Signal Analysis, Design of Experiments and System Identification
WiSe 2023/2024
2^{nd} Computer Exercise
Calibration 01 - Example: Equation of Motion

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1. **Model:** Work with the file `Myharmonic_Num.m`. It computes the solution of the equation of motion for a vector of input parameters. You can provide either $[k, c]$ or $[k, c, m]$. In the first case, m is set fixed to the value 4.
2. Vary the values of m, c and k and observe the different behavior.
3. Now, in the file `Myharmonic_Num.m`, set $Plot\_fig = 0$.
4. **Measurements:** The files $u\_meas0.mat - u\_meas09.mat$ contain different measurements. After loading, the measurements are stored in the vectors u_meas.
5. Make a plot comparing each u_meas with data plot of numerical results obtained from `Myharmonic_Num.m` (use: [4.5, 0.65, 4]).
6. **Cost function:** Study now the file `myCostFunctionHarmonicFit_Num.m`. Try to understand, how the value of the cost function and the gradient are computed.
7. **Optimization:**
   a. Use the optimization toolbox (`optimtool`), and work with the methods fminsearch (Nelder-Mead), fminunc (Solver Quasi-Newton, i.e. approximated Hessian), and the genetic algorithm. Activate the plot controls. What is visualized? Try the different options offered for each of the algorithms.
   b. Open the file `Matlab_NedlerMead_Num.m`:
      - Select one data file.
      - Use different initial values.
      - Start the optimization for 2 parameters (k, c) and 3 parameters (k, c, m).
      - What are the results?
   c. Plot how the value of the cost function and the length of the gradient change with increasing iterations. (Hint `doc fminsearch` and `optimset`).
   d. Plot how the parameters change with increasing iterations. Which parameters seem to converge faster? (Hint see the function `Get_opt_history`).
8. **Discussion:** Plot the contour lines of `myCostFunctionHarmonicFit_Num.m` for the following cases: Identification of the pairs (k, c), (k, m), and (c, m).
   The file (`contourLines_Num.m`) may help how to do so. What is spurious in the results and may give an answer to previously observed problems?
9. Perform a residual analysis for the $u\_meas0.mat - u\_meas09.mat$.
10. Document observations, findings and conclusions carefully.