AuE824 Homework 2   **Due: February 10 – before class**

Submission Rules: You should submit all your homework through Clemson Canvas. Your primary submission should be in a report format pdf file titled Firstname_Lastname_HW02.pdf. If coding is required, source codes must be submitted along with your primary submission in Canvas. Maximum securable points are 100.

Problem 1 (30 pts)

(1) Write the complete camera model, i.e., transformation from world frame coordinates to pixel frame coordinates. What are the meanings of all intrinsic and extrinsic parameters respectively? (10 pts)

(2) A camera is mounted in the front of a vehicle and all its intrinsic parameters are assumed to be known. Assume there is a front vehicle and its measured vehicle width and same-depth lane width in the camera's pixel frame are d and l respectively. Assume the actual lane width is L. Calculate the distance between the camera and front vehicle. (10 pts)
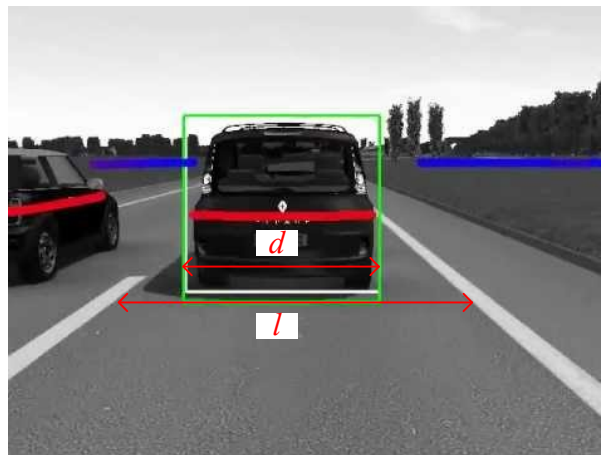
(3) Describe the process of KF, EKF and PF and their applicable conditions respectively. (10 pts)

Problem 2 (30 pts)

An inertial measurement unit (IMU) can report angular angles (roll ϕ, pitch θ, yaw ψ) using a combination of accelerometer, magnetometer and gyroscope. The accelerometer can measure roll ϕ and pitch θ with noises based on acceleration direction, the magnetometer can measure yaw ψ with noise, and the gyroscope can measure angular rates ($\dot{\phi}, \dot{\theta}, \dot{\psi}$) with noises and potential drifts. Design a multi-sensor fusion approach to fuse these three noisy sensors to calculate accurate angular angles: roll ϕ, pitch θ, yaw ψ.

(1) What sensor(s) should be used for prediction and what sensor(s) should be used for correction? What sensor fusion approach should be applied? (10 pts)

(2) Define the state to be estimate as a vector $y = [\phi, \theta, \psi]^T$, and write the prediction process in matrix form. (10 pts)

(3) Write the correction process in matrix form. (10 pts)

Problem 3 (40 pts)

Given two images of a mold: "left.jpg" and "right.jpg" from two cameras, and the coordinates (X, Y, Z) of some corners of the mold in world frame as below:
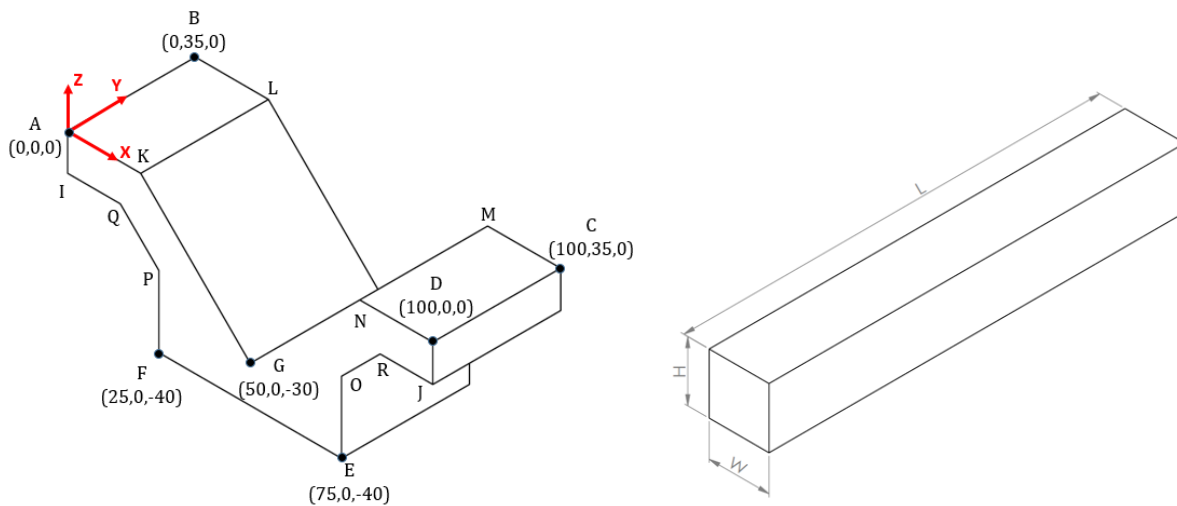
Units of the coordinates: mm

(1) Use least square approach to find the 11 parameters for the left camera. (10 pts)
(2) Use least square approach to find the 11 parameters for the right camera. (10 pts)
(3) Calculate the coordinates (X, Y, Z) of other marked corners of the mold based on the two images. (10 pts)
(4) Calculate the dimensions of the bar (length, width, height) beside the mold. (5 pts)
(5) Estimate the volume of the bottle. (5 pts)

For each question, please

     a. present your calculation/derivation process
     b. present your results
     c. submit your Matlab codes