Sword Health Trainee Program

Algorithms Engineer Screening Test

This document and its contents are confidential and thus should not be shared with anyone other than the applicant during or after the test.

Free Text Questions

Please provide your answer to the following questions in English, within a text document. Note that alongside the content, clarity and conciseness of your written communication will be taken into account.

1. **(max 150 words)** Tell us about a past project of yours where you used software (and actively wrote code) to solve a problem. Give us an overview of how you approached the problem and implemented the solution. If the project was not solo, please clarify what your role was.

2. **(max 100 words)** What are you looking for in your next job position? Describe your ideal company and work environment.

3. **(max 150 words)** Tell us about a concrete situation that led to learning and what you learnt. It may be an occasion where you felt you failed, a time where you had to face uncomfortable change or any other situation that caused you to reflect and grow.

Coding Question

When performing lower limb exercises, SWORD Health's patients have motion sensors placed on the chest, thighs and shanks as indicated in **Fig. 1**.

Figure 1 - The lower limb therapy sensor setup.

Each of these sensors provides two types of information:

- a 3D unit vector (reference vector) describing the orientation of the underlying segment - the spine for the chest sensor, the femur for the thigh sensors and the tibia for the shank sensors - in a coordinate system where the x component corresponds to Earth's North, the y component corresponds to Earth's West direction and the z component corresponds to the "up" direction
- the estimated norm of the linear acceleration in m/s^2 (0 corresponds to the sensor being at rest)

Fig. 2 illustrates the expected values of both quantities for a given movement, assuming the patient is facing North.

(a)

Sensor	Reference vector	Acc. (m/s^2)
Chest	$\simeq [0 \;\; 0 \;\; -1]$	$\simeq 0$
Right thigh	$\simeq [0 \;\; 0 \;\; -1]$	$\simeq 0$
Left thigh	$\simeq [0 \;\; sin\,30º \;\; -cos\,30º]$	> 0
Right shank	$\simeq [0 \;\; 0 \;\; -1]$	$\simeq 0$
Left shank	$\simeq [0 \;\; sin\,30º \;\; -cos\,30º]$	> 0

(b)

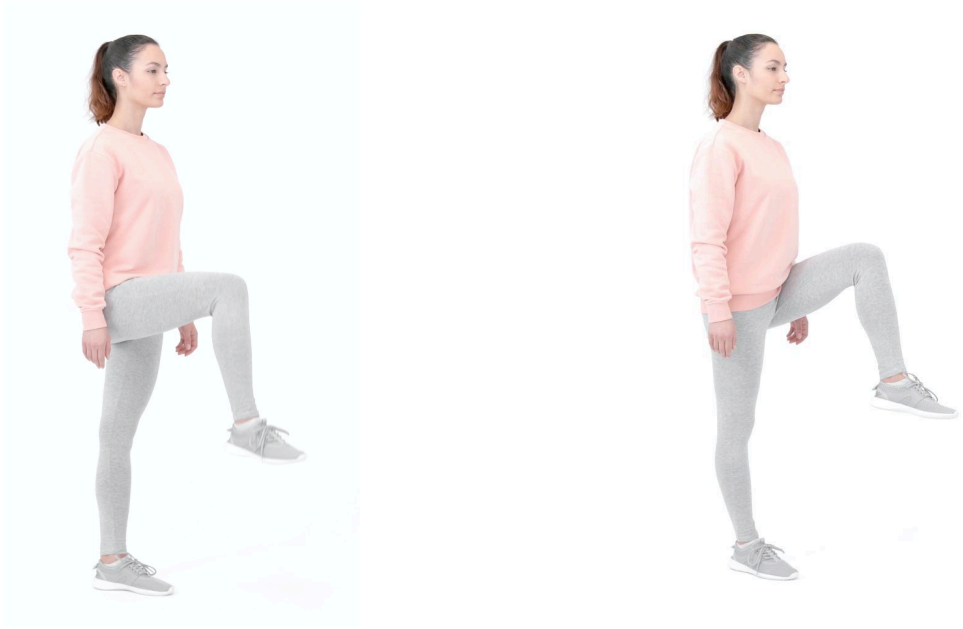
Figure 2 - Patient opening the leg to the side: illustration of the movement and the corresponding reference vectors **(a)**; expected values of the reference vectors and the linear accelerations **(b)**.

Assume you have a patient with the sensors placed as in **Fig. 1** and facing the North direction while performing a single repetition of the following movement: first lifting the right leg with the knee bent and then lifting the left leg in the exact same fashion, as illustrated in **Fig. 3,** below.

You will receive five continuous real-time streams of sensor data, i.e. for each instant in time (take 50 Hz as a possible rate) you receive one pair of reference vector and acceleration from each sensor, but you do not know on which of the five possible positions - chest, right thigh, left thigh, right shank and left shank - each sensor is placed although you do know that there is one sensor on each of these positions.

The goal of this challenge is to propose a solution capable of determining the position of each of the 5 sensors.

Attached to this test you will have a helper project in Python, which reads data from a file and passes it into an abstract class for processing, replicating the use-case of a real-time implementation and enabling you to implement and test your solution effectively.



(a) **(b)**

Figure 3 - Patient lifting the right leg **(a)** and the left leg **(b)** with the knee bent.

Implement your solution within the project while complying with the following requirements:

- Except for the *TODO* in the main file, all your code must be within a separate package (all existing code files are there to support your implementation and do not need to be changed)
- Your top class must extend `SensorPositionFinder` and must be instantiated in the mentioned *TODO*
- Each time an unknown sensor position is identified, your top class must call the `on_sensor_position_found` method of `SensorPositionRequester`
- Once all sensor positions are identified, your implementation should call the `on_finish` method of `SensorPositionRequester`

The purpose of this question is to assess your ability to put ideas in practice as much as it is to assess your Object-Oriented programming and code structuring skills, as such, you should place a similar effort in both.

You are free to create as many classes as you like as well as to use external libraries.

Briefly point out any merits and limitations of your solution, potentially including how it performs under the likely variability in the way the patients move and situations where patients do not strictly comply with the required movement. State and justify all assumptions made, either as comments/docstrings or within the text document containing the answers to the first section of this test.