Pattern Recognition Through Digital Image Processing for Unmanned Aerial Vehicles

*Gabino Rey Vidangos Ponce[1], Kishankumar Bhimani[2], Jalu A. Prakosa[3], Ana Beatriz Alvarez M. [4]

[1,2,3]Faculty of Electrical Engineering and Automation; Department of Robotics and Automation of Industrial Systems, Saint Petersburg Electrotechnical University-LETI, Saint Petersburg, Russia

[2]Research Center for Physics, Indonesian Institute of Sciences (LIPI). Tangerang Selatan, Indonesia.

[4]Centro de Ciências Exatas e Tecnológicas - CCET Universidade Federal de Acre - UFAC, Brasil.

[1]greyvidangos@gmail.com [2] info.bhimani@gmail.com [3] jalu001@lipi.go.id [4] anabe.alma@gmail.com

***Abstract* — This paper describes the implementation of two digital image processing methods for pattern recognition, by color boundary method and the Haar Cascade Classifier to detect objects in a video stream, both methods implemented on Python 3 and OpenCV. Patterns detection of images obtained from drones has advantages over traditional video recording drones. The drone has a streaming video system, based on the Raspberry Pi 3 minicomputer, which is sent by wireless communication to the base station where a pattern recognition algorithm performs operations on the video source coming from the drone. This proposed system has excellent performance based on an integrated streaming video system with 5.8GHz Wi-Fi connection acceptable to the base station. Both methods proved to be valid for certain types of patterns and objects under different light conditions.**

Keywords—Digital image processing, Pattern recognition, Boundary color detection, Haar Cascade method for customized object detection, Video Streaming, Wireless communication, Aerial robots, Drones.

I. Introduction

The pattern recognition is an essential field of research what makes patterns recognition systems is to identify, classify, detect and find useful information in images or video sources [1]. The development of techniques as well as methods based on finding relevant characteristics of a pattern or object can be detected due to a large number of objects have geometric forms such as a square, a circle. Binary transformations or filters are used to highlight the object in the image and are finding contours to identify objects of geometric and detectable shapes.

In 2001, Paul Viola and Michael Jones presented an approach for visual object detection which minimizes computation time while achieving high detection accuracy [2]. The approach was used to construct a face detection system, but can be used to detect various other desired patterns. Unidentified air vehicles* can carry easily connected devices on board, electronic devices that can be used for navigation of the same UAV and for acquiring and sending information relevant to the ground station for specific purposes.

This study examined the potential to use computer pattern recognition from images of an informative video collected from a UAV. The images captured through UAV were automatically analyzed using the patterns recognition techniques proposed by Viola-Jones. The developed algorithms use Python and OpenCV tools. A quadcopter UAV model will be transporting a Raspberry Pi Mini Computer Board and sending the information over a Wi-Fi antenna to the base station for the video processing. It is believed that automated image processing techniques can provide clear advantages for rapid asses the large volume of images generated during a UAV-based survey to detect, recognize patterns or objects, and quantify potential targets in different environments where manual techniques are labor extensive, time-consuming and possibly less accurate.

II. Conventional Approaches Of Pattern Recognition For Drones

A. Object Detection

Digital images Processing uses an image that process transforms and manipulates through mathematical operations to obtain specific features or patterns within the digital image. There are models color designed for different purposes such as RGB, CMYK mostly used to print and HSV, which is used most in graphics software such as OpenCV.

The transformation from RGB to HSV due to it facilitates processing by computer programs such as OpenCV [4].

In this paper to process images uses, transformation, segmentation, operations. S.Y. Shin and T.C. Woo.[5] Proposed Linear algorithms for finding the convex hull of a simple polygon in linear time nowadays is used in digital image processing programs such as OpenCV that have it implemented that takes a polynomial named *P* of *n* vertices, each vertex represent6ed by coordinates.

B. Haar Cascade Method

Haar Cascades method is well known because of its accuracy and fast to face detection, and also it can be customized to detect the desired object, presented by Paul Viola and Michael J. Jones [6]. It came out with new algorithms and describing machine learning approaches and concepts as an integral image.

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First; **Integral Image** that allows the characteristics used by the detector to calculated very quickly.[3]; The second is a learning algorithm, based on **AdaBoost** [2], which uses a weak classifier to have a robust classifier. Moreover, the third core component that is a method for combining more complex classifiers increasingly in a **Cascade** which allows background regions of the image, to quickly discarded if there is or isn't an object on the image looking for the features in the regions or sub-windows.

It was initially tested with 15 frames per second using an Intel Pentium III processor at 700MHz it was 15 times faster than any face detection algorithm back then which compared to now and the various modifications are still used and implemented in digital cameras to detect faces, eyes, smiles. Rapid Object Detection using a Boosted Cascade of Simple Features [6].

C. Video Streaming System

Video Streaming System can be defined in stages first the content; it may be an event or phenomenon is taking place and then capture is done by a video camera recording this process is where video captures encoded by an encoder such as H.264. Video Streaming systems use a medium to send the video encoded by a data transmission system using a wireless communication using Wi-Fi antennas adopting a transmitter and a receiver to short distances, Wireless LANs provide high-speed data within a small region, e.g., on campus or small building, as users move from place to place. Wireless devices that access these LANs are typically stationary or moving at pedestrian speeds [7].

D. Aerial Robots Drones

The development of aerial vehicles made more improvements in future models and prototypes, then to move from having models for passenger transport, for cargo services and many uses that humans make until they reach space and it is changing the awareness of people to having a topographical view.

Quadcopters helicopters are an emerging rotorcraft concept for the unmanned aerial vehicle [8]. The operating principle of the quadcopters is the use of four motors to be able to drive, which balance thrust forces. Figure.1, which is an adequate control system is needed using microcontrollers and position sensors and angle by a gyroscope and accelerometer for which mathematical models such as dynamics are required to achieve stability in the air.

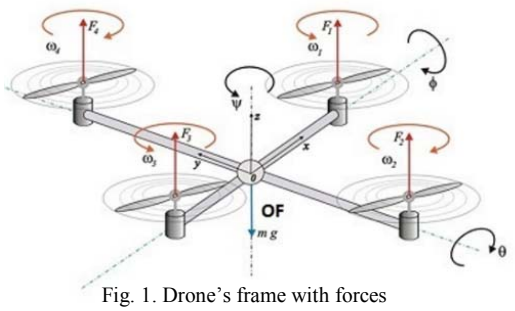


Fig. 1. Drone's frame with forces

III. Development of Method and Algorithms

Both methods are investigated and analyzed as first is the boundary color method to detect part of geometrical objects to extract the object from the images or video. The second method is Haar Cascade Classifier for customized object detection or pattern recognition of desired objects as people and objects of different characteristics taking important features training classifiers to test them with the desired patterns.

A. Boundary Color

In order to detect colored circles, the color numbers composition it must know whether in RGB space color or HSV space color to use this method red color is chosen and get their values in both colors space either RGB and HSV, because RGB is not a right space color for detecting it is preferable to use HSV color-space. This method selects a color and geometric shape, in this case, a circle. The program extracts the object's color, erodes, dilates to highlight the circular shapes and is detected as can be seen in Figure. 2. The whole process executed in a streaming video.

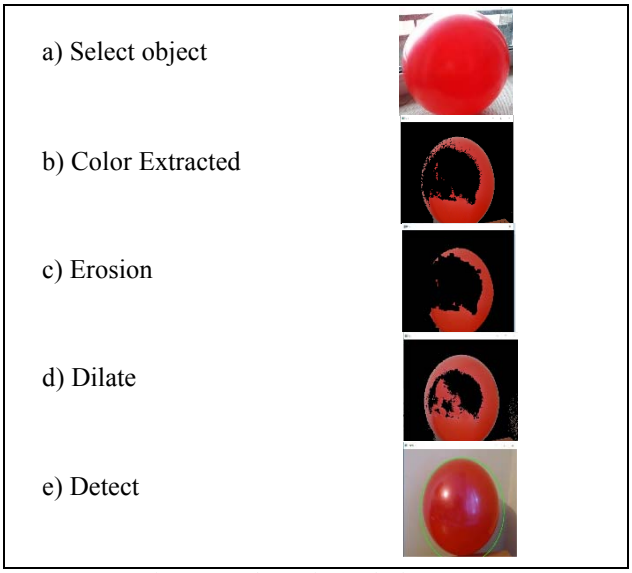


Fig. 2. Boundary color method process

B. Train Haar Cascade Classifier

To create a classifier it uses a dataset has been created using a digital camera photography by setting 18.0 Megapixels with aspect ratio 1:1 taken in black and white format, the photos arranged in different position, and various lighting scheme to take many variants of the images and do flexible the recognition, later on, the pattern to study will be a letter "S" inside of a pentagram as shown in Figure 3.

Cascade classifier to train and get relevant features needs a positive which are used to create a classifier containing all features that a sample has. The resizing of the process is to observe at what size is when can get the features in Figure 4, this samples has two main features a pentagram and S letter. From 8x8 pixels to 124x128 pixels, a positive image of 32x32 does not it does not look blurry still can observe its features.

The classifier has created along with this work as in Table I,

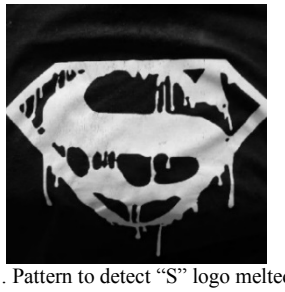


Fig. 3. Pattern to detect "S" logo melted.

Training	Stages	Training time (d:hh:mm:ss)	XML file size (kilobytes)
1	5	0:00:04:09	5.96
2	10	0:00:13:53	17.0
3	15	0:00:18:41	23.2
4	20	0:01:45:26	34.9
5	25	1:07:21:07	43.0

TABLE I
TRAINING OF CLASSIFIERS

all with high precision. The trained detectors have high accuracy in Figure 5. Because they were trained carefully in selecting the positive images, Haar Cascade classifiers trained with more than 20 stages take time to create an *XML* file that due to its file weight works slowly in the program.

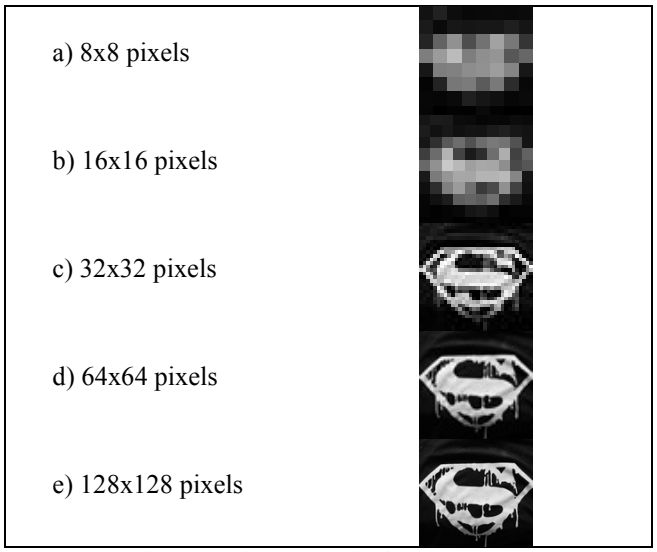


Fig. 4. Sample Images resized (1cm by 1cm).

Fig. 5. Pattern Detected

C. System Topology for Streaming System for Drones

The topology of the complete system shown in Figure 6, the drone has the policy of streaming of video based on a raspberry pi, webcam and a Wi-Fi antenna which sends the signal to the Ground Base where the methods had executed.

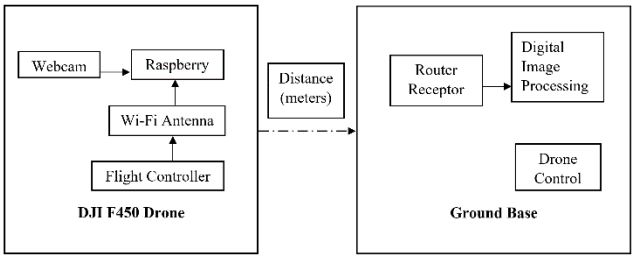
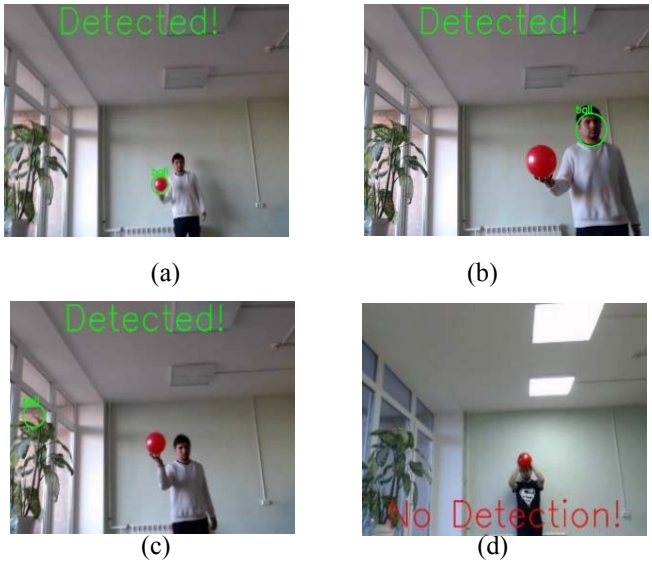


Fig. 6. Complete system topology

IV. Experimental Results and Comparison

A. Color boundary results

This method has difficulty in detecting the object, seen in Figure 7. (a) due to several adjustments in the detection radius more significant than 30 units as well as correct lighting the detected function. In (b), due to similar colors in the environment, the detector does not distinguish the object, in (c) due to the detection radius change of 10 units the object cannot found and in (d) the established color range cannot be detected due to artificial lighting. And make note that here our main objective is to identify the red ball and we achieve an accurate result in (a).

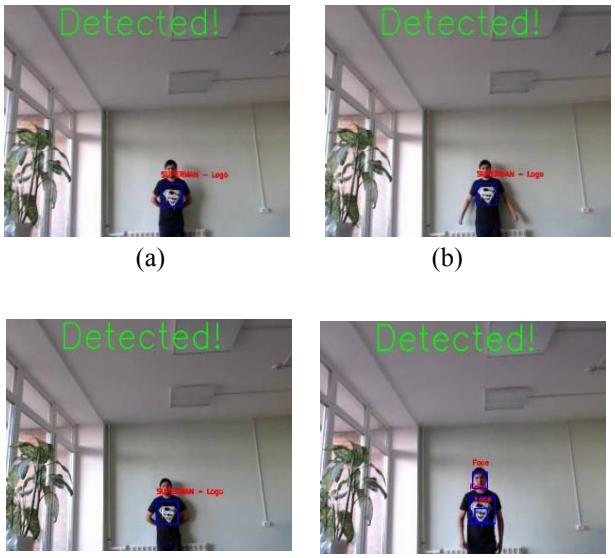


(a) (b) (c) (d)

Fig. 7. Complete system topology

B. Cascade classifier Results

This method has a 75% accuracy, seen in Figure 8. It is because in (a), (b) and (c). The detection is not lost. But when the classifier continues, many characteristics that analyze is confused as in (d).



(a) (b)

(c) (d)

Fig. 8. Complete system topology

The drone flying with the system on board as well as the program being used to detect patterns, it is evident that the first methods have difficulties in recognizing the object, but the second method does not lose the pattern in the video is caught it figure 9.— a summary on video about results available at https://youtu.be/IgDc2d8ywPo

Fig. 9. Complete system topology

V. Conclusion

In this work, the research and realization of digital image processing methods for the recognition of patterns for unmanned aerial vehicles could be carried out with excellent performance. both approaches proved to be valid for certain types of patterns and objects under different conditions. The red ball was only used with the first method because it does not have relevant characteristics and it is easy and quick to implement to create the model to be used to detect it. Haar Cascade Classifiers that are trained with more than 20 stages take time to create an XML file that, due to the weight of the file, works slowly in the program.

VI. References

[1] Hong Low, Chin & Kiat Lee, Ming & Wang Khor, Siak. (2010). Frame-Based Object Detection--An Application for Traffic Monitoring. Computer Research and Development, International Conference on. 322-325. 10.1109/ICCRD.2010.63, p1.

[2] Viola, Paul & Jones, Michael. (2001). Robust Real-Time Object Detection. International Journal of Computer Vision - IJCV. 57, p.1.

[3] Cen, K., (2016). Study of Viola-Jones Real-Time Face Detector. p.1.

[4] OpenCV. 2018. Color Conversion. [Electronic Source] https://docs.opencv.org/3.4.2/de/d25/imgproc_color_conversions.html#color_convert_rg b_hsv (application date: 11.03.2019).

[5] 5. S.Y. Shin and T.C. Woo.1985. Finding the convex hull of a simple polygon in linear time. Pattern Recognition. Vol. 19. No. 6. Pp. 453 458.1986. p.4.

[6] P. Viola and M. Jones. Rapid object detection using a boosted cascade of simple features. In Computer Vision and Pattern Recognition, 2001. CVPR 2001. Proceedings of the 2001 IEEE Computer Society Conference on, volume 1, pages I– 511. IEEE, 2001. p.4.

[7] Goldsmith, A., 2005. WIRELESS COMMUNICATIONS. Cambridge: Cambridge University Press.

[8] Hoffmann, Gabriel & Huang, Haomiao & Waslander, Steven & J Tomlin, Claire. (2007). Quadrotor Helicopter Flight Dynamics and Control: Theory and Experiment. 10.2514/6.2007-646. p.1.

[9] O. Surinta and S. Khruahong, "Tracking People and Objects with an Autonomous Unmanned Aerial Vehicle using Face and Color Detection," *2019 Joint International Conference on Digital Arts, Media and Technology with ECTI Northern Section Conference on Electrical, Electronics, Computer and Telecommunications Engineering (ECTI DAMT-NCON)*, Nan, Thailand, 2019, pp. 206-210.

[10] J. I. Flores-Delgado, L. G. Martínez-Santos, R. Lozano, I. Gonzalez-Hernandez and D. A. Mercado, "Embedded control using monocular vision: Face tracking," *2017 International Conference on Unmanned Aircraft Systems (ICUAS)*, Miami, FL, USA, 2017, pp. 1285-1291.

[11] D. Barik and M. Mondal, "Object identification for computer vision using image segmentation," *2010 2nd International Conference on Education Technology and Computer*, Shanghai, 2010, pp. V2-170-V2-172.

[12] G. Devi Ramaraj, S. Venkatakrishnan, G. Balasubramanian and S. Sridhar, "Aerial surveillance of public areas with autonomous track and follow using image processing," *2017 International Conference on Computer and Drone Applications (IConDA)*, Kuching, 2017, pp. 92-95.

[13] A. Schumann, L. Sommer, J. Klatte, T. Schuchert and J. Beyerer, "Deep cross-domain flying object classification for robust UAV detection," *2017 14th IEEE International Conference on Advanced Video and Signal Based Surveillance (AVSS)*, Lecce, 2017, pp. 1-6.

[14] J. A. Prakosa, D. V. Samokhvalov, G. R. V. Ponce and F. Sh. Al-Mahturi, "Speed Control of Brushless DC Motor for Quad Copter Drone Ground Test," *2019 IEEE Conference of Russian Young Researchers in Electrical and Electronic Engineering (EIConRus)*, Saint Petersburg and Moscow, Russia, 2019, pp. 644-648.

[15] *V. P. Kharchenko, N. S. Kuzmenko and I. V. Ostroumov, "Identification of unmanned aerial vehicle flight situation,"* 2017 IEEE 4th International Conference Actual Problems of Unmanned Aerial Vehicles Developments (APUAVD)*, Kiev, 2017, pp. 116-120.*

[16] *V. I. Chepizhenko and O. O. Tryzna, "Maintenace planing optimisation of Unmaned Aerial systems,"* 2015 IEEE International Conference Actual Problems of Unmanned Aerial Vehicles Developments (APUAVD)*, Kiev, 2015, pp. 120-123.*

[17] Z. Jiao, Y. Yang, H. Zhu and F. Ren, "Realization and Improvement of Object Recognition System on Raspberry Pi 3B+," *2018 5th IEEE International Conference on Cloud Computing and Intelligence Systems (CCIS)*, Nanjing, China, 2018, pp. 465-469.

[18] C. KAYMAK and A. UCAR, "Implementation of Object Detection and Recognition Algorithms on a Robotic Arm Platform Using Raspberry Pi," *2018 International Conference on Artificial Intelligence and Data Processing (IDAP)*, Malatya, Turkey, 2018, pp. 1-8.