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DESIGN A CONTROL SYSTEM FOR THE MOVEMENTS OF CAMERA IN UNMANNED AERIAL VEHICLES (UAV)

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This paper describes three controllers designed specifically for adjusting camera's position in a small unmanned aerial vehicle (UAV). The PID, PI controllers were displayed firstly and simulated and the results displayed graphically using MATLAB technique, then we displayed the fuzzy logic controller(FLC) and it was simulated .The goal of this paper is to make a comparison between the three controllers for the desired performance.

Unmanned Aerial Vehicles (UAVs) have been provided with video cameras for feeding video and images back to the ground control stations. Most of the UAV_S use the servo motors for the movements in both roll and pitch. The camera in the UAV is connected to the duel-axis (roll and pitch mechanism), the rotational position is controlled by a tow motors (servo motors or DC motors) position control and feedback circuits. Roll error and pitch error signals obtained from gyro systems in the UAV are subtractive combined with roll and pitch position signals, to generated control signals to be applied to rotate the camera in a way that compensates for the roll and pitch movements of the UAV, and effectively isolates the camera from roll and pitch movements of the UAV and the camera will provide a good photo or video without loss in information [1].

DC-servomotor is one of the most widely used prime movers in industry today. Generally speaking the DC servomotor System is low order (no more 2nd or 3rdorder) and presents no particular design or implementation difficulties. However, the system does contain nonlinearities which have an obstructive influence on system response, such as the load effect. The Servos are used for precision positioning, because of their high reliabilities, flexibilities and low costs, DC servo motors are widely used in industrial applications, robot manipulators and home appliances, also they are used in robotic arms and legs, sensor scanners and in RC toys like RC helicopter, airplanes and cars. Where speed and position control of motor is required [2]. The DC servo motor transfer function can be in the following form:

$$G_p(s)=\frac{\omega_n^2}{s(s+2\zeta\omega_n^2)} \tag{1}$$

The closed-loop transfer function is:

$$T(s)=\frac{G_p(s)}{1+G_p(s)}=\frac{\omega_n^2}{s^2+2\zeta\omega_n s+\omega_n^2} \tag{2}$$

From the experiments, the resulting transfer function for servo motor is found to be:

$$T(s)=\frac{17.64}{s^2+4.364S+17.64} \tag{3}$$

The proportional – integral – derivative (PID) controller operates the majority of the control system in the world [10]. It has been reported that more than 95% of the controllers in the industrial process control applications are of PID type as no other controller match the simplicity, clear functionality, applicability and ease of use offered by the PID controller [5]. The PID controller is used for a wide range of problems like motor drives, automotive, flight control, instrumentation. PID controllers provide robust and reliable performance for most systems if the PID parameters are tuned properly [6]. A PID controller is described by the following transfer function in the continuous s-domain:

$$G_c(s)=K_p+\frac{K_i}{S}+K_d*S \tag{4}$$

Fig. 1 shows the simulink model of the PID controller and the plant (servo motor) with unity feedback.

Fig. 1. PID controller system

Fig. 2-a, shows the output signal of the system designed. The final values for the PID controller gains after tuning are determined to bek$_p$ = 10, K$_i$= 1, and K$_d$ = 1.21 for T = 0.01 sec. As we see that the output has an overshoot and undershoot ripple of 10% but steady state error equal to zero. Let us now use the PI controller and decrease the controller gain Kd and Kp to minimum as possible for the desired response. By adjusting the controller gain Kd=0 and the Ki= 0.864 then the output will be as shown in Fig.2-b

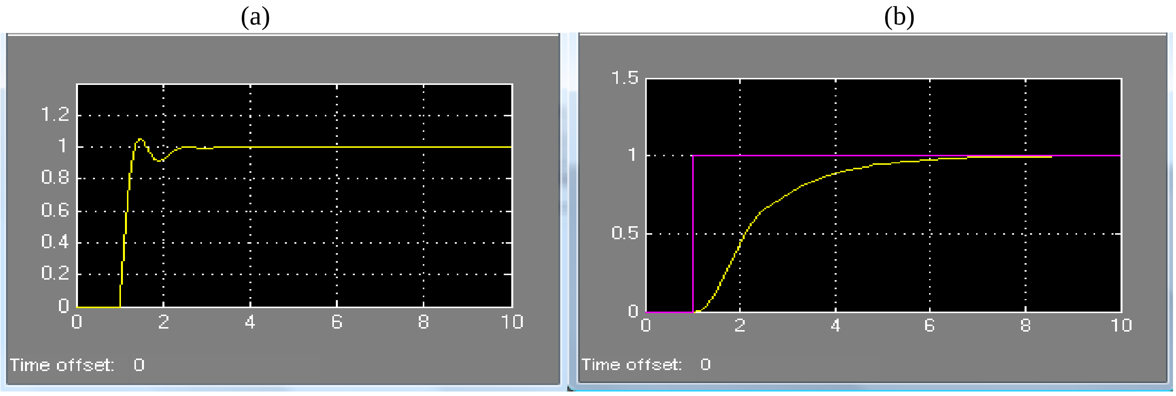


Fig. 2 .Output response for(a) PID controller (b) PI controller

The field of Fuzzy control has been making rapid progress in recent years [7]. Fuzzy logic control has been widely exploited for nonlinear, high order & time delay system [4]. Simulink model of the fuzzy controller and the considered process with unity feedback is shown in Fig. 3. For a two input fuzzy controller usually of (3, 5, 7, 9 and 11) membership functions for each input are mostly used [9]. In this paper, only two fuzzy membership functions are used for the two inputs error (e) and derivative of error (e*) as shown in Fig. 4-a. The fuzzy membership functions for the output parameter are shown in Fig.4-b, where (N) means Negative, (Z) means Zero and (P) means Positive. Depending upon whether the output is increasing or decreasing, 4 rules were conducted for the fuzzy logic controller (Table 1), where the sign of the output takes the sign of the error (e).These four linguistic rules are sufficient to cover all possible situations. The output response of the system is given in Fig. 5.

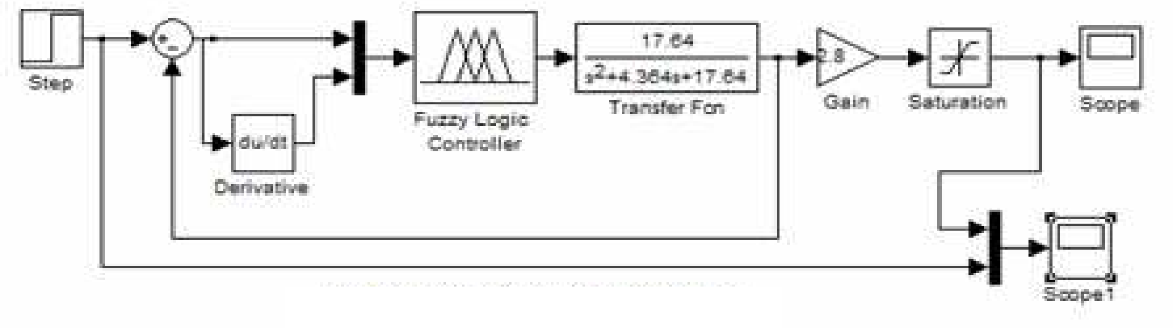
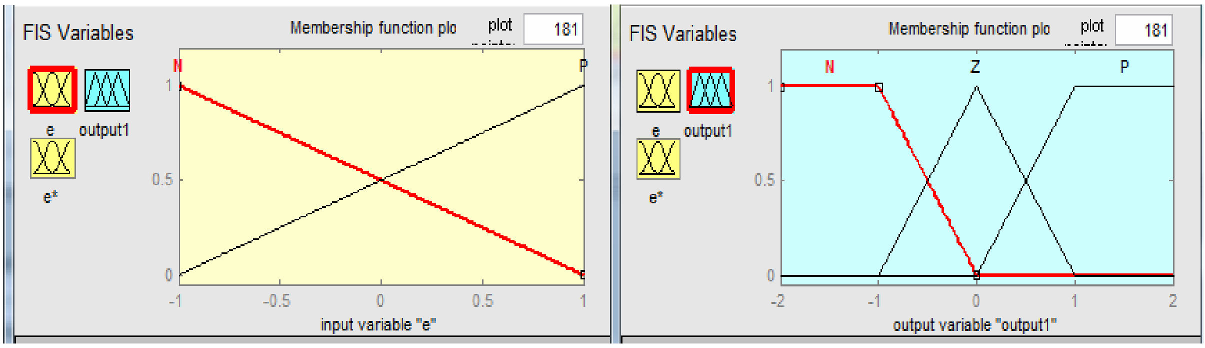


Fig. 3. Fuzzy logic controller scheme



a) b)

Fig.4. Input membership function (a), output membership function (b)

Table 1 – The rules for the designed fuzzy logic controller

e* e	N	P
N	N	Z
P	Z	P

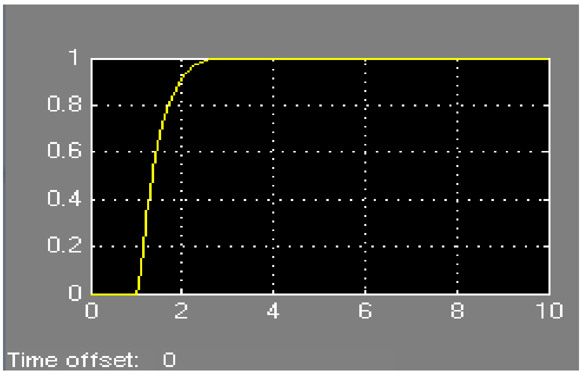


Fig. 5. Fuzzy logic controller output

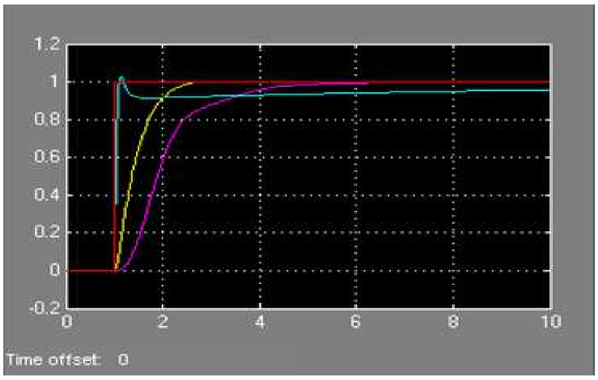


Fig. 6. Output signals for PI, PID and Fuzzy logic controller

The performance time domain specifications are now calculated by observing Fig. 6. These are compared and tabulated as shown in the Table 2.

Table 2 – Comparison between the three controllers

Controller used	Performance parameters			
	Overshoot Mp(%)	Settling time Ts(sec)	Rising time Tr(sec)	Steady state error Ess(%)
PID	10	2	0.1	7
PI	0	3.6	1.7	0
Fuzzy logic controller	0	1.8	0.8	0

The paper presented an overview of PI, PID and fuzzy logic controller using MATLAB / SIMULINK.

Fine-tuned PID controller gives high overshoot and settling time with 7% steady state error.

Fine-tuned PI controller gives high settling time with zero overshoot and steady state error.

The Fuzzy Logic controller gives no overshoot, zero steady state error and smaller settling time than obtained using with tuned PI, PID controllers.

The simulation results confirms that the proposed Fuzzy logic controller with simple design approach and smaller rule base can provide better performance comparing with the tuned PI and PID controllers.

REFERENCES

1. Jakobsen, O.C. Control Architecture for a UAV – Mounted Pan/Tilt/Roll Camera Gimbal /*AIAA* Infotech@Aerospace, Arlington / O.C. Jakobsen, E.N. Johnson. – Virginia, Sep. 2005. – 7145 p.
2. Guenard, N. A practical Visual Servo Control for a Unmanned Aerial Vehicle / N. Guenard, T. Hamel, R. Mahony. // Proceedings of the IEEE international conference on robotics and automation ICRA, 2002.
3. Panagopoulos, H. PID Control Design, Extension, Application / H. Panagopoulos // PhD thesis, Department of automatic Control, Lund Institute of Technology, Lund, Sweden, 2000.
4. Xu, J. Design of Adaptive Fuzzy PID tuner using optimization method / J. Xu, X. Feng // The 5th World Congress onIntelligent Control and Automation, China, 2004. – P. 2454 –2458.
5. Zhang, J. A developed method of tuning PID controllers with fuzzy rules for integrating process / J. Zhang, N. Wang, S. Wang. // The American Control Conference. – Boston, 2004. – P. 1109 – 1114.
6. Ang, K.H. PID control system analysis, design and technology / G. Chong, Y. Li // IEEE transaction on Control System Technology. – 2005. – Vol. 13. – No.4. – P. 559–576.
7. Mendel, J.M. Fuzzy Logic Systems for Engineering: A Tutorial / J.M. Mendel // Proceedings of the IEEE. – 1995. – Vol. 83. – No. 3– P. 345–377.
8. Zadeh, L.A. Fuzzy Logic, Neural Networks, and Soft Computing / L.A. Zadeh // Communication of the ACM. – 1994. – Vol. 3. – No. 3. – P. 77–84.
9. Chopra, S. Fuzzy controller: Choosing an appropriate & smallest rule set / S. Chopra, R. Mitra, V. Kumar // International Journal of Computational Cognition – 2005. – Vol. 3. – No. 4. – P. 73–78.
10. Vaishnav, S.R. Design of PID & Fuzzylogic controller for higher order system / S.R. Vaishnav, Z.J. Khan // International Conference on Control & Automation (ICCA'07), Hong Kong, China, 2007. – P. 1469 – 1472.
11. Yongquan, Y. The dynamic fuzzymethod to tune the weight factors of neural fuzzy PID controller / Y. Yongquan, H. Ying, Z. Bi. – IEEE, 2004. – P. 2397–2402.
12. Altas, H. A Generalized Direct Approach for Designing Fuzzy Logic Controllers in Matlab / Simulink GUI Environment / H. Altas, A.M. Sharaf. // International Journal of Information Technology and Intelligent.

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USING NONSTATIONARY ELECTROLYSIS FOR FORMATION SN-BI COATINGS

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The use of periodic pulse reverse current allows to form tin-bismuth electroplated coatings, with high value of term storage stable solderability. The reseach results of the influence of nonstationary electrolysis on solderability of the Sn-Bi alloy coatings have been demonstrated. The appropriate conditions for obtaining high-quality lead-free coatings with high solderability have been found. The best mode is $i^k_{av} = 1.0$ *A/dm*^{2}, τ_{forw}: τ_{rever} *= 4:1, f= 0.1…1 Hz.*

Among the special electrochemical coatings with high quality and reliability of solder joints in electronic equipment, Sn-coatings are especially pointed out. However, pure Sn tends to spontaneously phase transformation at low temperatures and during prolonged operation. Numerous bath compositions for formation of Sn-based alloys are developed in order to eliminate this phenomenon. Zinc, nickel, antimony, silver, copper, and bismuth are used as alloying components in those baths.

Most economical and promising for conditions of mass production of microelectronics are Sn-Bi, Sn-Sb, Ag-Sn alloys [1].

However, existing processes for the formation of deposited by DC Sn-based coatings are inefficient (0,1-0,12 m / h), and don't provide the desired solderability that decreases after three months of storage as a result of high value of porosity and low texturing of the coating.

One way of solving this problem is the use of nonstationary electrolysis. As electrocrystallization current is one of the main factors determining the electrochemical and structural conditions for the cementation, so it can widely control quality of the coatings by changing current according to certain laws.

Using periodic pulse reverse (PPR) current electroplating leads to changing of ordinary way of crystals formation, their growth and properties of coating.

PPR current is sequentially alternating cathodic and anodic processes on one electrode. Periodic dissolving the most active portions of the cathode (usually protrusions) tends to equalize the surface, makes it more uniform. In this case, number of lattice defects, porosity, and content of impurities in the precipitate are reduced [2].

Based on the above mentioned using nonstationary electrolysis for deposition Sn-Bi-coating is current and advanced affairs.

The influence of nonstationary electrolysis was tested on the Sn-Bi-coating. Plating solution contained $SnSO_4$ (50 g/l), $Bi(NO_3)_3$ (1.4 g/l), H_2SO_4 (125 g/l), neonol AF-9-10 (4 g/l), additive CCN-32 (2g/l), which was manufactured by research and production association «SEM.M». Coatings were plated at room temperature.