MTRN4230 Robotics Assignment 2 (Group) Description - version 2, edits in red

Asst2 requires you to work in your lab groups (up to 12 students) to implement a solution for a robot design task as well as developing a prototype using the IRB-120 arm. It is worth 30 course-marks in total.

Aims

The following assessment aims are derived from course learning outcomes 1, 3, 4 and 5

1.2. Simulation software
  1.2.1. RobotStudio / RVC Tools
3.1. Understanding of safety principles for industrial robot use.
  3.1.2. Explain how appropriate standards could be applied in a designed system
  3.1.3. Assess the level of risk in a robot system
4.3. Implement image processing techniques to solve basic/more advanced image processing tasks
  4.3.1. Demonstrate ability to break a complex problem down into subcomponents
  4.3.2. Demonstrate ability to combine one or more basic or advanced techniques to solve an unknown problem
5.1. Professional management of self and others in an engineering group project setting
  5.1.2.Team evaluation against management criteria
5.2. Participate in the engineering of a complex system
  5.2.1.Team evaluation with participation criteria
  5.2.2.Demonstration of complex system performance

Project scenario

Cake and Cookies Enterprise (CAKE) has hired your company to provide a conceptual design for a cake decorating shop. The shop will be fully automated with at least one cake decorating robot and one customer service robot. The general public is expected to interact with the customer service robot. You may assume undecorated cakes are delivered to the shop in preparation for decoration - i.e. baking is not within the scope. Otherwise, the scale of the shop is up to you. Your team is required to provide a design report and presentation of the conceptual design for the cake decorating shop, as well as demonstrate the feasibility of key features of the cake decorating robot using the IRB-120.

There are two required activities for cake decoration: placing chocolate blocks and tracing out edible ink text. The customer will place a cake design drawing under the table camera. The extent of the drawing will fit within the work area defined by the 9x9 square grid currently in the cell. For the first task, the drawing will have block locations with markings which match the location and type of block to be placed. Use the Qwirkle blocks in the lab to represent chocolate blocks. These blocks will be fed into the cell via the conveyor in a random order. Unused blocks should be placed on the table clear of the main work area.
There will also be some text the robot will need to trace out, formed of alphanumeric characters only (0-9, A-Z). The font of the text will be at least 50mm high. The speed to trace the text will be indicated by the width of the text lines, the normal line width indicating a speed of 50mm/s and bold lines indicating a speed of 100mm/s. Examples of the fonts are available on Moodle.

Teams with less than 12 enrolled students will be able to complete a proportion of the tasks by negotiation with their demonstrator.

Suggested team member roles:

These roles are for a guide to splitting the workload only and are not assessed independently.

1) Project manager:

It is the project manager's responsibility to set deliverables for each week to make sure the team is on track to complete the project on time. At the end of the project, the project manager needs to deliver a report on project management activities as well as collate the team's reflection on team performance.
NOTE: different roles require different skills and workloads, so it is the responsibility of the project manager to allocate and manage these effectively.

For the cake decorating shop design:

2) Robot engineer:

- Design the layout of the shop.
- Select the appropriate robots, end effector, camera.
- Perform cost-benefit analysis.

3) Robot simulation designer:

- Create a mockup of the whole cake decorating shop (RobotStudio is recommended).
- Create an animation of the cake decorating shop operation. This animation should include all steps from retrieving the pre-baked cake from storage to dispensing it to a customer.

4) Safety engineer:

- Perform a risk assessment of the designed system.
- Manage all risks to provide confidence to CAKE that it will operate safely.

5) Sales and marketing:

- Design, prepare and pitch the conceptual design to the client. The format of this is open-ended (video / website / pitch deck / ...).

For the proof of concept demonstration:

6) Test and Integration Engineer:

- Plan and document all the testing procedures.

7) Computer vision engineer (Ink Printing):

- Detect and plan the trajectory for the end effector to simulate printing with edible ink.

8) Computer vision engineer (Decoration):

- Detect Qwirkle blocks are they are supplied using the conveyor and detect the customer's desired decorating pattern from the camera view.

9) Programmer (GUI and Network):

- Provide a simple user interface for the user to start/stop and pause/resume the robot operations as well as show the status of the robot and task completion status.
- Provide Matlab networking capability to relay plans from the result of image processing to the robot via Ethernet.

10) Robot Programmer (Ink Printing):

- Program the robot to follow the path marking the outline of the customer's desired text.

11) Robot Programmer (Decoration):

- Pick and place the correct cake decorations as specified. Decorations in the form of Qwirkle blocks will be fed from the conveyor.

12) Robot programmer (Peripherals and safety):

- Control conveyor and vacuum pump, make sure the robot handles any error cases.

Assessed Tasks

Group Portfolio + Presentation (50 points)

The report and any presentation materials and code are to be submitted together as one portfolio by the end of week 12.

Your conceptual design will be pitched to CAKE executives in a 15 minute slot during your lab time in week 13, using the projector in J18-212.

Management + Communication (20 points)

- (2 points) Team structure and team reflection (report)
- (5 points) Evidence of project management practices (Asana / Trello / …), weekly meeting minutes including tracking of overall progress against the tasks, evidence of the use of code repositories (report)
- (3 points) Work breakdown structure for the completion of this assignment (report) (this doesn't mean the work breakdown structure if you actually had to build this designed system)
- (10 points) Pitch for the conceptual design (15 minute presentation + report)

Proposed Cake Decorating Shop Design (30 points)

- (5 points) Conceptual design of the shop, giving justification for the design decisions made (presentation + report)
    - Robot selection
    - The layout of the shop
    - Customer impression
    - Usability of the shop
    - Justification of the design decision compared to other alternatives.
- (5 points) Cost-benefit analysis (presentation + report)
    - Estimate the cost of the robotic systems.
    - Estimate the cost of other required components.
    - Estimate the operational and maintenance cost.
- (10 points) Animation of the 3D simulation (presentation)
    - Showing the layout of the shop, robots, sensors, safety system, etc.
    - Simulating a robot drawing a custom ink pattern, input by an image as per the real IRB-120.
    - Showing a robot pick and placing chocolate blocks onto the cake, input by an image as per the real IRB-120.
    - Show how the customers will interact with the robots in the shop from ordering to passing the cake to the customer.
- (5 points) Assess the level of risk in the proposed robot system (note Australian standards give a list of failure modes) (report)
    - Perform risk assessment according to the relevant standards.
    - Identify all the major risks in the design scenario.
    - Assess the risk rating of each identified risk.
    - Propose risk controls that can be used to mitigate the identified risks.
- (5 points) Explain how appropriate standards could be applied in a designed system (presentation + report).
    - Explain the key sections and requirements in AS4024.3302 and AS4024.3303 that are applicable to the design scenario and explain how those requirements are met in your design.
    - Provide a summary of the different cooperative robot operation modes specified in AS 4024.3303, select the most suitable mode for both the cake decorating robot and customer service robot and provide justification for your choice.

    - Identify other relevant standards (apart from AS4024.3301, AS4024.3302, AS4024.3303), regulations and laws that are applicable to the design scenario.

Group Demo (70 points)

Also during your lab time in week 13, demonstrate your cake decorating robot system operating on the IRB-120. Some elements of this demonstration will be included in the portfolio described above.

- (10 points) Testing plan and demonstration of a fully working system. (report + demo)
    - The demonstrator will follow the testing plan for the demonstration which you will provide in the report. The demonstrator will give marks for each requirement demonstrated to their satisfaction. The plan should include steps for each requirement, setup procedure, goal and pass or fail criteria.
- (10 points) Implement image processing to detect the text and generate a trajectory to trace the text (report + demo). Note that the characters in the text do not specifically need to be recognised, however each character needs to be traced as if the end effector was dispensing icing.
- (10 points) Implement image processing to detect blocks on the conveyor and specify target locations on the table (report + demo)
- (10 points) Implement code to turn the text-based trajectory into robot motion (demo)
- (10 points) Implement code to pick and place cake decorations (Qwirkle blocks) from the conveyor to the corresponding points on the table (demo)
- The tasks above will be assessed based on the demonstrator placing a piece of paper under the camera on the table which contains the text and block pattern which will lie within the square 9x9 grid. The performance of the system will be assessed based on:
    - Accuracy
    - Reliability
    - Repeatability
    - Degree of manual intervention required (ideally the system should operate as autonomously as possible)
- (5 points) GUI design and implementation (demo)
    - Used by the customer to place the order, as simple to use as possible while demonstrating all the test plan requirements
    - Store manager able to use the GUI to identify and fix any problem the robot may encounter (such as extra blocks)
    - Satisfy safety requirements by containing a startup checklist and recovering from any form of e-stop
- (5 points) Network protocol (report)
    - A network protocol is required to send data between IRB120 and a computer running the GUI.
    - Explain the network protocol. Describe the size, type, and order of each data field.
    - Example of a very detailed communication protocol:https://docs.novatel.com/OEM7/Content/PDFs/OEM7_Commands_Logs_Manual.pdf
- (10 points) Implement safety interlocking with the GUI / network and I/O functions of the robot cell, ensuring any error cases are handled efficiently (demo)
    - Able to handle all error cases (including detect the error, prompt the store manager, and resume operations efficiently).
    - Perform required I/O.
    - Example of error cases include but are not limited to light curtain, conveyor interlock, emergency stop, and robot motion limitation.

Team Evaluation (30 points)

Complete the Moodle team evaluation activity. This will calculate a relative contribution of yourself and your peers over the following aspects of the group project.

- Teamwork - To what degree was this team member effective in managing themselves and their interactions with other team members? This includes planning appropriately, adapting to changes, communicating professionally and carrying out tasks as promised.
- Contribution - What was the level of the contribution of this team member to the overall outcomes of the project, both in terms of quality and quantity?

The total of 150 points will be scaled out of 30 for your MTRN4230 Asst2 mark. Students whose team evaluation results in a mark greater than 30/30 will have these additional marks added to their Asst2 mark up to a maximum of 100% for Asst2 overall.

Due date

Submit your group portfolio (report + presentation + code) to Moodle by 5 pm Friday week 12 (all students including those in Monday tutorial times). There is no page limit on the report.

Demonstrate the system to your lab demonstrator and present your portfolio within your lab time in week 13. Due to the public holiday, Monday lab groups will still demonstrate on Monday week 13, but an additional lab timeslot will be arranged with their demonstrator.

Submit your team evaluation by 5 pm Friday week 13 (all students). Non-completion of the team evaluation means you will receive 0 for this component of the assessment.

Enjoy!