Theory of nonlinear dynamic systems
Practice 1

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Introduction - Requirements

- Participation, midterm, project, exam
- Matlab® (why?)
- The aim of the practices:
  deeper understanding of the lecture examples, implementing them in MATLAB (a framework will be given), „playing” with the parameters

Theory

- **Dynamic system**: the states of the system are changing with time based on some rules - mathematical description of a physical process
- **Phase space**: the collection of all possible states of the dynamic system
- **Trajectory**: the path (trace) of an element from the phase space
- **Types of the systems**: dissipative, conservative, explosive
- **Attractor**: stable and attracts its surroundings, can be point, periodic, chaotic

Exercises

- Implement the following equations in Matlab!
- Plot the trajectories, study the behaviour of the systems and investigate the effects of different parameters!
- Are there stable points in the systems? Zoom into the fixed points!
- What happens in longer simulations?
  - 1. $\ddot{x} + x = 0$
  - 2. $\ddot{x} + b\dot{x} + x = 0$;b=1/10

    What happens in case of other damping values?
  - 3. $\ddot{x} + x = \cos t$
  - 4. $\ddot{x} + x = \cos \omega t$
  - 5. $\ddot{x} + 2x = \cos t$

Exercises

- 6. $\ddot{x} + b\dot{x} + x = \cos t$
- 7. $\ddot{x} + \sin x = 0$
- 8. $\ddot{x} + b\dot{x} + \sin x = 0$
- 9. $\ddot{x} + b\dot{x} + \sin x = \cos t$

How sensitive is the shape of the trajectory to inital conditions?

- 10. $\ddot{x} + b\dot{x} + \sin x = \cos \omega t$;b=0.05; ω=0.9

- +1: Visualise the energy surface better (choose different lines to plot)!

Matlab® supplement

- [X,Y] = meshgrid(x,y) replicates the grid vectors x and y to produce a full grid.
- equation= @(t,y) [y(2); y(1)];
  [1. equ of the system; 2. equ of the system]
- [t,y]=ode45(equation, $[t_o,t_{max}][X_{init},Y_{init}]$);
  there are other solvers as well, first we try this
- figure creates figure graphics objects. Figure objects are the individual windows on the screen in which the MATLAB software displays graphical output.
- plot(x,y,how…) drawing, has many options
- subplot(m,n,p) (divide the figure m*n parts, draws in the p th region)
- contour(X,Y,Z), contour(X,Y,Z,n), and contour(X,Y,Z,v) draw contour plots of Z using X and Y to determine the x- and y-axis limits.

Thank you for your attention!