Computer Assignment 0
Getting started with the Matlab Optimization Toolbox

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Objectives

- Getting started with the Matlab optimization toolbox
- Learn to sketch (by hand) contour plots of 2 variable optimization problems

Course material

- Chapter 1 of Papalambros and Wilde [1]
- Matlab optimization toolbox [1].

Problem 1

Consider the optimization problem that has been implemented in Matlab as follows:

```
% Matlab file myfirstprogram.m
clear
f = [-3 -2];
A = [2 1; 1 1; 1 0];
b = [10 8 4];
Aeq = [];
beq = [];
lb = [0 0];
ub = [];
x = linprog(f,A,b,Aeq,beq,lb,ub)
```

Questions:

a) Copy the Matlab code into a Matlab m-file `myfirstprogram.m`. Start Matlab, and run the m-file. What outcome is returned?

b) Type `doc linprog` at your Matlab prompt. Give the mathematical formulation of the optimization problem (in negative null form) that been implemented in `myfirstprogram.m`.

c) Sketch (on paper) the contour plot of the optimization problem. Identify the feasible domain and the location of the minimizer. Which constraint(s) are active? Verify your plot with the outcome of question item a).

d) Which class of optimization problems can be solved using `linprog`?

Problem 2

The objective function of the optimization problem studied in Problem 1 is replaced by

$$f = (x_1 - 5)^2 + (x_2 - 5)^2 = x_1^2 + x_2^2 - 10x_1 - 10x_2 + 50 \tag{1}$$

Questions:

a) Adjust the contour plot of Problem 1 in accordance with the revised objective function.

b) Solve the optimization problem using `quadprog`. Verify the outcome with your picture.
(Note 1: you can re-use a large part of `myfirstprogram.m`)
(Note 2: you may receive a warning message that the default algorithm setting is not correct, and that a so-called active set algorithm is used instead. This is just a warning which algorithm setting is being used. No error. You may get rid of such a message by re-setting to 'active-set' using the `options` input argument to your `quadprog` call. The use of options is demonstrated in Problem 3.

c) Which class of optimization problems can be solved using `quadprog`?

Problem 3

Next consider the optimization problem implemented using three Matlab input files. An objective function file `objfun.m`:

```
function [f] = objfun(x)
f = 0.5*x(1)^2 + 0.5*x(2)^2;
```

a nonlinear constraint function file `nonlcon.m`:

```
function [g,h] = nonlcon(x)
g = [];
h = x(1)*x(2) - 4;
```

and a main file `mythirdprogram.m` which calls the `fmincon` algorithm:

```
clear
x0 = [3 4];
A = [];
b = [];
Aeq = [];
beq = [];
lb = [0 0];
ub = [];
```

```
options = optimoptions('fmincon');
options = optimoptions(options, 'Algorithm', 'interior-point');
% For older Matlab versions use optimset instead of optimoptions,
% refer to the documentation.
x = fmincon(@objfun,x0,A,b,Aeq,beq,lb,ub,@nonlcon,options)
```

Questions:

a) Give the mathematical expression of the optimization problem that has been implemented.

b) Run the program, and verify the outcome using a contour plot.

c) Which class of optimization problems can be solved using `fmincon`?

Problem 4

The Matlab Optimization Toolbox also has dedicated solvers for problems without constraints or problems with bound constaints only. For instance, the algorithms `fminunc`, `fminsearch`, and `lsqcurvefit` (or `lsqnonlin`).

Questions:

a) Use `fminunc` and `fminsearch` to find the minimizer to Rosenbrocks banana function:

$$f(x_1, x_2) = (1 - x_1)^2 + 100\left(x_2 - x_1^2\right)^2, \tag{2}$$

starting from $(-1, 1)$.

b) Use the documentation command `doc` to find out the difference between the algorithms `fminunc` and `fminsearch`.

c) When would you select the `lsqcurvefit` (or `lsqnonlin`) algorithm?

References

[1] Papalambros, P.Y. and Wilde, D.J., *Principles of optimal design: modeling and computation*, 2nd edition, Cambridge University Press, 2000.

[2] Matlab Optimization Toolbox, The Mathworks.