Due Date Nov 16. Fall 2017. Homework 4

Prof. Alan Yuille

October 28, 2017

Due on Nov 16 . Submit pdf file on Blackboard by 11:59:59 PM on the due date. Format file name as *firstname-lastname*-hw4.pdf. Do not include the iPython notebook code in the pdf submission as it is not required. If you have any questions about the homework, email TA Donald Li: sli97@jhu.edu

Question 1. Mean Field Theory (21 points)

1. Describe the mean field theory approximation for the Ising model $P(\vec{I}|\vec{S})$. (6 points) What is $Q(\vec{S})$ and how is the Kullback-Leiber divergence used as a measure of similarity between $P(.)$ and $Q(.)$? (6 points)

2. In mean field theory, what is the free energy? (3 points) Derive the update equations for the mean field model. (6 points)

Question 2. Boltzmann Machine (18 points)

1. What is the difference between a Boltzmann Machine and a Restricted Boltzmann Machine? (3 points) What is the difference between the hidden and the

output variables $(\vec{S}_o, \vec{S}_h)$. $P(\vec{S}) = \frac{1}{Z}\exp\{-E(\vec{S})\}$, where $E(\vec{S}) = C\sum_{ij}\omega_{ij}S_iS_j$. (4 points) What is the update rule for learning the weights $\{\omega_{ij}\}$ in terms of the expected statistics of S_iS_j with respect to the clamped and unclamped distributions. (3 points)

2. How can these expectations be computed by Gibbs sampling, briefly explain your proposed algorithm? (6 points) Why is it easier to learn these weights for the Restricted Boltzmann Machine. (2 points)

Question 3. Experimental Section: foreground-background segmentation (16 points)

In this question, you will use Gibbs sampling to apply the Ising model to foreground-background segmentation, IPython notebook is used for this project, download the material from either :

`https://github.com/shipui2005/ProbHW4/blob/master/HW4.tar.gz` or

`https://github.com/shipui2005/ProbHW4/blob/master/HW4.zip`

Note: The modeling conventions in the notebook are slightly different from those above. In particular, in the code, S takes values ± 1 and not $\{0, 1\}$.