DSC 540 - Topic 6 - Assignment-Problem2

September 15, 2021

[2]:
```
import numpy as np
import matplotlib.pyplot as plt
import skfuzzy as fuzz
from skfuzzy import control as ctrl
```

Let us define the three input variables x1,x2 and x3 and the output nonlinear function y

[4]:
```
x1 = np.linspace(1, 6, 10)
x2 = np.linspace(1, 6, 10)
x3 = np.linspace(1, 6, 10)
```

[5]:
```
y = np.power((1+np.sqrt(x1) + np.power(x2,-1) +np.power(x3,-1.5)),2)
```

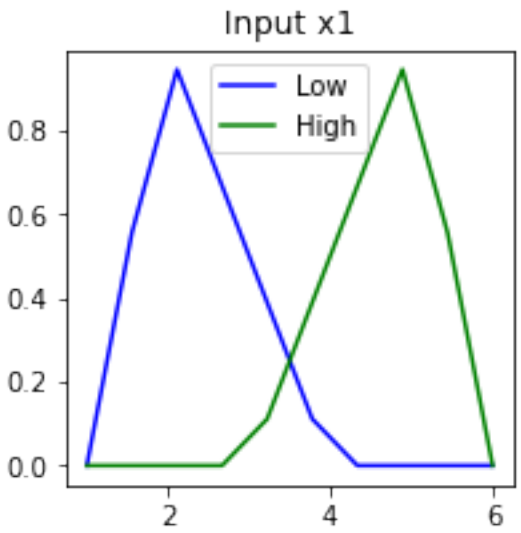
Define the membership function of each input variables. We will have triangular membership function for the input variables.

[6]:
```

```

[12]:
```
# Defining the triangular membership function for variable x1
x1_lo = fuzz.trimf(x1,[1,2,4])
x1_hi = fuzz.trimf(x1,[3,5,6])
```

[14]:
```
fig, (ax0) = plt.subplots(nrows=1, figsize=(3, 3))

ax0.plot(x1, x1_lo, 'b', linewidth=1.5, label='Low')
ax0.plot(x2, x1_hi, 'g', linewidth=1.5, label='High')
ax0.set_title('Input x1')
ax0.legend()
```

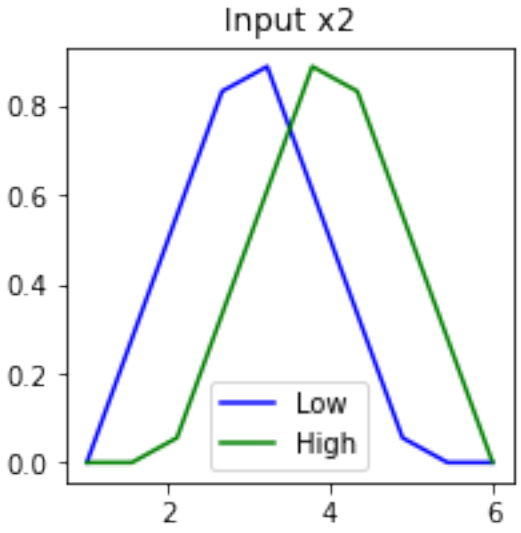
[14]:
```
<matplotlib.legend.Legend at 0x2760995f460>
```



[15]:
```
# Defining the trapezoidal membership function for variable x2
x2_lo = fuzz.trimf(x2,[1,3,5])
x2_hi = fuzz.trimf(x2,[2,4,6])
```

[17]:
```
fig, (ax1) = plt.subplots(nrows=1, figsize=(3, 3))

ax1.plot(x2, x2_lo, 'b', linewidth=1.5, label='Low')
ax1.plot(x2, x2_hi, 'g', linewidth=1.5, label='High')
ax1.set_title('Input x2')
ax1.legend()
```

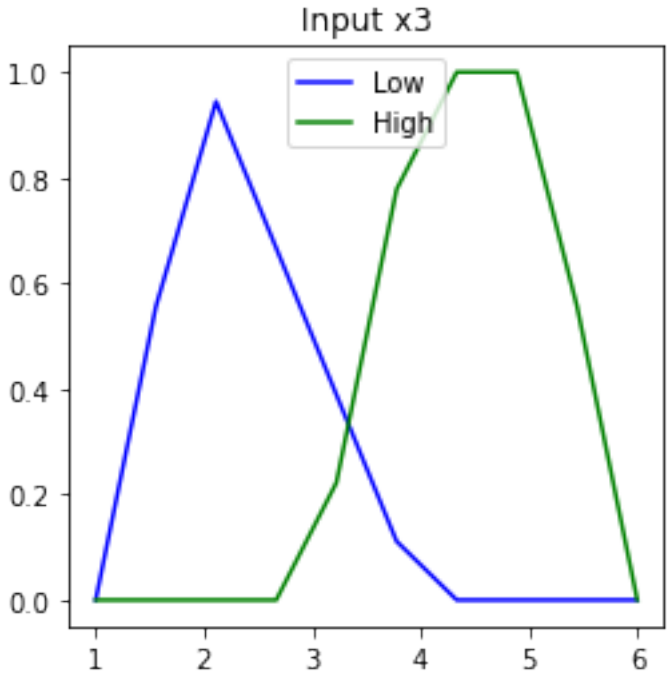
[17]:
```
<matplotlib.legend.Legend at 0x2760981d700>
```



[18]:
```
# Defining the triangular and trapezoidal membership function for variable x3
x3_lo = fuzz.trimf(x3,[1,2,4])
x3_hi = fuzz.trapmf(x3,[3,4,5,6])
```

[20]:
```
fig, (ax2) = plt.subplots(nrows=1, figsize=(4, 4))

ax2.plot(x3, x3_lo, 'b', linewidth=1.5, label='Low')
ax2.plot(x3, x3_hi, 'g', linewidth=1.5, label='High')
ax2.set_title('Input x3')
ax2.legend()
```

[20]:
```
<matplotlib.legend.Legend at 0x276098db250>
```



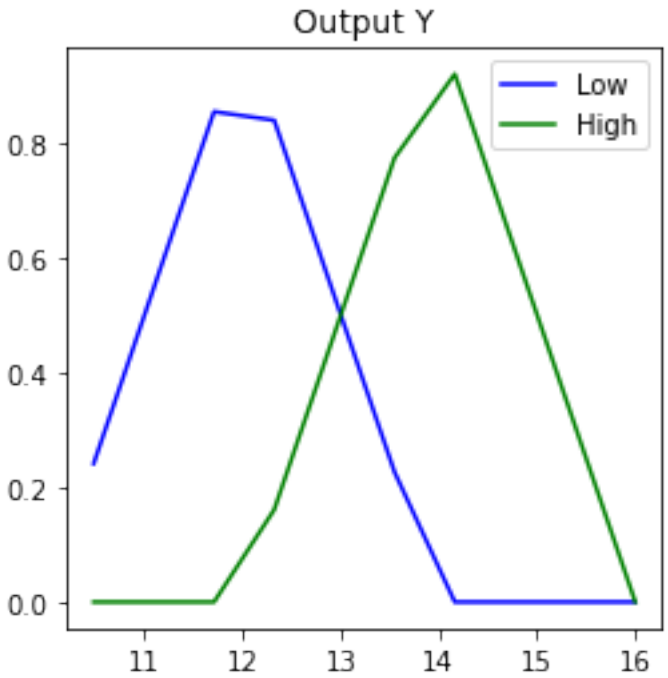
[24]:
```
y_c = np.linspace(min(y),max(y),10)
```

[26]:
```
y_c_lo = fuzz.trimf(y_c,[10,12,14])
y_c_hi = fuzz.trimf(y_c,[12,14,16])
```

[27]:
```
fig, (ax3) = plt.subplots(nrows=1, figsize=(4, 4))

ax3.plot(y_c, y_c_lo, 'b', linewidth=1.5, label='Low')
ax3.plot(y_c, y_c_hi, 'g', linewidth=1.5, label='High')
```

```
ax3.set_title('Output Y')
ax3.legend()
```

[27]: <matplotlib.legend.Legend at 0x2760981e580>



Rule Application

[42]:
```
# we will interpret for the target data for 1.5
x1_lvl_lo = fuzz.interp_membership(x1, x1_lo,np.linspace(1.5,5.5,10))
x1_lvl_hi = fuzz.interp_membership(x1, x1_hi,np.linspace(1.5,5.5,10))
```

[43]:
```
x2_lvl_lo = fuzz.interp_membership(x2, x2_lo,np.linspace(1.5,5.5,10))
x2_lvl_hi = fuzz.interp_membership(x2, x2_hi,np.linspace(1.5,5.5,10))
```

[44]:
```
x3_lvl_lo = fuzz.interp_membership(x3, x3_lo,np.linspace(1.5,5.5,10))
x3_lvl_hi = fuzz.interp_membership(x3, x3_hi,np.linspace(1.5,5.5,10))
```

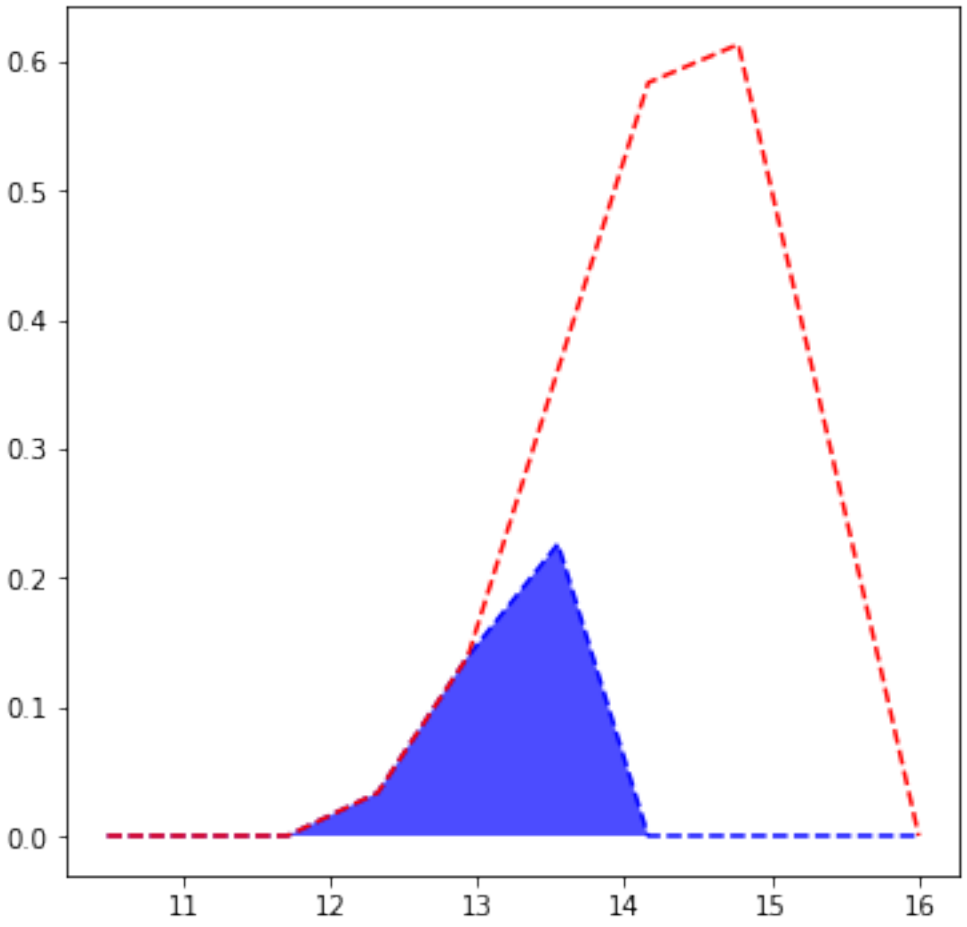
[49]:
```
# We will define all the rules associated for this function.
# Since we are using and condition we will use Min function
# Since there are 3 inputs we have 2*2*2 =8 rules
rule1 = np.fmin(x1_lvl_lo,x2_lvl_lo,x3_lvl_lo)
rule2 = np.fmin(x1_lvl_lo,x2_lvl_lo,x3_lvl_hi)
rule3 = np.fmin(x1_lvl_lo,x2_lvl_hi,x3_lvl_lo)
rule4 = np.fmin(x1_lvl_hi,x2_lvl_lo,x3_lvl_lo)
rule5 = np.fmin(x1_lvl_hi,x2_lvl_hi,x3_lvl_lo)
```

```
rule6 = np.fmin(x1_lvl_hi,x2_lvl_lo,x3_lvl_hi)
rule7 = np.fmin(x1_lvl_lo,x2_lvl_hi,x3_lvl_hi)
rule8 = np.fmin(x1_lvl_hi,x2_lvl_hi,x3_lvl_hi)
```

[61]:
```
#Now let's see the output membership function with respect to rule 1 & rule 8
y_low = np.fmin(rule1,y_c_lo)
y_hi = np.fmin(rule8, y_c_hi)
y0 = np.zeros_like(y_c)
```

[65]:
```
# Let's plot the outcome of rule 1 in the Output
fig, ax0 = plt.subplots(figsize=(6, 6))

ax0.fill_between(y_c, y0, y_low, facecolor='b', alpha=0.7)
ax0.plot(y_c, y_low, 'b', linewidth=1.5,linestyle='--' ,label='Low')
ax0.plot(y_c, y_hi, 'r', linewidth=1.5,linestyle='--' ,label='Low')
```

[65]:
```
[<matplotlib.lines.Line2D at 0x2760ad23160>]
```



Like above we can plot the output membership activity for other rules

Reference: https://pythonhosted.org/scikit-fuzzy/auto_examples/plot_tipping_problem.html