

Group Project: Implementation of AI-Powered Robots

Assigned: April 18, 2024

Deliverable 1 (Group Proposal Report) due: April 24, 23:59:59

Deliverable 2 (Progress Report) due: May 01, 23:59:59

Deliverable 3 (Project Presentation) due: May 08, 23:59:59

Deliverable 4 (Code, Demo, and Report) due: May 17, 23:59:59

Note: Group Project does NOT have a late submission period for any deliverable.

In this group project, you will work with your peers as a team to implement a complete software system for artificial intelligence (AI)-powered robots. This project is an opportunity for you to obtain an understanding of the concepts you have learned in the class or to explore new robot capabilities that are not fully covered in the lecture but provided by the Robot Operating System (ROS). Students are required to implement the software package in ROS Noetic that works on a real physical robot. Each team must work on one and only one topic that can be freely selected by each team. You will notice that what you have learned from Projects 1-3 can be helpful to implement these topics.

This project is expected to be completed as a team effort. For students who want to do an individual project must discuss the opportunity with the instructor and get an approval. Students will also need to discuss with the instructor and receive an approval in the cases that (1) you have access to other robotic platforms and want to use them in the group project, and (2) you'd like to use the Gazebo simulation only (e.g., to enable multi-robot coordination capabilities). The instructor will directly work with the teams on this project. The projects will also be graded by the instructor to make sure the the grading is fair for all teams.

An omnidirectional Triton robot will be provided to each team. The robot follows a classic two-level design for computing. It uses Nvidia Jetson Nano as its main computer to execute ROS and AI algorithms. Jetson Nano has moderate computing power to execute deep learning methods with GPUs. The robot also uses an Arduino to run real-time control, which can be treated as a blackbox in this course. The robots are equipped with a RPLIDAR (a 2D LiDAR), an Intel Realsense D435 (a color-depth camera) with an IMU, and wheel encoders. A LED ring is also equipped on the robot for visual communication. As the robot is still during its development phase, please expect issues and uncertainties and please treat the team project as a research project (the Triton robots are also used by the instructor's Human-Centered Robotics Laboratory to develop multi-robot UAV-UGV teaming capabilities).

The team project has multiple deliverables that are due at different times. For each deliverable, each team must submit a single, integrated report by the team leader via Canvas before the deliverable deadline. The contents required for each deliverable are listed as follows:

1 Deliverable 1 (Proposal Report)

The proposal report must be prepare using \LaTeX . You may use Overleaf.com for collaborative writing. The proposal report must:

1. Select one and only one topic for your team project;
2. Specify a team leader (or point of contact) who is responsible for contact;
3. Provide a description of the **objectives, methods, evaluation of success**, etc.;
4. Clearly state whether a Triton robot will be used; if not, explain and justify the plan (e.g., to use other robots or only simulations);

5. Include a timeline and workload breakdown to show your plan of completing the project.

Deliverable 1 must be submitted to the portal named GP-D1 in Canvas before the deadline.

2 Deliverable 2 (Progress Report)

The progress report must be prepared using \LaTeX . You may use Overleaf.com for collaborative writing. The progress report must:

1. Describe the progress of your team project (working hardware, design, method, etc.);
2. Include a workload report (agreed upon by all team members) that states what each team member does on this project, along with a percentage breakdown (totaling 100%).

Deliverable 2 must be submitted to the portal named GP-D2 in Canvas.

3 Deliverable 3 (Project Presentation)

Each group will give a presentation on the final project during the lecture time at 4 PM on May 7th. Every team member must present a part of the presentation slides, e.g., on their tasks in the team project. The presentation is around 12 minutes (8-minute talk + 4-minute Q/A). The presentation slides must be submitted as Deliverable 2 to the portal named GP-D3 in Canvas before the deadline.

4 Deliverable 4 (Code, Demo, and Report)

Deliverable 4 must include your (1) code, (2) video demos, and (3) a final report, with the following requirements:

(1) Code: Your code from this team project to enable certain robot capabilities must be submitted to this deliverable. If the size of your code is too big (usually the case), upload it to cloud storage (e.g., Google Drive or OneDrive), then submit the download link to Canvas.

- Submit the ROS packages/code you develop as a team;
- In a README file, include a detailed instruction of how to compile, use and test the code. In general, your code must compile, be well-documented, and run without crashing.

(2) Video demos: A video demo is required for this deliverable demonstrate (show off) the cool robot capabilities that you develop in this project. If the size of your demo is too big, please also upload it to cloud storage (e.g., Google Drive or OneDrive), then submit the download link to Canvas.

(3) Final report: Each team must prepare a 5-6 page project paper describing your work. Your paper must be formatted using \LaTeX and the standard 2-column IEEE RAS conference paper format (same as the individual projects' reports). You may use Overleaf.com for collaborative technical writing. Your paper must at least include the following sections that are often required by a real paper:

- **Abstract:** An abstract of 200 to 300 words summarizing your team project and findings.
- **Introduction:** An introduction describing your team project, including the task and formulation of research problems, a brief description of your methods, and structure of your paper.
- **Approach:** A detailed description of your approaches to solve the problem, with enough information to understand and enable someone to recreate your system.
- **Experiments:** Experimental results plus an explanation and discussion of the results, such as in what situations your system can obtain the best performance, when it fails, the efficiency of your program, etc.

- **Conclusion:** A conclusion and future work section that summarizes your team project, point outs future work you believe would improve your implementation, and includes any other insightful observations you'd like to make.
- **Appendix:** A workload report in Appendix (agreed upon by all team members), which states what each team member does on this team project in detail, along with a percentage breakdown (totaling 100%).

Deliverable 4 must be submitted to the portal named GP-D4 in Canvas before the deadline.

5 Grading

All team projects will be graded by the instructor to ensure fairness. All members of the team will receive the same grade as a starting point, based on the submission. Then, the Workload Report information (submitted with Progress Report and Final Report) either results in the scores staying the same, or it can result in one student's score moving down by some amount (maximum of 1 point).

The grade (totally 10 points) will be based on:

- Deliverable 1 (proposal report): 1 point
- Deliverable 2 (progress report): 1 point
- Deliverable 3 (project presentation): 2 points
- Deliverable 4 (code, demo, and report): 6 points
 - Code: 2.5 points
 - Demo: 1 point
 - Report: 2.5 points