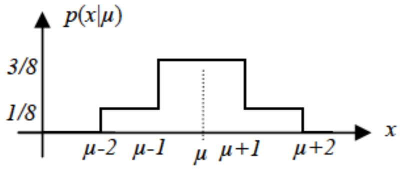
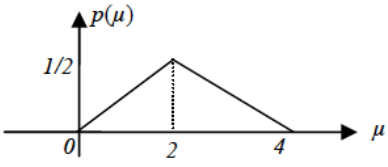
07.06.2018

CENG463 Introduction to Machine Learning
Final Exam
Duration: Two hours.

Q1 (25 points).

Bayesian Parameter Estimation : Given an observation set, consisting of 3 samples, X={1.25, 2.0, 2.75}, which are obtained thru a source with the following density form, $p(x|\mu)$ and an unknown (stochastic) mean μ. If density of μ is given as below, determine $p(x|X)$.





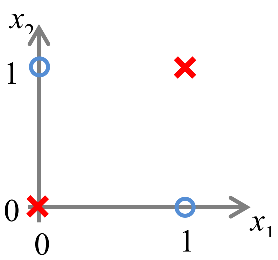
Q2 (20 points). In running a community detection algorithm, user can specify how many communities she would detect, or let the program determine the number of communities in the network from the topology of the network. If the user does not specify the number of communities to detect, the algorithm tries nc numbers from mc to xc: by default, as follows.

-mc:Minimum number of communities to try (default:5)
-xc:Maximum number of communities to try (default:100)
-nc:How many trials for the number of communities (default:10)

Please recommend a way to choose the number of communities to detect.

Q3 (10 points). In a gaussian mixture of n components, how many parameters you have to handle?

Q4 (25 points).
Construct a neural network for XOR operation (circles in the figure).

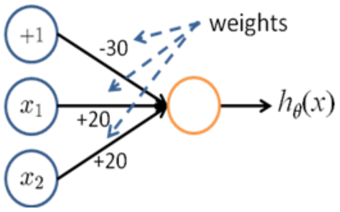


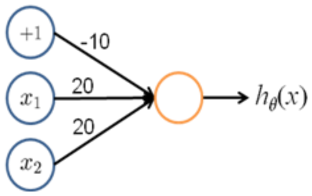
I.e. your network will take two binary-valued inputs $x_1, x_2 \in \{0,1\}$ and it will output 1 when x_1 XOR x_2 is TRUE.

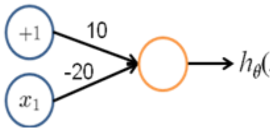
Use sigmoid function for the activation function in neurons:

$$h_\theta(x)=g(\theta,x) = \begin{cases} 0 & if\ (\theta_0 x_0 + \theta_1 x_1 + \theta_2 x_2 + \ldots) < 0 \\ 1 & if\ (\theta_0 x_0 + \theta_1 x_1 + \theta_2 x_2 + \ldots) \geq 0 \end{cases}$$

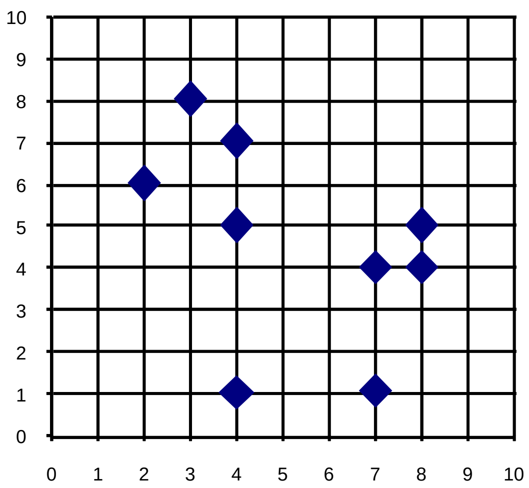
You can use the following one-neuron representations for AND, OR and NOT.
Hint: You will need at least one hidden layer to construct XOR operation.

AND: 

OR: 

NOT: 

Q5 (25 points). We want to perform agglomerative clustering using the following data:



Assume that the similarity (distance) between a new (merged or split) cluster and another cluster is measured as the minimum distance between the samples of the two clusters:

$$d_{\min}(\mathrm{C}_i, \mathrm{C}_j) = \min_{\mathbf{x}\in \mathrm{C}_i, \mathbf{x}'\in \mathrm{C}_j} \|\mathbf{x} - \mathbf{x}'\|$$

a) Starting from the first step, draw the result of the each step of the clustering algorithm on the figure above. You can name clusters as C_1, C_2, ... in the order they occur. Continue until the clustering algorithm stops.

b) For each step write the number of clusters. Continue until the clustering algorithm stops.

1. Step: ___________
2. Step: ___________
3. Step: ___________
4. Step: ___________
5. Step: ___________
6. Step: ___________
7. Step: ___________
8. Step: ___________
9. Step: ___________
10. Step: ___________