Reasoning and Knowledge Representation
Project

2022-2023
Faulty of computers and Artificial intelligence

Detection of Cardiac Arrhythmia
(Detection of Irregular Heartbeat)

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❖ India is facing a big problem which is coronary heart disease. There are several reasons that are dangerous, including:

1. **Genetic factors.**
2. **Variations of lifestyle.**
3. **The social and economic situation.**
4. **Cardiovascular disorders.**

and other factors..

❖ After several studies, they concluded that rheumatic heart disease and stroke are among the most important factors that led to progress (CHD), and that the South Indians are more susceptible to infection.

- **Our inputs**
  1. **high levels of Cholesterol.**
  2. **Blood Pressure.**
  3. **Age.**
  4. **High BMI.**
  5. **Smoking.**
  6. **Diabetes.**
- **Our outut**

  Our goal is to find out whether this person has coronary heart disease or not.

- Also, recently, lifestyle changes were one of the most important reasons for the growth of cardiovascular diseases, especially in the age over 35.
- So we will use Fuzzy logic to be able to diagnose cases if they are coronary heart disease or not

Also fuzzy logic is one of the ways that facilitates calculations and obtaining a

So we have the following knowledge base:

- *Inputs Variables:*

1. *Cholestrol*

-This variable range from 0 to 500 and has 4 fuzzy sets.
-The fuzzy set "Normal" is trapezoidal with x-coordinates(**0,0,50,250**).
-The fuzzy set "Medium" is triangular with x-coordinates(**190,220,300**).
-The fuzzy set "High" is triangular with x-coordinates(**220,300,350**).
-The fuzzy set "Very High" is trapezoidal with x-coordinates(**280,360,700,700**).

2. *Blood pressure*

-This variable range from 0 to 200 and has 3 fuzzy sets.
-The fuzzy set "Normal" is trapezoidal with x-coordinates(**0,0,67,110**).
-The fuzzy set "Medium" is triangular with x-coordinates(**120,130,160**).
-The fuzzy set "Very High" is trapezoidal with x-coordinates(**150,175,250,250**).

3. *Age*

-This variable range from 0 to 75 and has 4 fuzzy sets.
-The fuzzy set "Young" is trapezoidal with x-coordinates(**0,0,21,38**).
-The fuzzy set "Middle age" is triangular with x-coordinates(**33,40,45**).
-The fuzzy set "Old" is triangular with x-coordinates(**45,48,59**).
-The fuzzy set "Very old" is trapezoidal with x-coordinates(**52,60,80,80**).

4. *BMI*

-This variable range from 0 to 50 and has 3 fuzzy sets.
-The fuzzy set "Normal" is trapezoidal with x-coordinates(**0,0,10,26**).
-The fuzzy set "Over weight" is triangular with x-coordinates(**25,26.5,33**).
-The fuzzy set "Obese" is trapezoidal with x- coordinates(**30,40,70,70**).

5. *Diabetes*

-This variable range from 0 to 400 and has 2 fuzzy sets.
-The fuzzy set "Normal" is triangular with x-coordinates(**0,70,160**).
-The fuzzy set "Diabetic" is triangular with x-coordinates(**140,230,550**).

➢ *Output Variable:*

- *Heart disease*

  -This variable range from 0 to 4 and has 3 fuzzy sets.
  -The fuzzy set “Healthy” is triangular with x-coordinates(**0, 0, 1**).
  -The fuzzy set “Early stage” is triangular with x-coordinates(**1, 2, 3**).
  -The fuzzy set “Advanced stage” is trapezoidal with x-coordinates(**2,3,5,5**).

➢ And we have the following rule base:

1. **If** Age is young **and** Blood Pressure is normal **and** Cholesterol is normal **and** Diabetes is normal **or** BMI is obese **Then** Heart Disease is healthy.
2. **If** Age is very old **and** Blood Pressure is normal **and** Cholesterol is normal **and** Diabetes is normal **or** BMI is normal **Then** Heart Disease is early-stage.
3. **If** Age is old **and** Blood Pressure very high **or** Cholesterol is normal **and** Diabetes diabetic **and** BMI is normal **Then** Heart Disease is early-stage .
4. **If** Age is young **and** Blood Pressure is medium **or** Cholesterol normal **and** Diabetes is diabetic **and** BMI is over **Then** Heart Disease is early-stage.
5. **If** Age is middle age **and** Blood Pressure is normal **and** Cholesterol is high **and** Diabetes is diabetic **and** BMI is over weight **Then** Heart Disease is advanced-stage.
6. **If** Age is old **and** Blood Pressure is very high **or** Cholesterol is high **and** Diabetes is normal **or** BMI is obese **Then** Heart Disease is advanced-stage.
7. **If** Age is middle age **and** Blood Pressure is medium and Cholesterol is very high **and** Diabetes is diabetic and BMI over weight **Then** Heart Disease is advanced-stage.
8. **If** Age is old **and** Blood Pressure is medium **and** Cholesterol is very high **and** Diabetes is diabetic **and** BMI is **Then** Heart Disease is advanced-stage.
9. **If** Age is very old **and** Blood Pressure is very high **and** Cholesterol is very high **and** Diabetes is diabetic **and** BMI is over weight **Then** Heart Disease is advanced-stage.

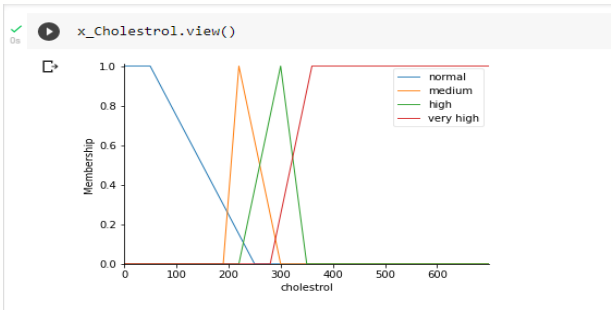
➢ *The Code:*

```
import numpy as np
import skfuzzy as fuzz
from skfuzzy import control as ctrl
```

```
x_Cholestrol =ctrl.Antecedent( np.arange(0,700,1),'cholestrol')
x_BloodPressure =ctrl.Antecedent( np.arange(0,250,1), 'Blood Pressure')
x_Age =ctrl.Antecedent( np.arange(0,80,1) , 'Age')
x_BMI =ctrl.Antecedent( np.arange(0,70,1) , 'BMI')
x_Diabetes =ctrl.Antecedent( np.arange(0,550,1) , 'Diabetes' )
x_HeartDisease =ctrl.Consequent( np.arange(0,6,1) , 'Heart Disease')
```

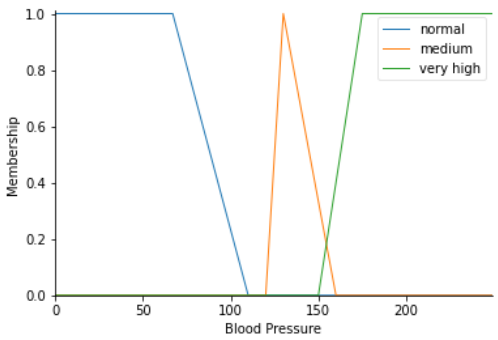
```
x_Cholestrol['normal'] = fuzz.trapmf(x_Cholestrol.universe, [0, 0, 50, 250])
x_Cholestrol['medium'] = fuzz.trimf(x_Cholestrol.universe, [190, 220, 300])
x_Cholestrol['high'] = fuzz.trimf(x_Cholestrol.universe, [220, 300, 350])
x_Cholestrol['very high']= fuzz.trapmf(x_Cholestrol.universe, [280,360, 700,700])
```

```
x_Cholestrol.view()
```

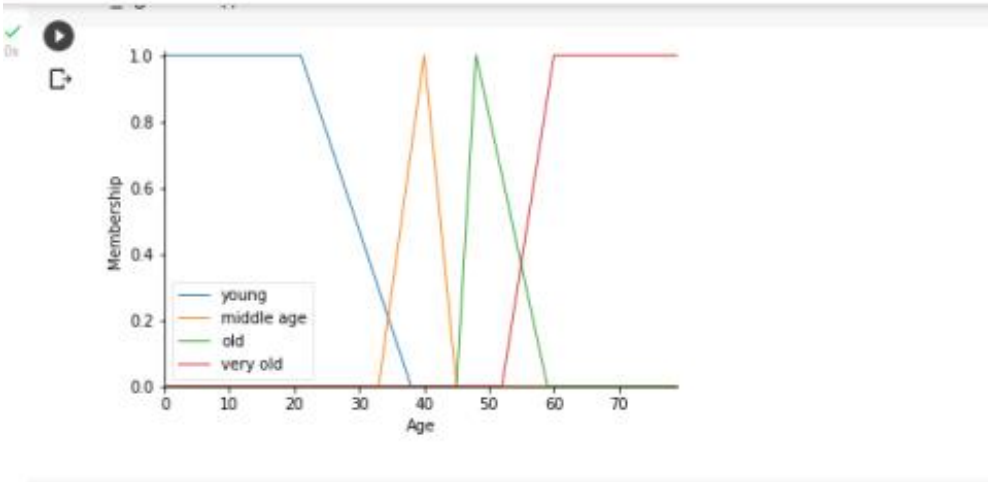


```
x_BloodPressure['normal'] = fuzz.trapmf(x_BloodPressure.universe,[0,0,67,110])
x_BloodPressure['medium'] = fuzz.trimf(x_BloodPressure.universe,[120, 130, 160])
x_BloodPressure['very high']= fuzz.trapmf(x_BloodPressure.universe,[150,175,250,
250])
```

```
[130] x_BloodPressure.view()
```

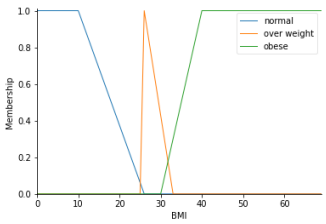



```
x_Age['young'] = fuzz.trapmf(x_Age.universe, [0, 0, 21, 38])
x_Age['middle age'] = fuzz.trimf(x_Age.universe, [33, 40,45])
x_Age['old'] = fuzz.trimf(x_Age.universe, [40, 48, 59])
x_Age['very old'] = fuzz.trapmf(x_Age.universe, [52, 60, 80, 80])
```



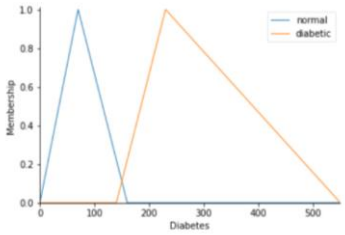
```
x_BMI['normal'] = fuzz.trapmf(x_BMI.universe, [0, 0, 10, 26])
x_BMI['over weight'] = fuzz.trimf(x_BMI.universe, [25, 26.5, 33])
x_BMI['obese']= fuzz.trapmf(x_BMI.universe, [30, 40, 70, 70])
```

```
[134] x_BMI.view()
```



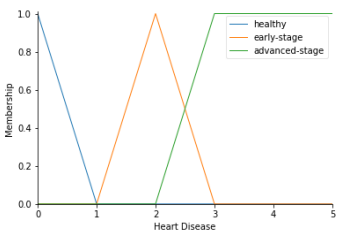

```
x_Diabetes['normal'] = fuzz.trimf(x_Diabetes.universe, [0, 70, 160])
x_Diabetes['diabetic'] = fuzz.trimf(x_Diabetes.universe, [140, 230, 550])
```

```
[136] x_Diabetes.view()
```




```
x_HeartDisease['healthy'] = fuzz.trapmf(x_HeartDisease.universe, [0, 0, 0.4, 1.7])
x_HeartDisease['early-stage'] = fuzz.trimf(x_HeartDisease.universe, [1.5, 2, 2.5])
x_HeartDisease['advanced-stage']= fuzz.trapmf(x_HeartDisease.universe,[2.4,3,5,5])
```

```
[138] x_HeartDisease.view()
```



➢ *Rule Base*:

```
rule1 = ctrl.Rule((x_Age['young'] & x_BloodPressure['normal'] &
x_Cholestrol['normal'] & x_Diabetes['normal']) | x_BMI['obese']
,x_HeartDisease['healthy']  )

rule2 = ctrl.Rule((x_Age['very old'] & x_BloodPressure['normal'] &
x_Cholestrol['normal'] & x_Diabetes['normal'] ) | x_BMI['normal']
,x_HeartDisease['healthy']  )

rule3 = ctrl.Rule (x_Age['old'] & x_BloodPressure['very high']  |
x_Cholestrol['normal']  & x_Diabetes['diabetic']  & x_BMI['normal']
,x_HeartDisease['early-stage']  )

rule4 = ctrl.Rule(x_Age['young'] & x_BloodPressure['medium'] |
x_Cholestrol['normal'] & x_Diabetes['diabetic'] & x_BMI['over weight']
,x_HeartDisease['early-stage']  )

rule5 = ctrl.Rule(x_Age['middle age'] & x_BloodPressure['normal'] &
x_Cholestrol['high'] & x_Diabetes['diabetic'] & x_BMI['over weight']
,x_HeartDisease['advanced-stage']  )

rule6 = ctrl.Rule( x_Age['old'] & x_BloodPressure['very high']  |
x_Cholestrol['high']  & x_Diabetes['normal'] | x_BMI['obese']
,x_HeartDisease['advanced-stage']  )

rule7 = ctrl.Rule(x_Age['middle age'] & x_BloodPressure['medium'] &
x_Cholestrol['very high'] & x_Diabetes['diabetic'] & x_BMI['over weight']
,x_HeartDisease['advanced-stage']  )

rule8 = ctrl.Rule(x_Age['old'] & x_BloodPressure['medium'] & x_Cholestrol['very
high'] & x_Diabetes['diabetic'] & x_BMI['obese'],x_HeartDisease['advanced-
stage']  )

rule9 = ctrl.Rule(x_Age['very old'] & x_BloodPressure['very high'] &
x_Cholestrol['very high'] & x_Diabetes['diabetic'] & x_BMI['over weight']
,x_HeartDisease['advanced-stage']  )
```

```
rule1.view()
```

```
(<Figure size 432x288 with 1 Axes>,
 <matplotlib.axes._subplots.AxesSubplot at 0x7fa71c54fe50>)
```

```
[383] rule2.view()
```

```
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 <matplotlib.axes._subplots.AxesSubplot at 0x7fa71c474210>)
```

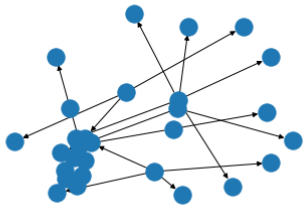

```
rule3.view()
```

```
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 <matplotlib.axes._subplots.AxesSubplot at 0x7fa71c40cdd0>)
```

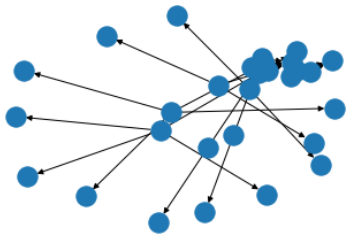

```
[385] rule4.view()
```

```
(<Figure size 432x288 with 1 Axes>,
 <matplotlib.axes._subplots.AxesSubplot at 0x7fa71c399810>)
```

```
rule5.view()
```

```
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 <matplotlib.axes._subplots.AxesSubplot at 0x7fa71c261390>)
```

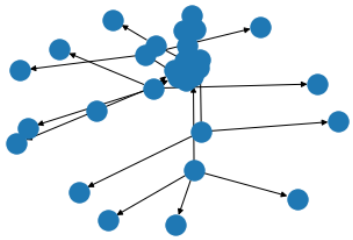

```
[387] rule6.view()
```

```
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```

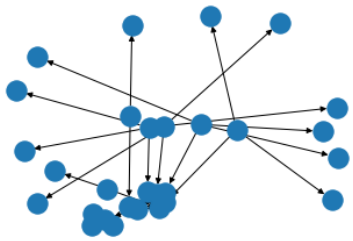

```
rule7.view()
```

```
(<Figure size 432x288 with 1 Axes>,
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```

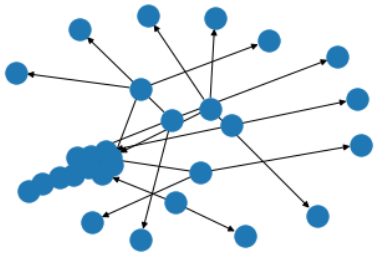

```
[389] rule8.view()
```

```
(<Figure size 432x288 with 1 Axes>,
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```
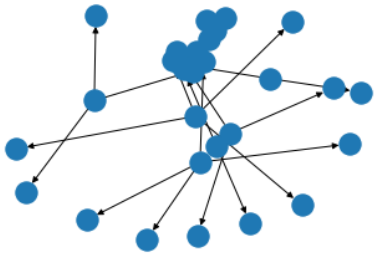
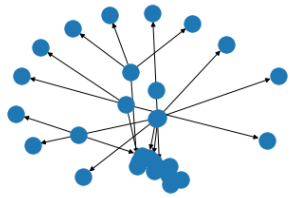



```
[390] rule9.view()

(<Figure size 432x288 with 1 Axes>,
 <matplotlib.axes._subplots.AxesSubplot at 0x7fa71d08d890>)
```



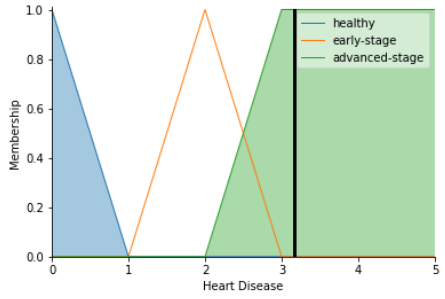
```
tipping_ctrl = ctrl.ControlSystem([rule1,rule2,rule3, rule4, rule5, rule6,
rule7, rule8, rule9])
```

```
tipping = ctrl.ControlSystemSimulation(tipping_ctrl)
```

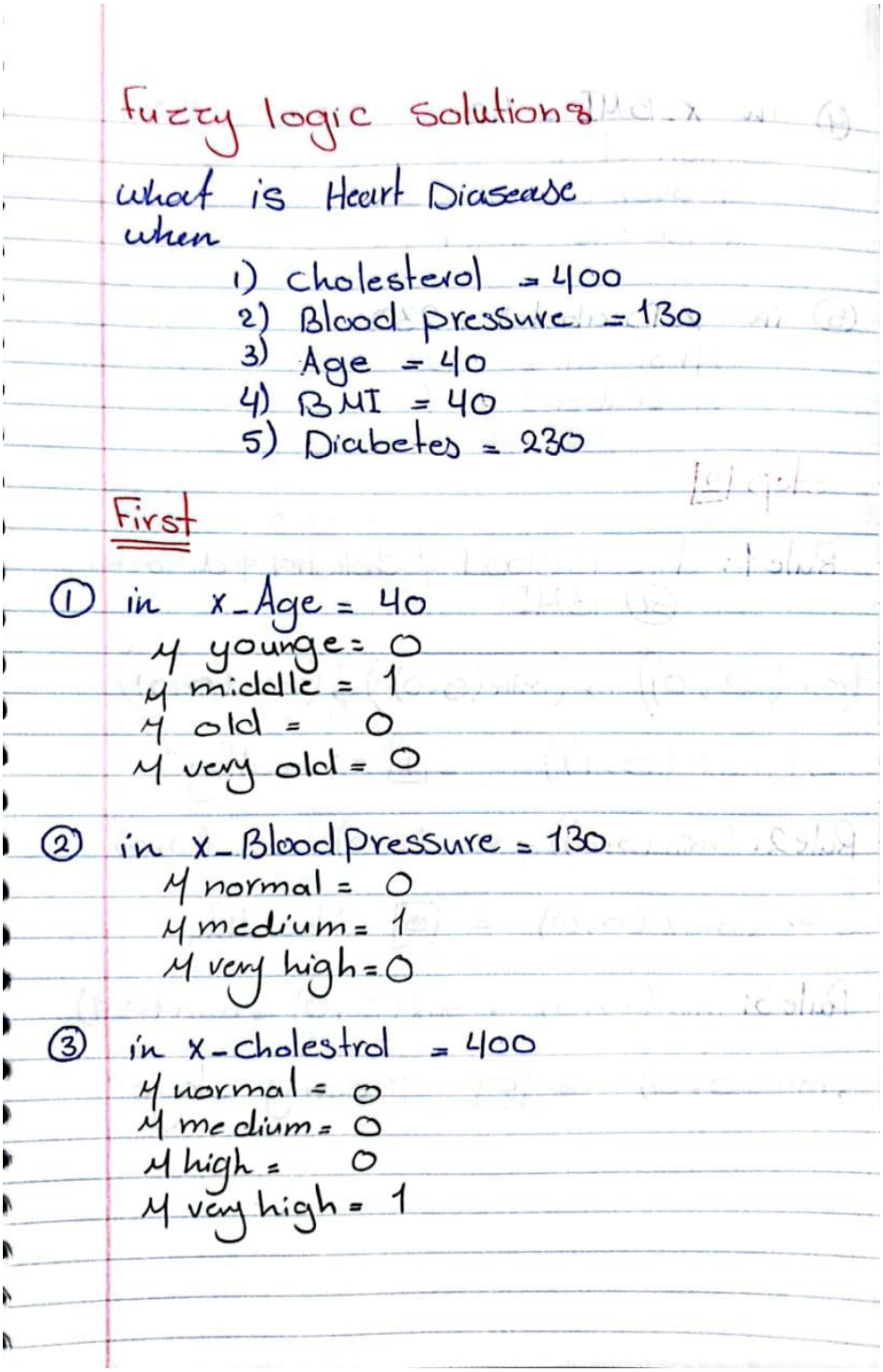
```
tipping.input['cholestrol'] = 400
tipping.input['Blood Pressure'] = 130
tipping.input['Age'] = 40
tipping.input['BMI'] = 40
tipping.input['Diabetes'] = 230

tipping.compute()
```

```
print (tipping.output['Heart Disease'])
x_HeartDisease.view(sim=tipping)
```

```
[152] print (tipping.output['Heart Disease'])
      x_HeartDisease.view(sim=tipping)

3.1666666666666665
```



➢ The solution:



Fuzzy logic solution:

what is Heart Diasease when

1) cholesterol = 400
2) Blood pressure = 130
3) Age = 40
4) BMI = 40
5) Diabetes = 230

First

① in x_Age = 40
- μ younge = 0
- μ middle = 1
- μ old = 0
- μ very old = 0

② in x_Blood Pressure = 130
- μ normal = 0
- μ medium = 1
- μ very high = 0

③ in x_cholestrol = 400
- μ normal = 0
- μ medium = 0
- μ high = 0
- μ very high = 1

④ in x_BMI = 40
- normal = 0
- over weight = 0
- obese = 1

⑤ in x_Diabetes = 230
- normal = 0
- diabetic = 1

step [2]

Rule 1: Age & Blood & cholestrol & diabetes (or) BMI

(min(0,0)) → (min(0,0)) → (min(0,0))

→ (max(0,1)) = [1] "healthy"

Rule 2: (min(0,0)) → min(0,0) → min(0,0)

→ (max(0,0) = [0] "healthy"

Rule 3: min(0,0) → max(0,0) → min(0,1)

→ min(0,0) = [0] "early-stage"

Rule 4 : min (0,1) → max (0,0)
→ min (0,0) → min (0,0)

= [0] "early-stage"

Rule 5 : min (1,0) → min (0,0) → min (0,1)
→ min (0,0)

= [0] "Advanced-stag"

Rule 6 : min (0,0) → max (0,0) → min (0,0)
max (0,1)

= [1] "Advanced-stag"

Rule 7 : min (1,1) → min (1,1) → min (1,1)
min (1,0)

= [0] "Advanced-stag"

Rule 8 : min (0,1) → min (0,1) → min (0,1)
→ min (0,1)

= [0] "Advanced-stag"

Rule 9 : min (0,0) → min (0,1) → min (0,1)
→ min (0,0)

= [0] "Advanced-stage"

step[3] Defuzzification

C Healthy = (0 + 0 + 1) / 3 = .333

C Early-stage = (1 + 2 + 3) / 3 = 2

C Advanced-stage = (2 + 3 + 5 + 5) / 4 = 3.75

* Applying the weighted average

- predicted Heart Disease -

① μ Healthy * C Healthy =

(1 + 0) * 0.333 = [.3] → ①

② μ Early-stage * C Early-stage

(0 + 0) * 2 = [0] → ②

③ μ Advanced-stage * C Advanced-stage

(0 + 1 + 0 + 0 + 0) * 3.75 = 3.7 → ③

∴ from ①, ② and ③

∴ ① + ② + ③ ≃ ④

※

The link of colab.research.google.com of the code

https://drive.google.com/file/d/1EkuMWVrvsCiql12TMrdtnOG1wznS-woE/view?usp=sharing