AAE4203 Guidance and Navigation

Assignment 1

Submission deadline: 24th Oct 2024

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Question 1: (25 marks) – Time Difference 0f Arrival (TDOA) Model

TDOA is widely used in geolocating RF signals. The principle behind TDOA is based on measuring the difference in time at which a signal arrives at multiple receivers located at different points. As shown in Fig. 1, given 3 TX's position: $TX_1(0,0,1), TX_2(10,0,0), TX_3(0,10,0), TX_4(10,10,1)$, and the distance from each TX received by RX at time t is: $d_1 = \sqrt{30}m, d_2 = \sqrt{29}m, d_3 = \sqrt{89}\,m, d_4 = \sqrt{90}m$, determine the position of RX at time t.

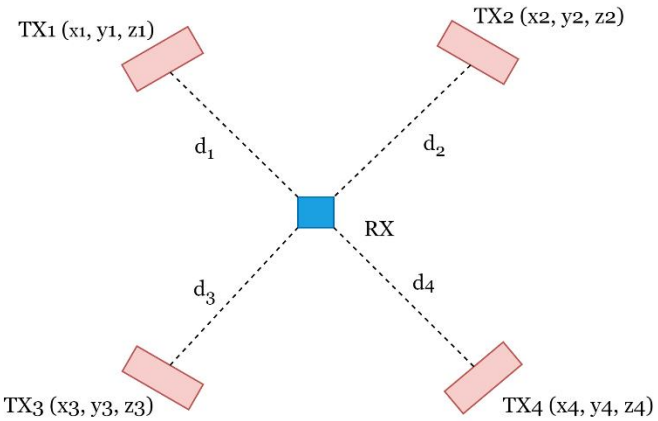

Fig.1 Illustration of TODA

Question 2: (25 marks) – Wi-Fi Positioning

(a) (5 marks) Write two methods of positioning using WIFI, and describe the principle and process of each method.

(b) (10 marks) Given the following access point (AP) position:

$$AP_1(0,0), AP_2(10,0), AP_3(5,10), AP_4(0,10)$$

and the distance from the mobile device to each AP: $d_1 = 3.0\,m, d_2 = 5.0\,m, d_3 = 7.0\,m, d_4 = 9.0m$, As shown in Fig.2, write a function using python to calculate the mobile device position. You can refer to the sample code in the GitHub repository: https://github.com/weisongwen/AAE4203-2425S1.

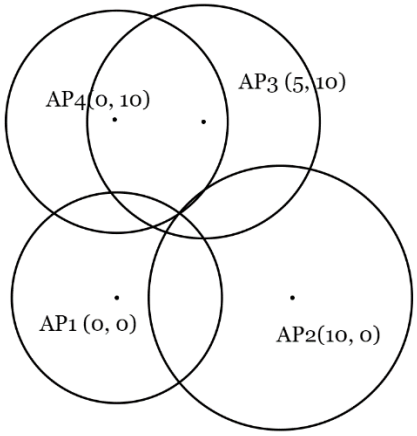

Fig.2 Wi-Fi RTT positioning

(c) (10 marks) Explain each line in the Python code.

Question 3: (25 marks) – Dead Reckoning

(a) (7 marks) What is the process of pedestrian dead reckoning using accelerometer, gyroscope, and magnetometer? What are the advantages and disadvantages of this approach?

(b) (8 marks) What is the flow of using LiDAR odometry for positioning? Briefly describe the advantages and disadvantages of LiDAR odometry.

(c) (10 marks) Given that point $\mathbf{a} = [4.0,5.0,6.0]^T$ is obtained by rotation $\mathbf{R} = \begin{bmatrix} 0.0 & -1.0 & 0.0 \\ 1.0 & 0.0 & 0.0 \\ 0.0 & 0.0 & 1.0 \end{bmatrix}$ and translation $\mathbf{t} = [1.0, 2.0,3.0]^T$ of point $\mathbf{b}$, what are the coordinates of point $\mathbf{b}$?

Question 4: (25 marks) – Linear Least Square (LLSE)

The method of Least Squares Linear Estimation minimizes the sum of the squared vertical offsets (residuals) between the observed values y_i and the values predicted by the linear model. Given a set of 2D points $p_1(1,2), p_2(2,3), p_3(3,5), p_4(4,4), p_5(5,6)$, using vertical offsets to find the best fit line.

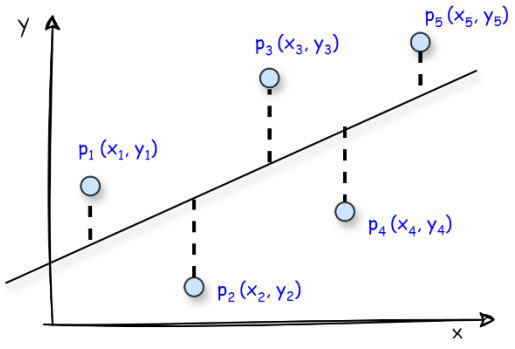

Fig.3 Vertical offset.

(a) (8 marks) Describes the process of solving a fitted linear equation using LLSE.

(b) (8 marks) Calculate the gradient of the built residual.

(c) (9 marks) Calculate the best-fit line function.