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SIMPLE DRONE FOR OBJECT COLOR DETECTION

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Abstract: Multirotor unmanned aerial vehicles (UAVs), such as quadcopters and hexacopters, have become increasingly popular in recent years. This is due to their capability to hover along with other specifications that make them viable in many applications. In this work, the development and integration of a quad-copter in X-configuration with an IP camera for object detection based on the color of an object are handled. A KK2 microcontroller is used to control the quadcopter movements. The controller has built-in gyros that provides heading rate information, which are used to control the movement of the quadcopter. The parts of the whole UAV are selected and integrated. The calibration processes are handled after installing necessary controller codes. This is to make quadcopter fly according to set commands and smoothly. The IP camera is integrated with quadcopter frame to acquire images of objects to detect a pre-specified target color. Mobile camera with GPS data is used here for the detection. Two algorithms were next implemented to acquire and analyze the images received from the IP camera. The results show that the Images were captured and analyzed successfully and the objects were remotely detected based on their color. As a result, the developed algorithms can be used as a part in remote observation systems.

Keywords: *quadcopter; UAV; drone; object detection; Image Acquisition and Analysis*

طائرة بدون طيار بسيطة لاكتشاف ألوان الأهداف

الخلاصة: ان الطائرات بدون طيار ذات النوع المتعددة المراوح، مثل الطائرات الرباعية والسداسية المراوح، أصبحت أكثر شيوعاً في السنوات الأخيرة وذلك لقدرة هذا النوع من الطائرات على الحوم حول منطقة معينه بالإضافة الى عدة عوامل أخرى والتي جعلتها حيوية في عدة تطبيقات. في هذا البحث تم تطوير ودمج طائرة رباعية المراوح (كوادكوبتر) تطير بشكل X مع كامرة أي بي لغرض الكشف عن الأهداف بالاعتماد على لون الهدف. تم استخدام متحكم نوع KK2 للسيطرة على حركة الطائرة. يحوي المتحكم على جايروسكوبات والتي توفر معلومات حول وجهة الطائرة والتي تستخدم في عملية السيطرة على حركة الطائرة الرباعية. بعد اختيار ودمج جميع مكونات الطائرة تم تحميل البرامج الضرورية للمسيطر وبعدها تم اجراء عمليات المعايرة وذلك لجعل الطائرة الرباعية تطير بحسب الأوامر المحددة لها وبشكل سلس ومستقر. أخيرا تم تركيب كاميرة أي بي الى متن الطائرة لاستخدامها في استحصال صور الأهداف وكشفها اعتمادا على لون الهدف المحدد مسبقا والمراد كشفه. تم استخدام كاميرة الهاتف المحمول مع نظام تحديد المواقع لغرض كشف الأهداف. تم تطوير وتنفيذ خوارزميتين لاستحصال وتحليل الصور المأخوذة من الكامرة. اثبتت النتائج نجاح الخوارزميات المقترحة بعملية استحصال وتحليل الصور وكشف الأهداف عن بعد اعتمادا على لون الهدف والذي يمكن استخدامه لاحقا كجزء في منظومات المراقبة عن بعد.

1. Introduction

Unmanned Aerial Vehicles (UAVs) are routinely charged for endeavors that are viewed as too much dull or perilous for a human pilot to finish. Beforehand, ask about including UAVs was onstrained by sweeping and expensive flight stages which offered

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more noticeable payloads. Regardless, late advances in embedded figuring and sensors have made close to nothing, ease self-representing systems accessible to the more broad research assemble [1]. These small flying robots are used for audit of daylight based loads up and besides associates. moreover, they can help ensure missions after calamitous occasions or impacts, or screen characteristic life and item.

They can in like manner supplant individuals in the midst of activities that could be damaging to life, for instance, reconnaissance in locales with an anomalous condition of radiation[2]. Unmanned Aerial Vehicles (UAVs) have starting late blended magnificent interests in both present day and military fields.

UAV is a sort of especially complex structure which organizes different gear portions, for instance, camera, Global Positioning System (GPS), controller, and particular programming parts, for instance, picture planning, way masterminding and internal circle control[3]. Vehicle systems have specific properties like flying in low heights and having the ability to float that make them suitable for applications that may be hard to get done with using settled wing vehicles[4].

It justifies indicating that regardless of the way that the quadrotor structure and its weight are unfaltering yet its payload can be changed in various applications. So, an adaptable feedback control is essential to have an OK execution regardless of different initial conditions and distinctive conditions in the midst of flight [5]. All around it swings to be impressively more snared for rotorcraft plans.

However speak to different central focuses appeared differently in relation to the settled wing systems for a wide plan of real–life applications, for instance, a) floating limit, b) higher payloads, and c) compelling maneuverability[6]. Cameras have the benefits of being negligible exertion, low power, minimal size and light weight, and the limit of being used for various endeavors, for instance, for investigating and moreover performing surveillance[7].

In this work, a UAV that uses PDA (used Huawei phone) as a bird's-eye IP camera to get pictures for targets and a GPS model to recognize their local positions. The processing steps of the developed prototype began by flying the quadcopter to a specified area, start acquiring images and searching for a target color of concern. Next, during UAV flying, two algorithms executed to capture the images and analyze detected objects based on their color. Finally, once an object detected, the position information is added by acquiring smart phone’s GPS data and associate it to the detected target.

A number of subsequent steps are followed to complete the overall work including quadcopter integration. The first step is literature review in which several types of UAVs models are studied to choose an appropriate platform for eye in the sky model to capture images of targets. After selecting the quadcopter type, the integration process of the overall UAV was started. Later, test and calibration of equipment such as electronic speed controls (ESCs), motors and microcontroller were considered. Next, testing UAV fly and its stability was carried out. Finally, the online mobile camera was used for targets detection task.

2. Quadrotor Modeling

Expecting that the quadrotor is an unbending body, the flow of the quadrotor can be portrayed utilizing Newton-Euler conditions. A few types of numerical models can be determined. In [8] a piecewise relative model was utilized to outline an exchanging model prescient demeanor controller. A linearized model of the quadrotor was utilized as a part of [9] to plan a direct quadratic (LQ) controller. This article concentrates on the nonlinear model concerning the inertial casing and furthermore to the body-settled edge, the model portrayed by quaternions and the model of the quadrotor close to the drift position. Every propeller pivots at the precise speed ωi delivering the comparing power Fi coordinated upwards and the neutralizing torque coordinated inverse to the bearing of the turn. Propellers with the rakish speed $\omega 1$ and $\omega 3$ turn counter-clockwise and the other two turn clockwise. The modification of the position and the introduction is come to by differing the push of a particular rotor. Angular velocities corresponding to the inertial frame EI (ζ) and the body fixed frame EB (η) are presented in figure (1).

The rotation matrix from EB to EI is an orthogonal matrix given by equation (1), where C angle and S angle designate cos (angle) and sin(angle) respectively, and φ the roll angle, θ the pitch angle and ψ the heading angle that describe UAV orientation [10, 11].

$$\mathbf{R}_M = \begin{bmatrix} C_\psi C_\theta & C_\psi S_\theta S_\phi - S_\psi C_\phi & C_\psi S_\theta C_\phi + S_\psi S_\phi \\ S_\psi C_\theta & S_\psi S_\theta S_\phi + C_\psi C_\phi & S_\psi S_\theta C_\phi - C_\psi S_\phi \\ -S_\theta & C_\theta S_\phi & C_\theta C_\phi \end{bmatrix} \quad (1)$$

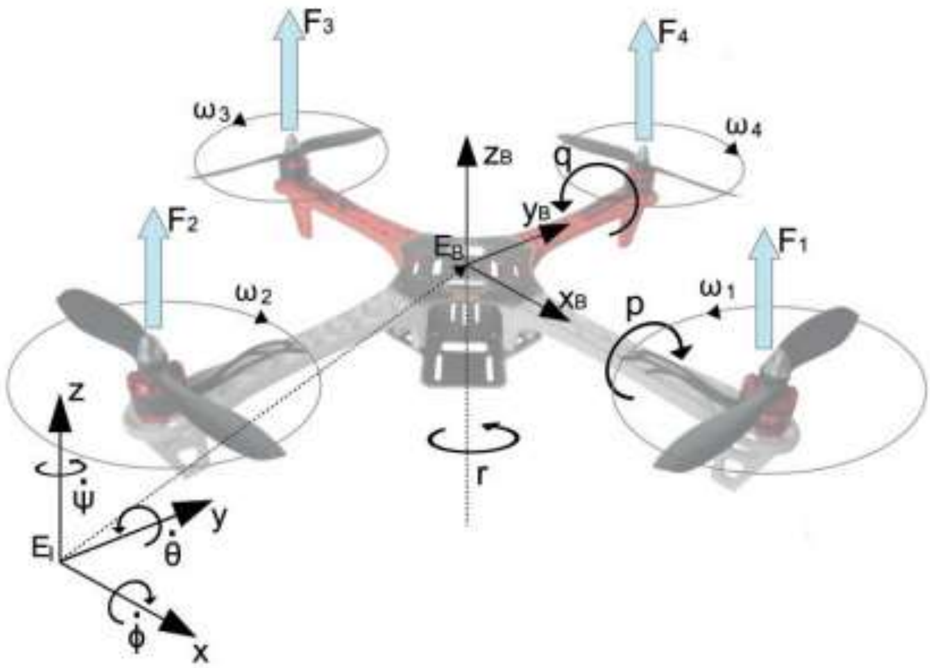


Figure (1) Inertial and body frames of the quadcopter

3. Control architecture of the UAV

The quadrotor position controller is designed as hierarchical control architecture. The low-level attitude control has already been realized in the quadrotor inner-loop controller by the developer. The high-level position control is implemented in our developed ground control station. A finite state machine controls the high-level behavior of the quadrotor. The desired behavior consists of four phases: taking off, hovering, tracking and landing. The control architecture of quadrotor is shown in Figure (2) The quadrotor takes off from the helipad on the carrier and holds a fixed height of 0.5 m in our experiments. Commands from the ground control station start the autonomous visual tracking and landing of the quadrotor. While the carrier is stationary, the quadrotor will hover overhead the helipad.

The quadrotor must hover right over the center of the helipad in our task. When the carrier is moving, the quadrotor must track overhead the center of the helipad. The precise autonomous position control is achieved by two independent Proportional–Integral–Derivative (PID) controllers. One PID controller is for the pitch channel, and the other for the roll channel. The input of the controller is the position errors, which can be obtained by our proposed computer vision algorithms.

The output of the controller is the attitude angle commands. The position error for the corresponding roll and pitch channel can be denoted with er(t) and ep(t). Figure (3) shows the PID controllers for our quadrotor's position control with real-time visual feedback. When the quadrotor is in the landing phase, it will maintain a constant descending velocity while keeping tracking of the helipad. As the position errors in pixels are adopted as the inputs of controllers, height compensation must be considered during landing process. In actual experiments, the landing phase can be separated into three circumstances, which can compensate for the controller outputs.

If the quadrotor's height is under 0.05 m, the helipad region in the image is too large to use for navigation. The quadrotor will directly shut off motors, and land on the helipad quickly. This proposed strategy can avoid the influence of the ground effect, and better performance can be guaranteed effectively.

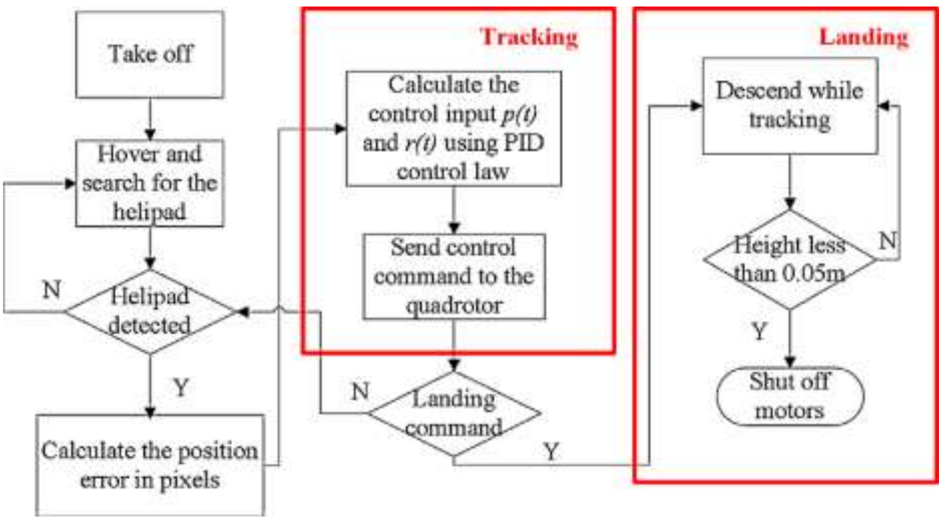


Figure (2) Control architecture of the quadrotor

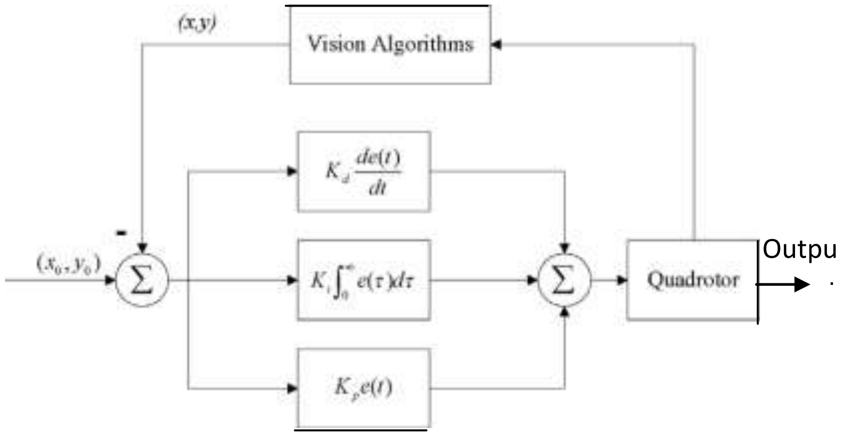


Figure (3) Position PID controller with visual feedback.

4. Integration Steps of the Quadcopter

The proper and required parts to complete integrating whole quadcopter are microcontroller, four electronic speed control (ESC), four motors each with sort 1000 KV, four propellers and Radio Controller RC transmitter and receiver.

After that, interfacing and integrating the quadcopter parts. First, ESC is connected to the casing board and microcontroller from one side. The opposite side of ESCs is connected with the motors. Each motor is integrated on one arm of the four arms of the quadcopter. The quadcopters utilizes four propellers and four engines which makes push and hoists high , out of four engines with propellers connected, two engines turns in clockwise(CW) course and other two pivots in counter-clockwise(CCW) bearing.

5. Layout of the Integrated Quadcopter

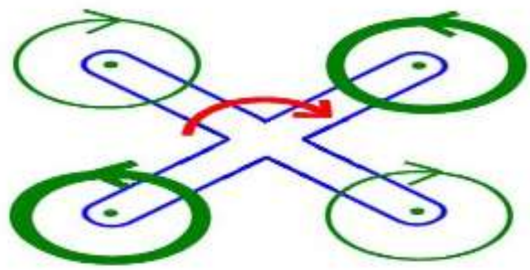
System layout consists of microcontroller which is consider the heart of quadcopter it control by the movement of quadcopter and it give stability and balance because it contain sensors such as gyro and accelerometer, microcontroller connected with RC receiver, which receives guidance from RC transmitter and passes them on to microcontroller and microcontroller changes movement of quadcopter through controls of the speed of motors by use ESCs. A mobile phone was also added to the system, which used as camera for online imaging purpose, the advantage of using mobile phone it high imaging resolution, few of weight and more battery life.

6. Operation and Control of the Quadcopter

Client utilize RC transmitter to control quadcopter and have many effect development to up down left and right developments of quadcopter ,this development can rolled out by improvement the speed of engines, and will talk about these kind of development. The principal development is Yaw which is the deviation/Rotating the leader of the quadcopter either to right or left, as shown in Figure (4), likewise called rudder.

The strong green mean speedier turn "more push" and quadcopter will move to right point. The second development is pitch, pitch is the development of quadcopter either forward or in reverse. Forward pitch is accomplished by pushing the aileron stick in RC transmitter forward, which makes the quadcopter tilt and advance, far from you.

In reverse pitch is accomplished by moving the aileron stick in RC transmitter in reverse (towards you), making the quadcopter come nearer to you. As shown in Figure (5). The last development is move; roll is making the quadcopter fly side wards, either to the left or to the right. Roll is controlled with the aileron stick, making it move left or right. If the aileron stick is moved to the left, the quadcopter will fly left and vise versa, as shown in Figure(6).



Figure(4) Yaw movement of qouadcopter

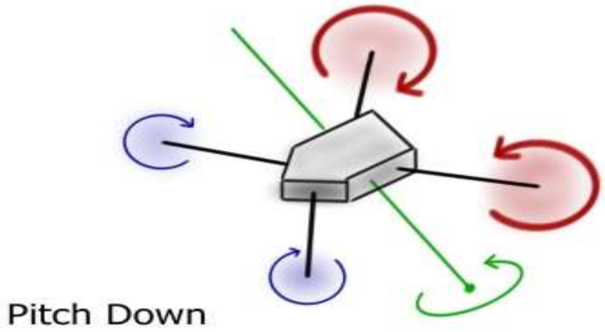
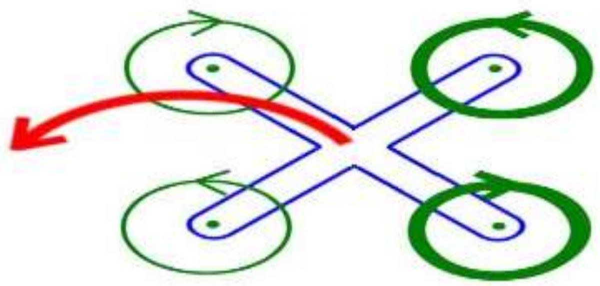


Figure (5) Pitch down movement of qouadcopter



Figure(6) Fly right movement of qouadcopter

6.1. *Mission Planner Configuration*

On the Mission Planner's Initial Setup screen select Mandatory Hardware | Frame Type. Select the frame for your copter. The default configuration is X. If you want one of the arms to serve as the exclusive front-facing direction, select the Plus configuration. For Tricopters , Traditional Helis and Y6s, the frame type is ignored (See Figure (7)).

Figure (7) Mission Planner that selects UAV frame type

7. Calibration of microcontroller

The flight-controller has a built in safety feature which disables the throttle stick. This is a great feature that probably will save your platform or face at least once. The KK-board on power up will be in the "locked"/disarmed position. The LED on the board indicates if the board is armed or not. LED off = "locked"/disarmed, LED on = Armed. To arm the board move the throttle/rudder stick down to the right corner and hold it there for about 5 seconds. The LED will turn on indicating that the board is armed and ready. To unarm/lock the board again move the throttle/rudder stick down to the left corner for 5 seconds.

7.1. *Check the throttle stick*

This is to ensure that the throttle stick is moving to the right direction and have enough throw to initialize the flight-controller. First, turn on the transmitter and then the flight-controller moves the throttle/rudder stick to the down-right corner. Accordingly, the LED will turn on.

7.2. *Calibrating the throttle range on the ESCs*

This is to ensure that all the ESC's have the same throttle range end points. This step only needs to be performed once. Fail to do this calibration can result in an uncontrollable platform. ESCs' calibration steps are as follows:

1- The flight-controller must turned off.
2- Turn the Yaw pot to the low position
3- Turn on the transmitter
4- Move the throttle stick to up (full)
5- Turn on the flight-controller
6- Wait until the ESC's beeps twice after the initial beeps, then swiftly move the throttle stick fully down (closed). The ESCs should beeps seven times.
7- Power off the flight-controller
8- Finally, restore the yaw pot to around 50%

7.3. *Checking the direction of the transmitter channels*

This process is to ensure that the sticks actually perform the actions in the way that they are supposed to operate. The processing steps carried in this section include:

1- Turn on the transmitter and then the flight-controller
2- Arm the controller (i.e. move the throttle stick to the down-right corner).
3- Start the motors by raising the throttle (around 1/4)
4- Move the pitch (elevator) stick on the transmitter forward. The back motor should speed up. If it doesn't, reverse the channel in the transmitter.
5- Move the Roll (Aileron) stick to the left. The right motor should speed. If it doesn't, reverse the channel in the transmitter.
6- Move the Yaw (rudder) stick to the left. The front and back motor should speed up. If it doesn't perform as expected, we have to reverse the channel in the transmitter. (This will make the arming function reversed as well, meaning that it is need to move the stick down in the left corner to arm the controller.

7.4. *Checking the gyro compensations*

This step is to ensure that the gyros compensate in the right direction. If they do not platform, it will be uncontrollable. The steps carried here are:

1- Turn on the transmitter and then the flight-controller
2- Arm the controller. (move the throttle stick to the down-right corner)
3- Start the motors by raising the throttle (around 1/4)
4- Tilt the quadcopter forwards. The front motor should speed up. If it doesn't, note it, fix this in the next step.
5- Tilt the quadcopter to the right. The right motor should speed up. If it doesn't, note it, fix this in the next step.
6- Rotate the quadcopter to the right (clockwise). The front and back motors should speed up. If it doesn't, fix this in the next step.

7.5. *Reversing the gyros*

This is how to reverse the compensation direction of the gyros. It involves the following steps:

1- Make the flight-controller turned off
2- Turn the roll pot to the low position
3- Turn on the transmitter then the flight-controller
4- The LED will flash rapidly 10 times and then turn off
5- Move the stick for the gyro you want to reverse (If you want to reverse the roll gyro, move the roll (aileron) stick).
6- The LED will flash continually to confirm your choice
7- Turn off the flight-controller
8- If more gyros needs to be reversed, turn on the flight-controller and repeat the process.

7.6. *Reversing the pot direction*

If the pots turn in the wrong direction, we have to reverse the direction. This means changing the low and high. The steps are:

1- Make sure that the flight-controller is turned off
2- Turn the roll pot to the low position
3- Turn on the transmitter then the flight-controller
4- The LED will flash rapidly 10 times and then turn off
5- Move the throttle up
6- The LED will flash continually to confirm
7- Turn off the flight-controller
8- The pots are now been reversed. If needed to reverse the pots back must turn the roll pot fully to the other direction and repeat the process. Otherwise, restore the pot to 50%.

8. Camera for Objects Detection

This project uses smart phone in the Huawei smart phone as an IP camera to get images for an object. Also, the detect object position is recorded and added to the detected objects using GPS receiver embedded in the smart phone. Developed algorithms for data acquisition and analysis to detect objects are presented in the following subsections. and applying the algorithm to detect the object .

8.1. *Image Acquisition and Analysis Code*

```
using System;
using System.Collections.Generic;
using System.ComponentModel;
using System.Data;
using System.Drawing;
using System.Linq;
using System.Text;
```

```
using System.Threading.Tasks;
using System.Windows.Forms;
using AForge.Video;
using System.IO;
using System.Drawing.Imaging;
using System.Threading;
namespace ipforg
{
    public partial class Form1 : Form
    {
        MJPEGStream stream;
        Bitmap img;
        public Form1()
        {
            InitializeComponent();
            stream = new
MJPEGStream("http://192.168.1.3:4747/mjpegfeed?640x480");
            stream.NewFrame += stream_newframe;

        }
        void stream_newframe(object sender, NewFrameEventArgs eventArgs)
        {
            Bitmap bmp = (Bitmap)eventArgs.Frame.Clone();
            pictureBox1.Image = bmp;
            img = bmp;

        }
        private void button1_Click(object sender, EventArgs e)
        {
            stream.Start();
        }

        private void button2_Click(object sender, EventArgs e)
        {
            stream.Stop();
        }

        private void Form1_FormClosing(object sender, FormClosingEventArgs e)
        {
            stream.Stop();
        }

        int cnt = 0;
        private void btn_timer_Click (object sender, EventArgs e)
        {
            stream.Stop();
            Thread.Sleep(1000);
            Bitmap tmp = img;
            tmp.Save("pic//" + cnt.ToString() + ".bmp",ImageFormat.Bmp );
            tmp.Dispose();
            stream.Start();


            pictureBox2.Load("pic//" + cnt.ToString() + ".bmp");
            Bitmap bmp = new Bitmap(pictureBox2.Image);
            Bitmap r = new Bitmap(bmp.Width, bmp.Height);

            for (int i = 0; i < bmp.Width; i++)
                for (int j = 0; j < bmp.Height; j++)
                {
                    if (bmp.GetPixel(i, j).R >= 80 & bmp.GetPixel(i, j).G <=70 &
bmp.GetPixel(i, j).B <= 70)
```

```
                    {
                        r.SetPixel(i, j, Color.FromArgb(255, bmp.GetPixel(i,
j).R, bmp.GetPixel(i, j).G, bmp.GetPixel(i, j).B));

                    }
                    else
                    {
                        r.SetPixel(i, j, Color.White);

                    }
                }
            pictureBox3.Image = r;
            cnt++;
        }
    }
}
```

8.2. *Connection method*

Using Wi-Fi technique to connect devices wirelessly using router. The proposed work uses droidcam application to get the images from smart phone, as depected in Figure (8)

Figure (8) User interface of the DroidCam application

9. Results

Using visual studio program to get the results, special code have been developed to identify a particular color and cancel the rest of the colors by giving them a specific color. For instance, white color to distinguish the chosen color from the rest of colors as illustrated in Figure (9) and GPS technique by using real-time GPS tracker application that is work online with internet to detect object position.

The resulting image is displayed in red for user friendliness. The helipad is extracted effectively from the sample image, which demonstrates that the computer vision algorithms meet requirements of the quadrotor system. This work can be compare with previous work, which is shown in Figure 10.

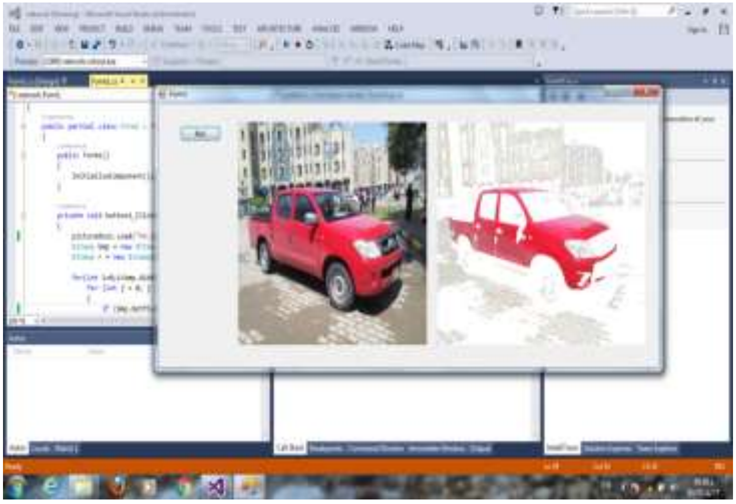


Figure (9) Image of a target and its analyzed image after red color detection

(a)

(b)

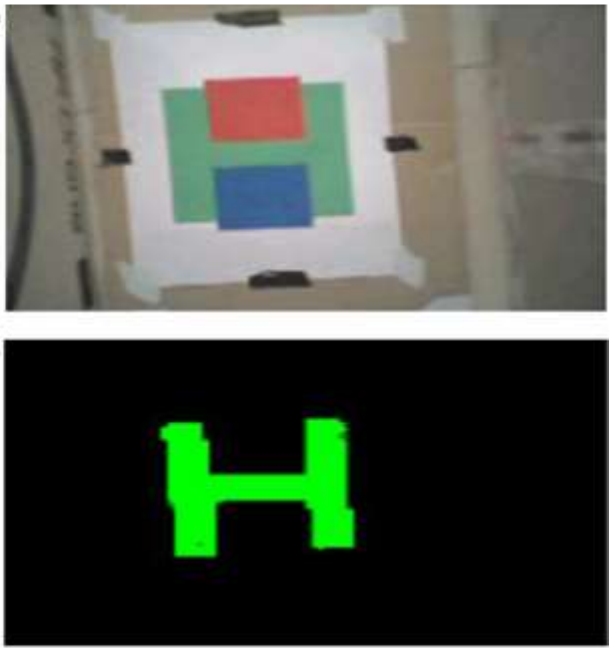


Figure (10) Effect of the vision algorithm: (a) original image of helipad and (b) resulting image of helipad [12]

10. Conclusions

In this project, the quadcopter integration and object detection based on object color had addressed. The identification of the color based on quantity (brightness) of color in the object that detects it and the other colors in the image will be discarded by set specific color to it. Also, using GPS technique will allow to detect object position by using smart phone application (Real-Time GPS tracker) that works online but requires internet access to detect object position at any place. The developed model can be applied in security system and observation applications. The results show the successful implementation of the developed algorithms.

11. References

1. Zhong Y. (2014).”*Robust Tracking Control of a Quadrotor Helicopter*”. J. Intell. Robot. Syst., vol. 75, no. 3, pp. 595–608.
2. Chovancová, A., and Hubinsk, P.,(2014).”*Mathematical Modelling and Parameter Identification of Quadrotor (a survey)*”. Procedia Eng., vol. 96, pp. 172–181.
3. Duan, H.,(2013), “*Implementation of autonomous visual tracking and landing for a low-cost quadrotor Opt*” . - Int. J. Light Electron Opt., vol. 124, no. 18, pp. 3296–3300.
4. Valvanis, K.,(2007), ”*Advances in unmanned aerial vehicles,”* Intell. Syst. Control. Autom. Sci, pp. 171–210.
5. Hoffmann, G. M and Tomlin, C. J.,(2007), *Quadrotor Helicopter Flight Dynamics and Control : Theory and Experiment,* Am. Inst. Aeronaut. Astronaut., vol. 4, no. August, pp. 1–20.
6. Alexis, K., and Tzes, A.,(2014),”*Experimental constrained optimal attitude control of a quadrotor subject to wind disturbances,”* Int. J. Control. Autom. Syst., vol. 12, no. 6, pp. 1289–1302.
7. Ghadiok, V., and Ren, W.,(2012), “*On the design and development of attitude stabilization, vision-based navigation, and aerial gripping for a low-cost quadrotor,”* Auton. Robots, vol. 33, no. 1–2, pp. 41–68.
8. K. Alexis, G. Nikolakopoulos, A. Tzes, (2011) “*Switching Model Predictive Attitude Control for a Quadrotor Helicopter subject to Atmospheric Disturbances,”* Control Engineering Practice. 19 (10) 1195–1207.
9. F. Rinaldi, S. Chiesa, F. Quagliotti, (2013). “*Linear Quadratic Control for Quadrotors UAVs Dynamics and Formation Flight*”, Journal of Intelligent & Robotic Systems. 70(1-4) 203-220.
10. T. Luukkonen, (2011) “*Modelling and control of quadcopter, Independent research project in applied mathematics* “, Espoo: Aalto University,.
11. A. Alaimo, V. Artale, C. Milazzo, A. Ricciardello, L. Trefiletti, (2013) “*Mathematical Modeling and Control of a Hexacopter*”, in: International Conference on Unmanned Aircraft Systems (ICUAS), Grand Hyatt Atlanta, Atlanta, GA, 2013, pp. 1043-1050.
12. Y. Bi and H. Duan, (2013) “*Implementation of autonomous visual tracking and landing for a low-cost quadrotor,*” *Opt. - Int. J. Light Electron Opt.*, vol. 124, no. 18, pp. 3296–3300.