Code:

sigmoid.m

```
function g = sigmoid(z)
%SIGMOID Compute sigmoid functoon
%   J = SIGMOID(z) computes the sigmoid of z.

% You need to return the following variables correctly
g = zeros(size(z));

% ====================== YOUR CODE HERE ======================
% Instructions: Compute the sigmoid of each value of z. (z can be a matrix,
%               vector or scalar).

% add by Chang Liu, for calculating th sigmoid function of each element
g = 1./(1+exp(-z));

% =============================================================

end
```

costFunction.m

```
function [J, grad] = costFunction(theta, X, y)
%COSTFUNCTION Compute cost and gradient for logistic regression
%   J = COSTFUNCTION(theta, X, y) computes the cost of using theta as the
%   parameter for logistic regression and the gradient of the cost
%   w.r.t. to the parameters.

% Initialize some useful values
m = length(y); % number of training examples

% You need to return the following variables correctly
J = 0;
grad = zeros(size(theta));

% ====================== YOUR CODE HERE ======================
% Instructions: Compute the cost of a particular choice of theta.
%               You should set J to the cost.
%               Compute the partial derivatives and set grad to the partial
%               derivatives of the cost w.r.t. each parameter in theta
%
% Note: grad should have the same dimensions as theta
%

% Chang Liu, for calculating the cost function
temp1 = -1 * (y .* log(sigmoid(X * theta)));
temp2 = (1 - y) .* log(1 - sigmoid(X * theta));
```

```
J = sum(temp1 - temp2) / m;

% for calculating the gradient
% Note: multiple xij is calculate the corresponding value, so we
% use the X' to get the correct value
grad = (X' * (sigmoid(X * theta) - y)) * (1/m);

% =============================================================

end
```

predict.m

```
function p = predict(theta, X)
%PREDICT Predict whether the label is 0 or 1 using learned logistic
%regression parameters theta
%   p = PREDICT(theta, X) computes the predictions for X using a
%   threshold at 0.5 (i.e., if sigmoid(theta'*x) >= 0.5, predict 1)

m = size(X, 1); % Number of training examples

% You need to return the following variables correctly
p = zeros(m, 1);

% ====================== YOUR CODE HERE ======================
% Instructions: Complete the following code to make predictions using
%               your learned logistic regression parameters.
%               You should set p to a vector of 0's and 1's
%

result = sigmoid(X * theta);
for i=1:size(result)
        if result(i) >= 0.5
           p(i) = 1;
        else
           p(i) = 0;
        end
end

% =========================================================================


end
```

costFunctionReg.m

```
function [J, grad] = costFunctionReg(theta, X, y, lambda)
%COSTFUNCTIONREG Compute cost and gradient for logistic regression with regularization
%   J = COSTFUNCTIONREG(theta, X, y, lambda) computes the cost of using
%   theta as the parameter for regularized logistic regression and the
%   gradient of the cost w.r.t. to the parameters.
```

```
% Initialize some useful values
m = length(y); % number of training examples

% You need to return the following variables correctly
J = 0;
grad = zeros(size(theta));

% ====================== YOUR CODE HERE ======================
% Instructions: Compute the cost of a particular choice of theta.
%               You should set J to the cost.
%               Compute the partial derivatives and set grad to the partial
%               derivatives of the cost w.r.t. each parameter in theta

% calculate similar the value of J, theta as before

temp1 = -1 * (y .* log(sigmoid(X * theta)));
temp2 = (1 - y) .* log(1 - sigmoid(X * theta));

% here we add the correction of the theta
thetaT = theta;
thetaT(1) = 0;
correction = sum(thetaT .^ 2) * (lambda / (2 * m));

% new cost function and gradients by adding correction as equation shows
J = sum(temp1 - temp2) / m + correction;

grad = (X' * (sigmoid(X * theta) - y)) * (1/m) + thetaT * (lambda / m);


% =============================================================

end
```

oneVsAll.m

```
function [all_theta] = oneVsAll(X, y, num_labels, lambda)
%ONEVSALL trains multiple logistic regression classifiers and returns all
%the classifiers in a matrix all_theta, where the i-th row of all_theta
%corresponds to the classifier for label i
%   [all_theta] = ONEVSALL(X, y, num_labels, lambda) trains num_labels
%   logisitc regression classifiers and returns each of these classifiers
%   in a matrix all_theta, where the i-th row of all_theta corresponds
%   to the classifier for label i

% Some useful variables
m = size(X, 1);
n = size(X, 2);

% You need to return the following variables correctly
all_theta = zeros(num_labels, n + 1);
```

```
% Add ones to the X data matrix
X = [ones(m, 1) X];

% ========== YOUR CODE HERE ==========
% Instructions: You should complete the following code to train num_labels
%               logistic regression classifiers with regularization
%               parameter lambda.
%
% Hint: theta(:) will return a column vector.
%
% Hint: You can use y == c to obtain a vector of 1's and 0's that tell use
%       whether the ground truth is true/false for this class.
%
% Note: For this assignment, we recommend using fmincg to optimize the cost
%       function. It is okay to use a for-loop (for c = 1:num_labels) to
%       loop over the different classes.
%
%       fmincg works similarly to fminunc, but is more efficient when we
%       are dealing with large number of parameters.
%
% Example Code for fmincg:
%
%     % Set Initial theta
%     initial_theta = zeros(n + 1, 1);
%
%     % Set options for fminunc
%     options = optimset('GradObj', 'on', 'MaxIter', 50);
%
%     % Run fmincg to obtain the optimal theta
%     % This function will return theta and the cost
%     [theta] = ...
%         fmincg (@(t)(lrCostFunction(t, X, (y == c), lambda)), ...
%                 initial_theta, options);
%

for k = 1:num_labels
    init_theta = zeros(n + 1, 1);
    options = optimset('GradObj', 'on', 'MaxIter', 50);
    [theta] = fmincg (@(t)(lrCostFunction(t, X, (y == k), lambda)), init_theta, options);
    all_theta(k,:) = theta';
end;


% =========================================================================

end
```

lrCostFunction.m

```
function [J, grad] = lrCostFunction(theta, X, y, lambda)
%LRCOSTFUNCTION Compute cost and gradient for logistic regression with
```

```
%regularization
%   J = LRCOSTFUNCTION(theta, X, y, lambda) computes the cost of using
%   theta as the parameter for regularized logistic regression and the
%   gradient of the cost w.r.t. to the parameters.

% Initialize some useful values
m = length(y); % number of training examples

% You need to return the following variables correctly
J = 0;
grad = zeros(size(theta));

% ====================== YOUR CODE HERE ======================
% Instructions: Compute the cost of a particular choice of theta.
%               You should set J to the cost.
%               Compute the partial derivatives and set grad to the partial
%               derivatives of the cost w.r.t. each parameter in theta
%
% Hint: The computation of the cost function and gradients can be
%      efficiently vectorized. For example, consider the computation
%
%           sigmoid(X * theta)
%
%      Each row of the resulting matrix will contain the value of the
%      prediction for that example. You can make use of this to vectorize
%      the cost function and gradient computations.
%
% Hint: When computing the gradient of the regularized cost function,
%      there're many possible vectorized solutions, but one solution
%      looks like:
%           grad = (unregularized gradient for logistic regression)
%           temp = theta;
%           temp(1) = 0;   % because we don't add anything for j = 0
%           grad = grad + YOUR_CODE_HERE (using the temp variable)
%

sig = sigmoid(X * theta);
cost = -y .* log(sig) - (1 - y) .* log(1 - sig);
thetaNoZero = [ [ 0 ]; theta([2:length(theta)]) ];
J = (1 / m) * sum(cost) + (lambda / (2 * m)) * sum(thetaNoZero .^ 2);
grad = (1 / m) .* (X' * (sig - y)) + (lambda / m) * thetaNoZero;

% =============================================================

grad = grad(:);

end
```

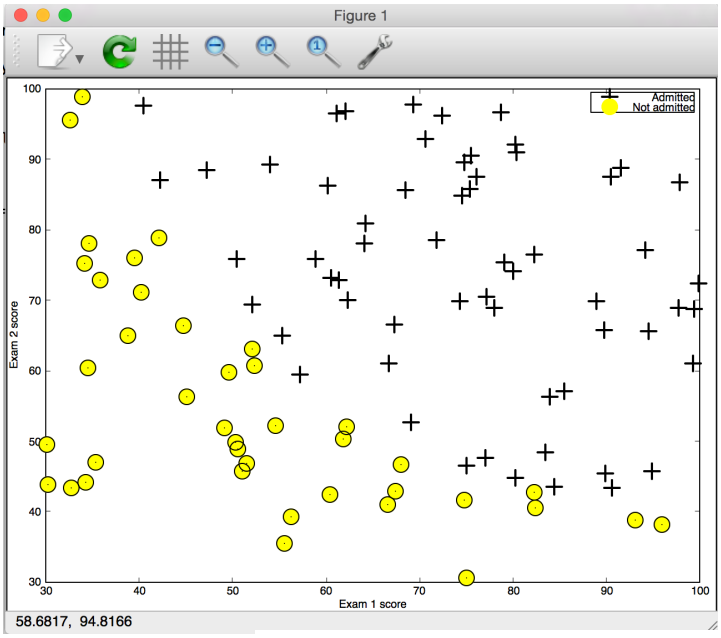
predictOneVsAll.m

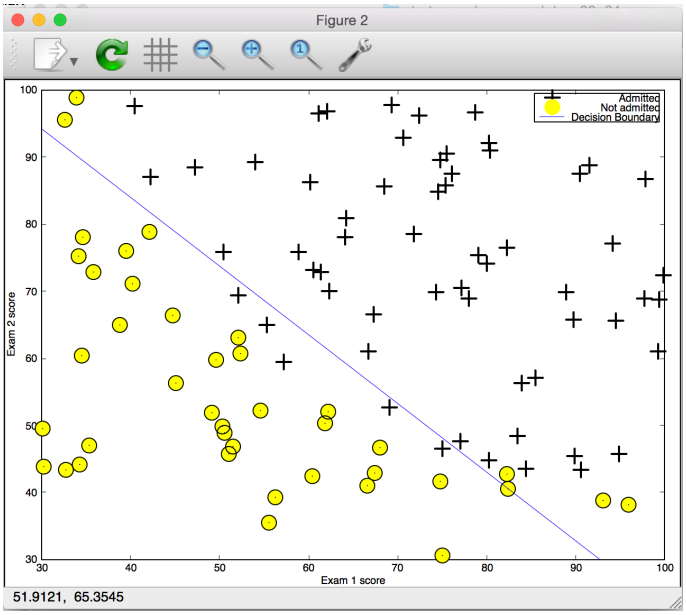
```
function p = predictOneVsAll(all_theta, X)
%PREDICT Predict the label for a trained one-vs-all classifier. The labels
```

```
%are in the range 1..K, where K = size(all_theta, 1).
%  p = PREDICTONEVSALL(all_theta, X) will return a vector of predictions
%  for each example in the matrix X. Note that X contains the examples in
%  rows. all_theta is a matrix where the i-th row is a trained logistic
%  regression theta vector for the i-th class. You should set p to a vector
%  of values from 1..K (e.g., p = [1; 3; 1; 2] predicts classes 1, 3, 1, 2
%  for 4 examples)

m = size(X, 1);
num_labels = size(all_theta, 1);

% You need to return the following variables correctly
p = zeros(size(X, 1), 1);

% Add ones to the X data matrix
X = [ones(m, 1) X];

% ====================== YOUR CODE HERE ======================
% Instructions: Complete the following code to make predictions using
%               your learned logistic regression parameters (one-vs-all).
%               You should set p to a vector of predictions (from 1 to
%               num_labels).
%
% Hint: This code can be done all vectorized using the max function.
%       In particular, the max function can also return the index of the
%       max element, for more information see 'help max'. If your examples
%       are in rows, then, you can use max(A, [], 2) to obtain the max
%       for each row.
%

[maxVal, index] = max(X * all_theta', [], 2);
p = index;

% =========================================================================
end
```

lda.m

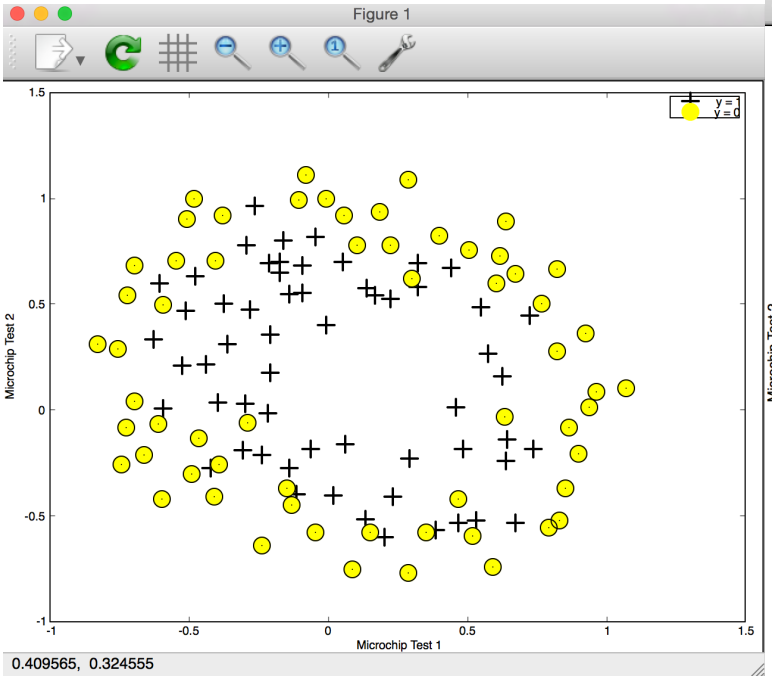
Machine Learning Assign2 Chang Liu chang_liu@student.uml.edu

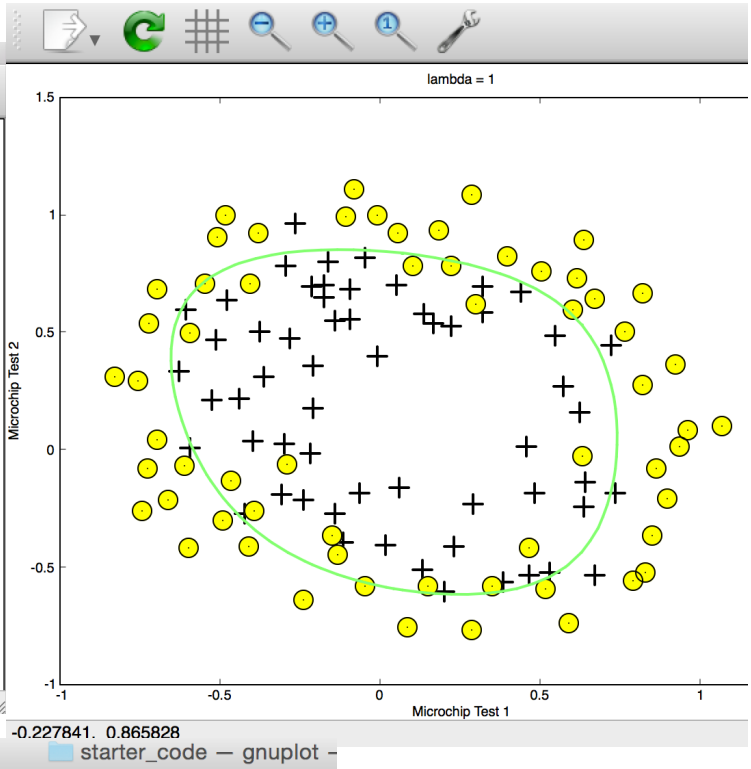




Screenshot:

```
Program paused. Press enter to continue.
Sigmoid function test:
 0.000000
 0.500000
 1.000000

Program paused. Press enter to continue.
Cost at initial theta (zeros): 0.693147
Gradient at initial theta (zeros):
 -0.100000
 -12.009217
 -11.262842

Program paused. Press enter to continue.
Cost at theta found by fminunc: 0.203498
theta:
 -25.161272
 0.206233
 0.201470

Program paused. Press enter to continue.
For a student with scores 45 and 85, we predict an admission probability of 0.776
289

Train Accuracy: 89.000000
```

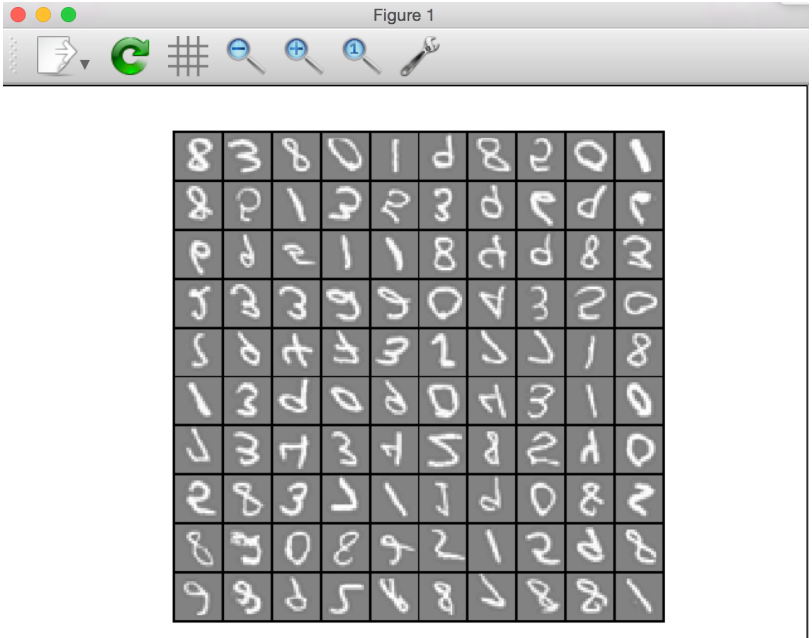




starter_code — gnuplot -

gnuplot

```
Cost at initial theta (zeros): 0.693147

Program paused. Press enter to continue.
Train Accuracy: 83.050847
octave:19>
```




```
Loading and Visualizing Data ...
Program paused. Press enter to continu

Training One-vs-All Logistic Regressi
Iteration    50 | Cost: 1.401010e-02
Iteration    50 | Cost: 5.725249e-02
Iteration    50 | Cost: 6.318403e-02
Iteration    50 | Cost: 3.589342e-02
Iteration    50 | Cost: 6.186099e-02
Iteration    50 | Cost: 2.173040e-02
Iteration    50 | Cost: 3.557343e-02
Iteration    50 | Cost: 8.462181e-02
Iteration    50 | Cost: 8.053560e-02
Iteration    50 | Cost: 9.611693e-03
Program paused. Press enter to continu

Training Set Accuracy: 95.100000
octave:20>
```