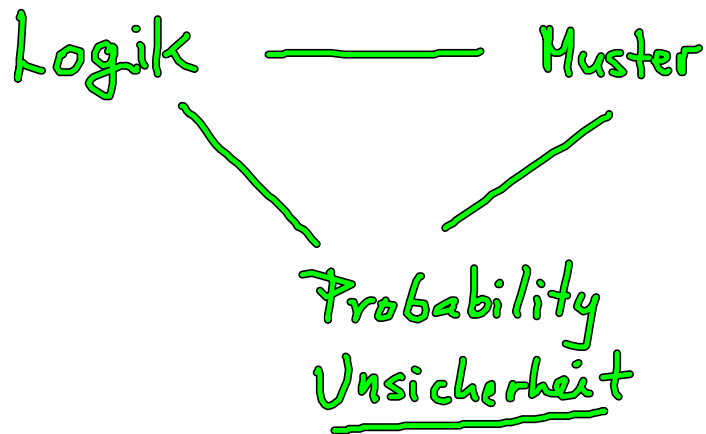


KI



Belief - Disbelief - Map

Hypothesen h

Evidenz e

→ $MB(h, e) \in \{0, 1\}$ Experten

$P(h|e) \leftrightarrow$ Bayes Formel

→ $MD(h, e) \in \{0, 1\}$ Experten

Expertensystem MYCIN

$$CF(h, e) = \mu_B(h, e) - \mu_D(h, e)$$

$$CF(h, e) \in \{-1..1\}$$

$$CF(h, e) = 1 \quad \text{absolut sicher}$$

$$CF(h, e) = -1 \quad \text{" " das } h \text{ nicht gilt}$$

Logische Verknüpfungen

$$\mu_B(h_1 \wedge h_2, e) = \min(\mu_B(h_1, e), \mu_B(h_2, e))$$

gegeben

$$\mu_B(h_1, e) = 0,5$$

$$\mu_B(h_2, e) = 0,1$$

z.B.

$$\mu_B(h, e) = 0,5$$

$$\mu_D(h, e) = 0,6$$

$$CF(h, e) = 0,5 - 0,6 = -0,1$$

$$\mu_B(h_1 \vee h_2, e) = \max(\mu_B(h_1, e), \mu_B(h_2, e))$$

$$MB(h_1, e) = 0,7$$

$$MB(h_2, e) = 1$$

Klassische Logik

x_1	x_2	\wedge
0	0	0 = min(0,0)
0	1	0 = min(0,1)
1	0	0 = min(1,0)
1	1	1 = min(1,1)

x_1	x_2	\wedge
0,1	0,3	0,1
0,2	0,7	0,2
...		

	\vee
0 0	0 = max(0,0)
0 1	1 = " (0,1)
1 0	1 = " (1,0)
1 1	1 = " (1,1)

x	$(1-x)$
0	1 = 1 - 0
1	0 = 1 - 1

Kombination von Evidenzen

$$MB(h, s_1 \wedge s_2) = \begin{cases} 0 & MD(h, s_1 \wedge s_2) = 1 \\ \dots \\ MB(h, s_1) + MB(h, s_2) & \text{sonst} \\ - MB(h, s_1) MB(h, s_2) \end{cases}$$

$$MB(h, s_1)$$

$$MB(h, s_2)$$

$$MD(h, s_1 \wedge s_2) = \begin{cases} 0 & MB(h, s_1 \wedge s_2) = 1 \\ MD(h, s_1) + MD(h, s_2) \\ - MD(h, s_1) MD(h, s_2) \end{cases}$$

Inferenz

$A \rightarrow B$



$MB(B, A)$

wenn A erfüllt

$$MB(B, A) = MB(B, A) \cdot \max(0, CF(A, e))$$

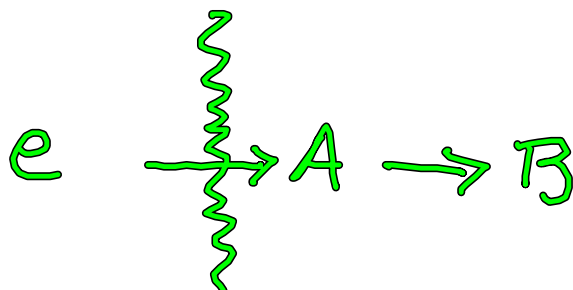
wenn A
sicher erfüllt

$0,5$

1

$0,5$

$A \rightarrow B \rightarrow C \rightarrow D$



— . —

	if	A	then	B	<u>Sicherheit</u> 1,0
	if	A	then	B	<u>0,6</u>
	$CF(A, e) = 0,2$				↙
	<u>0,12</u>				

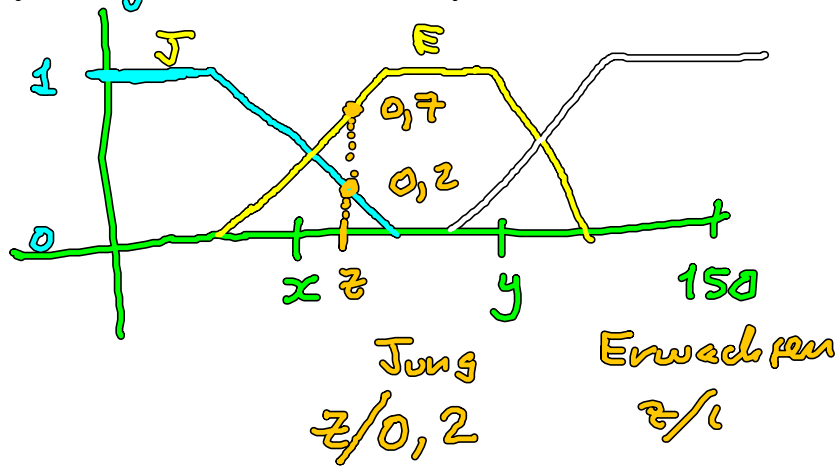
Fuzzy-Logik
 ↓
Fuzzy-Mengenlehre
 (Unschärf)

Altersgruppen

Jung, Erwachsene, Alt

$\{1 \dots x\}$	$\{x+1 \dots y\}$	$\{y+1 \dots \infty\}$
↑		
≥ Jahre alt	J	E
	1	0
		A
		0

Zugehörigkeitsfunktion



$$A = \underline{x_1}/1 + x_2/1 + x_3/0,5$$

$$\Rightarrow A = J_1/1 + J_2/1 + \dots + J_{30}/0,5$$

$$A = \{J_1, J_2, \dots, J_{30}\}$$

$$\Rightarrow B = \{J_{20}/0,1 + J_{21}/0,2 + \dots + J_{50}/1\}$$

$$A = \{a/1 + b/0,5 + c/0,3\} \quad B = \{a/0 + b/0,5 + c/1\}$$

$$A \cup B = \{a/\max(1,0) + b/\max(0,5;0,5) + c/\max(0,3;1)\}$$

$$A \cap B = \{a/\min(1,0) + b/\min(0,5;0,5) + c/\min(0,3;1)\}$$

$$A^c = \{a/(1-1) + b/(1-0,5) + c/(1-0)\}$$

Fuzzy Mengen \rightarrow Fuzzy logik

Aussagen x

Wahrheit von $x \in \{0 \dots 1\}$

Aussage (Tim ist Jung)
(27 Jahre) Wahrheit 0,8

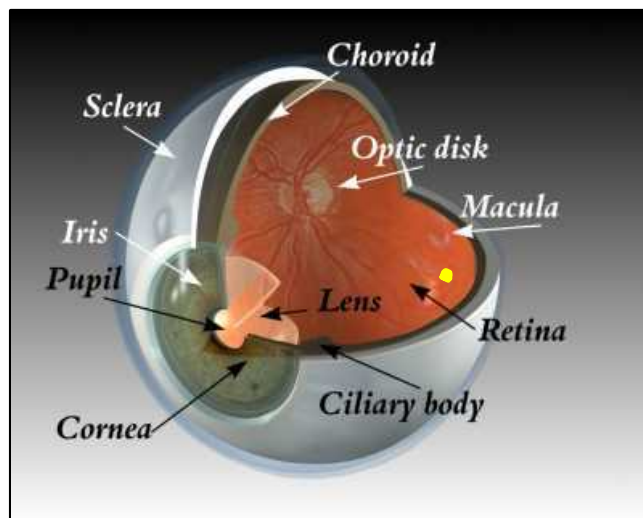
Farben

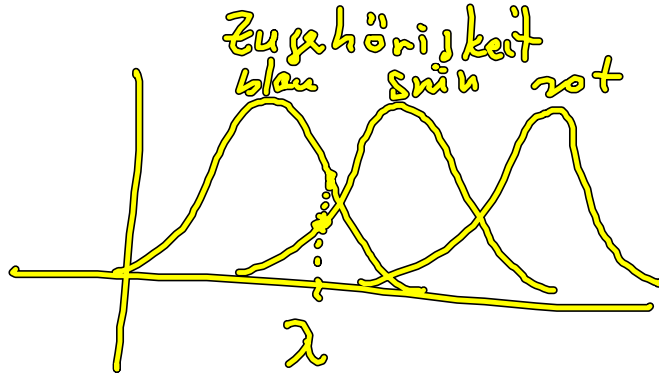
550 nm Wellenlänge

Rot, blau, gelb

$\lambda \in \text{Rot}$
 $\lambda \in \text{gelb}$

$\lambda \in \text{Rot}$ 0,7
 $\lambda \in \text{gelb}$ 0,4





logische Operatoren

$\mu(A)$
 \uparrow
 Aussage

— . —

Klassische Logik

A1) Werte an der Grenze

$$0 \tilde{\vee} 0 = 0$$

$$0 \tilde{\vee} 1 = 1$$

$$1 \tilde{\vee} 0 = 1$$

$$1 \tilde{\vee} 1 = 1$$

$$0 \tilde{\wedge} 0 = 0$$

$$0 \tilde{\wedge} 1 = 0$$

$$1 \tilde{\wedge} 0 = 0$$

$$1 \tilde{\wedge} 1 = 1$$

A2) Kommutativität

$$a \tilde{\vee} b = b \tilde{\vee} a$$

$$a \tilde{\wedge} b = b \tilde{\wedge} a$$

max
min

A3) Monotonie

$$a \leq a' \quad \text{und} \quad b \leq b'$$

$$a \tilde{\vee} b \leq a' \vee b'$$

A4) Assoziativität

$$a \tilde{\vee} (b \tilde{\vee} c) = (a \tilde{\vee} b) \tilde{\vee} c$$

$$a \tilde{\wedge} (b \tilde{\wedge} c) = (a \tilde{\wedge} b) \tilde{\wedge} c$$

A5) Idempotenz

$$a \tilde{\vee} a = a$$

$$a \tilde{\wedge} a = a$$

Negation

A1) Grenzwerte

$$\tilde{\neg} 1 = 0$$

$$\tilde{\neg} 0 = 1$$

A3) Involution

$$\tilde{\neg} \tilde{\neg} a = a$$

$$(1 - \overline{(1 - a)}) = a$$

$$\wedge \quad \min$$

$$\vee \quad \max$$

$$\neg \quad 1 - x$$

Expertensystem

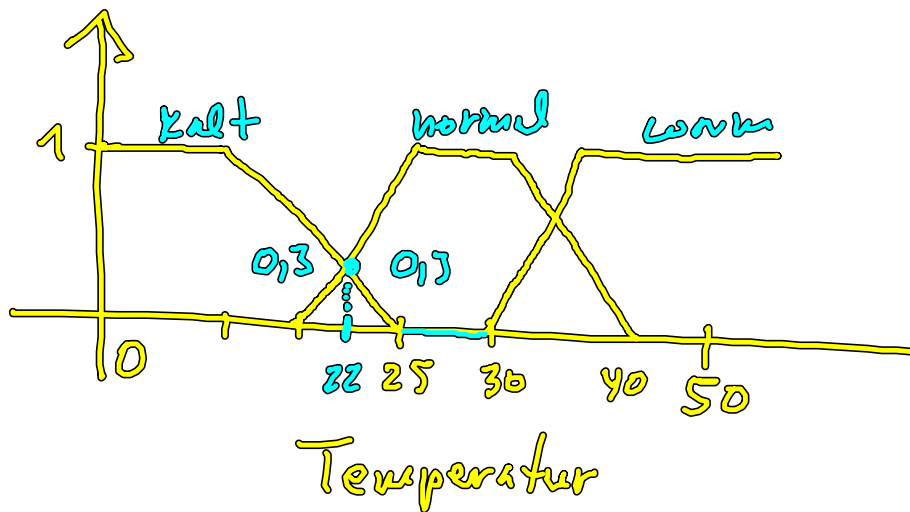
Thermostat

Messung \rightarrow Einstellung
 \rightarrow Formel \rightarrow

Linguistische Beschreibung

Kontroller

- R₁: if (temp = cold) then heat
- R₂: if (temp = normal) then maintain
- R₃: if (temp = warm) then reduce power



$$\text{Temperatur} = \text{kalt}/0,3 + \text{normal}/0,3$$

	+ warm/o	<u>Aktion</u>	<u>Aktivierung</u>
{	if (temp = cold) then	heat	0,3
	if (temp = normal) then	maintain	0,3
	if (temp = warm) "	reduce power	0

