GALWAY-MAYO INSTITUTE OF TECHNOLOGY

Department of Computer Science & Applied Physics

Fuzzy Logic with Sugeno Inference

In this lab we will implement the "dapping" example from the handouts using the JFuzzyLogic API and see how different Mamdani defuzzifiers (COG, MOM, SOM and LOM) effect the output. We will also implement the same set of fuzzy rules, but this time using a Suegno inference model.

Dapping is a traditional form of fly fishing that is common in the West of Ireland on the great western lakes (Lough Corrib, Lough Mask, Lough Conn etc.). This form of fishing involves impaling a live insect, such as a mayfly, a cranefly or a cricket, on a hook. The "livebait" is then fished on the surface of the water from a drifting board using a long dapping rod, typically 15+ feet. The wind is allowed to blow the fly out on to the water ahead of the drifting boat to tempt an unsuspecting trout. The success of this techniques relies on a decent wind and a high enough temperature. Dapping is very ineffective on a calm day and difficult to control in gusty or stormy weather. Ideal conditions are a force 6-7 wind and a temperature of 16-21 degrees.

Use the JFuzzyLogic API to implement the fuzzy sets for the input linguistic variables wind and temperature that are shown in the handouts. The name of the function block should be "**getDappingLevel**". As the JFuzzyLogic API does not support hedges, use the following 4 rules to implement the behaviour of the "expert dapper" system:

- RULE 1 : IF **wind** IS **stormy** OR **temperature** IS **low** THEN **dapping** IS **poor**;
- RULE 2 : IF **wind** IS **fresh** AND **temperature** IS **average** THEN **dapping** IS **mediocre**;
- RULE 3 : IF **wind** IS **stormy** OR **temperature** IS NOT **low** THEN **dapping** IS **excellent**;
- RULE 4 : IF **wind** IS **calm** AND **temperature** IS NOT **average** THEN **dapping** IS **poor**;

To start with, use the **COG** method of defuzzification and execute the inference system using a method similar to the following:

```
public double getDappingLevel(int windBeaufort, int tempCelsius) {
    FIS fis = FIS.load(FCL_FILE, true);
    FunctionBlock fb = fis.getFunctionBlock("getDappingLevel");
    fis.setVariable("wind", windBeaufort);
    fis.setVariable("temperature", tempCelsius);
     fis.evaluate();

     Variable dapping = fb.getVariable("dapping");
     JFuzzyChart.get().chart(fis);
     JFuzzyChart.get().chart(dapping.getDefuzzifier(), "Dapping Level", true);

    return dapping.getValue();
}
```

For the inputs wind=8 (Beaufort scale) and temperature=10 (Celsius) the COG defuzzifier should return a dapping "goodness" of 53.41%. Change the defuzzifier to each of the following Mamdani alternatives and then execute the inference system again on the same inputs:

- **MM**: Mean of Max //MOM
- **LM**: LeftMostMax //Same as Smallest of Max (SOM)
- **RM**: RightMostMax //Same as Larges of Max (LOM)

Examine the output results and defuzzifier chart for each of these forms of defuzzification. **Note:** the MM defuzzifier seems to be bug-ridden.

- Change the defuzzifier to **COGS** and execute the inference system again. You should get the following error message: ***MembershipFunction and Defuzzifier are neither both discrete nor both continuous***. The error relates to the fact that we are trying to use a **discrete** defuzzifier (**COGS**: Center Of Gravity Singletons / Sugeno) with a **continuous** membership function for the linguistic variable ***dapping***.

Create a new FCL file with the name "**dappingSugeno.txt**" and copy and paste into it the Mamdani *getDappingLevel* function block. Change the fuzzy set definitions to following:

```
FUZZIFY wind
  TERM calm := 2;
  TERM fresh := 6;
  TERM stormy := 10;
END_FUZZIFY

FUZZIFY temperature
  TERM low := 5;
  TERM average := 12;
  TERM high := 17;
END_FUZZIFY

DEFUZZIFY dapping //Method body....
  TERM poor := 25;
  TERM mediocre := 50;
  TERM excellent := 75;
  METHOD : COGS;
  DEFAULT := 5;
END_DEFUZZIFY
```

Make sure that the defuzzifier is set to COGS and execute the inference system again. Examine the output results and the defuzzifier chart and compare the results to the different Mamdani defuzzifiers.