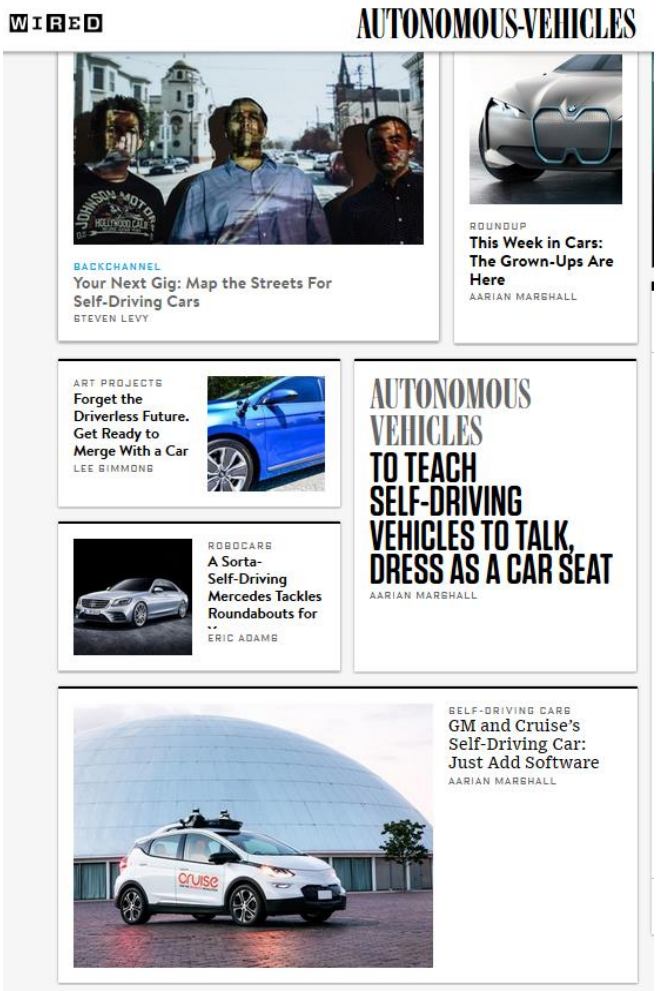
Planning and Approximate Reasoning

Practical Exercise 2: Fuzzy Expert Systems

- This practical exercise may be done individually or in teams of two students.
- The solution of the exercise must be uploaded in PDF into the Moodle URV platform **before December 17th, 2017, 21:00.**
- The exercise has to be done with the FuzzyTech software (for Windows). Laptop computers to lend are available at UPC if needed. www.fuzzytechcom
- You have to generate the documentation automatically with FuzzyTech. After that, you may remove the information that is not relevant (examples) and add the explanations required below.



News about autonomous vehicles have filled many newspapers and journals during the last months mainly due to the announcements of self-driving cars.

In this exercise we will design and construct a fuzzy expert system for assisting a self-driving car by analyzing weather conditions and taking the appropriate control decisions.

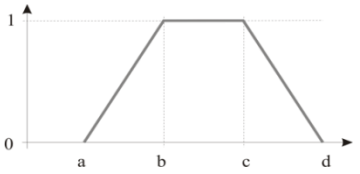
The information used may not correspond to reality. The purpose is just illustrating how fuzzy rules are suitable in this problem. In fact, they've been studied and showed great success as you can read about the AUTOPIA project in:

http://ieeexplore.ieee.org/document/4078954/

In this exercise, you must design a fuzzy expert system that uses the ***Mamdami inference procedure (min-max)*** and the defuzzification method ***"Center of Area" (CoA).***

Task1. Construct a rule block to calculate the **visibility level** using the following input variables: **rainfall** (in mm/h), **lightness** (using the scale of the L component in the HLS color model[1]) and **fog intensity** (in %). Use the definition given in the tables below for those 3 input linguistic variables. You can define the output variable as you consider appropriate.

NOTE: The trapezoidal functions which define each of the linguistic terms of the variables are given in the (a,b,c,d) format, being its graphical representation:



Rainfall

Negligible	(0,0,1,2)
Low	(1,2,8,10)
FairlyLow	(8,10,15,17)
Moderate	(15,17,30,40)
High	(30,40,100,100)

Lightness

Dark	(0, 0, .2, .4)
Cloudy	(.2, .4, .6, .8)
Clear	(.6, .8, 1, 1)

Fog

None	(0, 0, 10, 15)
Light	(10, 15, 30, 35)
Medium	(30, 35, 50, 60)
Strong	(50,60,100,100)

Define a set of rules according to your criteria. Remember that you can define rules with different number of premises and different confidence. Explain the rationale of your rules.

Once the car computer has calculated the visibility level, this value will be used for two different control tasks:

- Turn on the lights of the car
- Calculate the security distance to the front car

Now, the visibility level calculated into the vehicles computer system will be used to control two different elements of the car.

Task 2. Construct a second rule block that transforms the visibility level into one of the following **light instructions**: none, parkingLight, lowBeam.

Explain how you have decided the fuzzy sets of this variable and also explain the motivations for the proposed rules.

Task 3. Construct a third rule block with two three inputs: **visibility level, rainfall and tires pressure.** The output will be the **safe distance to the front car** (measured in meters).

Explain how you have decided the fuzzy sets of the new variables (pressure and distance) and also explain the reasons for the proposed rules.

[1] HLS color model: https://en.wikipedia.org/wiki/HSL_and_HSV#Lightness

Task 4. Testing the fuzzy expert system. Define 3 car situations, showing different weather and car conditions. Find interesting cases in which many rules are applied at the same time with different degrees of satisfaction.

4.1 Show in FuzzyTech the outputs of your expert system for these 3 cases (the final and intermediate).

4.2 Calculate manually (step by step) the final defuzzified value for the variable "Visibility level" for one of the cases that activates several rules concluding different outcomes.

4.3 Change the Degree of Support of some rules in the last block and analyze the consequences on the results.

4.4 Using the graphical tools of FuzzyTech, show which is the influence of the "tires pressure" in the determination of the safe distance to the front car.

Evaluation Criteria Fuzzy Expert System Exercise

Variables

- Names of the labels are appropriate (give insightful meaning)
- The number of labels is appropriate according to the range of the variable
- It is a fuzzy partition
- They have some unbalanced situations (i.e. not equally distributed)
- Implementation in FuzzyTech is correct

Rules

- The rules are correctly constructed
- They cover all the cases (all combinations of labels match with one rule), without duplication
- There are rules of different length
- Implementation in FuzzyTech is correct

Explanations

- Student provides explanations about the definition of the linguistic variables, supported with references to sources of information
- Student provides explanation about the meaning of the rules
- In case of using different DoS, it is explained why

Profiles

- Testing profiles are diverse, modelling different kind of situations
- Some profiles activate more than one rule, and others only one
- Their meaning is explained (what case each profile is representing)

Results

- Execution with FuzzyTech with the Debug mode is correct
- The document displays the results for all the cases with details about the output and the rules activated (screenshots)
- The meaning of the results is explained

Manually

- The manual calculations are correct
- All the steps are given (fuzzyfication, activation of rules, union of conclusions, defuzzification for all the rule blocks).

Other questions

- Changes are done correctly
- The answer to the final questions is correct
- Graphical support with FuzzyTech is given