Mechatronics Engineering and Automation Program
CSE473: Computational Intelligence
Fall 2022

Major Task Project: Optimization & Image Classifiers

Students are encouraged to work in groups. Each group has at most three students.

Due Date: Milestone (1): TBD - Milestone (2):TBD

Milestone (1):

The objective of this part is to find a solution for the following set of non-linear equations using different optimization techniques:-

$$g_1(x_1, x_2, x_3) = 3x_1 - \cos(x_2 x_3) - 0.5 = 0$$

$$g_2(x_1, x_2, x_3) = x_1^2 - 81(x_2 + 0.1)^2 + \sin(x_3) + 1.06 = 0$$

$$g_3(x_1, x_2, x_3) = \exp(-x_1 x_2) + 20x_3 + (10\pi - 3)/3 = 0$$

The problem can be reformulated as a minimization of the following suggested objective function:-

$$F(x_1, x_2, x_3) = \frac{1}{2}[g_1(x_1, x_2, x_3)]^2 + \frac{1}{2}[g_2(x_1, x_2, x_3)]^2 + \frac{1}{2}[g_3(x_1, x_2, x_3)]^2$$

a- Find an expression for the gradient vector of the function F.

b- Find an expression for the Hessian matrix of the function F. (Hint: the Hessian matrix is a square symmetric matrix. This will save a lot in finding the derivatives)

c- Write a program to optimize the above objective function using the conventional gradient descent technique. You need to demonstrate the solution in every step by plotting the gradient magnitude as well as the function value versus the iteration number showing the convergence of the algorithm. Also, repeat the execution of the program from different initial points. You may do that 100 times. What will be the resulting solution? You are not allowed to use any of optimization toolbox functions.

d- Repeat part (c) but using the Newton-Raphson's method.

e- Repeat part (c) but using the line search gradient descent (steepest). You may use one of the ready-made toolbox functions for optimization. Comment on the results.

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Milestone (2):

The aim of this project is to create and train a multilayer Neural Network to classify an image into its corresponding category. You must use the following well-known image data sets in

https://vision.princeton.edu/projects/2010/SUN/

1- First select at least 100 visual objects and construct a data set for each object with suitable number of images.

2- You may divide the data sets to be 70% for training, 15% for validation, and 15% for testing.

3- Normalize your data using the techniques explained in the course lectures by subtracting from the mean and dividing by the standard deviation at each dimension. Visualize your data after normalization.

4- Using tensor-flow, design a multilayer neural network to handle this classification case.

5- Using cross validation, what will be the best number of hidden layers as well as number of nodes per layer?

6- You need to visualize the training process (loss vs iterations).

7- What will be the best accuracy you get?

Important: You need to write a neat report for each milestone with the following contents:

- Problem definition and importance (1 Page).
- Methods and Algorithms (2-3 Pages).
- Experimental Results (samples of your trails) and discussions.
- Appendix with codes.

Warnings: (1) Plagiarism is prohibited. (2) Assignments with no reports and or no presentations will not be graded.
