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REAL TIME TELEMETRY SYSTEM FOR SURVEILLANCE AND TRACKING

Ali Akbar Siddiqui[1]
Department of Telecommunication Engineering
Mohsin Iqbal Vohra[2]
Department of Telecommunication Engineering
Jawad Ali Arshad[3]
Department of Telecommunication Engineering
Syed Faheem Haider Rizvi[4]
Department of Telecommunication Engineering
Dr. Tahir Qadri[5]
Department of Electronic Engineering
Sir Syed University of Engineering & Technology

ABSTRACT

In recent time a need of surveillance is of utmost necessary due to the crime situation in populous cities around the world. Men power alone may not be enough for covering an entire city around the clock. We have proposed an idea of a telemetry system capable of performing such tasks at reduced cost and even preventing casualties. Our telemetry system is based on a Quad copter model controlled by an AVR controller based APM (Autopilot Module). There is also GPS (Global Positioning Satellite System) and GSM (Global System of Mobile Communication) mounted on the model providing us with exact coordinate of its current location. Our proposed system is cheap and efficient in performing its task

Key Words: Telemetry System, AVR Controller Quad Copter Model.

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1 Ali Akbar Siddiqui : ali124k@hotmail.com
2 Mohsin Iqbal Vohra : mvohraz@gmail.com
3 Jawad Ali Arshad : jawwadaliarshad@gmail.com
4 Syed Faheem Haider Rizvi : faheem140@gmail.com
5 Dr. Tahir Qadri : mtahirq@hotmail.com

1. INTRODUCTION

Quad copter technology is not a new technology; this technology is evolving on daily bases. In early 1900 the Unmanned Aerial Vehicles (UAV) was first introduced and this technology was initially capable for military application purposes and it was more advanced then civilian applications point of view. Unmanned Aerial Vehicles (UAV) has an ability to operate in dangerous location and this can be helpful for human safety. Smaller UAVs is used for typical operation such as searching unknown areas or a village and find areas of enemy positions. Quad copters are a useful tool for university researchers to test and evaluate new ideas in a number of different fields, including flight control theory, navigation, real time systems, robotics, and firefighting assistance, border security, traffic surveillance and electronic media coverage (Gourley, et al, 2002).

Another name of Quad copter is quad rotor and it is a helicopter which has four rotors. These rotors have been placed in a square formation in such a way that it has adjusted in equal distance from center of the quad copter. Two rotors spin in clockwise and two are in anticlockwise direction that lifts the quad copter upwards and avoid net angular momentum (Lin, P.F.; Chang et al, 2012). The following fig 1shows the quad copter body frames (Lee, C.-S et al, 2013).

Atheer L. Salih, M. Moghavvemi have presented an approach for controlling the flight of autonomous quad rotor. In this paper they used PID (proportional-integral-derivative) controller for increasing the stability of quad rotor flight and also control the position and attitude of quad rotor flight (Shih, D.S.; Chen, 2014).

Dirman Hanafi, Mongkhun Qetkeaw have operated quad rotor remotely and controlled by using GUI (graphical user interface) and quad rotor is constructed by wireless communication system, they also balance the Quad copter by using FY90 controller and IMU 5DOF sensor for smooth landing (Chen, N; Wang, K, 2014).

Inkyu SA and Peter Corke have described the modeling, estimation and control horizontal motion of an open source cheap Quad copter. They also determine the dynamics of pitch roll and yaw of the open source Quad copter. They also produces velocity estimator of horizontal plane. They also presented the estimation results of their model in close-loop positioning (Castillo-Effer et al, 2004). Dr. G. Sathiyabama, R.Praveenkumar, A.V.K Viswanath, R. Visnupriyanhas proposed design method for accurate flight control of an autonomous Quad copter aircraft. In this technique they have used image control method by using lab view for the stability in flying the Quad copter. They also control the direction of Quad copter by using servo motor mechanism (C. Newman, 2008). Lucas M. Argentim, Willian C. Rezende, Paulo E. Santos, Renato A. Aguiar have presented an idea of dynamic model of Quad copter for obtaining 10 different attitudes by using ITAE tuned PID, a classic LQR controller and a PID tuned with a LQR loop(A. Mainwaring, 2002).

Srikanth Saripalli and Gaurav S. Sukhatme have proposed a vision based algorithm to design a helicopter for landing basis and for moving target. In this research they of inertia for acknowledgement of precise target and Kalman filter for target pursuing. They have developed the results which is capable for manual flights for confirming tracking algorithm (K. Martinez et al, 2009).

In our research work we have proposed Quad copter movement with the help of gyroscope mounted on it. Input coordinates of Quad copter is send through wireless communication system, for this purpose we use GSM wireless communication module. The data is send using SMS through mobile and it is transmitted to AVR. These coordinates is received by GPS receiver which is connected to the second serial UART AVR. The GPS receiver coordinates send to the AVR where both coordinates are compared and error is minimized. The Quad copter will move where the error starts to reduce and approaches to zero; it can be seen on Google map the approximate location of Quad copter model (C. E. Perkins and P. Bhagwat, 1994).

2. EQUIPMENT USED

2.1 GSM module SIM 900

The main function of the GPRS/GSM module is to send an alert with the corresponding coordinates of the location with the help of specialized sensor. It is a complete Quad-bands/GPRS module in a SMT type and designed with a very powerful single-chip processor integratingARM926EJ-S core. The benefits of SIM 900 are small dimensions and cost-effective solutions. In industrial point of view, the SIM900 delivers GSM/GPRS 850/900/1800/1900MHz performance for voice, SMS, Data, and Fax in a small form factor and with low power consumption. The configuration of SIM900 is24mm x 24mm x3 mm (C. Sadler and M. Martonosi, 2006).

2.2 GPS Fundamentals

GPS (Global Positioning System) is a satellite navigation system that was developed by U.S (United States) Department of Defense. It consists of 24 fully operational satellites that completed the GPS space segment orbiting the earth at about 20,000 km above sea level. All these satellites are rotating constantly and completing the orbits twice in less than 24 hours with a speed of 11,300 km/h. power of these satellites are provided by solar energy but in case of solar eclipse backup batteries are required for power (L. Selavo et al, 2007).

2.3 Gyro Sensor GS-12

Gyro sensor is used to balance the Quad copter and other moving objects. In Gyro sensor two 3P-DMS-5P cables included. This sensor is preferred for measuring tilt and inclined angle of Quad copter (P. Sikka et al, 2004).

2.4 APM (Ardupilot Mega)

It is basically a free open source autopilot firmware that is capable of supporting multi copter models. It is capable of providing us we two way telemetry protocol using MAVLink. Also has a build-in failsafe processor, when can return the copter to its launch position on the radio loss.

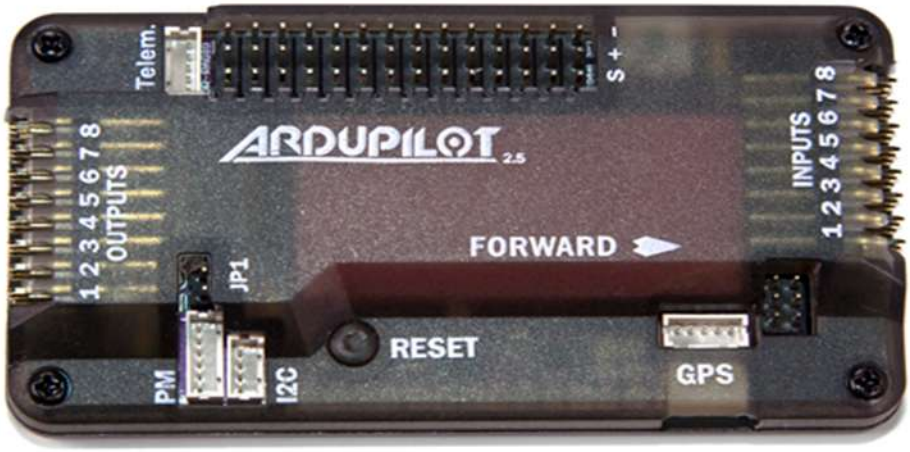

Figure 1: Quad copter block diagram.

3. HARDWARE MODEL

Figure 2 is a Block diagram represents the movement and the location of Quad copter and for this we have used SIM900 GSM/GPRS module, GPS tracking receiver Quad copter board and gyroscope is mounted on the bottom of Quad copter. The mobile phone is used to send the latitude and longitude coordinates to the GPRS module. These coordinates send to the QUAD COPTER CONTROL BOARD (2X3- AXIS GYROS AND 3-AXIS ACCELEROMETER) and to the AVR controller, GPS coordinates and gyro coordinates will match so that it can minimize the error. Quad copter moves on those sides where the error has minimized.

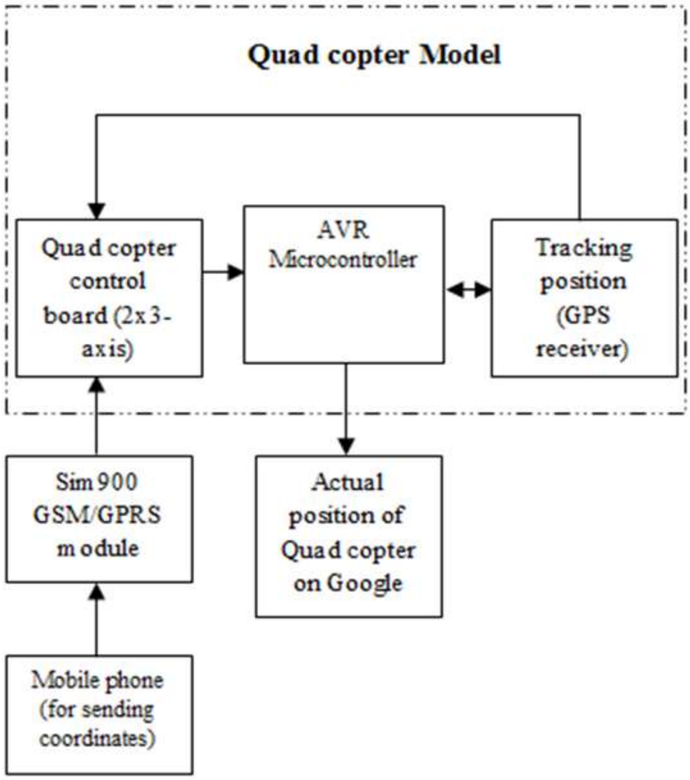

Figure 2: Quad copter block diagram.

4. MATHEMATICAL MODEL OF QUAD COPTER

Our proposed system works on 6 DOF and its dynamics varies continuously according to time. It is imperative to analyze the kinematics in the body and inertial frame before proceeding into the physics of the quad copter. Its velocity and an angular position in inertial frame are represented by $x=(x,y,z)^T$ an$x = (x,y,z)^T$, respectively. Where as $\theta =(\theta,Ø,ö)^T$ represents the roll, pitch and yaw of whole system corresponding to $\dot{\theta}=(\theta,Ø,ö)^T$ which are basically the angular velocities of Quad copter.

$$\ddot{X}=(\cos\phi\sin\theta\cos\psi+\sin\phi\sin\psi)\frac{1}{M}u_1 \quad (1)$$

$$\ddot{y}=(\cos\phi\sin\theta\sin\psi+\sin\phi\cos\psi)\frac{1}{M}u_1 \quad (2)$$

$$\ddot{Z}=(\cos\phi\cos\theta)\frac{1}{M}u_1-g \quad (3)$$

$$\ddot{\phi}=\dot{\theta}\dot{\psi}\left(\frac{I_{yy}-I_{zz}}{I_{xx}}\right)+\frac{u_2}{I_{xx}} \quad (4)$$

$$\ddot{\theta}=\dot{\phi}\dot{\psi}\left(\frac{I_{zz}-I_{xx}}{I_{yy}}\right)+\frac{u_3}{I_{yy}} \quad (5)$$

$$\ddot{\psi}=\dot{\phi}\dot{\theta}\left(\frac{I_{xx}-I_{yy}}{I_{zz}}\right)+\frac{u_4}{I_{zz}} \quad (6)$$

$$U_1=b(\gamma_1^2+\gamma_2^2+\gamma_3^2+\gamma_4^2) \quad (7)$$

$$U_2=b\rho(-\gamma_2^2+\gamma_4^2) \quad (8)$$

$$U_3=b\rho(\gamma_1^2-\gamma_3^2) \quad (9)$$

$$U_4=d(-\gamma_1^2+\gamma_2^2-\gamma_3^2+\gamma_4^2) \quad (10)$$

Where U_1 presents the total thrust, U_2 is the pitch movement, U_3 is roll movement and U_4 is the yaw movement, b is the thrust factor and d is the drag factor of Quad copter. ρ represents the length of arm form holding the propeller ϕ, θ,ψ represent the Euler angles in X,Y,Z axis respectively. Ixx, Iyy and Izzare the inertial component for the given three axes. As we increase or decrease the speed of four propellers they will be responsible for changing the altitude in position and velocity while the speed of one pair of propeller γ_3 and γ_1 varies the Quadcopter tilt at y ax is which is describe as pitch angle θ. The propellers speed varies by using pair (γ_4 and γ_2) will causes the Quadcopter to tilt about x-axis and it can be donated as roll angle ϕ. Finally the vector sum of reaction moment will be produced for the pair (γ_3 and γ_1) and (γ_2 and γ_4) will cause to spin the quad copter about its z-axis) which is denoted as yaw angle epsi "ψ". Figure 3 represents the 6 DOF model of our copter.

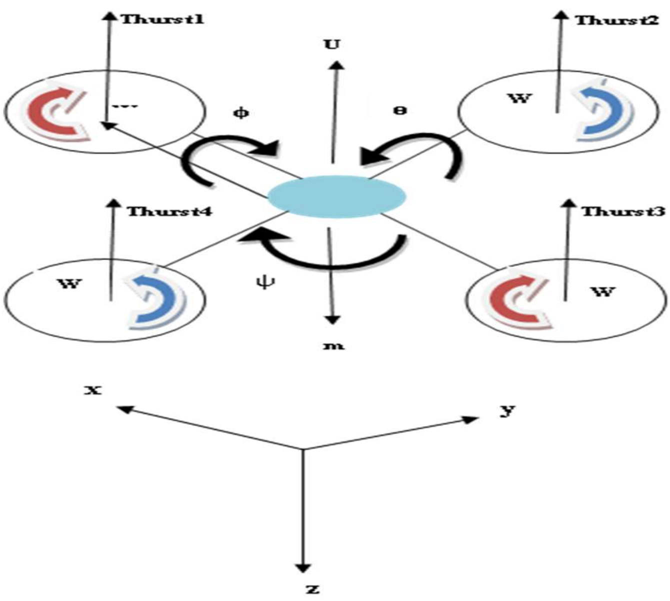

Figure 3: Quad copter 6 DOF freedom movement.

5. SOFTWARE MODEL

Figure 4 represents the flowchart of the software model. After the initialization of the system coordinates of the desired location is sent via 3G device. On board AVR Microcontroller controls the axis and the altitude of the copter. GPS accepts the coordinates and compare them with those received via GSM through a cell phone device. An android app displays the approximate location of the copter. Basically it works like a telemetry system with included feature of surveillance and tracking.

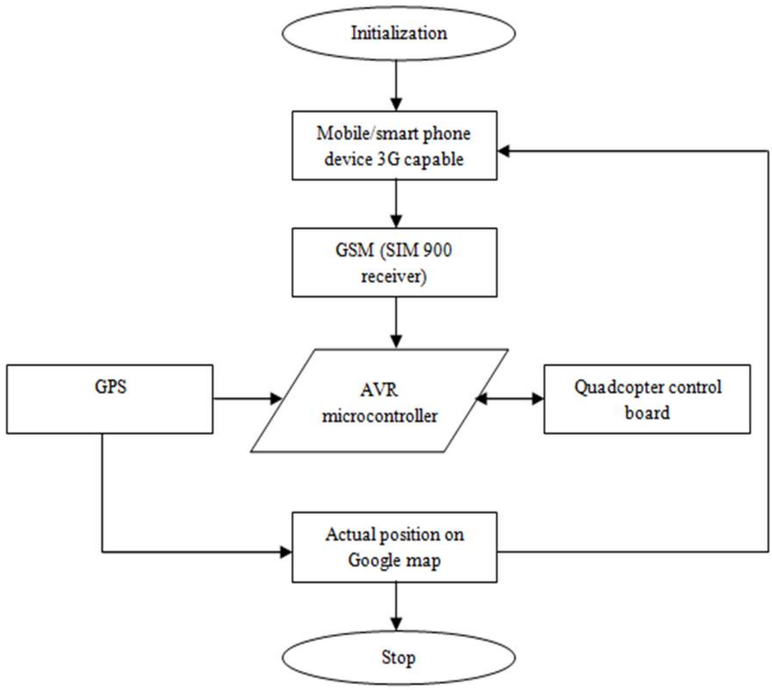

Figure 4: Quad copter Software Model.

6. RESULTS

Simulation results are verified with working of an actual model in controlled environment. There were some disturbances due to the wind which were neglected for the simulation. Figure 4 is the simulation result that was deduced for X-axis. Figure 5 is the response of Y-axis and Figure 6 is for the Z-axis also known as the altitude response of our system. Figure 7, 8 and 9 are the responses of Yaw, Pitch and Roll respectively describing the angular rates for the copter model.

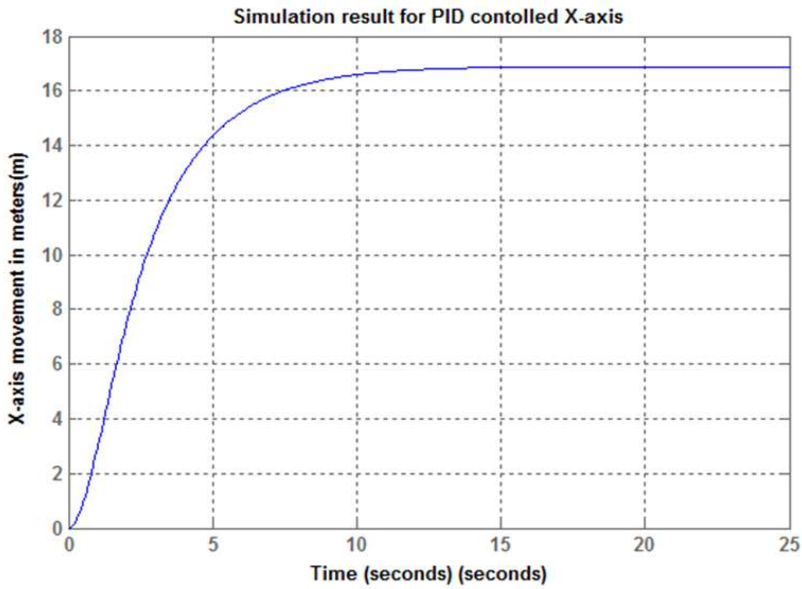

Figure 5: Simulation result for PID controlled X-axis

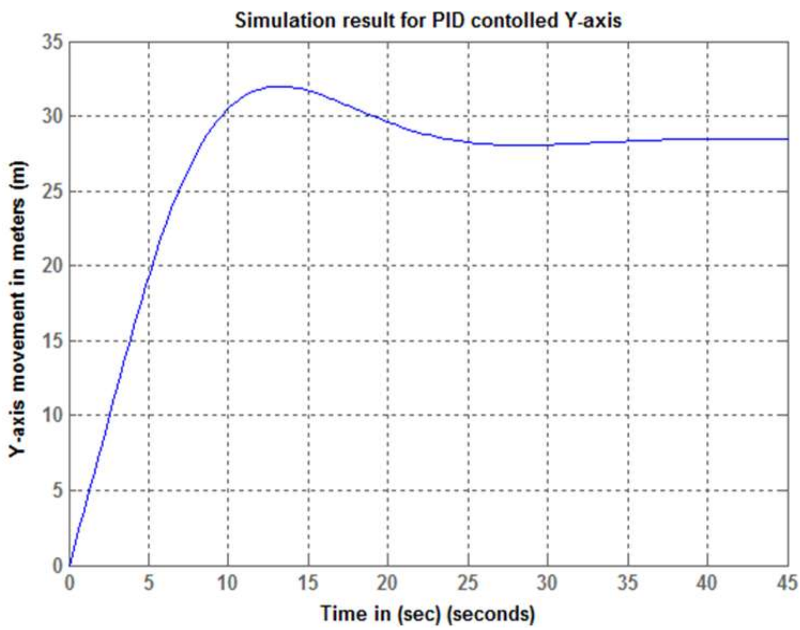

Figure 6: Simulation result for PID controlled Y-axis

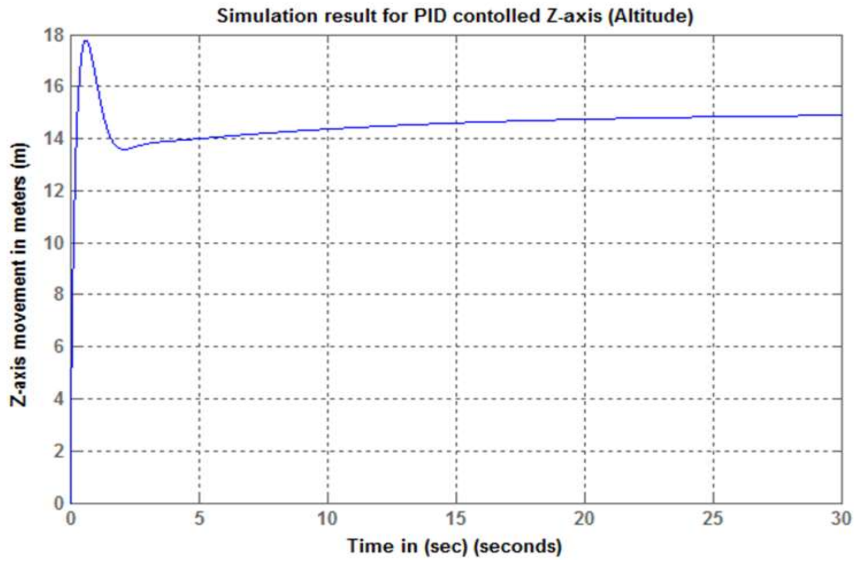

Figure 7: Simulation result for PID controlled Z-axis

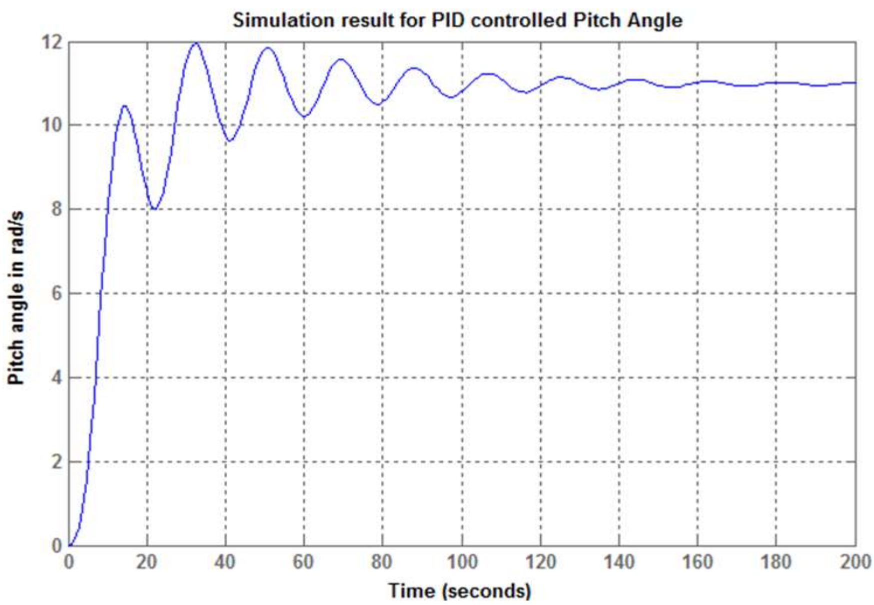

Figure 8: Simulation result for PID controlled Pitch angle

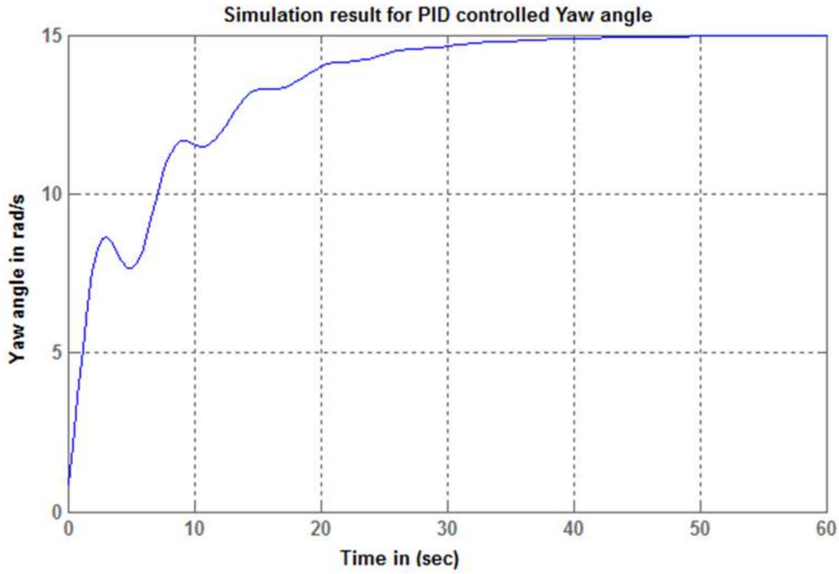

Figure 9: Simulation result for PID controlled Yaw angle

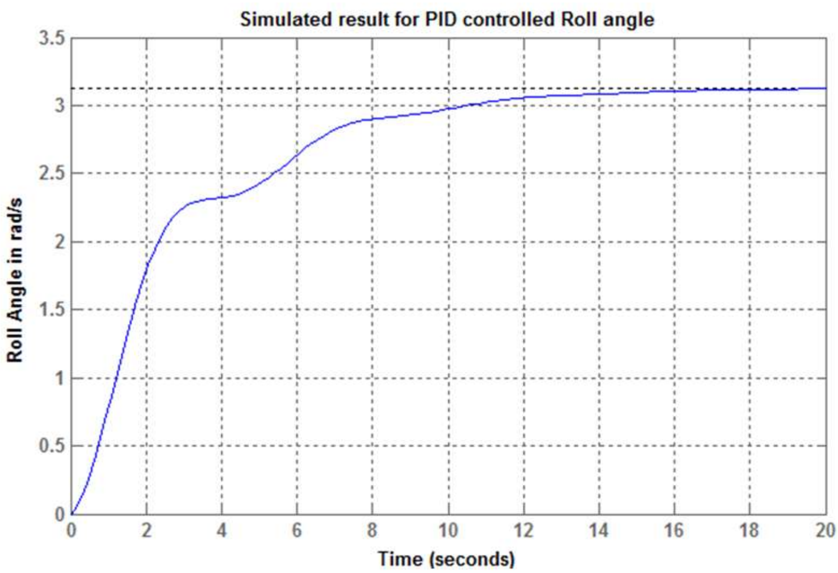

Figure 10: Simulation result for PID controlled Roll angle

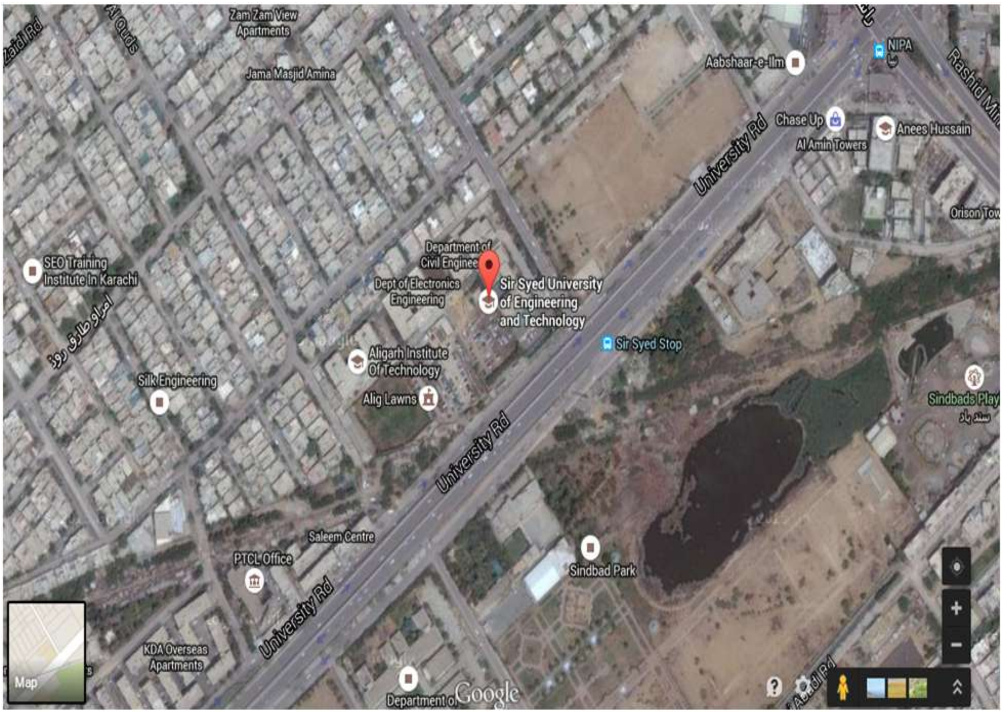

Figure 11: Position of Quad copter on Google map

Figure 10 basically displays the actual location of our copter model on the Google map. The red spot on the map is the location of the copter model. The GPS mounted on the model receives the coordinates and transmit them to our bases station through which the system displays its position on the map according to the coordinates received.

CONCLUSION

After analyzing our copter model we can conclude that it performed as we expected in the absence of the wind or in a controlled environment. Altitude calling of our model is approximately 13.21 meters. It successfully relocates itself by approaching the location it was provided by the GSM model from its initial location. Our model can be easily used to detect threats from a far in situations where lives are in eminent danger and develop a counter strategy to avoid someone getting hurt.

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