Introduction to Artificial Intelligence

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Exercises, v2

9 Modeling uncertainty

1 (T) The Bayes' rule makes it possible to infer the probability of hypothesis H based on observed evidence E. From the viewpoint of logic, such an inference corresponds to the abduction rule. **The conditional probability $P(E|H)$ in the Bayes' rule corresponds to which part of the abduction rule?**

A Implication $E \to H$ B Implication $H \to E$ C Fact E D Fact H

2 (C) Professor Balthazar's magical machine can work in three modes: "saving mode" (S), "ultra mode" (U), and "efficient" (E). The machine has two light bulbs: a green one (G) and a red one (R). We know what are the probabilities of the machine working in modes S and U, namely $P(S) = 0.2$ and $P(U) = 0.7$. After spending sleepless nights in front of the buzzing machine, we arrived at the following estimates of when the light bulbs are on: $P(G|S) = 0.9$, $P(G|U) = 0.3$, $P(G|E) = 0.2$, $P(R|S) = 0.1$, $P(R|U) = 0.4, P(R|E) = 0.8$. We are interested in learning two things: (1) the probability that the machine is in ultra mode when the red light bulb is on and (2) the probability that the machine is in efficient mode when both light bulbs are on. **What are these two probabilities?**

A 0.052, 0.7   B 0.737, 0.133   C 0.047, 0.7   D 0.211, 0.167

3 (P) We use the Bayes' rule for making inferences in the domain of pediatrics. We know the probability of a red rash appearing if the child has scarlet fever to be ten times larger than the probability of the rash if the child has no scarlet fever. We also know the probability of scarlet fever if the rash appeared to be at least two times larger than the probability of scarlet fever prior to observing the rash. **What is the probability P of scarlet fever prior to observing the rash?**

A $1/2 \leqslant P \leqslant 2/3$ B $P \leqslant 4/9$ C $P = 4/5$ D $P \geqslant 1/6$

4 (T) Fuzzy logic rests on fuzzy set theory. **What exactly is the link between fuzzy logic and fuzzy sets?**

A The disjunction of fuzzy sets P and Q is equivalent to a fuzzy set with $\mu(x) = \max(\mu_P(x), \mu_Q(x))$

B The value $\mu(x)$ is the lower bound on the probability of $P(x)$ being true

C The degree of $P(x)$ being true is equivalent to $\mu_P(x)$, i.e., the degree to which x belongs to fuzzy set P

D The atom $P(x)$ is true for all those and only those elements for which $\mu(x) \geqslant 0.5$

5 (P) We used the standard (Zadeh's) fuzzy operators and linguistic modifiers to build a fuzzy set *a very strong kangaroo*. Roger the Kangaroo, the strongest kangaroo ever, who died of old age in 2018, belongs to that set with $\mu = 0.9$. Using the same set of operators and modifiers, we built a fuzzy set *a not strong kangaroo*. **With what membership value does Roger the Kangaroo belong to this set**?

A $1 - 0.9^2$ B $(1 - 0.9)^2$ C $\sqrt{1 - 0.9^2}$ D $1 - \sqrt{0.9}$

6 (C) Assume three fuzzy sets are defined over the universal set $\{a,b,c,d\}$: $X = \{0.1/a + 0/b + 0.3/c + 1/d\}$, $Y = \{0.5/a + 0.4/b + 0/c + 0.2/d\}$, and $Z = \{1/a + 0/b + 0/c + 0.5/d\}$. Using the Zadeh's operators, we derive fuzzy set X corresponding to the linguistic expression *"Not X or (Y and Z)"*. **What is the fuzzy set X?**

- A $\{0.9/a + 1.0/b + 0.7/c + 0.2/d\}$
- B $\{0.5/a + 0/b + 0.3/c + 1/d\}$
- C $\{0/a + 0.4/b + 0.3/c + 0.5/d\}$
- D $\{0.5/a + 0/b + 0/c + 0/d\}$

7 (C) We are building a fuzzy inference system for fluid dynamics, which models the relationships between a fluid's pressure, temperature, and volume. We have defined the universal sets $P = \{100, 200, 300, 400, 500\}$ for pressure (in Pascal), $T = \{-100, -50, 0, 50, 100\}$ for temperature (in Centigrade), and $V = \{0, 5, 10, 15, 20, 25\}$ for volume (cubic meter per mole). On these sets we have defined *high pressure* as $P_h = \{0.1/200, 0.3/300, 0.6/400, 1/500\}$, *high temperature* as $T_h = \{0.2/0, 0.5/50, 0.8/100\}$, and *small volume* as $V_s = \{1/5, 0.5/10, 0.1/15\}$. We have also defined two rules (implications), $P_h \rightarrow V_s$ i $T_h \rightarrow P_h$, modeled as fuzzy relations. We now wish to know how small the fluid's volume will become if the temperature is very high, i.e., we wish to derive the fuzzy set V_s' given as premise the fuzzy set $T_h' = very(T_h)$. We can do this by using Zadeh's intensification modifier and by repeated applicaton of the generalized modus ponens. **What fuzzy set V_s' is derived using such an inference?**

- A $\{0.64/5, 0.5/10, 0.1/15\}$
- B $\{0.6/5, 0.5/10, 0.3/15\}$
- C $\{0.6/5, 0.3/10, 0.1/15\}$
- D $\{0.64/5, 0.5/10, 0.3/15\}$