

## AuE8240 Homework 2

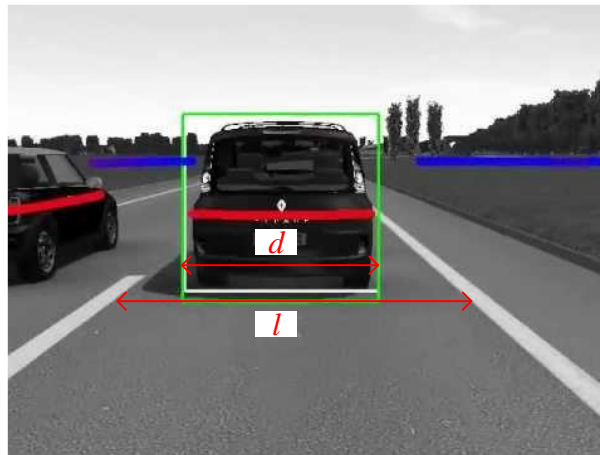
Due: February 16 – before class

**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)

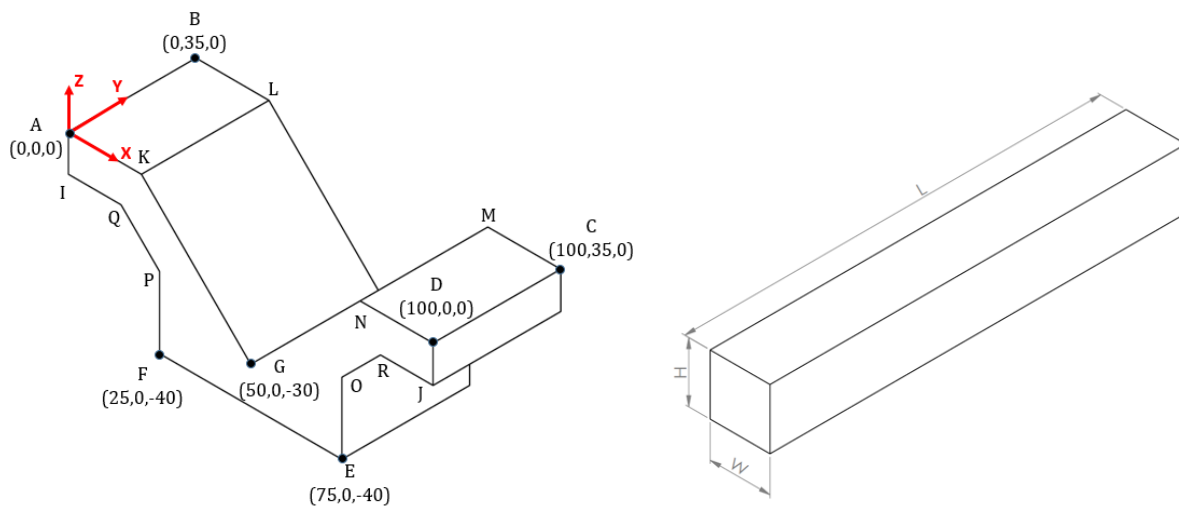
### Problem 2 (30 pts)

An inertial measurement unit (IMU) can report angular angles (roll  $\phi$ , pitch  $\theta$ , yaw  $\psi$ ) using a combination of accelerometer, magnetometer and gyroscope. The accelerometer can measure roll  $\phi$  and pitch  $\theta$  with noises based on acceleration direction, the magnetometer can measure yaw  $\psi$  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  $\phi$ , pitch  $\theta$ , yaw  $\psi$ .

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