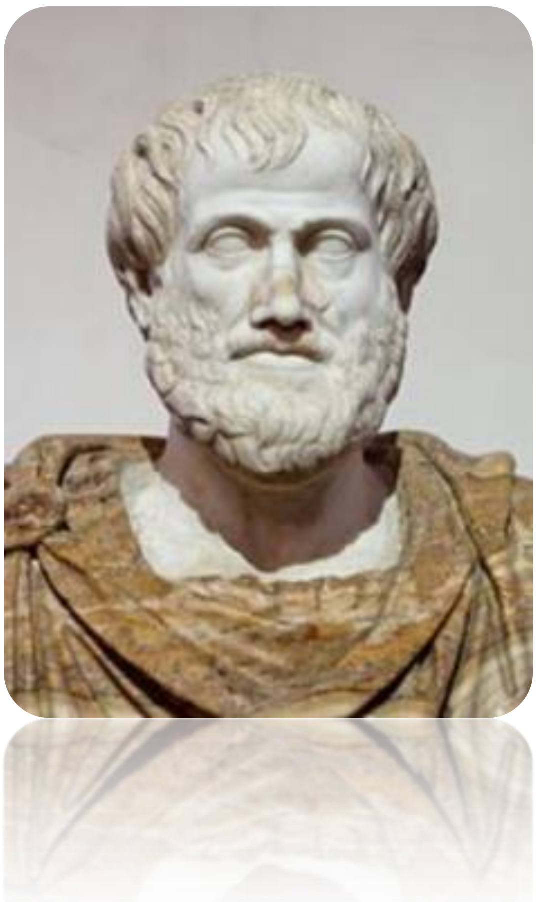
FUZZY LOGIC METHODS AND BASES OF RULES

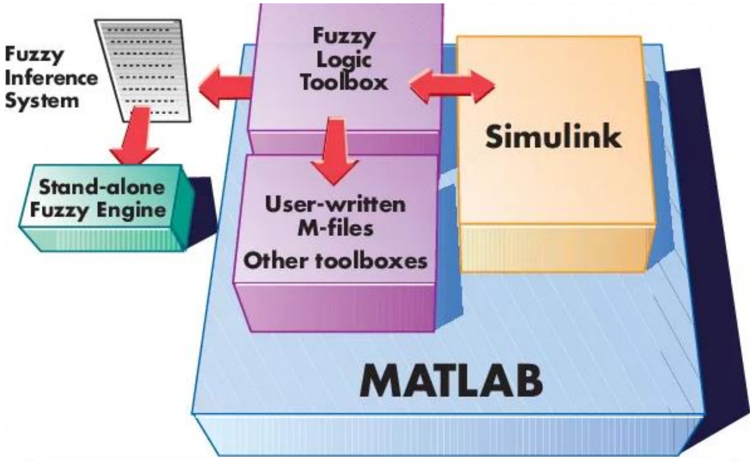
Practical session 1. Fuzzy Inference system of pendulum positioning control



1. WARM-UP TASK

2. INTRODUCTION TO FUZZY LOGIC TOOLBOX

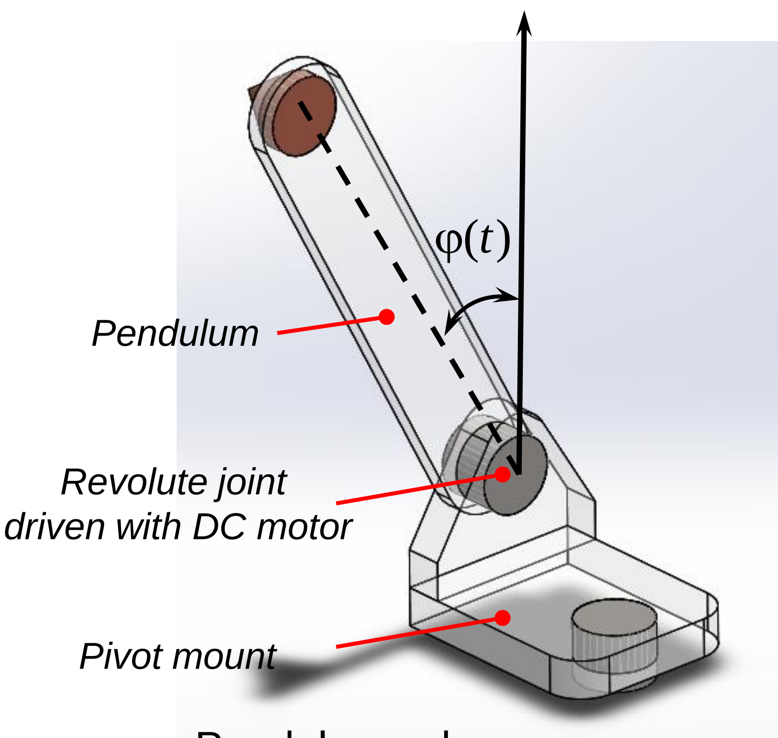
3. FUZZY INFERENCE SYSTEM OF PENDULUM POSITIONING CONTROL



Warm-up task: How to turn the pendulum on exact angle position using the time-depended signal of the torque

Pendulum with the mass “*m*” and the rotational inertia “*J*” driven with the DC motor should be turned on angle “φ_0” using time depended signal of voltage “*U*” or torque “*M*”. Let the friction force and the gravity force are to be negligibly small.

It is necessary to find the function *U=U(t)* or *M=M(t)*.



Pendulum scheme

$$J\frac{d\omega}{dt} = M,$$

$$\frac{d\varphi}{dt} = \omega.$$

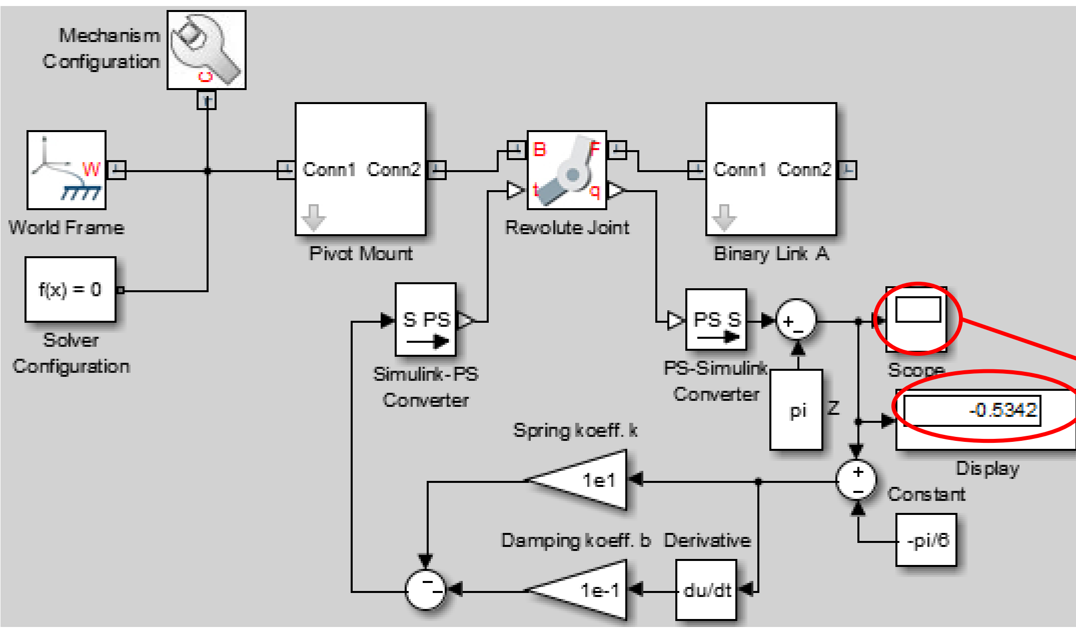
$$\varphi(t) = \varphi_0, \quad M(t) = \ldots ?$$

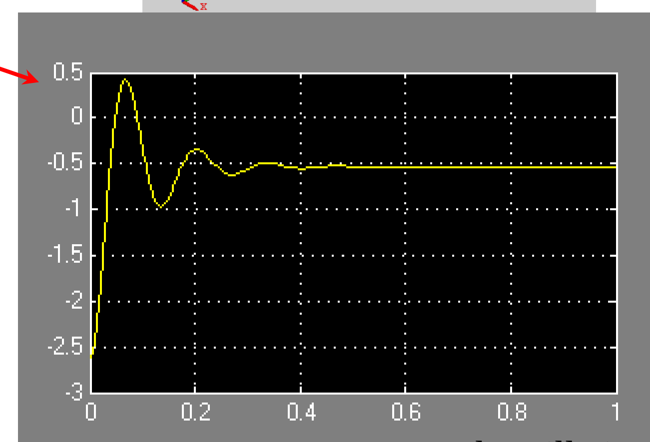
Warm-up task: How to turn the pendulum on exact angle position using the time-depended signal of the torque

Solution. Let us $\varphi_0 = -\pi/6 \approx -0.5236$ **, then answer is following:**

$$M = -k(\varphi - \varphi_0) - b\frac{d(\varphi - \varphi_0)}{dt} = -k(\varphi - \varphi_0) - b\omega.$$

Proportional part   *Derivative part*





Damped oscillations

For step-by-step instructions on how to build this model, see the "Model Double Pendulum" tutorial in the SimMechanics documentation.

MASTER PLAN

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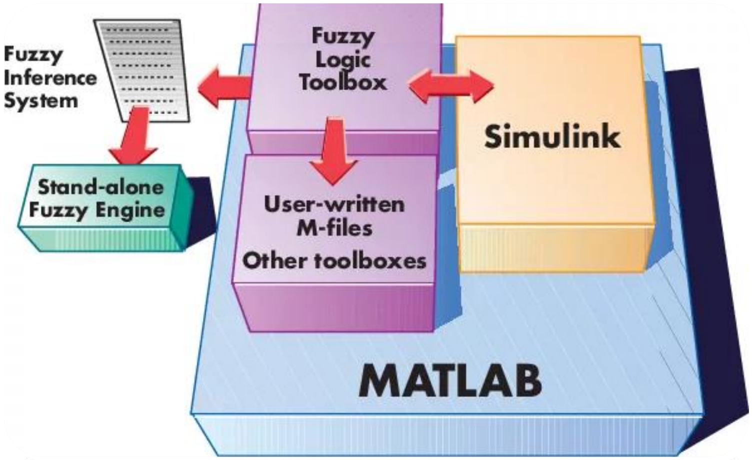
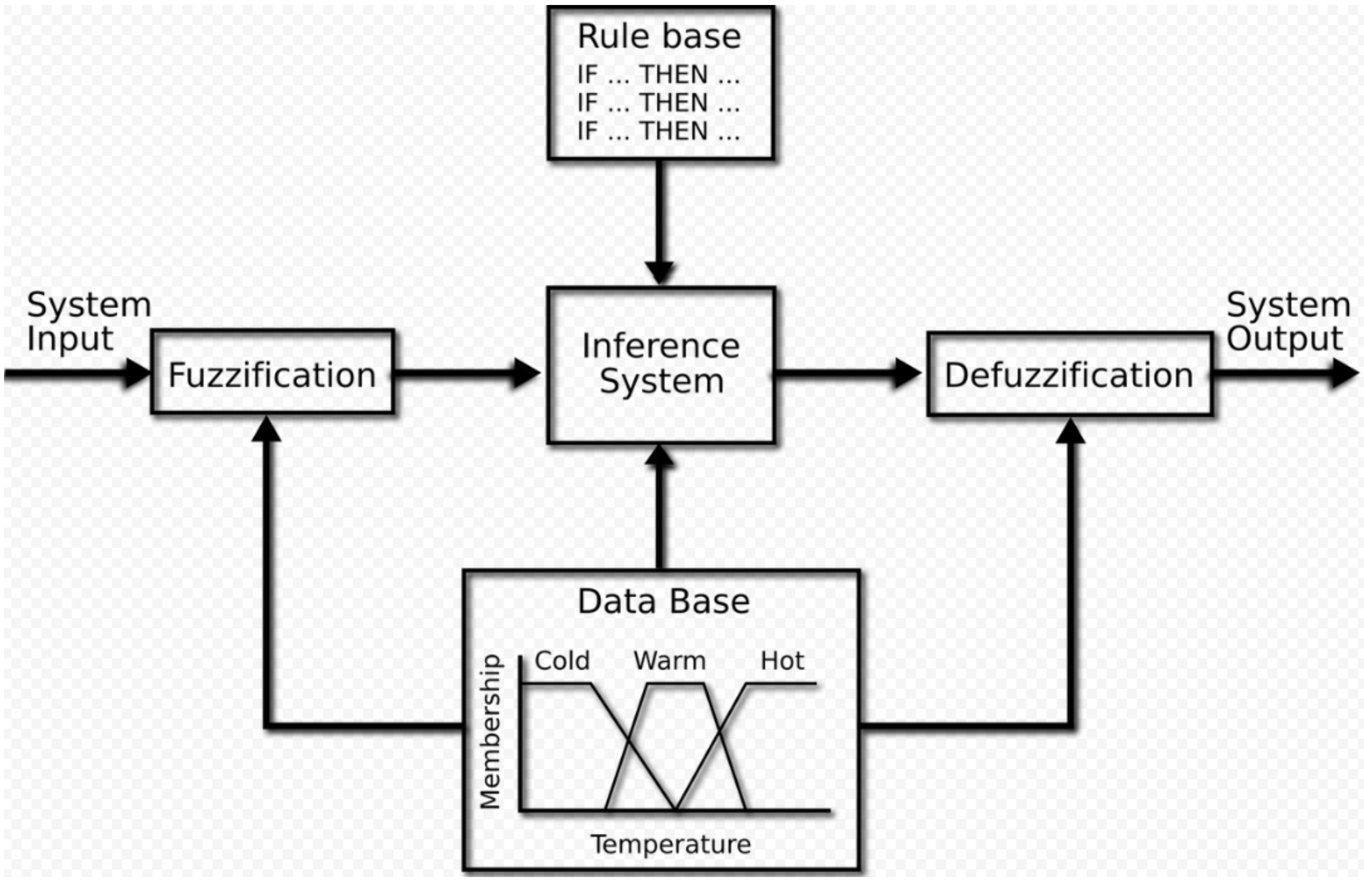
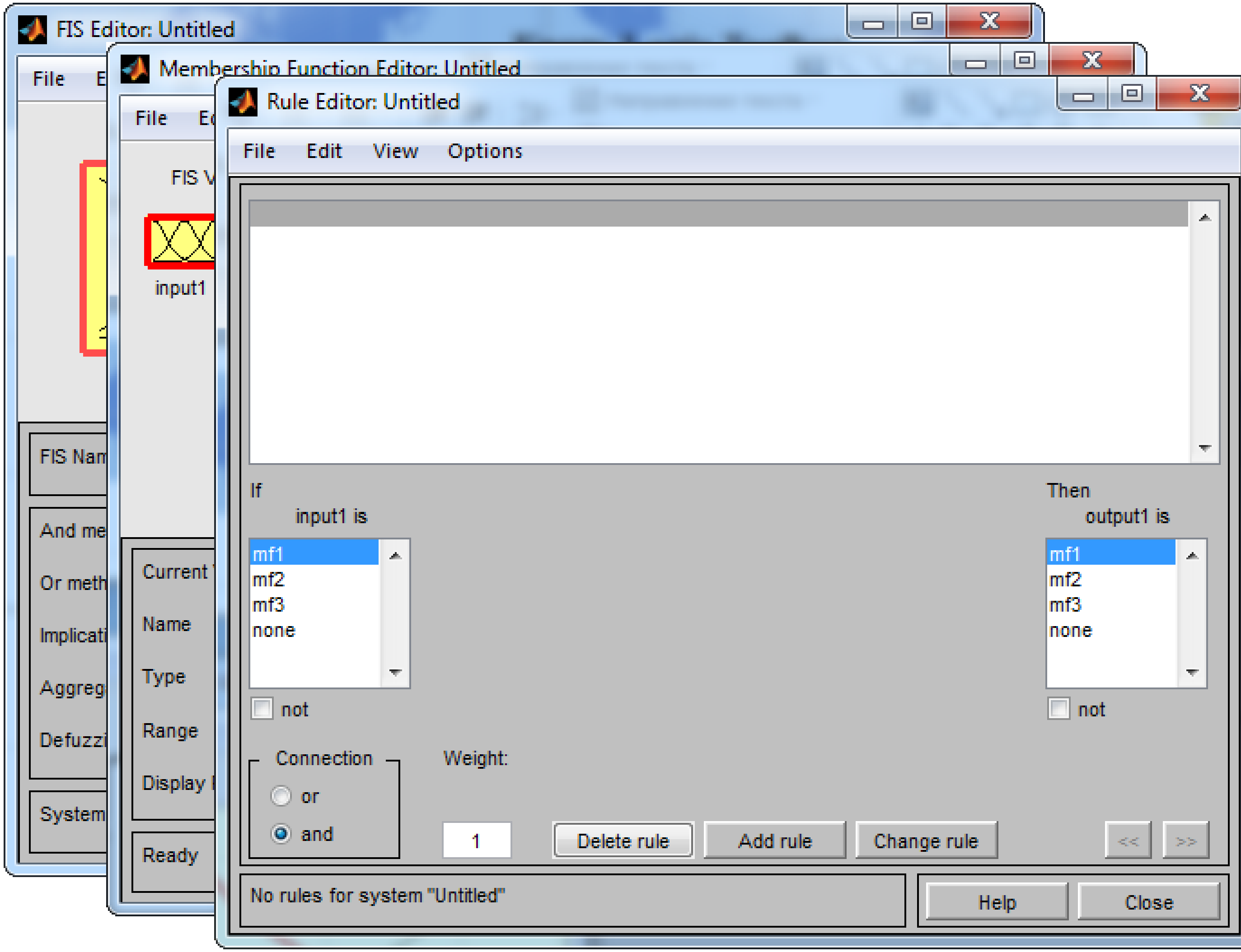




Fuzzy logic inference scheme

>> fuzzy


FIS Editor: Untitled
File
FIS Nam
And me
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input1
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Type
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Display
Ready
Rule Editor: Untitled
File Edit View Options
If
input1 is
mf1
mf2
mf3
none
not
Then
output1 is
mf1
mf2
mf3
none
not
Connection
or
and
Weight:
1
Delete rule
Add rule
Change rule
<<
>>
No rules for system "Untitled"
Help
Close

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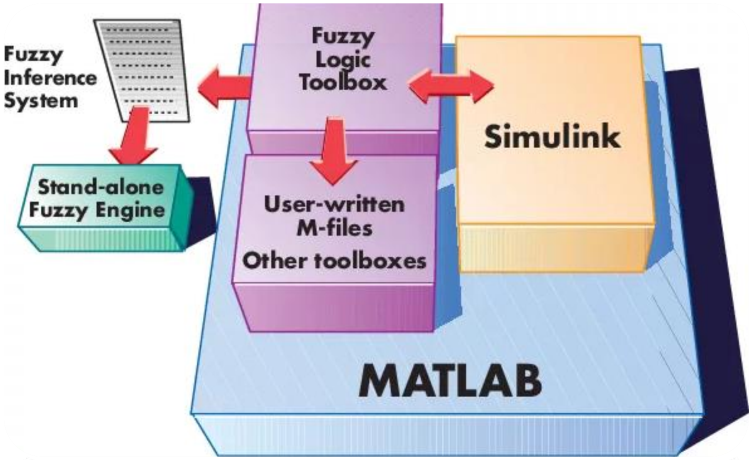
2. INTRODUCTION TO FUZZY LOGIC TOOLBOX

3. FUZZY INFERENCE SYSTEM OF PENDULUM POSITIONING CONTROL

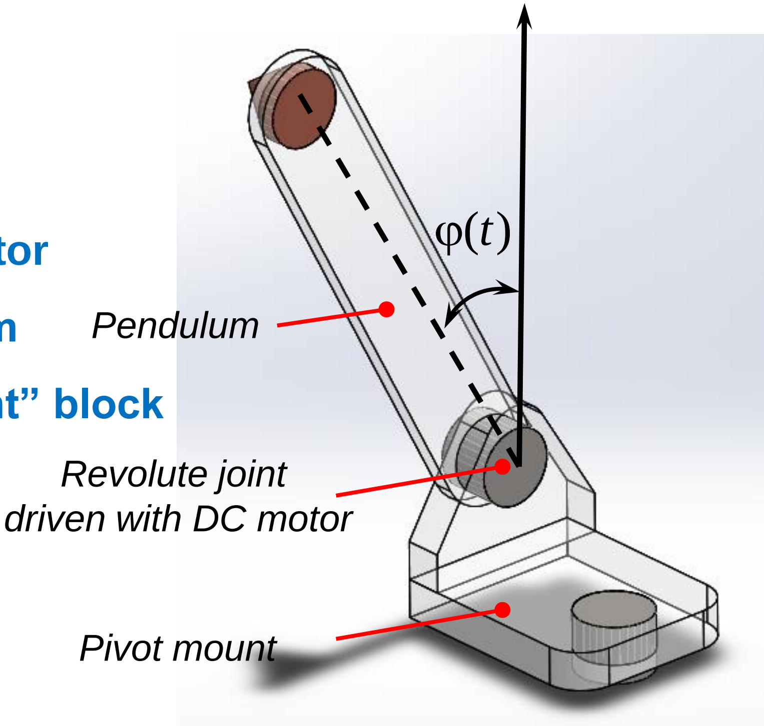


Pendulum with the mass "*m*" and the rotational inertia "*J*" driven with the DC motor should be turned on angle "φ_0" using time depended signal of voltage "*U*" or torque "*M*". Let the friction force and the gravity force are to be negligibly small.

It is necessary to find the function *U=U(t)* or *M=M(t)*.

Solution algorithm.

1. Create fuzzy rules
2. Develop a fuzzy inference system in the FIS-editor
3. Input the "Fuzzy controller" in Simulink program
4. Tune the values of input and output using "Giant" block to make the program work correctly

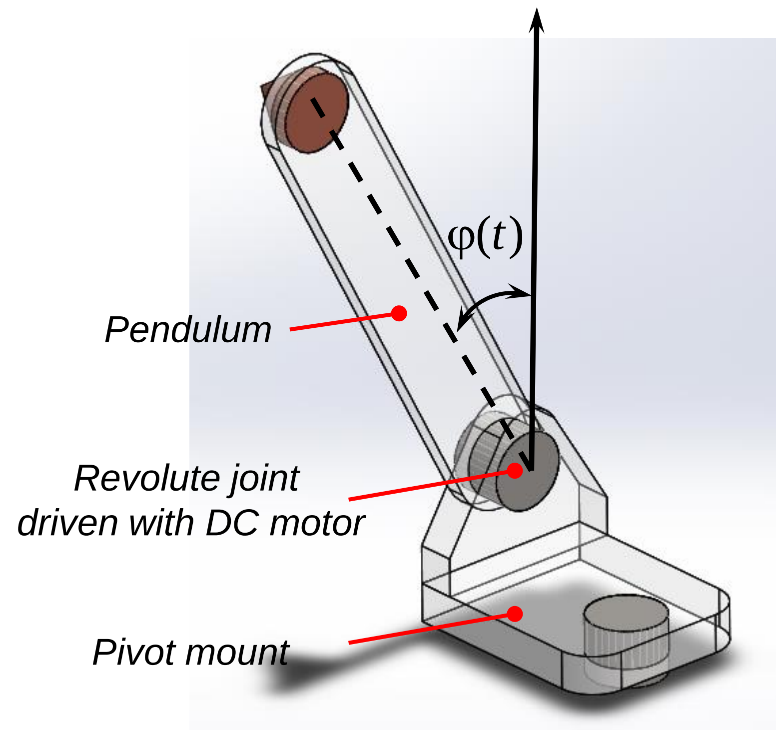


1. **Create fuzzy rules to connect the values of the position error and the torque**

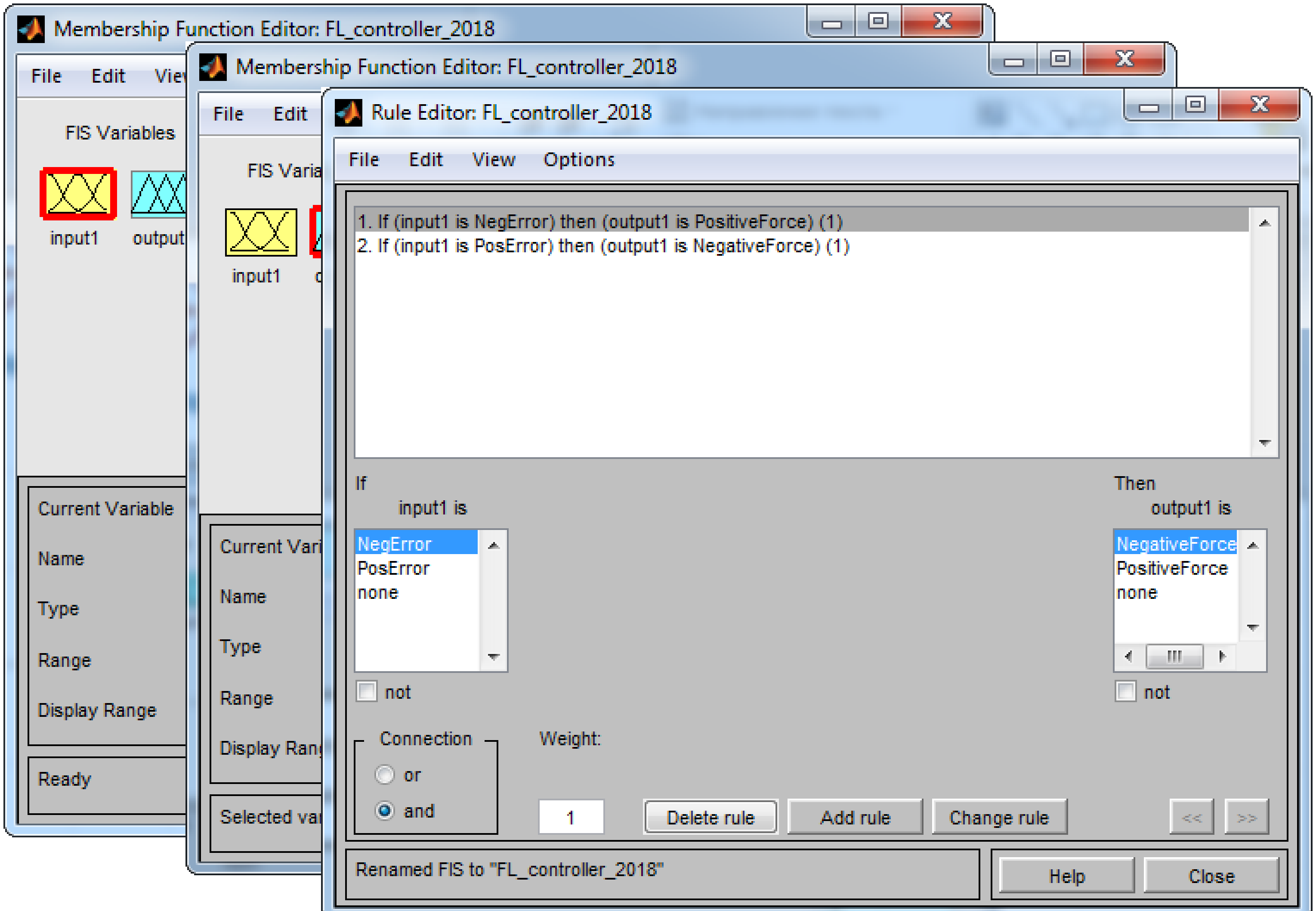
The rules has following form:

If the error is positive then the force is negative $(\varphi - \varphi_0) > 0, \quad M < 0;$

If the error is negative then the force is positive $(\varphi - \varphi_0) < 0, \quad M > 0;$



2. Develop a fuzzy inference system in the FIS-editor in three steps

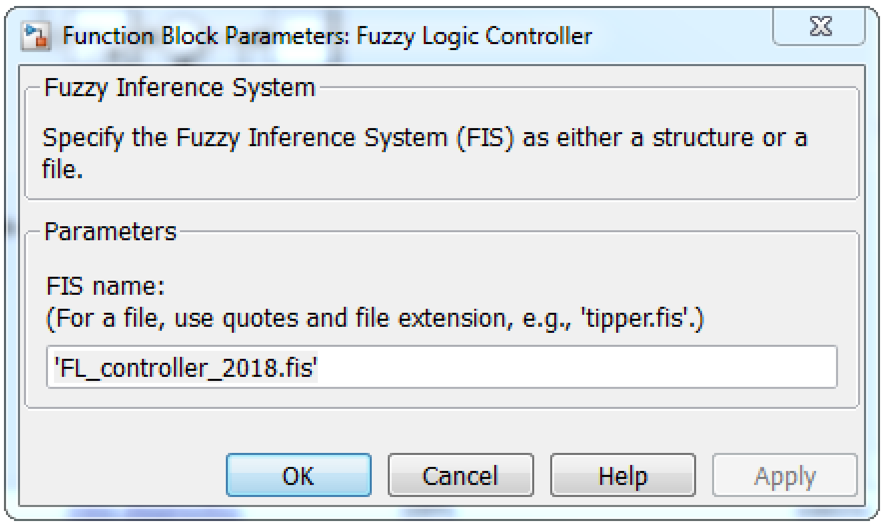


3. Input the “Fuzzy controller” in Simulink program

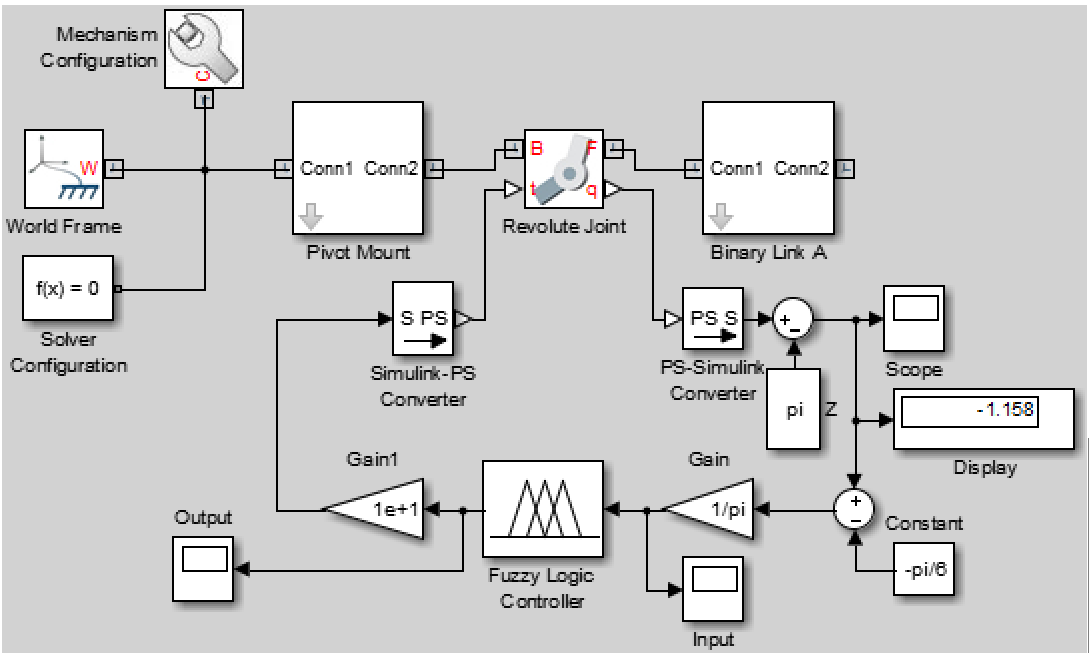
First of all, export the results from FIS-editor to fis-file and to Workspace using following commands: **File -> Export to Workspace**

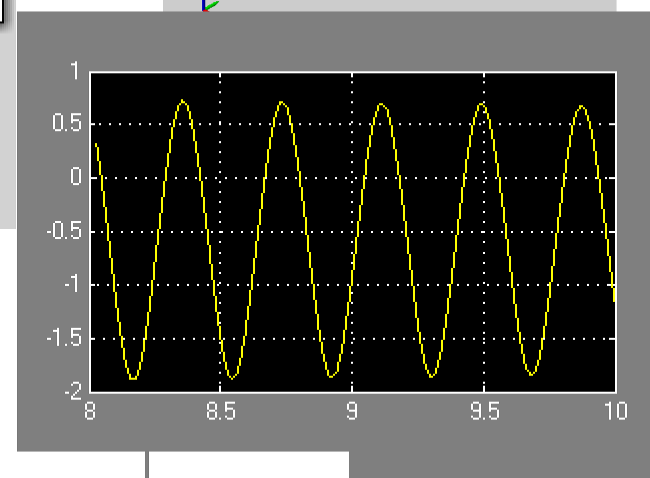
File -> Export to File -> FL_controller_2018.fis.

Then input the “Fuzzy Logic Controller” in Simulink program



4. Tune the values of input and output using “Giant” block to make the program work correctly.





And finally, try to stop the pendulum ;)

REFERENCES

1.https://www.youtube.com/watch?v=N5kwA6CQsAE
2.https://www.youtube.com/watch?v=FOvNoWMSqzA&t=17s
3.https://www.youtube.com/watch?v=Te4HGoZpRmY
4.https://www.youtube.com/watch?v=x6eBUpHpj6g
5.https://www.youtube.com/watch?v=woCdjbsjbPg
6.https://www.youtube.com/watch?v=cNZPRsrwumQ