Homework # 4

CIVE 646 - Water Resources Systems: Planning and Management

(Fall 2011-12)

Topics: Fuzzy logic

Problems

1. The question of whether a glass of water is half-full or half-empty is an age-old philosophical issue. Such descriptions of the volume of liquid in a glass depend on the state of mind of the person asked the question. Develop membership functions for the fuzzy sets ''half-full,'' ''full,'' ''empty,'' and ''half-empty'' using percent volume as the element of information. Assume the maximum volume of water in the glass is V_0. Discuss whether the terms ''half-full'' and ''half-empty'' should have identical membership functions. Does your answer solve this ageless riddle?

2. Industry *A* discharges wastewater into a nearby river. Wastewater contains high biological oxygen demand (BOD) and other inorganic contaminants. The discharge rate of rivers and wastewater is constant through the year. From research, it has been found that BOD values not exceeding 250 mg/L do not cause any harmful effect to aquatic ecosystems. However, BOD values higher than 250 mg/L have significant impact. Draw both a crisp and fuzzy membership function to show the effects of the BOD value on aquatic ecosystems.

3. A fuzzy set for a major storm event in Calgary, Alberta, could be described as a rainstorm in a subdivision that raised the level of the storm-water pond to within 70% of its design capacity. The membership function for a major storm set could be described as having full membership when 70% of the pond volume has been reached but varying from zero membership to full membership at 40% capacity and 70% capacity, respectively. Draw a typical membership function as it is described.

4. In soil mechanics soils are classified based on the size of their particles as clay, silt, or sand (clays having the smallest particles and sands having the largest particles). Though silts have larger particles than clays, it is often difficult to distinguish between these two soil types; silts and sands present the same problem. The following table shows a crisp classification of the soil types according to their grain size. Develop membership functions for these three soil types, in terms of their grain size, S.

Soil type	Grain size diameter (mm)
Clay	0.0001 – 0.002
Silt	0.002 – 0.06
Sand	0.06 – 2

5. Lebanese planners have developed a specific set of five water dams to be undertaken. The financial capability of Lebanon doesn't permit the execution of these projects in one lot; additional evaluations have to be performed to determine the priority preorder of these projects.

Accordingly, the need for a reliable macro priority planning of water resources projects was recognized by Lebanese decision-makers and water resources planners. Hence, it was decided to develop a flexible tool that could elaborate priority preorders of water projects and evaluate them in terms of their social, environmental and economic impacts. The priority is given to the projects that have direct positive impact on the country social and economic development. The following relevant variables were identified:

- Water Quantity (*WQ*)
- New energy resources (*NER*)
- New Eco-Systems (*NES*)
- Cost Effectiveness (*CE*)
- Motivation of Monetary Funds (MMF)

The following table I provide definitions of each of the variables, variables evaluation functions and measurable factors by which the functions can be evaluated and compared.

Table I: Definitions and presentation of variables

Variable Name	Variable Description	Variable Measurable Factors	Variable Evaluation
Water Quantity (WQ)	The purpose of this variable is to measure the water quantity that could be produced after the execution of the project. It takes values between 0 and 1	*EW* = The expected water quantity that could be produced after the execution of the project. *TW* = Total water quantity still required for the country.	$WQ = \frac{EW}{TW}$
New Energy Resources (NER)	The purpose of this variable is to measure the relative density of the expected energy from hydropower plant that could be produced after the execution of the project. It takes values between 0 and 1	*EN* = The expected energy that could be produced after the execution of the project. *TEN* = Total energy still required for the country.	$NER = \frac{EN}{TEN}$
New Eco-Systems (NES)	This variable concerns the density of Eco-systems land that could be developed after the construction of project. It takes values between 0 and 1	*EC* = The expected Eco-system land area that could be developed after the execution of the project. *TEC* = Total area of Eco-systems land still required for the country.	$NES = \frac{EC}{TEC}$
Cost Effectiveness (CE)	This variable concerns the Cost-benefit analysis of project based on a life span of 50 years.	*B* = Benefits *PC* = Project Cost (Investment + Operation and maintenance).	$CE = \frac{B}{PC}$
Motivation of Monetary Funds (MMF)	This variable concerns the motivation degree of those who could finance the project. This necessitates measuring the feasibility of the project at an accepted interest rate on the investment cost. It is evaluated by applying an interest rate of 8% to the investment cost of the project and recalculating the benefit-cost ratio.		

The evaluations of each project according to each variable mentioned above are presented in the following table:

Evaluation of projects according to the defined variables

Variables	Project 1	Project 2	Project 3	Project 4	Project 5
WQ	0.11	0.15	0.06	0.18	0.15
NER	0.5	0.58	0.42	0.42	0.5
NES	0.32	0.39	0.35	0.41	0.37
CE	1	1.5	1.2	1.2	0.84
MMF	0.5	0.8	0.64	0.64	0.4

Develop a fuzzy rule-based system to evaluate the priority index of each project.

Fuzzy toolbox of MATLAB:

Implement and solve the **Problem 5** using the fuzzy toolbox of MATLAB.

Given: Wednesday October 26, 2011

Due: Wednesday November 9, 2011

IMPORTANT NOTES

- Homework should be submitted on time.
- Homework should be clean, organized, and professional.

If you do not satisfy the above, your homework may be returned to you without grading.