Project Altair

Software and Automation Team Recruitment

Batch 21

Week - 1

General Instruction

1. You will submit one pdf file which will contain all the answers and related hyperlinks. You should rename the submission file as *ID_Name.pdf*
   Example: **`210048796_Abul Mia.pdf`**

2. You should paste the GitHub link of your code (For Coding Tasks) or circuits in the submission file and hyperlink them.
   Naming Convention of Coding Tasks: **`ID_Name_Week 1_Logical_Task 1_A.cpp`**
   All the codes of this recruitment process should be in a single GitHub repository. So create a GitHub Account if you don't have one already. For beginners, we prefer using GitHub Desktop as it is easier to use than GitHub CLI.
   How to use Github Desktop: https://youtu.be/PvUexC0-D2s
   The explanation of the codes should be in the main pdf file.

3. The tasks are divided into 3 segments.
   Theoretical, Logical, and Practical (Microcontroller).
   Each segment has been allocated 50 marks. It is not necessary that you must finish all the tasks, we would encourage you to try all the given tasks and finish as much as possible. It is about learning the process rather than completing the tasks.

4. Please make sure to submit within the deadline properly with the proper naming format. Failing to submit the weekly within the deadline without prior notification will result in silent disqualification from the recruitment process.

5. After every task document the process. We want to know how you have approached the problem and solved it. You will be asked about the tasks at your final recruitment viva. Mention what issues you faced during the tasks as well. You can add your explanation of each task below the link to your code. You can also add a screenshot or related images in the submission file for a better explanation.

6. We know that you guys love ChatGPT. However, in this process, we highly discourage Plagiarism and the use of ChatGPT or any kind of AI tools, as we are using paid AI and Plagiarism Detectors to check your scripts. They are highly capable even if you use some paraphrasing tools like Quillbot. We won't be warning you if you do so. If we find more than 20% AI writing or plagiarism, you will be disqualified from the process silently.
   We have given all the necessary links and youtube tutorials you might need and even after this if you need any assistance it's only one Google Search away. We encourage learning from the documentation and videos rather than Ctrl+C, Ctrl+V from ChatGPT.

7. If you take any direct help from any article or website please use the reference at the end of your submission file.

8. If you face any problem or you have any queries regarding the task, just leave a public comment in the Google Classroom post. So that we can answer it there as early as possible. We discourage reaching out personally to maintain the neutrality of this process.

All the best and happy learning!

Theoretical Part (50 Marks)

Task-1 (7 Marks) :

In the field of robotics and automation, the use of microcontrollers and single-board computers is abundant. From a small RC car to a huge Mars rover, there are microcontrollers of different architectures as well as SBCs.
To understand more about SBC and Microcontrollers give these a read,
Single Board Computer.
Microcontroller Basics

Imagine you have a self-driving delivery robot. The mechanical and electrical engineering has been done already. The robot has gear motors and PWM-controlled motor drivers for wheels, servo motors for steering, a rotary encoder, GPS, IMU, and a Stereo Camera.
Now it's your time to construct the brain of the robot. You have to decide on an architecture. You can choose as many microcontrollers as you want(can be zero) and/or as many SBCs as you want(can be zero)

So, what things have you decided to use? Justify your answer and give reasoning why you have chosen the option.

Task-2 (7 Marks) :

In embedded systems, different methods of communication are used. UART (Universal Asynchronous Receiver/Transmitter), SPI (Serial Peripheral Interface), and I2C (Inter-Integrated Circuit) are the most common among them. Here are some links that might be useful in learning different communication protocols: SPI-Serial Peripheral Interface, Protocols: UART, SPI, and I2C.

You are given an Arduino Mega and an Arduino Nano, they are put in a single PCB. Which protocol will you choose to establish communication between these two microcontrollers? Justify your answer and give technical reasoning for your chosen method. Also, justify why your method is better than the other protocols and which scenarios they can be used.
You can also add some code snippets of the use of different communication protocols.

Task-3 (10 Marks) :

A. Motors can be of different kinds. There are DC motors, AC motors, stepper motors, and servo motors. They have different usability and purposes.
Explain where DC motors and stepper motors are used and how we handle them differently.

B. Motor drivers are an essential part of a robotics system.
Explain how different types of motor driver chips are used for different types of motors and purposes.

C. PWM or pulse width modulation, is a type of modulation technique to obtain analog signals from digital signals. **Discuss the concept of PWM (Pulse Width Modulation) and how it is used to control motor speed**.
To give you a better understanding of the topic: Understanding Pulse Width Modulation

D. Frequently, it is essential to obtain motor feedback for better controlling the motor. **How would you implement motor feedback (e.g., using encoders) for precise rover movements?** To get you started on motor feedback: What is Encoder?

Task-4 (10 Marks) :

To answer this question, you will need some knowledge of the following microcontrollers: Arduino Mega, ESP32, and STM32. For some basic ideas on these microcontrollers:

▶ STM32 Guide #1: Your first STM32 dev board

▶ Introduction to ESP32 - Getting Started

▶ Getting Started with the Arduino Mega 2560

Choose among the 3 mentioned microcontrollers with respect to the following use cases separately, Justifying your choice.

1. **Motor Control:** A robot having multiple motors.
2. **Communication:** A transceiver for long-range communication.
3. **Real-Time Operation:** A drone flight controller.
4. **Sensor Integration:** A home automation project having relevant sensors.
5. **Power Efficiency:** A battery-operated remote sensor node deployed in a forest.

Task-5 (8 Marks) :

In a robotic system, sensors play a crucial role in providing multiple capabilities. For the localization of a robot, different sensors are used. In this regard, camera, Depth camera, IMU, LIDAR, Odometer, and Sonar are the names that frequently come up.

When humans finally land on Mars, your robot is going to be used in a Martian outdoor environment for food delivery.
In your opinion, which sensor/sensors are to be used to understand and control the movement of the robot as well as its motion planning? Justify your answer and reason why your chosen option/options are the best one to use.

Resources:
What is IMU
LIDAR Explained
Odometry
▶ wheeled robot control and odometry

Task-6 (8 Marks) :

The given link contains the rulebook of the European Rover Challenge competition's rulebook (remote edition). Briefly describe in your own words, how the maintenance task has to be carried out, including the end goals, and any limitations.

https://drive.google.com/drive/folders/1riF3epdDdEECZQXffx1hBp-GKXPlb49U

Files to be used:
ERC_2023_Remote_edition_Rules_v1.1
ERC_2023_Remote_maintenance

Logical Part (50 Marks)

Task - 1 (35 Marks)

Help Spirit!

Imagine the planet Mars, a captivating world with a network of interconnected paths and tunnels, forming a mesmerizing bi-directional graph. Its surface is adorned with diverse landscapes, from deep valleys and majestic canyons to ancient rock formations.
In this intriguing environment, a remarkable rover named "Spirit" embarks on an extraordinary exploration mission. Mission control has identified specific points of interest on the Martian surface – the source and destination. These points are believed to harbor secrets about the planet's past and potential signs of life, captivating the attention of space enthusiasts across the galaxies.
Guided by its sophisticated AI algorithms, Spirit meticulously analyzes the graph's structure. It skillfully navigates through junctions, always mindful to avoid loops that could lead it astray.
Spirit's expedition becomes a source of inspiration for those back on Earth, igniting humanity's passion for space exploration once again. Each transmission of data from the rover leaves scientists and space enthusiasts on the edge of their seats, eager to witness the next revelation.

In this momentous journey, Spirit's Navigation duty has been bestowed on your hands.

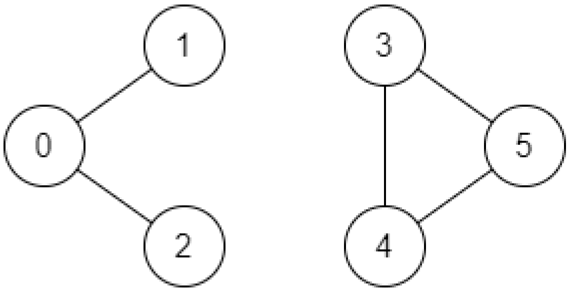
a. **There are exactly 7 locations that 'Spirit' is planning on visiting[vertices]. You are given a two-dimensional matrix on which location is directly connected to another location [Edges].**
   You have to write a code to determine if there is a valid path that exists to visit all 7 locations. The Function should return a boolean 'true' if a path exists or 'false' if it does not.

   Dataset for your code:

```
Vertices = 7
Edges = [[0, 1], [1, 2], [2, 0], [3, 4], [4, 5], [5, 6], [6, 3]]
```

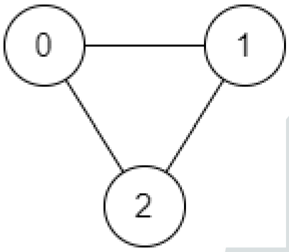
Example:

1.



```
n = 6, edges = [[0,1],[0,2],[3,5],[5,4],[4,3]]
      Output: false
```

2.



```
n = 3, edges = [[0,1],[1,2],[2,0]]
      Output: true
```

b. **Attach an illustration (can be digital or hand-drawn on paper) of the Bi-Directional Graph from the provided array:**

```
edges = [[0, 1], [1, 2], [2, 0], [3, 4], [4, 5], [5, 3], [6, 7],
[7, 8], [8, 6]]
```

Task - 2 (15 Marks) :

In Mars Rover, the Shortest Path Algorithms are used in many cases like Obstacle Avoidance, Terrain Analysis, Path Planning, Energy Optimization, Communication Planning, etc. Some of the widely used shortest-path Algorithms are

1. Dijkstra Algorithm
2. Bellman Ford Algorithm
3. Floyd Warshall Algorithm
4. A* (A Star) Algorithm

Give a brief overview of each algorithm stating their specific use cases (which is better in which use case), advantages, and disadvantages, and sample code snippets.

Resources for the Logical Part:

[Graph Data Structure]
[Dijkstra Algorithm]
[Bellman Ford Algorithm]
[Floyd Warshall Algorithm]
[A* Algorithm]

- Introduction to Graph Theory: A Computer Science Perspective
- Dijkstra's Algorithm - Computerphile
- A* (A Star) Search Algorithm - Computerphile
- Bellman Ford Algorithm | Shortest path & Negative cycles | Graph Theory
- Floyd Warshall All Pairs Shortest Path Algorithm | Graph Theory | Dynamic Programming

Microcontroller Part (50 Marks)

Instructions:

1. As it is a little bit problematic for all of you to arrange microcontroller boards, you will be performing these tasks in Tinkercad.
   An overview of how to navigate TinkerCAD - Using Tinkercad
   You can follow this playlist also:
   Blink an LED With Arduino in Tinkercad
2. You will submit a doc file or pdf. In this file paste the links of your circuits. Please don't forget to change the visibility of the circuit to "share link". (You will find this option if you scroll down a little)
3. Rename your circuits as ID_Name_Task_No. Example: 20021568_Abul Mia_Task_01
   After pasting the links of your circuits please write a short description of how you solved the task and what problems you faced while solving it.
4. Don't try to copy and paste the codes. Write your own codes and they don't have to be 100% perfect.

Task-1 (25 Marks) :

Communication between two microcontrollers

Send a message from one Arduino Uno to another Arduino Uno board using UART, SPI, or I2C communication and print the message on the serial monitor.

You can follow this tutorial to understand the communication between two microcontrollers and how to program them.
https://www.instructables.com/I2C-between-Arduino
I2C Part-1 Using two Arduinos
Also, you can take help from the Official Arduino documentation. Built-in examples

Task-2 (25 Marks) :

Controlling a motor with Arduino

Control a DC motor using an Arduino Uno and an encoder and print the speed in rpm on the serial monitor.

Here is an example of How to Control a DC Motor with an Encoder.
Instead of copying and pasting the code try to understand what is being done and how it is being done.
Here is another example of a DC Motor with an Encoder.

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End