# Development Of Quadcopter for Search Operations with Human Detection Abilities

## 1. FIELD OF INVENTION

[0001] The field of innovation is development of quadcopter for search operation with human detection abilities.

## 2. BACKGROUND

[0002] The proposed model can be developed and implemented for increasing efficiency in search operation and disaster management activities. The quadcopter system can perform human detection with geo-tagging by making use of sensors and camera. The controlling technology of the entire system is based on Arduino based flight controller for flight management. A Raspberry Pi and a camera module is provided in order to acquire aerial visuals. The proposed quadcopter is composed of four BLDC motors coupled with 10inch propellers for thrust and manoeuvrability. A 11.1V Li-Po battery supply is used as power source for system. The flight of quadcopter is controlled by using a 6 channel trans-receiver. Using the camera module fixed on board the raspberry pi acquires visuals and transmits the information to ground control.

## 3. OBJECTIVES

[0003] To assist rescuers in search operations.

[0004] To detect humans using camera and image processing.

[0005] To develop a positively stabilized quadcopter to fly in harsh environments.

## 4. DETAILED DESCRIPTION OF INVENTION

[0006] Block Diagram

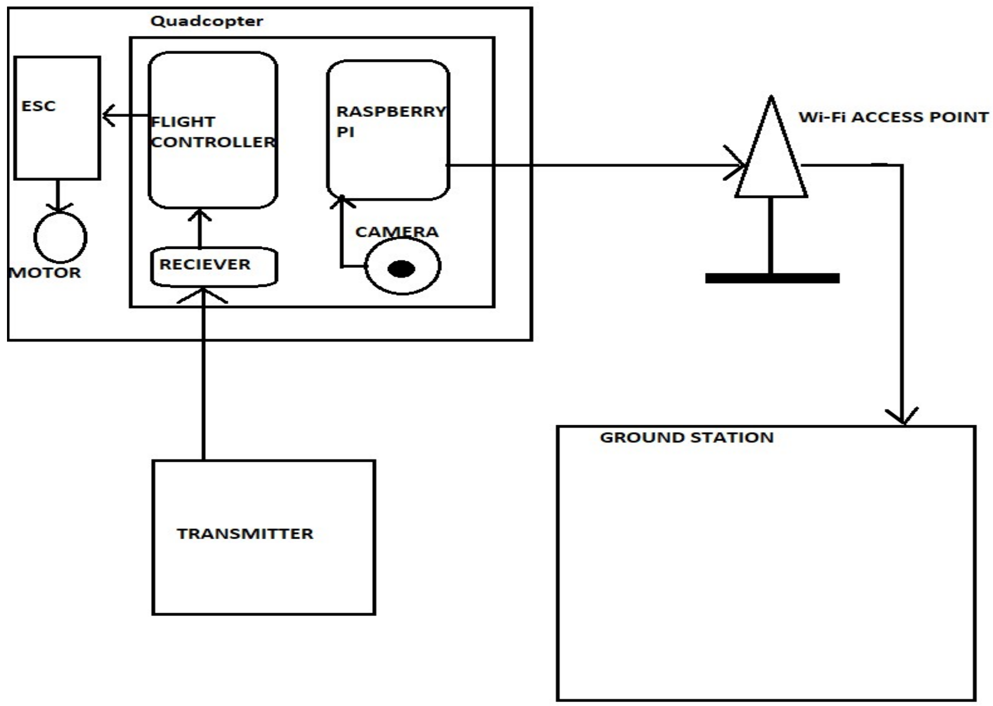


Fig 4.1 : Block Diagram

## 5. METHODOLOGY

[0007] Arduino micro-controller-based flight controller is heart of system, which is responsible for flight, stability and manoeuvrability of quadcopter. The flight controller is remotely controlled using a 6 channel, 2.4 GHz Trans-Receiver. A camera is interfaced to Raspberry Pi. And housed on board of quadcopter. The Raspberry Pi acquires visuals through camera and is processed further and extracted as bytes stream. The byte stream is then transmitted over a Wi-Fi channel with the help of raspberry pi's onboard Wi-Fi modem. Which is received at ground computing device, where the byte stream is packed together to form an image frame. The frames are passed as arguments to the pre-trained machine learning models to detect humans in the frame. If an human is detected in the frame, the geo location of when the frame was captured can be retrieved from frame detail as captured frames are geo-tagged.

## 6. HUMAN DETECTION USING IMAGE PROCESSING

### 6.1 IMAGE ACQUISATION

[0008] The first stage of any computer vision system is the image acquisition stage. The image can be acquired in digital form from a digital camera, which is a two-dimensional array of image sensors. Camera Description Name: PI Camera Pixel: 5 Megapixels(interpolated), Max. resolution: 640x480.

### 6.2 IMAGE CLASSIFICATION

[0009] It is a method to perform operations to detect and identify object of interest on an image, in order to detect and identify particular object of interest. It can be done by using CNN (Central Neural Network), Machine learning models and Python. It is a type of image processing in which input is a byte array of an image and output may be image or features of that image. Image classification basically includes the following three steps:

- Image acquisition
- Analysing and manipulating the image
- Output

## 7. QUADCOPTER SYSTEM

[0010] The quadcopter is built over F450 frame which is based on 4X configuration. The material is used is for frame is glass fibre and plastic. The system uses an Arduino based flight controller, and 1000KV BLDC motor on each arm coupled with 10 inch propeller. The system is powered by 11.1V Li-Po battery.

## 8. DATA TRANSMISSION

[0011] The Image acquired using pi camera is processed and stored as a stream of bytes. Which is then transmitted over Wi-Fi Channel using on board Wi-Fi modem in raspberry pi. The data is then received in ground computer, for image classification to detect humans.

## 9. BRIEF DESCRIPTION OF HARDWARE

### 9.1. ARDUPILOT

#### 9.1.1 INTRODUCTION

[0012] Ardupilot is an Atmega 2560 processor based, flight controller. Atmega 2560 is an AVR RISC based microcontroller, which is capable of executing powerful instruction in a single clock cycle. This improves efficiency in terms of power consumption and processing speed. The microcontroller has 256KB flash memory, with 8KB of SRAM. The microcontroller is clocked at 16MHz.

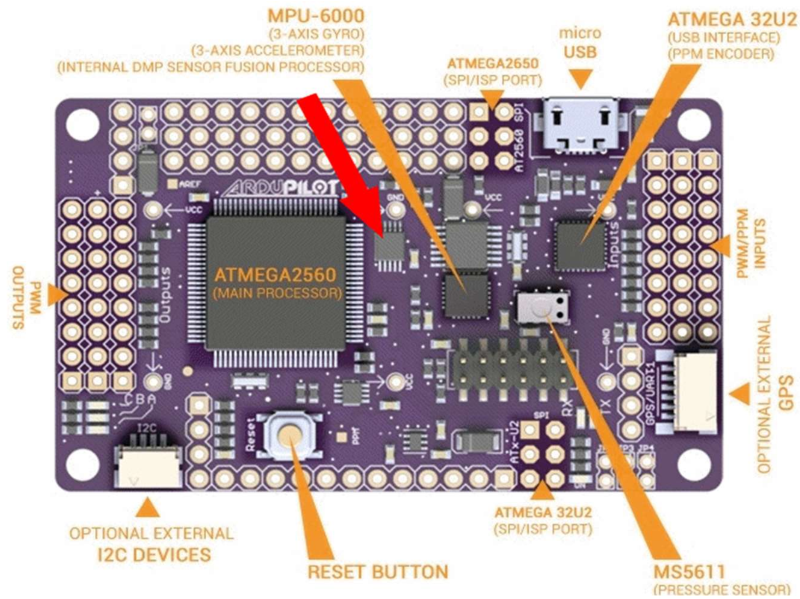


Fig 9.1.1.1: Ardupilot

### 9.1.2 ON-BOARD MOTION SENSOR

[0013] The Ardupilot has onboard MPU6050 absolute 6-axis motion sensor. Which is interfaced to microcontroller by I2C protocol. The MPU6050 has 3-axis accelerometer and 3-axis gyroscope. Which is capable of sensing the motion is tri-axial dimension, Roll, Pitch, and Yaw. The motion sensor is used to sense the motion which will be taken as input parameter for PID controller for stabilizing the flight.

### 9.1.3 INTERFACES

[0014] The Ardupilot has 8 input and output terminals which reads and commands using Pulse width modulation technique. The Flight controller also has facilities to interface external devices to improve its flight performance.

- GPS Port: This port is used to connect external GPS module, for location-based functionalities. This port supports UART protocol.
- Telemetry port: This port is used to connect telemetry dongle, to transmit flight parameters to ground station and receive flight commands, during flight or on ground. This port supports UART protocol.

## 9.2 ELECTRONIC SPEED CONTROLLER.

### 9.2.1 INTRODUCTION

[0015] Electronic speed controller is an essential module used in quadcopters, which is a Brushless DC motor driver. The motor driver used powered with Atmega micro controller, powered by SimonK firmware with maximum power load of 30 amps operating at 11.1V DC power supply.

Fig 9.2.1: ESC

[0016] An electronic speed control (ESC) is an electronic circuit that controls the speed of an electric Brush less DC motor. It provides variable speed of the motor and dynamic braking.

### 9.2.2 ESC INTERFACES

[0017] The ESC has one power supply port which has input voltage range of 11V to 14V and max 30 amps. It has a data input line which supports Pulse Width Modulation (PWM) signals, which is of time period 2000 micro-seconds. And minimum duty cycle of 50 percent.

[0018] The ESC has three output wires, which is connected to BLDC motors. The three wires send the voltage level in term of pulses which is time invariant with respect to speed of motor.

## 9.3 RASPBERRY PI 4

### 9.3.1 INTRODUCTION:

[0018] **Raspberry Pi** is a series of system-on-chip (SOC) developed in the UK, Europe by the RPi Foundation in association with Broadcom chip makers. The Raspberry pi is popular hobby device and used for rapid prototyping in industries due to its diverse characteristics and also technical supports to various programming language and well-built quality.

### 9.3.2 MODEL:

[0019] **RPi 4 Model B** was introduced in July 2019 with a powerful features such as, on-board 802.11ac Wi-Fi, Bluetooth 5, Ethernet, 2 USB 2.0 ports, 2 USB 3.0 ports, and dual-monitor support through a pair of micro HDMI ports for up to 4K resolution. Driven by powerful 1.5 GHz 64-bit quad core ARM Cortex-A72 processor, The Pi 4 is powered via a USB-C power supply port providing a maximum power of 12.5 watts at 5V.

### 9.3.3 Hardware:

[0020] The Raspberry Pi 4 Model B is a latest version of RPi computers with significantly improved CPU, GPU and GPIO performance, supporting up to 8GB RAM, in an exceptional form factor. The Pi 4B+ is released with different versions of 1, 2, 4 and 8 GB of LPDDR4 SDRAM.

[0021] RPi 4B Processor is clocked at 1.5 GHz for an optimum performance. For storing of operating system and program memory a microSD card is used. The boards have two USB2.0 ports and two USB3.0 ports. HDMI is used for video output, with a dedicated 3.5mm Audio jack for Audio. Digital Input/output for external interfaces is provided by General Purpose I/O (GPIO) pins with a voltage range 0 to 3.3V, which support common protocols like I²C, SPI, PWM. The Pi 4 on-board Bluetooth and Wi-Fi 802.11n which enables various connectivity.

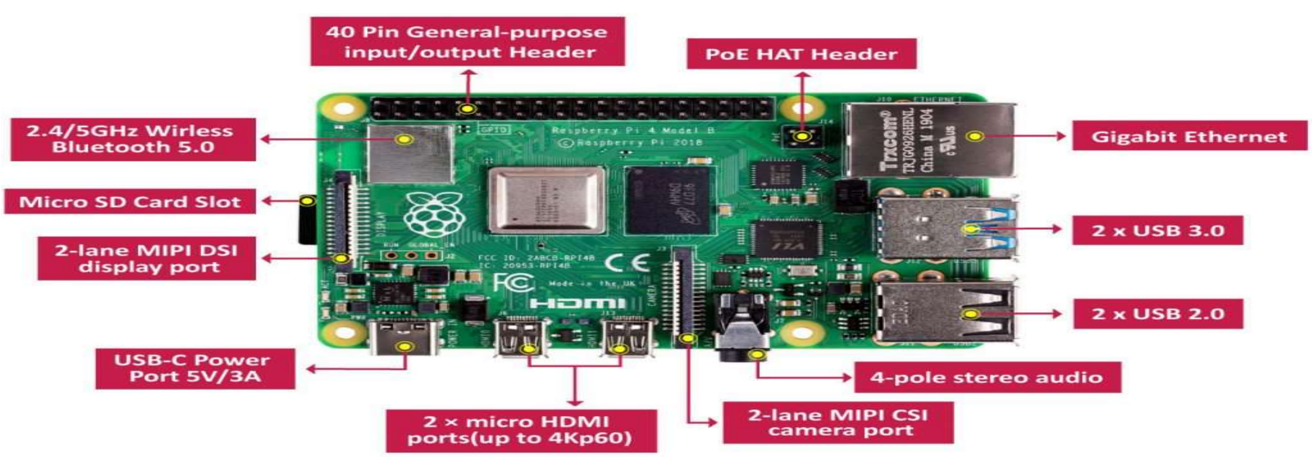


Fig 9.3.3 : Raspberry pi 4 B

### 9.3.5 Features of Hardware:

- Quadcore 64-bit ARM-Cortex A72 clocked at 1.5GHz
- 4 GB LPDDR4 RAM options
- H.265 (HEVC) hardware decode (up to 4Kp60)
- H.264 hardware decodes (up to 1080p60)
- Video Core VI 3D Graphics
- Supports dual HDMI display output up to 4Kp60

### 9.3.6 Features of Interface:

- Wi-Fi: 802.11 b/g/n/ac IEEE standards
- Bluetooth: with 5.0 protocol
- SD Card
- Dual displays up to 4K resolution through microHDMI
- USB2.0 ports
- USB3.0 ports
- Gigabit Ethernet port
- Raspberry Pi camera port (2-lane MIPI CSI)
- Raspberry Pi display port (2-lane MIPI DSI)
- 28x user GPIO supporting various interface options: – Up to 6x UART – Up to 6x I2C – Up to 5x SPI – 1x SDIO interface – 1x DPI (Parallel RGB Display) – 1x PCM – Up to 2x PWM channels – Up to 3x GPCLK outputs.

### 9.3.7 POWER REQUIREMENTS

[0022] The Pi 4B requires a constant power supply capable of delivering 5V at 2A through USB-C. if USB is loaded downstream consuming more than 500mA.

### 9.3.8 SOFTWARE

- Instruction Set: ARMv8 Instruction Set
- Mature Linux software stack
- Linux based Raspbian OS

### 9.3.9 PERIPHERALS

### 9.3.9.1 GPIO PINS

[0023] The Pi4B supports 28 BCM2711 GPIOs via a 40-pin header. The GPIO supports digital outputs of voltage level 0 to 3.3V, and various other communication protocols such as I2C, PWM, SPI and UART.

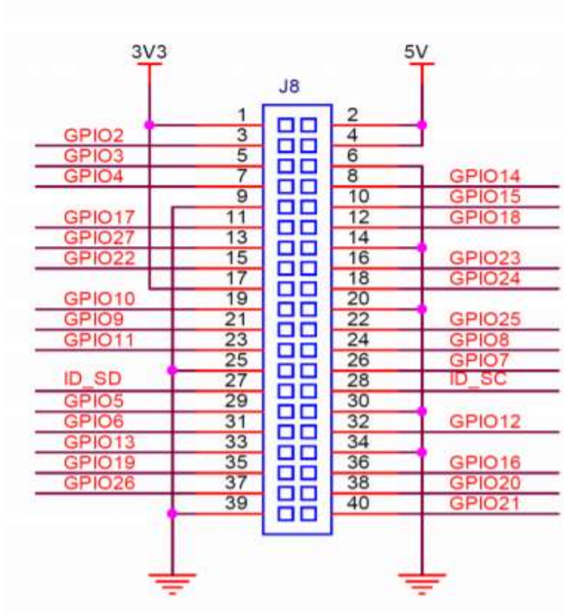


Fig 9.3.9.1 : GPIO Layout of Raspberry PI 4B+ model.

| GPIO | Default Pull | ALT0 | ALT1 | ALT2 | ALT3 | ALT4 | ALT5 |
|---|---|---|---|---|---|---|---|
| 0 | High | SDA0 | SA5 | PCLK | SPI3_CE0_N | TXD2 | SDA6 |
| 1 | High | SCL0 | SA4 | DE | SPI3_MISO | RXD2 | SCL6 |
| 2 | High | SDA1 | SA3 | LCD_VSYNC | SPI3_MOSI | CTS2 | SDA3 |
| 3 | High | SCL1 | SA2 | LCD_HSYNC | SPI3_SCLK | RTS2 | SCL3 |
| 4 | High | GPCLK0 | SA1 | DPI_D0 | SPI4_CE0_N | TXD3 | SDA3 |
| 5 | High | GPCLK1 | SA0 | DPI_D1 | SPI4_MISO | RXD3 | SCL3 |
| 6 | High | GPCLK2 | SOE_N | DPI_D2 | SPI4_MOSI | CTS3 | SDA4 |
| 7 | High | SPI0_CE1_N | SWE_N | DPI_D3 | SPI4_SCLK | RTS3 | SCL4 |
| 8 | High | SPI0_CE0_N | SD0 | DPI_D4 | - | TXD4 | SDA4 |
| 9 | Low | SPI0_MISO | SD1 | DPI_D5 | - | RXD4 | SCL4 |
| 10 | Low | SPI0_MOSI | SD2 | DPI_D6 | - | CTS4 | SDA5 |
| 11 | Low | SPI0_SCLK | SD3 | DPI_D7 | - | RTS4 | SCL5 |
| 12 | Low | PWM0 | SD4 | DPI_D8 | SPI5_CE0_N | TXD5 | SDA5 |
| 13 | Low | PWM1 | SD5 | DPI_D9 | SPI5_MISO | RXD5 | SCL5 |
| 14 | Low | TXD0 | SD6 | DPI_D10 | SPI5_MOSI | CTS5 | TXD1 |
| 15 | Low | RXD0 | SD7 | DPI_D11 | SPI5_SCLK | RTS5 | RXD1 |
| 16 | Low | FL0 | SD8 | DPI_D12 | CTS0 | SPI1_CE2_N | CTS1 |
| 17 | Low | FL1 | SD9 | DPI_D13 | RTS0 | SPI1_CE1_N | RTS1 |
| 18 | Low | PCM_CLK | SD10 | DPI_D14 | SPI6_CE0_N | SPI1_CE0_N | PWM0 |
| 19 | Low | PCM_FS | SD11 | DPI_D15 | SPI6_MISO | SPI1_MISO | PWM1 |
| 20 | Low | PCM_DIN | SD12 | DPI_D16 | SPI6_MOSI | SPI1_MOSI | GPCLK0 |
| 21 | Low | PCM_DOUT | SD13 | DPI_D17 | SPI6_SCLK | SPI1_SCLK | GPCLK1 |
| 22 | Low | SD0_CLK | SD14 | DPI_D18 | SD1_CLK | ARM_TRST | SDA6 |
| 23 | Low | SD0_CMD | SD15 | DPI_D19 | SD1_CMD | ARM_RTCK | SCL6 |
| 24 | Low | SD0_DAT0 | SD16 | DPI_D20 | SD1_DAT0 | ARM_TDO | SPI3_CE1_N |
| 25 | Low | SD0_DAT1 | SD17 | DPI_D21 | SD1_DAT1 | ARM_TCK | SPI4_CE1_N |
| 26 | Low | SD0_DAT2 | TE0 | DPI_D22 | SD1_DAT2 | ARM_TDI | SPI5_CE1_N |
| 27 | Low | SD0_DAT3 | TE1 | DPI_D23 | SD1_DAT3 | ARM_TMS | SPI6_CE1_N |

Fig. 9.3.9.1.2 Raspberry pi 4 GPIO Alternate Functions

### 9.3.9.2 USB

[0024] The Pi 4B has two USB 2.0 and two USB 3.0 type-A ports. USB output current is normalized to approximately 1.1A when all the four sockets is loaded.

### 9.3.9.3 CAMERA AND DISPLAY INTERFACE

[0025] A 2-lane MIPI CSI connector for interfacing Camera and one 2-lane MIPI DSI connector for interfacing Display connector.

### 9.3.9.4 HDMI

[0026] The Pi 4B has two micro-HDMI ports, both of which support CEC and HDMI 2.0 with resolutions up to 4K.

### 9.3.9.5 UART BRIDGE

[0027] PI-4 has six UART

| Name | Type |
|---|---|
| UART0 | PL011 |
| UART1 | mini UART |
| UART2 | PL011 |
| UART3 | PL011 |
| UART4 | PL011 |
| UART5 | PL011 |

Fig. 9.3.9.5 UART Bridge

## 10. ABSTRACT

[0028] The system proposed is implemented to assist rescuers and disaster management personnel, as it can acquire aerial visuals and transmit as individual frames to ground control. Whereas on ground a computing device processes the visuals and detects the humans in frames, the frames are geo- tagged. Therefore, the human detected in frame can be located on map, which will help the rescuers to find and rescue the person in an efficient way.

Fig 10.1: Development of Quadcopter for Search Operations with Human Detection Abilities

## 11. CLAIMS

- UAV system to assist rescuers in search operation, which transmits live visuals over a channel to ground computer to process the visuals to detect humans.
- Using Faster-RCNN we can process the frames in less time.
- Using Wi-Fi, we are further reducing latency in transmitting the frames from quadcopter to ground station.