

Figure 1. Echolocation

1. In Figure 1, the tracking system (including a transmitter and a receiver) tries to measure the distance to the tracking object using the echolocation ranging technique. In particular, it transmits an ultrasound pulse signal at 15kHz towards the tracking object. Then, the echo is captured with Δt seconds delay.
 - a. Write code to calculate the distance from the tracking system to the tracking object (d) when $\Delta t = 1.7s, 2s, 5s, 10s$. Speed of sound $v_s = 343$ m/s [20pt]
 - b. Assuming the tracking system is static. When the tracking object moves towards the tracking system with a velocity of $v_o = 3m/s, 6m/s, 9m/s, 12m/s$, write the code to calculate the Doppler shift observed at the receiver. [20pt]
 - c. Assuming the electromagnetic wave at 2.4 GHz is used instead of the ultrasound wave as mentioned above. If the distance between the tracking system and tracking object is 500m, what is the delay of the round-trip signal? Speed of electromagnetic field $v_{ef} = 3 \times 10^8$ m/s. (20pt)

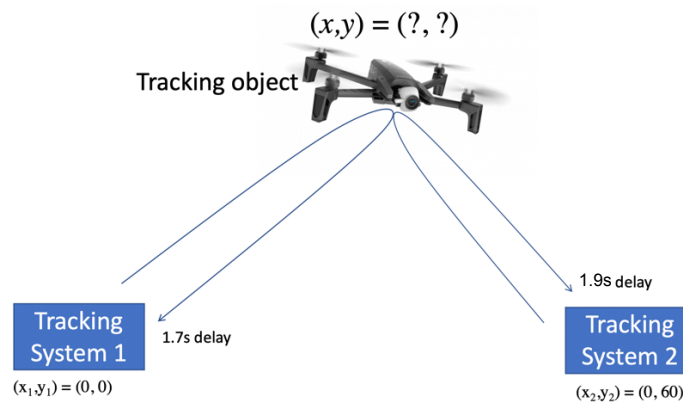


Figure 2. Localizing object using wireless signal

2. In Figure 2, tracking systems 1 and 2 transmit ultrasound signals at 15kHz and 16kHz towards tracking object, respectively. The 15kHz pulse signal arrives the receiver of tracking system 1 after 1.7s delay. Similarly, the 16kHz pulse signal arrives receiver of tracking system 2 after 1.9 s delay. Write a code to calculate the potential locations of the tracking object (x,y) assuming the location of tracking system 1 is $(x_1,y_1) = (0,0)$, and the location of tracking system 2 is $(x_2, y_2) = (0, 60m)$. Why there are multiple correct answers? [40pt]
3. **a) [Extra Credit]** Can the localization system in Figure 2 be used for localizing the tracking object in the 3D space? Why? (10pt)
4. **b) [Extra Credit]** Why do tracking system 1 and tracking system 2 transmit signals at different frequencies (i.e., 15kHz and 16kHz)? (10pt)

***Notes: You must write the code in one of the following languages: Matlab, C/C++, C#, Python**

- **Submission checklist:**

Put all the code, printed results and answers of the above questions to a single Microsoft Word file.