Image Processing for Drones Detection

Rangpum Hamatapa
Department of Defence Engineering
Faculty of Engineering,King Mongkut's
Institute of Technology Ladkrabang
Bangkok, Thailand
email address
rangpum08@hotmail.com

Assoc.Prof.Dr.Charoen Vongchumyen
Department of Computer Engineering,
Faculty of Engineering,King Mongkut's
Institute of Technology Ladkrabang
Bangkok, Thailand
email address charoen.vo@kmitl.ac.th

***Abstract*—Presently, Drones Quadcopter has caused tremendous problems threatening the military security boundary and the area under Thai Army's surveillance. This article presents a conceptual framework for detecting and tracking unmanned aircraft by applying image processing. Study and analysis Compare advantages and disadvantages in order to develop and provide suitable equipment and tools Replacement of imported high-priced With limiting factors, namely distance, time, terrain And interference resistance The researchers used the camera USB 3.0 Cameras and Open Source Computer Vision (OpenCV) as a software development library on Linux operating systems to automatically record movies. In order to bring the image to analyze and distinguish the object classification by using Machine Learning through a sample of correct information and some incorrect information. Which when detecting, the installed device will calculate the coordinates detected, lock the target, track the movement Voice notification and report. The experiment was conducted by using Anova to test various factors affecting the detection, such as speed, light, color and size in 350 feet with the equipment we installed. The results of the experiment concluded that there was only a speed that had an effect at 22.65.**

Keywords— Open Source Computer Vision (Open CV), Library, Drones Detection

I. INTRODUCTION

For the past 10 years, Drone has been developed for positive use by military and negative use by terrorists that caused severe threat to aviation safety from illegal trespassing in the aviation, military zones and restricted areas. Therefore, this research aimed to propose a framework for drone detection and follow-up, using the Fixed Camera to detect motion and drone movement path but the concern is focused on finding low cost with application of other detectable devices. Comparative methods were applied to compare advantages and disadvantages, including the precision of devices in use as shown in the next section: [1]

A. Audio Detection is used with the microphone to detect the direction of surrounded sound with the detectable distance of 30-25foot, which operated well in the area without disturbed noises. This device has few disadvantages, on rather high price and limited detectable distance.

B. Video Detection [2] is involved with the use of Video camera to compile image s for analysis and the detectable at least 350foot, which may be difficult to differentiate whether the images taken are those of birds, airplanes or Drones. Nonetheless, this method is inexpensive and enabled to detect Drones movement precisely.

C. Thermal Detection [3] can work well with large size Drones, with stable engine wing and the detectable distance 350foot, but often failed when the target used plastic parts that yield low heat resistance. Overall, operating expenses for this method is rather high, but limited in ability to detect and distance.

D. Radar Detection [4] is suitable for detect large aircraft, but often failed to detect Drones and rather high price. It had the detectable range 9,29-842, 527foot.

E. Radio Frequency Detection [5] is the 100 foot, depended on the power of transmitter and sensitivity of receiver. Nonetheless, price of this device is rather high.

This research is based on the detection of Drone at a distance not exceeding 350 feet during daylight hours. Above the horizon while the sky is clear, offering 2 main methods to apply:

- The application of Motion Detect to observe movement.
- Separation of Drone found through Machine Learning

There are 3 main tools currently in use involve Image Processing, namely, Matlab , Open Cv [6] and Emgu Cv, which could detect object as well. Nonetheless, the following advantages and disadvantages are shown:

TABLE 1 Compare tools to be used

Tool	Matlab	OpenCv	EmguCv
Image Processing	slowly	fast	slowly
Runtime	slowly	fast	slowly
Copy Light	Yes	No	No
Price	Cost	Free	Free
User friendly	No	Yes	No

- Matlab takes a relatively slow processing time / Standard price of not less than 100,000 baht per 1 license for research use with C or Fortran
- Open CV [7] is appropriate with the Program Run on Real time, having the Library for Image Processing as being the Open Source that could download free of charge and use with C , C++ .
- Emgu Cv is applied the steaming principle similar to Open Source as those used with Net in development. However, the runtime black and white employed more time, if being used with Data in large quantity, it is perhaps time-consuming and should be used with C#.

The comparison suggests the use of Open Cv as the Algorithm in the operation and subdivided major system into small sections.

978-1-7281-0067-8/19/$31.00 ©2019 IEEE

II Relevant Theories and Principles

The researcher had studied theories and principles that could be adopted for work in numerous topics such managing knowledge in Algorithm movement plan, including the tool in developing program.

A. Machine Learning [8]

That is the machine is capable of making own decision, without following Program order as to combine Multi-technology, whether being computer, engineering and statistic.

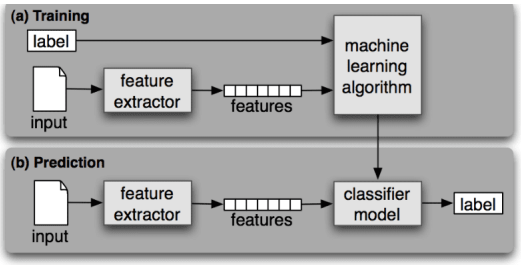

Figure 1 Machine Learning

Work process started from Input data, then the system would attempt to extract data, so called "Feature Extraction, enabled to reduce more resource. After finishing such process, the unnecessary portion was cut out first before comparing the acquired model with the accurate model to ensure the most suitable model. If the acquired model is the suitable on, it must be kept for predicting or testing for data accuracy with other set of data. This step is called a Cross-validation.

B. Adaptive Threshold [9]

It is the method for finding Threshold as to adjust value in Local Threshold in which appropriate for the image in irregular light that requires the use of many Thresholds. Due to each area using uneven threshold, then the Threshold derived from finding Mean of every pixel under Moving window with the size N*N. From there, repeat finding the value Threshold at different place until determining all threshold in every Pixel. If the Gray Level of Pixel is less than the Pixel of such threshold level. On the contrary, if determine value is white color and the Gray Level of such Pixel is less than the Threshold of such pixel, it would be black color. Repeat the same process for all pixels until the results came out as black and white.

C. Background Subtraction [10]

Finding the moving object is the step that the background had been cut out from the Frame Video and take one frame to erase the background to obtain such object as shown in the formula:

$$O = I - B \quad (1)$$

Given O represents Object

I represents image frame

B represents background image

As for compilation step, it is necessary to turn the image into Gray Scale in which 1 point used 8 bit while RGB 1 point used 24bit.

D. Finding the difference of the frame

Is a method that assumes that the background is estimated as the previous frame. For easy processing and the speed of the object and the number of frames per second Which will make the sensitivity and affect the threshold as much as the equation

$$I\ Frame_i - Frame_{i-1}\ I > Th \quad (2)$$

Where $Frame_i$ is the current frame

$Frame_{i-1}$ is the previous frame.

Th is the threshold

III Proposed Method

The researcher proposed the simple system and worthy of spending with low cost for use in the military area to the replace the existing device quite expensive. Therefore, the researcher had also designed both Hardware and Software as show in the following details:

A. Hardware

- Personal Computer Asus VivoBook Pro 15 N580VD resolutions 1920 x 1080 pixel Full HD CPU : Intel Core i7-7700 HQ model 4 Cores/8 Threads speed 2.80 GHz
- Camera CAM-CU135 Board USB Resolutions 4K Cinema 4096 x 2160 having Sensor receiving image 1/3.2 AR 1335 CMOS Plug-Play to support UVC

B. Software

- Operational System Linux Ubuntu/C ++
- Open source library for working on image processing

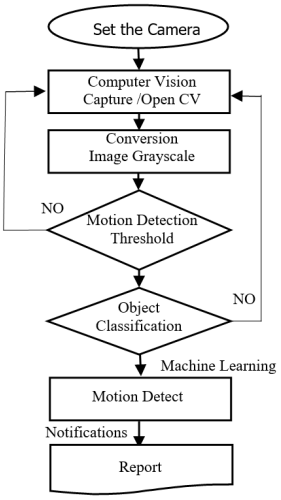

Figure 2 Flowchart for detecting and Tracking Drone

This design has the software and hardware which communicate with each other through USB of Software comprised with Linux Ubuntu/C++ as the operational system, including and tying Library with Open Cv through comparison of compilation.

- This is done to find which time interval having Drones flew in by considering similar and differences of current and next frames. $Frame_{i-1}$ is kept in Frame Buffer subjected to calculation and identify the

Threshold to ease calculation and object velocity per second.

- This method creates more sensitivity towards the Threshold, afterwards, the background motion was cut out for better Adaptive Threshold and changed along with the light by setting up all Pixel, having the intensity above set value)Threshold = 60) which represented the front floor. As for the remainder of Pixel, they would be assigned the back floor by divided main image into small image and in each image appeared own Threshold or Sub Window Process for checking the system with image as the Local Threshold in which each area value had been identified by the user.
- Choosing proper value based on the hypothesis that there is enough intensity between the Drones area and the background. Finding Mean in the area starting is done with the checking intensity of refection in each Pixel for each Pixel. As for the assessment, the result must be converted from RGB to Grayscale to reduce the memory units.
- Such process requires the starting 2 values, namely, Area of interest in order to reduce unnecessary calculated volume and another is the Background Image in the Learning process based on the input image at least 20 p ictures on the assumption that none of objects appears in the interested area of the background image.

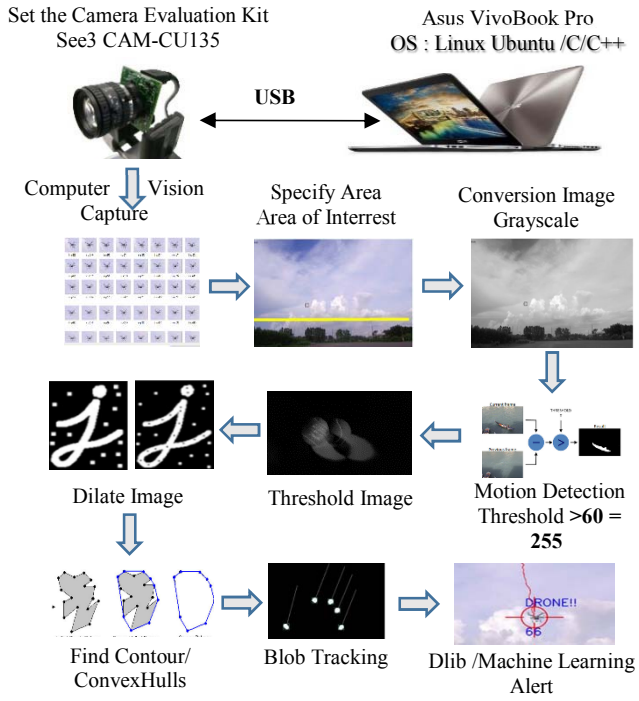

Figure 3 System Diagrame

All data are subjected for calculation to find Mean in the following formula:

$$B_0 = (\sum 20_{n=1} I_n) / 20 \qquad (3)$$

- When I_n is the input with the color format in RGB between 0-225, the Adaptive threshold must be set according to Algorithm, adapting for use with uneven light page in order to calculate criteria for small area. Therefore, there is the different criteria for Local Threshold in order to compensate for more or less light.

Next is to decide whether the outcomes should black or white by setting up Threshold = 60 from the image to observe which one has less whereas the one with more value would be adjusted to 255[11] as the formula: value than 60 to adjust to 0,

$$g(x,y) = 0 \text{ if } F(x,y) \geq \text{Threshold value} \qquad (4)$$

$$g(x,y) = 255 \text{ if } F(x,y) < \text{Threshold value}$$

Motion Detection is used to detect motion before recording the image automatically to save the area for storing data. When the camera has detected motion, the objects found would be separated to bring in only needed image for analysis and comparison with prior frame. [12] The separation of object used Object Classification to find out whether being Drone, bird, kite or balloon through the application of Machine Learning from the store Library (400-600 image) per 1 type of Drone 1 in which the Object Detection is presented in the following equation:

$$IOM(x, y, t) = \begin{cases} BDM(x, y, t), \text{ if } BI(x, y, t) = 1 \\ FDM(x. y, t), \quad \text{else} \end{cases} \qquad (5)$$

Dilate Image is used to expand the image until clearly visible, including elimination of noises and finding Contour /ConvexHulls to seek format, size and location in the image through the application of initial Simple Polygon and identify the use of ConvexHull of Polygon from edge to edge connection until able to eliminate image and remaining only the Convex Polygon as Blob Tracking used Algorithm to catch the object.

Figure 4 Motion Detection as a movement-based algorithm.

Use Dlib technique if Object motioned at 3 frames. After enlarging the image, Dlib would arrange analysis with Machine Learning, if the existing points over 5 images, it would lock the target and assume Drone was found, then the device send sound warning signal along with the report. From there, the researcher would try out to see if anything affected the detection with the application of Minitab Simulink and interpretation of compiled result is done though Table and Graph in order to conclude and decide which factors influence this presentation method and should use such device to solve problems. A graph within a graph is an “inset”, not an “insert”. The word alternatively is preferred to the word “alternately” (unless you really mean something that alternates).

IV. Experimental Results

After the analysis and study the probability in installing the system, simple pilot Application was constructed with the Video recording samples of parameter for 4 types of Drones and testing aviation each 5 times to find the Mean comprised of :

(Q1) Phanton 4 Pro flight distance 6.7 kilometers, white color Diagonal Size 350 mm.

(Q2) Agras MG-1s flight distance 3 kilometers, white color Diagonal Size 1520 mm.

(Q3) Pocket Drone JY019 flight distance 60-80 meters, black color Diagonal Size 300 mm.

(Q4) Mavic Pro flight distance 8 kilometers, black color Diagonal Size 335 mm.

TABLE 2 Results from the experiment

Drones	Motion Detection			Classisfication			Size/ mm.	Color
	Sec	Frame	Pixel	Sec	Frame	Pixel		
Q1	4	250	363	20	1320	206	350mm.	White
Q2	7	423	42	10	653	180	1520mm.	White
Q3	10	611	39	12	724	190	300 mm.	Black
Q4	4	244	16	8	390	200	320 mm	Black
Kite	5	289	26	-	-	-	508 mm.	Red
balloon	4	244	315	-	-	-	406.4 mm	Yellow
Bird	10	612	308	-	-	-	210 mm.	Brown

In loading image to store at Open Source library, the device that can identify Drone by detecting motion involved the use of stable background as the reference. Drone type separation has found with Machine Learning, successfully detecting motion if Drones from the moving object is proportionate with object size and inversely with camera distance. The use of this system could detect reliability of Quadcopters that able to fly within the radius 350 foot in the specified area, except bird, kite and balloon as shown on Table 3

Experimental outcomes reveal the effectiveness in detecting motion from the Mean that had been tried out 5 times. All tests used Frame per Second (no. of slide per second = (30-40 millisecond per frame. The findings suggest that Q1 value of Sec Mean 4 FPs would yield Tracking in the interval 250 and the Resolutions of Pixel, which had been compressed at 363 PPI by Classification value of Sec in the interval Mean 20 FPs in the frame 1320 and the Resolution of Pixel after compressing 206 PPI in the case that could be detected Drone separately with precision. After receiving the Mean, we will use the Minitap 18 program for data analysis and processing. To display results in tables and graphs Which can tell what factors affect the experiment

In this case, the researcher conducted the test using 2 factorial design to screen important variables by determining 4 factors comprised of Size, Speed, Light and Color. The most influenced operation factor is Speed in which derived from Pereto Chart of the Effects that identified Response = 0.05 , but the Residual analysis found no irregularities. Therefore, this Anova is appropriate for data analysis.

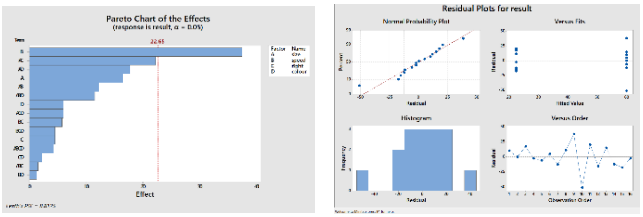

Figure 5 Statistical processing of what affects Drones

V. Limitation and Future Works

The proposed system is limited by a distance of no more than 350 feet, but can be compensated by using a high-quality camera. Adaptive Threshold Adjusts the Noize of the image according to lighting conditions. Tracking speed is limited to 30-40 milliseconds per frame. The frame can be modified by increasing the frame rate to the desired target speed.This system is developed with commercial equipment. And open source software As a result, the system cost is very low, with Past and respective costs at 1199 USD and has tested with 4 types of drones including foreign objects such as kites, balloons or birds. In all cases, the system can detect and distinguish precisely.

In the future, we need an application that is used to monitor Which will grow rapidly And develop to be more intelligent system. Test results show the device performance And restrictions on the speed that affects There may be other factors. Which we will continue to experiment in the future.

REFERENCES

[1] Sai Ram,G,Yoohwan,K "Implementation of Detection and Tracking Mechanism For small UAV" (ICUAS),2016 International Conference

[2] Mathe, K, Tamas, L. Busoniu, L. "Railway track following with the AR.Drone using vanishing point detection" Automation, Quality and Testing, Robotics, 2014 IEEE International Conference.

[3] Rees, D. Talha, M. Florescu, I. "Bayesian fusion of thermal and visible spectra camera data for region based tracking with rapid background adaptation" Multisensor Fusion and Integration for Intelligent Systems (MFI), 2012 IEEE Conference.

[4] Hao Ling, " Synthetic aperture radar imaging using a small consumer drone" Antennas and Propagation & USNC/URSI National Radio Science Meeting, 2015 IEEE International Symposium.

[5] Ergun, A.S, Khuri-Yakub, "Improved modeling and design of microphones using radio frequency detection with capacitive micromachined ultrasonic transducers" Ultrasonics Symposium, 2001 IEEE.

[6] Ivan C,David A,Tomislav P "A brief introduction to openCv" 2012 Proceedings of the 35th International Convention MIPRO 21-25 May 2012

[7] Willow Garage.(14 January 2018), OpenCV [Online]Available http://www.willowgarage.com/pages/software/ opencv

[8] Nils J. Nilsson INTRODUCTION TO MACHINE LEARNING Stanford University Stanford, CA 94305,2005

[9] N. Otsu, "A threshold selection method from gray level histograms," IEEE Trans. Systems, Man and Cybernetics, vol. 9, pp. 62–66, Mar. 1979, minimize inter class variance.

[10] Sanan Viwatthavorn "Motion Detection By Back ground Substraction" Computer engineering, Prince of Songkla University,2008

[11] jirayud Wirlyabanthon(29 May 2018),Thresshould OpenCv[Online] Available,https://medium.com/ @a5730051/ threshold-opencv

[12] karan Holingsworth "Computer Vision and Image Understand ing,Issue I,January 2009,Pages 150-154