

# ECE 6720 FUZZY CONTROL SYSTEMS

Fall 2011

Project Assignment #2

(Team Project)

Total: 80 pts. (20% of the course grade)

Due 3:30pm, Tuesday, December 6, 2011

Demonstrations are given in class

The **objective** of this project is to develop and verify by simulation **some of the functions of an automated assessment and training procedure** provided by an **Intelligent Decision Support System (IDSS)** for children with eye-hand coordination problem. A picture of the actual setup is given in Figure 1.



Figure1: Actual setup of the PHANToM Robot

A simplified block diagram of the system is shown in Figure 2. For the sake of simplicity, a variable (age) and the role of a supervisor person are eliminated. An automated assessment system is expected to reduce the burden and the associated cost of having a trained professional present at any assessment, or training session. The key block of the IDSS is based upon a fuzzy automaton. By using qualitative (fuzzified) data from the previous test the system will make a decision on the complexity of the next test to be performed. A set of assessment tests, commonly used by occupational therapists, are chosen that include the use of force, inertia and viscosity effects.

Three different test trajectories are illustrated in Figure 3. The subject is supposed to move the ball in the virtual environment (with the help of the PHANToM robot arm) along the desired trajectory. The system then measures the Time Taken (to execute a given task from the start to the end point) and the Accuracy (number of times the subject is out of the trajectory) and forwards them as inputs to the IDSS. By utilizing the fuzzy automaton the IDSS will then determine the next task to be executed by the subject.

The input measurements passed to the fuzzy automaton will be in fuzzified form as shown in Figure 4. You are to develop a program in MATLAB that will read the fuzzified inputs for Accuracy and Time Taken. It will then model the state transition of the fuzzy automaton using the B Algorithm that has been discussed in class. In each state the program should generate a 12-

element output vector in which only that bit should set that identifies the present state of the fuzzy automaton. Inputs Accuracy and Time Taken are measured on the scale of 0-100.

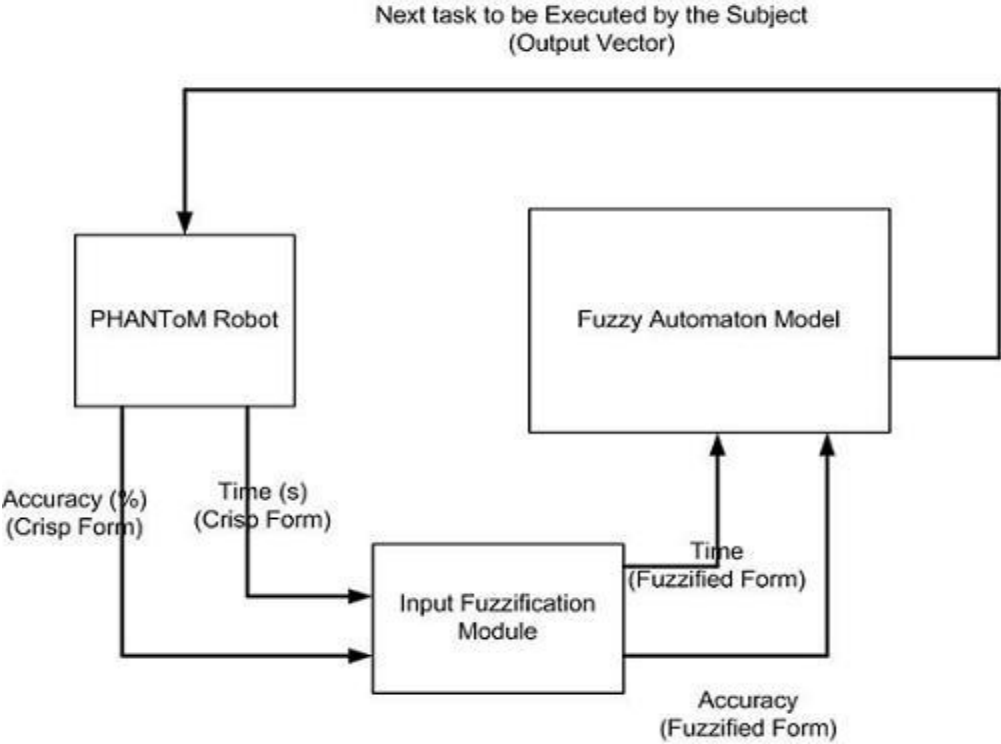


Figure 2. Simplified block diagram of the IDSS

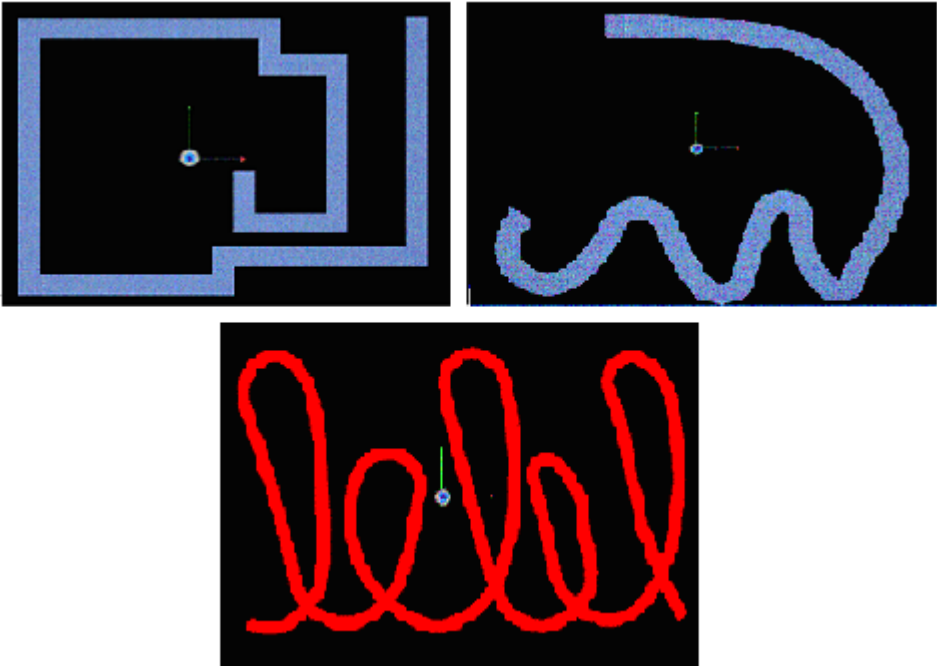


Figure 3: Different Test Trajectories

The membership functions for the Accuracy and Time taken are as shown in Figure 4. Please note that the membership function starts at (Input Universal Set Value for Cross Over Point – 5) and ends at (Input Universal Set Value for Cross Over Point + 5).

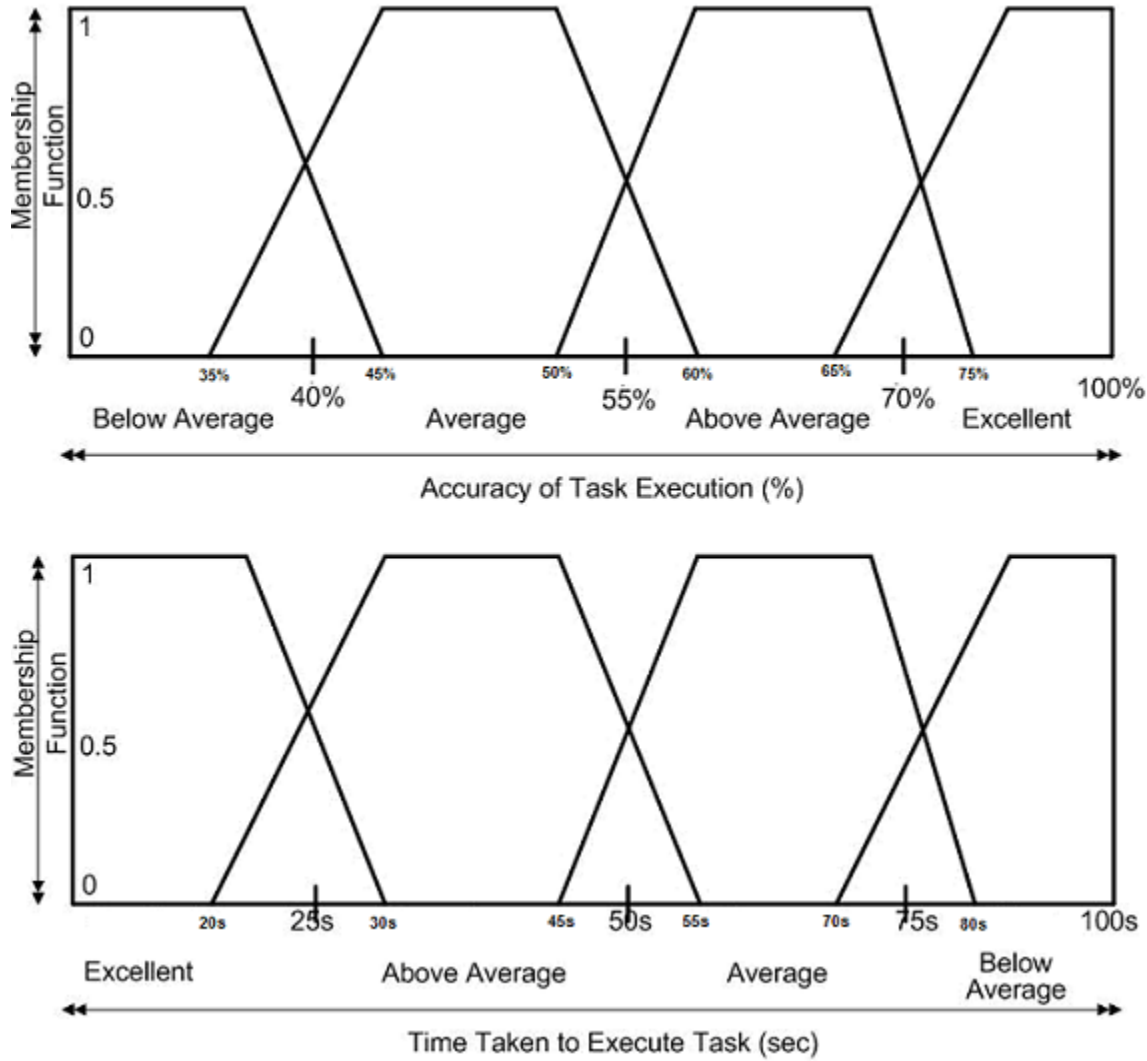


Figure 4: Membership Functions for Accuracy and Time Taken

The domains for Accuracy and Time Taken are divided into 4 different zones for the B algorithm as shown below:

	Accuracy (%)	Time Taken (sec)
Below Average	0-40%	75-100s
Average	40-55%	55-75s
Above Average	55-70%	25-55s
Excellent	70-100%	0-25s

The conditions for state-transitions of the fuzzy automaton are as follows:

<b>Current State</b>	<b>Next State</b>	<b>Transition Condition</b>
1	2	Time BA and/or Accuracy BA
1	3	Time A/AA and/or Accuracy A/AA
1	4	Time E and Accuracy E
2	1	Time BA and/or Accuracy BA
2	3	Time A/AA and/or Accuracy A/AA
2	4	Time E and Accuracy E
3	1	Time BA and/or Accuracy BA
3	4	Time A/AA and/or Accuracy A/AA
3	5	Time E and Accuracy E
4	5	Time BA and/or Accuracy BA
4	6	Time A/AA and/or Accuracy A/AA
4	7	Time E and Accuracy E
5	4	Time BA and/or Accuracy BA
5	6	Time A/AA and/or Accuracy A/AA
5	7	Time E and Accuracy E
6	4	Time BA and/or Accuracy BA
6	7	Time A/AA and/or Accuracy A/AA
6	8	Time E and Accuracy E
7	8	Time BA and/or Accuracy BA
7	9	Time A and/or Accuracy A
7	10	Time AA and/or Accuracy AA
7	11	Time E and Accuracy E
8	7	Time X and Accuracy X
9,10,11	12	Stop
	<b>BA</b>	<b>Below Average</b>
	<b>A</b>	<b>Average</b>
	<b>AA</b>	<b>Above Average</b>
	<b>E</b>	<b>Excellent</b>
	<b>X</b>	<b>Don't Care</b>
	<b>/</b>	<b>Or</b>
	<b>A and/or B</b>	<b>A and B, A or B</b>

The tests assigned to the various fuzzy states are given below:

State	Design Used for Testing
1	Labyrinth1 with no effects
2	Labyrinth1 with maximum force assistance
3	Labyrinth1 with minimum force assistance
4	Labyrinth 2 with no effects
5	Labyrinth 2 with minimum inertia effect
6	Labyrinth 2 with medium inertia effect
7	Handwriting style 1 with no effects
8	Handwriting style 1 with medium force assistance
9	Handwriting style 1 with minimum inertia effect
10	Handwriting style 1 with medium inertia effect
11	Handwriting style 1 with maximum inertia effect
12	Stop

Please note that the initial state of the fuzzy automaton should be State1. The Matlab program developed is supposed to read the Fuzzy Inputs for Accuracy and Time Taken. Two sets of data files are provided on the Class Web Page. A format of the fuzzy input for Accuracy in the file is as shown below.

50 0.1 0.2 0.4 0.4 0.4 0.8 0.9 1 1 1 1 1 1 1 1 0.9 0.7 0.6 0.5 0.2 0.1

This format implies that starting from input universal set point 50 the values for Fuzzy input for Accuracy will be 0.1, 0.2 etc and for the rest of the Input universal set points they are termed as zeros. Same format applies to the fuzzy input for Time Taken. The final output results obtained should be graphed similar to the graphs shown in Figure 5.

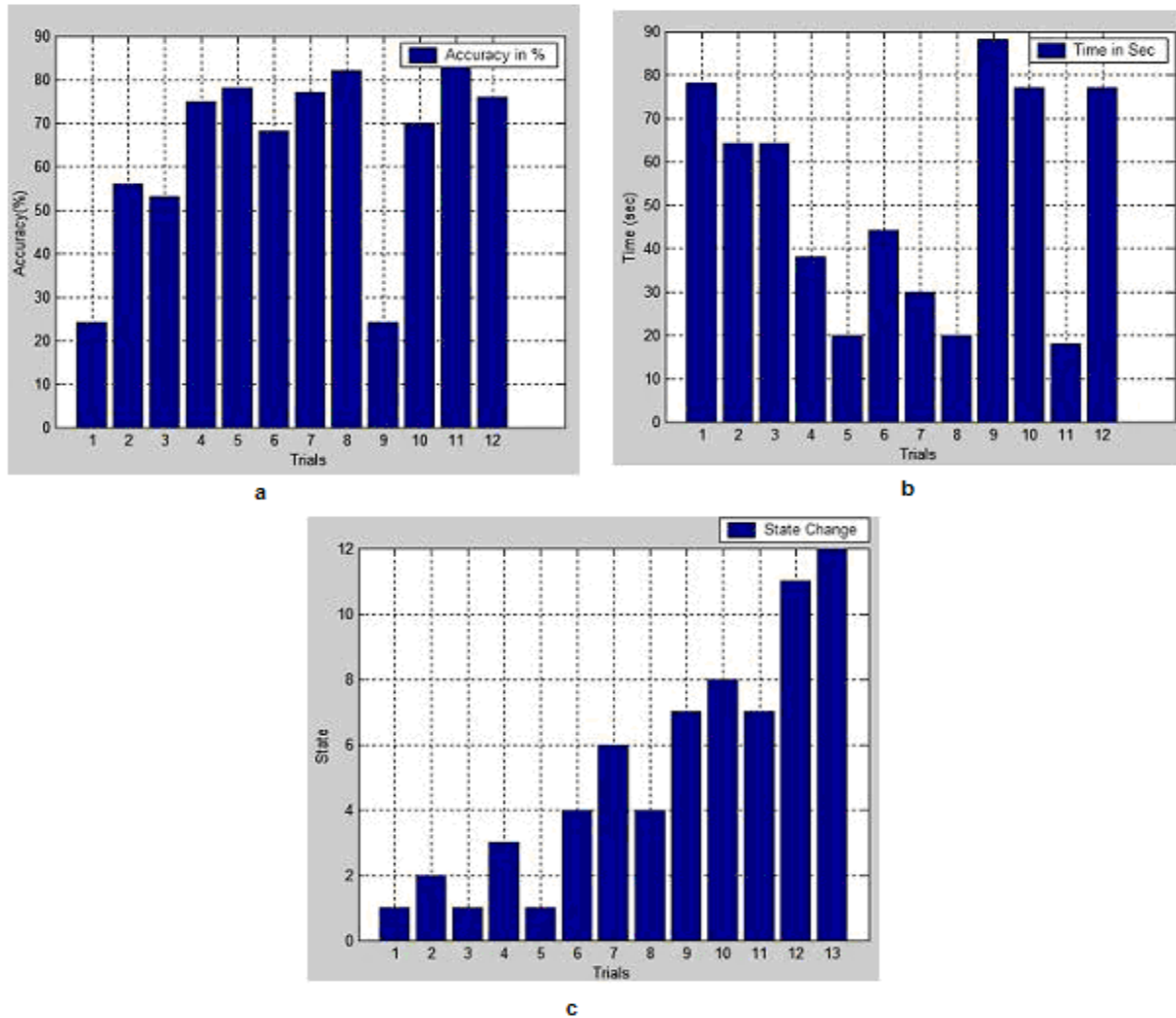


Figure 5: a. Input-Accuracy, b. Input-Time Taken, c. State Transitions

### Tasks

1. Develop a fully-functional MATLAB code for the project. For the I/O interface of the simulated automaton you should take into account the input and output file formats provided. (36 pts.)
2. Verify your code by simulation and demonstrate it to the instructor. (24 pts.)
3. Prepare a Project Report (hard copy) (20 pts.)
  - It should include
    - a) Introduction
    - b) Discussion of your design
      - Details of your design approach
      - Flowchart depicting the software flow
      - Boolean Subintervals and the State Transition Graph of the fuzzy automaton
    - c) Hard copy of your MATLAB code
    - c) Simulation results along with comments
    - d) Conclusion

Each Team must submit a **joint** Project Report.

**Note:** you will lose 8 pts. by each day your project is tardy. **No** credit will be given if the project is submitted **after** 5:00pm, Friday, December 9, 2011. If you fail to work on the project you will be given an X for the course.

**Note:** Use the Matlab help available in the software. That is the best source to learn Matlab if you are new to the software. Also use the **LOAD** command available in Matlab to read the input data file for Accuracy and Time Taken, respectively, and then proceed from there.

**Some useful Matlab tutorial links:**

1. <http://www.math.utah.edu/lab/ms/matlab/matlab.html>
2. <http://www.engin.umich.edu/group/ctm/basic/basic.html>
3. <http://www.math.mtu.edu/~msgocken/intro/intro.html>
4. [http://www.rit.edu/~pnveme/Matlab\\_Course/DEFAULT.HTM](http://www.rit.edu/~pnveme/Matlab_Course/DEFAULT.HTM)
5. <http://www.indiana.edu/~statmath/math/matlab/links.html>