Design of Fuzzy Controller

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Computer Applications in Control

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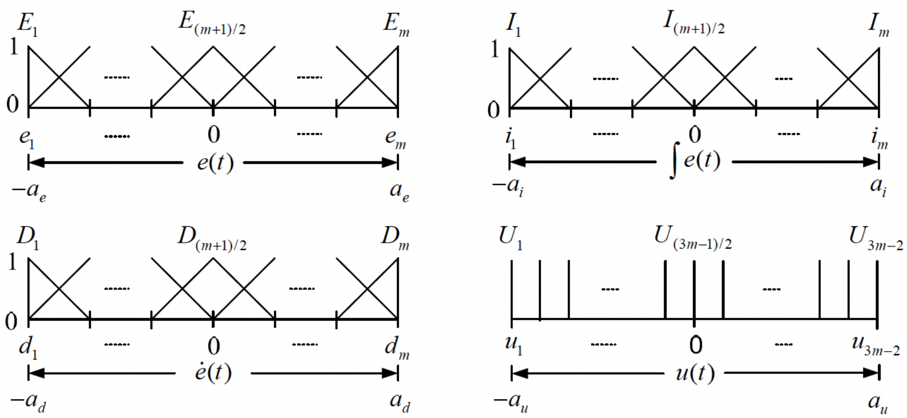
INSTRUCTIONS

The project involves the selection of a specific transfer function and the derivation of its PID parameters (Proportional, Integral, and Derivative) according to a specific rule. MATLAB is utilized for simulating the resulting F-PID controller, and the obtained results are visualized on scopes. The primary objective is to assess whether the proposed optimal F-PID controller yields faster responses compared to alternative approaches.

The relationship through which this controller can be obtained is as follows:

$$u(t) = K_P e(t) + K_I \int e(t)dt + K_D \frac{de(t)}{dt},$$

The shapes of the membership functions of fuzzy variables are as follows:



The rule is:

$$IF\ e(t) \text{ is } E_i \text{ and } \int e(t) \text{ is } I_j \text{ and } e(t) \text{ is } D_k \quad THEN\ u(t) \text{ is } U_l, l = i + j + k - 2,$$

We have:

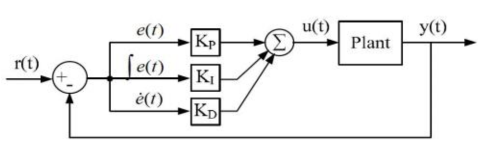
$$u(t) = \frac{a_u}{3a_e} e(t) + \frac{a_u}{3a_i} \int e(t)dt + \frac{a_u}{3a_d} \frac{de(t)}{dt},$$

&

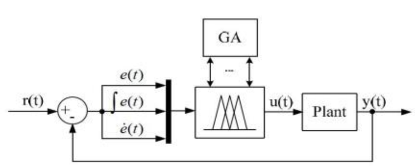
$$K_P = \frac{a_u}{3a_e}, \quad K_I = \frac{a_u}{3a_i}, \quad \text{and} \quad K_D = \frac{a_u}{3a_d}.$$

For example, considering the following transfer function, the unity feedback is obtained:

$$G(s) = \frac{s^2}{s^2 + 12s + 24}$$



(a)



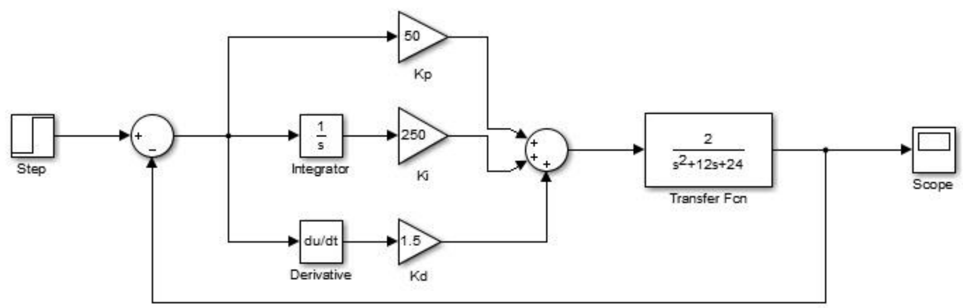
(b)

K_P=50, K_I=250, K_D=1.5

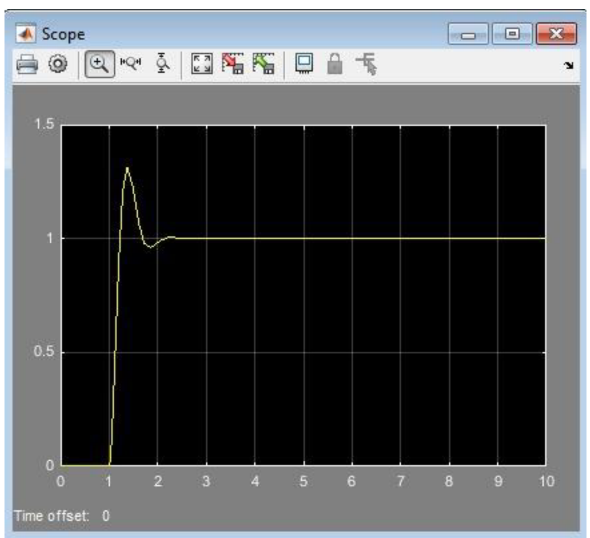
Reason for selection:

1. OR_e is set as $[-a_e,\ a_e] = [-1.33, 1.33]$, which is the range for $e(t)$.
2. OR_u is set as $[-a_u,\ a_u] = [-199.5, 199.5]$ to satisfy $K_P = 50$.
3. OR_i is set as $[-a_i,\ a_i] = [-0.266, 0.266]$ to satisfy $K_I = 250$.
4. OR_d is set as $[-a_d,\ a_d] = [-44.33, 44.33]$ to satisfy $K_D = 1.5$.

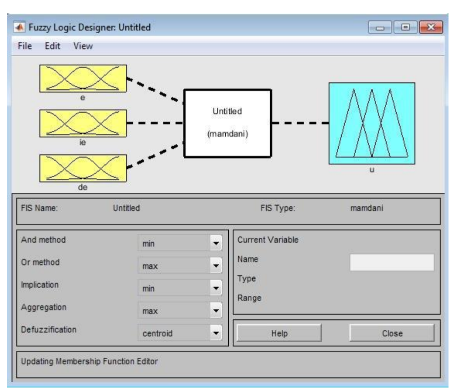
In the simulation section, we have:



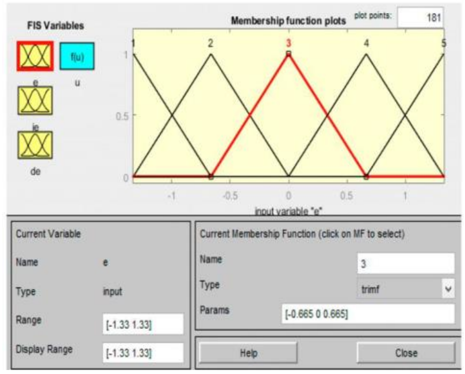
In the output, we observe:

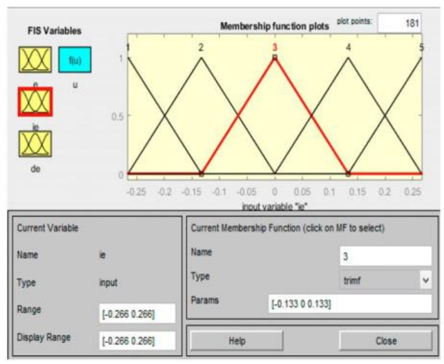


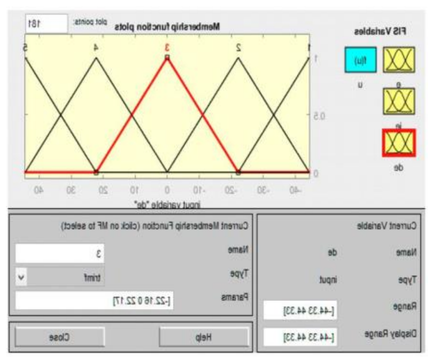
To open the fuzzy simulation environment, enter the command FuzzyLogicDesigner in the command window and define your inputs:

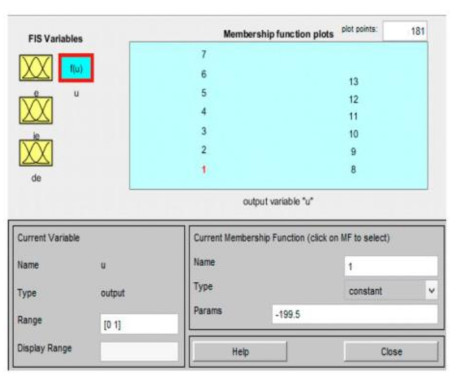


Entering inputs and outputs:

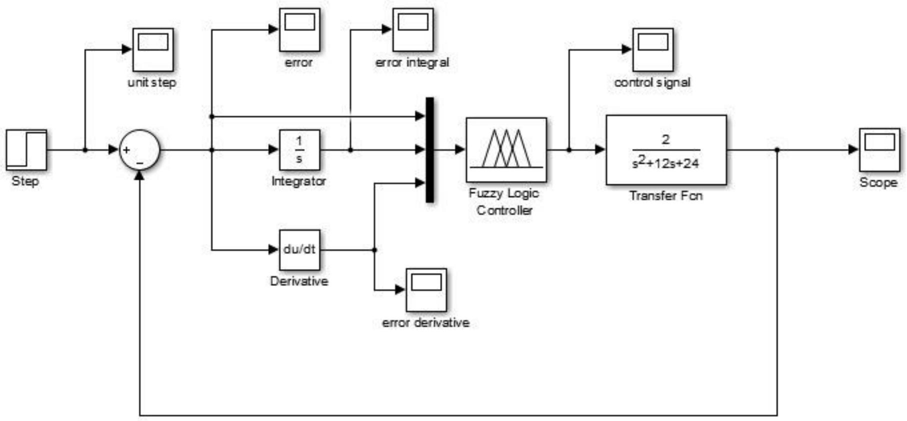




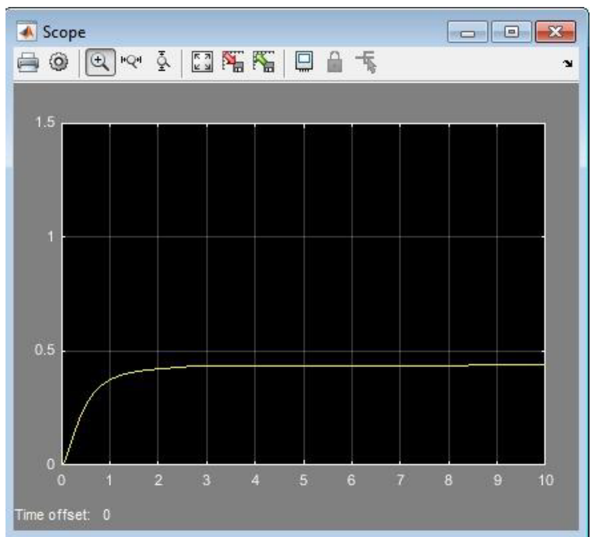




Then in Simulink, we have:



We observe in the output:



Conclusion

We conclude that the proposed optimized fuzzy PID controller exhibits faster responses with smaller rising time and settling time. However, we cannot yet claim that the proposed optimized FPID outperforms other methods.