ISTA 410/510 Assignment IV

For contribution to the final grade, due dates, current late policy, and instructions for handing the assignment in, see the assignment web page.

Please create a PDF document with your answers and/or the results of any programs that you write. You should also hand in your programs. (This assignment does **not** require any programing, but if you choose to write one for some part, you should hand it in).

For simplicity, all sub-problems are worth one point except the one with a "+" which is worth 2. There are 9 points common to grads and ugrads, and 4 more for grads. There are no optional or bonus questions, but if you would like to propose one, let me know!

1. Recall the model from the take-home midterm which was: Supposed that your undergraduate **grades** influence the **letters** that professors write for you (higher grade, better letter). Another thing that influences those letters is your **interactions** with those professors (better interaction, better letter). Now suppose that the **rank** of the graduate program you get into is influenced by your **GRE**, your grades, and your letter (better letter increases probability that rank will be higher). Finally, suppose that whether or not you get an academic **job** depends on the graduate program rank (better rank increases your chances), and the **state** where the job is located (political comment goes here).

    a) Remind the TA what your initial directed graphical model was ($), and convert it an undirected graph ($). Explain your steps ($). Does doing so loose any independence information($)?

    b) Provide potential functions for the undirected graph just made based on the directed graphical model ($).

2. The following matrix tells us who are friends in a cohort of 10 students who conveniently have a different first initial, and all initials are in the first ten letters (e.g., Alice, Bob, Carol, Doug, ...). The cells are "1" if the persons with the initials listed in the row label and the column label are friends. The matrix is symmetric.

	A	B	C	D	E	F	G	H	I	J
A		1	1							
B	1		1	1						
C	1	1		1						
D		1	1		1					
E				1		1			1	
F					1		1	1		
G						1				
H						1				
I					1					1
J									1	

a) Draw an undirected graph, one node per person, with links between friends ($). We will associate with each person a random variable representing whether their preferred computer is a mac or not. We also have a MicroSoft spy camera that detects whether each person is using a mac or not, but it is not very reliable. Represent the detector output on your graph as well ($).

b) Identify the maximal cliques in the graph ($).

c) Provide an expression using potential functions for the probability distribution for the assignment of all the values over the network (e.g., a distribution over any particular assignment of who prefers macs and what they were detected using) ($).

d) (*,+) Construct an energy function for this model that has the following properties: 1) Everyone has a fixed energy (bias) preference for macs. 2) If one of your friends has a mac, then you are more likely to have one; 3) Three mutual friends having a mac is less likely because mac users have to be different, and so one of them will switch to a PC running linux, rather than be in a group of three mac users; 4) The detector output for which computer you were spotted using is statistically correlated with your actual preferred computer. [Note that this does not necessarily specify the energy function exactly. You are simply creating an energy function of your choice with those properties.]

e) Is mac preference by A independent of mac preference of J? Provide an argument based on rules learned in class ($).

f) Is mac preference by A independent of mac preference by D given mac preference by C? Provide an argument based on rules learned in class ($).

g) Is mac preference by A independent of mac preference by E given mac preference by D? Provide an argument based on rules learned in class ($).

3. (*) Consider images with captions like the one shown below. Assume that you have very simple captions and a high quality parser than can extract noun-phrases and prepositions and their bindings. In other words, in the example, you know there are three nouns (sky, peak, trees) and that there are two spatial relations between (sky, peak) and (trees, peak). (It may seem obvious that you would know that sort of thing, but in natural language it can be very hard to get the correct parse). Assume that we have functions which are proportional to p(noun, region-features). Finally, we have a segmentation of the image into regions which we will assume do not span noun areas, but that may need to be merged to get a perfect semantic segmentation of the image.

The sky is above the peak. The trees are below the peak.

a) (*) Considering only nouns, provide a scheme for creating a Markov random field (MRF) for modeling the probability of region labels using the fact that adjacent regions are more likely to be associated with the same noun, and that nouns are linked to features (e.g., color and texture) via the function mentioned above ($). Explain in your own words how random assignments of labels to regions can be compared for fitness with respect to the model ($).

b) (*) Extend your scheme for your MRF to include prepositions ($). They are one level higher in abstraction, since they are about relations between nouns. Assume that if you have two adjacent labels you have a fitness function for preposition labels linking them. It may be easiest to assume that two identical adjacent labels are linked with a NULL preposition word. Using the example datum above, explain how random assignments of labels to regions includes prepositions, and how doing so can help get the noun assignment correct ($).

4. Consider a 10x10x10 cube of identical blocks with densities proportional to X*Y*Z, where X,Y, and Z are integers stepping from 1 to 10. So, if we make a coordinate system out of the cube, the block that is the 3rd in one direction, the 4th in a second direction, and the 5th in a third direction will have density 3*4*5=60. Assume each block has unit volume, compute the mass of the cube using the interchanging of products and sums trick.