetooth HC05 is used to connect with smartphones, and a 5000 mAh power bank is used to power the microcontroller.

METHODOLOGY

- For the faulty simulation of multirotor arms, it was modified by cutting and joining back using plastic brackets, as shown in Figure 4.

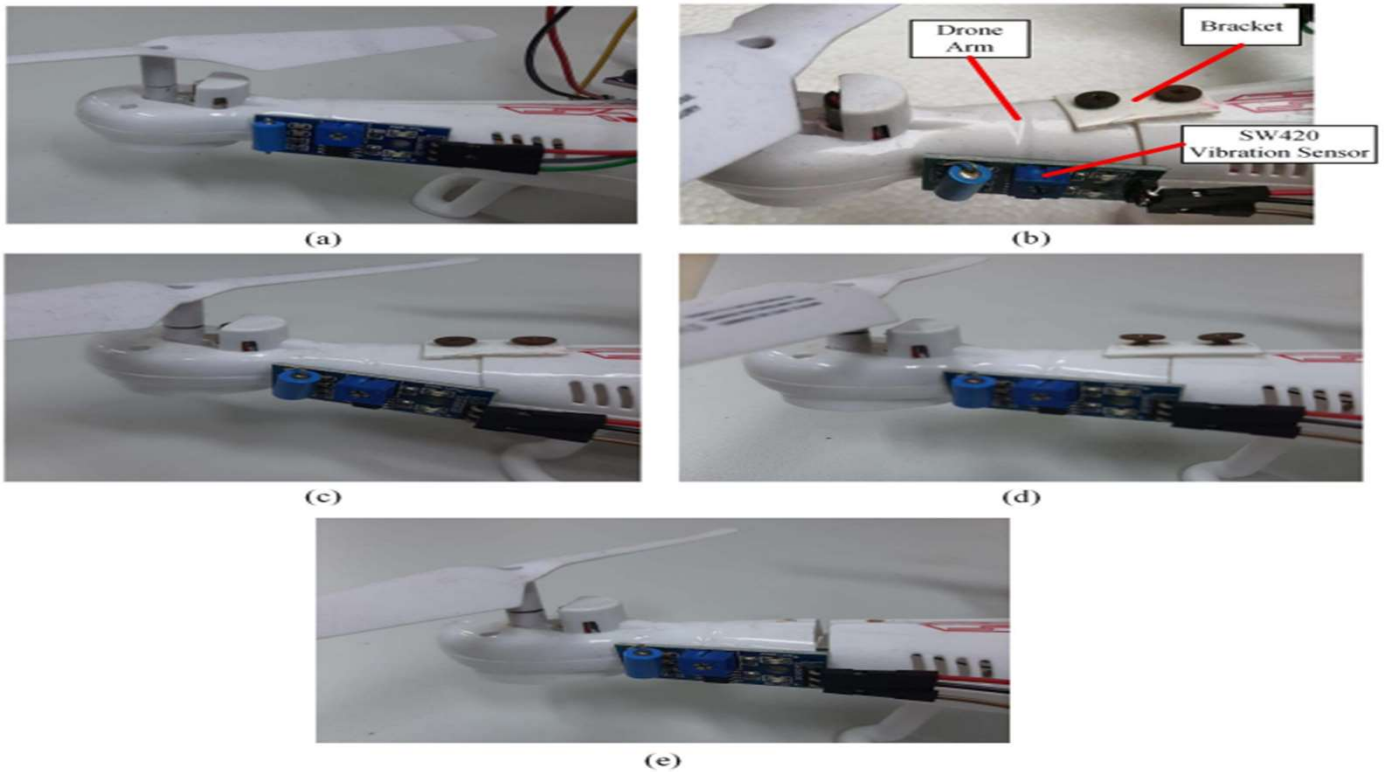


Fig. 4. Multirotor arms configuration: (a) Original arm condition, (b) 100% screwed (1.5 N.m), (c) 50% screwed (0.7 N.m), (d) 10% screwed (0.3 N.m), and (e) unscrewed multirotor arm.

METHODOLOGY

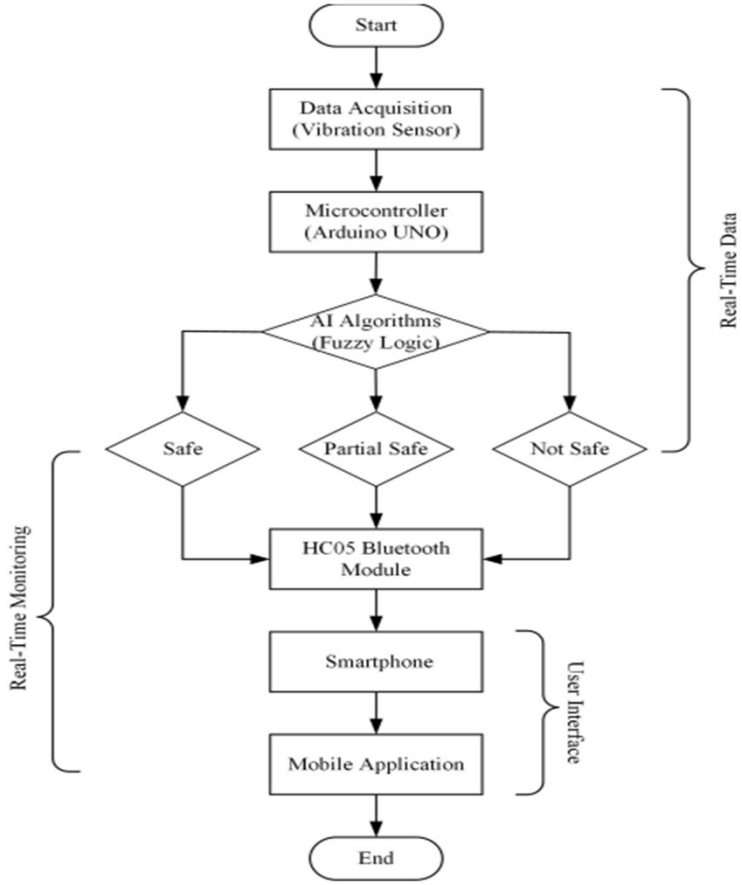


Fig 1: The block diagram of the proposed method

RESULT AND ANALYSIS

- The real time data are collected when the multirotor is on the ground. After collecting the vibration data, at each condition, the drone will take off and hover at a 1 m height using the experimental setup as shown in Figure 5.

- Based on the experimental work, the vibration input can be divided into low vibration amplitude (< 0.47 or 47000), medium vibration amplitude (0.47 or 47000 ≤ x < 0.72 or 72000), and high vibration amplitude (≥ 0.72 or 72000).

RESULT AND ANALYSIS

Five experimental conditions for vibration measurement in this study based on the multirotor arms configuration

Multirotor Arms Configuration	Drone Experiment Condition	Vibration Output Before Take Off	Threshold
Original arm condition	Can take off and hover safely	All vibration amplitude are less than 47000	safe
100%	Can take off and hover safely	All vibration amplitude are less than 47000	safe
50%	Can take off and hover for about 4 minute	Some of the vibration amplitude are above 47000, but all the amplitudes are below 72000	Partial safe
10%	Can take off but crash immediately	Some of the vibration amplitude are above 72000	Not safe
unscrewed	Can take off but crash immediately	Some of the vibration amplitude are above 72000	Not safe

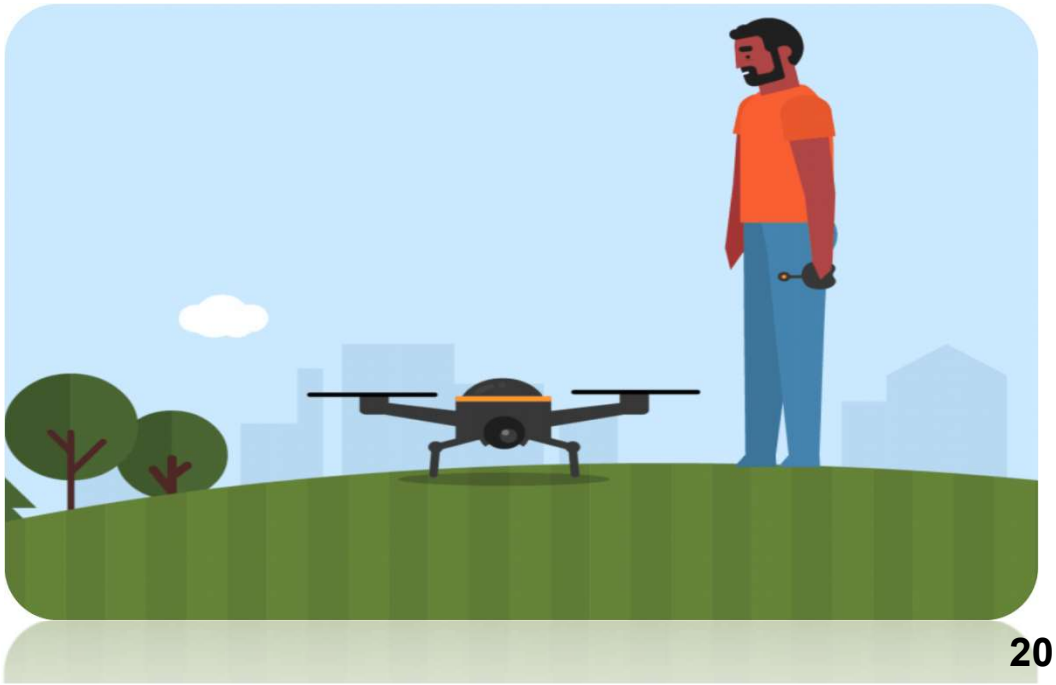
Table II Experimental results to determined threshold values

PERFORMANCE COMPARISON

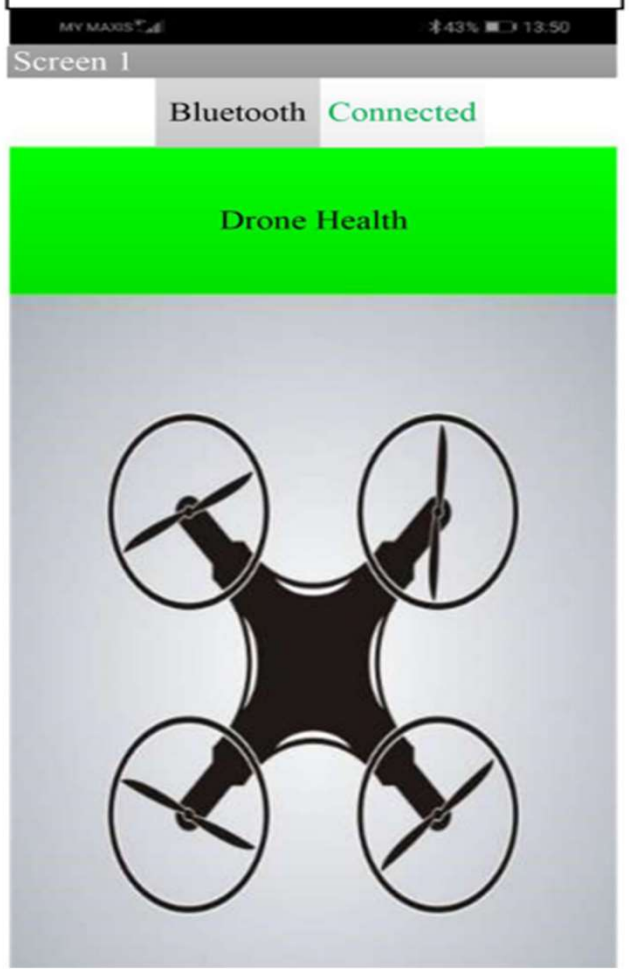
The performance between different AI systems were compared, and the fuzzy logic provided better results as it produced the results closest to the desired value.

USER INTERFACE

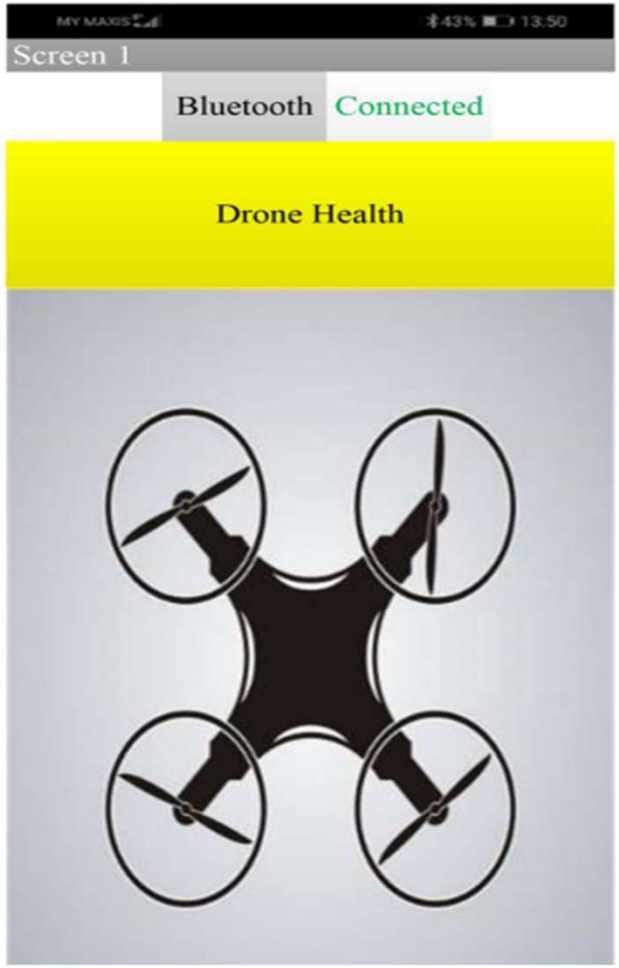
- MIT app inventor is used to create the application in APK specifically for better and easier monitoring.
- Created mobile application can be accessed using a smartphone.
- This application will show three possible decisions.
  - Green - referring to safe to operate.
  - Yellow - referring to partial safe.
  - Red - referring to not safe to operate.



Original and 100% Screwed Multirotor Arms Configuration



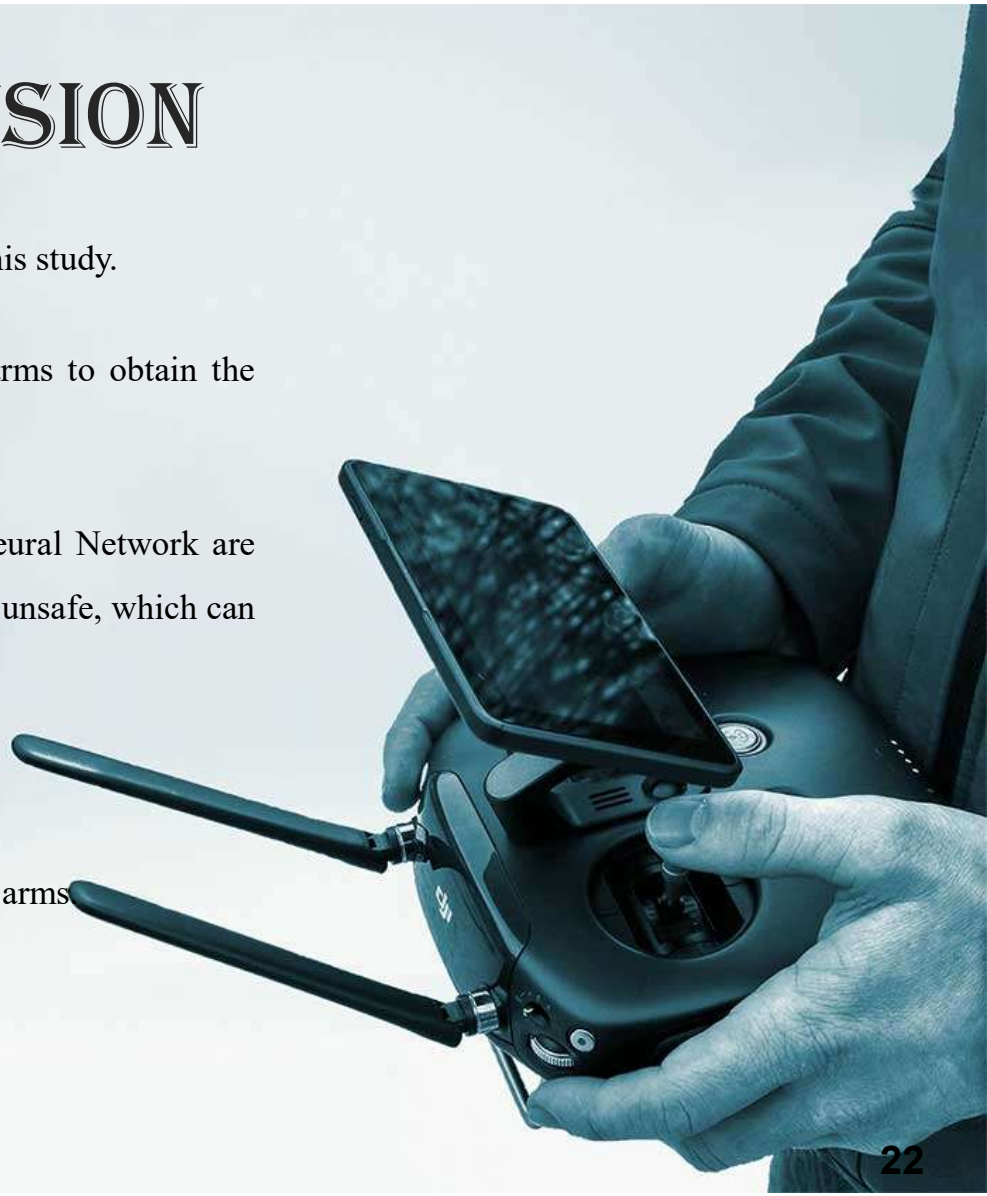
50% Screwed Multirotor Arms Configuration



10% Screwed and Unscrewed Multirotor Arms Configuration

CONCLUSION

- Vibration-based fault detection using AI techniques was introduced in this study.
- This method used the vibration sensors attached to the multirotor's arms to obtain the vibration data, which was then fed to the AI decision making systems.
- The AI techniques such as fuzzy logic, neuro-fuzzy, and Artificial Neural Network are used to make a decision whether the multirotor is safe, partially safe, or unsafe, which can be monitored using a smartphone.
- The fuzzy logic provided better results.
- This study is also limited to only one parameter, which is the multirotor arms



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THANK YOU