The University of Western Australia
Dept. of Electrical, Electronic & Computer Engineering
Associate Lecturer Kieran Quirke-Brown

Mobile Robots

AUTO4508

Group Project	Autonomous Navigation	weeks 7-12

GROUPS: Form groups of 4 students

EQUIPMENT: Pioneer 3-AT Outdoor Mobile Robot Platform
Industrial Linux PC with touch screen display
IMU: Phidget Spatial 3/3/3
Camera: Stereo Camera OAK-D V2
Lidar: SICK 2D-Lidar TIM781-2174101
Software: ROS2 / ARIA

Groups will share the pioneer robots located in the robotics lab.

Tasks to complete

Your robot has landed on an unknown surface and it must explore the area and log any details for the arrival of future modules. In order to safely deploy the modules a 15x15 meter area around the initial landing place needs to be searched. Your robot must be able to identify certain colour markers noting the location and colour. There are several areas of interest that will be marked as waypoints and after the initial exploration the robot will need to inspect them a second time as quickly as possible. Your team will need to build a simulation as well to demonstrate the robots capabilities before real world testing can begin.

1. For safety reasons, implement a Bluetooth link between the robot's on-board PC and a gamepad controller for manual instruction:

1 https://www.digitalocean.com/community/tutorials/mnist-dataset-in-python

a. Button 'X' enables **autonomous** mode.
In autonomous mode, use the back pedals (R2 or L2) as a dead-man switch. If released, the robot has to stop.

b. Button 'O' enable manual mode (disable automated mode).
In manual mode, the steering controls can be used to manually drive the robot forward and left/right.

2. From a set home position you need to explore an unknown area, mapping it as you drive.
3. Within the unknown environment are a number of hand drawn numbers, as seen in Figure 1. These numbers will be located randomly around the environment on different surfaces at approximately knee height. You will need to use image recognition to determine the number and note its location.

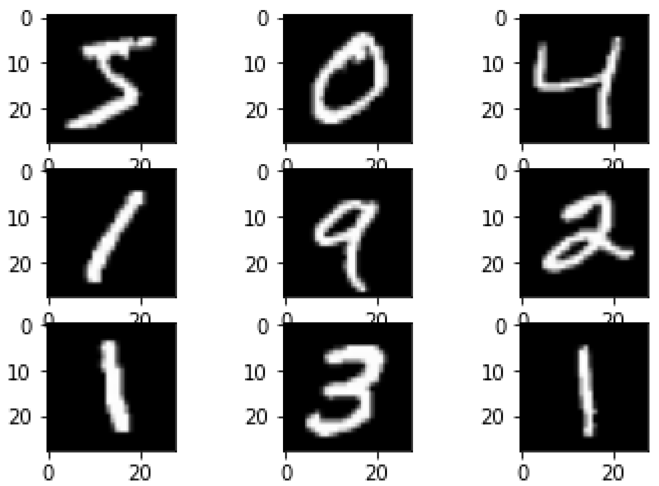

Figure 1: Hand drawn numbers[1].

4. Use the Lidar sensor to avoid collisions with stationary objects that may be located in the area.
5. You should take photos and note the location of any yellow or red colour obstacles in the area as these are of special interest to the team back home.
6. Avoid collision with moving obstacles and record an incident if an emergency stop is needed (an emergency stop should occur if a moving object comes within 1m of the robot). Note you don't need to press the estop, this is a software requirement.
7. If a estop event occurs, save the last 5 seconds of recorded data so that it can be reviewed by the team.
8. Upon completion of mapping the unknown environment, print the map, all marker photos and locations to the screen.
9. Implement a user interface with graphics and text on the robot's display that always displays the robot's internal state and its intended actions.
10. Once your first run is completed you will be given 3 waypoints noted by the hand drawn numbers to drive to. Your team must plan the fastest path to each of these locations and the path back to home. Your robot must then drive through the

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unknown environment a second time to each of these waypoints and return home in the fastest time possible.

11. Display the robots planned path graphically to a screen.
12. Your system should record the drives so it can be review again offline.

Getting started

You can program the robot using the ROS2 software stack. Make use of the software libraries for Phidget (IMU) and OAK-D (stereo camera), sick_scan_xd (Lidar) as well as OpenCV (image processing) which stops you from having to reinvent the wheel. As a suggested first node, try and get the PlayStation controller working using the joy library.

Note that the robots are designed to **only drive outside** on grass or sand.
For **indoor testing**, you need to wrap all tires with tape to allow the rigid wheels to slip – otherwise the robot's motors will burn out (this already happened in the past)!

Resources

Pioneer:

- ARIA Library: https://github.com/cinvesrob/Aria

Phidget IMU:

- User Guide: https://www.phidgets.com/?tier=3&catid=10&pcid=8&prodid=1204
- Code Samples https://www.phidgets.com/?tier=3&catid=10&pcid=8&prodid=1204

OAK-D Camera:

- DepthAI API: https://docs.luxonis.com/projects/sdk/en/latest/
- Code Samples: https://docs.luxonis.com/projects/api/en/latest/tutorials/code_samples/

SICK Lidar:

- Info/ROS-Driver: https://www.sick.com/fr/en/tim781-2174101/p/p594148

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VIDEO

Create a video of about 1-2 min. in length that shows your robot's capabilities, you should outline your team's journey, what went well and what didn't go so well, as well as design decision and changes in decisions. If anything goes wrong during demonstration day, at least you have the fallback of the video.
Submission is in week 11, one week before the project demonstration.

DEMONSTRATION

On the scheduled presentation day at the end of the semester, all groups will give a practical demonstration of their projects and answer the project supervisors' questions re. their implementation.

SUBMISSION

Submit a hardcopy and softcopy with official coversheet incl. declarations of all team members:

1. Project design report (*pdf*), which includes
    - Report on which team member did what
    - Software design description
    - Diagrams, photos, screenshots, plots, etc.
    - Include page numbers
    - Max 10 pages plus 1 Title page
    - This should be a document you could hand to another design team and they could develop the same solution and understand your design decisions

    Do NOT include:
    - Program code
    - Table of contents, etc.
    - Half-empty pages
2. User Manual (*pdf*)
    - Max 5 pages, **no** Title page
    - As if it was sold to a customer
        - Think about what you see in other user manuals both bad and good
3. Source code *(email to project supervisor only, no hardcopy)*,
clearly marking any imported code with referencing the source.

MARKING

60% Functional Performance, Design, Complexity, Innovation
- 10% Simulation
- 50% Real world

20% Project Design Report
10% Video
10% User Manual

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