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# Design and Implementation of Quadrotor Guidance and Detection System Hardware for Passing Through Window Based on Machine Vision

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**Abstract**

Quadrotor is one of the types of flying robots that has been highly regarded by researchers due to its simple structure and vertical flight capability. This paper presents a new method based on machine vision for the correct detection of window in an ever-unknown environment. One of the challenges of controlling the path of a quadrotor in an unknown environment is to accurately identify the window through which it passes. In this research, Parrot Bebop2 quadcopter is used, which is equipped with a camera. Also, an algorithm is proposed to perform image processing to identify the window in the environment and control the movement path of the quadrotor, which is implemented on the quadrotor. This method consists of three parts: processing, detection and identification. First, by applying image processing algorithms, we improve the image and delete data unrelated to the intended purpose. In addition, to control the path of the quadrotor, a proportional-integral-derivative controller has been designed and implemented using the Ziegler and Nichols method, which will be performed during a real indoor flight and in an automatic path tracking. According to the obtained results, it can be concluded that the use of flying robots can have positive results in military processes and low delivery to people in a short time.

***Keywords**: Machine Vision, Image Processing, Window Detection, Zeigler and Nichols, Quadrotor*

## 1.Introduction

The unmanned aerial vehicle has been the subject of much research by many researchers for many years. They are used to investigate problems ranging from control, navigation and route planning to object identification and tracking as well as visual navigation [1]. A UAV's visual navigation system is a complex device designed to capture objects or events discovered on Earth [2-3]. On the other hand, according to various researches presented to identify the object, in addition to segmentation methods, there are also different classification methods [4]. In this case, a robust control system must be designed to be resistant and safe against all kinds of hazards in the environment, this issue plays a very important role in the safety of the unmanned aerial vehicle (UAV) [5].

Due to the advantages such as lower cost, small size, high technology and convenient guidance, micro-aircraft vehicles are highly regarded in applications such as transportation systems, surveillance, photography and video recording of areas, rescue and rescue, which in some cases humans are able to do not do it, put hand [5-6].

One of the problems that micro-aircraft vehicles face is getting too far away from the place, out of sight of

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the pilot and disconnecting the signals that are used to solve this problem of autonomous systems today, which need to be measured, have a position and understanding of the environment so that they can use it to identify the environment, identify obstacles in the environment and move in it [7]. In fact, the main purpose of using micro-aircraft (MAV) vehicles is the ability to independently identify obstacles in their path and avoid them to achieve independent flight [8] (since different ways of understanding the environment by micro-aircraft vehicles) MAV (suggested using RGB_D, LIDAR, HOKOYO, etc. sensors, but implementing such sensors on small MAVs is very expensive [6].

In this article, we use a Parrot Bebop2 unmanned vehicle that has Low cost, low volume, high flexibility and easy navigation are among MAVs. In addition, low weight, small size, power consumption, useful information extraction and camera quality are the most important tools in this small air vehicle [9]. In this paper, we propose UAV performance using visual algorithms and image processing to correctly detect windows and avoid obstacles in real time.

The continuation of the article is as follows, in Section 2, we review the various methods presented in this field. In Section3, we examine the existing methods for identifying windows and identifying obstacles. In Section 4, we discuss the controller used for the reference path, and in Section 5, we present the main results of this paper.

## 2.Literature Review

Many advances in electronics, mechanics, and robotics have made it possible to develop micro-aircraft and flying robots. Researchers in robotics have used a variety of techniques to identify objects and avoid obstacles. Which is based on artificial intelligence and machine learning algorithms. In [10] by Tinne Tuytelaars and Klaas Kelchtermans The RNN and LSTM neural network algorithms are used to cross the room. The main problem of these algorithms is the very high correlation between the samples, which makes us have a slower process to reach the goal. Also, [11] used advanced CNN neural network algorithms and a single UAV forward camera to cross an unknown corridor, and the implementation of these algorithms, in addition to wasting time, was computationally very expensive.

In [12] Wilbert G. Aguilar et al. Used the SURF algorithm to detect and prevent an UAV obstacle in an unfamiliar environment, and to control the UAV, they proposed to use a manual controller path, which is very time consuming and it is tedious, this method is not possible to plan the route in real time and the number of successful factors to travel the route has not been satisfactory. [13] HOG and SVM image processing algorithms were used to identify and classify civilians from the military, as well as to control the quadrotor from a proportional suction controller. They used integrals and derivatives. All works is done with Quadrotor single camera. In [14] Abhinav et al. Used image processing and vision algorithms to detect a rectangular window to enter the building, in addition to an optical current sensor attached to the quadrotor to determine its position.

Finally, he used the Newton-Euler controller to calculate the route. This method has been complicated and wasted a lot of time due to the excessive use of various algorithms and filters to accurately identify the window and eliminate noise in the image. Next, the stereo vision system is presented as an indoor positioning system for drones, which uses two cameras to record and a set of algorithms to obtain real-time information that implements these sensors in one device. Small air vehicles are very expensive. When working with MAVs, we need to consider the amount of cargo that these drones can carry and limit the use of any sensors or cameras so that we can have a reasonable amount of time to operate [15].

In this paper, a machine vision-based method for designing and controlling the trajectory of the quadrotor is presented, which as far as possible does not have the limitations and problems and very complex calculations in the mentioned methods and has acceptable results. The innovation of our method is that it has the ability to detect the window according to the shape, size, material and color and requires far less calculations than the mentioned methods.

## 3.Basic Concepts

In this section, we introduce the basics of object detection and obstacle avoidance in unmanned vehicle systems (UAVs): The most important basic requirements for UAVs include positioning and independent navigation, where the relevant information is estimated using the behavior of UAV angles such as inertia sensors (gyroscope, accelerometer, inertial detection unit), while the most common method for off-site positioning is system. Global Positioning System. Unfortunately, when UAVs need to navigate indoors, GPS Global Positioning Systems may not have much noise or even be available, leading to poor or poor performance of the UAV [16][17]. In this paper, we will use a Parrot Bebop2 unmanned vehicle capable of flying indoors using stereo vision and an inertial navigation system. The vehicle used in our laboratory is shown in Figure (1).

Fig.1. Bebop2 quadcopter equipped with visual navigation system [18]

In connection with the sensors on the Parrot Bebop2, which are equipped with sonar and pressure sensors to estimate altitude on low and high-altitude flights, and the CPU, which reads position and mode signals, sends commands to control motors to the engines.
As well as inertia sensors that accurately calculate rotational angles and linear accelerations. Finally, the stereo visual system, which we use to identify the environment and identify and distinguish objects in the image [19]. The quadrotor has four propellers and four motors on the main body, and is configured in such a way that the motors facing each other are clockwise (clockwise) and the motors facing each other are counterclockwise.
This is because they counteract the force exerted on the vertical axis of the quadrotor caused by the collision of air with air. In addition, the quadrotor is able to control six degrees of freedom by increasing and decreasing the speed of the motors.

It is also able to control the height of the quadrotor by increasing or decreasing the angles of the four motors at the same time, or the quadrotor can be steered in different directions by making a difference in the rotation speed of the propellers. Controlling and adjusting the speed of the robots' motors is released.

The controllers try to achieve a balance force for a suitable flight by changing the speed of the rotors. By changing the speed of each rotor, the lifting force of the same motor increases or decreases and causes the quadrotor to move.
In this way, to move around the angle of roll, if we increase the speed of the right motors by the same amount and reduce the speed of the left motors by the same amount, the roll angle will increase and the quadrotor will incline to the right, and vice versa (x)Also, to move around the angle of turn, the speed of the left and right motors remains constant and with increasing the speed of the rear motors by the same amount and decreasing the speed of the front motors by the same amount of forward quadrotor (y), and finally to increase the angle of the Yaw All four motors change so that the speed of the front and rear motors decreases and the speed of the left and right motors increases. In Figure (2) A view of the quadrotor structure is displayed [19].

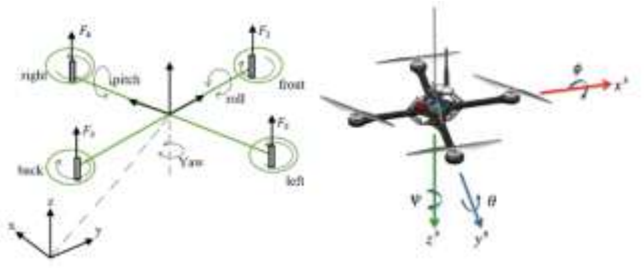


Fig. 2. Quadrotor structure

As can be seen, $y$, $x$ and $z$ are the positions of the center of mass in the quadrotor and $\theta$, $\varphi$ and $\psi$ are Euler angles.

## 4.Window Identification

Object identification is very important and researched in robotics today. The first step in recognizing a window is to recognize the edges of the image. Edge recognition is one of the most important factors in machine science. We use edge recognition in window recognition to divide the image and understand the structure of the image. The edges shown in the image are the boundaries between objects that give us very important information. These edges are formed by changing the characteristics of the object such as shape, size, geometry, light intensity, in fact, it will be a border between two areas.

Since the edge is an important part of object recognition, a method must be used that is resistant and efficient against factors such as noise and disturbance. Most edge detection operators, including: Laplace-Gaussian, slope operator and Laplace operator these are edge detectors, are very simple, and when the intensity of the image discontinuity or the intensity of the first-order pixel derivative is greater than some thresholds The pixel detects the edge, but it detects very limited edges and reacts to a lot of noise, which in many cases causes cracks and scattered edges [20].

We use a window that is an optimal edge detector and uses a gray image to determine the position of the edges detected by the severity of the discontinuity [21]. We use the contour algorithm. The contour algorithm is mainly used for object recognition and image perception. Object contours usually consist of straight lines, corner points and simple curves [22]. According to [23], Contour algorithm plays a very important role in areas such as semantic division and image classification. In fact, contour corresponds to the two basic concepts of edge and border.

In this article, we will use the contour algorithm to classify objects in the image. First, according to the specific properties extracted from a pixel, we determine whether the pixel belongs to this contour or not, then, using the edge-based approach, we identify the edges and obtain the contours by dividing or optimizing the exposed edges. Next, we use the color algorithm to increase the accuracy of window detection, which is very useful for many robotic vision applications. Object tracking is a key element that should be considered in intelligent video surveillance. In many cases, due to changes in state, obstruction, changes in light and noise in the environment, objects are not properly identified, the main causes of these problems are often Reason, 1) The similarity of the properties of the object to the background is very high. 2) It is difficult to identify the ideal properties due to obstruction. 3)The appearance of the object has changed due to the increase of light or direct radiation of light and is not recognizable [24].

These algorithms fail, so we designed the color detection algorithm to achieve better accuracy and performance, as well as to solve the problem of failure due to misdiagnosis of object models, which is a key step in improving tracking performance. In addition to the shape model, the algorithm also deals with the shape model. Next, we use the threshold filter algorithm as a tracking framework to remove noise in the image. It is detected by canny and contour algorithms and extracted with color properties. Then, the window model is made with properties appropriate to the condition of the window. Finally, the tracking result is obtained through a search strategy for the position of the window guided by the color property. This process is based on adjusting the window size and the window color is traced. In this step, we will identify the window in the image by combining several color contrast features with the weight of the connection to the background as well as the color distribution. This function is used to highlight the window and suppress the background.

$$f_1 = \sum_i \sum_j p(i,j)^2 \quad (1)$$

$$f_2 = \sum_{n=0}^{N-1} n^2 \sum_{i=1}^{N} \sum_{i=1}^{N} p(i,j) \quad (2)$$

Using the color feature in the form of an algorithm, the quadrotor accurately detects and locates the window. Existing, moves indoors. The results of our indoor test confirm acceptable performance [25].

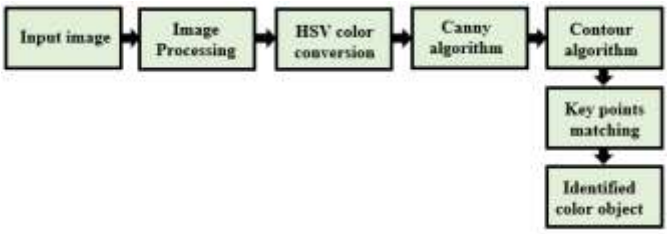


Fig. 3. Diagram Block Diagnosis and Identification of window

## 5.Implemented Image Processing Algorithms

The Parrot Bebop2 quadrotor follows the following steps to track the target: image acquisition, image processing, noise reduction, segmentation, feature extraction, and recognition and interpretation. After capturing the image from the quadrotor camera as input data, the first step is to record the image, which is possible by running the robot operating system (ROS) [22]. We capture the image using the robot operating system and capture it as we send the message and use the CvBridge library to convert the message format from ROS format to OpenCV format, so that we can use pre-trained classes and specialized libraries to track the target. The steps of this process are shown in Figure (4).

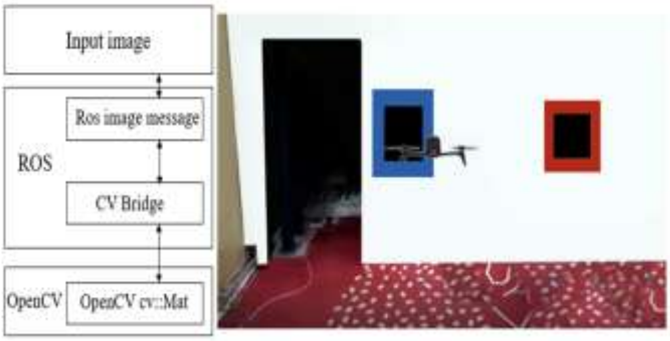


Fig. 4. Relationship between ROS and Open CV operating systems

After receiving the image, we process the image and extract information from it. One of the most common methods for recognizing objects in an image is to use features. Attribute means finding unique parts and properties that represent the object. By finding these features inside the image, you can detect the presence of an object in the image.

Objects in images are always positioned with features such as resize, angle, brightness, and color. Hence the features should be selected in such a way that If changes occur, they are still detectable and identify the object correctly [26]. In the first step, using the color recognition algorithm, we process the color in the image. In this method, the color of the dots (pixels) is used to determine the characteristics of each location of the image. These dots are selected in such a way that they are a good representative of the color of the dots (pixels) are adjacent and around them.

In this case, selecting dots that can play a role as a feature is very difficult and sensitive. RGB are strongly influenced by ambient light and their range varies greatly with the change of light and the movement of the camera, so histogram HSV is used for accurate color processing, because parameters H, S and V have more color stability. Better color, the image is transferred from the color space to the histogram space which indicates the saturation, intensity and amount of the desired color. First, the histogram image is received as input and by setting the minimum and maximum threshold for each Conclusion [27].

In this article, the detection of indoor windows by a four-propeller flying robot (quadrotor) in order to cross the window has been investigated. As mentioned, each robot has advantages and disadvantages that the robot performs in a specific mission. In fact, trying to achieve better and more optimal results in achieving the goal by using the benefits of different robots, the ultimate goal of this research is to use the same benefits in order to perform the tasks of robots more efficiently and accurately. This paper describes the process of window detection and passing through a single forward camera of the Parrot Bebop2 quadcopter, as well as the sonar sensor, gyroscope and accelerometer in the quadcopter, which uses the information obtained from the image to identify the desired window scale. In addition, the results of this work showed that the proportional-integral-derivative controller by Ziegler and Nichols method has a good performance in controlling the position and tracking the path compared to the trial-and-error method in flying robots. And has an indoor environment.

It should be noted that the use of alignment, contour, threshold and color algorithms in window detection and obstacle detection, as well as establishing a proper connection between the sensors in the electronic board of the quadrotor, including accelerometer, gyroscope and inertial measurement unit, resulted in optimal quadrotor performance, which resulted in improved proper condition control and route tracking. Intensity and amount of color (the desired color is detected. In the second step, to distinguish Find the square window of the canny algorithm and the contour algorithm (Hue, Saturation, Value) Expensive program utilized. In this step, we use the quadrilateral feature of the window to accurately detect it.

canny algorithm is an optimal edge detector and uses a gray image to determine the position of the edges detected by the intensity of the discontinuity. In this stage of processing, the pixels are examined in groups and hands. Useful sets include those pixels that are in the same color and adjacent to each other, when placed next to each other, create a shape in the image.

To introduce the pixels of a set, we use the contour algorithm. To represent the pixels of a set, we use the contour algorithm. A contour defines an outline of an object, constraining an object, or a curve around an object. We classify objects in the image using the contour algorithm. First, according to the specific properties extracted from a pixel, we determine whether this pixel belongs to this contour or not, then, using the edge-based approach, we identify the edges and by dividing or optimizing the exposed edges, we get the pixels of a set. Figure (5) shows the flowchart of the proposed algorithm.

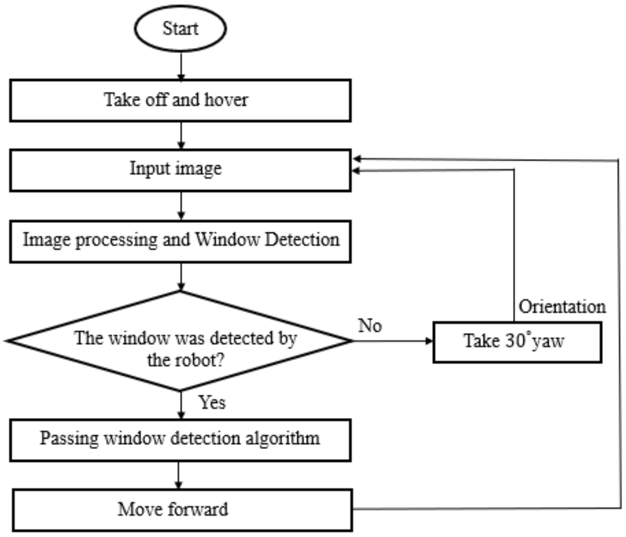


Fig. 5. Flowchart of the proposed algorithm for passing the error position window

## 6. Position Error

After detecting the window, the quadrotor should retrieve the path and according to the position error and the distance between the quadrotor and the window should select the optimal path and move in it. The most important step to track the path is to determine the position error. During tracking, the main goal is to target and hold the detected window in the center of the received image. As shown in Figure (6), the center of the image is shown at point 240 × 320 and the amount of error at point $M(y1, z1)$. Position error value $Me(y:z)$ is the difference between the center of the image and the center of the error [13].

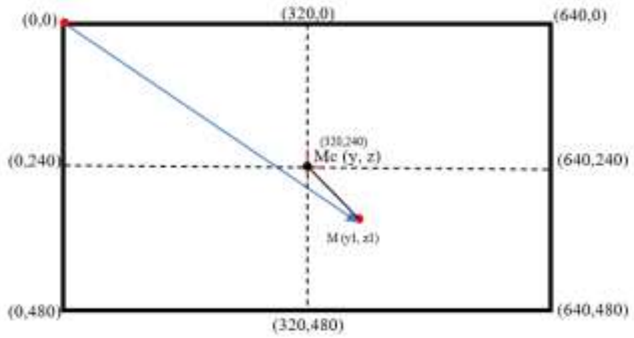


Fig. 6. Center position and position error [13]

To determine the position of the error in relation to the center of the image, we use Equation (3):

$$Me(y:z) = M(y1, z1) - MC(320, 240) \qquad (3)$$

Where $Me(y:z)$ is the calculated error point, $M$ is the error center point, and is the image center point. The calculated position error may show values in the range of ±320 pixels for the y-axis and ±240 pixels for the z-axis. In the next step, the position error is converted to velocity, and to convert the position error values to velocity values, a scaling operation is performed, in which on the y-axis, +320 takes the value of -1 and -320 takes the value of +1, [7].

When the target is on the left edge, the control command sends a maximum value of 1, so the quadrotor moves to the left until the position of the quadrotor reaches the center of the image point. As the x-axis (x-axis) is a different type of analysis, it is done by adding the areas obtained from the target, when placed at a certain distance in the image, the distance The target is confirmed and selected. Figure (7) shows a view from the perspective of the Parrot Bebop2 quadcopter [7].

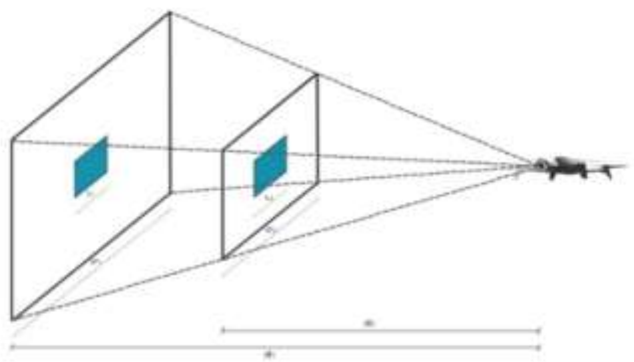

Fig. 7. Angle of view of Parrot Bebop2 quadrotor [7]

## 7.Proportional Integration Differentiable Controller Design

After achieving the previous steps to identify the window and the position of the error, the design of the quadrotor controller must be done to determine the position of the quadrotor at any point in space, in fact its position must be determined for a fixed reference point and its orientation for an inertial frame so that the quadrotor can detect its path. When the quadrotor moves on each of its axes, the rotation speed of its rotors changes by applying more or less force to reach the desired movement at the angle of the Roll, screw and Yaw.

In this part, we used the proportional-integral-derivative controller algorithm for quadrotor routing, which is designed with high reliability, good stability and high compatibility, simple, easy and is widely used in process control [25]. And is one of the most common examples of feedback control that is widely used for processes such as engine speed control, temperature control and pressure control, etc., which aims to use this algorithm in closed loop control, fast and accurate control of system output the situation is different without knowing the behavior of the system in response to input.

This controller consists of three separate parts, each of which separately receives the error signal as input and performs an operation on it, and finally their output is added together, then the output of this set, which is the output of the controller, to correct the error, it is sent to the system [26].

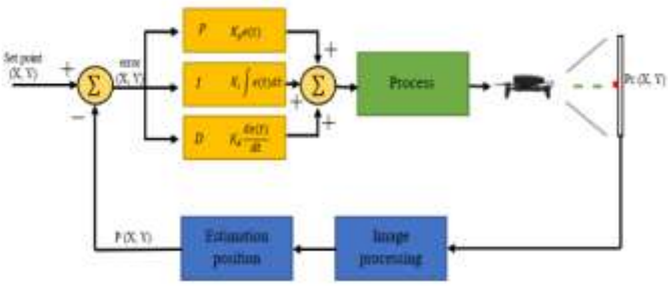


**Fig. 8**. Closed-loop controller block of the window detection system

Because tracking is real-time, image processing must be fast. With this in mind, we use a resolution of 480 x 640 pixels to process the data. And the current position of the quadrotor is calculated, the value obtained is added to the value of the initial position of the quadrotor and enters the controller block to eliminate the error [28].

Which have coefficients of $K_i$, $K_p$ and respectively. The function of the proportional controller is to reduce the sitting time of the system. Based on the system error, this controller provides the required control input, which can be added to the proportional controller to reduce the permanent system error. By adding this controller to the system, the system response oscillates. To reduce the response fluctuations, we can use a controller. Add a derivative to the system.

Adding this control part to the system causes the controller to predict the behavior of the system and to correct the control input before the error rate increases [29]. In this paper, a proportional-integral-derivative controller is used, in which the control coefficients must be adjusted in order to achieve the optimal and desired result of the system. The coefficients required for the proportional-integral-derivative controller include the proportional ($K_p$), integral ($K_i$), and derivative ($K_d$) coefficients. The use of two methods, trial and error method and Ziegler and Nichols method to determine the proportional control coefficients – integral – derivative has been evaluated.

First we consider the integral and derivative control coefficients to be zero and then we increase the proportional control coefficient until the system response starts to fluctuate, then we increase the integral control coefficient to reach equilibrium, and finally the derivative control coefficient In the trial and error method, by repeating this process to achieve the desired result, control coefficients are extra Cerro In Ziegler and Nichols method, first by considering the derivative and integrator control coefficients as zero, the proportional control coefficient ($kcr$) was increased to such an extent that the system response is oscillating. Then by measuring the time of one cycle of the system response ($T_{cr}$) And using the relation (4) controller coefficients are extracted. In Figure (8) general schematic of this controller is shown [29].

$$G_c(s) = 0.6K_{cr}(1 + \frac{1}{0.5T_{cr}S} + 0.125T_{cr}s) \tag{4}$$

In the design of the proportional-integral-derivative controller, the control inputs follow the relation (5), [29].

$$u(t) = K_P\, e(t) + K_i \int_0^t e(\tau)d\tau + K_d \frac{de(t)}{dt} \tag{5}$$

Where the coefficients $K_i$, $K_p$and $K_d$ are the control coefficients designed for the proportional, integral and derivative controller, the proportional control gain $kp$ is the control feedback to the error between the desired value and the actual value. Derivative control interest $kd$, control feedback to error rate change, and integrator control interest $ki$, control feedback to the sum of the error values included in the control input. The error $(t)$ is the measured value of the sensors and the expected value at moment, and $de$ $(de)$ is the error rate of the measured value of the sensors and the expected value.

The design of a proportional, integral, and derivative controller with optimal performance depends on the choice of control interests. The PID system changes the values of the control interest by taking the error and the error derivative at any time as input. Then the control interest is calculated using the relations (6), [30][31].

$$K_p = 0.6K_{cr} \quad (6\text{-A})$$

$$K_i = 1.2\frac{K_{cr}}{T_{cr}} \quad (6\text{-B})$$

$$K_d = 0.075K_{cr}T_{cr} \quad (6\text{-C})$$

The coefficients adjusted by Ziegler and Nichols method and trial and error method are given in Table 1.

Table 1
Coefficients adjusted by Ziegler and Nichols methods and trial and error

| Controller parameters | $k_p$ | $k_i$ | $k_d$ |
|---|---|---|---|
| Ziegler and Nichols method | 1.2 | 0.8 | 0.45 |
| Trial and error method | 2.2 | 2.38 | 1.4 |

## 8.Controller Structure

In this part, the control structure of the four-legged flying robot is discussed. As mentioned in the introduction of the quadrotor components, the sensors in the electronic board of the quadrotor include a three-axis accelerometer, a three-axis gyroscope and a three-axis magnetic sensor. An electric pulse is applied to the motors and controls the quadrotor. The speed of the motors is sent to the quadrotor motors by the motor speed controller. It has an 8-bit processor and a serial output. It is worth mentioning that in all stages of implementation, quadrotor positioning has been done using the sensors in the quadrotor.

As you can see in the figure below, the position of the quadrotor, the position of the window, the distance of the quadrotor to the window and also the angle of view of the Parrot Bebop2 quadrotor are displayed. The performance of the quadrotor depends on the resolution of the camera, for each image we record a size of 480 x 640 pixels.

If the window is out of sight of the quadrotor, it will not be detected. The quadrotor camera acts like a visual system. In this way, the image information is received from the environment and in the next part, this information is sent as a code to the processor system, which after sending the information by the camera to the computer, in this part, the necessary processing is done to the content of the information on the image. As a result, it is sent to the motors as an instruction to move the quadrotor. In this article, the quadrotor's job is to detect the window and move towards it.

Due to the position of the color pixels in the image, the quadrotor has the ability to move in different directions to correctly detect the location of the window and move forward. After determining the position of the object, the position of the motors changes so that the image of the object is inclined towards the center of the image. If the image is to the right, the quadrotor moves to the right, and vice versa, if it is to the left of the image, it tilts to the left, and if it is in the center of the image, it moves forward.

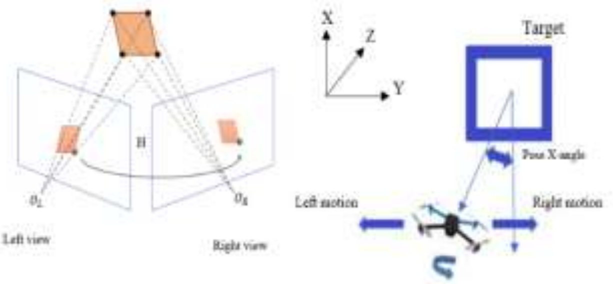


Fig. 9.Relationship between window position and Parrot Bebop2 quadrotor

## 9.Implementation Results

According to the proposed quadrotor algorithm mentioned in the previous section, the intelligent window detection and detection algorithm presented in Python programming language has been implemented in Linux operating system. The Parrot Bebop2 quadcopter connects to a laptop with the following features via Wi-Fi. Intel Core i7 processor and 8 GB of memory that runs the Linux operating system. We used open algorithms (opensource computer vision), an opensource library of more than 500 optimized algorithms for image and video analysis, to connect the laptop to the quadrotor, and obtain real-time images from the quadrotor camera.

In this experiment, the quadrotor is housed indoors. In order to evaluate the performance of the proposed algorithm, two experiments have been designed and implemented, in which the characteristics of the flying robot are first extracted and stored in a database. These features are then matched to the image properties in each frame to identify the desired window. The quadrotor camera acts like a visual system. First, the image information is received from the environment and in the next part, this information is sent as a code to the processor system. After sending the information by the camera to the computer, in this part, the necessary processing is done. The content of the information is done on the image and as a result is sent as an instruction to the motors to move the quadrotor [32].

In the first experiment, the goal is to detect the window and pass it through the quadrotor. Parrot Bebop2 quadrotor approach to window detection is that first the quadrotor is calibrated using Free flight Pro software via Wi-Fi connection which sets the initial position of the point (0, 0).

Then it starts moving from zero, the windows in the perimeter is 1.5 meters away from the quadrotor. The quadrotor faces two types of windows of different sizes, a large window that the quadrotor is able to pass through, a size of 50 × 50 and a small window that the quadrotor must detect as an obstacle and turn back is 30 ×30, the size of this window is smaller than the size of the quadrotor and the quadrotor will not be able to pass through.it is set to 1 meter, Also, the ambient light is assumed to be constant during the test. Our problem is the quadrilateral nature of the use window we did ten, so that if a quadrilateral was identified in the image that the angle between its sides was 90 degrees and its two diameters were equal, this quadrilateral is a square. In more complete terms, we used the quadrilateral scale property to correctly identify the window.

After identifying the window, the quadrotor must provide this data to the computer so that the computer can process it. After processing the image, we use the visual machine to analyze the images so that we can identify the objects in the image and obtain the target coordinates relative to the reference coordinates. In fact, the visual machine is used to determine the reference input for the control system. Then we send the calculated coordinates as a reference signal to the control system so that the quadrotor can detect its path using it and move towards the target. Figure (10) shows the window detection using the Parrot Bebop2 quadrotor.

Fig. 10. Indoor window identification using a quadrotor Bebop2

The obstacle avoidance process is generally divided into three parts: system identification, controller design, and obstacle avoidance algorithm. In the second experiment, to identify a smaller window that is considered an obstacle, we proposed a vision-based diagnosis and estimation of the fixed obstacle position for a quadrotor. Knowing the status of a fixed obstacle, that is, the position of the obstacle, is essential to achieving better performance for an intelligent unmanned aerial vehicle system (quadrotor), especially in navigation and automatic landing operations.

Low computational costs, using a combination of inertial unit sensors as well as the development of fixed obstacle detection and estimation method, based on Parrot Bebop2 quadrotor vision system confirm the effectiveness results [33]. Quadrotor collision avoidance has been proposed for optimization and evaluation with four motors. In order to do this, the implementation and parameterization of the image processing and signal control algorithm for such a system must be considered, so that a drone can avoid collision remotely.

In this project, we present a method that uses human behavior to detect the state of collision with obstacles. Using algorithm detects changes in size, smaller window area as an obstacle

We estimate the detected method and then the obstacle properties are detected by the algorithm, thus extracting the obstacle distance (window) that is most likely to be close to the quadrotor. It may or may not pass through the detected window. Finally, by estimating the position of the obstacle (window) in the image, the quadrotor performs the maneuver to avoid the window. We will use the output image to calculate the width and height. Figure (11) shows the relationship between the quadrotor and the obstacle graphically.

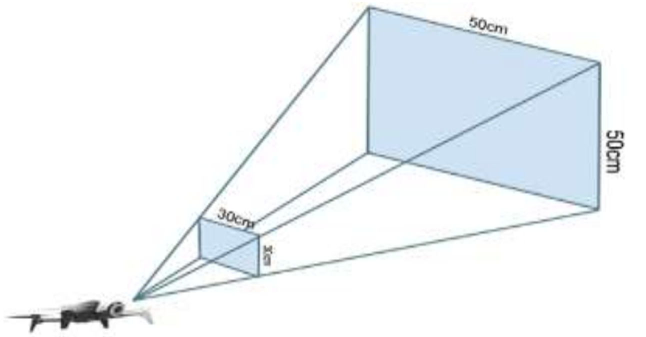


Fig. 11. How to identify a smaller window as an obstacle indoors

The results of window identification were performed using two proportional-integral-derivative control methods (trial and error method, Ziegler and Nichols method). It goes through the path.

Table 2
General comparison of the response of the designed control methods

| calculation method | Total number of flights | Successful flights | Unsuccessful flights | Flight success rate | Time (seconds) |
|---|---|---|---|---|---|
| trial and error | 10 | 6 | 4 | 60% | 28.87 |
| Ziegler and Nichols | 10 | 8 | 2 | 80% | 22.48 |

## 10.Use unmanned Vehicle for Identification

Today, due to the progress of humanity in various fields, has led researchers to show interest in technological innovations, especially in the field of robotics. Over the years, various types of mobile or remote-controll robots have been developed. Many of these robots use wheels or feet to move on the ground, so that they can perform the desired mission. In some cases, due to the nature of the obstacles or the type of mission defined for the robot, it is possible to use robots that move on the ground. It is not possible. In such cases, the use of flying robots is a logical solution, Surveying, irrigation and spraying of fields, etc. in a very short time and high speed of operation.

Flying robots can be a great help to humans in dangerous situations. This unmanned vehicle, with its efficient arms, can move and move objects completely autonomously or help build simple structures. They also have great potential for exploring unfamiliar and indoor environments and can perform search and rescue missions in the face of various events. No need for a flight deck, high flexibility, controllability, small size and light weight make them able to carry out their mission at high speed [34]. The benefits of using this research include the following:

- Ease of access to dangerous or inaccessible places without human intervention
- Achieve better results in a short time
- Accuracy in identifying and tracking the target
- Reduce costs

## 11.Conclusion

In this article, the detection of indoor windows by a four-propeller flying robot (quadrotor) in order to cross the window has been investigated. As mentioned, each robot has advantages and disadvantages that the robot performs in a specific mission. In fact, trying to achieve better and more optimal results in achieving the goal by using the benefits of different robots, the ultimate goal of this research is to use the same benefits in order to perform the tasks of robots more efficiently and accurately. This paper describes the process of window detection and passing through a single forward camera of the Parrot Bebop2 quadcopter, as well as the sonar sensor, gyroscope and accelerometer in the quadcopter, which uses the information obtained from the image to identify the desired window scale.

In addition, the results of this paper showed that the proportional-integral-derivative controller by Ziegler and Nichols method has a good performance in controlling the position and tracking the path compared to the trial-and-error method in flying robots in an indoor environment. It should be noted that the use of alignment, contour, threshold and color algorithms in window detection and obstacle detection, as well as establishing a proper connection between the sensors in the electronic board of the quadrotor, including accelerometer, gyroscope and inertial measurement unit, resulted in optimal quadrotor performance, which improved proper condition control and route tracking.

## Reference


[1] Vahid Tikani, Hamed Shahbazi, "Design and implementation of attitude PID controller with fuzzy system to adjust the controller gain values for quadrotor", Modares Mechanical Engineering 2016

[2] Gergely Soós, Csaba Rekeczky, "Elastic Grid Based Analysis of Motion Field for Object-Motion Detection in Airborne Video Flows", 2007 IEEE International Symposium on Circuits and Systems

[3] Ivan´ F. Mondragon´ and Pascual Campoy and Carol Mart´ınez and Miguel A. Olivares-Mendez, "3D pose estimation based on planar object tracking for UAVs control", 2010 IEEE International Symposium on Circuits and Systems

[4] Qing Wang, Xiaodong Zhang, Yao Wang, Guanzhou Chen, and Fan Dan, "The Design and Development of Object-Oriented UAV Image Change Detection System", Springer-Verlag Berlin Heidelberg 2013

[5] Alireza abbaspour, kang k Yen, shirin Noei, Arman sar golzaei, "Detection of Fault Data Injection Attack on UAV Using Adaptive Neural Network", 2016 The Authors. Published by Elsevier

[6] Li Yamin, Wang Yong, Wang, Dianhong, "Multiple RGB-D sensor-based 3-D reconstruction and localization of indoor environment for miniMAV", 2017 Elsevier Ltd

[7] Wilbert G. Aguilar, Verónica P. Casaliglla, and José L., "Obstacle Avoidance Based-Visual Navigation for Micro Aerial Vehicles", Pólit, Electronics 2017

[8] Murali Mohan Gade, Swaroop Hangal, Dileep Krishnan, Hemendra Arya, "Development of Obstacle Avoidance Controller for MAVs: Testing in Hardware-In-Loop Simulation", 2016, IFAC (International Federation of Automatic Control)

[9] Muhammad Fazlur Rahman and Rianto Adhy Sasongko, J Keshavan, G Gremillion, H EscobarAlvarez et al, Albert Bugayong and Manuel Ramos, Jr, "Object Detection Technique for Small Unmanned Aerial Vehicle", 2017 International Conference on Mechatronics

[10] Klaas Kelchtermans and Tinne Tuytelaars, "How hard is it to cross the room? Training (Recurrent) Neural Networks to steer a UAV", The Author(s) 2017

[11] Ram Prasad Padhy, Sachin Verma, Shahzad Ahmad, Suman Kumar Choudhury, "Pankaj Kumar Sa Deep Neural Network for Autonomous UAV Navigation in Indoor Corridor Environments", 2018 The Authors. Published by Elsevier Ltd.

[12] Changwu Zhang, Hengzhu Liu, Yuchen Tang, "Analysis for UAV Heuristic Tracking Path Planning Based on Target Matching", 2018 IEEE

[13] Carlos Paucar1, Lilia Morales1, Katherine Pinto1, Marcos Sánchez1, Rosalba Rodríguez1(&), Marisol Gutierrez1, and Luis Palacios, "Use of Drones for Surveillance and Reconnaissance of Military Areas, Springer International Publishing AG", part of Springer Nature 2018

[14] Abhinav Pachauri, Vikrant More2, Pradeep Gaidhani2, Nitin Gupta2 1 IIT Kharagpur, "Autonomous Ingress of a UAV through a window using Monocular Vision2 Navstik Autonomous Systems", 2016

[15] Yasir Mohd Mustafah, Amelia Wong Azman, Fajril Akbar, "Indoor UAV Positioning Using Stereo Vision Sensor", 2012 Published by Elsevier Ltd

[16] Luis Rodolfo García Carrillo·Alejandro Enrique Dzul López· Rogelio Lozano·Claude Pégard, "Combining Stereo Vision and Inertial Navigation System for a Quad-Rotor UAV", 2012 Published by springer

[17] Jose-Ernesto Gomez-Balderas·Pedro Castillo· Jose Alfredo Guerrero·Rogelio Lozano, "Vision Based Tracking for a Quadrotor Using Vanishing Points", 2012 Published by springer

[18] https://www.cavesvalleytech.com/product/parrot-bebop-2/

[19] Ahmed Alkamachi1 · Ergun Erçelebi, "Modelling and Genetic Algorithm Based-PID Control of H-Shaped Racing Quadcopter", 2017 Published by springer

[20] Naveen Singh Dagara, Pawan Kumar Dahiya, "Edge Detection Technique using Binary Particle Swarm Optimization", 2020 The Authors. Published by Elsevier B.V.

[21] Fatimah Al-Hafiz, Shiroq Al-Megren and Heba Kurdi, "Red blood cell segmentation by thresholding and Canny detector", 2018 The Authors. Published by Elsevier Ltd.

[22] Guili XU a, Zhengbing WANG, Yuehua CHENG, Yupeng TIAN, Chao ZHANG, "A man-made object detection algorithm based on contour complexity evaluation", 2017 Chinese Society of Aeronautics and Astronautics. Production and hosting by Elsevier Ltd

[23] Xin-Yi Gong, Hu Su, De Xu, Zheng-Tao Zhang, Fei Shen, Hua-Bin Yang, "An Overview of Contour Detection Approaches", 2018 Published by springer

[24] Jing Wang, Hong Zhu, Shunyuan Yu, Caixia Fan, "Object Tracking Using Color-Feature Guided Network Generalization and Tailored Feature Fusion", 2017 Neurocomputing

[25] Sidra Mehtab, "Object Detection and Tracking Using OpenCV in Python", 2020

[26] Mohammed Abdallah Khodja1, Mohamed Tadjine1, Mohamed Seghir Boucherit1, and Moussa Benzaoui , Tuning PID attitude stabilization of a quadrotor using particle swarm optimization (experimental), 2016

[27] M.H. Sangdani and A.R. Tavakolpour-Saleh, "Modeling and Control of a Vision-Based Target Tracker Robot with Active Force Control Capability", 2016

[28] Jialiang Gan and Zhimin Li, "Simulation and Stability Analysis of SRM Speed Control System Based on Fuzzy Self-Tuning PID", 2013 Springer-Verlag Berlin Heidelberg

[29] Rouhollah Norouzi, Hamed Shahbazi, Kamal Jamshidi, "Design and Implementation of a Neural Intelligent Controller and a Hybrid PD Controller for Quadrotor", 2017

[30] https://www.youtube.com/watch?v=n829SwSUZ_c

[31] Seyed Jamal Hadadi, Payam Zarafshan, Implementation of Attitude Control for an Octorotor Flying Robot in an Autonomous Trajectory Tracking, 2016

[32] Ehsan fani, Alireza khodayari, "Introduces a new intelligent image processing algorithm for detecting and recognizing traffic signs based on fuzzy logic", Journal of Mechanical Engineering Amirkabir, 2019

[33] Martha A. Grover, Daniel J. Griffin, Xun Tang, "Control of Self-Assembly with Dynamic Programming", 2019

[34] Carlos Paucar1, Lilia Morales1, Katherine Pinto1, Marcos Sánchez1, Rosalba Rodríguez1(&), Marisol Gutierrez1, and Luis Palacios, "Use of Drones for Surveillance and Reconnaissance of Military Areas, Springer International Publishing AG", part of Springer Nature 2018.