Computational Cognitive Science, Tutorial 05

Wai Keen Vong (waikeen.vong@adelaide.edu.au)
University of Adelaide, School of Psychology

April 1, 2014

1 Unsupervised Learning

- What is unsupervised learning? Besides the phoneme learning example we covered in class, can you think of any other examples where humans might be doing unsupervised learning?
- Outline the k-means clustering algorithm. When does it break down? What problems does the soft k-means clustering fix with the original algorithm? Where does it still fail?
- What is the Expectation-Maximization algorithm? Describe both the E and M steps when learning a Mixture of Gaussians model. We'll go through this in closer detail in case any of you are wondering how to do this for the first problem set.

2 The Chinese Restaurant Process Prior

- What is the Chinese Restaurant Process (CRP) prior? This is a much more complex kind of prior than many of the simpler priors we have covered in class, but many of the models you will see in future lectures will use this prior, suggesting that it is a useful tool! What does this additional complexity buy us?
- The CRP prior has one free parameter α. Look at the two equations governing whether a new customer sits at one of the existing tables, or instead chooses to sit at a new table. What do you think the value of α has on the kinds of cluster assignments the CRP prior produces?
- One of the properties of the CRP prior is a statistical concept known as *exchangability*, which means that the order of observations does not have an effect on the probability of any given partition occurring. Let $\alpha = 2$. Given that the total probability of observing a given partition is the product of the probability of observing each of the table assignments, what is the total probability of observing the following two sequences of events?
  - The first person sitting at Table 1, the second person at Table 2, the third person at Table 1, the fourth person at Table 3, and the fifth person at Table 2?
  - The first person sitting at Table 1, the second person at Table 1, the third person at Table 2, the fourth person at Table 2, and the fifth person at Table 3?
- If you're interested about reading more about the CRP prior, Dan has a nice technical note which you can read here: `http://health.adelaide.edu.au/psychology/ccs/docs/ccs-class/technote_chineserestaurantprocess.pdf`. You are not expected to understand everything in this note, this is only if you are curious and interested in learning more about non-parametric Bayesian statistics!

3 The Rational Model of Categorization

- What is the Rational Model of Categorization/Dirichlet Process Mixture Model? How does it represent categories, and why is this an improvement over the prototype and exemplar models we have seen before?
- What is the generative process behind the Rational Model of Categorization? That is, how was the two-dimensional data set that was used in the classification lectures produced?
- What is simulated annealing? How does it let us discover a good partitioning of the data with the Rational Model of Categorization? Hint: Have a read through and run the RMC code Dan has written to see how the simulated annealing algorithm works.