Assignment 2: The Robot (Summative - Worth 40%)

Contents

Format

There are two self-paced practical sessions to support data collection for this assignment. The assigment has team and individual components. All physical experiments to gather data for the tasks must be a combined team effort, with results and codes shared across your team members. Task 1 is a combined team submission of your final results. Task 2, 3 and 4 are individual submissions that must be completed independently. You may include additional analysis of data acquired during the practicals, and you may do additional simulations to complete the individual tasks.

The general rule is that physical experiments and data gathered are done as a team. In depth explanation of methods and interpretation of results are done individually. Marks are awarded based on both your final submissions and continual-assessment components for both the team and indvidual aspects.

Final Submission

- Deadline Friday 7th March 2025 @23:00 *(10% penalty per day late)*

Each team member must submit via Blackboard Turnitin:

- Slide deck and video recorded presentation addressing Task 1 (maxiumum 3 slides, 2 min presentation). Submissions must be identical for all team members.
- Individual report addressing the Tasks 2, 3 and 4 (maximum three A4 pages)
- Supplementary material, i.e., annotated code implementing your method, data logs used in your report. Code and data for Task 1 must be shared across your team members. Additional individual analyses and contributions for individuals tasks can also be included.
- Completed GenAI Declaration Form (see Blackboard)

You must also individually complete a Peer review form

Feedback will be provided via Blackboard.

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Continual Assessment

- Individual Contribution Logs: Team members must complete and submit these *BEFORE* the start of each self-paced practical session. There is a submission portal for each session.
- `Live Demos and Viva`: During practical sessions you will be allocated time on a WheelySmart robot. You may be asked to demonstrate your progress up to that point, and asked about your team and individuals plans and technical contributions. Your responses form part of your continual assessment. You should log and significant comments or feedback you receive and reflect on these in subsequent `Individual Contribution Logs`. No presentations or handouts are required for this.

If you are unable to make a practical session or have to miss part of the session for circumstances beyond your control, you must let teaching staff know as soon as possible. Otherwise there will be a 5% individual penalty for each missed session.

Assignment

Tasks

Task 1 (Team): Implement realtime EKF or PF based self-localisation and execute $\geq$2 laps of a course with multiple right angle turns and straight line sections. Design experiments that systematically demonstrate the impact of different process and measurement noise parameters. Your results must include physical experiments, but may also included results of simulations as necessary. Your submission must include:

- A table that shows the range of parameters you did experiments
- Plots showing the planned trajectory, realtime EKF or PF model estimates with corresponding lidar observations, and the actual ground truth trajectories in the e frame for at least three sets of parameters.
- Plots of how the realtime position uncertainty changed with time for at least three sets of parameters.

Detailed explanations of the method and interpretations are not required for the slides, but you should include captions to explain what is shown and any dominant trends that you have observed as a team. The video recording of you presentation may contain additional relevant footage and should be narated. Submissions for this task should be identical for all team members. [10 marks]

Task 2 (Individual): Explain the probabilistic localisation method your team implemented in Task 1. Present the relevant equations, justifying their assumptions and your choice of parameters. Discuss the sensitivity of your method to different process and measurement noise parameters and justify your final choice for these parameters. Compare and provide theoretical reasons for any differences in the pose uncertainty and error with respect to ground truth pose data. Use tables, figures, data plots and equations to support your answer.

You may use data from any additional physical experiments your team carried out, and any independent simulations you carried out individually. You may refer to results in Task 1 without duplicating content here. [10 marks]

Task 3 (Individual): Consider the robustness of your implemented approach when operating in larger environments for long periods of time (several hours). Discuss the advantages and disadvantages of your team's chosen method compared to an alternative method taught on this module (i.e., EKF or PF). Justify your expectations for both aspects using theoretical, experimental and literature based reasoning, citing relevant papers. You may run additional simulations and generate additional plots, but this is not a requirement. [10 marks]

Task 4 (Individual): Select one of the individual technical contributions you made to your team (it is fine if it wasn't finally used in Task 1). Explain the process you used to develop the contribution, providing theoretical, experimental (simulation or physical), and literature based reasoning to justify your approach and assess its performance. Make references to your individual contribution log and critically reflect on how your efforts reflected feedback from staff and your team mates, and how you adapted your contributions to accomodate developments of other team members. [10 marks]

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Schedule

Description	Date
Assignment release	7th Feb
P4 session - Individual Contribution Log, Demo and viva	25th Feb
P5 session - Individual Contribution Log, Demo and viva	4th March
Assignment submission	7th March

All group members should be present in timetabled practical sessions.

Assessment criteria

The following categories carry equal weighting and apply to all tasks.

Category	Criteria	Unsatisfactory (0-40%)	Adequate (40-50%)	Fair (50-60%)	Good (60-70%)	Excellent (70-100%)
Design and methods	Justified choices and understanding of methods; demonstrating thorough planning; effective logging and response to feedback					
Analysis and interpretation	Documentation of results; Relevance and criticality of analysis; Justification and evidencing of conclusions and recommendations.					
Presentation	Logical structure; Quality of figures, tables, and referencing					

You are marked on how you implement the methods taught in this module (e.g., actuators operating under time gating is not a taught method, so get no marks). Graphs with no explanation beyond “see code for method” get no marks. Supplementary material is used to verify the implementation of methods and data you describe in your main report, but is not directly marked.

Rules and other considerations

Use of GenAI

- This is a GenAI Tier 2 assignment. Read and complete the assignment GenAI Declaration Form on Blackboard. The amount of GenAI use is not restricted, as long as it remains within the defined allowable use cases.

Team vs individual contributions

- Team task submissions should be identical between team members. Final codes and practical experiment data logs must be shared between members.
- Individual components must be completed independently by each team member. Additional individual data analyses and simulations are allowed (and recommended). You may also use any data that was gathered by your team but not used in the team submission.

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Use of robots and data

- All simulation and practical experimental evidence must be generated using the Webots simulation and/or WheelySmart platforms provided.
- Robots will be available for use during timetabled practical sessions. You should test codes using the simulator to avoid having to debug software during these sessions. -Teams can book to borrow their laptop in office hours (09:00-17:00) during term time. Laptops must not be removed from campus. Bookings must be received via email to staff at least 1 day in advance and can only be up to 1 week ahead. Teams can only make 1 laptop booking at a time.
- Teams can book to borrow a robot kit during office hours in 3h blocks (10:00-13:00, 13:00-16:00). The robots must not be removed from the campus. Bookings must be received via email to staff at least 1 day in advance and can only be up to 1 week ahead. Teams can only make 1 robot booking at a time.
- Aruco position and heading data will only be available during timetabled practical sessions. High-frequency tracking data will be made available at the end of each timetabled practical sessions for use as your robot's `ground truth`. This is only for validating your results and should not be used in your localisation algorithms. A lower rate stream will be transmitted to your robot for use as realtime sensor measurements. These will be flagged in the `ground truth` for you to use in your methods during offline analysis.
- If you are unable to gather data during physical experiments, you should still describe your attempts (e.g., use simulations to generate data if you had hardware issues, or analyse robot data offline if you couldn't implement methods in realtime) and discuss the expected outcomes.

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Assignment 1: Planning and Control (Formative)

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C1 Robot and Simulator