Structure and Synthesis of Robot Motion
Semester 2
Tutorial 1

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1 Question 1 – System Identification

Consider the simple first-order, homogeneous linear ordinary differential equation (ODE)

$$\dot{x} + 3x = 0 \tag{1}$$

with initial condition $x(0) = 0.2$, and where the dot refers to differentiation w.r.t time.

1. Solve the ODE for a function of the form $x(t)$. This will be used as the exact solution for comparing the results of system identification.

2. Generate some sample data from $x(t)$, from $t = 0$ to $t = 1$ in steps of 0.1. Add a small amount of Gaussian noise. This is the sample data with which you will perform system identification.

3. Now use the discrete least-squares procedure mentioned in class, with **one step**, to minimise the prediction error. i.e. you want to be able to find a parameter θ allowing you to compute $x(t+1)$ from $x(t)$.

4. Repeat the procedure using a **two step** model. i.e. predict $x(t+1)$ from $x(t)$ and $x(t-1)$.

5. Comment on the differences between the one and two step models.

2 Question 2 – Discovering Dynamics Manifolds

Consider a mobile robot placed in the centre of a unit square area, so that it is constrained to the arena. It moves around for say 10,000 time steps, at each t moving a random distance $h_t \in [0, 0.01]$ in the current direction, which changes by a random amount $\Delta\theta_t \in [-\frac{\pi}{2}, \frac{\pi}{2}]$.

The robot is observed by four range sensors, situated at the corners of the unit square. At each timestep, each sensor only reports the Euclidean distance to the robot.

Simulate this scenario in MATLAB, to give the 4D output of the sensor array. Perform PCA on this data to recover the latent manifold on which the robot moves.

How do the results differ if the robot does not change direction during the course of the simulation?