

COMP3516 Data Analytics for IoT

Problem Set

Due date: 23:59 pm, April 30, 2026

Total 10 points

1. Answer True/False for Questions (a)-(e), and fill in the blanks for Questions (e)-(f).
 - (a) WiFi networks suffer from severe interferences due to its dense deployment. Suppose your phone is connected to the one HKU WiFi Access Point, the network performance will NOT be interfered by nearby Access Points as long as they are on a different WiFi channel from your connected one. (0.5 pt)
 - (b) In FMCW radar sensing, the Rx chirp is basically a delayed version of the Tx chirp signal, with a delay τ . Suppose the speed of light is $c = 3 \times 10^8 m/s$. An increment of $0.01 \mu s$ in the delay τ indicates a larger distance of 0.75 meters between the radar and the target. (0.5 pt)
 - (c) Next-generation WiFi will feature larger bandwidths and massive MIMO (with many antennas). Considering a future WiFi device that uses 160MHz bandwidth and 8 antennas, its range resolution will be enhanced by 16 times compared to a current WiFi device with 40MHz bandwidth and 2 antennas. (0.5 pt)
 - (d) Statistical WiFi sensing allows us to estimate speed and breathing both by finding the first peak of the ACF. In practice, we can tell whether the first peak corresponds to speed or breathing signals by examining the absolute value of the height of the first peaks. (0.5 pt)
 - (e) When estimating 3D orientation from IMUs, we can rely more on the gyroscope and magnetometer when the device is static, while relying more on accelerometer when the device is moving. (0.5 pt)
 - (f) The FMCW mmWave radar used in our lecture can achieve centimeter-level range resolution thanks to its bandwidth of a few GHz. Considering an FMCW radar using sound signals, to achieve a range resolution of 5 cm, the required bandwidth will be _____ . (Assume the speed of sound is 343 m/s). (0.5 pt)

(g) To accurately capture the steps of a user who takes 2 steps per second on average, the minimum IMU sampling rate should be at least _____ Hz. If we perform FFT to estimate the steps and want to achieve a precision of 2 steps error per 10 seconds, we should use a window length of at least _____ seconds. Increasing this window length will improve _____ resolution but increase _____. (2 pts)

2. Harry is building a WiFi sensing system using an ESP32 as the sensing node. The ESP32 is placed on a desk in the HKU library and connects to a campus WiFi access point (AP), typically mounted on the ceiling. The ESP32 continuously pings the AP to collect Channel State Information (CSI) at a specific sampling rate. Answer the following questions to help Harry troubleshoot, optimize, and reason through his WiFi sensing setup. (1 point for each question)

- (a) Harry wants to monitor his breathing rate using the system. He plans to apply an FFT to estimate the breathing frequency. He chooses a window of 1000 CSI samples—i.e., 10 seconds at 100 Hz. However, he recalls that using more samples may lead to better frequency resolution, so he wonders if he should increase the CSI sampling rate to 1000 Hz instead. Should he stick with 100 Hz or switch to 1000 Hz? Explain your reasoning.
- (b) To reduce delay and make the system more responsive, Harry considers increasing the sampling rate from 100 Hz to 200 Hz while shortening the time window to 5 seconds (still collecting 1000 samples). Is this a good idea? Why or why not?
- (c) The HKU WiFi AP supports both 2.4 GHz and 5 GHz bands. Which band would you recommend Harry to use for his sensing application? Give **two** key reasons for your choice.
- (d) With the system properly configured, Harry begins testing in the library. However, it often fails to detect breathing—even when he sits completely still. What is the **most likely** cause of this issue?
- (e) To reduce interference with normal WiFi usage, Harry tries to eliminate the ping packets and instead extracts CSI from **regular WiFi data traffic**. However, the system performance becomes even worse. Give no more than two **most likely reasons** for this degradation.