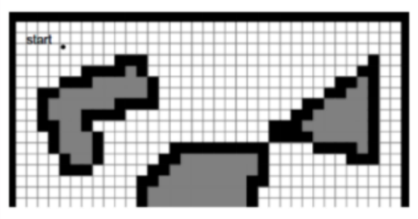
Q1: 1pt

Let us assume that the robot lives in a discrete world similar to what is depicted below. Which one of the following filters is suitable to localize the robot?

a) Monte Carlo filter, b) Kalman filter, c) Extended Kalman filter, d) Histogram filter

· Very briefly justify your answer (1-2 lines):



Q2: 1 pt

Let us suppose that our robot moves on corridors of a building where all the walls and doors look alike (like Konetalo!). This means that there are situations where the robot's belief about its location is not unimodal, in other words, it may believe that it is likely to be in different locations in the building. Which one of the following filters would you use for this problem?

a) Monte Carlo filter, b) Kalman filter, c) Extended Kalman filter, d) Histogram filter

· Very briefly justify your answer (1-2 lines):

Q3: 5 pt

Suppose a mass is falling by gravity force. The equations of motion after discretization can be written as follows.

$$v_{t+1} = v_t + T_S g - T_s b v_t + \epsilon$$

where $g = 10\ [ms^{-2}]$ is the gravity, $b = 2\ [s^{-1}]$ is the viscose friction coefficient, $\epsilon \sim N(0,0.3)$ is the modeling error, and sampling time is $T_s = 0.1[s]$. For simplicity, we have assumed unit mass, that is, $m = 1\ [kg]$. We have a camera that can measure speed v_t, according to the following model

$$z_t = v_t + \delta$$

where $\delta \sim N(0,0.5)$ is the measurement error.

Note: The following calculations are easy enough to do by a calculator. You do not need to make a code for it.

i) Use the measurement to initialize your filer. Let's assume your sensor gives $z_t = 2\ ms^{-1}$. What is initial state belief (mean and covariance)? **[1 point]**

ii) Run one step prediction after the above initialization. What is now the state belief (mean and covariance)? **[2 point]**

iii) Run update (after the above prediction). Let's assume your sensor gives $z_t = 3\ ms^{-1}$. What is now the state belief (mean and covariance)? **[2 point]**

NOTE: If you need to write equations, you can use simple text forming, such as Ts instead of T_s.

Q4: 3 pt

Suppose a mass is falling by gravity force (a similar case as Problem 3). The equations of motion after discretization can be written as follows.

$$v_{t+1} = v_t + T_s g - T_s b v_t + \epsilon$$

where $g = 10\ [ms^{-2}]$ is the gravity, and b is the viscose friction coefficient, $\epsilon \sim N(0,0.3)$ is the modeling error, and sampling time is $T_s = 0.1[s]$. For simplicity, we have assumed $m = 1\ [kg]$. We have a camera that can measure speed v_t, according to the following model

$$z_t = v_t + \delta$$

where $\delta \sim N(0,0.5)$ is the measurement error.

In this question, we assume that the viscos friction is unknown, and we model it as $\dot{b} = 0$, that is, we assume it is constant.

Note that in this problem, there is no need for numerical calculations.

i) Write down the discretized model of the viscos friction. **[1 point]**

ii) To estimate b, you can construct a filter. What is the system state vector of your filter? **[1 point]**

iii) Is the prediction model linear or non-linear? Do we need a Kalman filter or Extended Kalman filter? **[1 point]**

NOTE: If you need to write equations, you can use simple text forming, such as Ts instead of T_s.