HOMEWORK PROBLEMS 11, ANLY 561, FALL 2018
DUE 11/25/18

Readings: §6.4, 6.5 of **Goodfellow, Bengio, and Courville**. Chapter 9 of **Géron**.

Exercises:

1. Use TensorFlow to implement gradient descent **using backtracking** for training logistic regression on the first 400 examples from the Wisconsin Breast Cancer Dataset. Perform 10^3 gradient descent steps, and report the test accuracy of your final answer. In particular, your implementation should only compute gradients using TensorFlow operations. Use $\alpha = 0.1$ and $\beta = 0.5$ inside backtracking.

2. Consider the 3 by 2 by 2 by 2 tensor $\mathcal{A}$ given by

$$\left(\begin{pmatrix} a_{1,1,1,1} & a_{1,1,1,2} \\ a_{1,1,2,1} & a_{1,1,2,2} \end{pmatrix}, \begin{pmatrix} a_{1,2,1,1} & a_{1,2,1,2} \\ a_{1,2,2,1} & a_{1,2,2,2} \end{pmatrix}\right), \left(\begin{pmatrix} a_{2,1,1,1} & a_{2,1,1,2} \\ a_{2,1,2,1} & a_{2,1,2,2} \end{pmatrix}, \begin{pmatrix} a_{2,2,1,1} & a_{2,2,1,2} \\ a_{2,2,2,1} & a_{2,2,2,2} \end{pmatrix}\right), \left(\begin{pmatrix} a_{3,1,1,1} & a_{3,1,1,2} \\ a_{3,1,2,1} & a_{3,1,2,2} \end{pmatrix}, \begin{pmatrix} a_{3,2,1,1} & a_{3,2,1,2} \\ a_{3,2,2,1} & a_{3,2,2,2} \end{pmatrix}\right)$$
$$= \left(\begin{pmatrix} 1 & -1 \\ -2 & 1 \end{pmatrix}, \begin{pmatrix} 1 & 1 \\ -2 & 2 \end{pmatrix}\right), \left(\begin{pmatrix} 2 & -1 \\ -1 & 1 \end{pmatrix}, \begin{pmatrix} 2 & 1 \\ 1 & 2 \end{pmatrix}\right), \left(\begin{pmatrix} 1 & -2 \\ -2 & 1 \end{pmatrix}, \begin{pmatrix} 1 & 1 \\ -1 & 1 \end{pmatrix}\right)$$

   and

$$\mathcal{B} = \begin{pmatrix} b_{1,1} & b_{1,2} \\ b_{2,1} & b_{2,2} \end{pmatrix} = \begin{pmatrix} 1 & -1 \\ -2 & 2 \end{pmatrix}.$$

   Let $\mathcal{F}$ denote the contraction of $\mathcal{A}$ with $\mathcal{B}$ along the $\mathbf{i} = \{2, 3\}$ and $\mathbf{j} = \{1, 2\}$ indices. That is,

$$f_{i_1,i_2} = \sum_{k_1=1}^{2} \sum_{k_2=1}^{2} a_{i_1,k_1,k_2,i_2} b_{k_1,k_2}$$

   (a) What are the order and shape of $\mathcal{F}$?

   (b) Compute all the entries of $\mathcal{F}$ by hand, showing your work. Check your answer using TensorFlow's `tensordot` function.

3. In this next problem, you'll provide some information regarding the data you are using for your video presentation project. You will perform some summaries and exploratory data analysis for data pertinent to your project.

   (a) Indicate how many records (data points) are in your dataset, as well as the number of fields for each record. Indicate whether your data contains spatial or temporal fields.

   (b) Use `matplotlib.pyplot.boxplot` to visualize summary statistics for your numerical data. For categorical data, provide histograms illustrating the relative frequencies of each categorical value for each categorical field.

   (c) Choose one of the following plots to visualize your data:

   - If your data points consists of less than ten numerical fields, import the pandas library and use `pandas.tools.plotting.scatter_matrix` to generate a matrix of scatter plots for your data.
   - If your data points consists of only numerical fields, but has more than ten fields, use `pca=sklearn.decomposition.PCA(n_components=10)` and `pca.fit(X)` to obtain the scores of each data point against the first 10 principal components, and then use `pandas.tools.plotting.scatter_matrix` to compare these scores across the dataset.
   - If your data consists of categorical fields, convert your data to indicator variables (that is, each categorical field of n categories is replaced with n binary fields that together "indicate" the categorical assignment), use then `pca=sklearn.decomposition.PCA(n_components=10)`, `pca.fit(X)`, and `pandas.tools.plotting.scatter_matrix` on this numerical data to visualize the dataset.
   - If you data consists of qualitative (i.e. notes or text entries) data, perform a word-count operation for each qualitative field, and replace each qualitative field with indicators for the top 100 words found in those counts. After replacing these qualitative fields with indicators, use `pca=sklearn.decomposition.PCA(n_components=10)`, `pca.fit(X)`, and `pandas.tools.plotting.scatter_matrix` to illustrate your data.
   - If you have temporal data, create an animation of one of the above graphs as a function of your temporal variable.
   - If you have spatial data, for each other field in the data, provide a scatter plot consisting of markers positioned at the spatial coordinates so that the value of the field entry for that spatial point is incorporated in the size or color of the marker. If time is also a field, provide an animation of these images as a function of time.
   - If your data involves comparisons of two alternatives (e.g. sports teams), create a "comparison" matrix by associating each row and column indices with the various alternatives, and then fill entries with values indicating how the row alternative compares to the column alternative. Display this matrix using `imshow`. If these comparison occur over time, provide an animation of these images over time.

   If your data doesn't conform to any of the above, please email me so that we can determine a meaningful plot that you can provide instead.