CPSC 522 — Spring 2013

Assignment 1

Due: 12:30 pm, Wednesday 16 January 2013

The aim of the assignments in this course get beyond what you were taught in class. Feel free to post any questions to the course Connect site. Use full sentences in your answers.

Question 1

Suppose we want to diagnose school student's addition of multi-digit binary numbers. Suppose we are only considering subtracting a two-digit number from a three digit number.

That is, problems of the form:

$$\begin{array}{ccc} X_2 & X_1 & X_0 \\ - & Y_1 & Y_0 \\ \hline Z_2 & Z_1 & Z_0 \end{array}$$

Here X_i, Y_i and Z_i are all binary digits.

In this question you will represent this problem as a belief network, and test it with a belief network implementation.

(a) Describe how to do multi-digit binary subtraction. [This procedure that you are assuming students are carrying out will affect the network produced.] What errors would you expect students to make?

(b) What variables are needed to model subtraction of this form and the errors students could make? Give a DAG that specifies the dependence of these variables. [Hint: think about what will be observed, what will be queried, and hidden variables that you may have used in your description.]

(c) What are reasonable conditional probabilities for this domain?

(d) Implement this, for example using the belief network tool at:
`http://www.aispace.org/bayes/` Test the implementation (don't forget to save your graph).

(e) Explain how to extend your graph to allow for two different subtraction problems to help us better test a student. [Hint: What nodes should be shared and what should be replicated?] It is up to you whether you implement this, but it's probably instructive to do so.

Question 2

In this question we will explore ideas to extend the idea of belief networks. Be brief.

(a) What would happen if there were two distinct methods that students used to solve such subtraction problems and we are not certain which method a student will use? Explain how your network could be adapted to handle this.

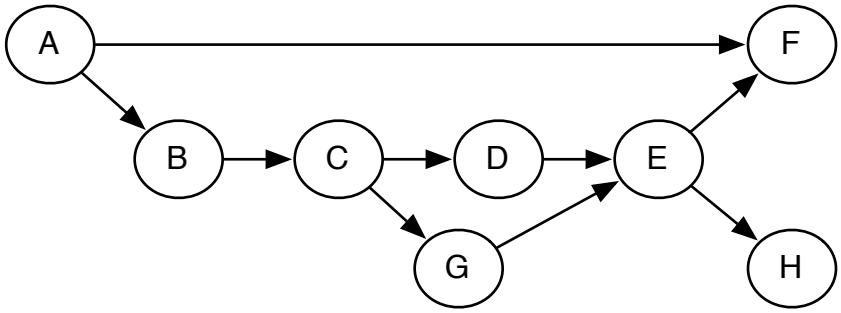
(b) What happens if we allow for a different base (say base 10 instead of base 2)? What is the size of the resulting tables? Suggest what could be done to make this more manageable.

(c) What if we were to allow for an arbitrary number of digits for each subtraction problem and an arbitrary number of different subtraction problems to test each student? What if there were multiple students? Suggest what facilities you would like to be able to handle this.

(d) Suppose we wanted to model teaching the student something. How could we model this? [Hint: think about teaching as a node that specifies what is taught and have separate variables representing before and after teaching. What nodes need to be duplicated?]

Question 3

Consider the following belief net:



(a) What are all of the factors required to represent this belief network?

(b) Consider the query: $P(G|F = true, H = false)$. What are the factors after the observations have been taked into account?

(c) For that query and for the elimination ordering, B, D, E, A, C give all of factors created in VE. For each factor created, specify which factors were removed, and what variable was summed out. You do not need to consider any numerical values.

(d) What is the treewidth of this graph for this elimination ordering? Explain how you know this.

(e) Consider using recursive conditioning for the same query, assuming that the variable were split in the order G, C, A, E, D, B. What values are used from the cache in this computation? Do any of the assignments disconnect the graph? If so, which ones?

Question 4

For each question in this assignment, say how long you spent on it. Was this reasonable? What did you learn?