Assignment 4. Dependable multi-robotic systems. Safety case.

To obtain P only Task 1 (a and b subtasks) should be solved
To obtain P+ only Task 2 (a and b subtasks) should be solved

Task 1. Safe multi-robotic system (without optimization)

(a)
We continue to work with our smart warehouse system. Our focus in this assignment is to understand how centralized control and safety monitoring interact with local control and safety monitoring and how the system adapt to various deviations. You can abstract away from considering different failures and their causes and focus on mission level: what should be done by which system component and how deviations and potential safety hazards are resolved.

You can re-use the grid from Assignment 3 Task 3 or make another grid if you would like to. You should consider at least one robot per group member (four-person group – four robots, five-person group – five robots etc.). I would not recommend considering too many robots either because it would be hard to test and demonstrate the algorithm.

Define a (fragment of a) mission of WMS. I am leaving it up to you to decide on the exact parameters. An example of a mission definition would be "bring a box from conveyor belt to shelf x position y, bring a box from a shelf w position v to conveyer belt, bring a box from shelf a place b to shelf c place d etc. "

Define executing the mission as the top-level goal and perform goal decomposition. As a result of goal decomposition each task in the mission – bringing a box from one place to another -- is allocated to some robot. We assume that there is a sufficient amount of idle robots to perform the mission. Draw a simple mission decomposition tree to show the result.

In this task, WMS creates a mission execution plan by defining a path for each robot. It picks up a robot that has sufficient battery charge to perform each task. We assume that manipulation of an arm consumes a negligible amount of battery power, so we omit considering this and focus only on motion-related consumption. A move from one position to another in the grid takes 1 unit of power charge, so the length of the path equals to the required amount of energy.

WMS defines the paths for the robot using Dijkstra's algorithm (reused from Assignment 3). It does not try to minimize possible intersections. Robot's paths can intersect, so some robots should execute collision avoidance maneuvers while executing their tasks. As a result of this, they can end up in positions that are outside of the initially defined plan and signal the new position to WMS. WMS needs to recalculate the path after this.

We also assume that some robots might overconsume an energy and should signal WMS that they needs to be charged. WMS should calculate a path for the robot to reach a vacant charging station.

Communication between WMS and the robots should be kept very simple. All messages are being delivered and communication is reliable and delay-free.

Please include the goal-decomposition tree and pseudocode of WMS systems in the report. The presentation is demonstration of the program, i.e., showing how the mission is getting executed.

(b)

Create a safety case (was explained in Lecture 9) for your system. Include the safety case done in Goal-Structuring Notation in your report.

Task 2. Safe and efficient (with optimization) multi-robotic system.

(a)

We continue to work with our smart warehouse system. Our focus in this assignment is to understand how centralized control and safety monitoring interact with local control and safety monitoring and how the system adapts to various deviations. You can abstract away from considering different failures and their causes and focus on mission level: what should be done by which system component and how deviations and potential safety hazards are resolved.

You can re-use the grid from Assignment 3 Task 3 or make another grid if you would like to. You should consider at least one robot per group member (four-person group – four robots, five-person group – five robots etc.). I would not recommend considering too many robots either because it would be hard to test and demonstrate the algorithm.

Define a (fragment of a) mission of WMS. I am leaving it up to you to decide on the exact parameters. An example of a mission definition would be "bring a box from conveyor belt to shelf *x* position *y*, bring a box from a shelf *w* position *v* to conveyer belt, bring a box from shelf *a* place *b* to shelf *c* place *d* etc. "

Define executing the mission as the top-level goal and perform goal decomposition. As a result of goal decomposition each task in the mission – bringing a box from one place to another -- is allocated to some robot. We assume that there is a sufficient amount of idle robots to perform the mission. Draw a simple mission decomposition tree to show the result.

In this task, WMS creates a mission execution plan by defining a path for each robot. It picks up a robot that has sufficient battery charge to perform each task. We assume that manipulation of an arm consumes a negligible amount of battery power, so we omit considering this and focus only on motion-related consumption. A move from one position to another in the grid takes 1 unit of power charge, so the length of the path equal to the required amount of energy.

WMS defines the paths for the robot using ICA algorithm (Lecture 8). It tries to minimize possible intersections and overall traveled paths for all robots. Nevertheless, robot's paths can intersect, so some robots should execute collision avoidance maneuvers while executing their tasks. As a result of this, they can end up in positions that are outside of the initially defined plan. WMS needs to recalculate the paths of all robots after this to maintain efficiency. Implement a safety monitor that can detect it, analyse the current positions with respect to safety and decide either invoke path planner to find safer and more efficient path. Be ready to demonstrate the paths and reaction on deviations

Communication between WMS and the robot should be kept very simple. All messages are getting delivered and communication is reliable and delay-free.

Please include the goal-decomposition tree and pseudocode of WMS systems in the report. The presentation is demonstration of the program, i.e., showing how the mission is getting executed as well as possible deviations.

Recommendations: reuse the shortest path algorithm from Assignment 1 to define the paths between all points on the grid. It allows you to have only one deterministic plan from one point to another for all the locations.
Think about the idea of representing the entire path by just one point. Since you have defined the shortest paths between all the locations, one point defines the entire path for a robot. This is this robot's path of the chromosome. Hence, when we are generating the populations we are generating the new sets of middlepoints.
You can simplify some selection strategies since we are not really analyzing the performance of the algorithm.

(b)
Create a safety case (explained in Lecture 9) for your system. Include the safety case done in Goal-Structuring Notation in your report.