FUZZY LOGIC CONTROL OF THE HIGHT OF THE AIRPLAINE

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Abstract – In this publication it is shown that a simple fuzzy logic controller can contol the hight of the airplain Aerosonde UAV. The designed fuzy logic controller is tested on a non-linear 6 DOF airplane. The simulations show that an excellent hight controll of the airplain can be sucseeded with simple fuzzy PID controler. More over, the stability of the airplain, the speed control and the bank angle are also controlled by additional fuzzy controlers.

Keywords – fuzzy control, attack angle, membership function, PID

1. INTRODUCTION

The use of fuzzy logic controllers (FLC) are used in many industrial linear and non linear systems. Today, the FLC replace the classic method of PID controll. Although the classical PID controllers and FLC are not really comperable, it is shown that they are excellent replacement in controll of many processes. The main dificulty with the FLC is that for their design, there is a need for a great experts knoledge of the problem for which they are designed.
In this paper, a FL PIC controller is desiged to simulate the height change of the unmanned air vehicle Aerosonde UZAV.

2. DESCRIPTION OF THE AIR VEHICLE

The testing of the designe FLC is performed in a air vehicle Aerosonde UAV (figure 1). It is a small airplane that is used in different weather conditions and with actions that require remote control. The Aerosonde UAV has a large number of military applications, both actual and potential. The usefulness of UAVs has long been recognised because they can perform dangerous missions without risking any lives, and often at low cost.

2.1. PHISICAL CHARACTERISTICS OF THE AIRPLANE AEROSONDE UAV

The medium aerodynamic chord (MAC) is 0.189941 m, the wing span is b = 2.8956 m, and the surface of the wings is S = 0.55; m2. when it is thanked, it weights 13,5 kg. The speed linitations are [15 50] m/s, and the attack angle is [-0.1 0.3] rad.
The input variables are inserted into a vector: Input controls = 7x1 vector of controlls of the airplane [flap elevator aileron rudder throttle mixture ignition]. The aerodynamic controls are in radians, throttle varies from 0 to 1, mixture is fraction air/fuel flow, ignition is 0 (engine off) or 1 (engine on). The initial values of the input vactor are: [0 -0.1 0 0 0.4 13 1]. the widn is 3x1 vector that includes the wind speed in navigational manner [north east downwards]

Figure 1: Aerosonde UAV

3. SCHEMA OF AEROSONDE UAV IN MATLAB

The schema of the air vehicle in matlab is givn on Figure 2. The unbalanced roll moment caused by the propulsion system excites the spiral mode and the aircraft settles in a constant bank angle turn.

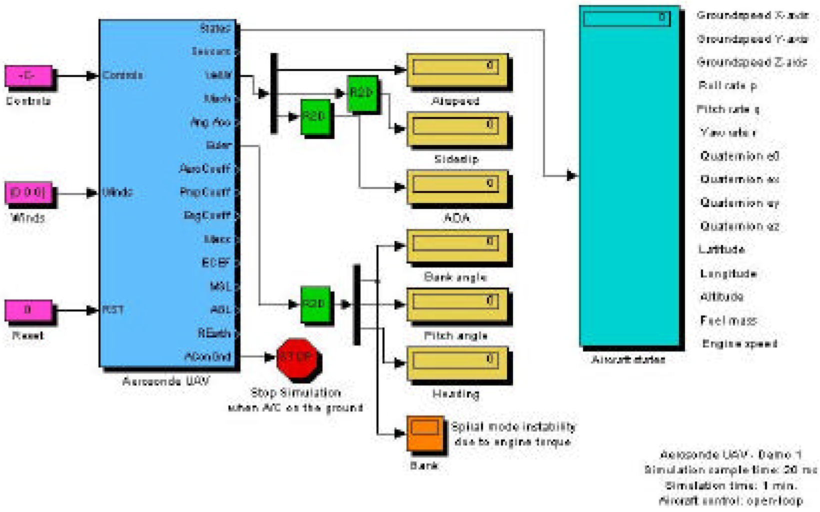

Figure 2: Schema of Aerosonde UAV in MATLAB

This model is stabilized by using three fuzzy controllers given on Figure 3. The three fuzzy controllers regulate the attack angle (and the elevator) and the roll angle (with the ailerons) and the air vehicle speed (throttl?). The fourth FLC is used for height controlof the airplane, which was the goal of this paper. As input signal to the tructure block for haight control, enters the current heiht of the airplane and the height on which we would like the airplane to fly. As output siglan from the conrol block comes out the attack angle at which the airplane has to fly so that it reached the desired height.

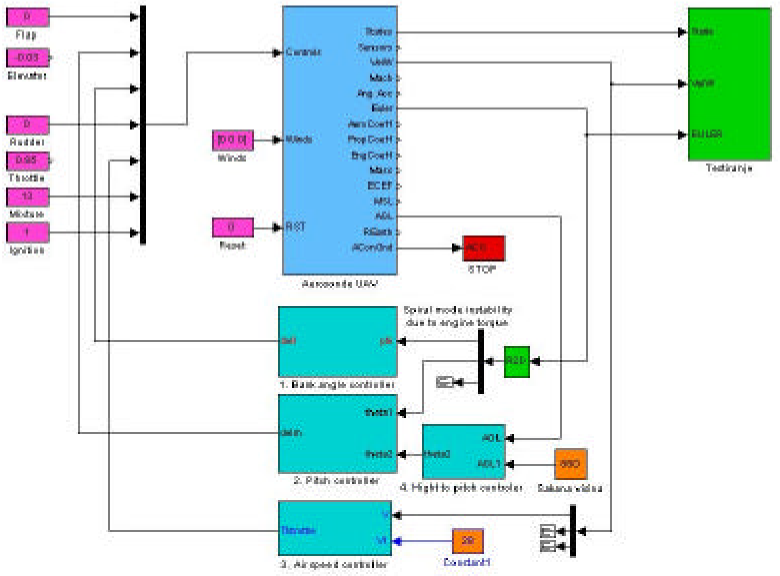

Figure 3: Schema of stabilized Aerosonde UAV with PI and PID controler in MATLAB

4. DESCRIPTION OF THE FUZZY LOGIC CONTROLLER FOR HEIGHT CONTROL OF THE AIR VEHILE

The main goal of this paper is to control the heigt with FLU. The developed FLC acts as PID controller. In the control theory, the tranfer function of the PID controller is given with a proportional, integral and diferential component:

$$K_p + (K_I / s) + K_D s \qquad (1)$$

while the controled signal with freedback is given with the followig equation:

$$u(t) = K_p e(t) + K_I \int e(t)dt + KD\frac{de(t)}{dt} \qquad (2)$$

PID fuzzy logic controller has a simelar structure as the konventional PID controller given with the above equations. The design of the fuzzy logic PID controller starts with design of the fuzzy logic rules. The FLC has three input and one output variable. as input to the FLC comes the error (substract between the current heihght and the esigred height of the air vehicle), the diferential component of the error and the sum of the total error. the attack angle is the output signal of the FLC (Figure 4).

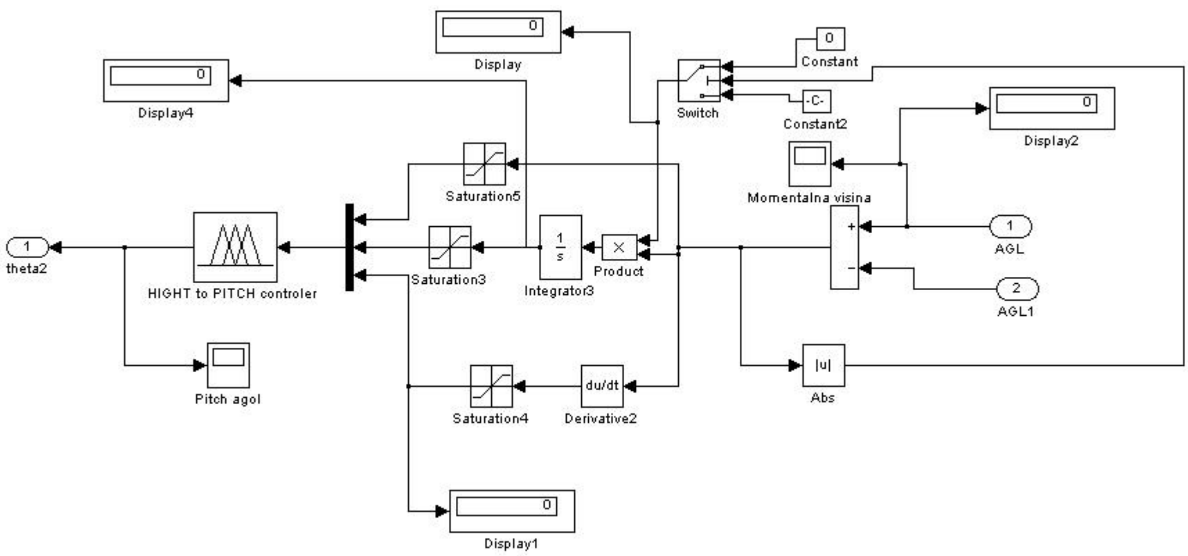

Figure 4 Inside structure of the block for transferring the height into attack angle of the air vehicle

In order to decrease the overshot, the error is scale in the integral component of the fuzzy logic PID controller and it has the following apperiance:

$$e_i(t)= \begin{cases} e(t) = 0, if \Delta e(t) > 0{,}5 \\ e(t) = 0.05 * abs \Delta e(t), otherwise \end{cases} \quad (3)$$

This way, the overshot is significantly avoided. Typical example of the controllibg lingvistic variables is:

if $x_1=A_i$ and $x_2=B_i$ and $x_3=C_i$ then $u=D_i$

where A, B and C are the fuzzy sets of the error, the change of error and the sum of the total error, while D is fuzzy set of the controlled output. The used shortnames N, Z, P, NB, PB, NS. PS stand for negative, zero, pozitive, negative big, pozitive big, negative small and positive small. The four fuzzy sets are presented with trianular membership functions. For firening rules from the fuzzy logic controller, the used criteria is Mamdani mini – max. In the process of defazzyfication, the used method is center of gravity and the output siglal is:

$$u = FLC\ (e, e, e_i)$$

the fuzzy rulebase is the following:
If (P is Z) then (attack_angle is Z)
If (P is P) then (attack_angle is N)
If (P is PB) then (attack_angle is NB)
If (P is N) then (attack_angle is P)
If (P is NB) then (attack_angle is PB)
If (P is N) and (D is Z) then (attack_angle is PB)
If (P is P) and (D is P) then (attack_angle is Z)
If (P is Z) and (I is P) and (D is Z) then (attack_angle is N)
If (P is Z) and (I is N) and (D is Z) then (attack_angle is P)
If (P is Z) and (I is Z) and (D is Z) then (attack_angle is Z)
If (P is P) and (I is P) and (D is N) then (attack_angle is PB)
The membership functions are given on the following diagrams:

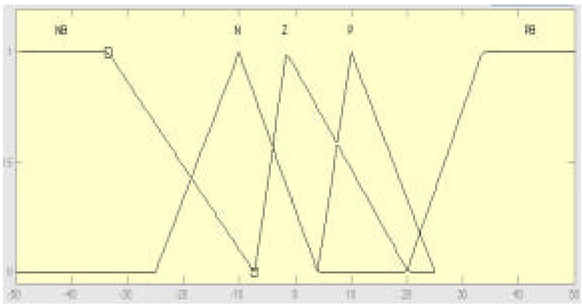

Figure 4: The membership functions of the proportional component of the error

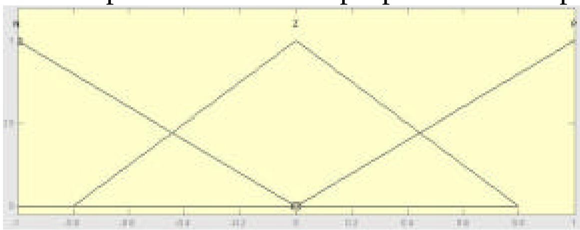

Figure 5: The membership functions of the differential component of the error

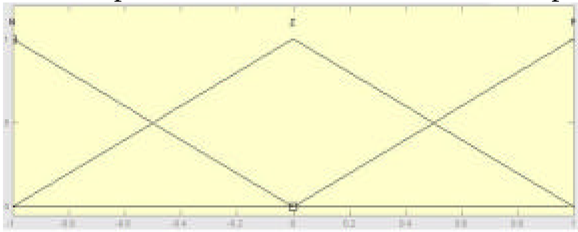

Figure 6: The membership functions of the integral component of the error

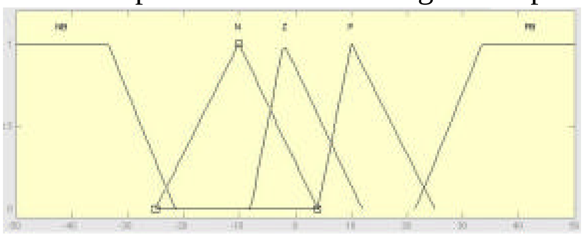

Figure 7: The membership functions of the output value of the attack angle

5. SIMULATIONS AND RESULTS

The Figures 8 – 13 show the results of the simulations that were made with the constructed fuzzy logic controllers.

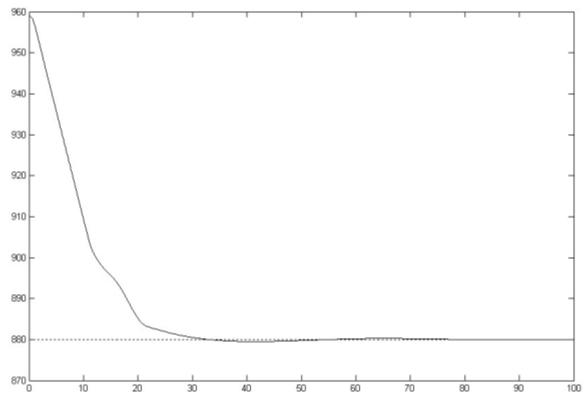

Figure 8: Simulation of the path of the airplane from 960 m to 880 m

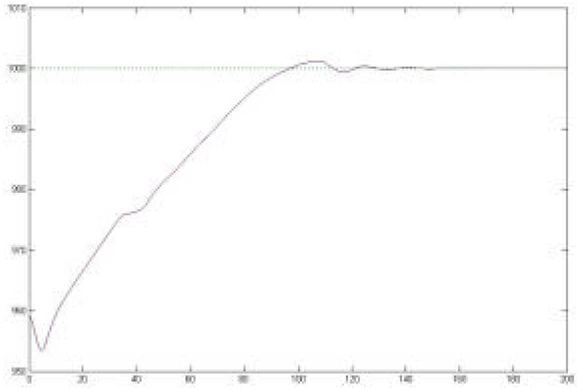

Figure 9: Simulation of the path of the airplane from 960 m to 1000 m

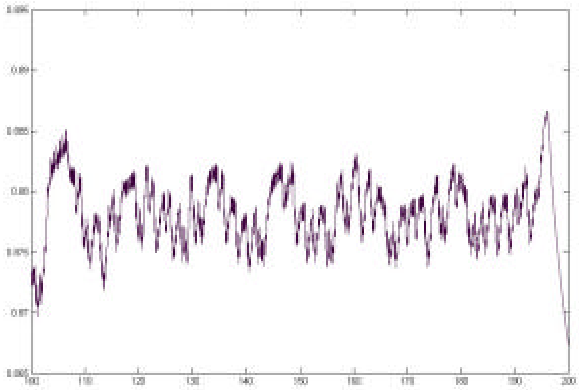

Figure 10: Throtel change
at height decrease from 960 to 880m

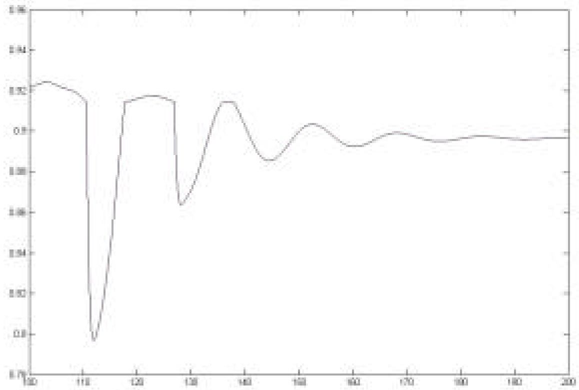

Figure 11: Throtel change
at height increase from 960 m to 1000 m

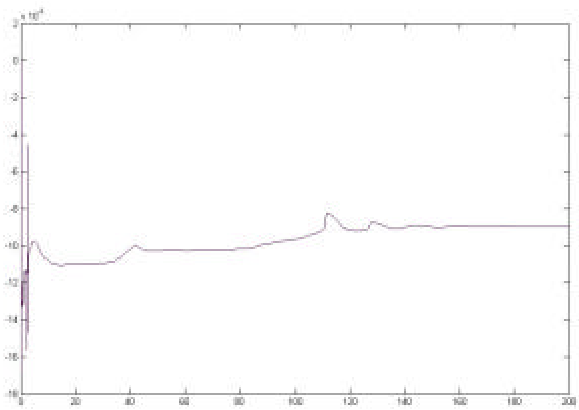

Figure 12: Bank angle change
at height increase from 960 m to 1000 m

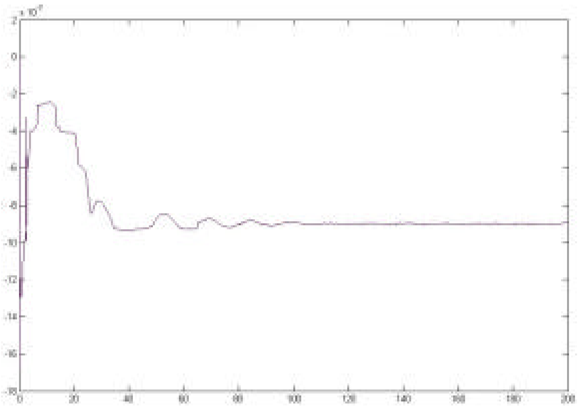

Figure 12: Bank angle change
at height decrease from 960 m to 880 m

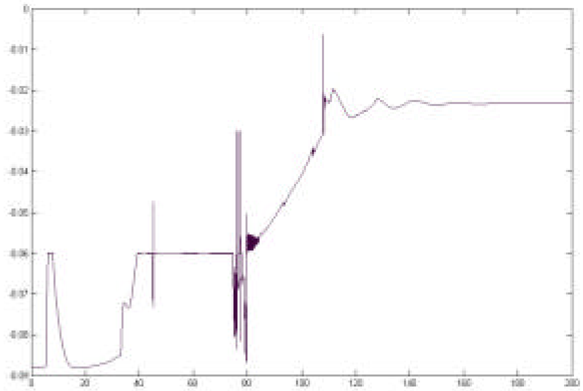

Figure 13: Elevator change
at height decrease from 960 m to 880 m

6. CONCLUSION

The goal of this paper is to simlate the height change of nonlinear model of an airplane using fuzzy logic. The advantage of the fuzzy logic is the simple design of the FLC and its robustness when there are large number of inital conditions. This paper shows thet the simple FLC is robust enough to aloud acceptable performances of the controlability and stability of teh nonlinear model of an aitcraft.

7. LITERATURE

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