Applications of Artificial Intelligence

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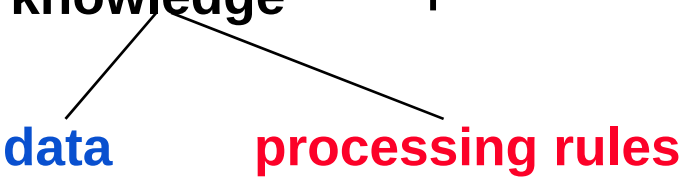
Chapter 4:
Knowledge-Based Systems

4.1: Representation and Classification of Knowledge

Representation of knowledge: How ?

knowledge + problem solver = WBS



logic knowledge:

atoms	rules	derivative rules
facts	if ... then ...	resolution, unification

functional knowledge:

data	funktions	function evaluation

object-oriented knowledge:

objekts	methods	compiler / interpreter

deklarative	procedural	conrol	knowledge

Classification of knowledge: What ?

The following criteria are mutually independent:

- **deep vs. shallow** (consider how a statement is composed of smaller units)

  model-based vs. universally valid

- **certain vs. uncertain** (consider the probability of a statement)

  deterministically vs. probabilistically

- **exact vs. fuzzy** (consider the accuracy of a statement)

  quantitative vs. qualitative

Classification of knowledge: What ?

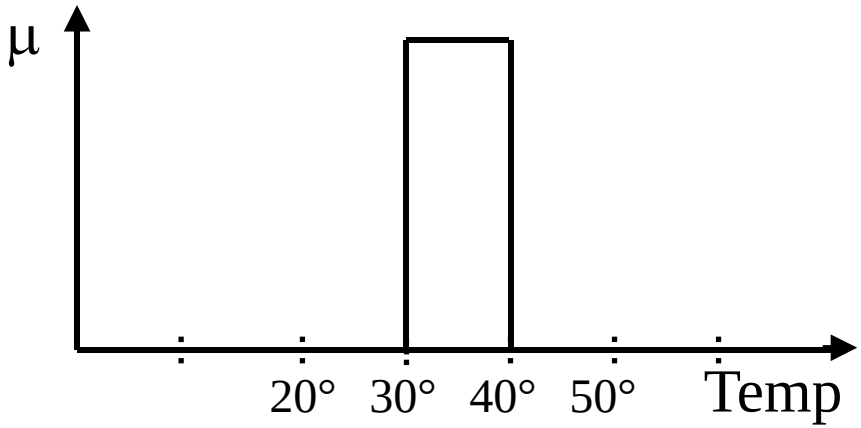
Example for distinguishing probability from accuracy:

- The train comes in 10 minutes. *certain, exact*
- The train comes in about 10 minutes. *certain, fuzzy*
- The train comes probably in 10 minutes. *uncertain, exact*
- The train comes probably in about 10 minutes. *uncertain, fuzzy*
- The probability that the train comes in 10 minutes is 0.9. *uncertain, exact*
- The plausibility range of the hypothesis that the train comes in 10 minutes is in (0,05; 0,95). *uncertain, exact*

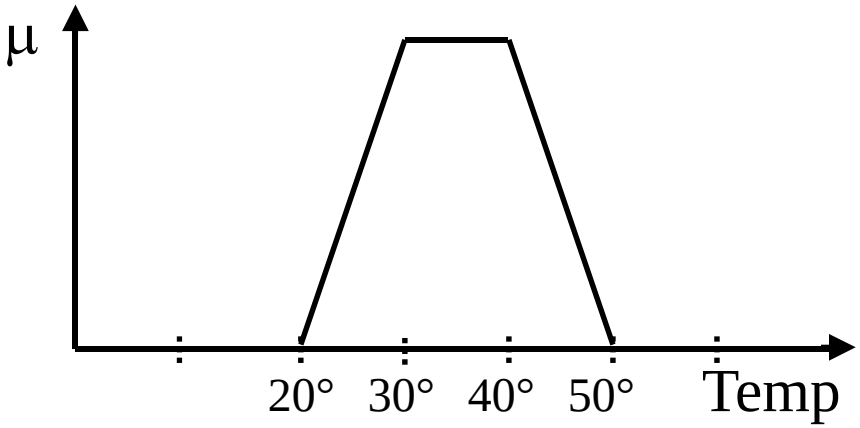
Classification of knowledge: What ?

Fuzzy sets as example for qualitative knowledge

exact set



fuzzy set



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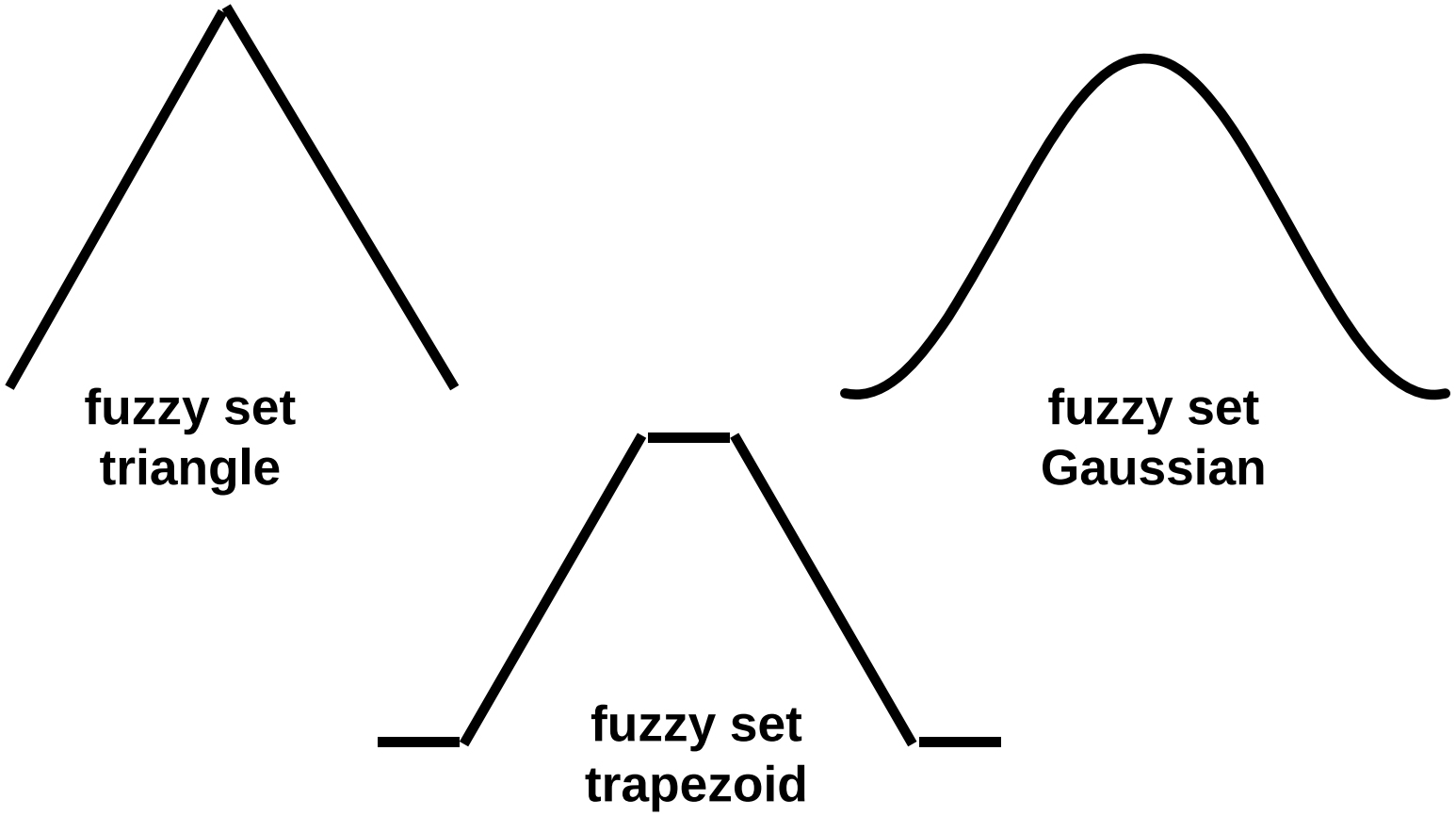
Classification of knowledge: What ?

Fuzzy sets as example for qualitative knowledge



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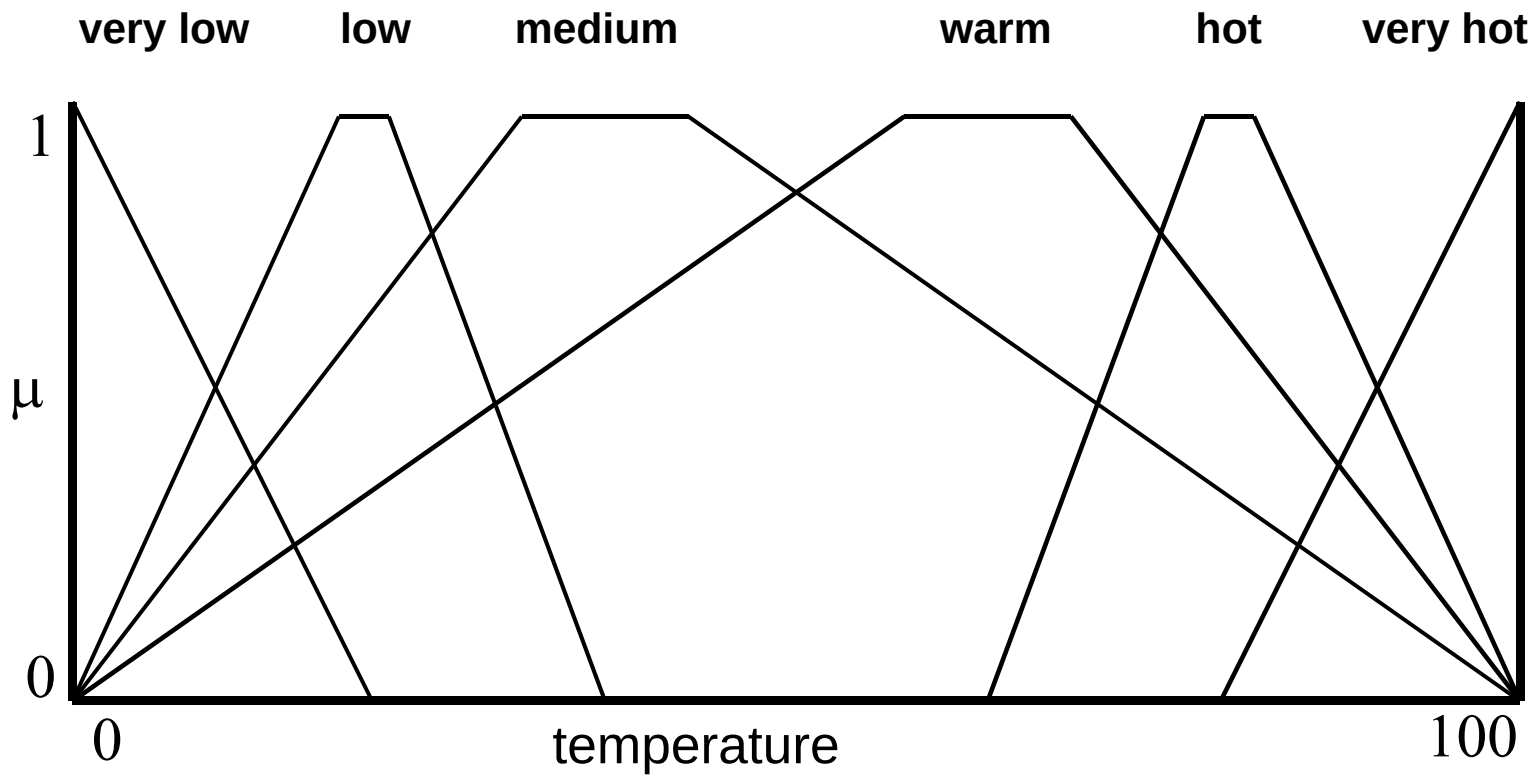
Classification of knowledge: What ?

Fuzzy sets as example for qualitative knowledge

The linguistic variable „temperature“



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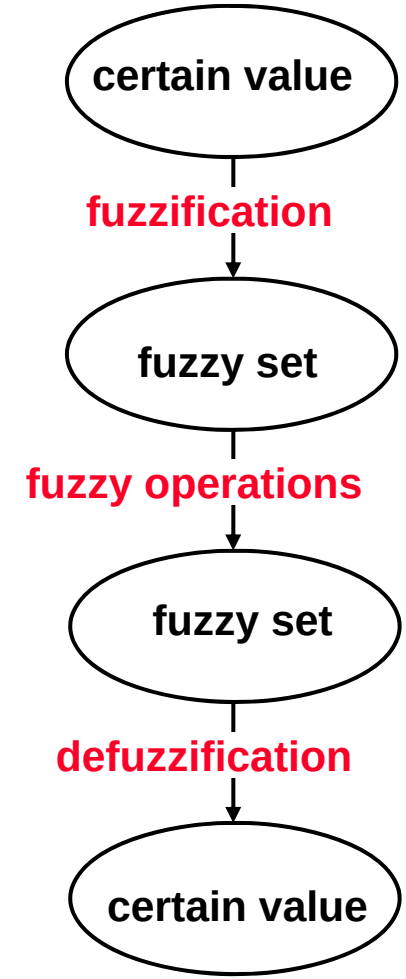
Classification of knowledge: What ?

Fuzzy sets as example for qualitative knowledge

Prinziple of fuzzy technology:



Fuzzy operations:

- ***operators*** **for building new sets from old ones**
- ***rules*** **for mapping sets to other sets**

Classification of knowledge: What ?

Fuzzy sets as example for qualitative knowledge

Examples for fuzzy operators:

- $\mu_C(x) = \min \{\mu_A(x), \mu_B(x)\}$ $\quad x \in X$
- $\mu_C(x) = \max \{\mu_A(x), \mu_B(x)\}$ $\quad x \in X$
- $\mu_C(x) = 1 - \mu_A(x)$ $\quad x \in X$

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Classification of knowledge: What ?

Fuzzy sets as example for qualitative knowledge

you can have it more complicated:

- μ_C **(x)** = γ **min**$\{\mu_A$**(x)**, μ_B**(x)**$\}$ + ½ (1 - γ)(μ_A(x) + μ_B(x)) ($\gamma \in [0,1]$)

What does this function compute ?

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Classification of knowledge: What ?

Fuzzy sets as example for qualitative knowledge

Example for fuzzy rules:

if (distance = small)
and (velocity = large),
then (braking power = large)

if (distance = medium)
and (velocity = large),
then (braking power = medium)

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Classification of knowledge: What ?

Representation of temporal knowledge

Allen‘s interval logic for the qualitative representation of time intervals

1. STARTS(t1,t2)

   t1 starts with t2 but ends before t2

2. FINISHES(t1,t2)

   t1 ends with t2 but starts after t2

3. DURING(t1,t2)

   t2 contains t1 completely

4. BEFORE(t1,t2)

   t1 starts before t2, and t1 and t2 do not overlap or contain each other

5. OVERLAP(t1,t2)

   t1 starts before t2 and ends after the start of t2 and before the end of t2

6. MEETS(t1,t2)

   t1 starts before t2 and ends when t2 starts

7. EQUAL(t1,t2)

   t1 and *t2* denote the same interval

Classification of knowledge: What ?

Representation of spatial knowledge

exact knowledge

- geo coordinates
- relative distance of objects in m

qualitative knowledge

- relative orientation (west of, ...)
- relative order (in front of, behind, left of, right of, etc.)

Classification of knowledge: What ?

Practical problem for temporal and spatial knowledge:

How exact should the knowledge be ?

- year, month, day, hour, second, millisecond, ...
- country, city, address, exact geo coordinates, ...

Summary:
knowledge representation and classification

Various forms of knowledge representation

- frames, semantische networks
- logic, production rules
- constraints

Various qualities of knowledge

- deep vs. shallow (consider how a statement is composed of smaller units)
- certain vs. uncertain (consider the probability of a statement)
- exact vs. fuzzy (consider the accuracy of a statement)