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Assignment 9

8.1 A logical knowledge base represents the world using a set of sentences with no explicit structure. An analogical representation, on the other hand, has physical structure that corresponds directly to the structure of the thing represented. Consider a road map of your country as an analogical representation of facts about the country—it represents facts with a map language. The two-dimensional structure of the map corresponds to the two-dimensional surface of the area.

a. Give five examples of symbols in the map language.
Answer:
Depending on the scale and type of the map, symbols in the map language typically include city and town markers, road symbols (various types), lighthouses, historic monuments, river courses, freeway intersections, etc.

b. Anexplicit sentence is a sentence that the creator of the representation actually writes down. An implicit sentence is a sentence that results from explicit sentences because of properties of the analogical representation. Give three examples each of implicit and explicit sentences in the map language.
Answer:
Explicit and implicit sentences: this distinction is a little tricky, but the basic idea is that when the map-drawer plunks a symbol down in a particular place, he says one explicit thing (e.g. that Coit Tower is here), but the analogical structure of the map representation means that many implicit sentences can now be derived. Explicit sentences: there is a monument called Coit Tower at this location; Lombard Street runs (approximately) east-west; San Francisco Bay exists and has this shape. Implicit sentences: Van Ness is longer than North Willard; Fisherman's Wharf is north of the Mission District; the shortest drivable route from Coit Tower to Twin Peaks is the following . . . .

c. Give three examples of facts about the physical structure of your country that cannot be represented in the map language.
Answer:
Sentences unrepresentable in the map language: Telegraph Hill is approximately conical and about 430 feet high (assuming the map has no topographical notation); in 1890 there was no bridge connecting San Francisco to Marin County (map does not represent changing information); Interstate 680 runs either east or west of Walnut Creek (no disjunctive information).

d. Give two examples of facts that are much easier to express in the map language than in first-order logic.
Answer:
Sentences that are easier to express in the map language: any sentence that can be written easily in English is not going to be a good candidate for this question. Any *linguistic* abstraction from the physical structure of San Francisco (e.g. San Francisco is on the end of a peninsula at the mouth of a bay) can probably be expressed equally easily in the predicate calculus, since that's what it was designed for. Facts such as the shape of the coastline, or the path taken by a road, are best expressed in the map language. Even then, one can argue that the coastline drawn on the map actually consists of lots of individual sentences, one for each dot of ink,

especially if the map is drawn using a digital plotter. In this case, the advantage of the map is really in the ease of inference combined with suitability for human “visual computing” apparatus.

e. Give two other examples of useful analogical representations. What are the advantages and disadvantages of each of these languages?
Answer:

Examples of other analogical representations:

• Analog audio tape recording. Advantages: simple circuits can record and reproduce sounds. Disadvantages: subject to errors, noise; hard to process in order to separate sounds or remove noise etc.
• Traditional clock face. Advantages: easier to read quickly, determination of how much time is available requires no additional computation. Disadvantages: hard to read precisely, cannot represent small units of time (ms) easily.
• All kinds of graphs, bar charts, pie charts. Advantages: enormous data compression, easy trend analysis, communicates information in a way which we can interpret easily. Disadvantages: imprecise, cannot represent disjunctive or negated information.

8.10 Consider a vocabulary with the following symbols:
Occupation(p,o): Predicate. Person p has occupation o.
Customer(p1,p2): Predicate. Person p1 is a customer of person p2.
Boss(p1,p2): Predicate.
Person p1 is a boss of person p2.
Doctor, Surgeon, Lawyer, Actor:
Constants denoting occupations.
Emily, Joe: Constants denoting people.

Use these symbols to write the following assertions in first-order logic:

a. Emily is either a surgeon or a lawyer.
Answer:

$O(E, S) \vee O(E, L)$.

b. Joe is an actor, but he also holds another job.
Answer:

$O(J, A) \wedge \exists p \; p \neq A \wedge O(J, p)$.

c. All surgeons are doctors.
Answer:

$\forall p \; O(p, S) \Rightarrow O(p, D)$.

d. Joe does not have a lawyer (i.e., is not a customer of any lawyer).
Answer:

$\neg \exists p \; C(J, p) \wedge O(p, L)$.

e. Emily has a boss who is a lawyer.
Answer:

$\exists p\ B(p, E) \wedge O(p, L)$.

f. There exists a lawyer all of whose customers are doctors.
Answer:

$\exists p\ O(p, L) \wedge 6q\ C(q,\ p) \Rightarrow O(q, D)$.

g. Every surgeon has a lawyer.
Answer:

$\forall p\ O(p,\ S) \Rightarrow \exists q\ O(q, L) \wedge C(p,\ q)$.