Date: Wednesday, 21 February 2024, 12:50 AM

ITMLA3-11 Assessments (2024)

Project

1. Project

Faculty:	Information Technology
Module Code:	ITMLA3-11
Module Name:	Machine Learning for Robotics Applications
Content Writer:	Mr Mohale Molefe
Internal Moderation:	Community of Practice
Copy Editor:	Mr Kyle Keens
Total Marks:	100
Submission Week:	Week 6

This module is presented on NQF level 7.

5% will be deducted from the student's assignment mark for each calendar day the assignment is submitted late, up to a maximum of three calendar days. The penalty will be based on the official campus submission date.

Assignments submitted later than three calendar days after the deadline or not submitted will get 0%. [1]

This is an individual project

This project contributes 40% towards the final mark.

[1] Under no circumstances will assignments be accepted for marking after the assignments of other students have been marked and returned to the students.

2. Instructions to Students

1. Please ensure that your answer file (where applicable) is named as follows before submission: **Module Code – Assessment Type – Campus Name – Student Number.**
2. Remember to keep a copy of all submitted assignments.
3. All work must be typed.
4. Please note that you will be evaluated on your writing skills in all your assignments.
5. All work must be submitted through Turnitin. The full originality report will be automatically generated and available for the lecturer to assess. Negative marking will be applied if you are found guilty of plagiarism, poor writing skills, or if you have applied incorrect or insufficient referencing. (See the "instructions to students" book activity before this activity where the application of negative marking is explained.)
6. You are not allowed to offer your work for sale or to purchase the work of other students. This includes the use of professional assignment writers and websites, such as Essay Box. You are also not allowed to make use of artificial intelligence tools, such as ChatGPT, to create content and submit it as your own work. If this should happen, Eduvos reserves the right not to accept future submissions from you.

3. Section A

Section A

3.1. Question 1

Question 1	20 Marks

Depicted in Figure 1 is a SCARA manipulator, two conveyors, a concrete block specimen and two industrial disposal bins in a manufacturing warehouse. Installed at the head bearing plate of conveyor A are infrared sensors that detect the presence of the specimen and send a signal to the manipulator. The end-effecter of the manipulator has a gripper arm that picks and drops the detected specimen from conveyor A to conveyor B, respectively for further processing. The manipulator has a reference frame at its base {0}, three reference frames at its joints {1},{2},{3} and one reference frame at its end-affecter {4}. The specimen has its reference frame located at its center {5}.

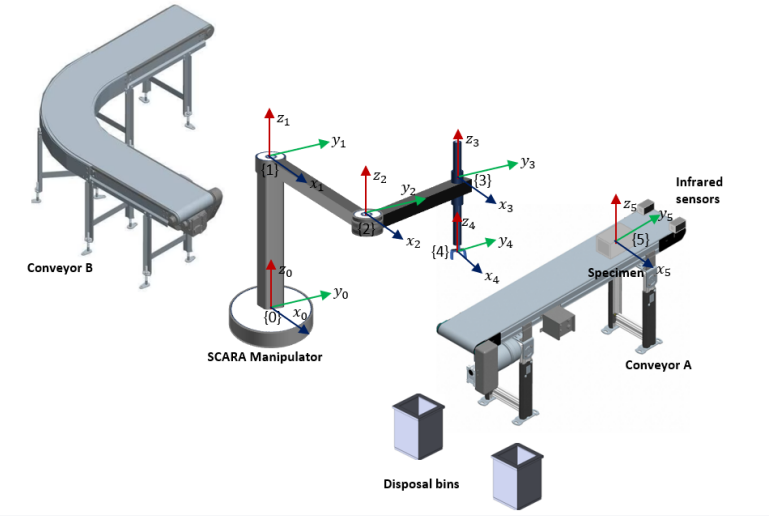

Figure 1: SCARA Manipulator

1.1 Explain the difference between position and orientation in the context of the system shown above and provide an example of how each contributes to the robot's movements and tasks.

(6 marks)

1.2 Describe two different methods commonly used to represent position in robotic systems and discuss the advantages and disadvantages of each method in the context of the given robotic scenario.

(7 marks)

1.3 Compare and contrast two different methods commonly used to present orientation in robotics, specify which method you would choose for controlling the gripper arm end-affecter orientation during specimen manipulation above, and explain your reasoning.

(7 marks)

End of Question 1

3.2. Question 2

Question 2	**20 Marks**

Consider the labelled diagram of the SCARA manipulator shown in Figure 2.

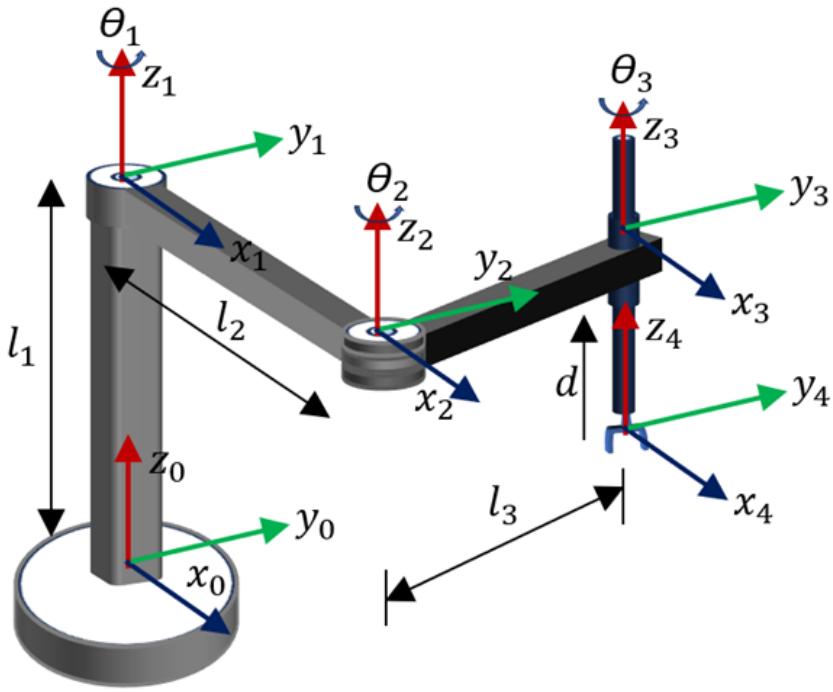

Figure 2: Labelled SCARA Manipulator

2.1 Demonstrate how you would calculate the Homogenous Transformation Matrix (HTM) representing the position and orientation of the manipulator base frame to the end-affecter frame.

(15 marks)

2.2 Given that the specimen lies on the point p (k,l,-m) from the manipulator end-affecter, compute the mathematical expression of its position with respect to the base frame.

(5 marks)

End of Question 2

3.3. Question 3

Question 3 — 30 Marks

The manual separation of defectless concrete blocks from defective ones has proved to be costly, time-consuming and less efficient as some of the defective blocks are mistakenly identified as defectless. To address the above-mentioned concerns, the SCARA manipulator is now required to pick and drop only the defectless concrete blocks while the defective ones are disposed of into the industrial bin. This new requirement means the use of infrared sensors is no longer effective. As a result, the sensor is replaced with a vision-based, RGB camera system that is supposed to send a signal to the manipulator only when it captures defectless concrete blocks.

Using the provided dataset, you are tasked to design a model that will allow the camera to achieve the required task, by classifying concrete blocks into defective or defectless classes. The model can be designed using image processing and machine learning algorithms from sklearn library or any other python libraries you are comfortable with. In a form of a system diagram, explain the steps you would follow in designing the model. Explain and justify which image enhancement, feature extraction and classification algorithms you would use. Explain how you would select optimal parameters of your chosen classification algorithm. Provide the model metrices achieved by your trained model and explain how you would use it to classify unseen concrete block images.

Hint: Your design should include the following functions or more.

a. *def image_enhancement*.

b. *def feature_extraction*

c. *def feature_normalisation*.

d. *def train_test_split*

e. *def classifier_training*

f. *def classifier_testing*

(30 Marks)

End of Question 3

3.4. Question 4

Question 4	30 Marks

A mobile robot equipped with an RGB camera and limited resources is now tasked to autonomously navigate through the cluttered warehouse environment, pick up the disposal bin and navigate it to the waste management site outside of the warehouse. As depicted in Figure 1 of question 1, the warehouse floor has various obstacles such as conveyor systems. Additionally, the floor outside of the warehouse is uneven and the environmental conditions can vary at anytime of the day.

4.1 Considering the environments that the mobile robot is subjected to, how would you use image segmentation to assist the robot in achieving the required task?

(2 marks)

4.2 Describe two specific features the robot can extract from the segmented image and how they can be used for navigation.

(4 marks)

4.3 Considering the robot limitations, compare and contrast two suitable image segmentation algorithms and explain which one you would use for this application. Justify your choice based on factors such as accuracy, computational complexity, and robustness to illumination changes.

(6 marks)

4.4 Write a python-pseudo code detailing how you would apply the chosen image segmentation algorithm for the above application.

(14 marks)

4.5 Name and explain two factors you would use to evaluate the robustness of your chosen image segmentation technique.

(4 marks)

End of Question 4