Development of an Autonomous Drone for Surveillance Application

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Abstract - *Drones/unmanned aerial vehicles (UAV) are defined as an aerial vehicle that does not need human intervention. Drones are best known for their use in military operations including the use of weaponized drones for targeted killing, especially in pre-emptive strikes and surveillance at a specific location. The UAVs can be deployed for military applications to counter both domestic and international terrorism. This paper describes the development of a UAV for surveillance in the region of deployment for monitoring, based on human body detection along with soldiers uniform color and pattern recognition. This has been achieved by using most stabilized flight controller and sending the live visual feedback to the monitoring station and mail alert message to the control station using SMTP protocol and OpenCV library for object detection.*

Key Words: UAV, OpenCV, Raspberry Pi, Pixhawk, IOT.

1. INTRODUCTION

Recent development and advancement in the engineering field such as propulsion system, airframes, batteries, and microcontroller are seen as an important issue. The concept of an unmanned aerial vehicle is of dire importance to take this development phase to an entirely new horizon. Development of an aerial vehicle that can operate autonomously and perform a designated task on its own without the considerable guidance of a pilot is in itself a task to achieve. UAV can be managed remotely via radio, but currently, a new control system has been developed which is capable of maintaining stable UAVs in the air along the proposed route. This intelligent system is placed on board with UAV to replace human factor in flight operations and is called as an automatic pilot or autopilot. Thus they control the altitude, speed heading and other variables of the UAV autonomously by generating required control signals.

The UAV can be operated by radio frequency controller and send live visual feedback which can be controlled by onboard computers or by remote control of a pilot on the ground. This UAV technology can be deployed for military application to counter both domestic and international border issues. This paper describes the surveillance using human body detection along with color pattern recognition. The proposed system notifies any unauthorized entry along with GPS coordinates which aid to locate enemies.

In case of remote-controlled drone, there might be a chance of damage in transmission section which would result in loss of control over the flight which in turn may lead to catastrophe. While a manned aerial vehicle puts the pilots at risk during the crash, a UAV is able to fly anywhere even into the zones where it would be dangerous for the pilot.

2. PROPOSED METHODOLOGY

While designing the autonomous drone, the auto-pilot was used with four brushless DC motors, GPS module, telemetry, and the receiver. The whole system was powered via a power module with a Lithium Polymer battery of 18v. When the system is powered up and necessary configuration and calibrations are done, the system is armed for the flight.

Flight controller interacts with other units via standard communication interfaces such as pulse width modulation (PWM) module[1].

For the autonomous mission, Pixhawk controller is the most preferred one. It is supported with a number of flight modes and most of the flight modes associated with a GPS signal. In 'Return to Launch'(RTL) mode, flight controller will note down takeoff coordinate points so that in case of an emergency such as low battery or poor signal strength, it will automatically return to the position from where the flight was started. During the arming process, the auto-pilot checks the fail-safe conditions like low battery voltage, GPS unable to lock, recalibration of the magnetic compass or any other sensors. When all the fail-safe test is passed, the drone is ready for take-off.

On the other side, the waypoints are set using "Mission planner" a software which has a great graphic user interface (GUI) and makes it possible to change the upcoming waypoints altitude, change the mode of flight and can even change the direction of flight. The drone in flight and the computer with the mission planner software is connected by telemetry module using radio frequency (MAV-link protocol).

The Raspberry-Pi which is powered up using a buck converter is connected to a computer in the base station using open source remote desktop (XRDP) protocol. Raspberry Pi camera module offers better image representation with reduced noise contamination in the image. UAV sends a live visual feedback to the ground station and also sends mail alert notification in case of detection of an any unauthorized entry using the SMTP protocol.

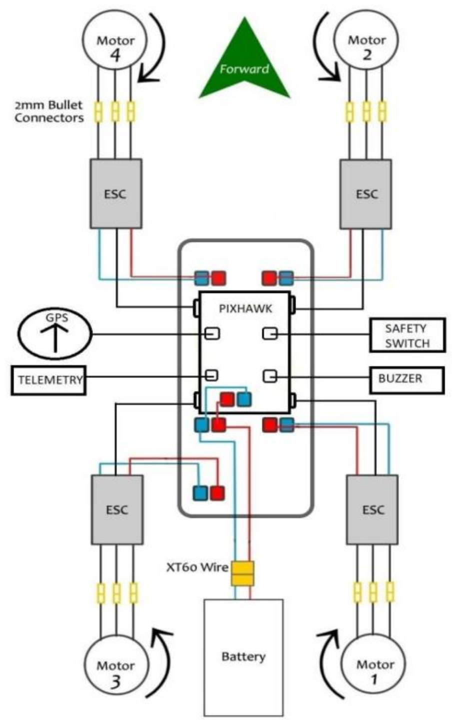

Fig -1: Drone Design

3. IMPLEMENTATION

Mission planner software developed by Michael Oborne which was specially designed for autonomous flight mission. The software is used to achieve communication between the base station and UAV. It is also used to program the commands such as returning conditions, GPS coordinates, altitude points etc., into a drone. The software allows the flight controller to fly using various flight modes such as acrobatic mode, altitude hold, loiter mode and stabilize mode. There are a number of calibrations to be done on the flight controller in synchronization with other hardware components using mission planner[2]. Few of the mandatory hardware calibrations are briefed below.

- Compass Calibration

  Electronic compass in the Pixhawk module is affected by the magnetic field generated by the motors and also other nearby magnetic fields. By calibrating the compass, one can compensate the effect of the surrounding magnetic fields and in turn, the drone can fly in the determined path.

- ESC Calibration

  Electronic speed controller (ESC) is responsible for rotating the motors at the speed required by the autopilot. ESCs need to be calibrated so that they know the minimum and maximum pulse position modulation (PPM) values that the flight controller will send.

Python is widely used high-level language and extensively used with Raspberry Pi. Python syntax allows to express concepts in fewer lines and it support wide user-defined class.

- OpenCV

  Open Source Computer Vision (OpenCV) is a cross-platform library using which one can develop real-time computer vision applications. It mainly focuses on image processing, video framing, and analysis including features like face detection and object detection[3]. OpenCV has a wide objective that mainly used to convert image pixel into a grayscale image and processes the image depending on the intensity level of each pixel.

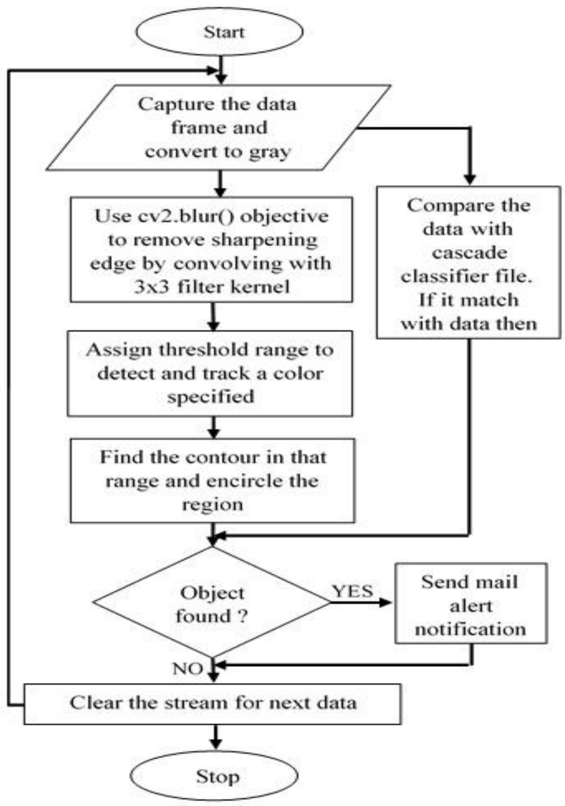

Chart -1: System Flowchart

Step1: Initialize and import the OpenCV, SMTP library which is extensively used in image processing into the python IDE platform.

Step2: Capture the data frame, in which OpenCV default color space model is BGR format well known as the RGB model. Camera module captures continuously the frames and converts it to a grayscale image[4], so that template matching is easier in grayscale intensities than the RGB color model, which also enhances processing delay.

Step3: Using OpenCV objective cv2.blur( ), we can reduce sharpening edges by convolving with a filter that assigns an average pixel intensity value of neighboring 3x3 filter size. Meanwhile match the grayscaled data with cascade classifier, for upper body, full body, frontal face detection.

Step4: If the UAV is at a higher altitude then it should suspect using specified color, now we assign the lower and upper-intensity range to find out the threshold value to track suitable color.

Step5: Find the contour (which is a mapping of similar intensity pixel value) of tracked color and adjust the area if it exceeds the contour range. And encircle that tracked color to locate in data frames.

Step6: Check the condition, return true if data frame matches with cascade classifier or if the specified color is identified.

Step7: If the condition is true, mail alert message is sent by UAV to notify the ground control station using SMTP protocol[5].

Step8: Clear and refresh the frame to capture the next frame for further processing until it is terminated.

4. RESULT

An autonomous drone using effective utilization of GPS mapping with flight controller has been developed.

Fig -2: Autonomous Drone Flying

Live frame visual feedback is sent from drone to the control station, which is used to detect, suspect and notify any unauthorized human entries using body and color detection algorithms.

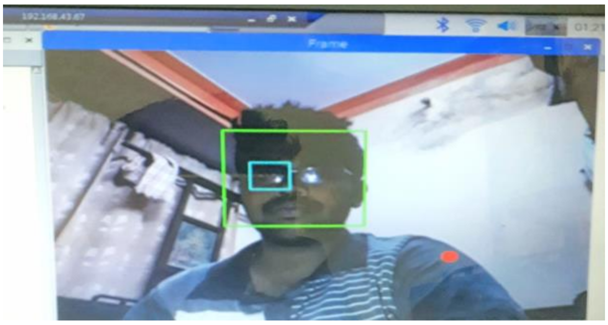

Fig -3: Body and Color Detection

3. CONCLUSIONS

A UAV usually has a rapid launch as compared to manned aircraft while it has maneuverability as compared to ground vehicles. This system can communicate using the wireless network to receive control instructions from the base station as well send the images taken from the UAV to the base station. New methods are being developed for data collection and advanced image processing of remotely sensed data. The UAV can be deployed in building and ships surveillance with the use of a proportional integral derivative (PID) closed loop gain feedback controller.

Using autonomous flight mission planning i.e., by setting up waypoints with accurate geographical co-ordinates it can also serve as medicine carrying drone with first aid treatment facilities which can be used in case of a medical emergency.

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