Fuzzy logic course

(Beatrice Lazzerini, Uni. Pisa)

Atinç Ylmaz, Seçkin Aria, Ümit Kocabiçak, **Risk analysis of lung cancer and effects of stress level on cancer risk through neuro-fuzzy model**,

Computer methods and programs in biomedicine 137 (2016) 35-46

Stefano Martina

stefano.martina@unifi.it

UNIVERSITÀ DEGLI STUDI FIRENZE

17 May 2017

Fuzzy logic in medicine

- ✔ insufficient information
- ✔ provided information is subjective
- ✔ unclear border between healthy and pathological
- ✔ errors and misconducts on diagnostic tests
- ✔ faked symptoms
- ✔ limited experiments (1536 subjects in this)

Fuzzy logic in medicine

- ✔ insufficient information
- ✔ provided information is subjective
- ✔ unclear border between healthy and pathological
- ✔ errors and misconducts on diagnostic tests
- ✔ faked symptoms
- ✔ limited experiments (1536 subjects in this)

Fuzzy logic in medicine

- ✔ insufficient information
- ✔ provided information is subjective
- ✔ unclear border between healthy and pathological
- ✔ errors and misconducts on diagnostic tests
- ✔ faked symptoms
- ✔ limited experiments (1536 subjects in this)

Fuzzy logic in medicine

- ✔ insufficient information
- ✔ provided information is subjective
- ✔ unclear border between healthy and pathological
- ✔ errors and misconducts on diagnostic tests
- ✔ faked symptoms
- ✔ limited experiments (1536 subjects in this)

Fuzzy logic in medicine

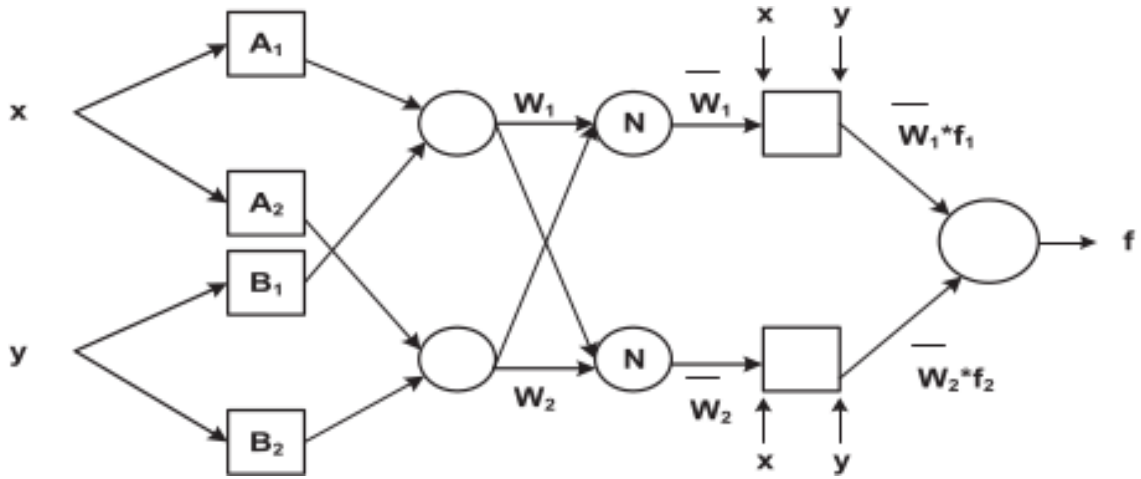
- ✔ insufficient information
- ✔ provided information is subjective
- ✔ unclear border between healthy and pathological
- ✔ errors and misconducts on diagnostic tests
- ✔ faked symptoms
- ✔ limited experiments (1536 subjects in this)

Fuzzy logic in medicine

- ✔ insufficient information
- ✔ provided information is subjective
- ✔ unclear border between healthy and pathological
- ✔ errors and misconducts on diagnostic tests
- ✔ faked symptoms
- ✔ limited experiments (1536 subjects in this)

Adaptive neuro-fuzzy inference system (ANFIS)

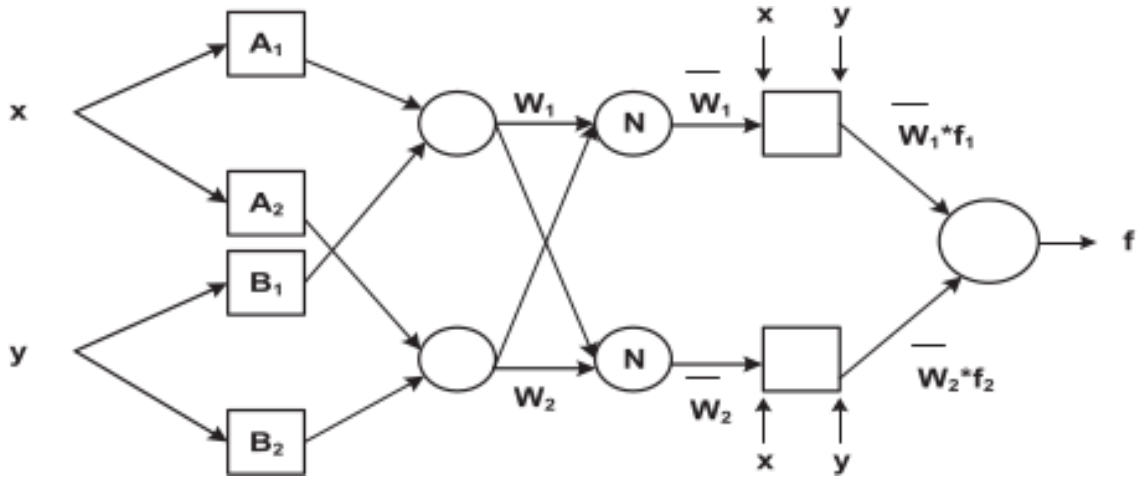
Unifies decision ability and verbal expression of fuzzy logic with learning ability and adaptivity of neural networks.



- Layer 1 is input
- Layer 2 cluster membership degree (least squares)
- Layer 3 are the rules (different t-norms)
- Layer 4 is normalization
- Layer 5 is defuzzification (backpropagation)
- Layer 6 is output

Adaptive neuro-fuzzy inference system (ANFIS)

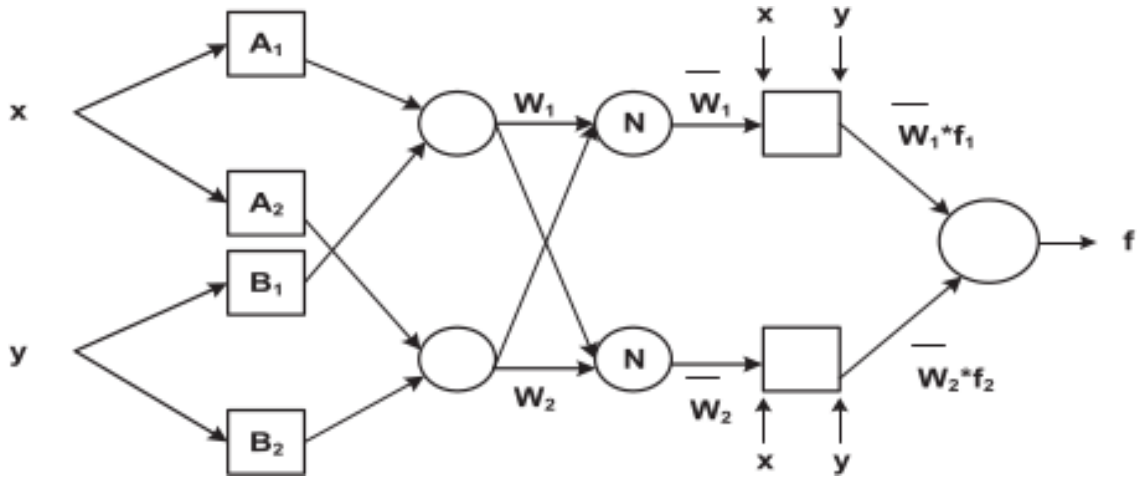
Unifies decision ability and verbal expression of fuzzy logic with learning ability and adaptivity of neural networks.



- ✔ Layer 1 is input
- ✔ Layer 2 cluster membership degree (least squares)
- ✔ Layer 3 are the rules (different t-norms)
- ✔ Layer 4 is normalization
- ✔ Layer 5 is defuzzification (backpropagation)
- ✔ Layer 6 is output

Adaptive neuro-fuzzy inference system (ANFIS)

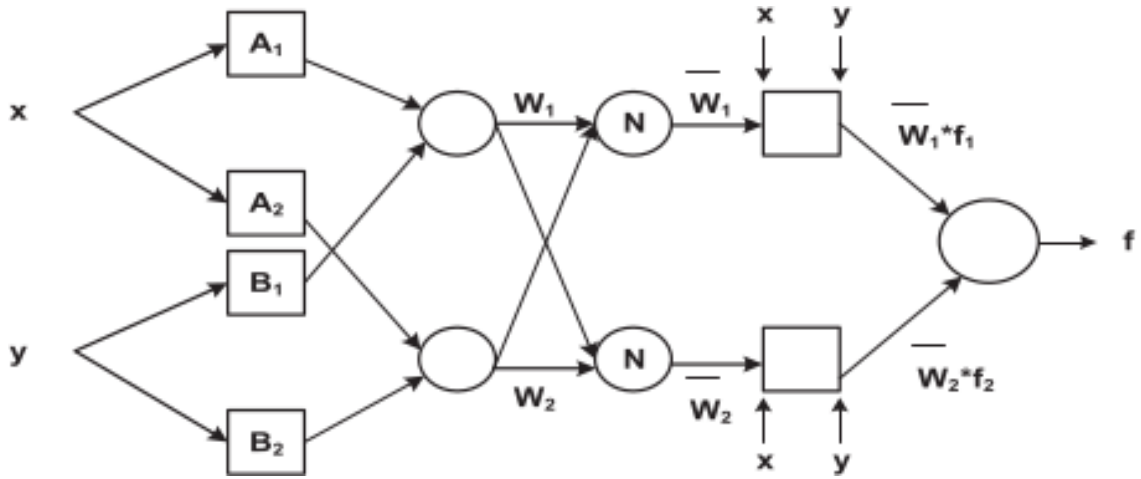
Unifies decision ability and verbal expression of fuzzy logic with learning ability and adaptivity of neural networks.



- ✔ Layer 1 is input
- ✔ Layer 2 cluster membership degree (least squares)
- ✔ Layer 3 are the rules (different t-norms)
- ✔ Layer 4 is normalization
- ✔ Layer 5 is defuzzification (backpropagation)
- ✔ Layer 6 is output

Adaptive neuro-fuzzy inference system (ANFIS)

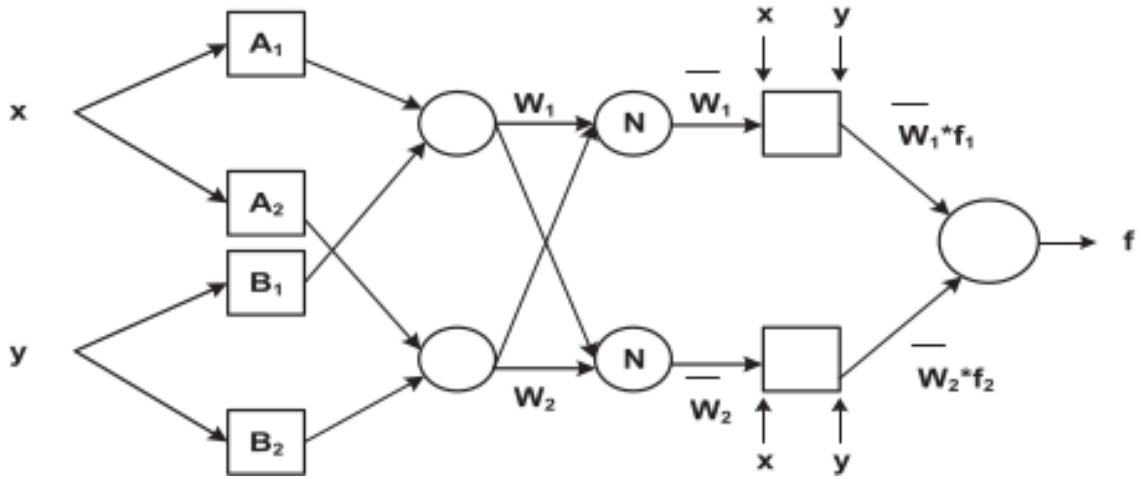
Unifies decision ability and verbal expression of fuzzy logic with learning ability and adaptivity of neural networks.



- ✔ Layer 1 is input
- ✔ Layer 2 cluster membership degree (least squares)
- ✔ Layer 3 are the rules (different t-norms)
- ✔ Layer 4 is normalization
- ✔ Layer 5 is defuzzification (backpropagation)
- ✔ Layer 6 is output

Adaptive neuro-fuzzy inference system (ANFIS)

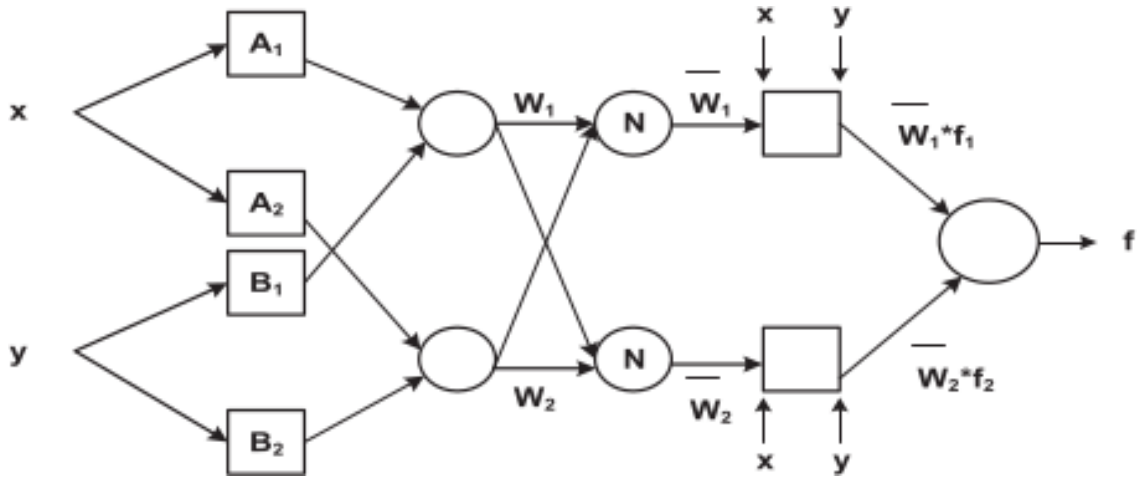
Unifies decision ability and verbal expression of fuzzy logic with learning ability and adaptivity of neural networks.



- ✔ Layer 1 is input
- ✔ Layer 2 cluster membership degree (least squares)
- ✔ Layer 3 are the rules (different t-norms)
- ✔ Layer 4 is normalization
- ✔ Layer 5 is defuzzification (backpropagation)
- ✔ Layer 6 is output

Adaptive neuro-fuzzy inference system (ANFIS)

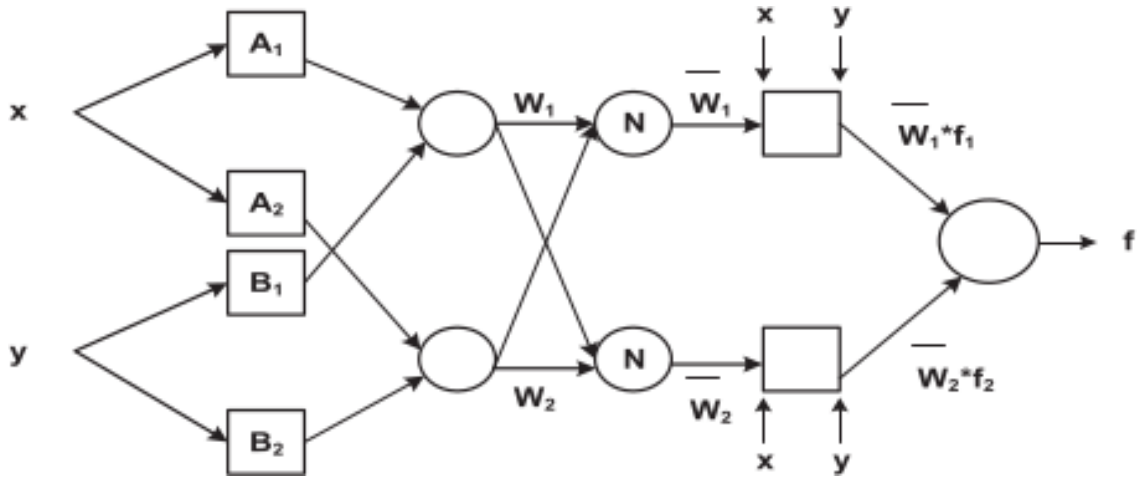
Unifies decision ability and verbal expression of fuzzy logic with learning ability and adaptivity of neural networks.



- ✔ Layer 1 is input
- ✔ Layer 2 cluster membership degree (least squares)
- ✔ Layer 3 are the rules (different t-norms)
- ✔ Layer 4 is normalization
- ✔ Layer 5 is defuzzification (backpropagation)
- ✔ Layer 6 is output

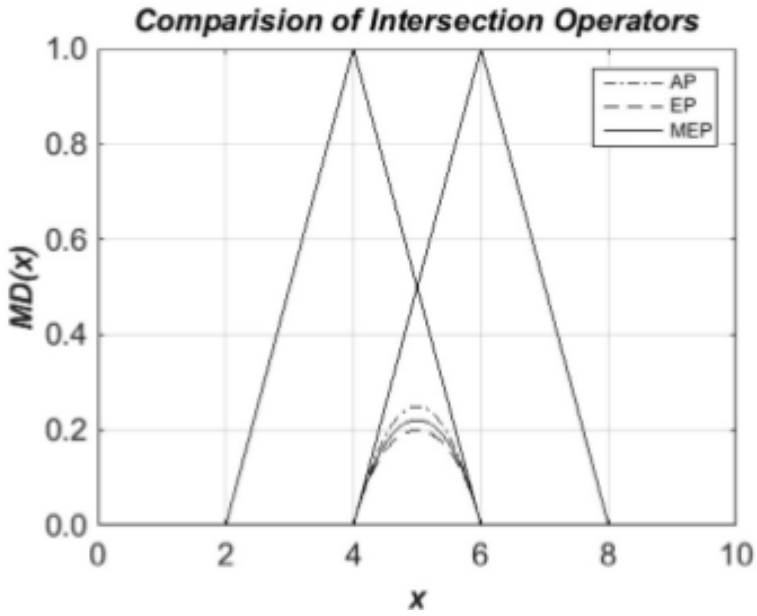
Adaptive neuro-fuzzy inference system (ANFIS)

Unifies decision ability and verbal expression of fuzzy logic with learning ability and adaptivity of neural networks.



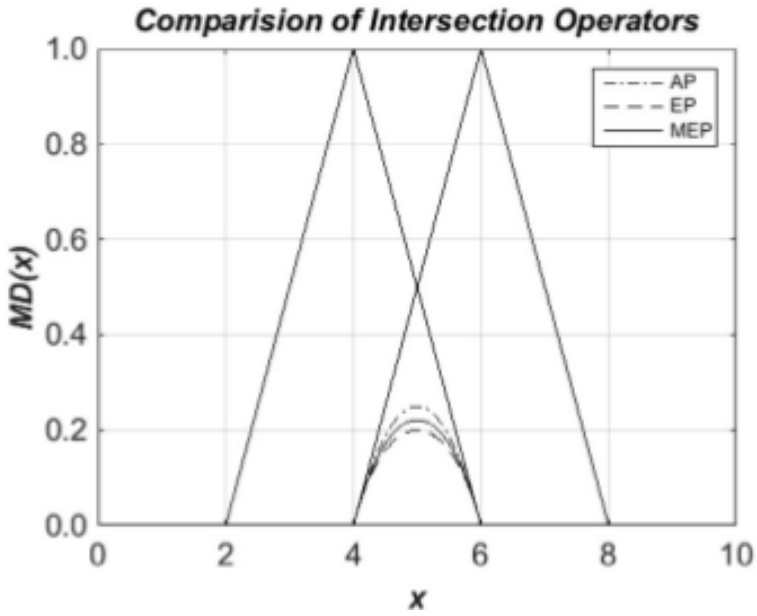
- ✔ Layer 1 is input
- ✔ Layer 2 cluster membership degree (least squares)
- ✔ Layer 3 are the rules (different t-norms)
- ✔ Layer 4 is normalization
- ✔ Layer 5 is defuzzification (backpropagation)
- ✔ Layer 6 is output

Intersection operators



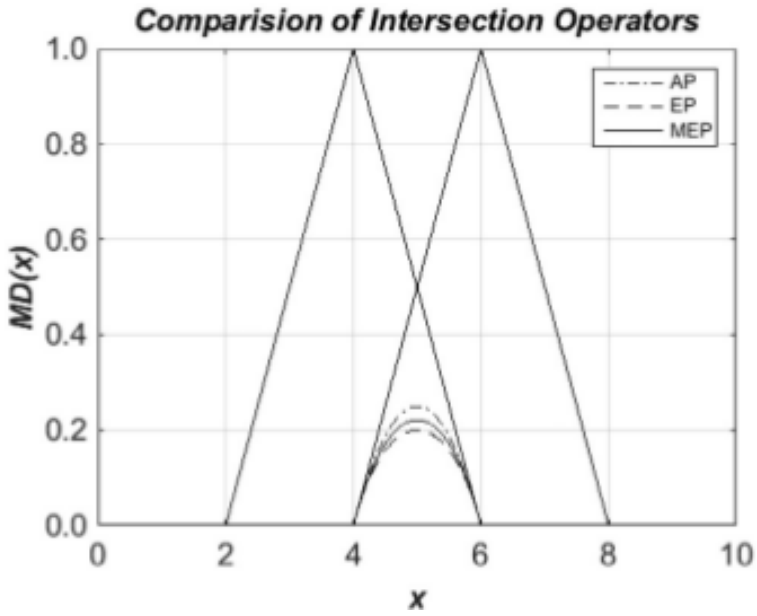
- ✔ Algebraic product $\mu_{A_i}(x)\mu_{B_i}(y)\ldots\mu_{T_i}(t)$
- ✔ Einstein product $\frac{\mu_{A_i}(x)\mu_{B_i}(y)}{1+(1-\mu_{A_i}(x))((1-\mu_{B_i}(y)))}$
- ✔ Modified Einstein product $\frac{K\mu_{A_i}(x)\mu_{B_i}(y)\ldots\mu_{K_i}(k)}{K+(1-\mu_{A_i}(x))((1-\mu_{B_i}(y))\ldots((1-\mu_{K_i}(k)))}$
  - converges to algebraic product

Intersection operators



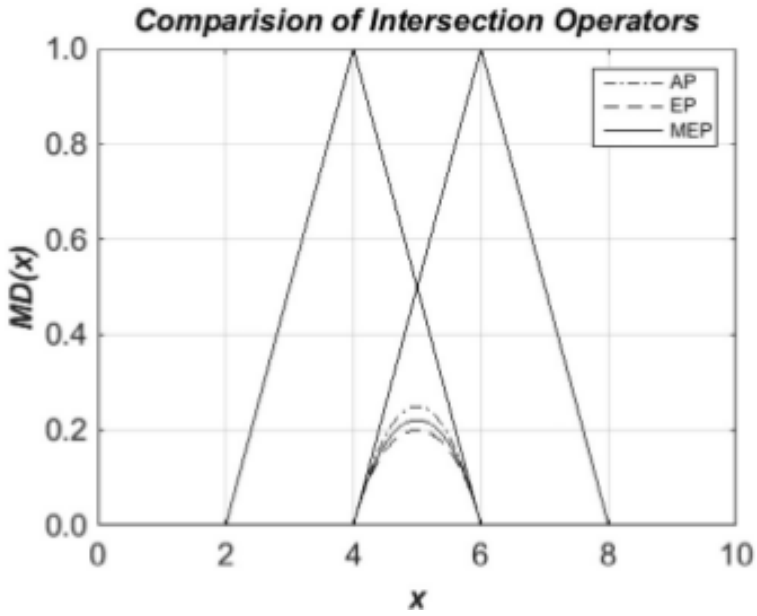
- ✔ Algebraic product $\mu_{A_i}(x)\mu_{B_i}(y)\ldots\mu_{T_i}(t)$
- ✔ Einstein product $\frac{\mu_{A_i}(x)\mu_{B_i}(y)}{1+(1-\mu_{A_i}(x))((1-\mu_{B_i}(y)))}$
- ✔ Modified Einstein product $\frac{K\mu_{A_i}(x)\mu_{B_i}(y)\ldots\mu_{K_i}(k)}{K+(1-\mu_{A_i}(x))((1-\mu_{B_i}(y))\ldots((1-\mu_{K_i}(k)))}$
  - converges to algebraic product

Intersection operators



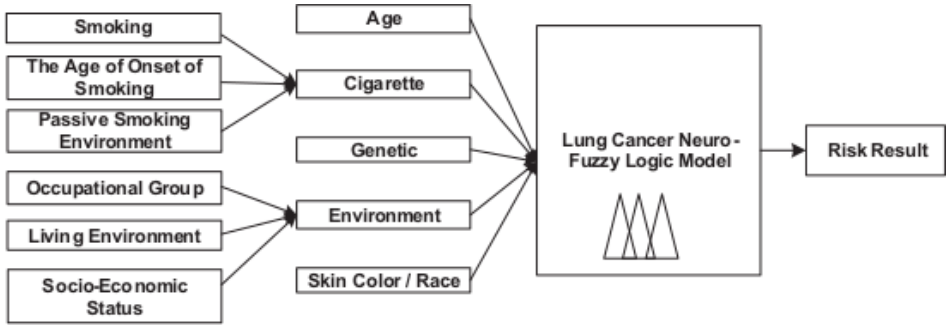
- ✔ Algebraic product $\mu_{A_i}(x)\mu_{B_i}(y)\ldots\mu_{T_i}(t)$
- ✔ Einstein product $\frac{\mu_{A_i}(x)\mu_{B_i}(y)}{1+(1-\mu_{A_i}(x))((1-\mu_{B_i}(y)))}$
- ✔ Modified Einstein product $\frac{K\mu_{A_i}(x)\mu_{B_i}(y)\ldots\mu_{K_i}(k)}{K+(1-\mu_{A_i}(x))((1-\mu_{B_i}(y))\ldots((1-\mu_{K_i}(k)))}$
  - converges to algebraic product

Intersection operators



- ✔ Algebraic product $\mu_{A_i}(x)\mu_{B_i}(y)\ldots\mu_{T_i}(t)$
- ✔ Einstein product $\frac{\mu_{A_i}(x)\mu_{B_i}(y)}{1+(1-\mu_{A_i}(x))((1-\mu_{B_i}(y)))}$
- ✔ Modified Einstein product $\frac{K\mu_{A_i}(x)\mu_{B_i}(y)\ldots\mu_{K_i}(k)}{K+(1-\mu_{A_i}(x))((1-\mu_{B_i}(y))\ldots((1-\mu_{K_i}(k)))}$
  - converges to algebraic product

Cancer model



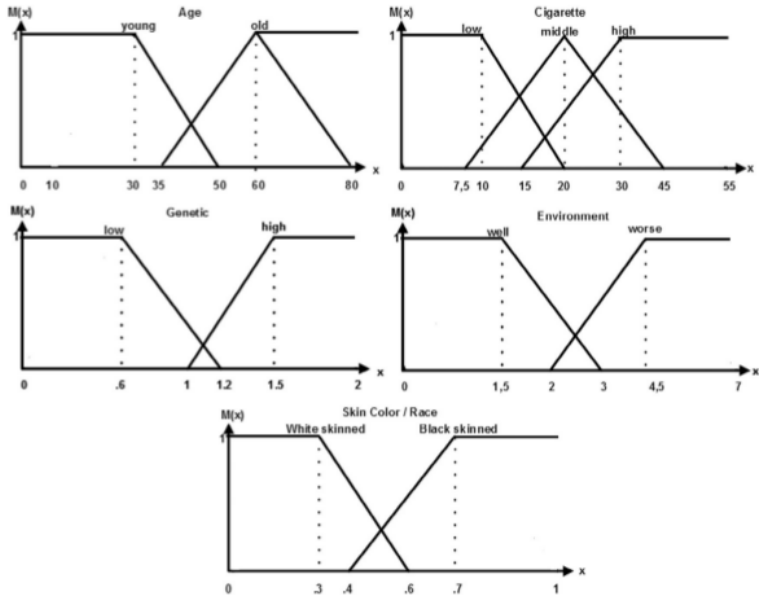


Table 1 – Sample rules lung cancer neuro-fuzzy logic model.

Sample rules

$f_i = p_i * age + q_i * cigarette + r_i * genetic + s_i * environment + t_i * skin\ color + u_i$

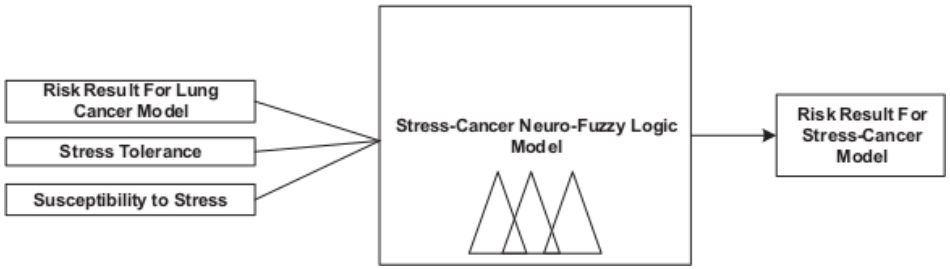
Age = young & Cigarette = low & Genetic = low & Environment = well & Skin Color = white skinned →
$f_1 = p_1 * age + q_1 * Cigarette + r_1 * Genetic + s_1 * Environment + t_1 * Skin\ Color + u_1$

Age = young & Cigarette = low & Genetic = low & Environment = worse & Skin Color = black skinned →
$f_4 = p_4 * age + q_4 * Cigarette + r_4 * Genetic + s_4 * Environment + t_4 * Skin\ Color + u_4$

Age = young & Cigarette = middle & Genetic = low & Environment = worse & Skin Color = white skinned →
$f_{12} = p_{12} * age + q_{12} * Cigarette + r_{12} * Genetic + s_{12} * Environment + t_4 * Skin\ Color + u_{12}$

Age = old & Cigarette = high & Genetic = high & Environment = worse & Skin Color = black skinned →
$f_{48} = p_{48} * age + q_{48} * Cigarette + r_{48} * Genetic + s_{48} * Environment + t_{48} * Skin\ Color + u_{48}$

Stress model



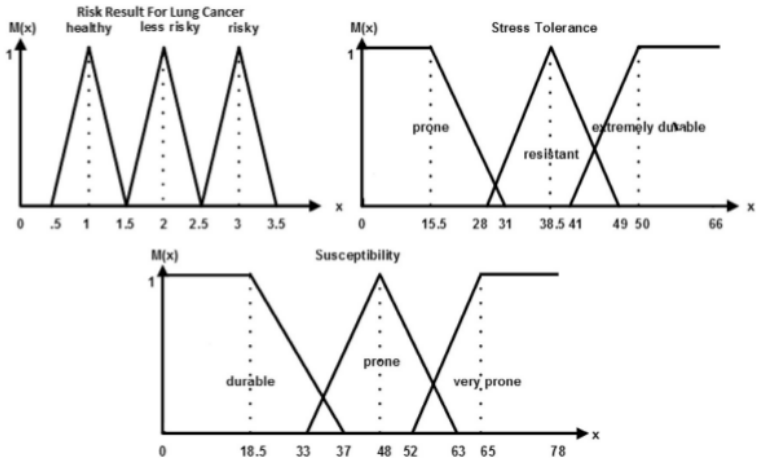


Table 2 – Sample rules stress–cancer neuro-fuzzy logic model.

Sample rules

$f_i = p_i$ * risk result for lung cancer + q_i* stress tolerance + r_i* susceptibility to stress + s_i

Risk result for lung cancer = healthy & Stress tolerance = prone & Susceptibility to stress = durable → f1 = p1*risk result for lung cancer+q1*stress tolerance+r1*susceptibility to stress+s1

Risk result for lung cancer = less risky & Stress tolerance = resistant & Susceptibility to stress = prone → f15 = p15*risk result for lung cancer+q15*stress tolerance+r15*susceptibility to stress+s15

Risk result for lung cancer = risky & Stress tolerance = prone & Susceptibility to stress = prone → f21=p21*risk result for lung cancer+q21*stress tolerance+r21*susceptibility to stress+s21

Risk result for lung cancer = risky & Stress tolerance = extremely durable & Susceptibility to stress = very prone → f27=p27*risk result for lung cancer+q27*stress tolerance+r27*susceptibility to stress+s27

Results

Table 3 – Accuracy rates of methods.		
	Lung cancer (%)	Effects of stress (%)
ANFIS	92.04	95.75
Einstein product	93.18	98.11
Proposed method	94.64	96.69