Fuzzy Interface System

User Manual

Version 0.3

Date 11/11/01

Contents Page

1.0 Introduction

1.1 Intended readership

The fuzzy system software manual is intended for use by those who require information relating to the set-up and running of the program and also provides a complete description of the softwares components. It is recommended first time users of the software package consult this document before preceding further.

1.2 Applicability statement

This software user manual applies to version 0.1 of the Fuzzy Inference System software package. For later versions please consult the accompanied documentation for changes or additions.

1.3 Purpose

The purpose of this user manual is to aid the user in the installation and also the operation of the Fuzzy Inference System software and in doing so help them to understand all components of the software package. The purpose of the software is to provide a user-friendly interface through which fuzzy rule systems can be run and output displayed, whilst also allowing the user to make changes to the system.
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1.4 How to use this document

Users

This document contains information for first time and experienced users of the software package. First time users will need to consult sections relating to the installation of the software and may also find the included tutorials useful. More competent users however, may only need to use this document as a reference and should therefore skip straight to the sections they require.

Developers

For further information relating to the design of the software package, please refer to the following section on related documents.
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1.5 Related documents (including applicable documents)

This document is not intended for use by software developers who require information relating to the design of the software. In addition it does not highlight what the objectives where when developing this software package. For more information relating to these areas, please refer to the URD, SRD, ADD or SDD.

1.6 Conventions

In order to make the program as user friendly as possible a number of standards were implemented into the GUI. The following three symbols represent icons displayed on the boxes of messages to the user.

Information message box – informs user of an event good or bad

Question box – requires input from the user

Error message box - tells user what error occurred

Additionally the display is made up of a number of internal windows, the functions of which are explained in the later sections of this manual. In general however, these windows have a number of buttons, represented as small icons. Left clicking the mouse on these icons will attempt to carry out a task assigned to it.

1.7 Problem reporting instructions

For information relating to problems with the software, please refer to Appendix B of this document, on error messages and recovery. For further assistance please report all problems to:

mroberts@it.net.au

or visit our website at

http://www.westnet.com.au/kristi/b316

2.0 Overview section.

The software allows users familiar with concept of fuzzy logic, to easily run a given data set through a given set of fuzzy rules producing and displaying a number of outputs. This software package supports the following processes:

1. Opening of pre-existing data set and fuzzy inference system files.
2. The running of singular or multiple data rows.
3. Display of the result for the current run.
4. Display of the firing weights for each data row.
5. Determination of rules fired during running.
6. Determination of rules closest to being fired (if none fired)
7. Addition or removal of data rows to or from the current data file.
8. Addition or removal of rules to or from the current FIS file.
9. Disabling or enabling of rules within the current FIS file.
10. Graphical display of relationships between the inputs and output.

For more information regarding the processes consult section 3 and 4 of this document.

2.1 System Hardware Requirements

Recommended:
166MHz or faster CPU
64MB of RAM
50MB of free hard drive space

2.2 Supported Operating Systems

Windows 9x, NT, 2000, Me, Linux (Kernel version 2.4.0 and above) and Solaris.

2.3 Additional Software Requirements

Java Runtime Environment v1.3
Java3D Extensions

In addition to the above requirements, the user will need to supply a data file formatted into column data with each column representing an input or output and a FIS file, formatted according to the standard set out by the MATLAB Fuzzy Logic Toolbox.

3. Instruction section.

3.1 Installation

First ensure the system and software requirements described in Section 2.1, 2.2 and 2.3, have been met before attempting to execute the program.

To run the program, enter the following command at the MS-Dos prompt or equivalent for your operating system, at the directory, where the file named **FIS.jar** is located.

 java –jar FIS.jar

3.2 Main Interface and Navigation - First Time Users

For new users of the Fuzzy Interface System this section explains the main components that make up the user interface. It is through interaction with these components that allows the processes listed in section 2.0 to be carried out. These components can be seen in figure1.0 (next page) and are described in more detail in the following sections.

3.2.1 Main Menu

The main menu bar allows the user to perform a number of tasks and is made up of three sub-menus.

1. File
2. View
3. Help

3.2.1.1 File

Within the file menu, there are four further options, Save Data, Load Data File, Load FIS File and Exit. Save data allows the user to save the currently selected data file including any changes made to data rows. Load Data File allows the user to open an existing data file, Load FIS file allows the user to open an existing FIS file and Exit closes and exits the program.

3.2.1.2 View

The view menu allows the user to select one of the three main windows, the **Data Window**, the **Rules Window** or the **Graphing Options Window**. If the windows are currently closed then selecting this option will open the window. If the window is currently open, this option will close the window.

3.2.1.3 Help

Displays a brief summary of the client the software was prepared for, the production team and the production supervisor.
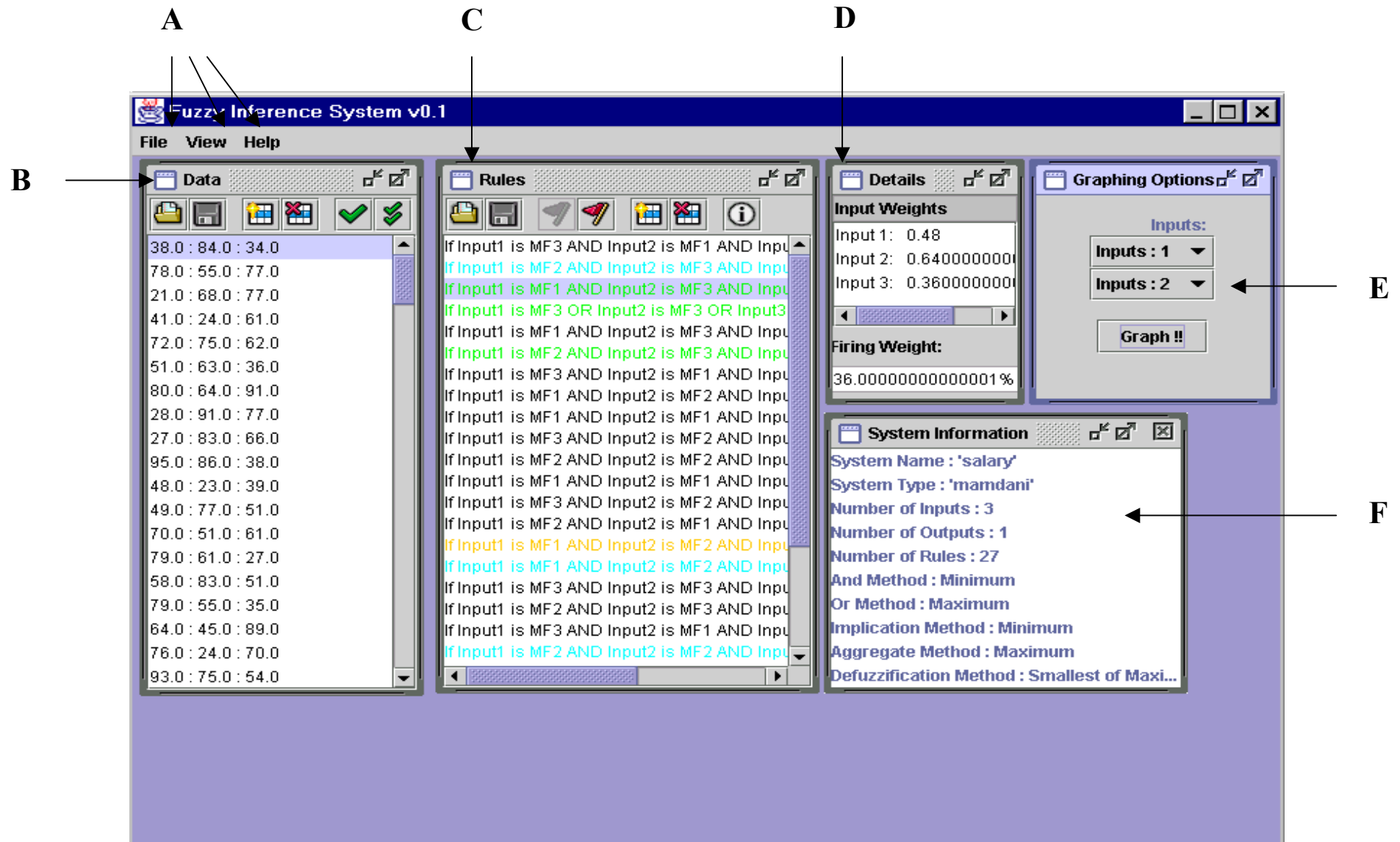
Figure 1.0: Main Interface

Key Figure 1.0:

A. Main Menu - Provides menus for opening and saving of files.
B. Data Window - Displays the current data set and operations.
C. Rule Window - Displays the current FIS file rules and operations.
D. Details Window - Displays firing weights for selected data row.
E. Graphing Window - Displays options for graphing.
F. System Information - Displays system information for the current FIS file.

While components A→ E all have functional roles in the program, the system information window (F) simply displays the current status of the FIS file for the purpose of user reference.

3.3 Getting Started - For Beginners

### 3.3.1 Task 1 – Opening a data file

a) Functional Description:

This task allows the user to open a specified data file to be used by the program.

b) Cautions and Warnings:

Ensure the data file to be open is formatted into columns separated by white space and each representing an input or output.

If there is already a data file open, which has been edited or changed, ensure to save changes if needed before opening a second data file, as only one data file can be open at any one time. Upon attempting to open a second file, the user will be prompted if they wish to save their changes.
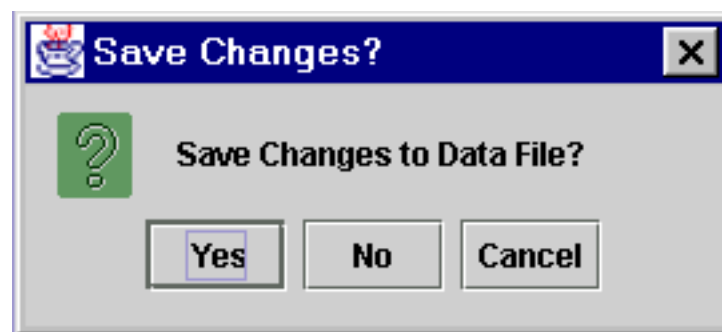

Choosing **Yes** will save the current file and proceed to open a new file, selecting **No** looses changes and proceeds to open a new file and **Cancel** aborts the loading of a new file.

c) Procedure:

Data files can be opened by selecting **Load Data** from the **File** sub-menu of the **Main Menu** see Figure 1.0 or by left clicking the **open file** icon located at the top of the **Data Window** (Figure 1.1). A box will then be displayed allowing the user to browse the computer to find the selected file. Once selected, click open and the all data rows contained in the file will be loaded into the **Data Window**. Requires a valid data file.
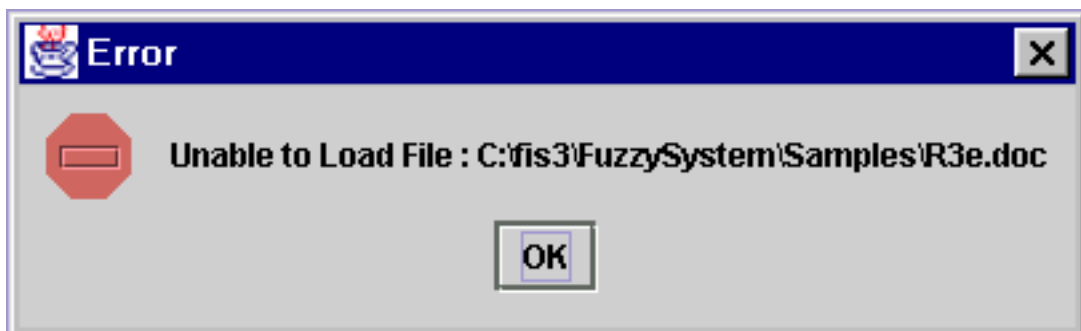
Figure 1.1: Data Window
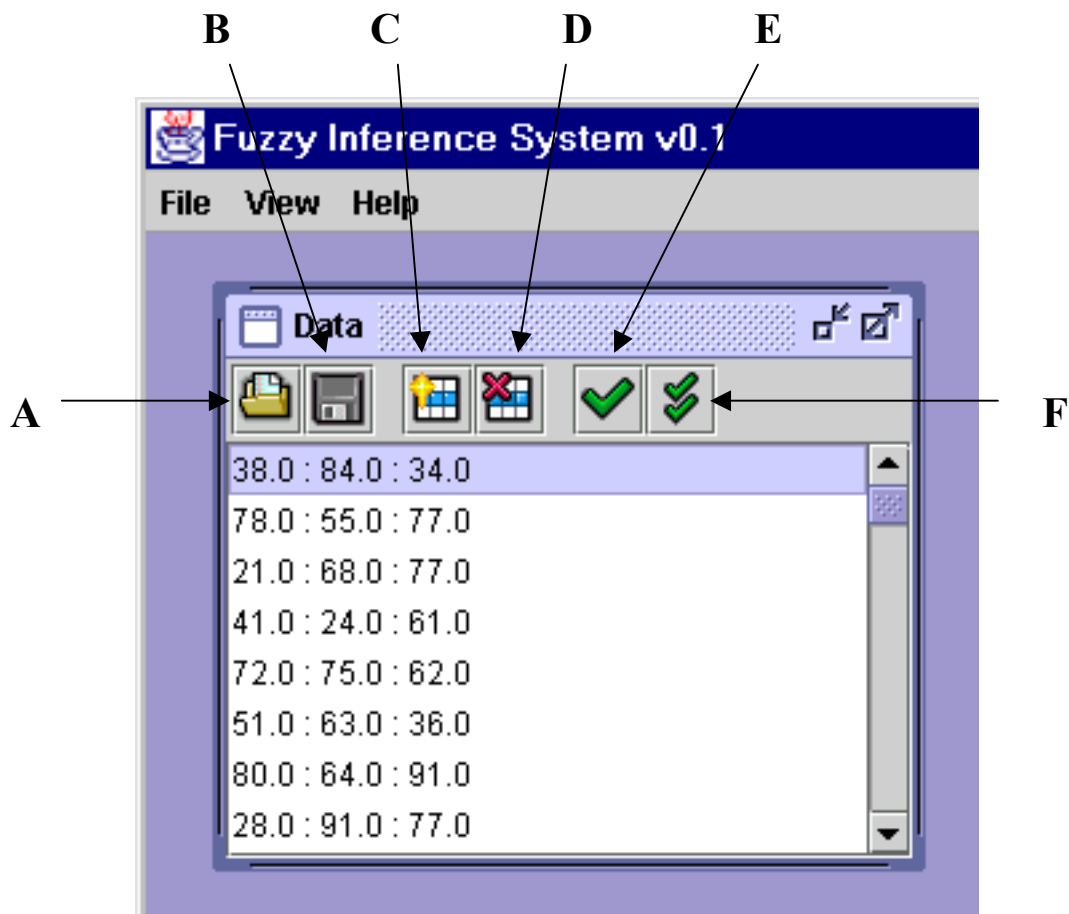
Key Figure 1.1:
A. **Open an existing data file**
B. **Save the current data file**
C. **Add new data row to the data file**
D. **Delete selected data row**
E. **Run data row**
F. **Run all data rows**

d) Probable Errors and Possible Causes:

If an error occurs loading the specified file, an error message similar to the following will be displayed.

The most likely reason for this error is an incorrectly formatted data file.

3.3.2 Task 2 – Opening a FIS file

a) Functional Description

Allows user to load a specified FIS file containing the rules to be applied to the current data set.

b) Cautions and Warnings

Ensure the FIS file is formatted according to the standard set out by the MATLAB Fuzzy Logic Toolbox.

As for the data file, only one FIS file can be used at a time. Therefore attempting to open a new file will prompt the user to save changes if any have been made.

c) Procedure

Data files can be opened by selecting **Load FIS** from the **File** sub-menu of the **Main Menu** see Figure 1.0 or by left clicking the **open file** icon located at the top of the **Rules Window** (Figure 1.2). The rest of the procedure is then the same as for opening a data file (Section 3.3.1). Requires a valid FIS file.

Figure 1.2: Rules Window
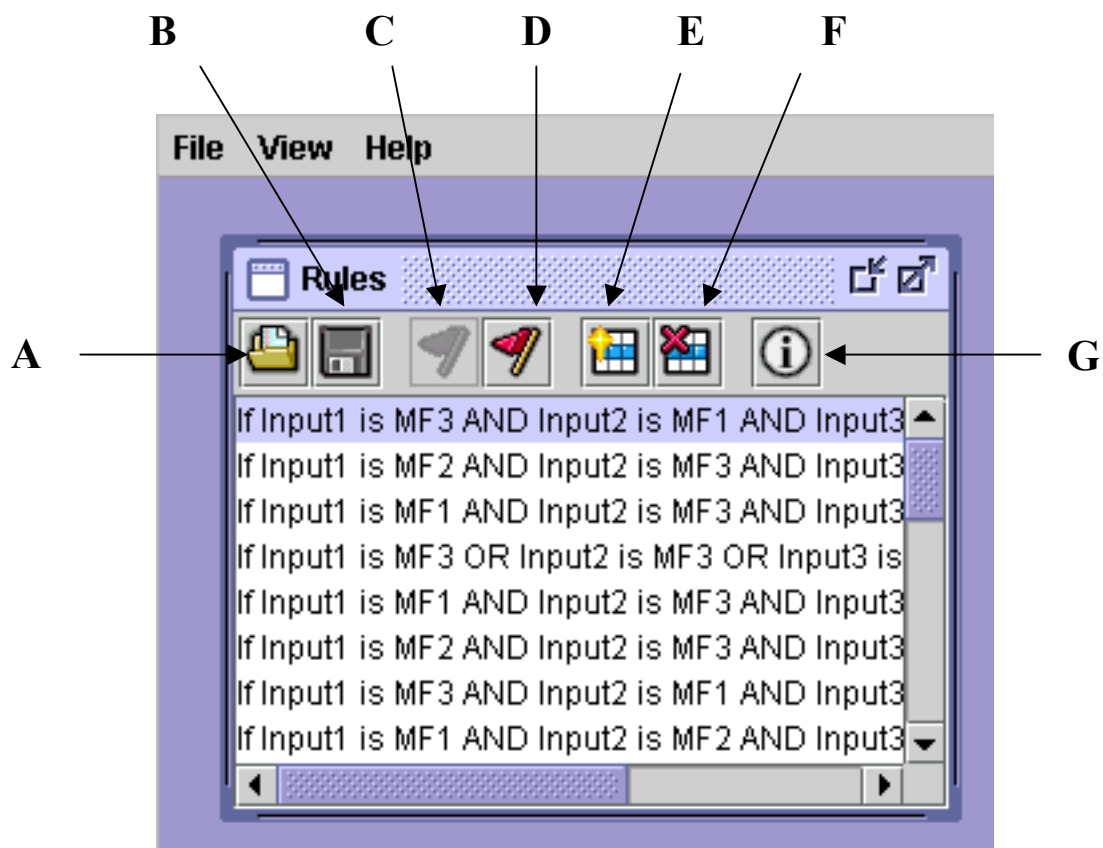
Key Figure 1.2:

    A. **Opens an existing FIS file.**
    B. **Saves the current FIS file.**
    C. **Enable the currently selected disabled rule.**
    D. **Disable the currently selected enabled rule.**
    E. **Add a rule to the current rules file.**
    F. **Remove a rule from the current rules file.**
    G. **Display information for the current FIS file.**

d) Probable Errors and Possible Causes

For errors see section 3.3.1 Probable Errors and Procedures. Possible cause is most likely an incorrectly formatted FIS file. Consult MATLAB standards as mentioned in the Cautions and Warnings part of this section.

3.3.3 Task 3 – *Running the Data Set (Fired, Unfired and No Fired Rules)*

a) Functional Description

This is the main function of the program and will run either a single selected row or all rows in the **Data Window** against the current set of rules in the **Rules Window** and produce a number of outputs.

b) Cautions and Warnings

Ensure that both a valid data file and FIS file have been loaded before trying to run the program. For more information relating to loading files see sections 3.3.1 and 3.3.2.

In an instance where no rules are fired, the closest rules to being fired will only be displayed when running a single row of data.

c) Procedures

Load a valid data file and FIS file, then either select a single data row in the **Data Window** and click the **run single** data row icon or click the **run all** data rows icon (Figure 1.1).

Run Single Row

After the data row has been run the outcome of the operation will be displayed as follows.
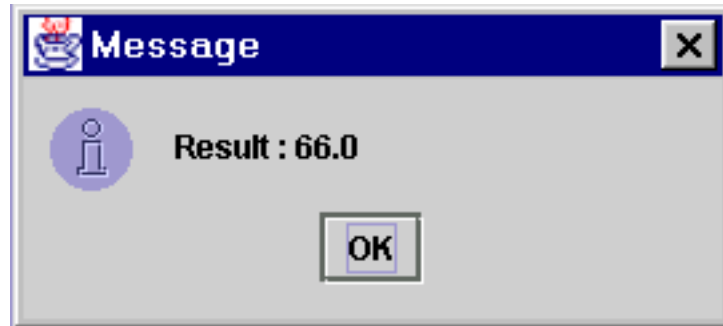
Run All Rows

When this option is selected a box will open prompting the user for a filename in which to save the outputs of the operation. All outputs for the run are then written to this file and the message box displayed in the case of running a single row is not shown.

Run Single and Run All Rows

After a successful run, each fired rule displayed in the **Rules Window**, will become highlighted in colour indicating the **strength of the firing weight**. From the strongest to weakest these colours are red, magenta, pink, orange, yellow, green, cyan, blue.
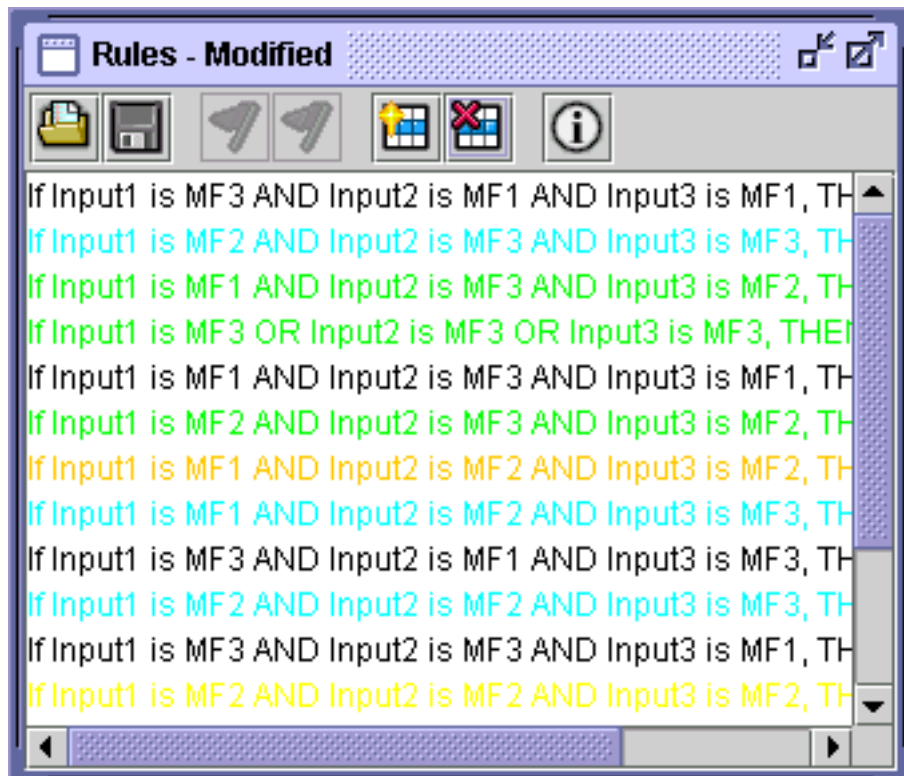

In the above figure we can see the rules, which were fired, are coloured according to the strength of their firing weight and the rules which were not fired, remain black.

Clicking on an individual rule in the **Rules Window** will open the **Details Window**, which displays the individual input weights and the firing weight for that rule. An unfired rule will have a firing weight value of **Not Fired**.
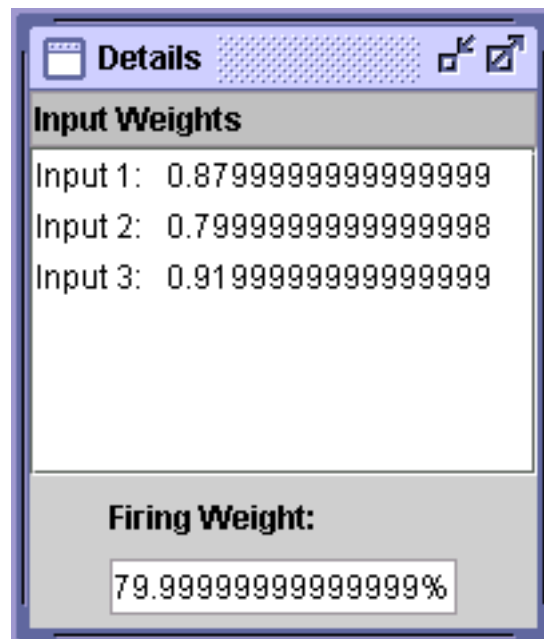
No Fired Rules

If a single data row is run and no rules are fired then the rules closet to being fired are highlighted in colour and the rules details box displays the firing weight that it would have had if it were fired (see the figure below).
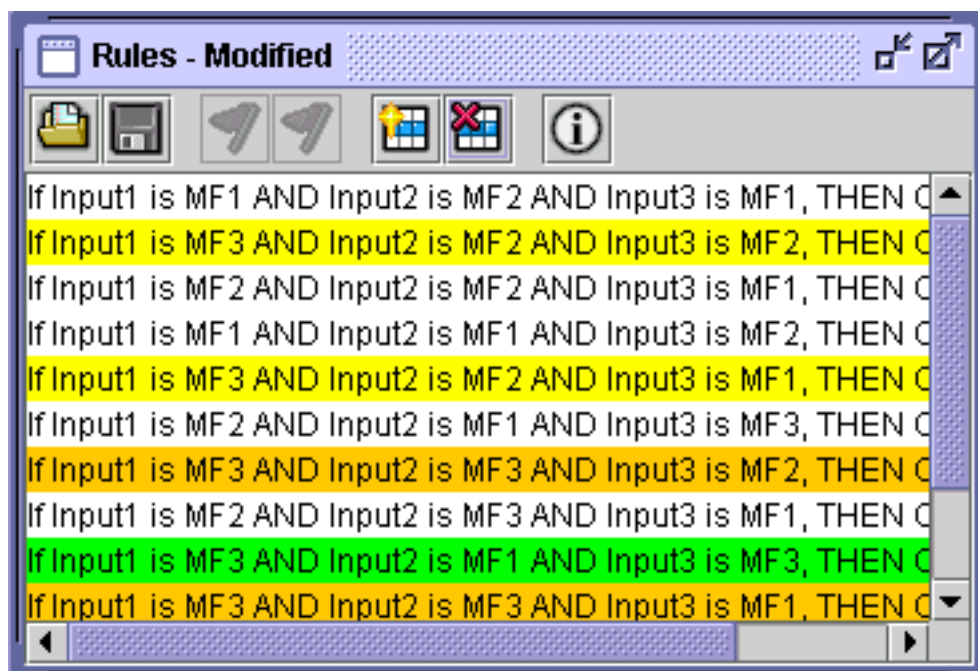

The colours used to highlight the closest rules to being fired are same as the colours used to indicate the strength of firing weights for fired rules.

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The colours used to code the **Fire Weights** for both fired rules and close to being fired rules are:

- 0% to 12.5% -Blue
- 12.6% to 25% -Cyan
- 25.1% to 37.5% -Green
- 37.6% to 50% - Yellow
- 50.1% to 62.5% -Orange
- 62.6% to 75% -Pink
- 75.1% to 82.5% -Magenta
- 82.6% to 100% -Red

d) Probable Errors and Possible Causes

The following error message will be displayed if there is no FIS file loaded into the **Rules Window** and the user tries to run data opened in the data file.
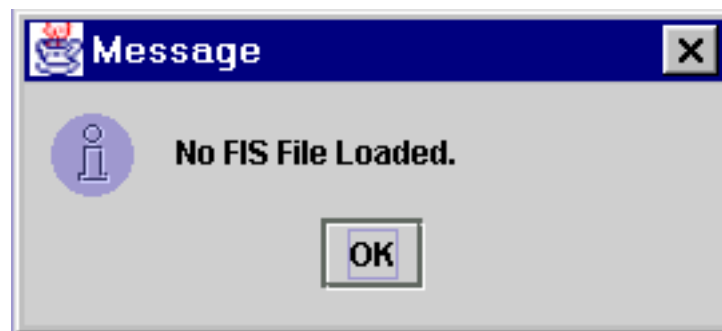
If this error occurs check to ensure an FIS file has been loaded. For more information regarding the opening of FIS files consult section 3.3.2.

3.3.4 Task 4 – Graphing the Results

a) Functional Description

Allows the relationship between the inputs and the resulting output to be graphed 3-dimensionally.

b) Cautions and Warnings

No inputs are chosen by default for graphing purposes so the user must indicate which input or inputs to include in the graph.

c) Procedures

To bring up the **Graphing Options Window**, using the main menu select **View** and then **Graph Data**. To view the relationship between one input and the result, select an input using either the **input 1 drop-down button** or the **input 2 drop-down button**.

If you want drop lines to appear on the graph click on the **drop line check box** and then finally click on the **graph button**.

If only one input is chosen this will display a 2d graph, but if two inputs are chosen using the **input 1 drop-down button** and **input 2 drop-down button** then a 3d graph will be displayed.
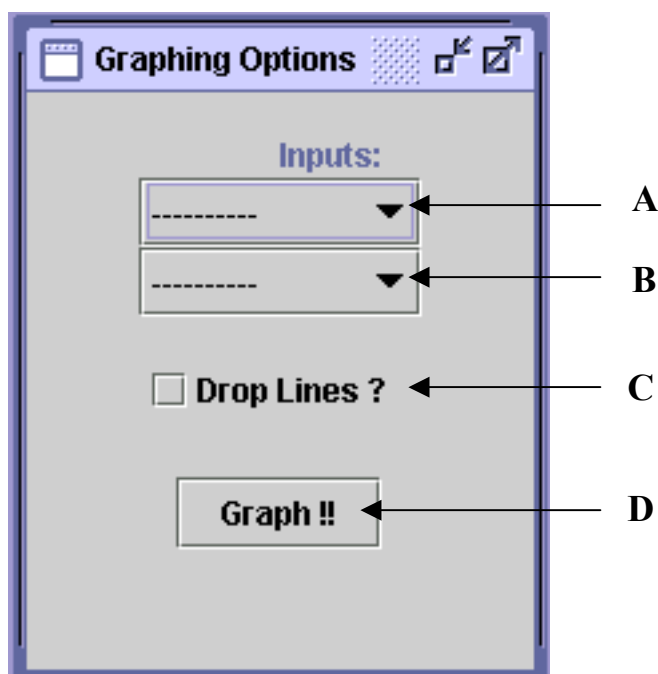
A. **Input 1 drop-down button**
B. **Input 2 drop-down button**
C. **Drop Line Check Box**
D. **Graph**

Rotating the Graph

To rotate the 3d graph hold down the left mouse button and move the mouse left or right to spin the graph left or right or move the mouse up or down to rotate the graph up or down.

d) Probable Errors and Possible Causes

Attempting to run the graphing tool without selecting at least one input to graph against the results may result in the following error.
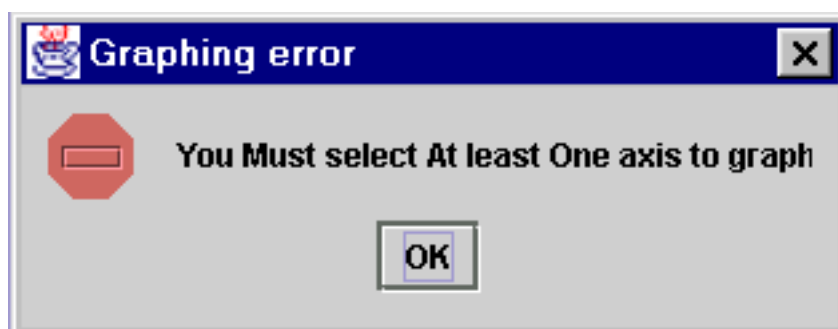
Make sure you select an input before trying to graph results.

3.3.5 Task 5 - Saving Data File and FIS File (Auto-save)

a) Functional Description

Allows the user to save any changes they have made to the data file, such as adding or removing rows or to the FIS file such as adding or removing rules from the FIS file.

b) Cautions and Warnings

During the saving process, the user will not be prompted to save over an existing file. Therefore the user should ensure that the save name is either different to other files in the directory the file is to be saved, or that the old file is no longer needed.

c) Procedures

To save changes to the current data file click on the **save changes** icon (Figure 1.1) of the **Data Window,** or to save changes to the current FIS file click on the **save changes** icon in the **Rules Window** (Figure 1.2).

Auto-Save Prompt

In case the user attempts to exit the program after modifying data or rules files, the program automatically prompts the user asking if they wish to save changes.
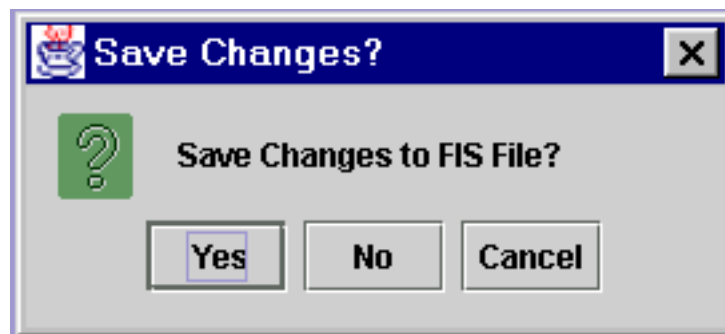
If both files were modified a second prompt will appear asking the user if they wish to save the second file.

d) Probable Errors and Possible Causes

No errors currently known.

4.0 Reference Section.

4.1 Data Window Operations – For Experienced Users

4.1.1 Add Data Row

a) Functional Description

Allows user to add additional data rows to the current data file.

b) Cautions and Warnings

It is not possible to add data rows to an empty data list or run an empty data list against an FIS file. For resulting errors relating to these operations, refer to part e) of this section.

c) Formal Description

Adding a new data row requires the user to enter values for the new row and also requires a currently open data file.

d) Examples

To add a new data row to the data file click on the **Add new data row** icon on the **Data Window** and enter the new values in to the input box (Figure 1.1). The new data row must contain the same number of inputs as the other data rows in the data file.
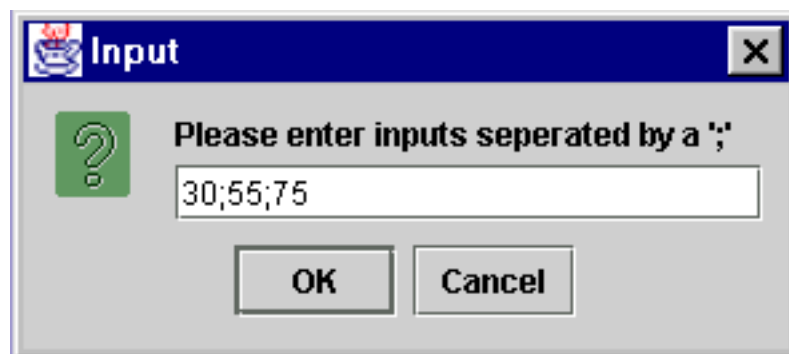
If successful the new data row should be added to the bottom of the list of data values in the **Data Window**.

e) Possible Errors and Causes

If the user does not enter the new values in correctly then the following error message will be displayed.
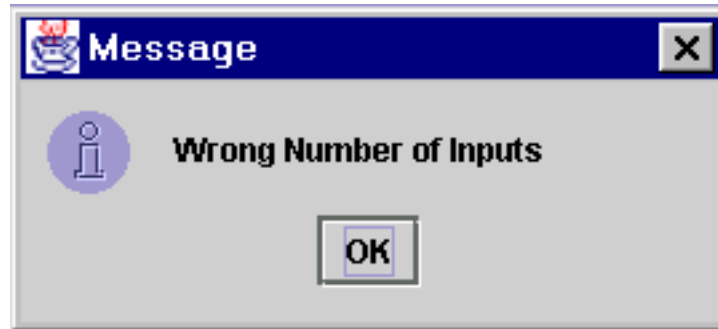
This error may occur either as a result of not entering in the same number of values, as there are columns in the data file. Check that a "**;**" has been placed between each number.

f) Cross References to Other Operations

Other related operations include deleting a data row and running a data row sections 4.1.2 and 3.3.3 respectively.

4.1.2 Delete Data Row

a) Functional Description

Allows user to delete a data row from the currently selected data file.

b) Cautions and Warnings

If all data rows are deleted then it will no longer be possible to run the program until a new data row is added or file updated.

c) Formal Description

Requires a data file to be open and a data row to be selected. Operation removes the selected row from the database but is not permanent until the data file is saved.

d) Examples

To delete a data row from the data file select the row by left clicking on it then click on the **Delete data row** icon on the **Data Window** (Figure 1.1).

e) Possible Errors and Causes

Deleting a data row should not directly result in an error, however if all data rows are removed from a data file after a run operation has been performed and an attempt is made to graph the result the following error message may occur.
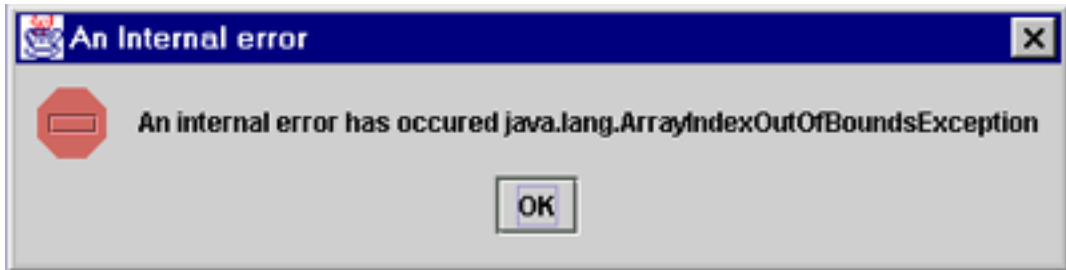
To prevent this error, run the new data set before using the graphing tool.

f) Cross References to Other Operations

See related sections 4.1.1 adding a new data row and section 3.3.3 running a data set.

4.2 Rules Window Operations – For Experienced Users

4.2.1 Add New Rule

a) Functional Description

Allows user to add additional rules to the current FIS file.

b) Cautions and Warnings

If the new rule to be added already exists in the FIS file than the identical rule will not be added.

c) Formal Description

Adding a new rule requires the user to specify which member function to apply each input to and the also the resulting output if the rule is fired. The user must also select the aggregate, for example **AND** or **OR.**

d) Examples

For example to add the rule,

If Input1 is MF1 OR Input2 is MF2 OR Input3 is MF1 then Output MF1

to the FIS click on the **add new rule** icon (Figure 1.2), and the **Add Rule Window** (shown over page) will be displayed.

Using the windows drop-down menus, set **Input 1** to 1, **Input 2** to 2 and **Input 3** to 1. Next set the **Output** to 1 and the **Aggregate** to OR.

Finally click the okay button to confirm addition of the new rule.
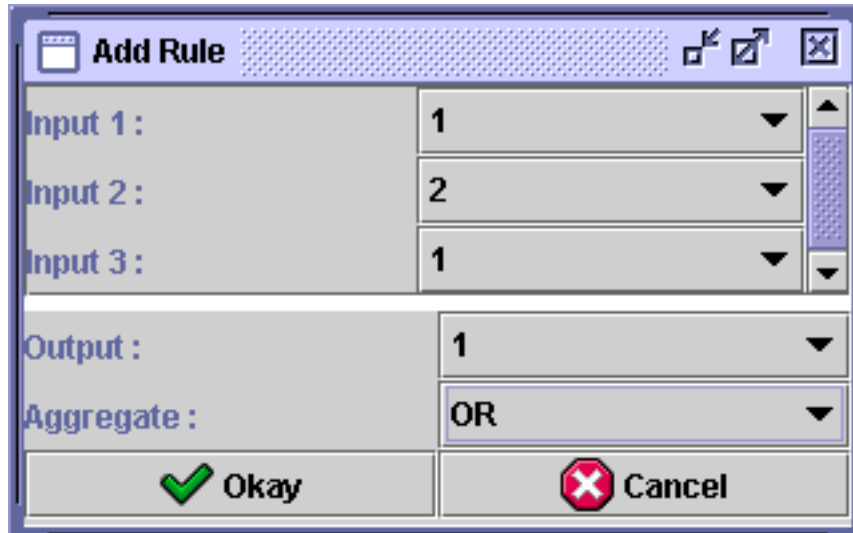
Once the rule is confirmed, the program checks to see if the rule already exists and if it doesn't, the rule is added to the FIS file.

e) Possible Errors and Causes

No current errors known.

f) Cross References to Other Operations

For related operations see section 4.2.2 deleting rules.

4.2.2   Delete Rule

a) Functional Description

Allows user to delete rules from the currently opened FIS file.

b) Cautions and Warnings

If all rules are removed from the current FIS file then no result will be obtained from a run option.

c) Formal Description

Deleting a rule is a very simple operation and only requires that there be an opened FIS file containing at least one rule.

d) Examples

To delete a rule, highlight the rule in the **Rules Window** by left clicking on it, and then click on the **delete rule** icon (Figure 1.2).

e) Possible Errors and Causes

No current errors known.

f) Cross References to Other Operations

For related operations see section 4.2.1, add new rule.

4.2.3 Disable Rule

a) Functional Description

Allows the user to temporarily disable a rule without deleting it.

b) Cautions and Warnings

If all rules are disabled in the current FIS file then no result will be obtained from a run option. Additionally the disable rule icon will only be active if a currently enabled rule is selected.

c) Formal Description

Disabling a rule only requires an opened FIS file containing an enabled rule. Unlike deleting rules however, disabling rules is a temporary way of removing a rule so that it is not fired when the program is run.

d) Examples

To disable a rule, highlight the rule in the **Rules Window** by left clicking on it, and then click on the **disable rule** icon (Figure 1.2).
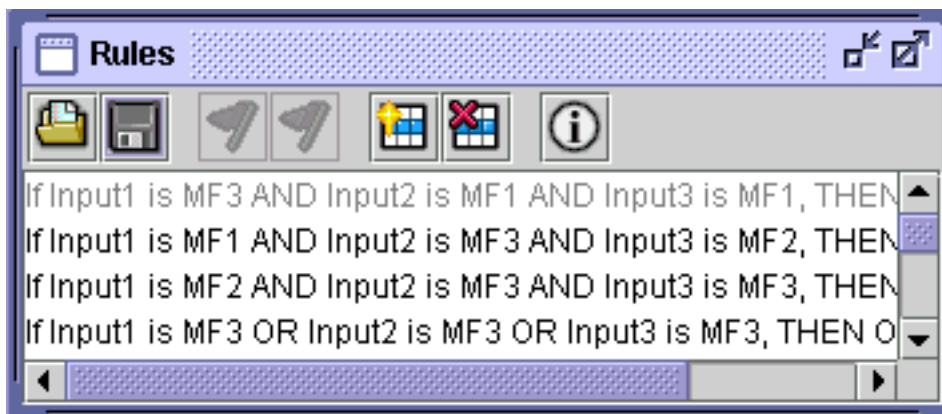
A disabled rule will then appear in grey font so it can be distinguished from active rules (black font) as indicated in the above figure.

e) Possible Errors and Causes

No current errors known.

f) Cross References to Other Operations

For related operations see section 4.2.1, add new rule, section 4.2.2, delete a rule and 4.2.4 enable rule.

4.2.4   Enable Rule

a) Functional Description

Allows the user to enable a rule that was temporarily disabled.

b) Cautions and Warnings

The enable rule icon will only be active if a disabled rule is highlighted.

c) Formal Description

Enabling a rule only requires an opened FIS file containing a disabled rule. Once the rule is enabled it can then be fired when the program is run.

d) Examples

To enable a rule, highlight a disabled rule in the **Rules Window** by left clicking on it, and then click on the **enable rule** icon (Figure 1.2). A disabled rule is displayed in grey font so it can be easily identified (see section 4.2.3). Once the rule has been enabled it will appear in black font.

e) Possible Errors and Causes

No current errors known.

f) Cross References to Other Operations

For related operations see section 4.2.1, add new rule, section 4.2.2, delete a rule and 4.2.3 disable rule.

Appendix A – Error Messages and Recovery Procedures

As the system tries to handle most errors internally, there are only a few error messages that should arise during normal use of the program.

Error: Unable to Load File: <filename>

May occur if the user attempts to load a corrupted or wrongly formatted data file or FIS file.
Check the formatting standards set out by MATLAB Fuzzy Logic Toolbox for further information.

An Internal error: An Internal Error Has Occurred java.lang.ArrayIndexOutOfBoundsException

May occur if a user runs a data file, and then closes the data window before attempting to graph the results.
Program may need to be restarted to restore proper functionality. Save and close of data windows and exit then restart the program.

Graphing Error: You must select at least one axis to graph

May occur if a user attempts to graph the results of a run operation with out selecting one or more inputs in the graphing window.
No recovery required.

Message: Wrong Number of Inputs

May occur if a user incorrectly attempts to add a new data row to the current data file.
No recovery required

Message: No FIS file Loaded

May occur if the user attempts to run a data set when there is no FIS file currently open.
No recovery required

For further information regarding these or other errors please consult section 1.7 of this document, entitled "Problem reporting instructions".

Appendix B - Glossary

☉**Fuzzy System -**A collection of fuzzy rules, Inputs and Outputs. Data is passed into the system through the System Inputs possibly activating some of the rules. The rules that are activated determine what Output will be returned from the system.

☉**FIS File -**A Fuzzy System defined in a specific format allowing it to be recorded into a file on disk.

☉**Fuzzy Rule -**A factor affecting the output of a fuzzy system. Each rule describes a situation using the inputs, if the inputs fit the range defined by that rule then that rule is said to have fired and the output is affected.

☉**Input -**A piece of data being passed into the System. Each input represents some factor affecting the system.

☉**Output -**A piece of data being returned from the System. Each output represents a factor calculated by the system.

☉**Member Function -**Provides a description to a given range of Input Values, also determines how well a data element fits that description. Each Input and Ouput contains multiple Member Functions. An Input may be describing Age, the Member Functions for that Input may be 0-30 = 'Young', 30 - 60 = 'Middle Aged', 60 - 100 = Old.

☉**Fire Weight -**A representation of how well the data fits the rule. The more the data fits the rule the greater the fire weight percentage.

☉**Data File-**A file containing data elements for each of the inputs for a given system. The file may have more than one data row, each Data Row contains one value for each Input into a system.