Machine Learning, Fall 2019: Project 2
out on 9/24/19 - due on 10/8/19 by noon on Blackboard

Your Name Here

Header: List the major resources you used to complete this project and the programming language you used. It is expected that your project report may require 2 pages if you are good about making interesting figures and making them not too large, or 3-4 pages if your figures are big. The LaTex that generated this page is available here: `https://www.overleaf.com/read/mrrmmcmdycvb`. Please submit a pdf file and your code for project 2.

You may use any programming language you like (Matlab, C++, C, Java, Python . . .). All programming must be done individually from first principles. You are only permitted to use existing tools for simple linear algebra such as matrix multiplication/inversion. **Do NOT use any toolkit that performs machine learning functions and do NOT collaborate with your classmates. Cite any resources that were used.**

1 Perceptron: Iris flower classification

This version of the iris data set contains 2 classes of 50 instances each, where each class refers to a type of iris plant. The task is to select if a given flower is Iris-setosa or Iris-virginica. Evaluate your Perceptron implementation on this version of the iris dataset that is linked on the syllabus with 10-fold-stratified-cross-validation.

1. **(20 points)** What happens when the learning rate is 0.00005, 0.001, and 0.005?
2. **(20 points)** Does the algorithm converge? Plot the classification accuracy for each learning rate from 1 to 20 training epochs.
3. **(20 points)** Come up with a confidence metric in your classification. (For example come up with an activation function that might correspond to confidence.) Create a scatter plot for confidence vs classification result for all instances with learning rate 0.00005.
4. **(20 points)** Is this dataset linearly separable? Justify your answer with a scatterplot. Explain why and how you created this scatterplot.

2 Parameter Estimation: MLE and MAP estimates

If X (e.g. packet arrival density) is Poisson distributed, then it has pmf

$$P(X|\lambda) = \frac{\lambda^X e^{-\lambda}}{X!}$$

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1. **(10 points)** Show that $\hat{\lambda} = \frac{1}{n}\sum_i X_i$ is the maximum likelihood estimate of λ and that it is unbiased (that is, show that $\mathbb{E}[\hat{\lambda}] - \lambda = 0$).
2. **(10 points)** Recall that the Gamma distribution has pdf:

   $$p(\lambda|\alpha, \beta) = \frac{\beta^\alpha}{\Gamma(\alpha)}\lambda^{\alpha-1}e^{-\beta\lambda}, \qquad \lambda > 0$$

   Assuming that λ is distributed according to $\Gamma(\lambda|\alpha, \beta)$, compute the posterior distribution over λ.
3. **(5 points)** Derive an analytic expression for the maximum a posteriori (MAP) estimate of λ under a $\Gamma(\alpha, \beta)$ prior.