Mat 128B Project 2: Backpropogation Neural Networks

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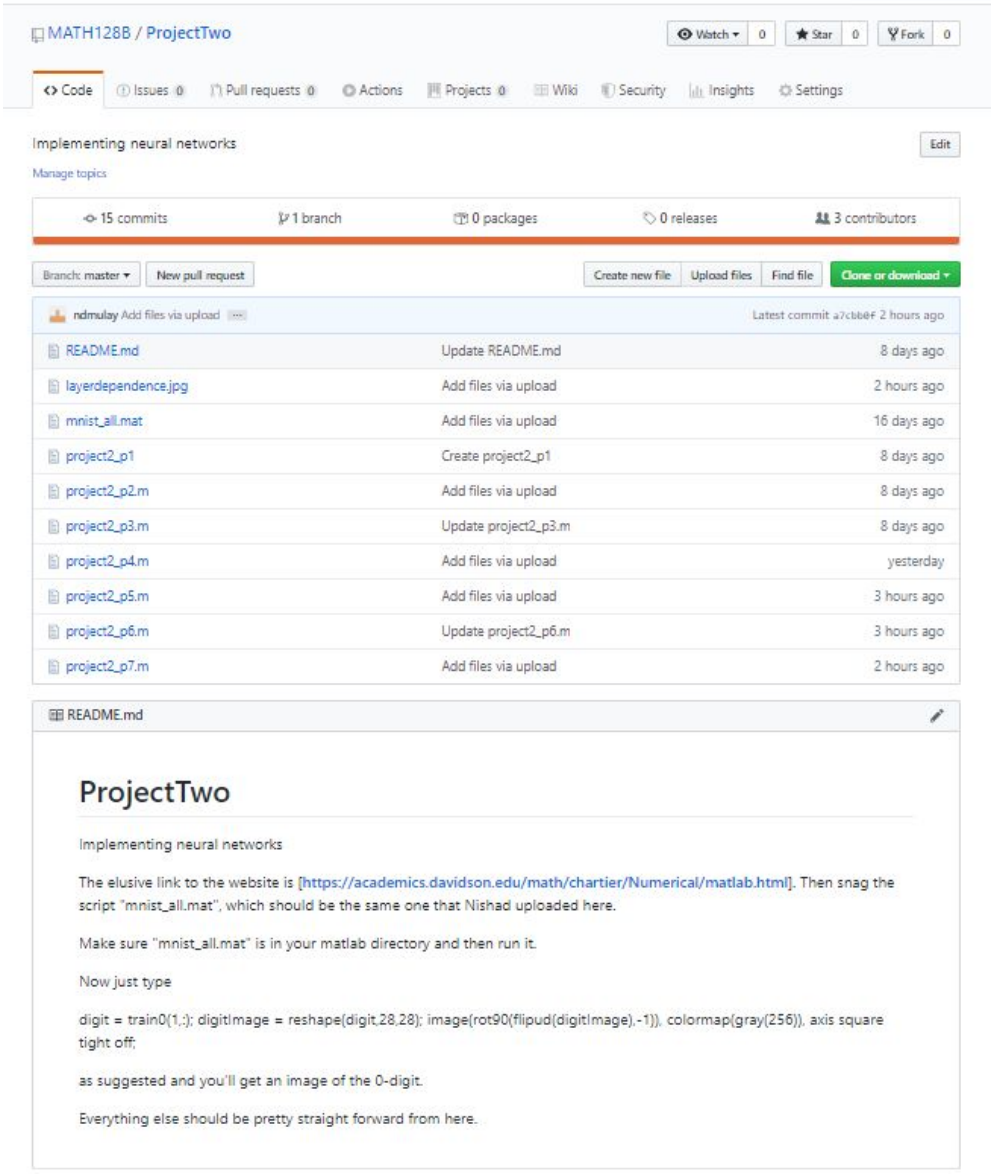
Our team is organized in the following way: Michael-River focused on the first three parts of the project dealing with the MINST data base, plotting the digits, and implementing a neuron. Cole focused on parts four and five, creating and initializing the multilayer network. Nishad focused on the sixth and seventh parts, training the network on the test data and plotting the errors and their dependence on different parameters. Additionally, we made use of Github to track our progress, maintain a code base, and keep our work and resources straight. On the following page is a screen capture of our collaboration on Git.



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README.md

ProjectTwo

Implementing neural networks

The elusive link to the website is [https://academics.davidson.edu/math/chartier/Numerical/matlab.html]. Then snag the script "mnist_all.mat", which should be the same one that Nishad uploaded here.

Make sure "mnist_all.mat" is in your matlab directory and then run it.

Now just type

digit = train0(1,:); digitImage = reshape(digit,28,28); image(rot90(flipud(digitImage),-1)), colormap(gray(256)), axis square tight off;

as suggested and you'll get an image of the 0-digit.

Everything else should be pretty straight forward from here.

i. MINST Data Base

```
digit = train2(1,:);
digitImage = reshape(digit,28,28);
image(rot90(flipud(digitImage),-1))
colormap(gray(256))
axis square tight off
```

ii. Plot Digits

```
%Read digits from data base.
%Type lines 3-6 in command window to produce a zero-image.
digit = train0(1,:);
digitimage = reshape(digit, 28, 28); %little i
image(rot90(flipud(digitimage),-1));
colormap(gray(256)), axis square tight off

%Compute average digit (from 17a)
%plot them and compare with p. 180.
T(1,:) = mean(train0);
T(2,:) = mean(train1);
T(3,:) = mean(train2);
T(4,:) = mean(train3);
T(5,:) = mean(train4);
T(6,:) = mean(train5);
T(7,:) = mean(train6);
T(8,:) = mean(train7);
T(9,:) = mean(train8);
T(10,:) = mean(train9);

for j = 1:10
    subplot(2,5,j);
    i = T(j,:);
    digitImage = reshape(i, 28, 28); %big I
    image(rot90(flipud(digitImage),-1));
    colormap(gray(256)), axis square tight off
end
```

iii. A Neuron

```
format long

% Give several pairs of InputList and InputWeight values
C1 = [10; 20; 30];
w1 = [10 20 30];
Neuron(C1, w1)
% NET = 1400, OUT = 1

C2 = [.1;.1;.1];
w2 = [.2 .2 .2];
Neuron(C2, w2)
% NET = 0.06, OUT = 0.514995501619410

C3 = [.01;.01;.01];
w3 = [.02 .02 .02];
Neuron(C3, w3)
% NET = 6.000000000000001e-04, OUT =  0.500149999995500

% Given F = sigmoidal (logistic) function:
% As the values of NET decrease, so do the OUT values

function [ OUT ] = Neuron(C, w)
%INPUT: n input connections, "C"
```

```
%       n input weights "w"
% NET is summation of two matrices
NET = w * C
OUT = 1/(1+exp(-NET));
end
```

iv. Multilayer Network

```
%Part 4 MultiLayer Network

function[O]= project2_p4(C1,w1)
                            % C1 is in format [x1,x2,x3,...,xn]
                            %w1 is in format [w11,w12,w13,...,w1n];
O=C1;                       where each
for i=1:length(w1)          % w1i is a weight matrix
    NETWORK= (w1(i).*O); %NETWORK = Xw where w is the input vector
and X is the
    O=1/(1+exp(-NETWORK));% ith matrix contained in w1
    O=O.'; % The output O=F(NETWORK)
end
```

v. Initializing the Network

```
%Part 5 Initializing the Network
%To initialize the network we assign random small numbers to each
weight
n=3; %setting number of layers to 3
WMatrix=cell(1,n);
for i=1:n
    WMatrix{i}= rand([4 4]); %This assigns weights for each layer,
which
end                         % will be random numbers between 0 and 1
WMatrix = cell2mat(WMatrix);
in=[1;2;3;4];
project2_p4(in,WMatrix)
```

vi. Training the Network

```
% part 6 - training the network

function percenterror = project2_p6(input, train, weight)

% input - cell array of input column vectors (C1,C2,etc.)
% train - cell array of output column vectors (train0, train1, etc.)
% weight - cell array of weight matrices (w1, w2, etc.)

layers = length(weight);

for i=1:length(input)
    o = input(i);
    out = cell(1, layers);

    % forward pass
    for j = 1:layers
        net =  o * weight(j);  % net = xw where x is the input
vector, C1,
                               % and w is the weights in between
layers of
                               % neurons
        o = 1./(1 + exp(-net)); % o = f(net), this output vector will
be
                                 % the input of the next layer
        out{j} = o;
    end

    % backward pass - adjusts the hidden layers by propogating the
error
    % back and adjusting weights on the way
    output = out{layers}; % start with the last layer
    error = output - train(i);  % difference between output and
target
                                % output
end
```

```
    delta = output .* (1 - output) .* error; % modified error
    updatedweight = out{layers-1}' * delta; % iterated weight update
                                            % based on delta
    weight(layers) = weight(layers) - updatedweight;

    % for other hidden layers
    for j= (layers-1):-1:2
        delta = (delta * weight(j+1)') * out{j} * (1 - out{j});
        updatedweight = out{j-1}' * delta;
        weight(j) = weight(j) - updatedweight;
    end

out = cell2mat(out);
percenterror = ((1 - out)./ out)*100

end
```

vii. Dependence on Parameters

```
% part 7 - dependence on parameters
x = [0 1 2];

% ran the training program while changing the input and weights which
% affected the number of layers
% changed the output of the training program to percent error
a1 = project2_p6(C2,train1,w1);
a2 = project2_p6(C3,train1,w1);
a3 = project2_p6(C1,train1,w2);
a4 = project2_p6(C2,train1,w2);
a5 = project2_p6(C3,train1,w2);
a6 = project2_p6(C1,train1,w3);

figure
plot(x,a1,'LineWidth',2)
hold on
plot(x,a2,'LineWidth',2)
hold on
plot(x,a3,'LineWidth',2)
```

```
hold on
plot(x,a4,'LineWidth',2)
hold on
plot(x,a5,'LineWidth',2)
hold on
plot(x,a6,'LineWidth',2)
hold off
title('Dependence on Layers')
ylabel('Percent Error (%)')
```