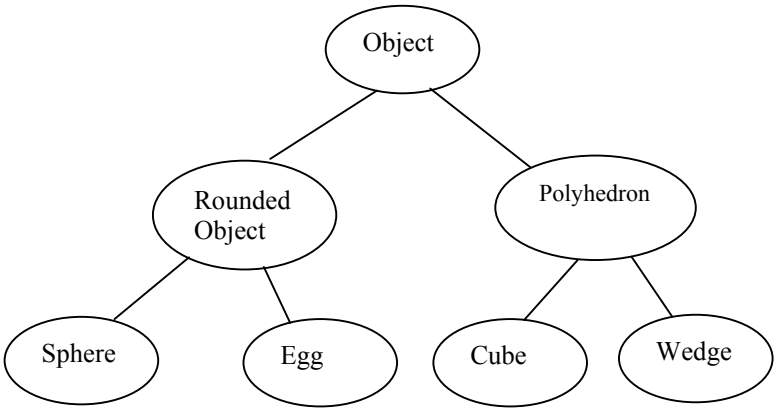
Recitation 12: Learning by Analyzing Differences Problem Solutions

Problem 1

You want to teach a Martian about apples. You assume that the Martian's perceptual system builds semantic nets with only the following information in them:

- An object's color is red, green, blue, purple, white, or black.
- An object's weight is a number.
- An object's shape is any one of those in the tree shown below.
- An object may be inedible, fragrant, or smelly.

There are no other properties that an object can have.



You elect the following teaching sequence. For each example, note what heuristic is applied and explain what is learned. Heuristics (see page 356 in Chapter 16): require link, forbid link, climb tree, enlarge set, drop link, close interval.

Example	Result	Color	Shape	Weight	Quality
1	positive	red	sphere	4	fragrant
2	positive	red	sphere	4	
3	negative	red	sphere	4	inedible
4	positive	green	sphere	4	
5	positive	green	sphere	7	
6	positive	red	egg	5	
7	negative	red	cube	4	

Example	Heuristic	Result
1	none	One apple is a red fragrant sphere with weight 4.
2	Drop link	Apples do not need to be fragrant.
3	Forbid link	Apples must not be inedible.
4	Enlarge set	Apples must be red or green
5	Close interval	Apple weights must range from 4 to 7.
6	Climb tree	Apples must be round
7	none	Nothing new

Note that if you follow the specialize procedure described on page 356 in Chapter 16, then example 7 will produce no new information because the shape link is already in place. An alternate implementation of the specialize procedure might add a Forbid link instead.

Problem 2

You decide that you have had it with computer science; you earn a degree in medicine instead. As a junior resident in a university hospital, you are asked by a department head to study a patient who has a mysterious allergy.

You somehow feel absolutely sure that the allergic reaction is caused by the patient's eating a combination of certain foods over the course of a day. For example, the allergic reaction may be caused by eating apples, fish, *and* honey during the same day.

Accordingly, you ask the one and only patient with the allergy to write down what he eats every day, and to indicate whether he has an allergic reaction on that day. During 7 days, the patient produces the following data:

Day	Apples	Beef	Cake	Dates	Eggs	Fish	Grapes	Honey	Reaction
1	yes	no	yes	yes	yes	yes	yes	yes	yes
2	no	no	yes	yes	yes	yes	no	no	no
3	yes	no	yes	yes	yes	no	yes	no	yes
4	yes	no	yes	no	no	no	no	no	no
5	yes	no	yes	yes	yes	yes	no	yes	yes
6	yes	yes	no	yes	yes	yes	no	no	no
7	no	yes	no	yes	yes	yes	no	no	no

Part 1. From the positive examples, determine which foods could be involved. Then, using the negative examples and the near-miss idea, determine which foods you can proscribe such that the patient absolutely will not have an allergic reaction if he avoids at least one food from the proscribed group every day.

Solution: Consider the following table, which contains only reaction cases:

Day	Apples	Beef	Cake	Dates	Eggs	Fish	Grapes	Honey	Reaction
1	yes	no	yes	yes	yes	yes	yes	yes	yes
3	yes	no	yes	yes	yes	no	yes	no	yes
5	yes	no	yes	yes	yes	yes	no	yes	yes

Evidently, the patient has a reaction on days when he eats apples, cake, dates, and eggs. Some subset of these foods, or perhaps all of them eaten together, must cause the reaction.

Near-miss analysis does the rest. Plainly, apples are implicated because on day 2, the patient eats cake, dates, and eggs, but no apples, and has no reaction. Similarly, cake is implicated because on day 6, the patient eats apples, dates, and eggs, but no cake, and has no reaction. Finally, either dates or eggs are implicated because on day 4, the patient eats apples and cake, but neither dates or eggs, and has no reaction. You cannot, however, nail down for sure which of dates or eggs, if either, the patient can avoid and be safe.

Part 2. Now suppose that your patient misunderstands your instructions and writes down what he eats on only those days (1, 3, 5) when he has an allergic reaction. What food or combination of foods would you proscribe such that the patient absolutely will not become allergic, yet is minimally constrained in the face of the data.

Solution: The loss of negative examples does a great deal of damage because you cannot distinguish between foods that cause the reaction and foods that happen to be eaten on days when

the reaction occurs. You can only tell the patient that he must not eat any of the four foods that were eaten on reaction days; i.e., he must not eat apples, cake, dates, or eggs

Part 3. Explain whether more data will help you to reduce the constraints placed on the patient, given that the patient continues to record what he has eaten only when he has an allergic reaction and that the patient decides whether to eat each food on each day by flipping a coin.

Solution: More data will help because it becomes increasingly unlikely that the patient will always have eaten an irrelevant food on a reaction day. Eventually, with a vanishingly small probability of failure, you can advise the patient that he can avoid a reaction by avoiding any one of the foods that always appear.

Part 4. Now suppose you change your mind. You feel absolutely sure that the allergic reaction is caused by the patient's eating any one of certain foods over the course of a day. For example, the allergic reaction may be caused by eating apples *or* eggs *or* fish *or* honey.

From the data, determine which foods could be involved. Then using the near-miss idea, determine which foods you can proscribe such that the patient absolutely will not have an allergic reaction if he avoids all of them every day.

Solution: Now you need to concentrate on the foods that are never eaten on no-reaction days. Consider the following table, which contains only no-reaction cases:

Day	Apples	Beef	Cake	Dates	Eggs	Fish	Grapes	Honey	Reaction
2	no	no	yes	yes	yes	yes	no	no	no
4	yes	no	yes	no	no	no	no	no	no
6	yes	yes	no	yes	yes	yes	no	no	no
7	no	yes	no	yes	yes	yes	no	no	no

Evidently only grapes and honey are not eaten on no-reaction days. One of these, or perhaps either, causes the reaction.

Near-miss analysis does the rest. On the third day, the patient eats grapes but no honey, and has a reaction. On the fifth day, he eats honey but no grapes, and has a reaction. Evidently, eating either causes the reaction.