TTIC 31230 Fundamental of Deep Learning
Problem set 1
Due Thursday, January 12

This problem sets involves understanding and modifyint the education framework (EdF). Everyone should start by installing Anaconda with Python 3.5 (https://www.continuum.io/downloads). Then open a terminal and go the problem set directory. Then enter "jupyter workbook". This should open a window in your browser from which can open PS1.ipynb (for Interactive PYthon NoteBook). You can also open the source code edf.py of the framework. It is about four pages of Python.

Problem 1. a. Show that the backpropagation algorithm is correct in the sense that the derivative of the loss function with respect to the value of a component equals the sum over the users of that component of the derivative of the loss with respect to that input of the user. In particular show that for the loss $\ell(g(x), h(x))$, where ℓ, g and h are arbitrary differentiable functions, we have that $\partial\ell/\partial x$ equals the sum over the users of x of the gradient of the loss with respect to the user's input.

b. Show that backpropagation fails for computing second derivatives — that for $\ell(g(x), h(x))$ we do *not* have that $d^2\ell/dx^2$ is not the sum of second derivatives of the users of x.

Problem 2. Examine the implementation of Softmax in edf.py. Give a formal derivation of the correctness of the implementation of the the backward method for softmax.

Problem 3. You are to expand the framework EdF by adding an implementation of $\text{ReLU}(x) = \max(0, x)$ and of $\tanh(x) = (e^x - e^{-x})/(e^x + e^{-x})$. rather than edit the edf.py file you should enter your implementations into the appropriate cells of the jupyter notebook so that all the cells run.

You should turn in your complete jupyter notebook and a write up of the solution to problems 2 and 3.