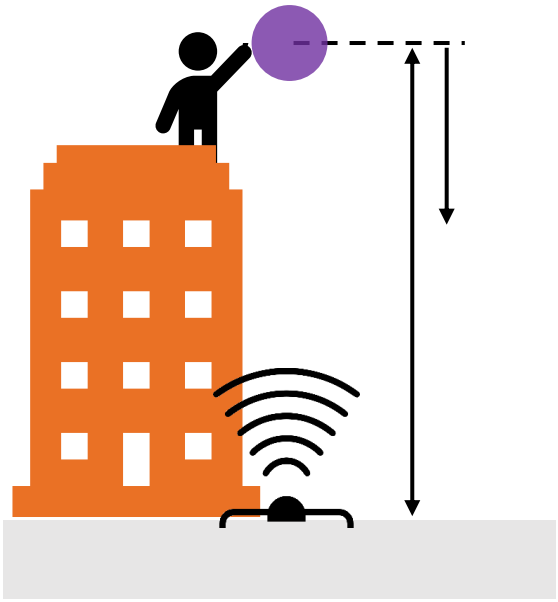
Optimal State Estimation

Practice 1. Simulation



Our goal is to develop a simulation program with MATLAB. The simulation target a dynamic state vector (altitude, speed, and acceleration) of of free-falling object and a range sensor which can measure the altitude of a free-falling object.

A discrete model of the free-falling object can be represented as follow:

$$r_{t+1} = r_t + v_t \Delta t + \frac{1}{2} a_t \Delta t^2$$

$$v_{t+1} = v_t + a_t \Delta t$$

$$a_{t+1} = a_t$$

, where r_t is an altitude (range between object and ground) at time t, v_t is the velocity of object at time t, and a_t is the acceleration of the object at time t.

The discrete state space description of this system can be written as

$$\begin{bmatrix} r \\ v \\ a \end{bmatrix}_{t+1} = \begin{bmatrix} 1 & t & \Delta t^2/2 \\ 0 & 1 & \Delta t \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} r \\ v \\ a \end{bmatrix}_t$$

We have the sampling time and initial information as below:

1) $\Delta t = 0.1$
2) gravitational acceleration ($a = g = -9.80665 m/s^2$) model
3) initial velocity $v_0 = 40 m/s$
4) initial range $r_0 = 100 m$

[Practice 1]

Please simulate the r_t, v_t, and a_t from time $t = 0$ to $t = 10$. Plot the simulation (x-axis is time and y-axes are r_t, v_t, and a_t. Submit the figure for the simulation.

[Practice 2]

Please simulate r_t^{range}, which is a range sensor simulation data for the previous simulation. The standard deviation of the sensor noise is 0.1m. Plot the simulation results and save to m file. Submit the simulation figure and m. file.

(Hint: using gaussian random variable ”normrnd” in Matlab)