Machine Learning implemented in MATLAB - Notebook 1: Linear Regression

Author: Alberto Ibarrondo | *Date:* 20/03/2017 | *License:* MIT Free software

Contents

1 INTRODUCTION

The objective of this first notebook is to implement a Linear Regression model in MATLAB and apply it on a dataset.

Files included with this notebook

- MachLearnInMATLAB_1_LinearRegression.m - implementation MATLAB script
- data1.txt - Dataset for linear regression with one variable
- data2.txt - Dataset for linear regression with multiple variables
- computeCost.m - Function to compute the cost of linear regression
- gradientDescent.m - Function to run gradient descent
- featureNormalize.m - Function to normalize features
- normalEqn.m - Function to compute the normal equations

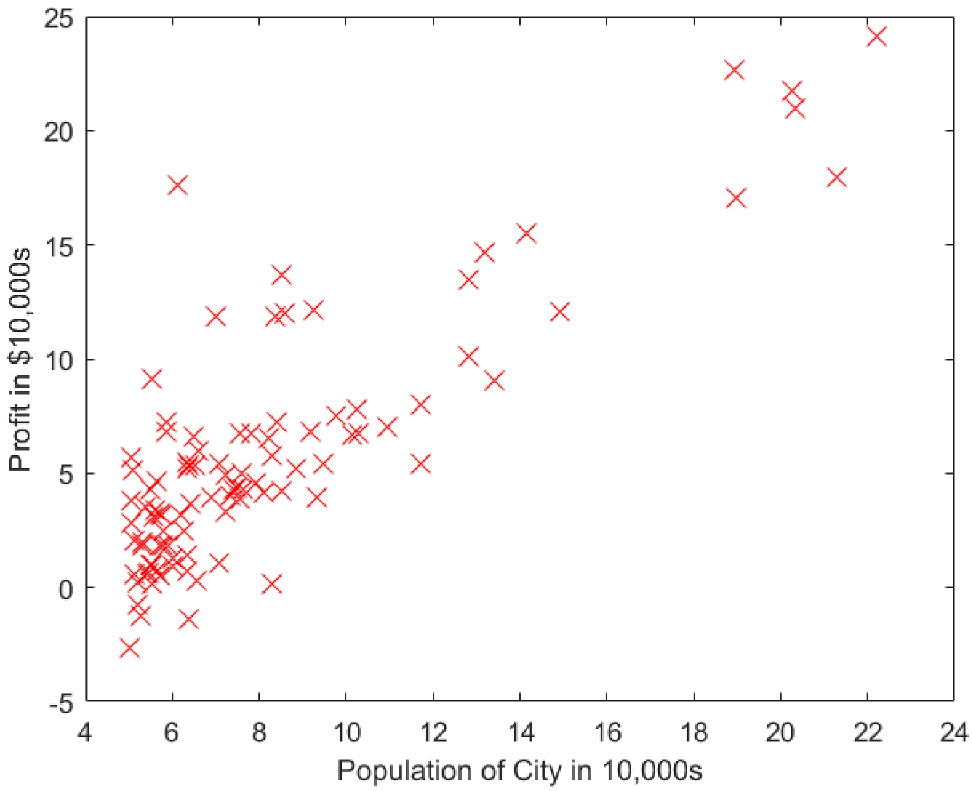
2 LINEAR REGRESSION WITH ONE VARIABLE

2.1: Loading & Plotting

x refers to the population size in 10,000s y refers to the profit in $10,000s

```
clear ; close all; clc
fprintf('1. Loading and Plotting Data ...\n')
data = load('data1.txt');
X = data(:, 1); y = data(:, 2);
m = length(y); % number of training examples

% Plot Data
figure; % open a new figure window
plot(X, y, 'rx', 'MarkerSize', 10); % Plot the data
ylabel('Profit in $10,000s'); % Set the y axis label
xlabel('Population of City in 10,000s'); % Set the x axis label
```

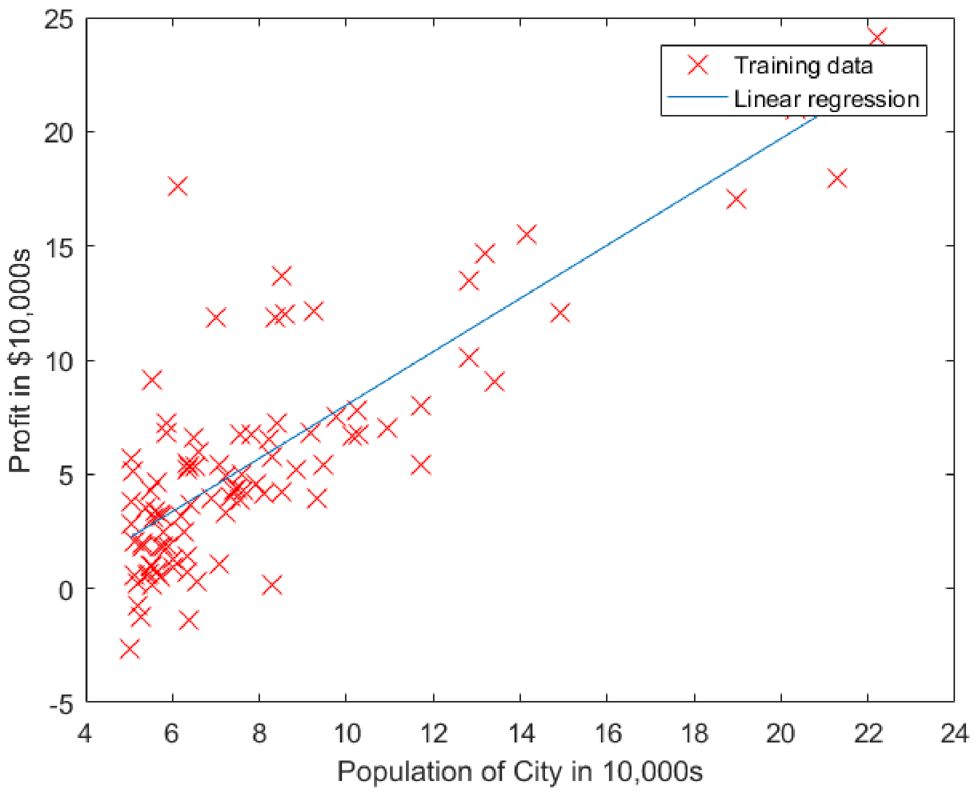
```
1. Loading and Plotting Data ...
```



2.2: Gradient Descent

```
fprintf('2. Running Gradient Descent ...\n')

X = [ones(m, 1), data(:,1)]; % Add a column of ones to x
theta = zeros(2, 1); % initialize fitting parameters

% Some gradient descent settings
iterations = 1500;
alpha = 0.01;

% compute and display initial cost
computeCost(X, y, theta)

% run gradient descent
theta = gradientDescent(X, y, theta, alpha, iterations);

% print theta to screen
fprintf('Theta found by gradient descent: ');
fprintf('%f %f \n', theta(1), theta(2));

% Plot the linear fit
hold on; % keep previous plot visible
plot(X(:,2), X*theta, '-')
legend('Training data', 'Linear regression')
hold off % don't overlay any more plots on this figure

% Predict values for population sizes of 35,000 and 70,000
predict1 = [1, 3.5] *theta;
fprintf('For population = 35,000, we predict a profit of %f\n',...
    predict1*10000);
predict2 = [1, 7] * theta;
fprintf('For population = 70,000, we predict a profit of %f\n',...
    predict2*10000);
```

```
2. Running Gradient Descent ...

ans =

   32.0727

Theta found by gradient descent: -3.630291 1.166362
For population = 35,000, we predict a profit of 4519.767868
For population = 70,000, we predict a profit of 45342.450129
```

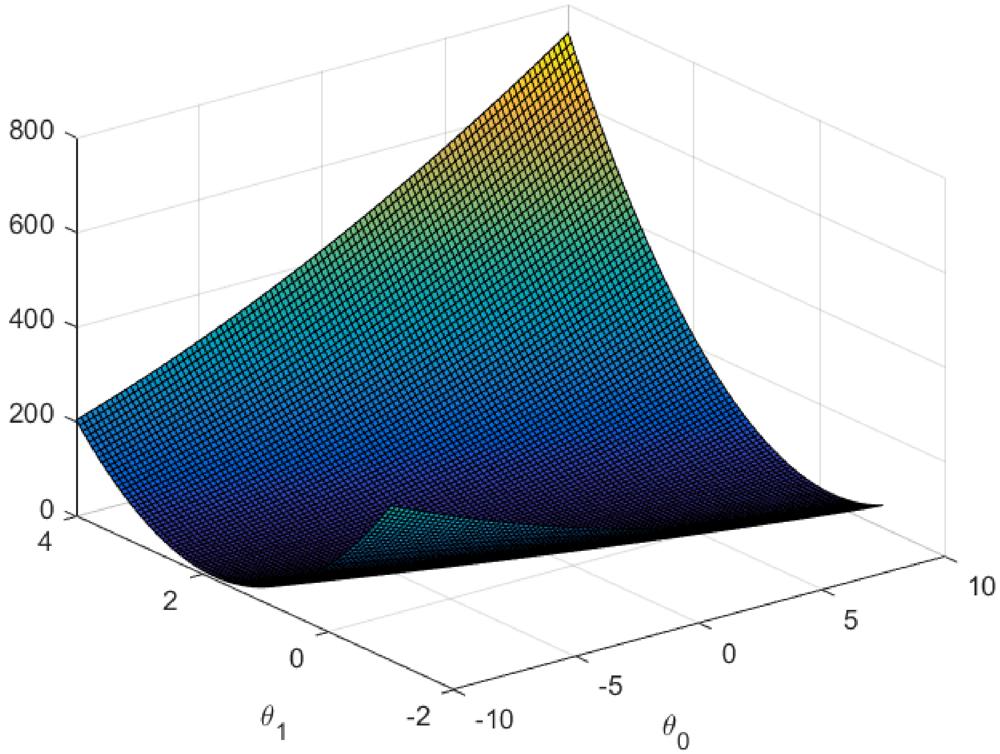


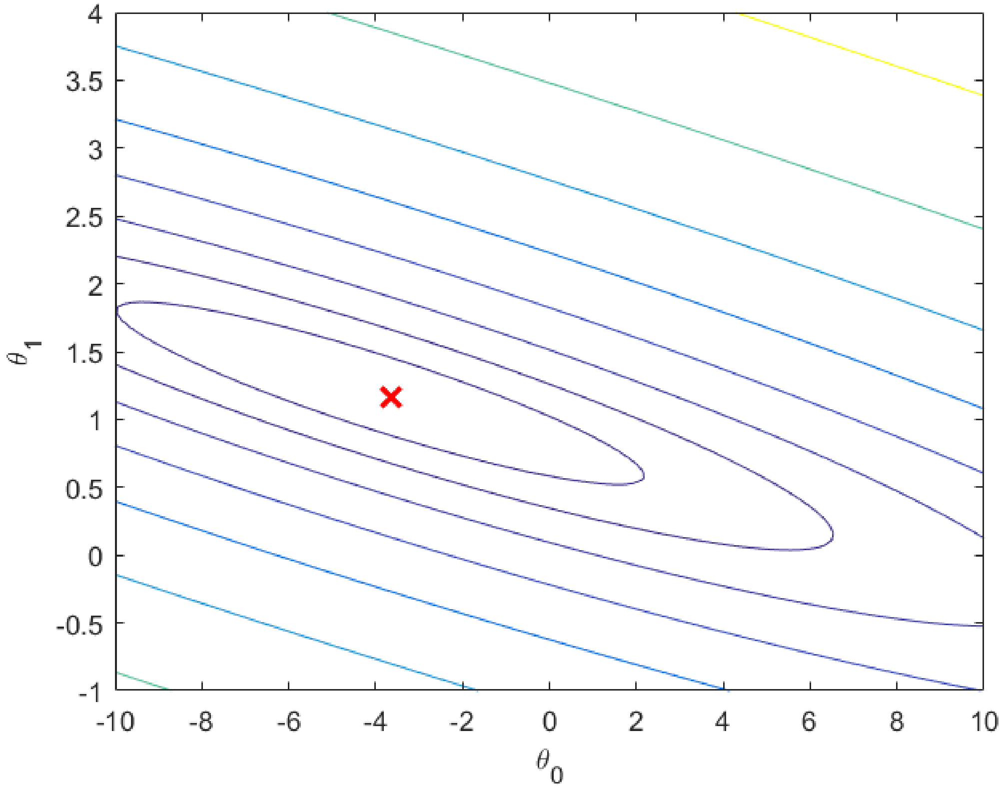
2.3: Visualizing J(theta_0, theta_1)

```
fprintf('Visualizing J(theta_0, theta_1) ...\n')

% Grid over which we will calculate J
theta0_vals = linspace(-10, 10, 100);
theta1_vals = linspace(-1, 4, 100);

% initialize J_vals to a matrix of 0's
J_vals = zeros(length(theta0_vals), length(theta1_vals));

% Fill out J_vals
for i = 1:length(theta0_vals)
    for j = 1:length(theta1_vals)
          t = [theta0_vals(i); theta1_vals(j)];
          J_vals(i,j) = computeCost(X, y, t);
    end
end


% Because of the way meshgrids work in the surf command, we need to
% transpose J_vals before calling surf, or else the axes will be flipped
J_vals = J_vals';
% Surface plot
figure;
surf(theta0_vals, theta1_vals, J_vals)
```

```
xlabel('\theta_0'); ylabel('\theta_1');

% Contour plot
figure;
% Plot J_vals as 15 contours spaced logarithmically between 0.01 and 100
contour(theta0_vals, theta1_vals, J_vals, logspace(-2, 3, 20))
xlabel('\theta_0'); ylabel('\theta_1');
hold on;
plot(theta(1), theta(2), 'rx', 'MarkerSize', 10, 'LineWidth', 2);
```

```
Visualizing J(theta_0, theta_1) ...
```





3 LINEAR REGRESSION WITH MULTIPLE VARIABLES

3.1 Feature Normalization

```
clear ; close all; clc
% Load Data
fprintf('Loading data ...\n');
data = load('data2.txt');
X = data(:, 1:2);
y = data(:, 3);
m = length(y);

% Print out some data points
fprintf('First 10 examples from the dataset: \n');
fprintf(' x = [%.0f %.0f], y = %.0f \n', [X(1:10,:) y(1:10,:)]');

% Scale features and set them to zero mean
fprintf('Normalizing Features ...\n');
[X, mu, sigma] = featureNormalize(X);

% Add intercept term to X
X = [ones(m, 1) X];
```

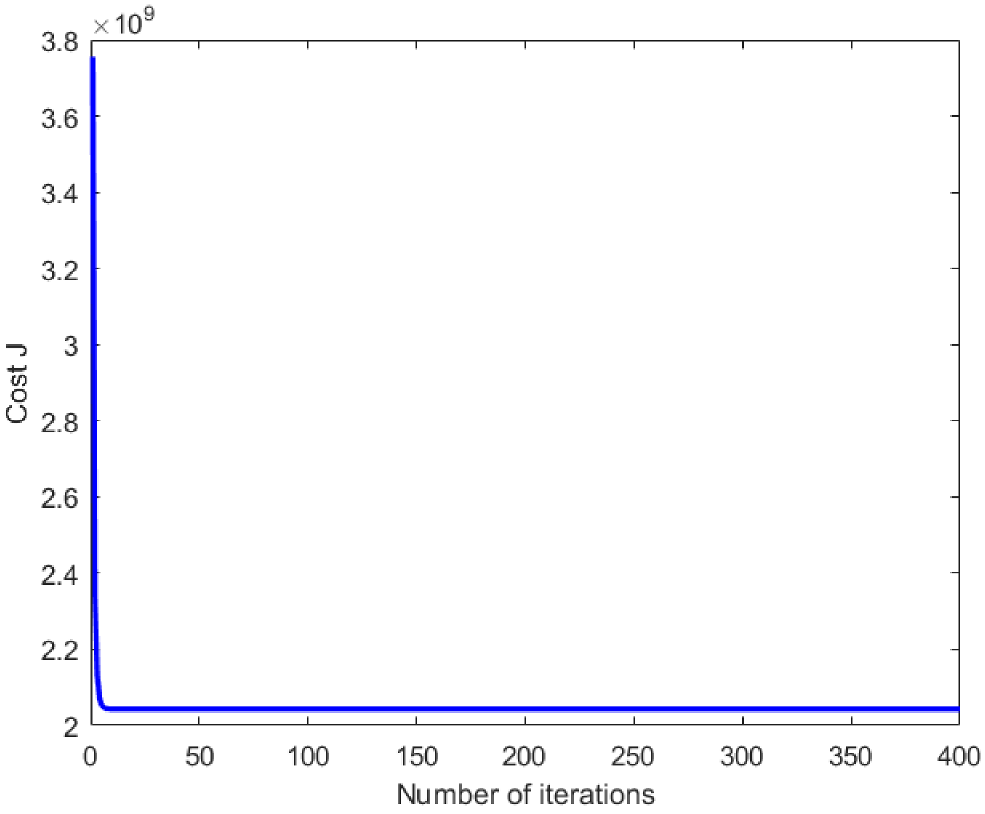
```
Loading data ...
First 10 examples from the dataset:
 x = [2104 3], y = 399900
 x = [1600 3], y = 329900
 x = [2400 3], y = 369000
 x = [1416 2], y = 232000
 x = [3000 4], y = 539900
 x = [1985 4], y = 299900
 x = [1534 3], y = 314900
 x = [1427 3], y = 198999
 x = [1380 3], y = 212000
 x = [1494 3], y = 242500
```

```
Normalizing Features ...
```

3.2 Gradient Descent

```
fprintf('Running gradient descent ...\n');

% Choose some alpha value
alpha = 0.9;
num_iters = 400;

% Init Theta and Run Gradient Descent
theta = zeros(3, 1);
[theta, J_history] = gradientDescent(X, y, theta, alpha, num_iters);

% Plot the convergence graph
plot(1:numel(J_history), J_history, '-b', 'LineWidth', 2);
xlabel('Number of iterations');
ylabel('Cost J');
hold on
% Display gradient descent's result
fprintf('Theta computed from gradient descent: \n');
fprintf(' %f \n', theta);
fprintf('\n');

% Estimate the price of a 1650 sq-ft, 3 br house
newX=[1650 3];
newX=(newX-mu)./sigma;
newX=[1 newX];
price = newX*theta;

fprintf(['Predicted price of a 1650 sq-ft, 3 br house ' ...
         '(using gradient descent):\n $%f\n'], price);
```

```
Running gradient descent ...
Theta computed from gradient descent:
 340412.659574
 110631.050279
 -6649.474271

Predicted price of a 1650 sq-ft, 3 br house (using gradient descent):
 $293081.464335
```



3.3 Normal Equations

```
fprintf('Solving with normal equations...\n');
data = csvread('data2.txt');
X = data(:, 1:2);
y = data(:, 3);
m = length(y);

% Add intercept term to X
X = [ones(m, 1) X];

% Calculate the parameters from the normal equation
theta = normalEqn(X, y);

% Display normal equation's result
fprintf('Theta computed from the normal equations: \n');
fprintf(' %f \n', theta);
fprintf('\n');


% Estimate the price of a 1650 sq-ft, 3 br house
newX=[1 1650 3];
price = newX*theta; % You should change this
fprintf(['Predicted price of a 1650 sq-ft, 3 br house ' ...
         '(using normal equations):\n $%f\n'], price);
```

```
Solving with normal equations...
Theta computed from the normal equations:
 89597.909543
 139.210674
 -8738.019112

Predicted price of a 1650 sq-ft, 3 br house (using normal equations):
 $293081.464335
```

Published with MATLAB® R2016b