1 Fuzzy Application for Tipping Problem (FIS Mamdani)

Source Reference : Fuzzy Logic Toolbox User's Guide For Use with Matlab Version 2

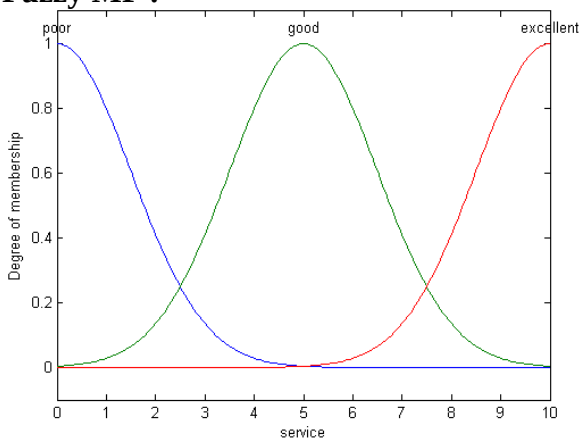
Problem : (From page 58 pdf)
Given a number between 0 and 10 that represents the quality of service at a restaurant (where 10 is excellent), and another number between 0 and 10 that represents the quality of the food at that restaurant (again, 10 is excellent), what should the tip be?

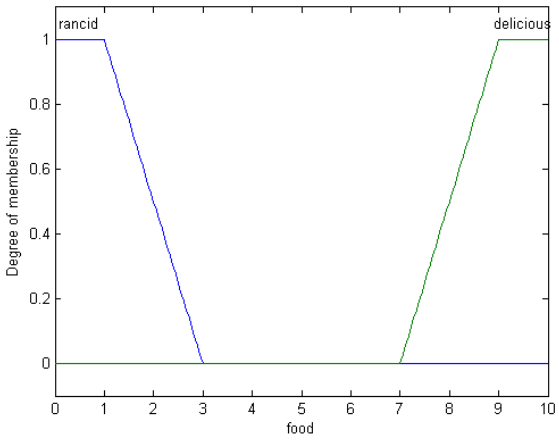
Fuzzy Rule : (From page 58 pdf)
1. If service is poor or the food is rancid, then tip is cheap
2. If service is good, then tip is average
3. If service is excellent or food is delicious, then tip is generous

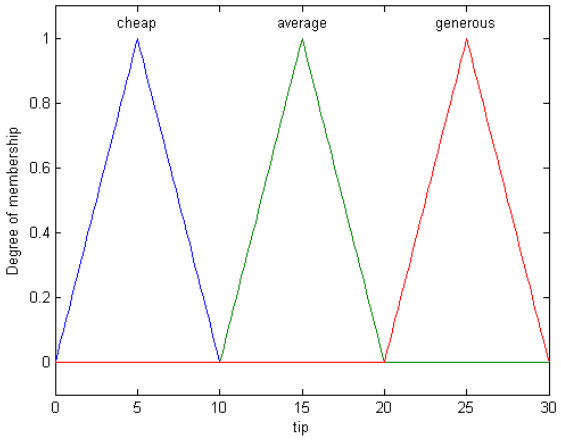
From page 83

```
a=newfis('tipper');
a=addvar (a,'input',1,'service',[0 10]);
a=addmf(a,'input',1,'poor','gaussmf',[1.5 0]);
a=addmf(a,'input',1,'good','gaussmf',[1.5 5]);
a=addmf(a,'input',1,'excellent','gaussmf',[1.5 10]);
a=addvar(a,'input','food',[0 10]);
a=addmf(a,'input',2,'rancid','trapmf',[-2 0 1 3]);
a=addmf(a,'input',2,'delicious','trapmf',[7 9 10 12]);
a=addvar(a,'output','tip',[0 30]);
a=addmf(a,'output',1,'cheap','trimf',[0 5 10]);
a=addmf(a,'output',1,'average','trimf',[10 15 20]);
a=addmf(a,'output',1,'generous','trimf',[20 25 30]);
ruleList=[ ...
1 1 1 1 2
2 0 2 1 1
3 2 3 1 2 ];
a=addrule(a,ruleList);
```

Fuzzy MF :



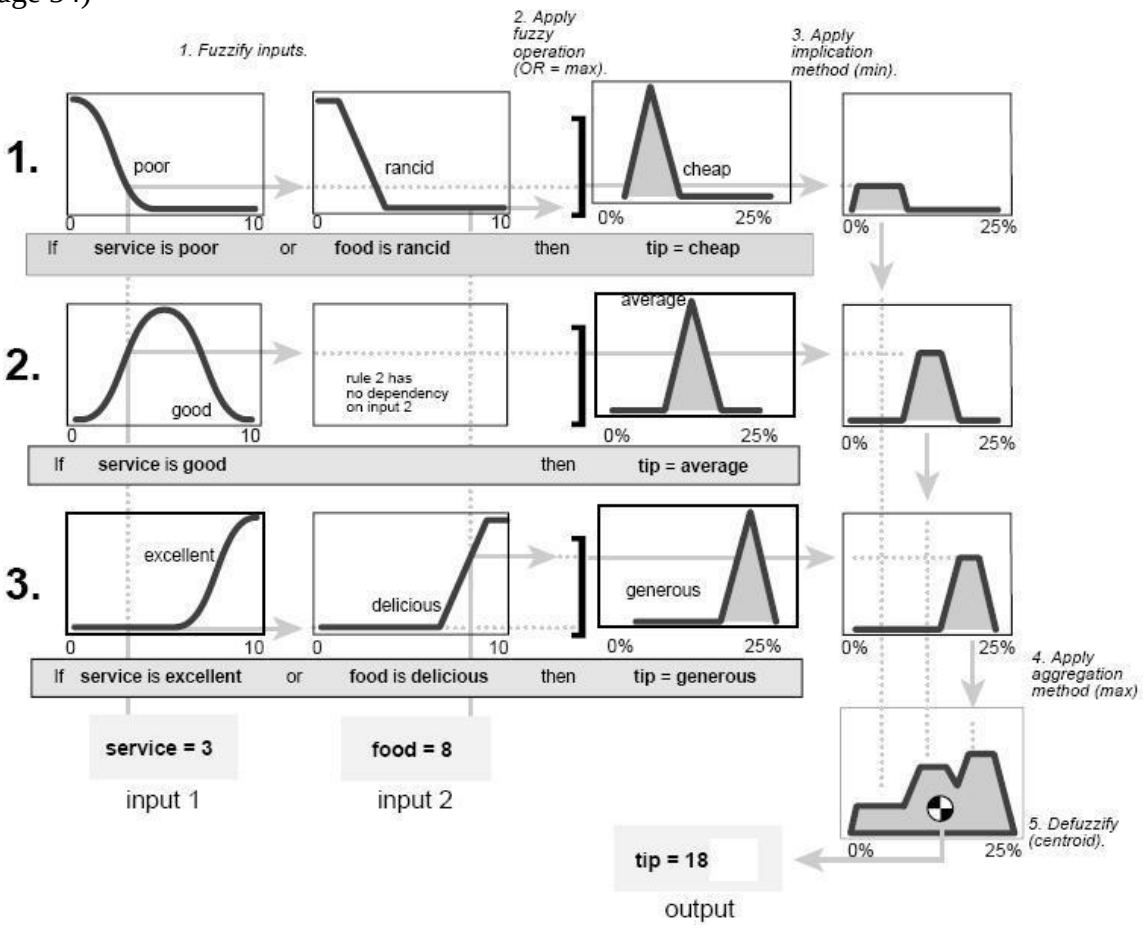




Fuzzy Structure : (page 76)

```
name: 'tipper'
type: 'mamdani'
andMethod: 'min'
orMethod: 'max'
defuzzMethod: 'centroid'
impMethod: 'min'
aggMethod: 'max'
input: [1x2 struct]
output: [1x1 struct]
rule: [1x3 struct]
```

(page 54)



Calculation Example :
Service = 3
Food = 8

$$\mu_{poor}(3;1.5,0) = e^{\frac{-(x-c)^2}{2\sigma^2}} = e^{\frac{-(3-0)^2}{2(1.5)^2}} = 0.1353$$

$$\mu_{good}(3;1.5,5) = e^{\frac{-(x-c)^2}{2\sigma^2}} = e^{\frac{-(3-5)^2}{2(1.5)^2}} = 0.4111$$

$$\mu_{excellent}(3;1.5,10) = e^{\frac{-(x-c)^2}{2\sigma^2}} = e^{\frac{-(3-10)^2}{2(1.5)^2}} = 1.8664 \times 10^{-5}$$

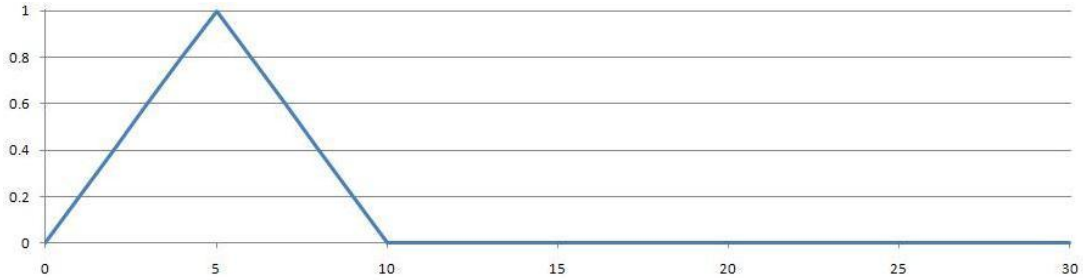
$$\mu_{rancid}(8;-2,0,1,3) = max\left(min\left(\frac{x-a}{b-a}, 1, \frac{d-x}{d-c}\right), 0\right) = max\left(min\left(\frac{8-(-2)}{0-(-2)}, 1, \frac{3-8}{3-1}\right), 0\right) = 0$$

$$\mu_{delicious}(8;7,9,10,12) = max\left(min\left(\frac{x-a}{b-a}, 1, \frac{d-x}{d-c}\right), 0\right) = max\left(min\left(\frac{8-7}{9-7}, 1, \frac{12-8}{12-10}\right), 0\right) = 0.5$$

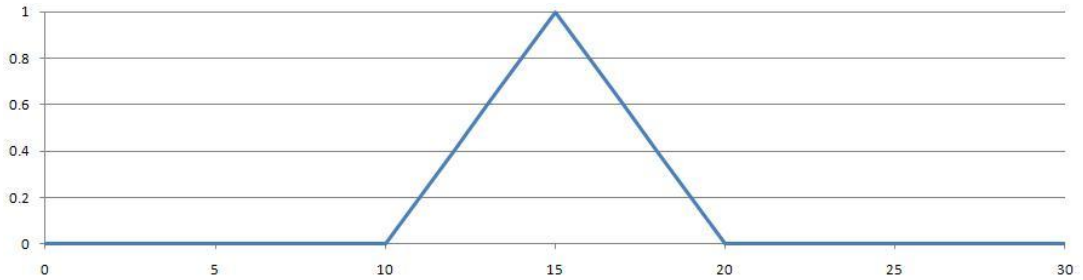
$$w_1 = max\left(\mu_{poor}(3;1.5,0), \mu_{rancid}(8;-2,0,1,3)\right) = max(0.1353,0) = 0.1353$$

$$w_2 = \mu_{good}(3;1.5,5) = 0.4111$$

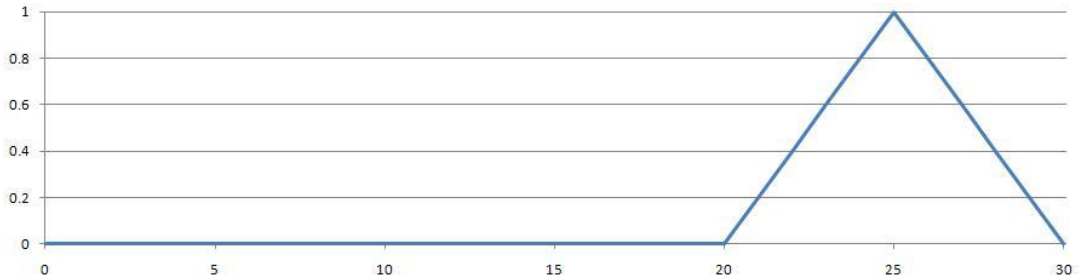
$$w_3 = max\left(\mu_{excellent}(3;1.5,10), \mu_{delicious}(8;7,9,10,12)\right) = max(1.8664 \times 10^{-5}, 0.5) = 0.5$$



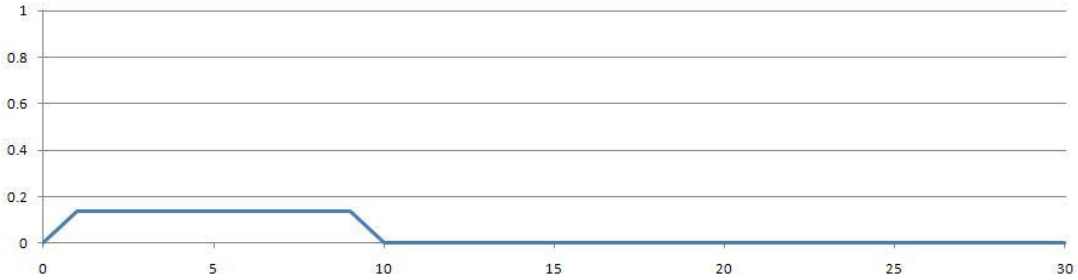
0	0.2	0.4	0.6	0.8	1	0.8	0.6	0.4	0.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30



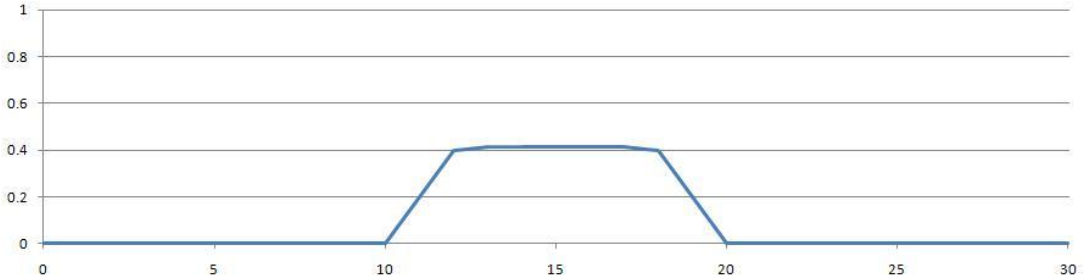
0	0	0	0	0	0	0	0	0	0	0	0.2	0.4	0.6	0.8	1	0.8	0.6	0.4	0.2	0	0	0	0	0	0	0	0	0	0
0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30



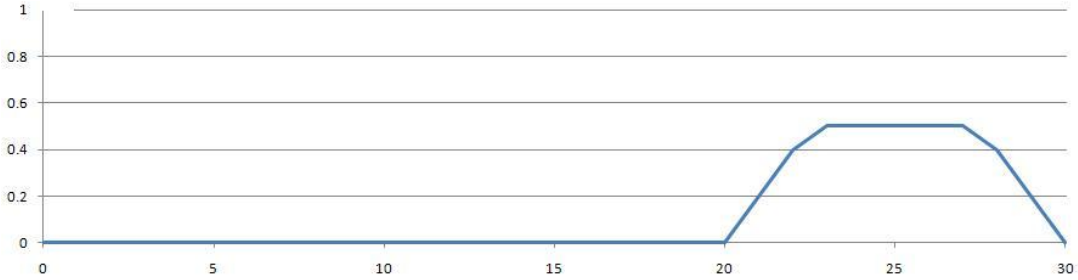
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.2	0.4	0.6	0.8	1	0.8	0.6	0.4	0.2	0
0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30



0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30

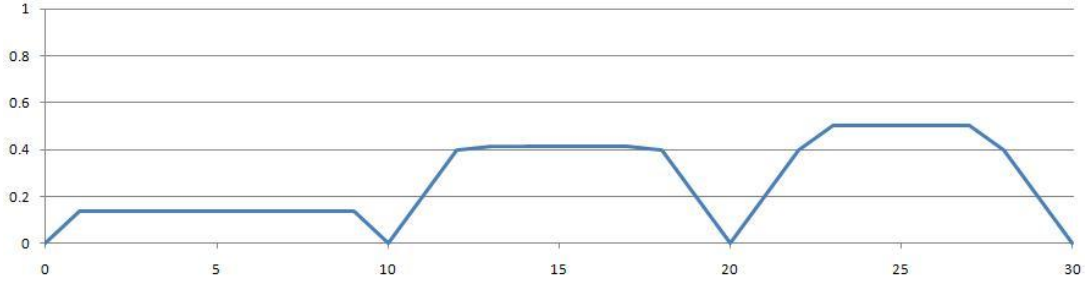


0	0	0	0	0	0	0	0	0	0	0	0.2	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.2	0	0	0	0	0	0	0	0	0	0
0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30



0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.2	0.4	0.5	0.5	0.5	0.5	0.5	0.4	0.2	0
0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30

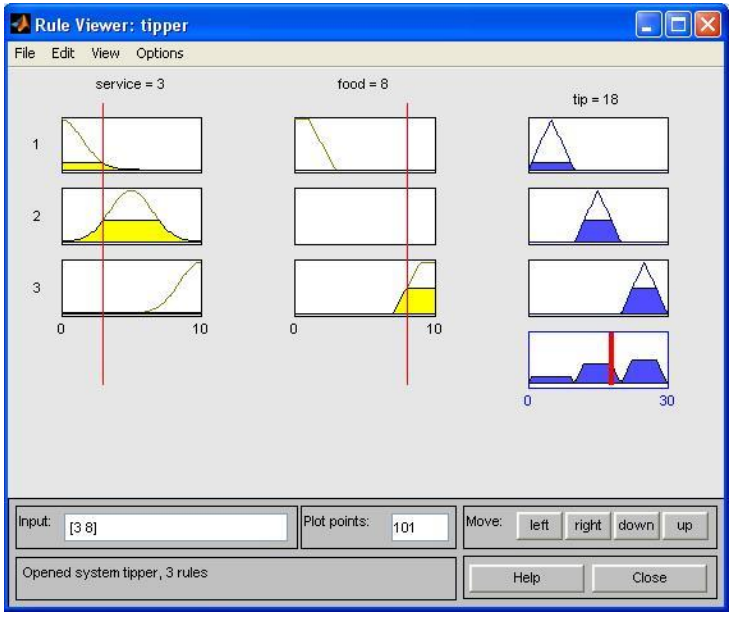
Hasil aggregation



0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0	0.2	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.2	0	0.2	0.4	0.5	0.5	0.5	0.5	0.5	0.4	0.2	0
0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30

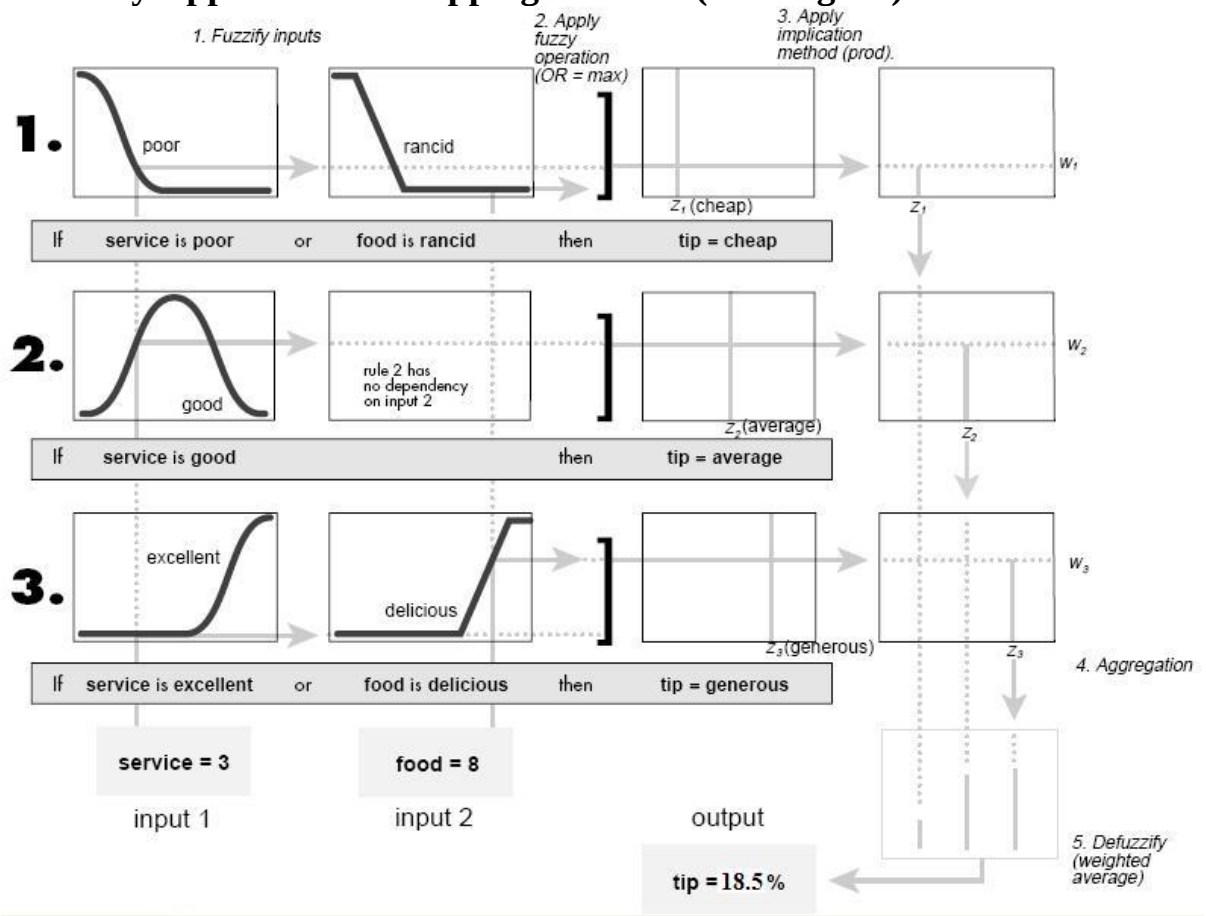
$$out = \frac{0 \times 0 + 1 \times 0.1 + 2 \times 0.1 + \cdots + 28 \times 0.4 + 29 \times 0.2 + 30 \times 0}{0 + 0.1 + 0.1 + \cdots + 0.4 + 0.2 + 0} = 18.03712$$

Hasil dari MATLAB :



(tutorial : Fuzzy Logic Toolbox User's Guide.pdf page 60 – 72)

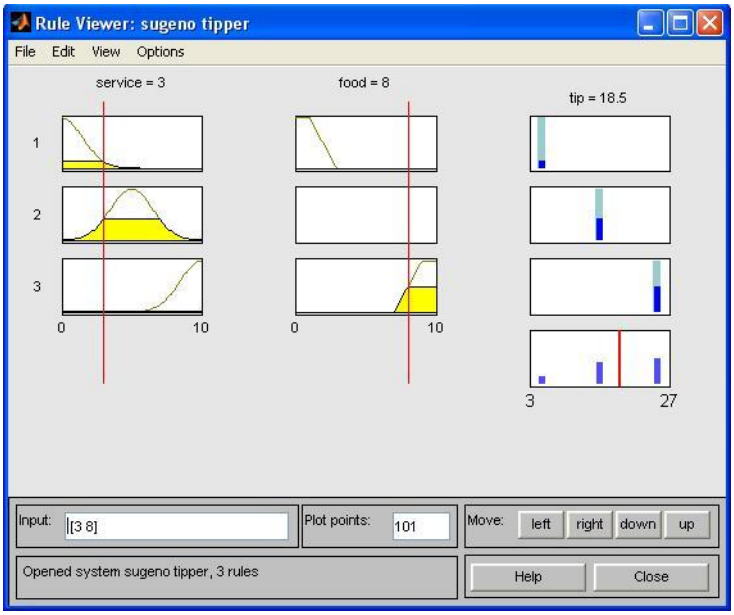
2 Fuzzy Application for Tipping Problem (FIS Sugeno)



cheap = 5 %
average = 15 %
generous = 25 %

$$out = \frac{\sum_{i=1}^{N} w_i z_i}{\sum_{i=1}^{N} w_i} = \frac{0{,}1353 \times 5\% + 0{,}411 \times 15\% + 0{,}5 \times 25\%}{0{,}1353 + 0{,}411 + 0{,}5} = 17{,}80\%$$

Hasil dari MATLAB :



Contoh Aplikasi Fuzzy :

1. Automated Parking System
   Referensi : Fuzzy Logic Reference Manual.pdf

2. Control of a Complex Traffic Juntion
   Referensi : Control of a Complex Traffic Juntion.pdf

3. Control of a 3 Degrees-of-Freedom Helicopter