

Application case 1

Part 1: Fuzzy controller design

The objective of this case study is to perform the speed control of a separately excited DC motor (figure 1) using fuzzy logic controller (FLC). The controller will be designed based on the expert knowledge of the system. For the proposed dc motor case, we recommend **7 fuzzy rules** for fuzzy logic controller.

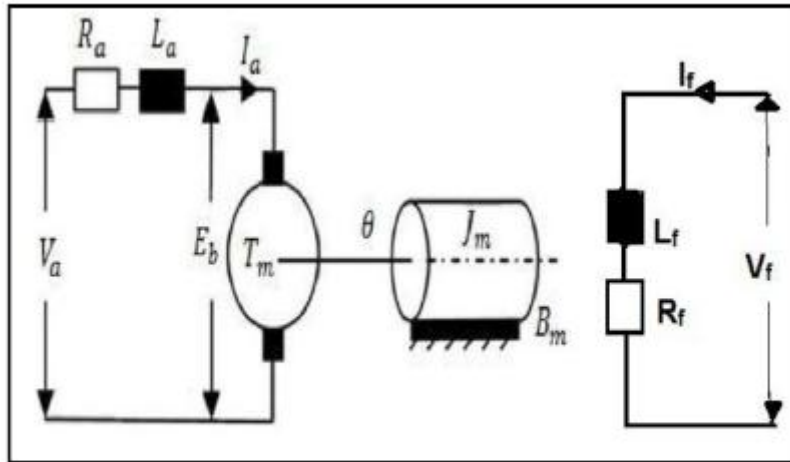


Fig.1 separately excited dc motor model

Taking field flux as ϕ and Back EMF Constant as K_ϕ .
Equation for back emf of motor will be:

$$E_b = K_\phi \omega$$

Torque:

$$T_m = J_m \left(\frac{d\omega}{dt} \right) + T_L$$

$$T_m = K_\phi I_a$$

ω is the angular velocity (speed) and friction in rotor of motor is very small (can be neglected) so $B_m = 0$.

Armature Time Constant:

$$T_a = \frac{L_a}{R_a}$$

- 1) Plot the block diagram of separately excited dc motor based on Laplace transformations of the motor's armature voltage and balance torque.
- 2) Define the required fuzzy controller inputs and outputs. Then complete this diagram:

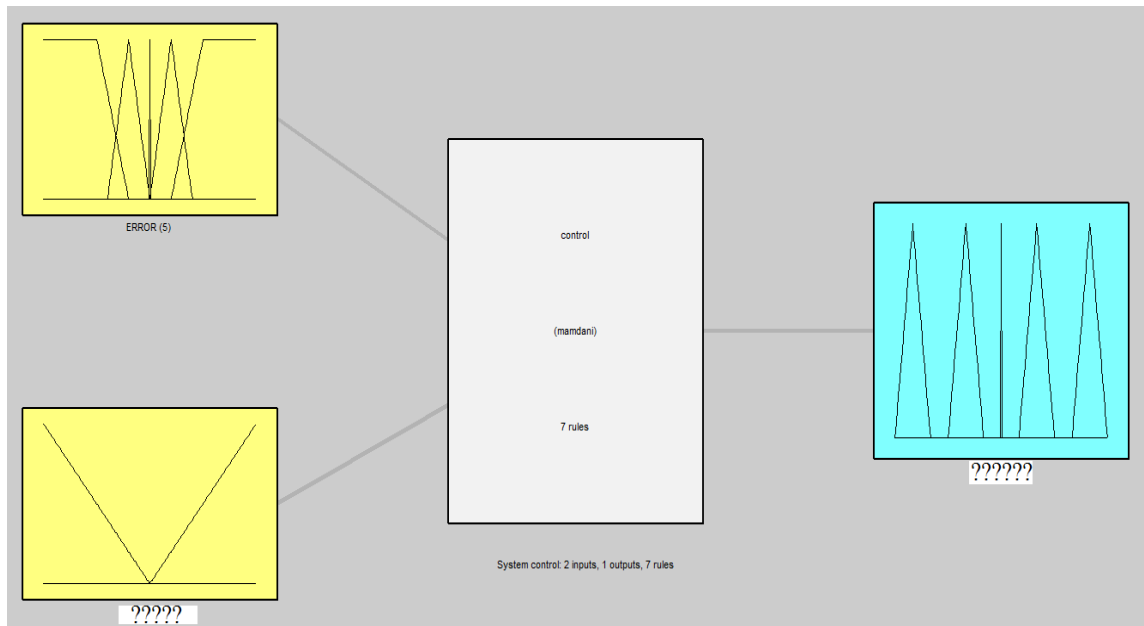


Fig. 2: General structure of the fuzzy controller.

- 3) Deduce the structure of the fuzzy logic controller with closed loop (synopsis of all system with fuzzy controller).
- 4) Represent membership functions for inputs and output variables.
 Input 1 range: [-1 1]
 Input 2 range: [- 1 1]
 Output range: [-30 30].
- 5) Enunciate the 7 “if-then” rules necessary for separately excited dc motor speed control.
- 6) What is the inference system type used here? Is there another type?
- 7) What is the contribution (benefits) of fuzzy logic in comparison with a conventional PID controller for these case studies?

Part 2: Fuzzy controller implementation

We want to implement the proposed fuzzy controller under Matlab Simulink fuzzy logic toolbox.

- 1) What is the instruction to type on matlab to start the fuzzy logic toolbox?

2) Comment and give the output of every line of code in Matlab :

```
>> a = readfis('control.fis')
>> getfis(a,'input',1)
>> getfis(a,'output',1)
>> plotfis(a)
>> mfedit(a)
>> ruleview(a)
```

Correction

Part 1: Fuzzy controller design (7pts)

- 1) Plot the block diagram of separately excited dc motor based on Laplace transformations of the motor's armature voltage and balance torque.

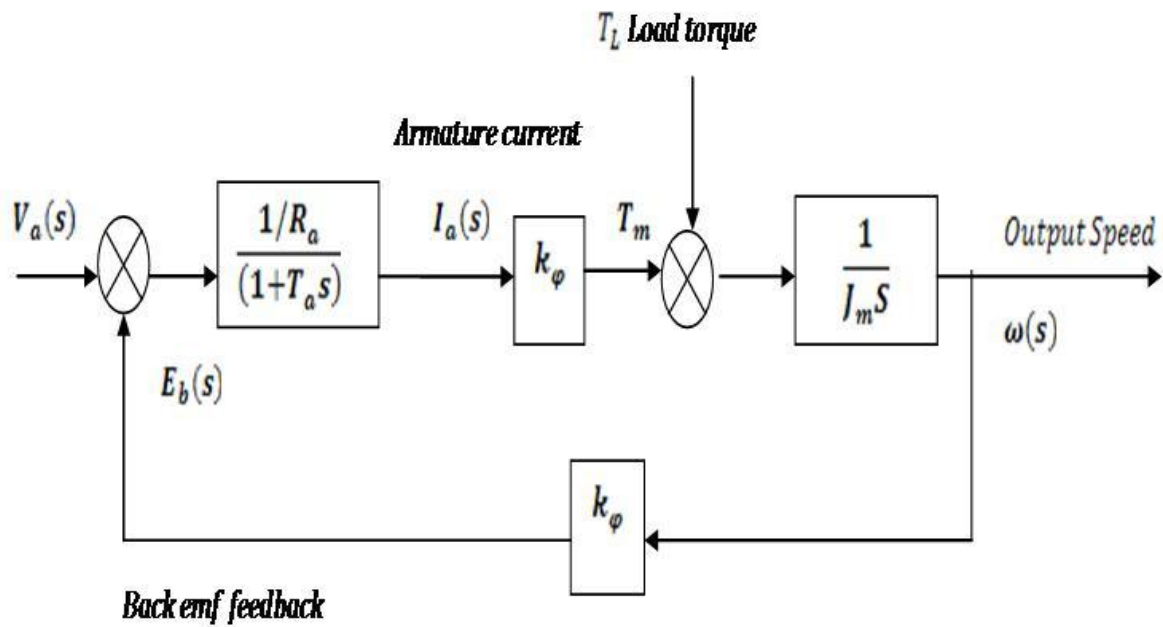
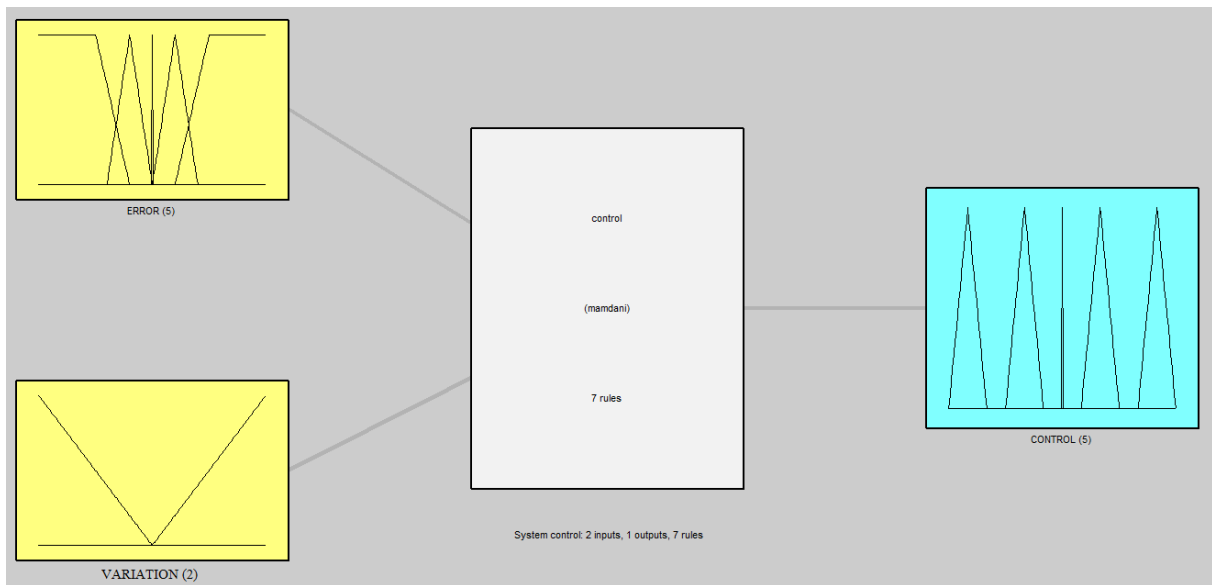


Fig.2 Block diagram of separately excited dc motor

2) Define the required fuzzy controller inputs and outputs. Then complete this diagram:



3) Deduce the structure of the fuzzy logic controller with closed loop (synopsis of all system with fuzzy controller).

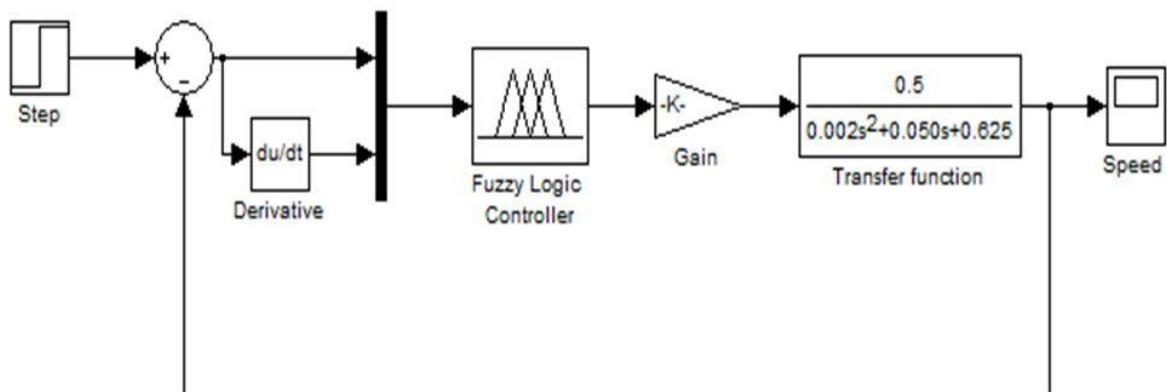


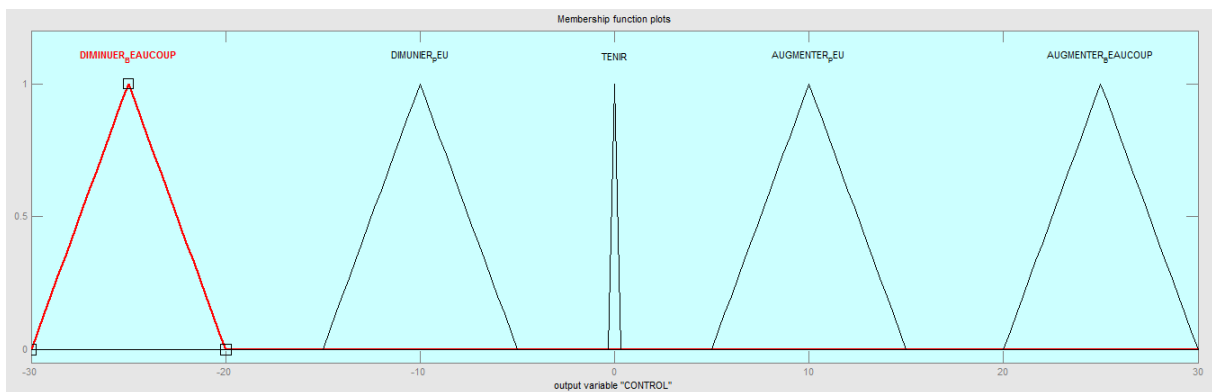
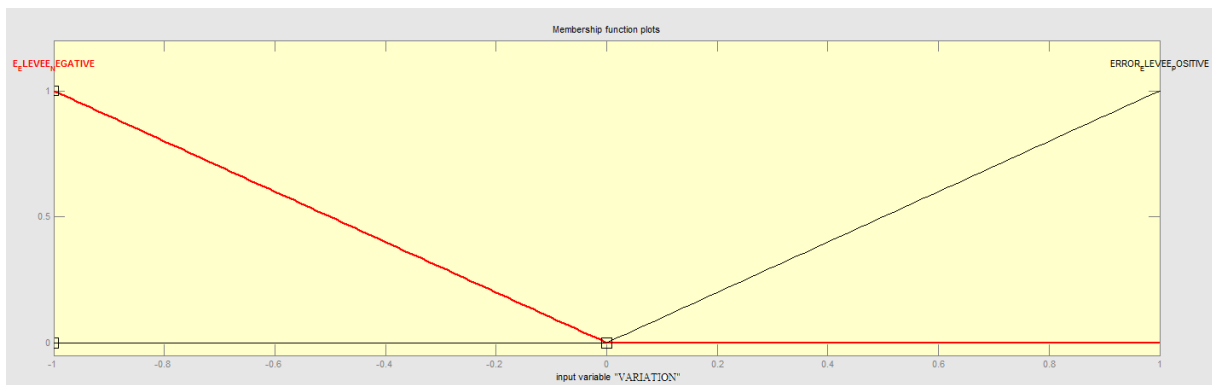
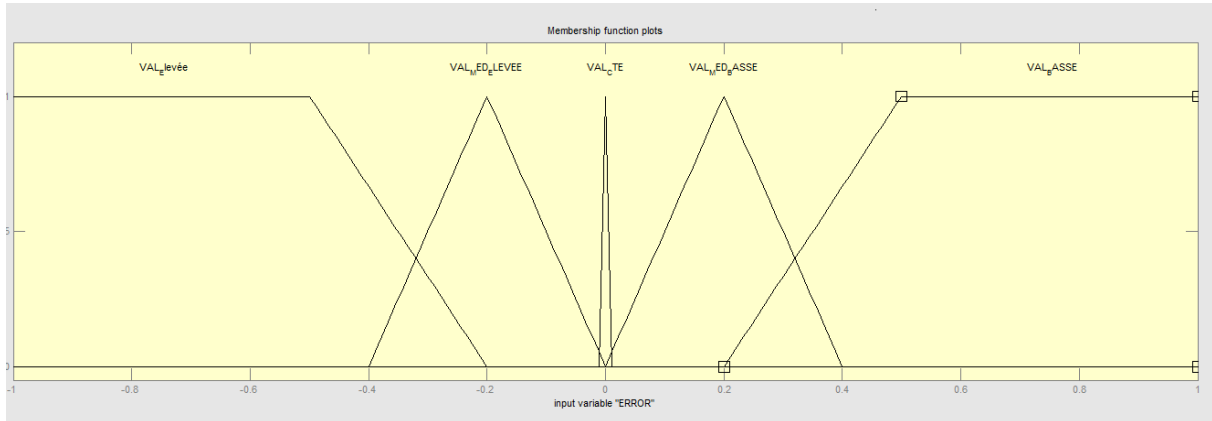
Fig.3 Model of system using fuzzy logic controller

4) Represent membership functions for inputs and output variables.

Input 1 range: [-1 1]

Input 2 range: [- 1 1]

Output range: [-30 30].



- 5) Enunciate the 7 “if-then” rules necessary for separately excited dc motor speed control.
- If (ERROR is VAL_BASSE) then (CONTROL is AUGMENTER_BEUCOUP)
 - If (ERROR is VAL_Elevée) then (CONTROL is DIMINUER_BEUCOUP)
 - If (ERROR is VAL_CTE) and (VARIATION is E_ELEVVEE_NEGATIVE) then (CONTROL is DIMUNIER_PEU)
 - If (ERROR is VAL_CTE) and (VARIATION is ERROR_ELEVVEE_POSITIVE) then (CONTROL is AUGMENTER_PEU)
 - If (ERROR is VAL_CTE) and (CAMBIO is ERROR_ELEVVEE_POSITIVE) then (CONTROL is AUGMENTER_PEU)
 - If (ERROR is VAL_MED_BASSE) then (CONTROL is AUGMENTER_PEU)
 - If (ERROR is VAL_CTE) then (CONTROL is TENIR)

6) What is the inference system type used here? Is there another type?

MANDANI. YES SUGENO METHOD.

7) What is the contribution (benefits) of fuzzy logic in comparison with a conventional PID controller for these case study?

The fuzzy logic approach has minimum overshoot, minimum transient and steady state parameters, which shows more effectiveness and efficiency of FLC than conventional PID controller.

Part 2: Fuzzy controller implementation (3pts)

We want to implement the proposed fuzzy controller under Matlab Simulink fuzzy logic toolbox.

1) What is the instruction to type on matlab to start the fuzzy logic toolbox?

Fuzzy

1) Comment and give the output of every line of code in Matlab :

```
>> a = readfis('control.fis')
>> getfis(a,'input',1)
>> getfis(a,'output',1)
>> plotfis(a)
>> mfeedit(a)
>> ruleview(a)
```

```
>> a = readfis('control.fis')
```

Creates a FIS matrix in the workspace corresponding to the FIS file 'control' on disk.

```
>> getfis(a,'input',1)
```

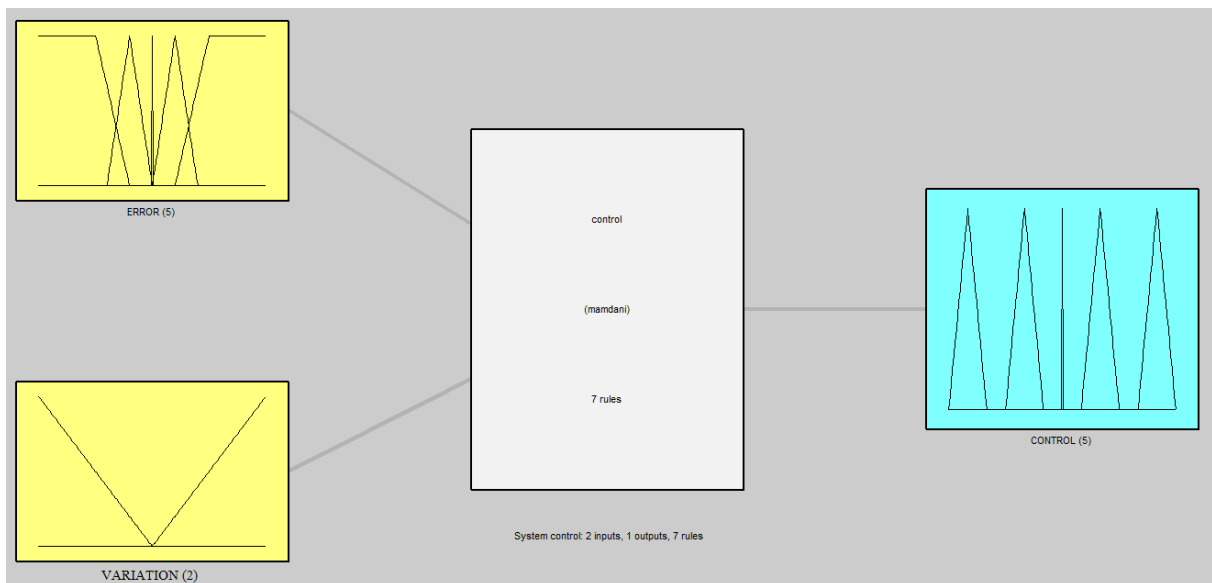
Gives the first input: ERROR

```
>> getfis(a,'output',1)
```

Gives the output: CONTROL

```
>> plotfis (a)
```

Creates an input-output display of the fuzzy inference system associated with the FIS structure FISSTRUCT.



```
>> mfedit(a)
```

Generates a membership function editor that allows you to modify all the membership functions for your FIS stored in the file a.fis.

```
>> ruleview(a)
```

Opens the Rule Viewer, or Inference Diagram Viewer, for the fuzzy inference system, fis.