Fuzzy Logic

Defuzzification

Membership Function

The Defuzzification process

Defuzzification is the process of producing a crisp value given fuzzy sets and corresponding membership degrees.

It is the process that maps a fuzzy set to a crisp set.

Recall that an FIS has fuzzy rules that transform a number of variables into a fuzzy result.

Defuzzification is interpreting the membership degrees of the fuzzy sets into a specific decision or real value.

A simple defuzzification method

Assume that we have to build a fuzzy controller that controls amount of fuel to be injected into a car engine

We can have three possible decisions (outputs): “Lot”, “Moderate”, “Low”

Recall that there will be several rules, and each will have a different firing strength.

Assume that rules designed to decide how much fuel to inject, for a specific instance, result in

- Lot (0.10), Moderate (0.30), Little (0.70)

The simplest but least useful defuzzification method is to choose the set with the highest membership.

In our example “Little" will win since it has a 0.70 membership

This defuzzification ignores other rules and converts this 0.70 to some number.

The problem with this approach is that it loses information.

The rules that gave “Lot” or “Moderate” do not have any effect on the final outcome.

The Center of Gravity method

"Lot (0.10), Moderate (0.30), Little (0.70)" – inputs for de-fuzzifier.

Let there be membership functions

$$\mu_{Lot}(x),\ \mu_{Moderate}(x),\ \mu_{Little}(x)$$

Assume these to be triangles (for the sake of simplicity)

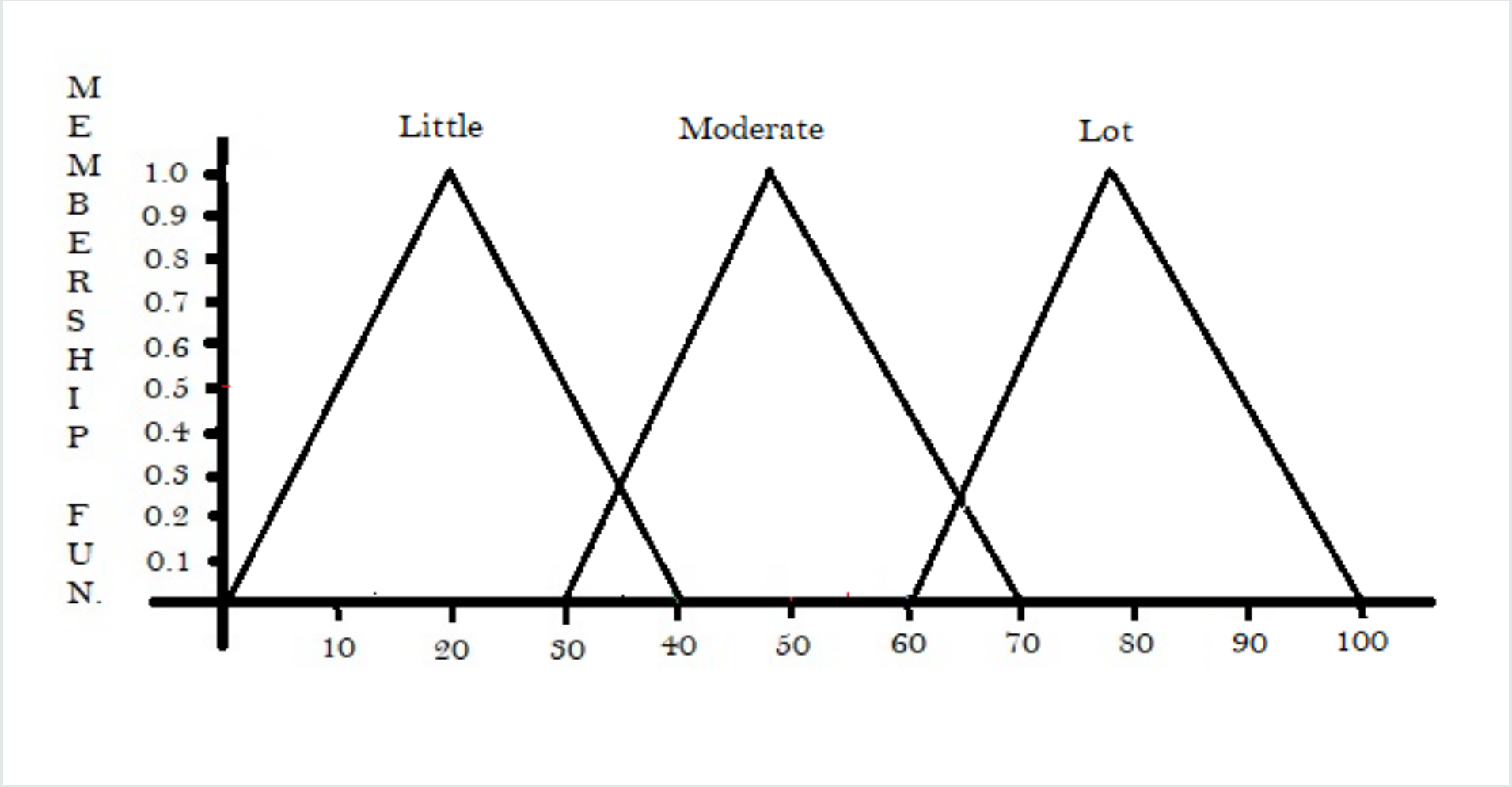
You can assume any other suitable shape.

Derive $\mu'_{Lot}(x)$, $\mu'_{Moderate}(x)$, $\mu'_{Little}(x)$ by chopping from the top the respective MFs at the values 0.1, 0.3 and 0.7.

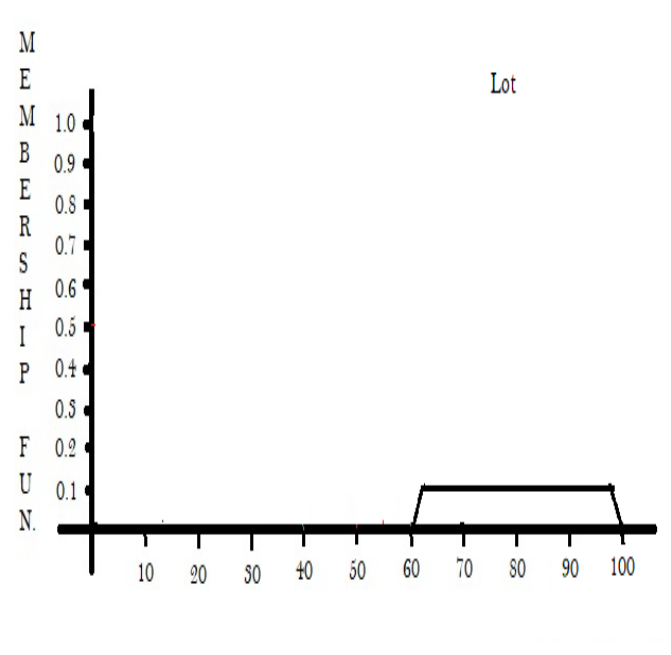
This will lead to trapezoidal shapes.

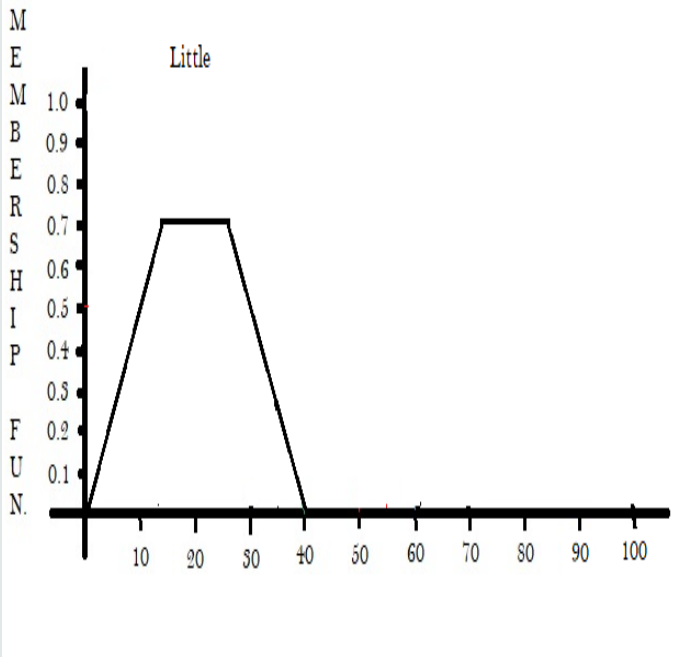
Now, add these shapes and find the CoG.

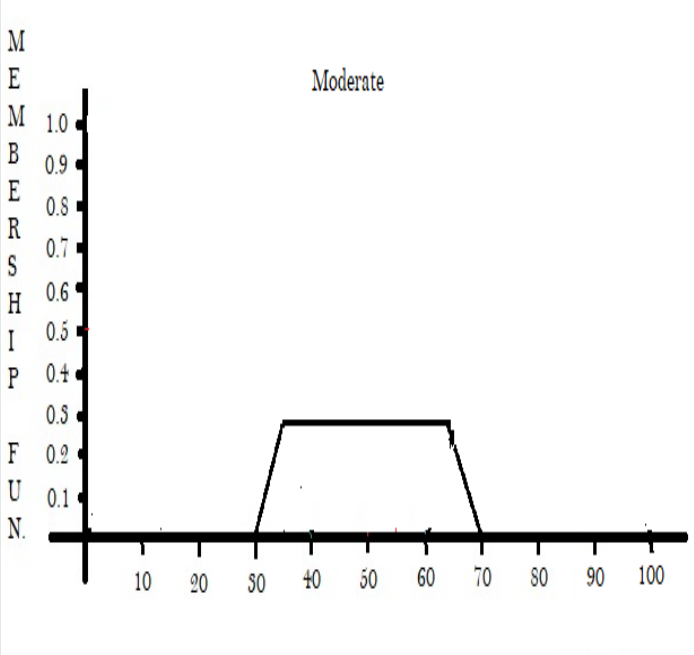
The Membership Functions



The truncated Membership Functions







The Center of Gravity method contd.

Note that we have just created α-cuts for the three MFs.

The α values are:

- 0.1 for $\mu_{Lot}(x)$
- 0.3 for $\mu_{Moderate}(x)$
- 0.7 for $\mu_{Little}(x)$

The actual α *values are obtained only at run time*

This created trapezoids with different bases

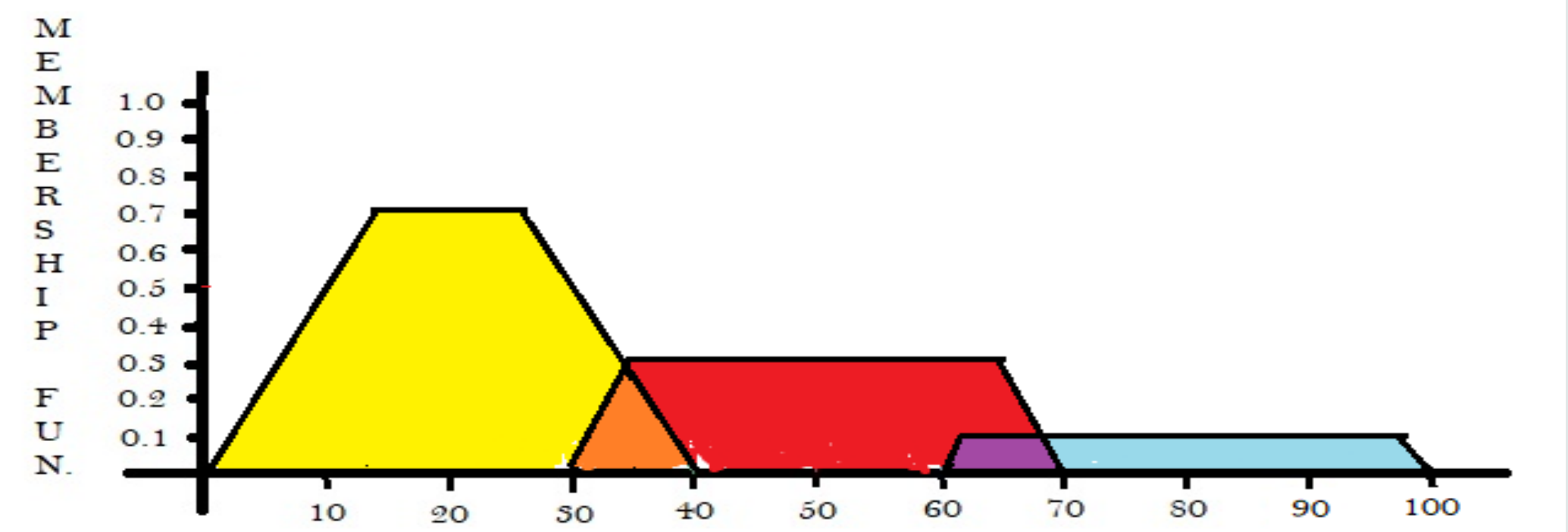
- since we chose triangles

For the CoG method, add these figures geometrically

Then find the CoG of the resulting figure.

The resultant trapezoid

Notice the overlapping areas



Calculating the CoG

So, how do we get the CoG for the resultant?

$$z = (\sum_{j=1}^{Q} Z_j \mu_c(Z_j))/(\sum_{j=1}^{Q} \mu_c(Z_j))$$

z is the CoG

$\mu_c(Z_j)$ is the membership in class ‘c’ at value Z_j

Calculating the CoG can be time consuming if we have complicated membership functions