Lab Assignment 4b: Optimization for Machine Learning

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Write python codes of descent methods with inexact line search technique for the following function:

(1) $f : \mathbb{R}^2 \to \mathbb{R}$ is defined by $f(x) = (x_1 - r_1)^4 + (x_1 - 2x_2)^2$ with and $x^0 = (0.5, 0.25)$ where r_1 is the last digit of your roll number. If last digit of your roll number is 0 then choose $r_1 = 1.75$. Use $\beta_1 = 10^{-4}$ $r = 0.5$, and stopping criteria $\|\nabla f(x^k)\| < 10^{-3.5}$ or maximum 500 iterations. Find number of iterations, function evaluations and gradient evaluations.

(2) Solve the above problem with (i) $d^k = -B^{-1}\nabla f(x^k)$ (ii) $d^k = -B\nabla f(x^k)$ where $B = \begin{bmatrix} 2r_1 & \sqrt{r_1} \\ \sqrt{r_1} & r_1 \end{bmatrix}$. Find number of iterations, function evaluations and gradient evaluations. Does this method take less number of iterations?

(3) Solve the following problem

$$\min_{x \in \mathbb{R}^{10}} \sum_{i=1}^{5} \left[100(x_{2i-1}^2 - x_{2i})^2 + (x_{2i-1} - 1)^2\right]$$

using (i) gradient descent method (ii) $d^k = -B^{-1}\nabla f(x^k)$ where B is a symmetric positive definite matrix with diagonal elements in $[5, 10]$ and off diagonal elements in $[0, 1]$. Use initial approximation $(0.5, 0.5, \ldots, 0.5)$, stopping criteria $\|\nabla f(x^k)\| < 10^{-3.5}$ or max iteration 10000.

(4) Solve the problem

$$f(x) = -20e^{-0.2\sqrt{\frac{1}{2}(x_1^2 + x_2^2)}} - e^{\frac{1}{2}(\cos(2\pi x_1) + \cos(2\pi x_2))}$$

solve by (i) gradient descent method (ii) $d^k = -B^{-1}\nabla f(x^k)$, where $B = \begin{bmatrix} 2.5 & -1.1 \\ -1.1 & 4.5 \end{bmatrix}$ with $x^0 = (-R/10, R/10)$ stopping criteria $\|\nabla f(x^k)\| < 10^{-3.5}$ or max iteration 10000.