UNIVERSIDADE D COIMBRA

MEB, MEI, MES, MIEBIOM

Aprendizagem Computacional/Machine Learning

Computação Neuronal e Sistemas Difusos/ Neural Computation and Fuzzy Systems

Departamento de Engenharia Informática

2021/2022

ASSIGNMENT 3

Degree of Maturity Recognition

1. Context and document structure

The main goal of this work is to develop a fuzzy inference system that recognizes the degree of maturity of a crop.

Before starting you should:

- study Chapters 6 and 7,
- read this document until the end,
- consult MATLAB Mathworks help, namely (but not only):
  - https://www.mathworks.com/help/fuzzy/building-systems-with-fuzzy-logic-toolbox-software.html
  - https://www.mathworks.com/help/fuzzy/types-of-fuzzy-inference-systems.html
  - https://www.mathworks.com/help/fuzzy/
  - https://www.mathworks.com/help/fuzzy/fis-parameter-optimization-with-k-fold-cross-validation.html

The assignment is to be completed in 2 weeks. Students should implement their solutions and answer the challenges in a **report** that should be submitted on Inforestudante together with the **MATLAB code files** before the deadline: 10/12/2021.

Conditions: Groups: two elements of the same PL class

Duration: 2 weeks

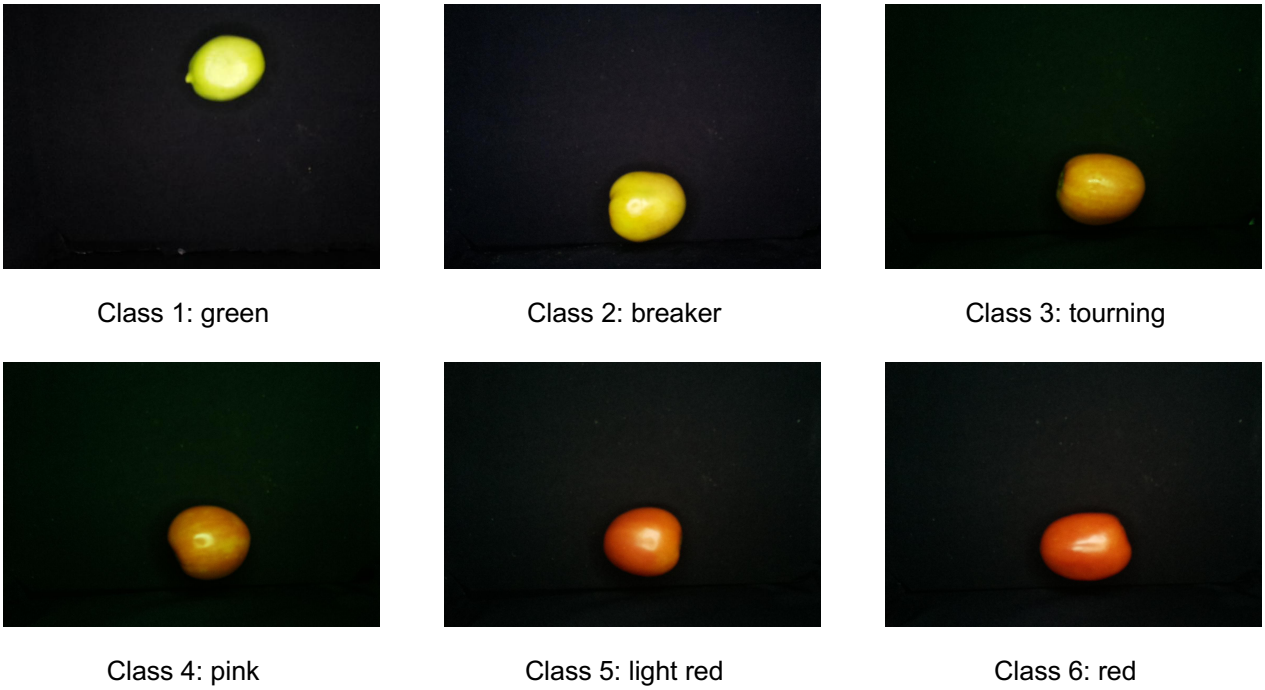
Workload: 8h per student

Document structure:

2. Degree of Maturity Recognition

2.1 Problem definition

The problem to be addressed is the recognition of the degree of maturity stage according to these classes:



Class 1: green | Class 2: breaker | Class 3: tourning

Class 4: pink | Class 5: light red | Class 6: red

Figure 1 Examples of images of the classes with the degree of maturity

2.2 Dataset information

The dataset is provided in six folders, available as a file Maturity.zip, one for each class, containing jpg color images of the examples of each class:

Table 1 Number of examples per class in the maturity recognition problem

Class	Number of examples
1	124
2	140
3	120
4	196
5	208
6	72

3. Fuzzy Inference Systems (FIS)

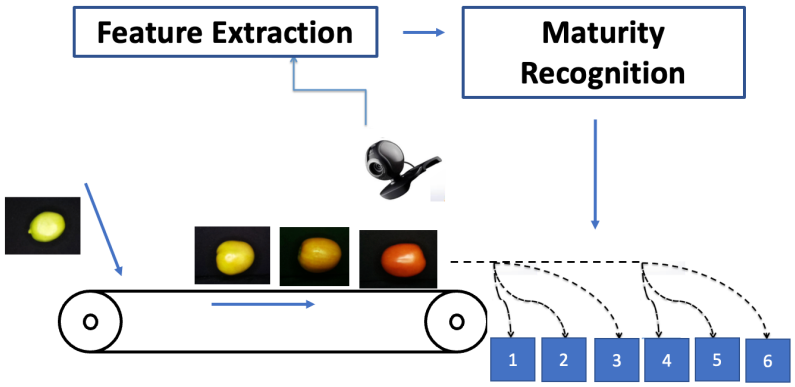


Figure 2 Degree of maturity recognition system

The goal is to implement and compare two types of fuzzy inference systems:

- Mamdani with (i) 9 rules, (ii) 25 rules
- Sugeno with (i) 9 rules, (ii) 25 rules

Nevertheless, students can propose alternative configurations that better fit the problem.

The system to be implemented should support the functioning of Figure 2, namely the two parts:

1. the images in the dataset should be preprocessed to determine the best representation
2. the FIS should be performing the maturity recognition

Different hypotheses for both parts should be proposed and tested. Notice that, as in all Machine Learning systems, appropriate train (, validation) and test sets should be defined to assure the proper generalization of the resulting solution.

4. Report

The report should focus the following:

1. Data set and feature representation

How does the data set and feature representation influence the performance of the recognition system?

2. FIS architecture

Which architecture provides better results, discussing the choices that were put in place.

3. Results

Is the recognition system able to achieve the main objectives (maturity recognition)? Which is the percentage of well classified examples?

How is the generalization capacity? Is the recognition system robust enough (to give correct outputs when new inputs are provided)? Which is the performance of well classified new inputs? Does it vary with the class?

The delivered report file must be named **ML2021MatRecPLxGy.pdf**, where x is the number of the class and y is the number of the group in the class, to ease its identification.

All the files, including the pdf report and data files, must be packed in a .zip or .rar that by uncompressing will create the directory structure adequate for running the scripts. The compressed file (zip or rar) must have the name **ML2021MatRecPLxGy.pdf**.zip[.rar]

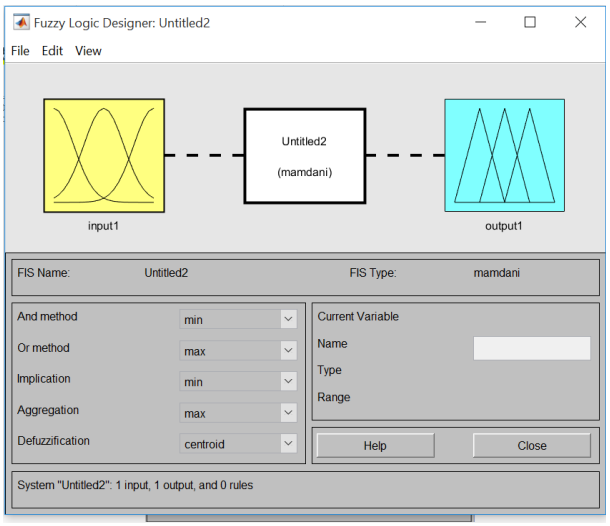
Please make easy the tasks of the reader and the user of your software (many thanks for that).

5. APPENDIX - MATLAB Implementation Notes (from Prof. António Dourado, last year's)

Using the *fisditor*, writing in the Matlab command line

>fuzzyLogicDesigner (or > fuzzy, previous version still working)

a very practical GUI is opened to design a rule based fuzzy system, either Mamdani or Sugeno type.



Basic window of *fiseditor*

The several menus of *fiseditor* allow

- to define the number of inputs and outputs (edit > add/remove variable),
- define the membership functions for each input and each output (edit> membership functions),
- to write the rules using the created membership functions (edit> rules).

The several operators for conjunction/disjunction of the antecedents (And/Or method), for implication, for aggregation of the outputs of each rule, the defuzzification method, studied in the classes, are chosen in the shown window.

After creating the fuzzy system, it is saved, for example named *myController.fis,* in a file (export it with file>export>to file), for posterior use, and it must also be exported to the Matlab working space (file > export > to workspace).

To use a controller previously developed, it must be firstly imported to the fiseditor (file>import>from file) and afterwards exported to the working space. If you try to execute 'myController.fis' in the command line, an error appears, because it takes the file as ASCII. **To import a fis from a directory to the working space may be done through the fiseditor or by the function readfis:**

FISMAT=readfis('filename') creates a FIS matrix in the workspace corresponding to the FIS file 'filename' on disk.

Too save a fis in a directory, the function writeFIS(FIS) can be used. See Matlab help.

Controllers to be implemented (minimum requirement):

- Mamdani with (i) 9 rules, (ii) 25 rules
- Sugeno with (i) 9 rules, (ii) 25 rules