University of Genoa

Flexible Automation
Code: 66044

Academic Year: 2021/22

Assignment: Virtual Prototyping of a Robotics Work Cell with CoppeliaSim

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Topic 5: Simulation

Out: November 22, 2021

Due: December 13, 2021 [23:59 CET]

Total Score: 25

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Problem Statement

A car engine parts manufacturer approaches you seeking a robotic automated solution for one of their problem in their loading and unloading station. The station receives three parts of the engine. The job of the station is to segregate the products and load it to the appropriate loading line. Your task is to design a flexible manufacturing cell (FMC) with robot centered layout for the above function. The design should handle the requirements below.

1. Ability to supply multiple vendors at the same time
2. Fully automated solution from product in to out
3. Flexible in terms of volume and mix product handling
4. Zero-defect product

Your solution must also take into account the practicalities like accessibility of robots and tools for maintenance, repair, and cleaning. Safety features like enclosures and a separate control station. Following the successful design and implementation of the simulation, you must also provide two reports: one including the technical implementation details and assumptions made in developing the simulation, and the other for the client to prove that your solution works and convince them it is a good idea to implement your solution.

The solution can be implemented in four parts: Plant layout simulation, robot simulation, analysis and optimization of the cell, and report generation.

Part 1: Plant Layout Design and Simulation [3 pts]

1. Import the parts model provided as mesh (obj files in the link section Page 3)
2. Based on the size of the parts, setup the conveyors (4 in total, 1 in and 3 out)
3. Setup the floor shop like adding enclosures, modifying the visual aspects.
4. Program the motion of the conveyor.
5. Program the in conveyor to spawn one of the three parts in random (consecutive spawning of the same part is allowed too for a maximum of 2 iterations)

Part 2: Robot Simulation [15 pts]

1. Based on your requirement of workspace from your previous setup, select a type of mechansim and formulate its DH/MDH parameters. (more workspace is better)
2. From your MDH parameters, draw the schematic representation.
3. Model necessary files in any CAD software of your choice and export it as OBJ [Or download from external resources in web]
4. Using OOPs strategy, assemble your mechanism in CoppeliaSim.
5. Choose an appropriate gripper for all three parts [Implement tool change if you prefer]

6. Implement the inverse kinematics using the built in simIk API
7. Implement Pick and place logic using trajectory planning. [Feel free to reuse the materials provided in the class material]
8. Extend the logic above to pick the part an place it in the right conveyor

Part 3: Analysis and Optimization of the cell

From part 1 and 2, you should have a robot picking and placing the parts in their corresponding conveyor line. Now you have to analysis and optimize your cell such that all the requirements mentioned in the problem statement is validated. Feel free to make any choice but each and every choice must be detailed and justified. Few hints for each requirement:

1. Ability to supply multiple vendors at the same time [1 pt]:
    - Ensure that the all three output conveyors have the same number of products
    - Adjust the speed of the conveyors and the routes to the delivery end
2. Fully automated solution [1 pt]:
    - Ensure that there is no presence of human mannequin models in the enclosed area.
    - Add enclosures to indicate no human passing area.
3. Flexible in terms of volume and mix product handling [1 pt]:
    - If the rate of number of items increase, how it will affect your solution and how will you manage it
    - If the parts are changes, how your solution will be able to adapt especially grasping the new product.
4. Zero-defect product [1 pt]:
    - Using sensors make sure at the each conveyor out end that there are no wrong items.

These are only few hints, feel free to add any functionalities to meet the requirements.

Part 4: Report Generation

Now that you have made a virtual prototype of your solution, its time to communicate the concepts of your solution. This will happen by preparing two different documents:

Technical report [2 pts]

This report must include detailed description of your solution. Explain each part in detail with necessary images. Part 1: Include the conveyor program logic and how you added the obj to the scene. Part 2: Explain your choice of mechanism, include the schematic diagram of your mechanism. Explain your logic of pick and place. Part 3: This is the most important part to report, for each requirement explain in detail why the choices were made and how it improved your solution. Include graphs and other necessary materials to prove your point.

Client report [1 pt]

This is a one page report providing the stats and non technical information to convince the client that your solution meets the requirement. Nothing simulation related. Include information about the cost of robot and time taken to adapt the system. Just positives about your solution and why it should be implemented in their loading and unloading station.

Links

Model of the engine parts:
https://unigeit.sharepoint.com/:f:/r/sites/FLEXIBLEAUTOMATION2021/Documenti%20condivisi/ModelForSimulationAssignment?csf=1&web=1&e=B9YCQ1

General Information

Evaluation

Total	25
Part 1	3
Part 2	15
Part 3	4
Part 4	3

Note:

- If you cannot make your own mechanism, you can use any available model in CoppeliaSim at a penalty of **5** from your total.
- If threaded scripts are used for inverse kinematics and trajectory planning, **10** points will be detected
- **Thus for part 2, if you use an existing model and threaded script, you will lose the entire 15 allocated for it**
- The reports must be written in latex. If other software is used, **1** points will be reduced.
- **For each day delay after 13 December 2021 23:59 CET, 1 point will be reduced**
- If github commits are not made reguarly i.e., if there is less than 5 commits, **6** points will be reduced from your total. The commit should reflect on your .ttt file.

Submission Procedure

- Create a folder inside the 'SimulationAssignmentRepo'folder in the sharepoint shared with you for flexible automation. Naming convention: MatricolaWithoutS_LastName, eg: 4287186_Ikbal
- In the repository created, upload the following:
  1. Scene file (MatricolaWithoutS_LastName_Solution.ttt)
  2. Video file (MatricolaWithoutS_LastName_DemoVideo.mp4)
  3. Technical report (MatricolaWithoutS_LastName_TechnicalReport.pdf)
  4. Client report (MatricolaWithoutS_LastName_ClientReport.pdf)
  5. Txt file with the github repo link (MatricolaWithoutS_LastName_gitlink.pdf)

Github Repository

- Before beginning to work on the scene, create a public Github repository for this assignment.[Name it as you like, preferably a professional one which you can add to your portfolio]

- Clone the repo locally and add a empty scene file with the proper naming convention mentioned in the submission procedure
- Commit regularly at your will and push it regularly
- I recommend you to commit every sub task you achieved.
- Finally, update the readme.md file with necessary information to use your file.
- Before your submit, make sure you can clone your repo again and run the file

Additional Information

- No time extension will be awarded, for each day 1 point will be reduced. [Each day ends at 23:59 CET, a minute late will be considered as a day late so submit well in advance]
- This 25 point total will be added to your final FA score of 100. As a result, if you lose 1 point on this assignment, you will also lose 1 point on your final score.
- Apart for the above mentioned rules, few students will be randomly selected to attend the oral exam for this particular assignment.