G53FUZ Coursework (2012/13)

Designing and Tuning a Fuzzy Inference System

Overview

The coursework is to design an imaginary fuzzy inference system for advising a doctor whether a patient should be referred to a hospital for emergency investigations based on two biomedical inputs: the patient's temperature and blood pressure. You will create several different fuzzy inference systems, with different terms in the linguistic variables, different membership functions and different rules, carry out inference using different operators and different defuzzification techniques (and perhaps other similar variations), and tune the various models by analysing the performance of the various systems. You will write a report on your various fuzzy models and discuss which is your 'best' final model. Marks will be awarded for the processes employed and the analysis carried out, rather than the absolute performance of your final system (there is no 'correct' final model that you must end up with).

Scenario

The following scenario is obviously a simplified version of a real medical scenario, but nevertheless you will need to use the same principles and processes involved in creating a solution for a realistic real-world scenario. You have been asked to create a fuzzy inference system (FIS) to provide advice to family doctors that they can use to assess patients when they come in with an illness, to establish whether the patient needs to be sent to hospital for emergency attention. In this very simple scenario, the FIS will take two inputs, *Temperature* and *BloodPressure*, which will be represented as two fuzzy linguistic variables, and produce a single output, *Urgency*, which represents the degree of urgency (or severity) of the patient's condition. When provided with numerical inputs in terms of temperature and blood pressure, the system will use a set of rules like:

- IF *Temperature* is *high* AND *BloodPressure* is *low* THEN *Urgency* is *medium*
- IF *Temperature* is *very high* AND *BloodPressure* is *very high* THEN *Urgency* is *emergency*

to produce a single numerical output in the range 0 to 100, with 0 meaning the patient's condition is not at all urgent (no need to go to hospital) and 100 meaning extremely urgent (rush to hospital as quickly as possible). Hint: for both variables there is a normal range, and both low and high values can indicate a health problem. Feel free to research normal and abnormal ranges of temperature and blood pressure on sites such as *Wikipedia*, *NHS Direct* and so on.

Fuzzy Inference System(s)

You should develop a variety of different FIS using R and the R Fuzzy Toolkit. When constructing various FIS models, you should consider:

- the number of terms in each input variable (3, 5 or 7 terms) and in the output variable (3 or 5 terms), giving each term an appropriate linguistic label
- various types of membership functions (triangular, trapezoidal, Gaussian, sigmoidal)
- the precise parameters of each membership function
- the rules that connect the input terms to the output terms
- the fuzzy operators used within the FIS (consider both min-max and prod-probor families)
- various defuzzification methods

You can make up the various terms in the variables and the rules within your FIS (this is not a test of actual medical knowledge) in order to create systems with the properties you require. You should examine the output of different systems at various inputs, including by using **gensurf** to plot the input-output surface.

FIS Deliverable

Save your single final 'best' FIS and hand it in as described below. This final FIS must be loadable into R and should be able to create your final surface plot via **gensurf**.

Data Report Deliverable

In addition to your final FIS, you must submit a written report describing the fuzzy modelling process conducted. The length of your report is **1000 - 2000 words (maximum) and eight sides of A4**, *excluding the cover page, but **including all** tables and figures*, minimum font size 11pt (a full page of text in a similar style to this document would contain about 800 words, so the only around 2½ pages **maximum** of the total report will be text). The report should clearly explain what you did, how and why you did it, and should be well structured and illustrated. It is alright to use less than 2000 words if you are able to describe the details required. Your report should consist of three main sections. The first should describe the various models you have created, taking into account the various model choices described above. The second section should detail the final model, including its configuration and its full rule set. You must include the final input-output surface plot created using **gensurf**, and provide illustrative example input-outputs. The third section should briefly discuss why you have arrived at this final system, and discuss its operation (why do you feel it works well). You should not include lengthy code, or raw output in the main body of your report, but you may include these in appendices. Note that appendices will not contribute to the word count, and are not explicitly marked: they are for additional reference only. While marks will not be specifically deducted for going over length, ONLY the first 2000 words will be marked (so, for example, if you use 2000 words in Sections 1 & 2, as per below, you will receive no marks for Section 3).

Assessment Criteria and Marking Guidelines

The report will be assessed out of 50 marks as follows:

- **Section 1 – Description of Alternative Fuzzy Models** [15 marks]: Marks will be awarded for the variety of different models you consider, the creativity and imagination used in deriving the terms, membership functions, rules, etc. While not describing every alternative model in detail, you should provide evidence that you have implemented these.
- **Section 2 – Detail of Final Fuzzy Model** [15 marks]: Marks will be awarded for the clear and accurate description of your 'final.fis', proper creation of input-output surface, and examples.
- **Section 3 – Discussion of Final Fuzzy Model** [10 marks]: Marks will be awarded for the clarity and depth of discussion as to why you consider your final FIS to work well, why you made the choices you made, how you have assessed its performance, and whether you feel it is of good standard. Discuss limitations of your final FIS and/or problems you encountered.

A further 10 marks will be awarded for the overall structure, style and presentation of your report. A first class report would have a clear structure with appropriate sub-headings, well written, clear informative text, and clear and attractive pictures, graphs and tables. There is no need to provide references. Note that your 'final.fis' code will not be marked separately – it is only to confirm that your final FIS does actually work as described in your report.

Plagiarism vs. Group Discussions

As you know, plagiarism is completely unacceptable and will be dealt with according to the University's standard policies. Having said this, we do encourage students to have general discussions regarding the coursework with each other in order to promote the generation of new ideas and to enhance the learning experience. This being said, you must be very careful not to cross the boundary into plagiarism. The important part is that when you sit down to actually do the fuzzy modelling and write about it, you do it individually. If you do this, and you truly understand what you have written, you will not be guilty of plagiarism. Do NOT, under any circumstances, share code, figures, or graphs, etc.

Deadline and Submission Procedure

- The submission deadline is Wednesday 1st May via Moodle.
- Name your FIS file FUZ-FIS-XXX.fis, and name your report FUZ-CWK-XXX.pdf, where XXX should be replaced by your student ID number (e.g. 4078181)
- Submit both files via Moodle (see website for details).
- A late penalty of *5% per calendar day (**including weekends**)* will be applied, to a maximum of one week (7 calendar days), after which a mark of zero will be automatically awarded.