# Fuzzy Coursework – Helpful Information

**The Coursework Overview**

The fuzzy coursework will involve you creating a fuzzy inference system of **YOUR** choosing. From previous years the coursework would often involve the creation of a fuzzy system for a given specific environmental domain. This year, I feel more inclined to allow you, the student, to decide upon a domain for deployment. With that being the case, I anticipate many different fuzzy systems and areas of application; something I am very much looking forward to.

The final fuzzy system will have at least:

* 3 input variables
* 1 output variables

Take special care when describing how you justified your **rulebase** for your chosen system. I want to be able to understand your thought processes on why you decided upon on what you did.

There is **NO** maximum number of input variables you could choose to incorporate, but be aware, the more inputs you decide to use, the more rules you will need to implement by proxy to cater for the additional fuzzy sets and membership functions.

You are also expected to use a suitable number of fuzzy sets and membership functions for your chosen input and output variables. There will be a point in the development of your systems, where the **trade-off** between how detailed you want it to be, against the number of rules needed to allow for sufficient execution; will become apparent.

You are also expected to provide a report, that details and documents the final fuzzy system that you have created, it will also justify the final configuration that you have decided upon.

Please make use of the provided **Feedback\Mark Scheme** to understand what is being marked and taken into consideration. A well designed and implemented fuzzy inference system, along with a detailed and well-presented report, provides for a good quality project.

**The Deadline**

Friday - 6th December 2019.

Expect feedback to be given with 4 weeks from the deadline date.

**The Deliverables**

This coursework only requires an online submission through the provided Turnitin coursework link; this can be found under the **Coursework Tab** of the Module Shell. Please follow the instructions there for what to submit.

**The Report**

The report itself will detail all aspects regarding how the final fuzzy system came to be. You will need to provide sufficient content and substance. The information you include will need to tell the story of how your system came to be. please remember that the page count is a maximum of 12 pages of content. A possible indicative guideline may look similar to the following:

**Title Page** - Title, module name, author details and so on... *(***Not included in page count***)*

**Abstract** - A few sentences providing a summary of the contents. (**Not included in page count**)

**Introduction** - Self-explanatory.

**Literature Review\Background** - Depending on your chosen domain, I would like to see that you have read and used publications from reputable sources to provide more credence to your chosen fuzzy system. This section does not have to be a great amount, roughly 2 pages will provide a good amount of detail. This could begin with a general overview and then become more specific, linking in to your chosen domain of execution.

**The System** - Describe the system(s) you have created. Link this in with the area of application, how and what will your system be implemented on? There will be several subsections contained within this section.

**Experimental Design and Evaluation** - This will include the testing of your system(s). There are many aspects regarding a fuzzy inference system that can be tested, so please reflect and use thorough consideration. The majority of the testing can be contained within appendices, therefore leaving the more important testing aspects to be included in the main body of the report. Again, there will be several subsections contained within this section.

**Critical Reflection** - Critique the performance of your system(s).

**Conclusion** - Self-explanatory.

**Bibliography\References** - Self-explanatory. (**Not included in page count**)

**Appendices** - Optional. (**Not included in page count**)

As this is only a guideline, feel free to adapt it how you see fit. Make sure pages are numbered and a consistent text style and presentation is used throughout. If you decide to include figures, tables, diagrams and so on, please make sure that they are labelled and captioned accordingly. For example, do not simply refer to a figure, with ‘the above figure’. Use the correct captain and inline citation; please refer to Fig. [?]... or figure [?], whatever convention you decide to use, please make sure it is maintained throughout the report.

**Ideas**

If you have already decided upon what your fuzzy inference system is going to do; perfect. If however you are still a little unsure, let the literature review provide some form of inspiration, read and understand the current trends occurring in fuzzy. If you are still left pondering on a final direction consider the following applicable fuzzy domains:

* Controllers - Fuzzy control systems. Create a fuzzy inference system that controls an application or appliance:
  + Washing machines.
  + Elevators.
  + Air conditioning unit.
  + Temperature control.
  + Robotic controllers.
  + And so on...
* Classification - Create a fuzzy inference system that helps with classification problems:
  + Colour spectrum - Define if a pixel belongs to a particular colour channel.
  + Categorising - Define the classification of a given input
  + And son on...

This list goes on and on. If you would to discuss your ideas with me, feel free to email me or talk to me in the lecture or the labs. The fact that you get to decide upon the fuzzy inference system that you create, I expect to see many wonderful and varied approaches and application domains. If some projects show novelty, I will then take this forward and discuss how this could be adapted for a possible future publication.

## Aerospace

In aerospace, fuzzy logic is used in the following areas −

* Altitude control of spacecraft
* Satellite altitude control
* Flow and mixture regulation in aircraft deicing vehicles

## Automotive

In automotive, fuzzy logic is used in the following areas −

* Trainable fuzzy systems for idle speed control
* Shift scheduling method for automatic transmission
* Intelligent highway systems
* Traffic control
* Improving efficiency of automatic transmissions

## Business

In business, fuzzy logic is used in the following areas −

* Decision-making support systems
* Personnel evaluation in a large company

## Defence

In defence, fuzzy logic is used in the following areas −

* Underwater target recognition
* Automatic target recognition of thermal infrared images
* Naval decision support aids
* Control of a hypervelocity interceptor
* Fuzzy set modelling of NATO decision making

## Electronics

In electronics, fuzzy logic is used in the following areas −

* Control of automatic exposure in video cameras
* Humidity in a clean room
* Air conditioning systems
* Washing machine timing
* Microwave ovens
* Vacuum cleaners

## Finance

In the finance field, fuzzy logic is used in the following areas −

* Banknote transfer control
* Fund management
* Stock market predictions

## Industrial Sector

In industrial, fuzzy logic is used in following areas −

* Cement kiln controls heat exchanger control
* Activated sludge wastewater treatment process control
* Water purification plant control
* Quantitative pattern analysis for industrial quality assurance
* Control of constraint satisfaction problems in structural design
* Control of water purification plants

## Manufacturing

In the manufacturing industry, fuzzy logic is used in following areas −

* Optimization of cheese production
* Optimization of milk production

## Marine

In the marine field, fuzzy logic is used in the following areas −

* Autopilot for ships
* Optimal route selection
* Control of autonomous underwater vehicles
* Ship steering

## Medical

In the medical field, fuzzy logic is used in the following areas −

* Medical diagnostic support system
* Control of arterial pressure during anaesthesia
* Multivariable control of anaesthesia
* Modelling of neuropathological findings in Alzheimer's patients
* Radiology diagnoses
* Fuzzy inference diagnosis of diabetes and prostate cancer

## Securities

In securities, fuzzy logic is used in following areas −

* Decision systems for securities trading
* Various security appliances

## Transportation

In transportation, fuzzy logic is used in the following areas −

* Automatic underground train operation
* Train schedule control
* Railway acceleration
* Braking and stopping

## Pattern Recognition and Classification

In Pattern Recognition and Classification, fuzzy logic is used in the following areas −

* Fuzzy logic based speech recognition
* Fuzzy logic based
* Handwriting recognition
* Fuzzy logic based facial characteristic analysis
* Command analysis
* Fuzzy image search

## Psychology

In Psychology, fuzzy logic is used in following areas −

* Fuzzy logic based analysis of human behaviour
* Criminal investigation and prevention based on fuzzy logic reasoning

**The Configuration**

With the requirements that each system needs at least **3 input variables**, you could have the inputs themselves be the outputs of additional fuzzy systems, i.e. fuzzy systems that feed into successive fuzzy inference systems. So you can have one input that is the output of a 2 input fuzzy system, along with another 2 viable inputs. How the inputs are created is up to you, I only ask that the final fuzzy system makes use of at least 3 input.

**What to Avoid**

Please be aware, I am only interested in seeing the final fuzzy systems created in a MATLAB script file (.m file).

*Please do not code your fuzzy system up in another programming language.*

Although it is expected that you will be making use of figures and tables, cherry pick what you would like to be seen in the main body of the report and keep the repetitive content in the appendices. Please refrain from creating page after page of figures, tables and diagrams for the main body of the report, this makes everything look too cluttered and indicates you are simply page padding.

**A Reminder**

Remember, when creating your rulebase, for a 3 input 1 output system for example, the following column indexes will be in use when creating your system in a script file (.m file):

***[****Input 1, Input 2, Input 3, Output 1, Weight, Operator****]***

No matter how many inputs (n) your system makes use of, the first most left column will always be indicative of **Input 1**, the second column will be indicative of **Input 2**, and so on and so forth.

(n + 1) is the column directly after the last specified input. In our case, this is column 4. n + 1 is therefore equal to 3 + 1 = 4, the 3 is the number of inputs, so therefore the column directly right of the last input will always be the **first** **Output**.

Column number 5 is the representative of the weight. Typically this is set to 1, but it can be any value in the range of between 0 and 1. For example, the weight for a particular rule could be 0.8. The weight allows you to dilute the strength of the rule further still; even after the firing strength has been computed.

The final column, is always indicative of the operator that the rule is making use of. This column can take 1 of 3 values:

* 0 - Indicates that it is a THEN
* 1 - Indicates it is an AND
* 2 - Indicates it is an OR

For example, assume we had a Mamdani type fuzzy system with the following membership functions for the following inputs and output:

* **Input 1:**
* Small
* Medium
* Big
* **Input 2:**
* Light
* Moderate
* Heavy
* **Input 3:**
* Cold
* Moderate
* Warm
* **Output 1:**
* A
* B
* C

It doesn’t matter what the system is representing, but assume we has the following rule:

***[****1, 1, 1, 1, 1, 1****]***

This would equate to the following understanding:

*If* ***Input 1*** *is Small AND* ***Input 2*** *is Light AND* ***Input 3*** *is Cold THEN* ***Output 1*** *is A with a weighting of (1)*

***[****0, 0, 3, 3, 1, 0****]***

*If* ***Input 3*** *is Warm THEN* ***Output 1*** *is C with a weighting of (1)*

Please Remember that a single rule cannot make use of different operators, it has to be one type, for example the following rule will not be acceptable:

*If Input 1 is Big* ***OR*** *Input 2 is Heavy* ***AND*** *Input 3 is Warm THEN Output 1 is C with a weighting of (0.8)*

Instead, what you should do is break the rule down into sub-rules, for example the above rule can be written as 2 new rule sub-rules:

*If Input 1 is Big* ***OR*** *Input 2 is Heavy THEN Output 1 is C with a weighting of (0.8)*

*If Input 2 is Heavy* ***AND*** *Input 3 is Warm THEN Output 1 is C with a weighting of (0.8)*

Each rule of your system does not have to make use of all 3 inputs, you could use any combination of inputs to generate each rule. For example you could have a rule with simply one input, or a rule that used just 2 inputs. If you want to have rules which make use of all 3 inputs, that is completely acceptable. As there will be many different variations of fuzzy systems, it will understandably be dependent on the application of the domain, that provides the basis for the structuring of the rules.