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MATLAB II

Exercise for Lecture 1

This exercise involves the first lecture of the minicourse Matlab continuation, concerning mostly with handling and interpreting data. Once you have solved the problems, please send **published pdf** and your **source code** to *juha.kuortti@aalto.fi*.
The deadline for the return of the exercise is 15.3.2018.

1. Download the data file `ex_data1.csv`, and load it into MATLAB. The goal is to fit a parametric model of the type
$$(x - c_1)^2 + (y - c_2)^2 = r^2$$
to the data. Here c_1, c_2, and r are the unknown parameters you'll try to discover, and x and y are the datapoints you have.

   i) There are some missing entries in the file. You'll need to decide what to do with them. Use plotting and trial to decide the best course of action.

   ii) We'll do a bit of math next: our model is
$$(x - c_1)^2 + (y - c_2)^2 = r^2.$$
If we open the parenthesis and reorder a bit we get
$$2xc_1 + 2yc_2 + (r^2 - c_1^2 - c_2^2) = x^2 + y^2.$$
which is a linear system of equations for our unknown parameters – and a few extra too, which can make your matrix rank deficient. To get rid of the extras, we lump some parameters together:
$$2xc_1 + 2yc_2 + \underbrace{(r^2 - c_1^2 - c_2^2)}_{c_3} = x^2 + y^2.$$
$$2xc_1 + 2yc_2 + c_3 = x^2 + y^2.$$
You can now write a linear system
$$\begin{bmatrix} 2x & 2y & 1 \end{bmatrix} \begin{bmatrix} c_1 \\ c_2 \\ c_3 \end{bmatrix} = \begin{bmatrix} x^2 + y^2 \end{bmatrix}$$
and solve the parameters (c_1 and c_2 you get straight, r might need some thinking).

   iii) Once you have the relevant parameters, its time to see how the model fits the data. Since its a little hard to do implicit plots in MATLAB, we'll use polar coordinate form. Plot $c_1 + r\cos(\theta)$ against $c_2 + r\sin(\theta)$, where $\theta \in [0, 2\pi]$ in a same figure with the datapoints.

2. Download the data file `ex_data2.csv`, and load it into MATLAB. The goal is to fit a parametric model of the type

$$\frac{(x-c_1)^2}{a^2} + \frac{(y-c_2)^2}{b^2} = 1$$

to the data.

   i) There are again some missing entries in the file. This time, use *linear interpolation* to fill the missing lots. Can you hypothesise why interpolation in this instance seems to work, whereas previously it (probably) didn't?

   ii) Instead of doing some fancy math, this time we'll do a straight up optimization. Write your model function and objective function, and find the parameter values using `fminsearch`.

   iii) Plot your model as before; this time the polar form will be $c_1 + a\cos(\theta)$ against $c_2 + b\sin(\theta)$, and $\theta \in [0, 2\pi]$.