Object Tracking Combat FPV Drone for Sri Lanka Short Range Military Operations

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Abstract*—Targeting an object in a war situation will be more complicated when that object starts to move. Carrying a large number of weapons causes much fatigue for soldiers and it reduces mobility and efficiency of own troops. If a complete system of flying device can be used as a remote-controlled, unmanned reconnaissance or observation drone in combat areas or buildings that are difficult to access or hazardous to personnel will be a convenient tool. A drone of this kind can approach objects on the ground, analyse them precisely as well as to provide an overview from the air, or cover great distances quickly. This paper describes the design and implementation of a new combat drone system for Sri Lankan military environment. Developed drone system is capable of autonomously approaching targeted areas and the facility of real time video streaming, enabling to monitor situations and target tracking during operation, getting an enemy GPS coordinate and semi-automated gun for point and shoot to tracked targets. Drone handling uses 2.4Ghz RF range and video transmission in 5.8Ghz frequency range. These two frequencies will avoid signal interferences if any. Telemetry data is used to control drone autonomously. Camshift algorithm is used in the python coding for object detection and tracking and is controlled by a Rasberry pi board functioning as the main processing unit and two micro servos have been used to control a porotype gun autonomously. An NRF24l01 Radio Transceiver module and a microcontroller based platform is used for manual control of the prototype gun.*

Keywords— Unmanned aerial vehicle, Quadcopter, autonomous, Object tracking, FPV, Real time monitoring, Prototype of pistol

I. INTRODUCTION

The initial idea for this project came from research papers based on future military weapons systems. This type of remotely accessible human tracking armoured drone system does not readily used by Sri Lankan military even though it has great potential.

This armoured drone can autonomously detect, track and shoot at a desired moving target, also with the capability of allowing a user to remotely access and control the gun via computer. The mobility, hardness, and function of this system allows a reliable replacement for human beings under harsh conditions in small range missions like recce patrols, raids, pursuits, camp attacks and attacks in urban areas.

The system would replace active functions of an armed guard while keeping a human life away from harm's way. Since this system would replace a human, it is more important to consider its accuracy and reliability. Therefore, the proposed system will allow the access of remote operator. This will enable remote operator to observe the field in real time, confirm the target to the drone before firing function, collect information about the operating area which will assist further military planning. Overall, this system has a lot of potential in modern day military strategy and would help spare hundreds of ally's lives.

II. PROBLEM STATEMENT

Real time object detection in the field is tedious, also number of weapons carried will affect the efficacy and mobility of own troops.

The accessibility is one key factor in the theatre where it is almost impossible to balance out the risk in reaching out towards a precarious position and the advantage gained if attained the same.

It is furthermore required to overcome great height differences and obstacles, reach inaccessible areas or higher floors of buildings as well as enter buildings through open windows or damaged window panes as part of police or military actions which will result in humans having to be exposed to danger. If the described flying device designed as a drone that additionally carries suitable remote-controlled devices for disarming booby traps or bombs, it can also be used for a mission in accordance with the previous section in order to remove dangers. When the drone is used as part of police or military missions, there is also the possibility of equipping the drone so that it can release anesthetizing gas Which then enables dangerous criminals, such as hostage takers or terrorists.

III. METHODOLOGY

Development of combat drone was carried out under two categories.

A. Drone development

Drone handling uses 2.4Ghz RF range and video transmitting part in 5.8Ghz frequency range. We planned to use two frequency range to control the drone and video transmitting. This will avoid the signal interference.

Brushless DC motors was used as our main motors and motors are controlled by main control board. Using 2.4 GHz transmitter we give controlling signal to main board and by varying motors speed we navigate drone to take movement, it can be forwarded, back ward, up, down, hovering or pitching.

We planned implement a GPS location system to our drone for acquire current position co-ordinates. If drone can send us its current GPS location through the OSD, we can get our target extract latitude through the GPS we can fire that target with heavy weapon like artillery or other missile system.

When considering the power consumption and our other requirement we chose quadcopter as a drone for our basic platform. We try to programme this quadcopter with above facilities and low weight, flips and role and easily handle interface. We supposed to develop our human tracking system using raspberry pi, and by using computer vision system we developed our tracking part. In hear critical part is to identify our moving target and tracking that object and keep weapon always to that moving point. For our model drone, we planned to use a toy gun to simulate, in real scenario we can replace it by using real weapon. We highly consider about our drone's stability when getting target and firing, so we recommended for design a new automatic low weight weapon with less backfire. We only developed our tracking method and how it applicable for Sri Lanka military scenarios.

This drone is designed for short range missions, it's most suitable for urban situation or raids and catch running target and track that target and fire in to that target in accurate way than human. This process similar to human tracking bullet which follow/track the human thermal and hit that target. Getting target in bird eye view is easier than ground targets, and also it`s accurate than ground targets. In hear our drone can track human motion through the camera module and PIR sensor, we lock that target and move designed gun where tracked target move. Figure 01 describe the overall project block diagram.

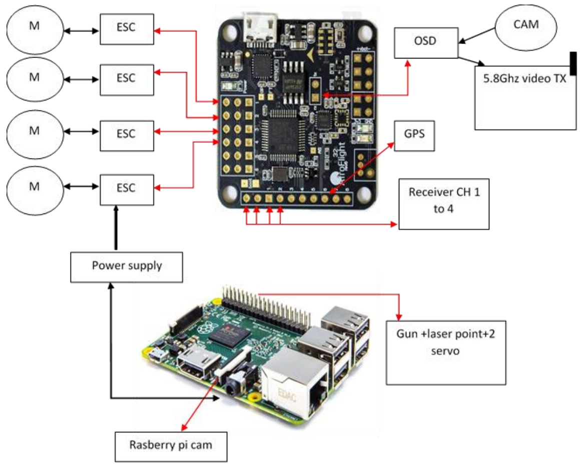

Figure 1: Overall project block diagram

Basically, a Quadcopter is a quad-rotor helicopter that is lifted and propelled by four rotors. A quadcopter is a flying vehicle possessing four identical rotors, evenly spaced around the central fuselage (hub). Brushless DC motors are used as rotors & they use symmetrically pitched propellers. Control of vehicle motion is achieved by altering the pitch and rotation rate of one or more motors, thereby changing its torque load and thrust/lift characteristics. Various movements are possible by varying the direction of rotation of propellers & by altering the speed of the motors.

Proportional-integral-derivative and PID controller is a control loop feedback mechanism widely used in control systems It is a closed-loop control system that try to get the actual result closer to the desired result by adjusting the input. Quadcopters or multicopper. Use of PID controller is to achieve stability. A PID controller calculates an "error" value as the difference between a measured variable and a desired set-point. The controller attempts to minimize the error by adjusting the control inputs. In multicopper terms this means the PID controller will be taking data measured by the sensors on the flight controller (gyros / accelerometers etc.) and comparing that against expected values to alter the speed of the motors to compensate for any differences and maintain balance. The PID controller calculation algorithm involves three separate constant parameters, the proportional, the integral and derivative values, denoted P, I, and D. Heuristically, these values can be interpreted in terms of time. P depends on the present error I on the accumulation of past errors D is a prediction of future errors, based on current rate of change.

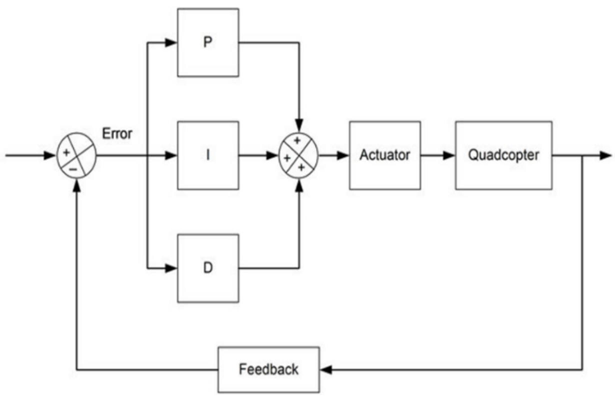

Figure 2: PID control system

To have any kind of control over the quadcopter or multicopper, we need to be able to measure the quadcopter sensor output like pitch angle, so we can estimate the error, how far we are from the desired pitch angle. We can then apply the 3 control algorithms to the error, to get the next outputs for the motors aiming to correct the error. There are three parameters that a pilot can adjust to improve better quadcopter stability. These are the coefficients to the 3 algorithms as mentioned above. The coefficient basically would change the importance and influence of each algorithm to the output. These are the effective parameters that's need to the stability of our drone.

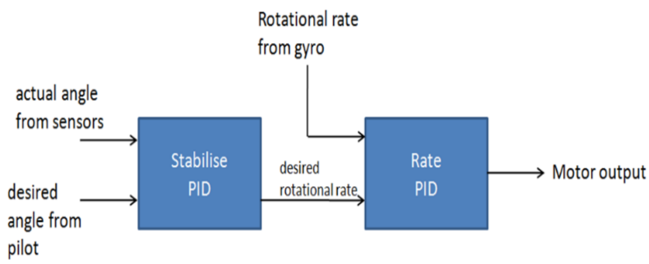

Figure 3: Per Axis PID structure

The variation of each of these parameters alters the effectiveness of the stabilization. Generally, there are 3 PID loops with their own P I D coefficients, one per axis, so we have to set P, I and D values for each axis (pitch, roll and yaw).

B. Detecting and tracking

Object detecting and tracking system is included with three main parts

- Selecting the object, we need to be tracked
- Object detection and tracking
- Weapon and camera control

The detection algorithm is running on a Raspberry pi 3 model B board and it work as main processing unit and two micro servos have used to control pan and tilt.
The Raspberry Pi is a low cost, credit-card sized computer that plugs into a computer monitor or TV, and uses a standard keyboard and mouse. It has 1.2Ghz 64-bit quad-core processor, 1GB RAM and integrated 802.11n wireless and Bluetooth facility. Software using in Raspberry pi 3 include.

Selecting the object, we need to be tracked. Here the object recognition system had two major problems that need to be solved. Detecting the object from the background and keep it tracked while moving. General challenge for Computer Vision - objects may variable due to external effects.

Object detection and Tracking Here we used Camshift algorithm in our python coding for object detection and tracking. The Mean Shift algorithm is a robust, non-parametric technique that climbs the gradient of a probability distribution to find the peak of the distribution the theory behind the meanshift is simple. Consider a set of points. (It can be a pixel distribution like histogram back projection). It is given a small window (may be a circle) and we have to move that window to the area of maximum pixel density (or maximum number of points). It can illustrate as figure 04.

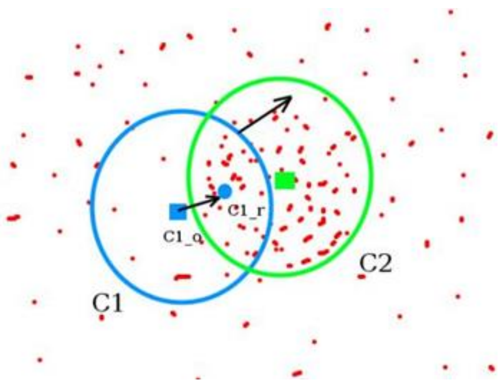

Figure 4: Pixel distribution

The initial window is shown in blue circle with the name "C1". Its original center is marked in blue rectangle, named "C1_o". But if you find the centroid of the points inside that window, you will get the point "C1_r" (marked in small blue circle) which is the real centroid of window. Surely, they don't match. So, move your window such that circle of the new window matches with previous centroid. Again, find the new centroid. Most probably, it won't match. So, move it again, and continue the iterations such that center of window and its centroid falls on the same location (or with a small desired error). So finally, what you obtain is a window with maximum pixel distribution. It is marked with green circle, named "C2". As you can see in image, it has maximum number of points.

CAMshift Algorithm can be summarized as below:

- Set the region of interest (ROI) of the probability distribution image to the entire image.
- Select an initial location of the Mean Shift search window. The selected location is the target distribution to be tracked.
- Calculate a colour probability distribution of the region centred at the Mean Shift search window.
- Iterate Mean Shift algorithm to find the centroid of the probability image. Store the zero moment (distribution area) and centroid location.
- For the following frame, center the search window at the mean location found in Step 4 and set the window size to a function of the zero moment. Go to Step 3

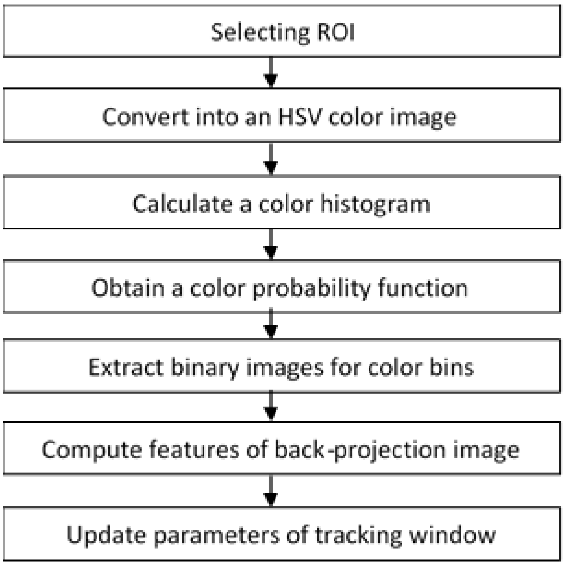

Figure 5: CAMshift Algorithm

IV. CONCLUSION

The thesis has been a final outcome of a designing of an object tracking Armoured FPV drone for Sri Lanka which have capability of both autonomous and manual tracking of desired target in precisely and efficiently than human do. Not only that this smart Armoured drone has mainly included with GPS module and camera module. So, it helps operator to observe the target, locate the target and make further decisions. Drone handling has done using 2.4Ghz radio frequency range and video transmitting part in 5.8Ghz frequency range. These two-frequency range will avoid the signal interference.

Brushless DC motors have been used as our main motors and motors are controlled by main control board. Using 2.4 GHz transmitter we give controlling signal to drone's main board and according to that it controls the drones' speed and movements (forwarded, back ward, up, down, hovering or pitching). GPS module is there to get GPS coordinates of drones' location coordinates and that can send to the operator via OSD system. OSD has used to make the system more user friendly for operator. OSD co-ordinates with main flight controller so it can access the drones' information like battery status, motor RPM, GPS coordinates, angle altitude etc. Therefore, it can send that information to the operator to observe drones' current health condition.

We used Arduino and U-center V8-01 desktop application to programme the NEO 06 GPS module and programming of Minim OSD was carried out using Arduino language based MultiWii software. The display interface was programmed using MW OSD GUI interface.

Motion detection was done using separate digital camera and its tracking part was isolate with other system for more accuracy. We used tower pro 9g two servos, NRF module and Arduino Nano board for manual controlling of the weapon. Detection and tracking an object was initially done using raspberry pi 3 with raspberry pi camera but due to low image processing speed we had to look for other method. Therefore, we used PIXY camera module for object detection and tracking. This includes SPI, I2C and UART interfaces. The serial interfaces use a simplified protocol with a small code and memory footprint, and the code is simple to port to different microcontrollers. This is the method that is used for communication with Arduino. Using the serial protocol, Pixy sends complete information about what it detects, and it accepts simple commands for setting the pan/tilt servos.

Weapon controlling block diagram described under figure 06.

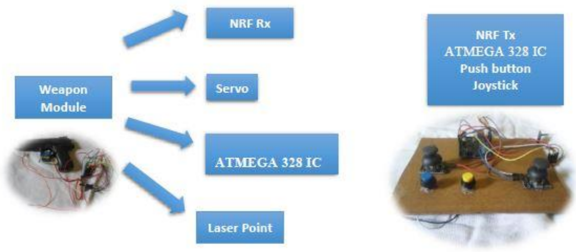

Figure 6: Weapon control in manual

Wireless Remote Using 2.4 GHz NRF24L01 module is a by default half- duplex fabricated module and it has the capability to send and receive data simultaneously. By display it is a very small size module but it's features are astonishing. For example, this module is capable of sending from 1 to 25 bytes of raw data simultaneously and the data transmission rate is up to 1 megabyte per second. If we summarize all the features of this small size but big capability module then, we can say that:

- By this module, we can send a message to a particular receiver.

- We can receive a message from some particular sender. (we can do the both steps simultaneously).
- During sending the message through this module, we will have to specify the message sender's and receiver's address.
- Also, we will have to specify the size of that particular message, which we are going to transmit through this module.
- In some particular applications, we also have to perform switching between the receiver and sending state. For example, if you are received a particular message then, we will stop the communication first and will read it and then you will send it. So, in such situations, we have to perform the switching while sending or receiving data through this module.

V.FUTURE WORK

The work conducted in this thesis is considered to be an initial feasibility test and a demonstration of the prototype to show the autonomous drone system with object tracking. Further, testing is necessary to demonstrate that the system will operate being more reliable over an extended period of time in air and of object tracking. Also, hardware development is required to strengthen the drone structure, guard the propellers and to sustain in any weather condition. As well as further software development required to be done in order to minimize the delay of responses.

System can be further developed as a hex copter to fasten and for more flying time. Here we have used laser point instead of a weapon, so further we recommend to upgrade the system with a real weapon and make changes on drone according to the weapons' weight and its recoil.

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