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Optimization and simulation
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Project 6: Augmented Lagrangian methods

Objective:
The aim of this project is to implement the augmented lagrangian method for solving different problems and analyze the role of the different parameters on the algorithm's efficiency.

Requirements
The student will implement and apply algorithm 20.1 to the following problems (Hock & Schittkowski, 1981):

$$\begin{aligned} \underset{x\mathbb{R}^2}{\text{minimize}} \quad & -32.174(255ln\frac{x_1+x_2+x_3+0.03}{0.09x_1+x_2+x_3+0.3}+280ln\frac{x_2+x_3+0.03}{0.07x_2+x_3+0.03} \\ & +290ln\frac{x_3+0.03}{0.13x_3+0.03}) \\ \text{subject to} \quad & \\ & x_1+x_2+x_3-1=0 \\ & 0 \leq x_i \leq 1 \quad i=1,2,3,4 \end{aligned}$$

Optimal solution $f(x^*) = -26272.51448$,
$x^* = 0.6178126908, 0.328202223, 0.5398508606E-1$.
Suggested starting point: $x_0 = (0.7, 0.2, 0.1)$.
b)

$$\begin{aligned} \underset{x\mathbb{R}^{10}}{\text{minimize}} \quad & f(x) = \frac{an - \frac{(b(e^{x_1}-1)-x_3)x_4}{e^{x_1}-1+x_4}}{x_1} \\ & x_3 - 2\phi(-x_2) = 0 \\ & x_4 - \phi(-x_2 + d\sqrt{n}) - \phi(-x_2 - d\sqrt{n}) = 0 \\ & \phi(x) = \int_{-\infty}^{x} \frac{e^{\frac{-y^2}{2}}}{\sqrt{2\pi}} dy \\ & 0.0001 \leq x_1 \leq 100, 0 \leq x_2 \leq 100, \\ & 0 \leq x_3 \leq 2, 0 \leq x_4 \leq 2 \end{aligned}$$

with $a = 0.0001, b = 1, d = 1, n = 24$
Optimal solution: $f(x^*) = -0.920425026$
$(0.06785874, 3.6461717, 0.00026617, 0.8948622)$
Suggested starting point: $(1, 1, 1, 1)$.

The student will analyze the impact of the following parameters:

Penalty parameter Initial values $c_0 = 1, 10, 100$ and augmentation factor $\tau = 2, 10, 100$.

We encourage the students to compare their results with the Matlab built-in optimisation algorithms and justify the differences (if there exist any)

Constraints' precision Analyze the impact on the approximation of dual variables with respect to values $\beta = 0.1, 0.5, 0.9$.

Remark Problems' formulation must comply with the required formulation

$$\begin{aligned} \underset{x\mathbb{R}^n}{\text{minimize}} \quad & f(x) \\ \text{subject to} \quad & h(x) = 0 \end{aligned}$$

Implementation:

- Algorithms 11.5, 20.1.
- Useful Matlab functions for this project: **chol**.