Wydział Matematyki i Nauk Informacyjnych
POLITECHNIKA WARSZAWSKA

MI DATALAB

Fuzzy Cognitive Map - Decision Tree for making medical decisions

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Weekly Seminar at MI2 DataLab
Monday, March 21, 2022

Outline

1/ **Fuzzy** Cognitive Map

2/ Conversation of medical doctors

3/ Decision Tree

4/ Hybrid model FCM-DT

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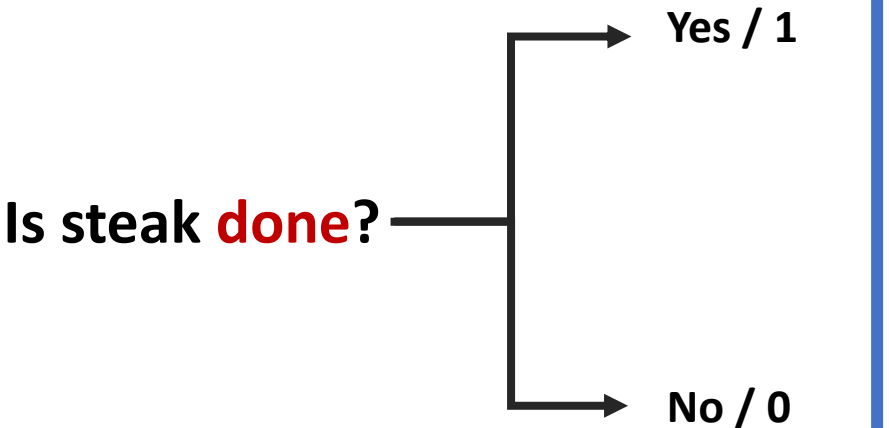
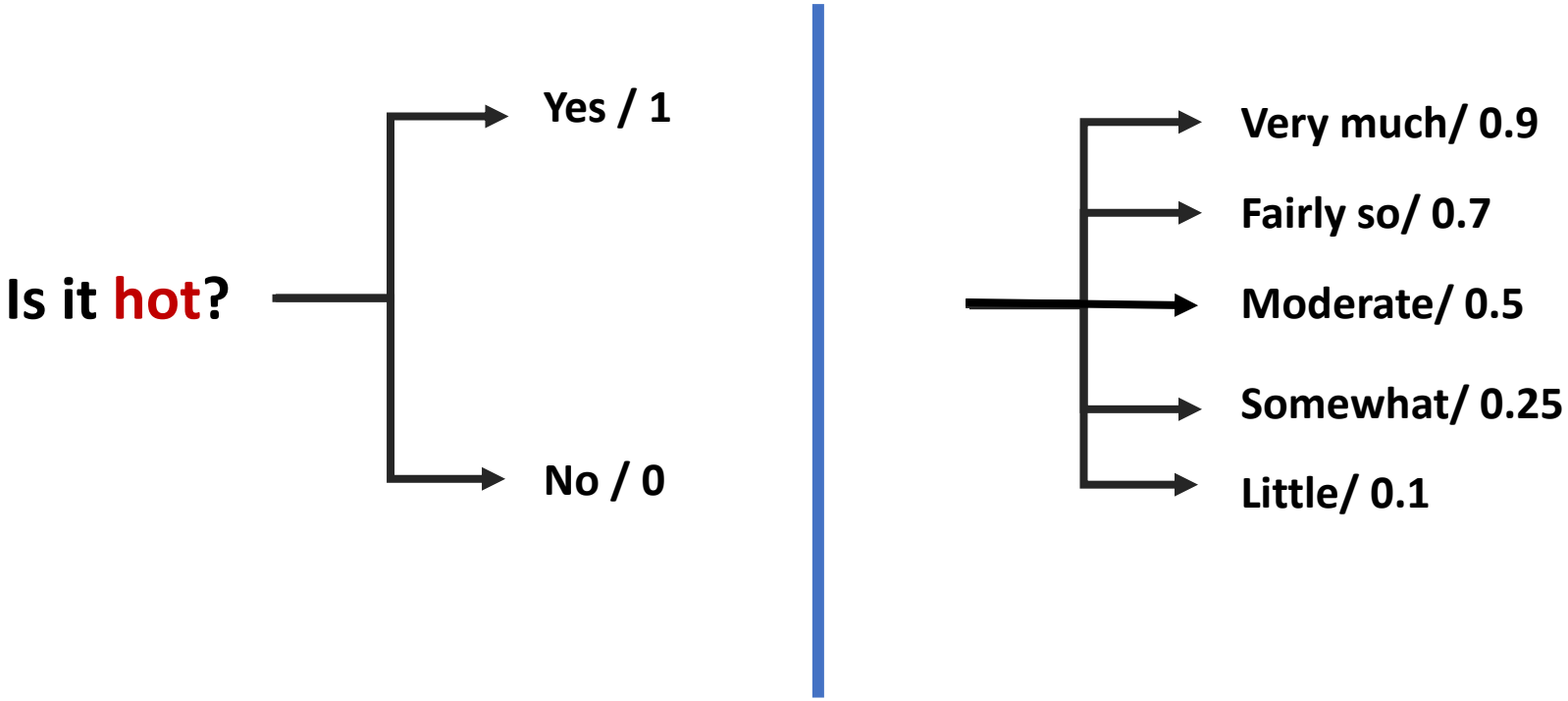
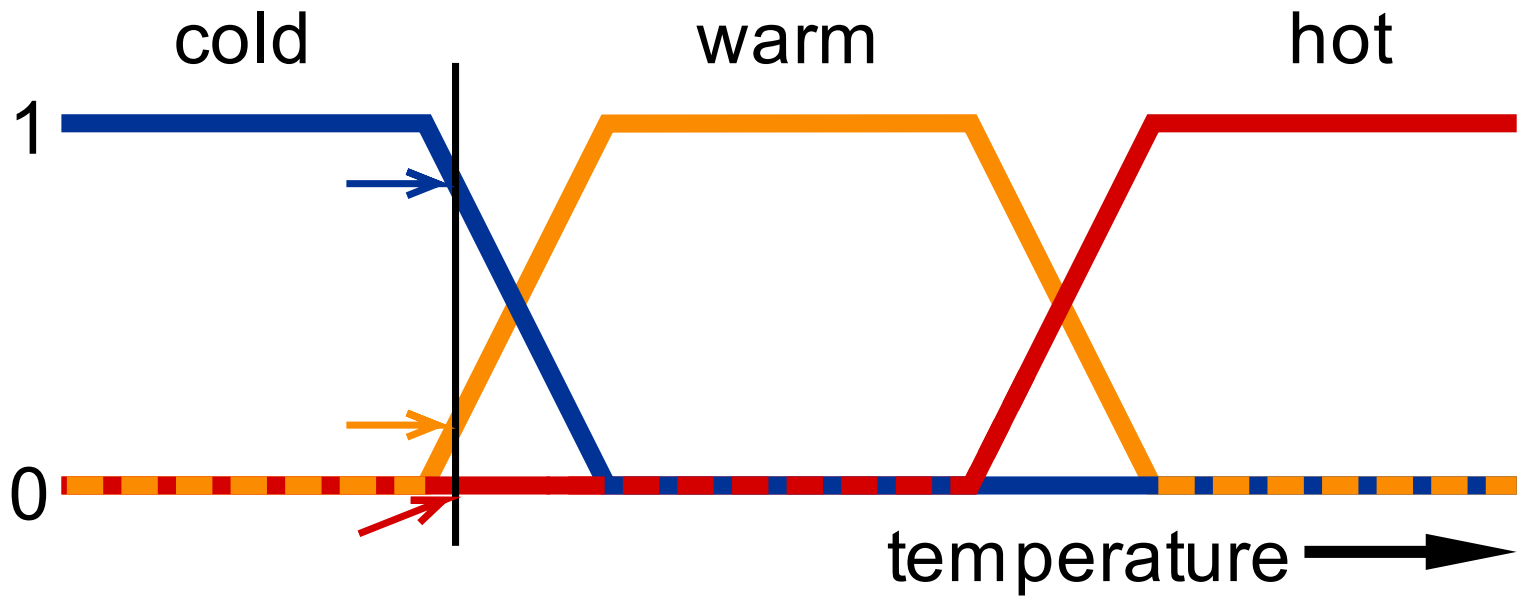
Boolean logic vs. fuzzy logic



Boolean logic vs. fuzzy logic



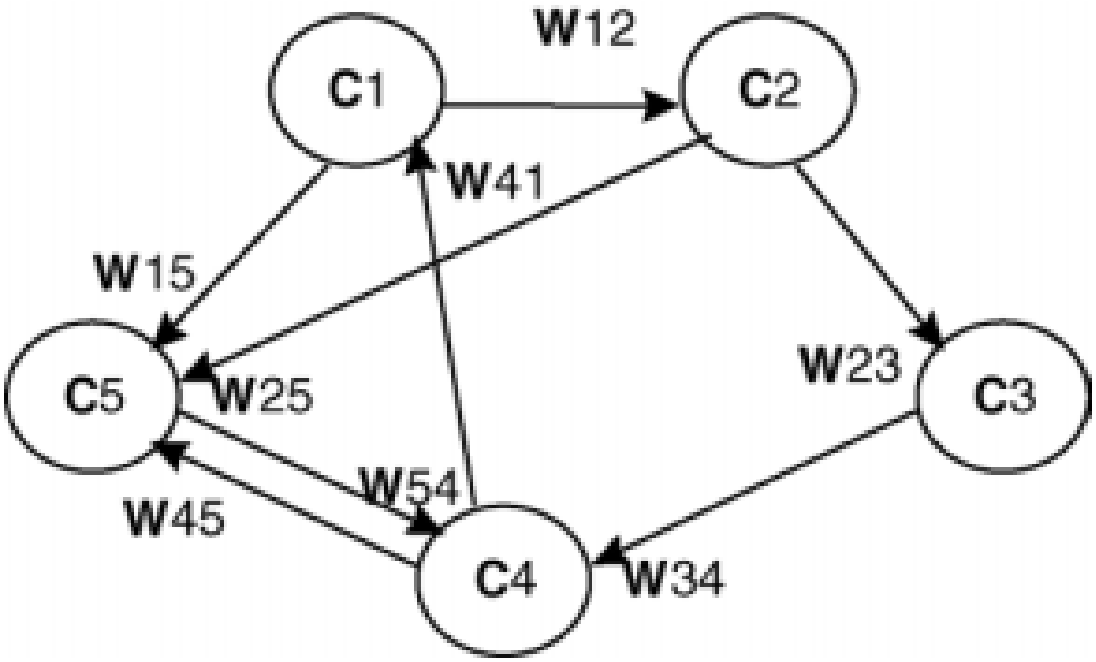
Degree of membership

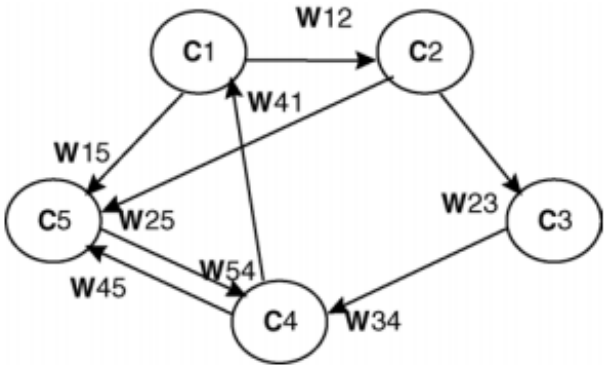


At 0^0C 0.8 in “cold”, 0.2 in “warm”

Fuzzy Cognitive Map

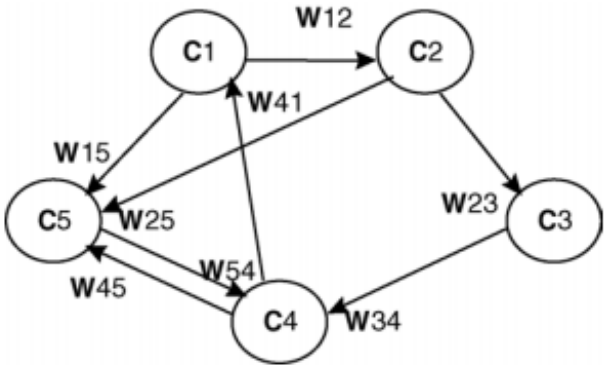
- Consist of nodes (concepts) & weights.
- Nodes ~ attributes, Weight [-1,1] ~ relation





Three possible types of causal relationships:

- $W_{ji} > 0$: positive causality C_i and C_j. An increase (decrease) in value of C_j leads to an increase (decrease) in value of C_i.
- $W_{ji} < 0$: negative causality.
- $W_{ji} = 0$: no relationship.



Value of each concept is the influence of other concepts to the specific concept, calculated by:

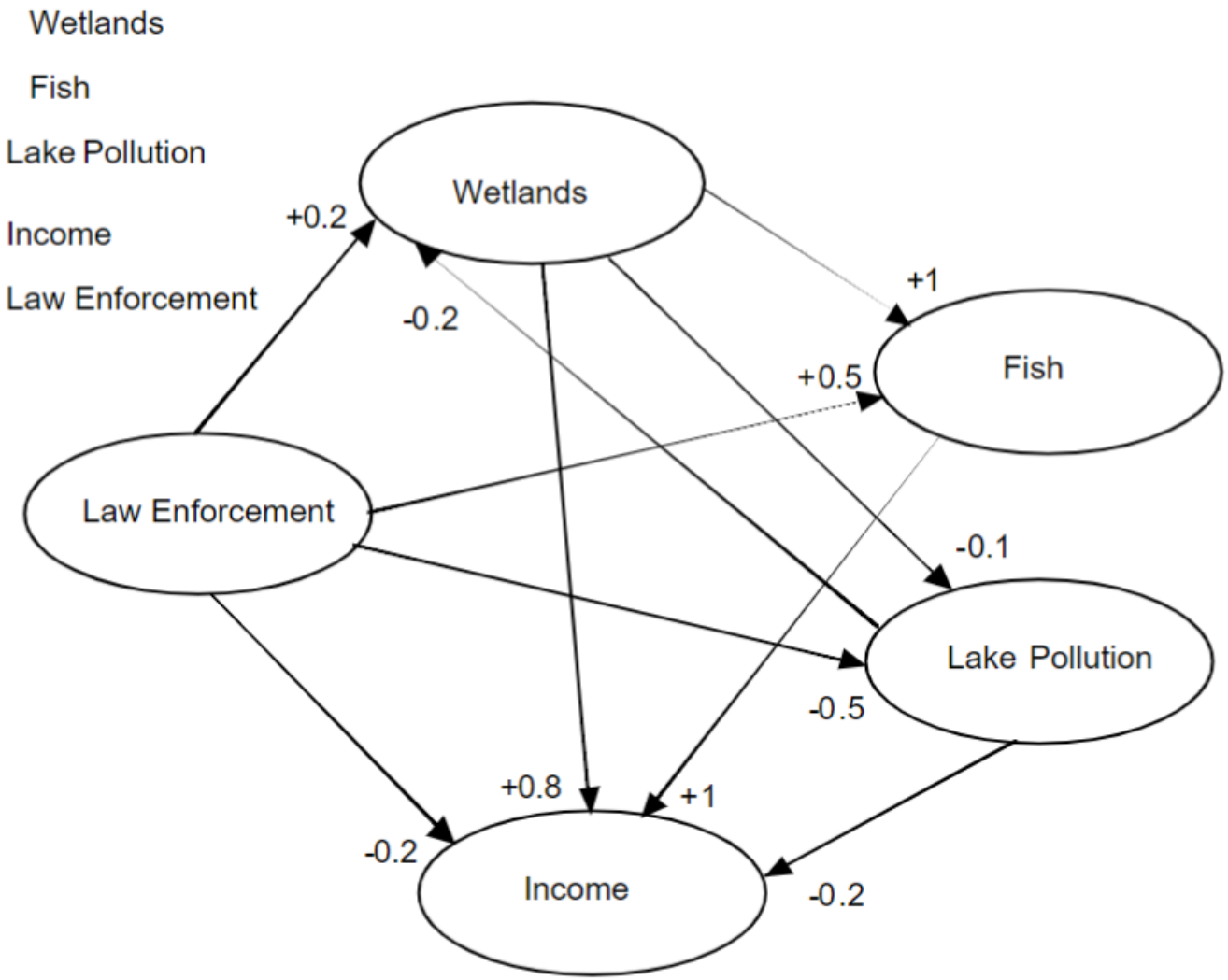
$$A_i^{(k+1)} = f\left(A_i^{(k)} + \sum_{\substack{j \neq i \\ j=1}}^{N} A_j^{(k)} \cdot w_{ji}\right)$$

where:

$A_i^{(k+1)}$: value of C_i at time k+1

$A_j^{(k)}$: value of C_j at time k

$f = \frac{1}{1 + e^{-\lambda x}}$: sigmoid threshold function



Ozesmi, U. (2004) Ecological models based on people's knowledge: a multi-step fuzzy cognitive mapping approach. Ecological Modelling, 176(1), 43-64

Outline

1/ Fuzzy Cognitive Map

2/ **Building Fuzzy Cognitive Map**

3/ Decision Tree

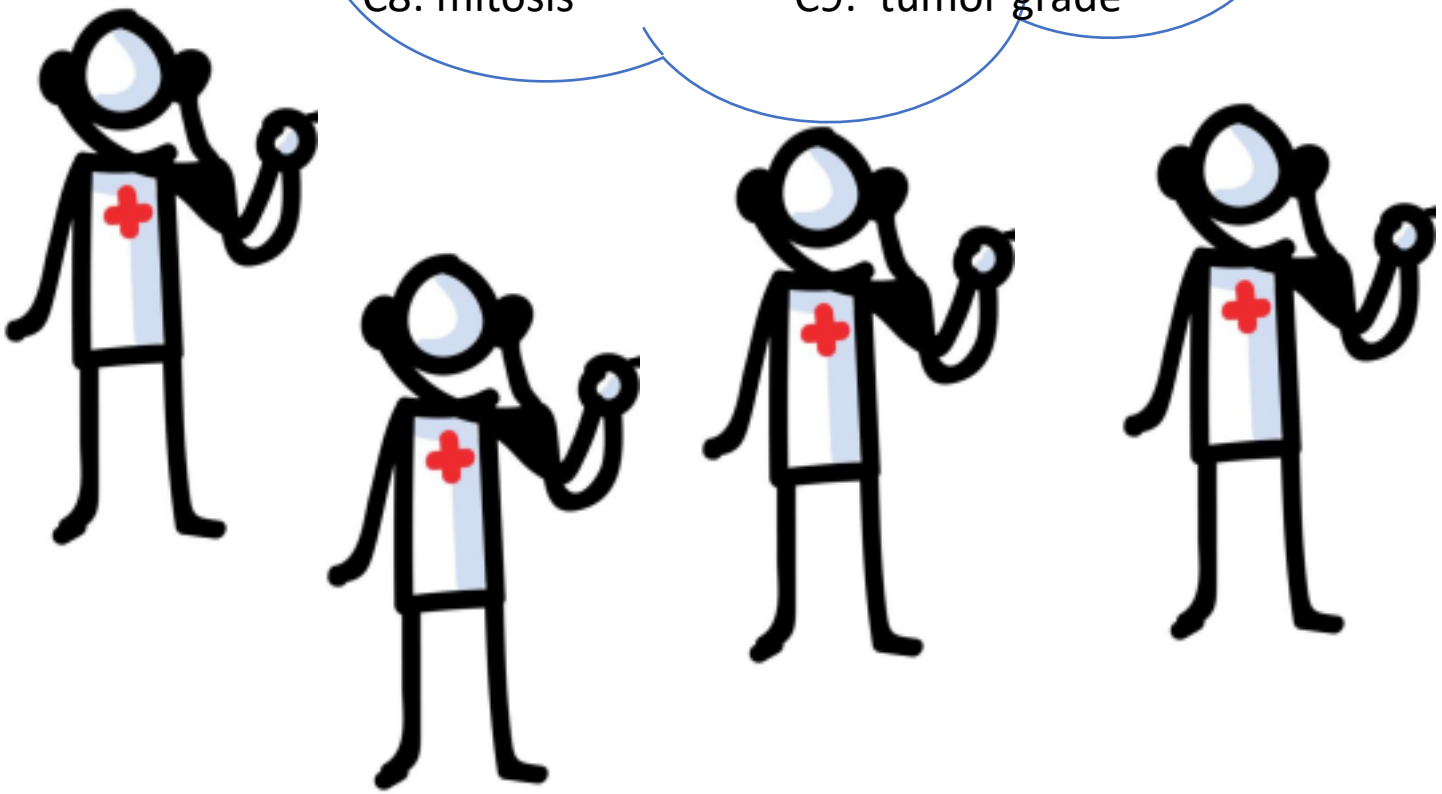
4/ Hybrid model FCM-DT

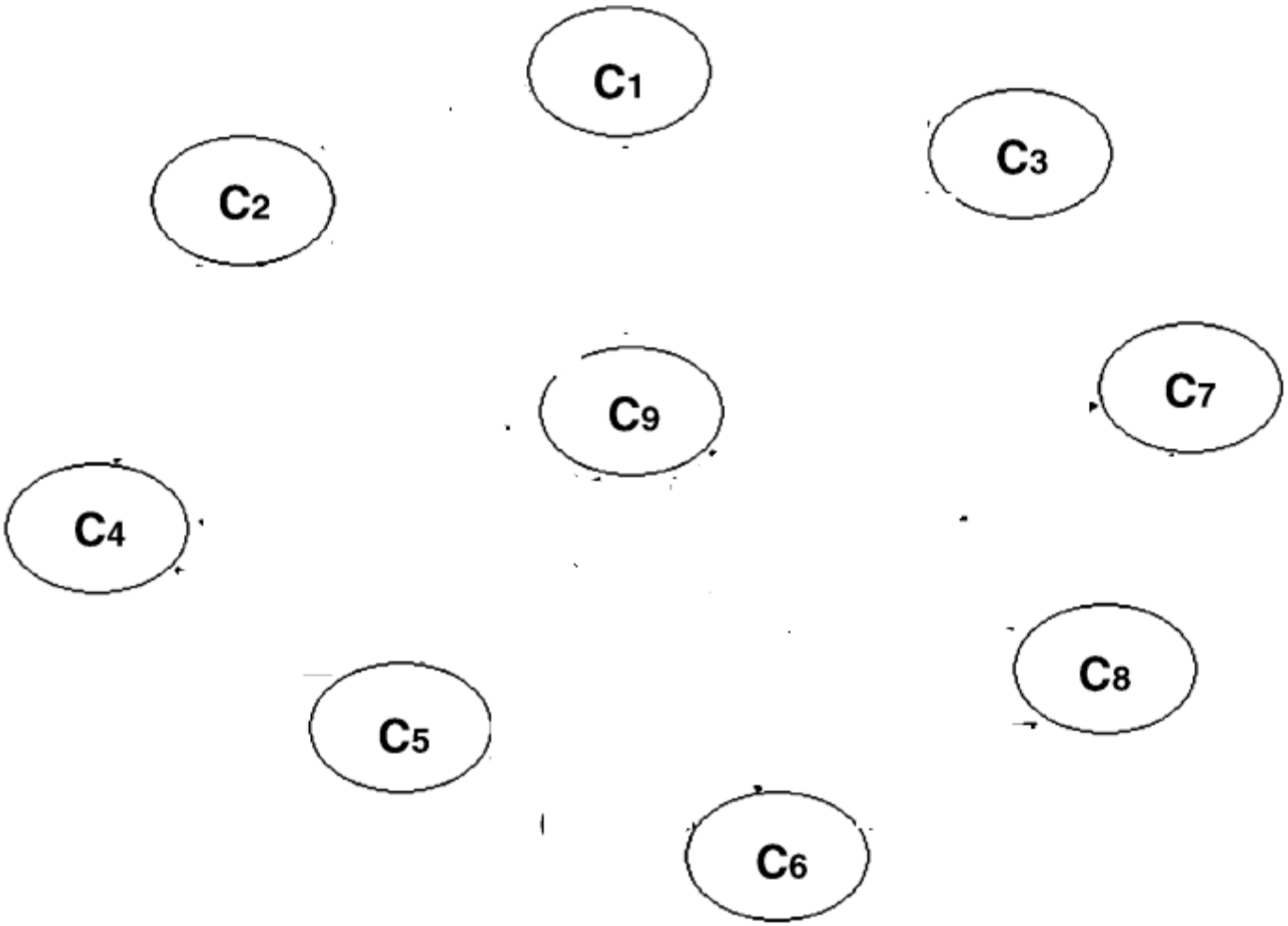
I think I am having bladder tumor (guz pęcherza moczowego). Please perform a tumor grading for me to check my illness.

Alright! In general, bladder tumors are graded 1,2 and 3:

- G1: similar to normal cells, slow-growing (low grade)
- G2: less like normal cell (high grade)
- G3: very different from normal cell

Main variables to consider are:
C1: cell distribution
C2: cell size
C3: cell number
C4: cytoplasm (cytoplazma)
C5: nuclei
C6: nucleoli
C7: necrosis
C8: mitosis
C9: tumor grade



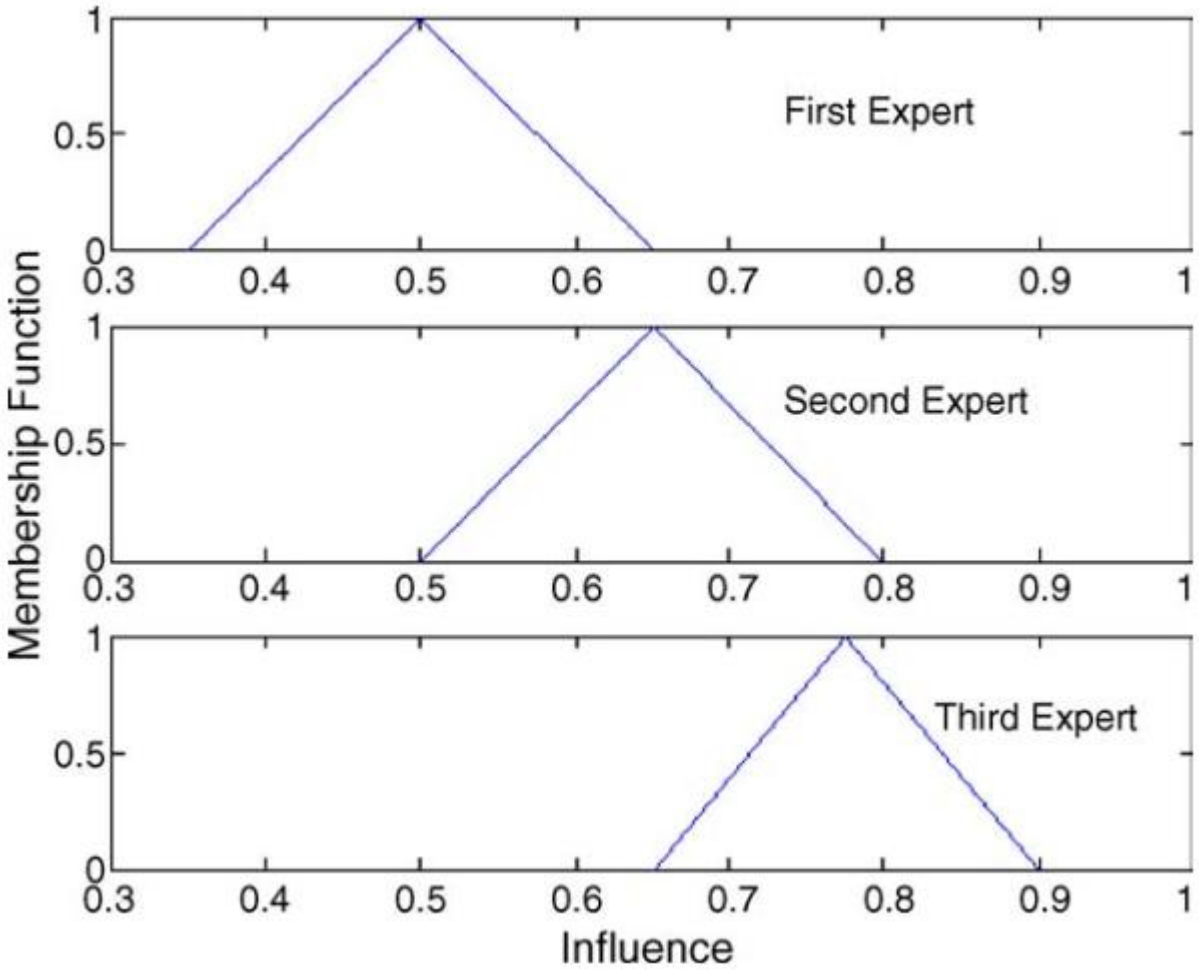

C1
C2
C3
C4
C5
C6
C7
C8
C9

- IF-THEN rule
- Influence value in [0,1]
- Fuzzy set {very very low, very low, low, medium, high, very high, very very high}

- Eg: **IF** a small change occurs in value C_1 (cell distribution), **THEN** a small change is caused in value C_9 (tumour grade)

➔ The influence from C_1 to C_9 is positive very low.

- Expert 1: Influence from C_5 to C_9 positive medium
- Expert 2: Influence from C_5 to C_9 positive high
- Expert 3: Influence from C_5 to C_9 positive very high



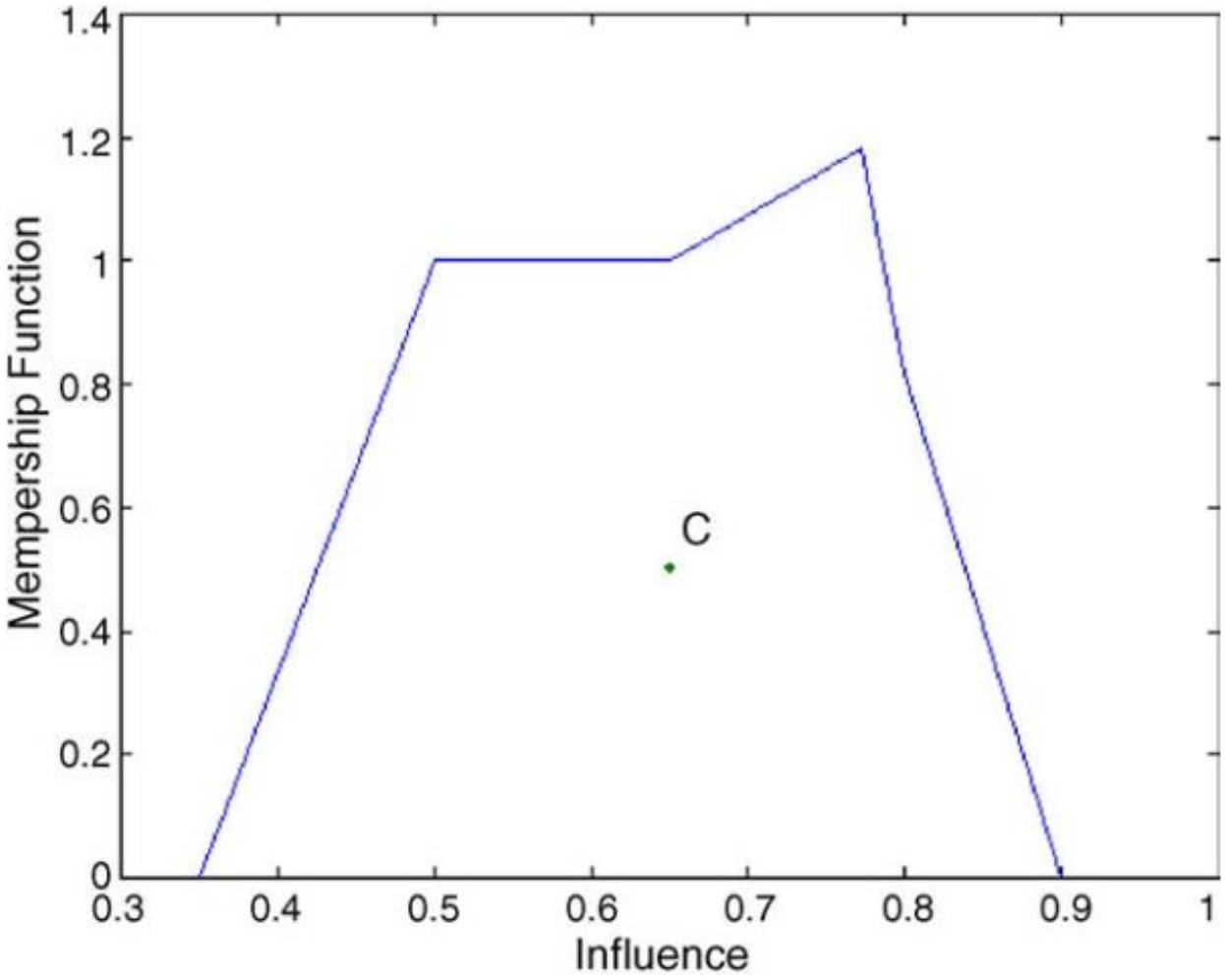


Figure 4 Aggregation of three linguistic variables using the SUM technique. Point C is the numerical weight after defuzzification using the CoA method.

$W_{59} = 0.65$

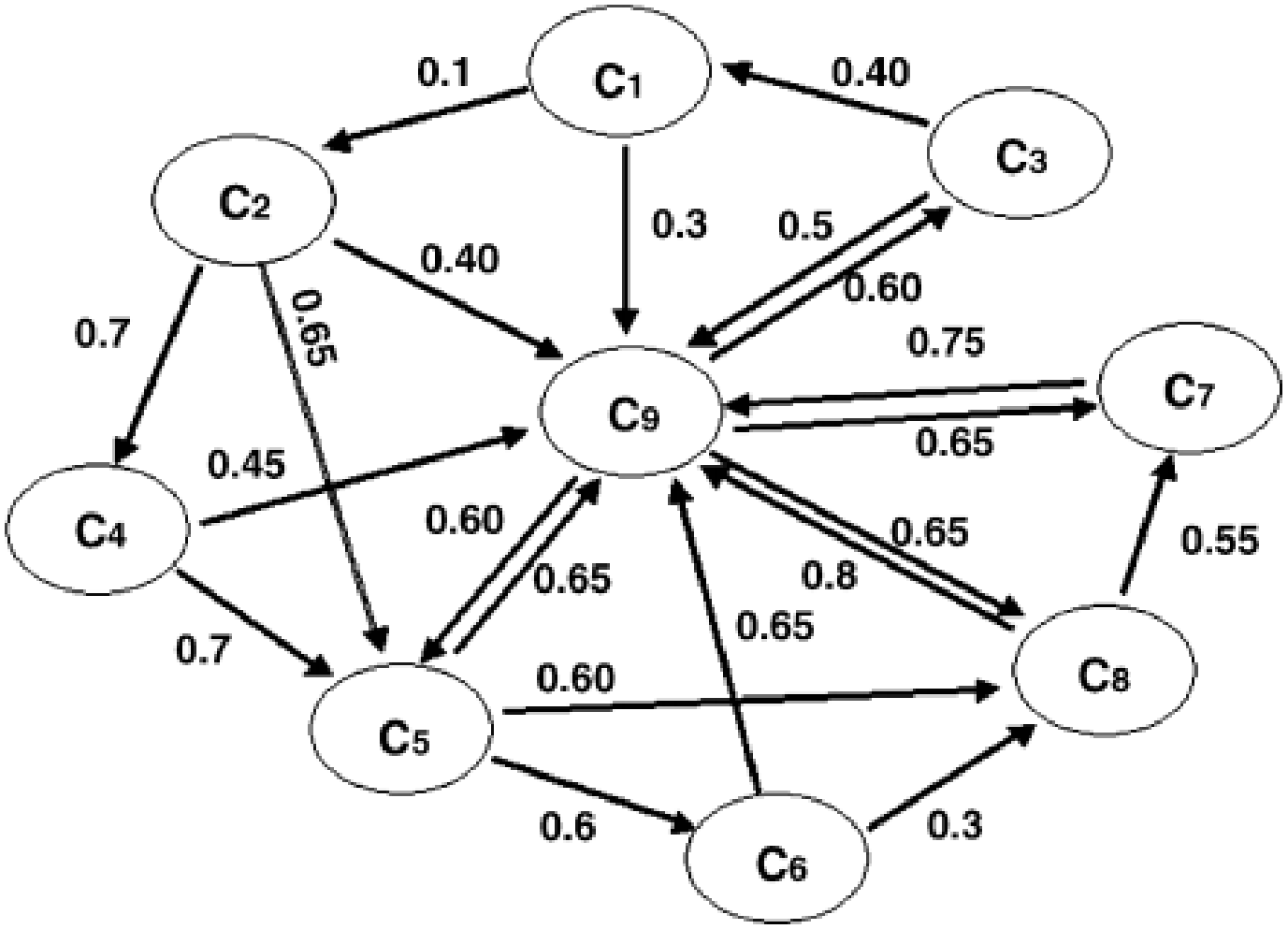


Figure 5 The FCM tumour grading model.

Ready to assign grade of every tumor!!

-> Initial value of C_9 was set a random value in [0,1]
-> AHL algorithm (Activation Hebbian Learning)
-> Value of C_9 (grade for tumor)

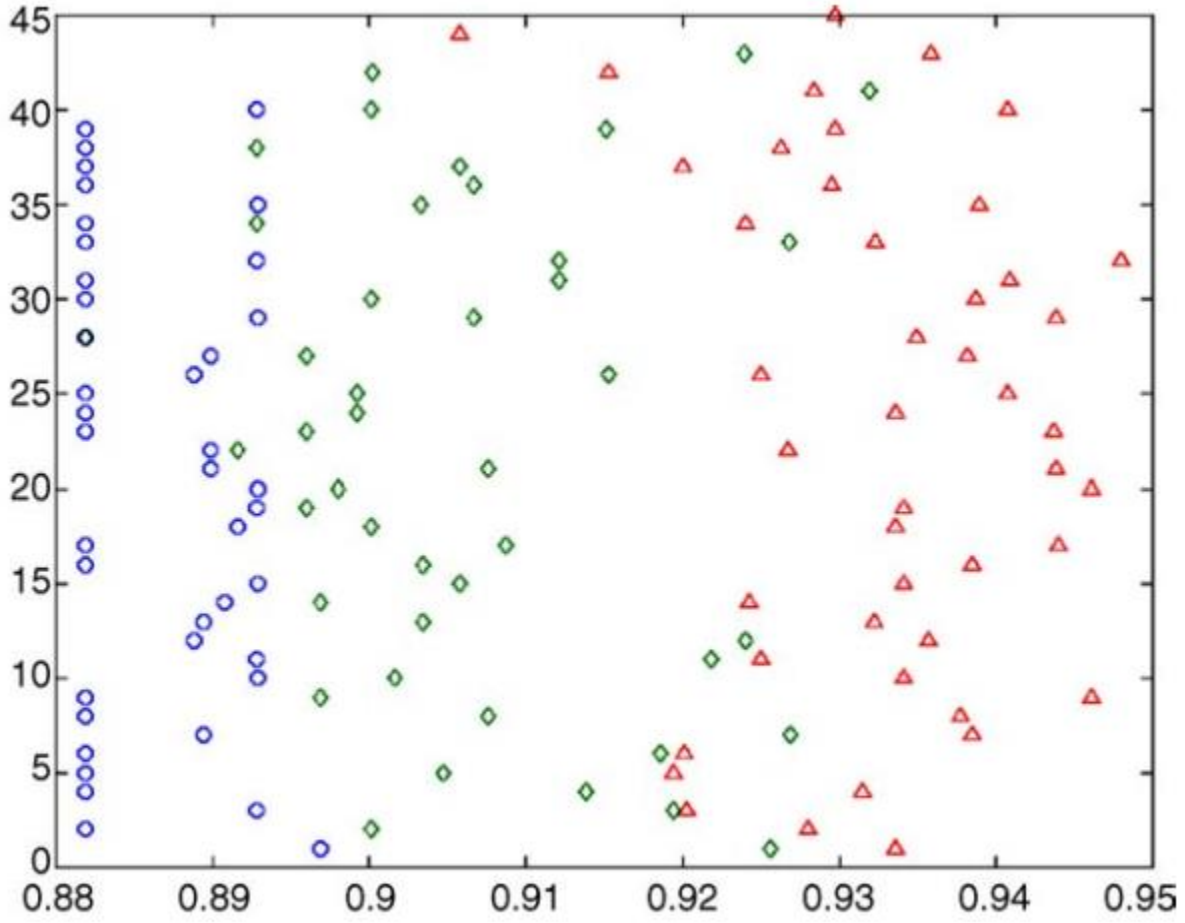
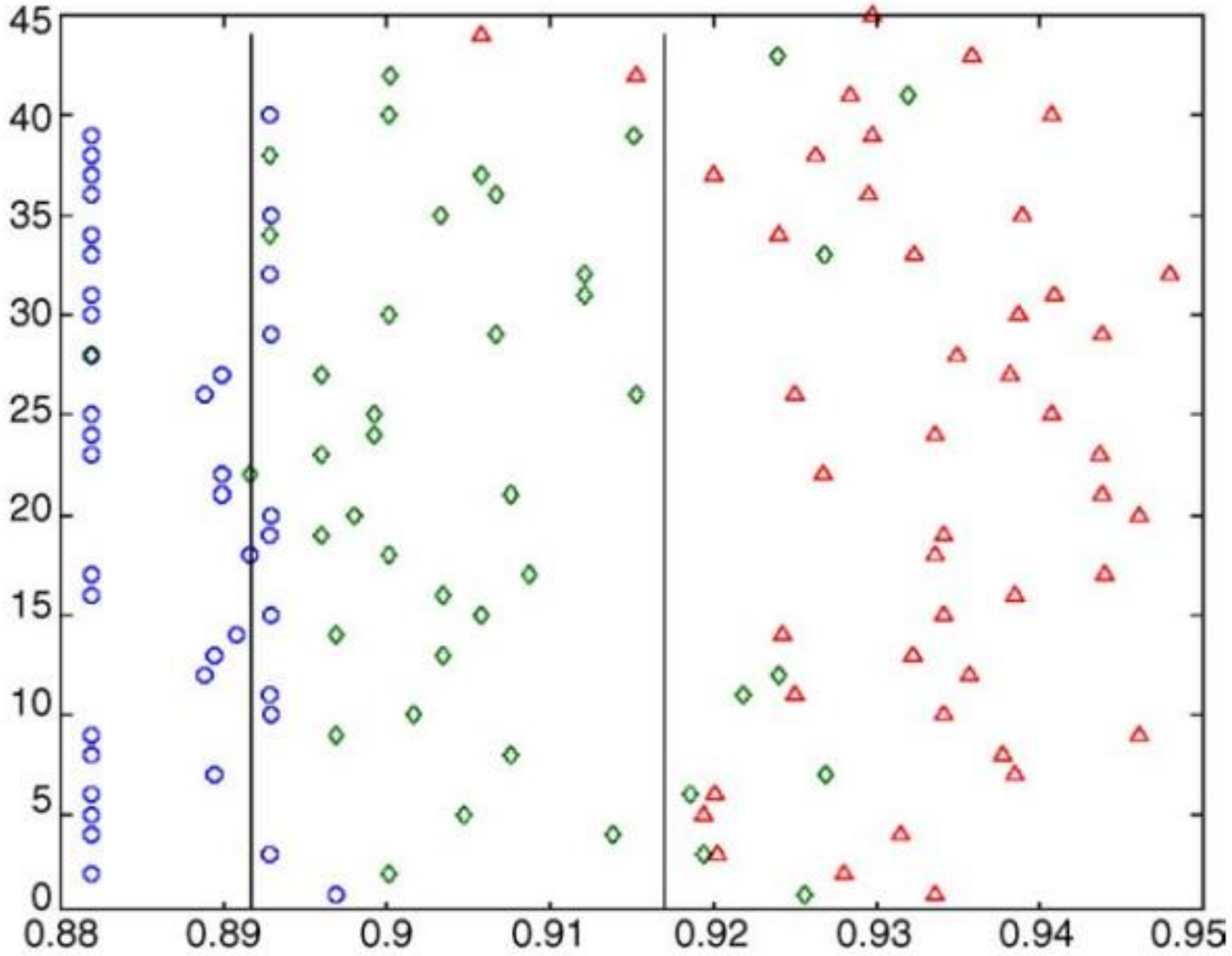


Figure 7 The estimated 'Grade' values for the 128 cases.


45
40
35
30
25
20
15
10
5
0
0.88
0.89
0.9
0.91
0.92
0.93
0.94
0.95

Bright sides of FCM:

- Unlimited number of medical doctors
- Combination of theories of neural network & fuzzy
- Effective decision-making technique
- High performance
- Gathering existing & domain knowledge
- Have been used, especially for radiotherapy
- ….

Dark sides of FCM:

- Heavily relies on human experience
- Undesired traps of steady states
- Inability of physicians working with big data, especially quantitative data
- ….

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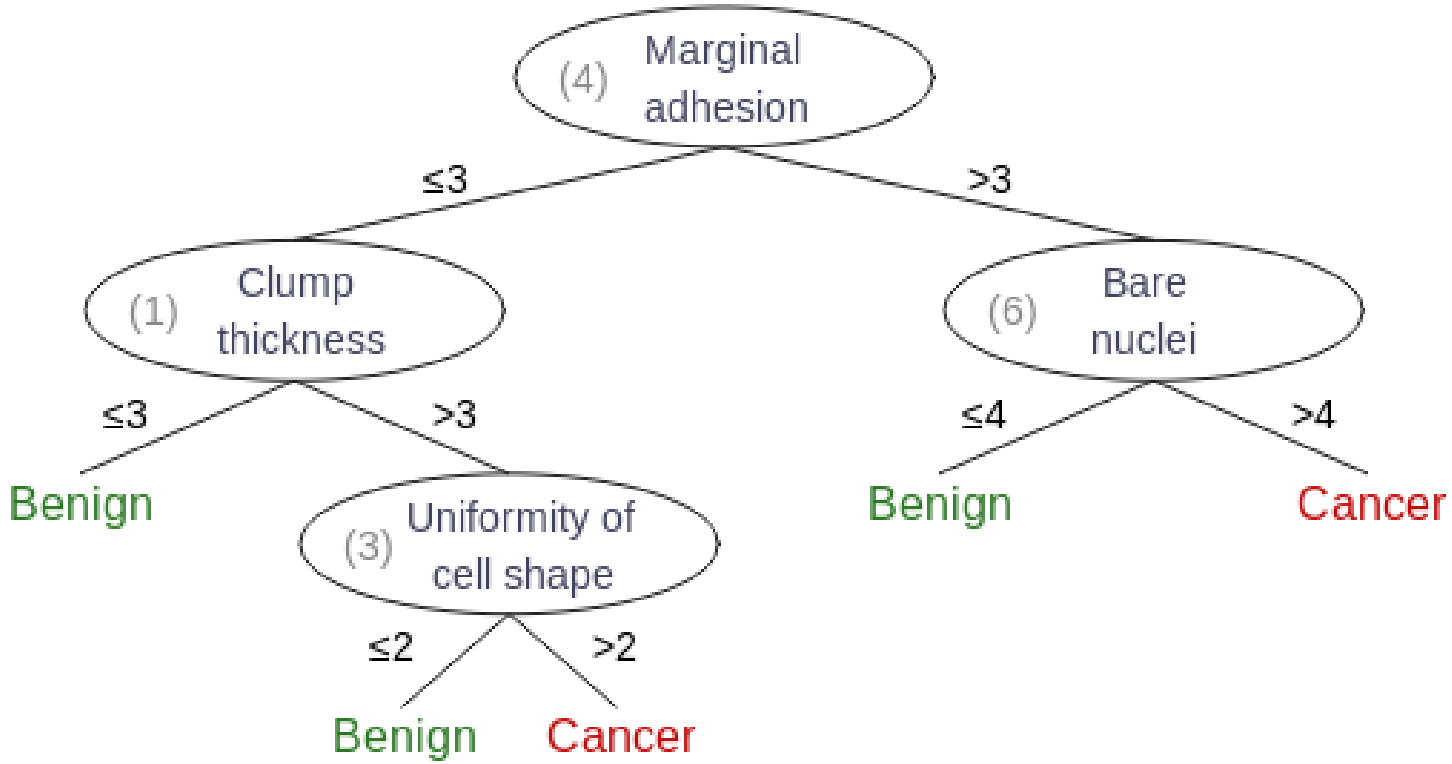

Set of IF-THEN rules

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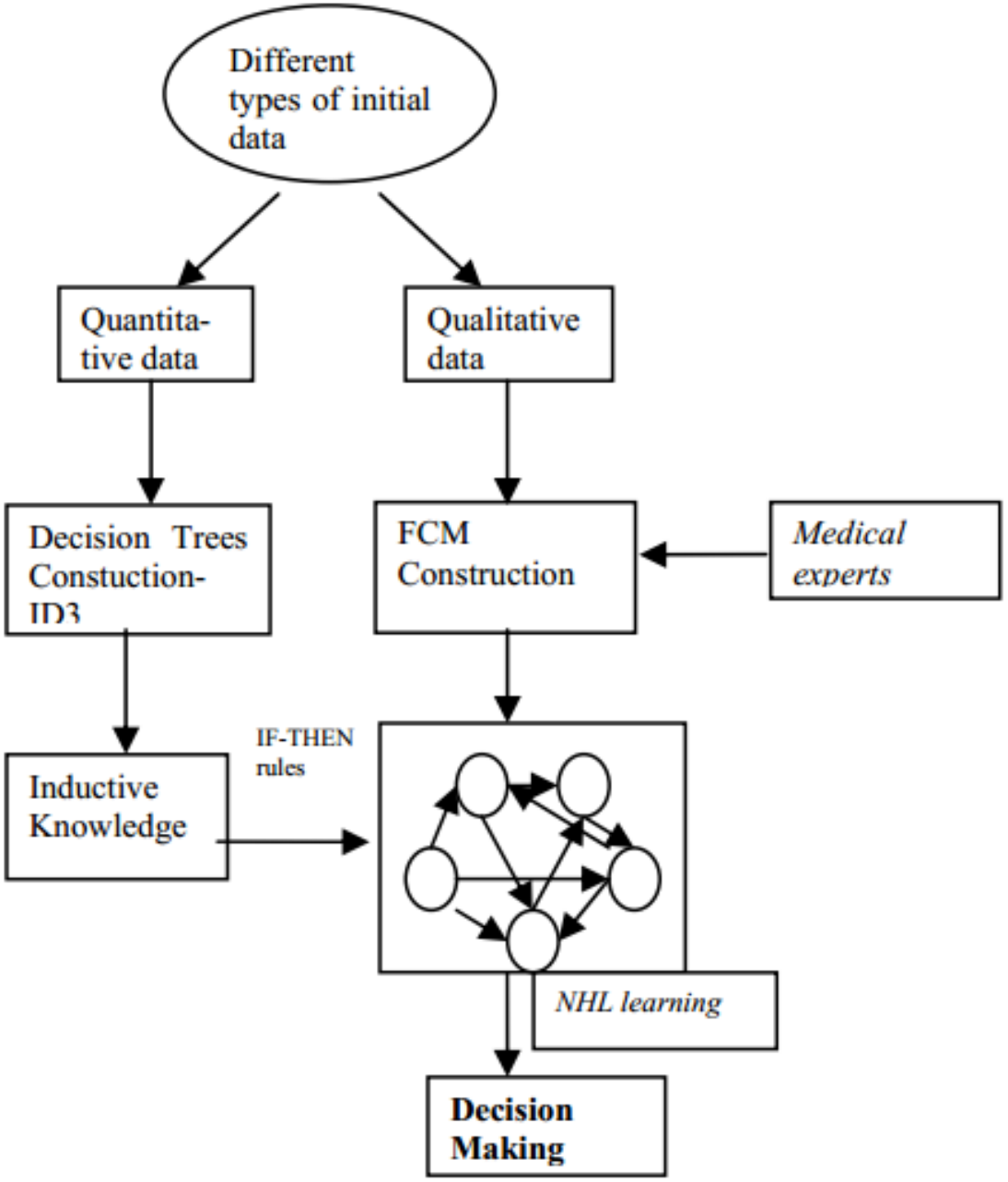
Different types of initial data
Quantita-tive data
Qualitative data
Decision Trees Constuction-ID3
FCM Construction
Medical experts
IF-THEN rules
Inductive Knowledge
NHL learning
Decision Making

References:

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- Papageorgiou, E., Stylios, C., Groumpos, P. (2003). Fuzzy Cognitive Map Learning Based on Nonlinear Hebbian Rule. In: Gedeon, T.(.D., Fung, L.C.C. (eds) AI 2003: Advances in Artificial Intelligence. AI 2003. Lecture Notes in Computer Science(), vol 2903. Springer, Berlin, Heidelberg. https://doi.org/10.1007/978-3-540-24581-0_22

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- Papageorgiou EI, Spyridonos PP, Stylios CD, Ravazoula P, Groumpos PP, Nikiforidis GN. Advanced soft computing diagnosis method for tumour grading. Artif Intell Med. 2006 Jan;36(1):59-70. doi: 10.1016/j.artmed.2005.04.001. Epub 2005 Aug 10. PMID: 16095888.

Table 1 Histological features for coding tumours' malignancy

Histological features	Assessment	Type of values scaled
C_1: cell distribution	Even, clustered	Two discrete (0 or 1)
C_2: cell size	Uniform, pleomorphic	Two discrete (0 or 1)
C_3: cell number	Numerous, variable	Two discrete (0 or 1)
C_4: cytoplasm	Homogeneous, variable	Two discrete (0 or 1)
C_5: nuclei	Uniform, irregular, very irregular, bizarre	Four fuzzy values (zero, low, medium, high)
C_6: nucleoli	Inconspicuous, evident, prominent	Three discrete (0, 0.5 or 1)
C_7: necrosis	Inconspicuous, frequent	Two discrete (0 or 1)
C_8: mitosis	Absent rate, occasional, numerous	Three discrete (0, 0.5 or 1)