Navigation Workflow

ROB 102: Introduction to AI & Programming

Lab Session 4

2021/10/08

Administrative

Project 2 is out, due **Monday, October 25th, at 11:59 PM.**

Watch the rest of the potential field navigation lecture before Monday.

Monday's activity: Potential field navigation on a robot.

There will be new team assignments for Project 2.

Today…

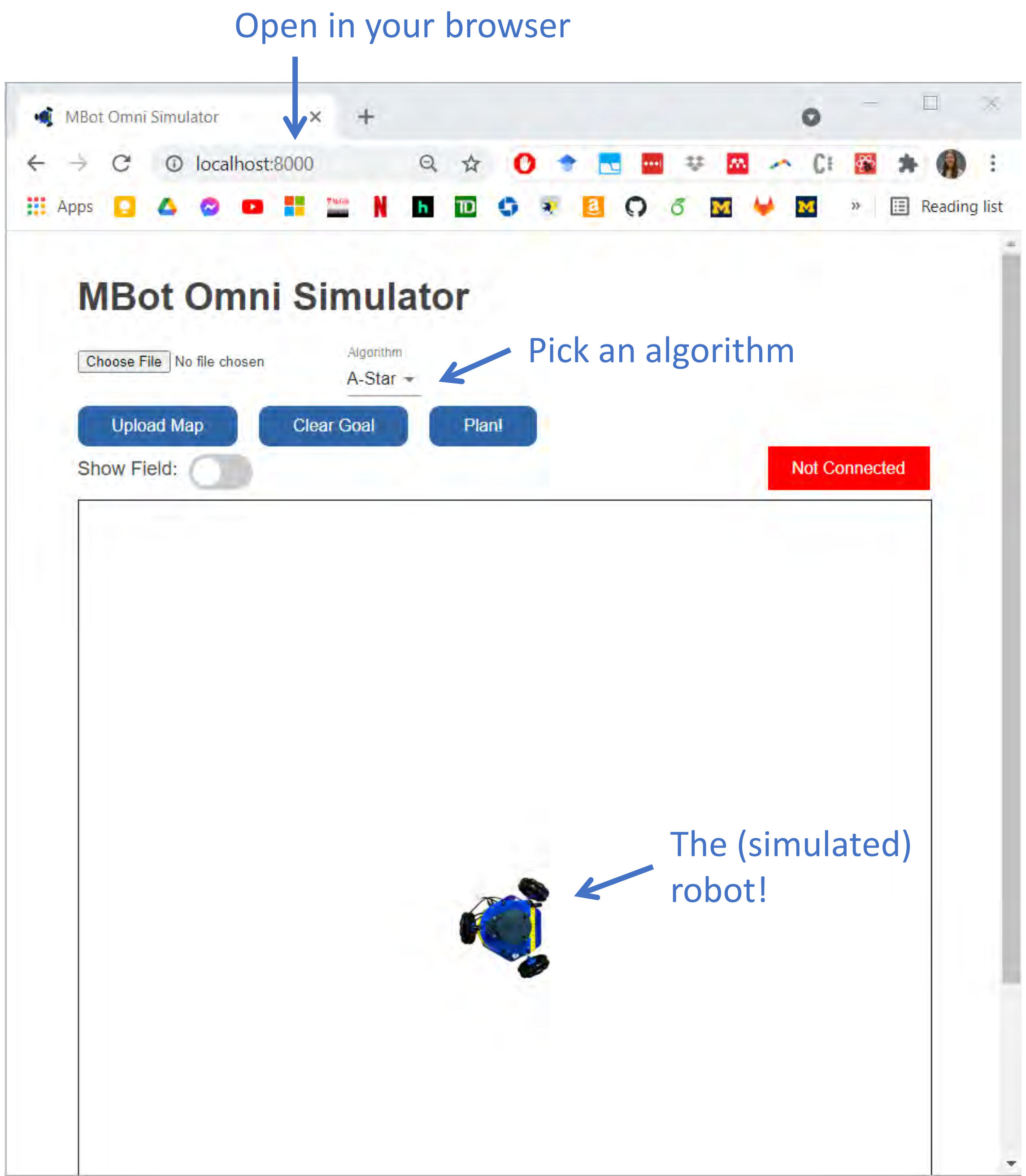
1. Navigation workflow & how to use the navigation web app.
2. Autonomous navigation code structure
3. Storing a map in C++ code
4. Building a map on the robot

TODO Today:

1. Clean up robots from Project 1
2. Get Docker and the web app running
3. Build a map on the robot

The Navigation Web App

We built a web app to help you visualize maps, your potential fields, and paths.



Running the Web App

The web app must be run in the provided Docker container.

In a terminal open in the repository directory:

1. Build the Docker image:

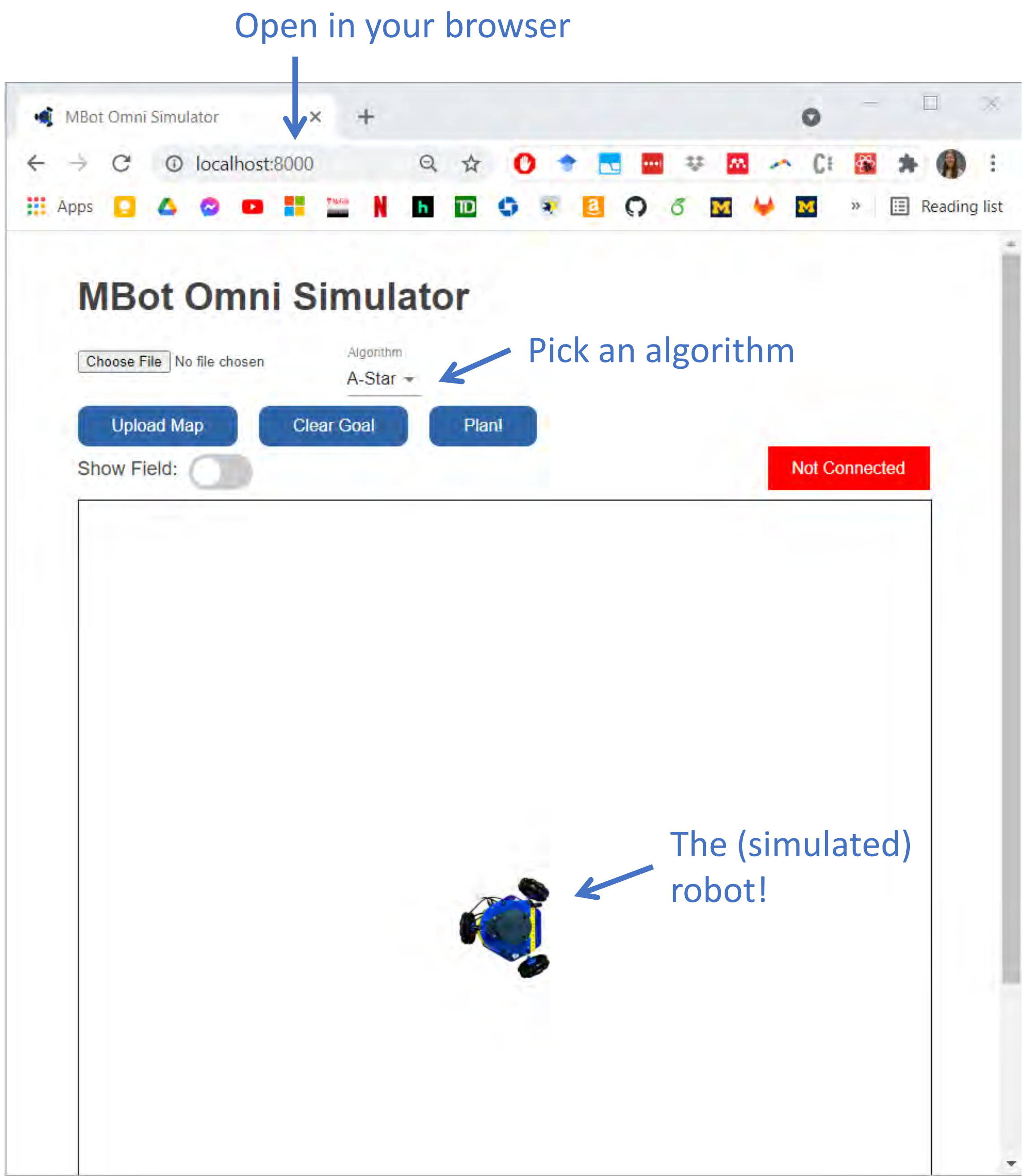
   `./docker_build.sh`

2. Run the Docker container:

   `./docker_run.sh`

3. Open a browser and go to:

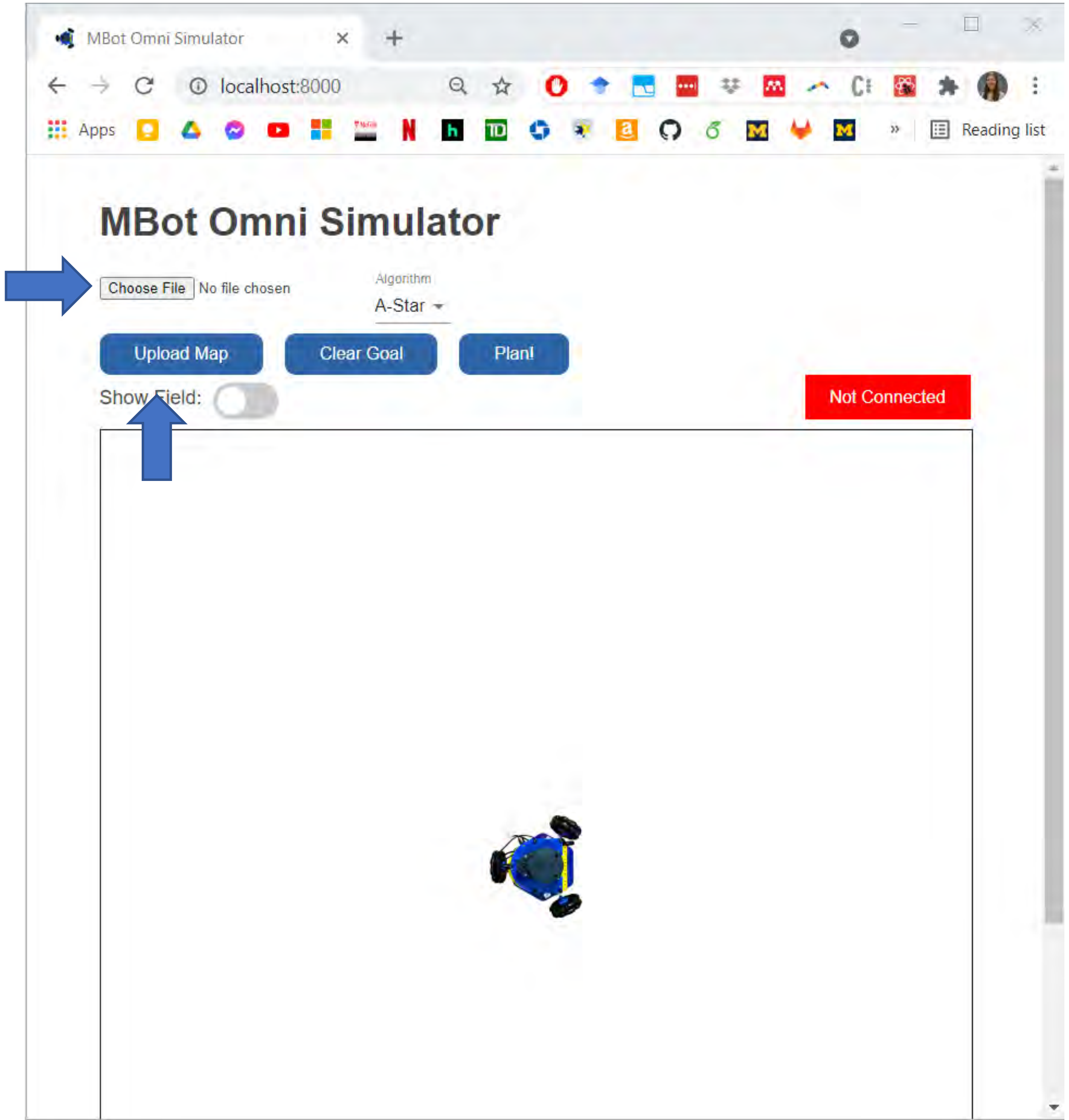
   `http://localhost:8000`



Using the Web App

To upload a map:

1. Click the “Choose File” button and navigate to one of the files that ends in “.map” in the “data” folder of the repository.
2. Click “Upload Map”

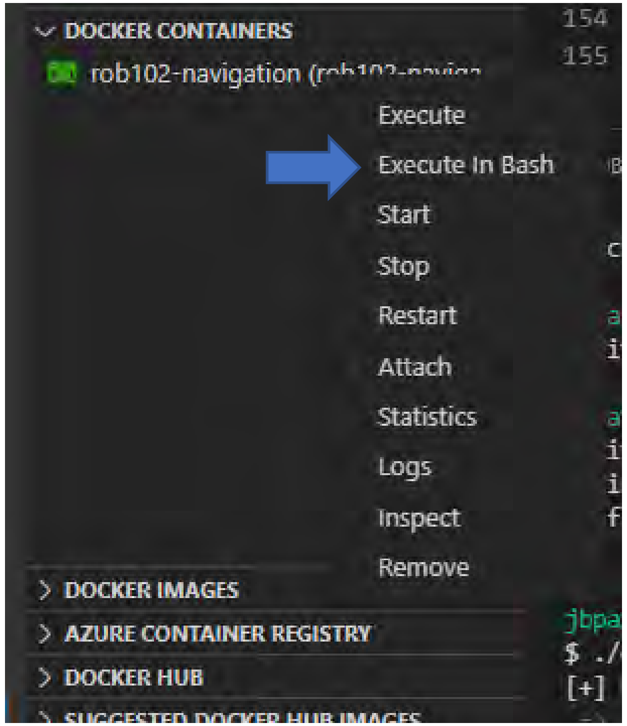


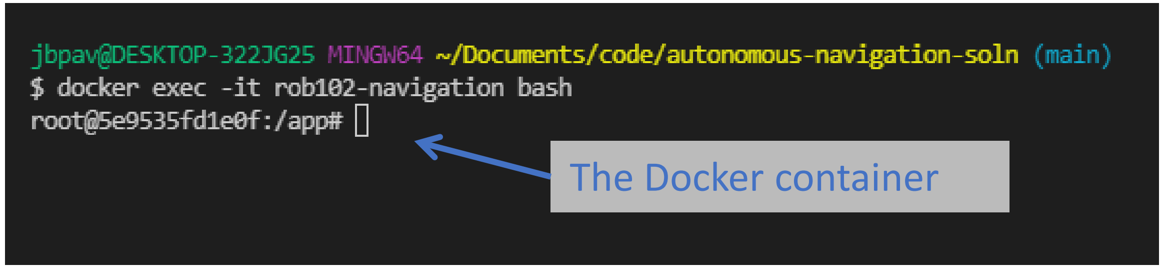
Testing C++ Code

We have written a C++ interface between the functions you will write and the web app.

1. Open a terminal in the Docker from the Docker Explorer in VSCode.
2. Compile and run the code in the Docker:

```
cd /code/build
cmake ..
make
./nav_app_server
```



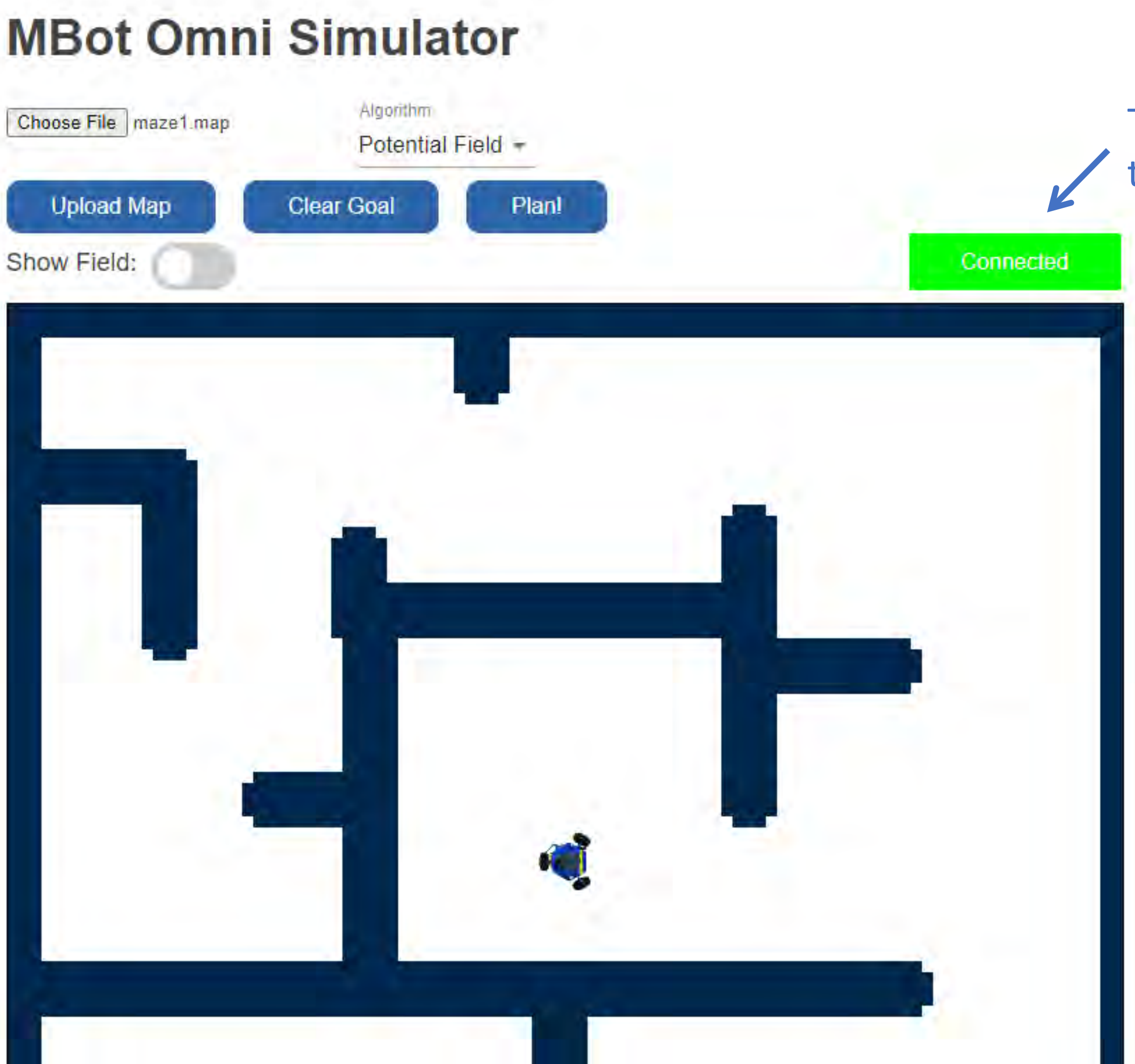


Testing C++ Code

Choose a map file

Upload the map (to the web app and the server)

The status is “connected” if the C++ server is connected

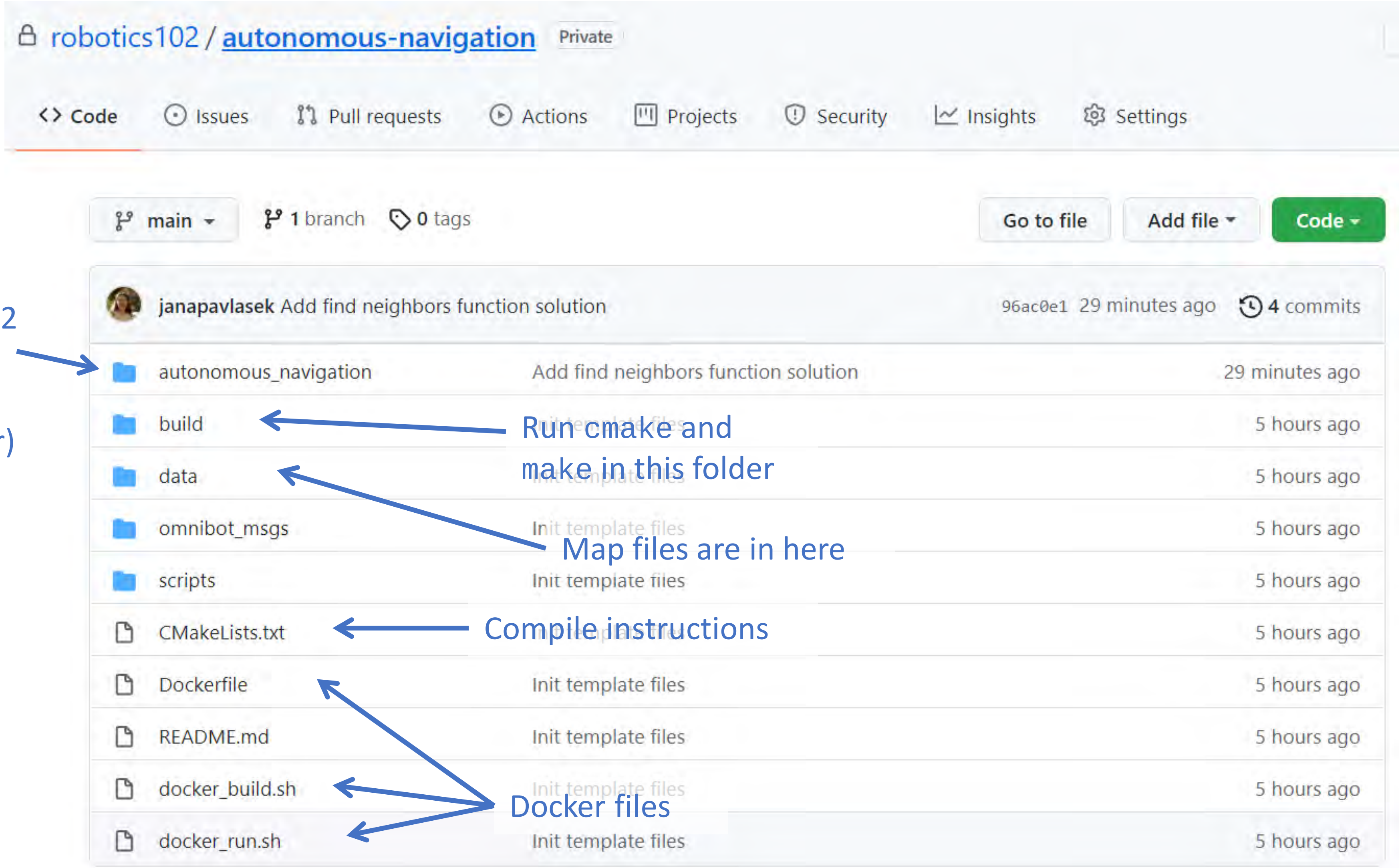


Testing C++ Code

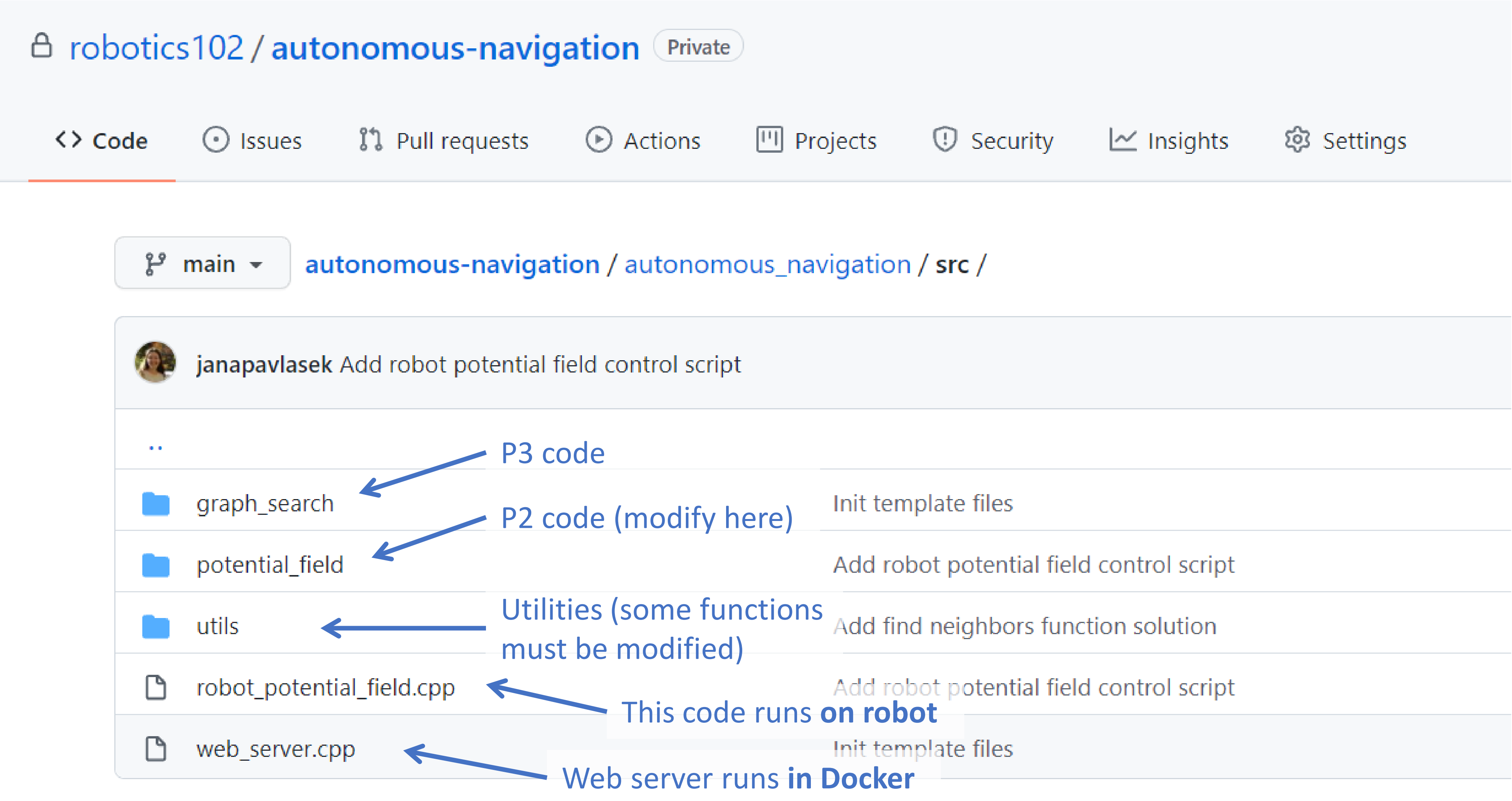
Show the distance transform (computed in C++)

Code Structure

The C++ code for P2 and P3
(this folder is mounted in Docker)



Code Structure



Code structure

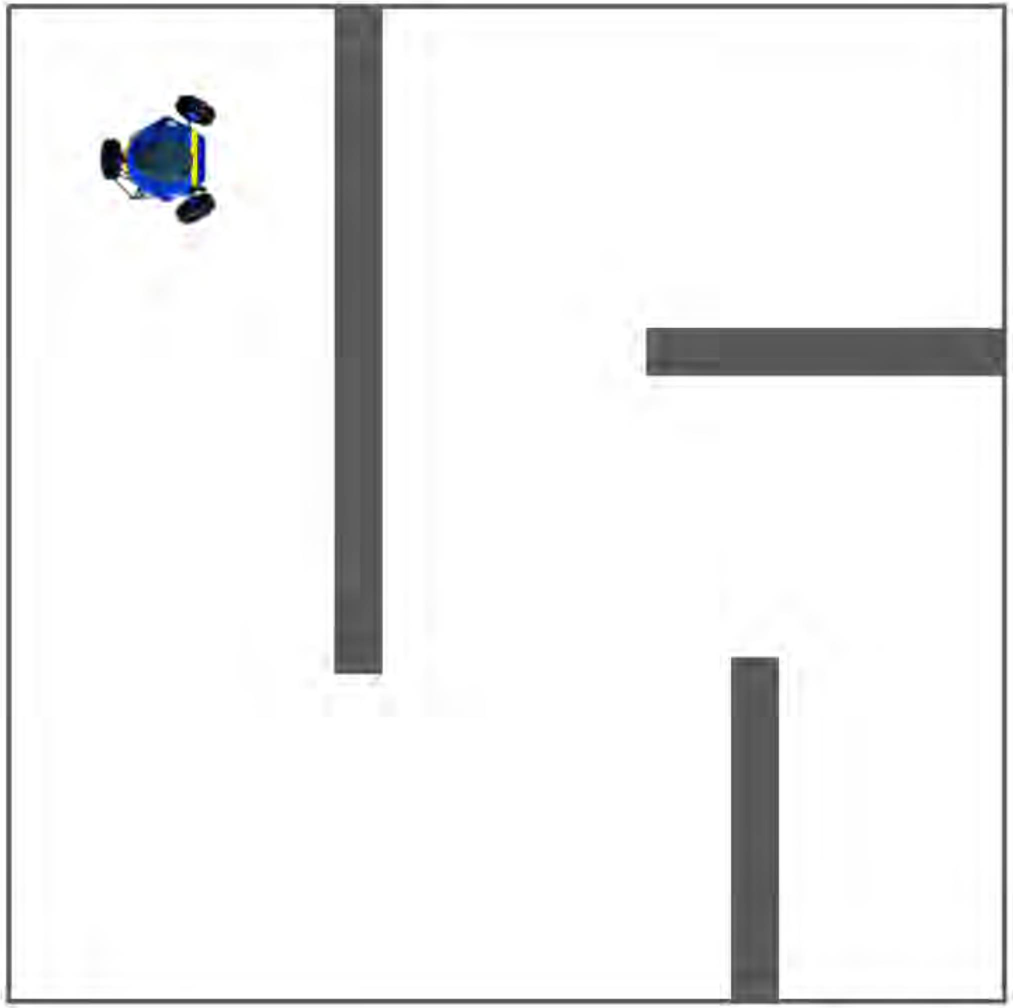
There are three things you will run for this project:

1. Navigation web server: When you want to run your algorithms and visualize the field, and simulate the robot.
   - Run in the Docker on your computer.
2. Test files: To run tests on components of your algorithm on small scale examples for sanity-checking.
   - Run in the Docker on your computer, or on the robot.
3. Robot control scripts: To control the robot. The robot code will use the same functions for 1. and 2.
   - Run on the robot.

Storing a Map in C++

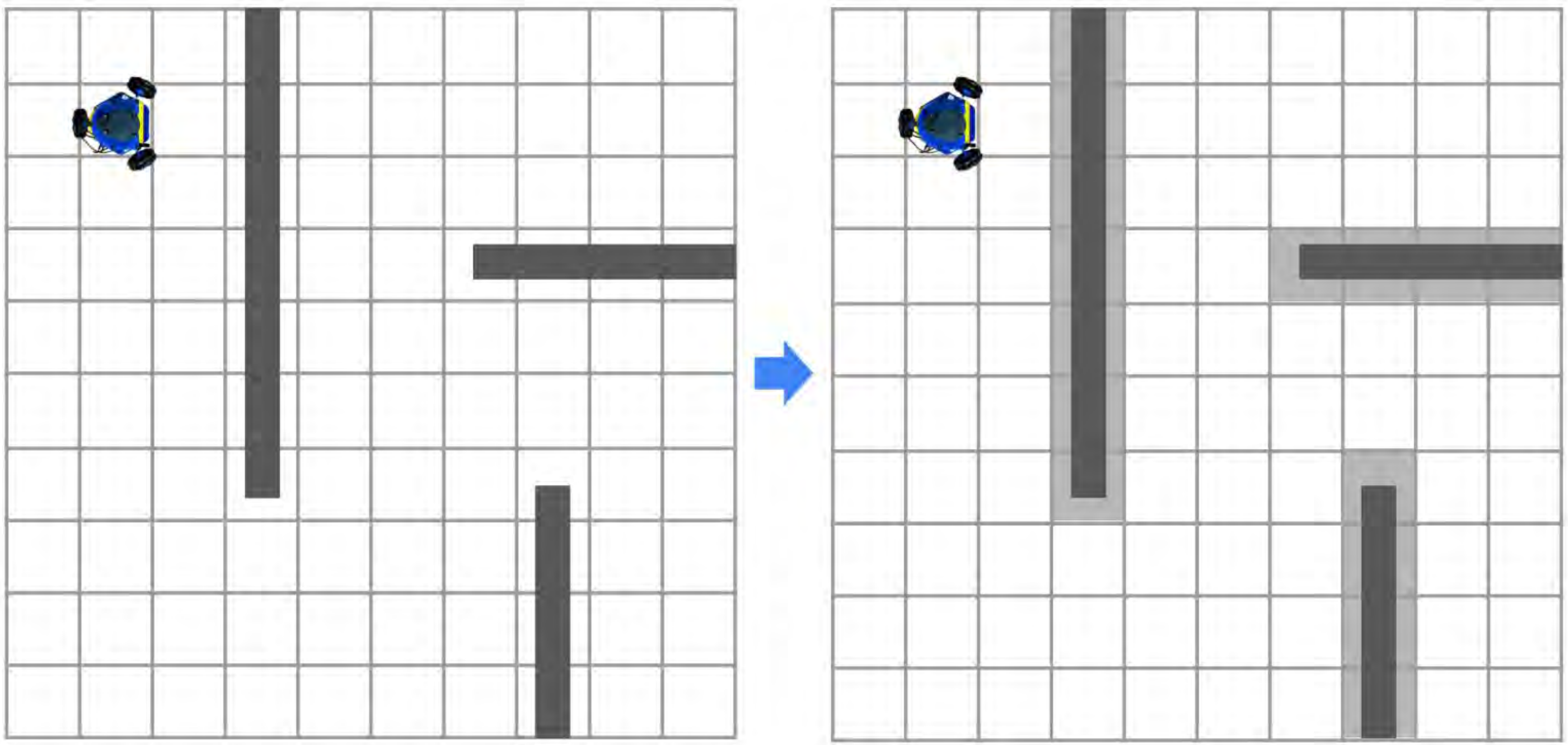
Imagine you have a robot in a map like this one.

How can we represent the map in a computational structure?



Storing a Map in C++

We can draw a grid in the environment and mark every cell as either free (white) or occupied (grey).

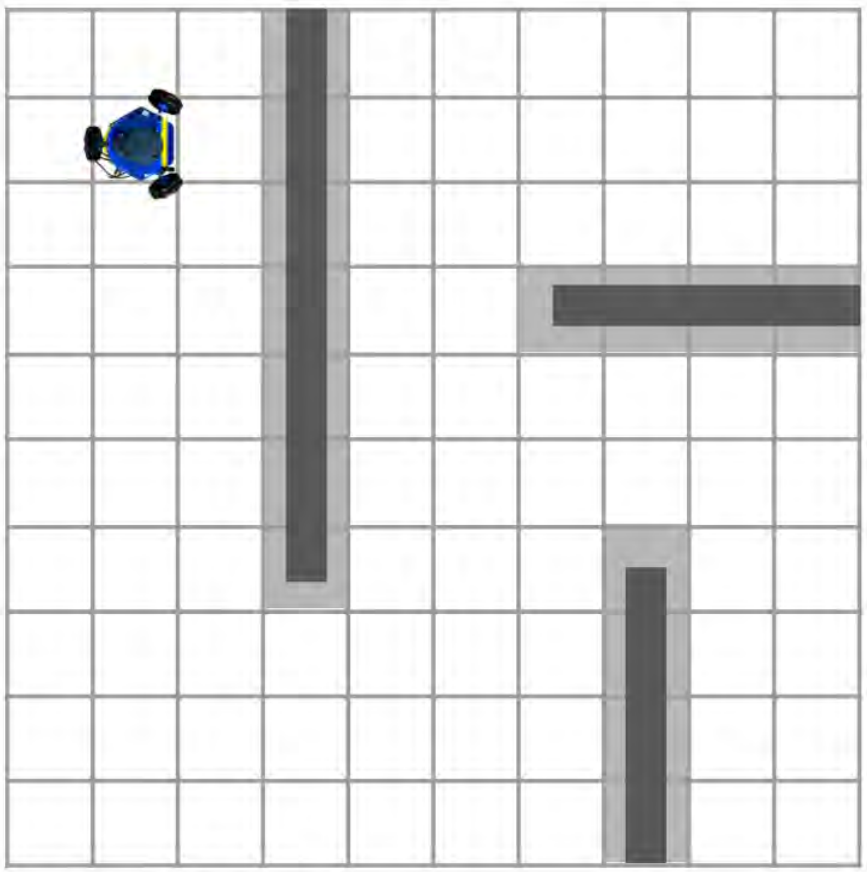


Storing a Map in C++

GridGraph has a vector called `cell_odds` which has a value in the range [-128, 127] for each cell.

A **high** value means the cell is likely to be occupied.

A **low** value means the cell is likely to be free.



Storing a Map in C++

We represent the cell in terms of a coordinate in the grid.

The coordinate is written `(i, j)`, where `i` is the index of the column and `j` is the index of the row.

rows										
9	-128	-128	-128	127	-128	-128	-128	-128	-128	-128
8	-128	-128	-128	127	-128	-128	-128	-128	-128	-128
7	-128	-128	-128	127	-128	-128	-128	-128	-128	-128
6	-128	-128	-128	127	-128	-128	127	127	127	127
5	-128	-128	-128	127	-128	-128	-128	-128	-128	-128
4	-128	-128	-128	127	-128	-128	-128	-128	-128	-128
3	-128	-128	-128	127	-128	-128	-128	127	-128	-128
2	-128	-128	-128	-128	-128	-128	-128	127	-128	-128
1	-128	-128	-128	-128	-128	-128	-128	127	-128	-128
0	-128	-128	-128	-128	-128	-128	-128	127	-128	-128
	0	1	2	3	4	5	6	7	8	9

columns

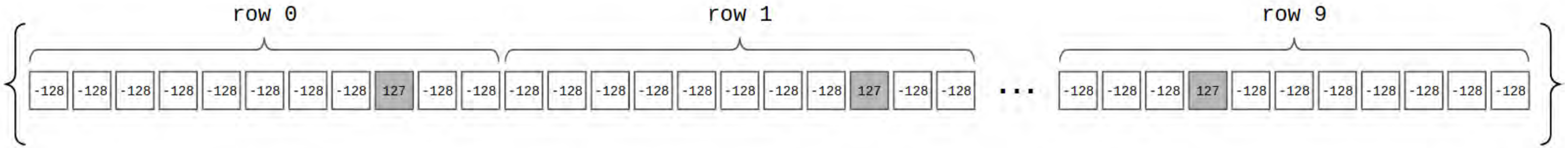
Storing a Map in C++

We will store the cell odds data in a single vector.

We can line up each row next to each other.

P2.0: Write functions to convert from a cell coordinate to an index in the vector (and the inverse).

rows \ columns	0	1	2	3	4	5	6	7	8	9
9	-128	-128	-128	127	-128	-128	-128	-128	-128	-128
8	-128	-128	-128	127	-128	-128	-128	-128	-128	-128
7	-128	-128	-128	127	-128	-128	-128	-128	-128	-128
6	-128	-128	-128	127	-128	-128	127	127	127	127
5	-128	-128	-128	127	-128	-128	-128	-128	-128	-128
4	-128	-128	-128	127	-128	-128	-128	-128	-128	-128
3	-128	-128	-128	127	-128	-128	-128	127	-128	-128
2	-128	-128	-128	-128	-128	-128	-128	127	-128	-128
1	-128	-128	-128	-128	-128	-128	-128	127	-128	-128
0	-128	-128	-128	-128	-128	-128	-128	127	-128	-128



Storing a Map in C++

```
struct GridGraph
{
    GridGraph() :
        width(-1),
        height(-1),
        origin_x(0),
        origin_y(0),
        meters_per_cell(0),
        collision_radius(0.15),
        threshold(-100)
    {
    };

    int width, height;
    float origin_x, origin_y;
    float meters_per_cell;
    float collision_radius;
    int8_t threshold;

    std::vector<int8_t> cell_odds;
    std::vector<float> obstacle_distances;
};
```

Width and height in cells

(x,y) location in meters of cell (0,0)

Width of a cell in meters

Value at each cell (length width * height)

Distance transform will go here!

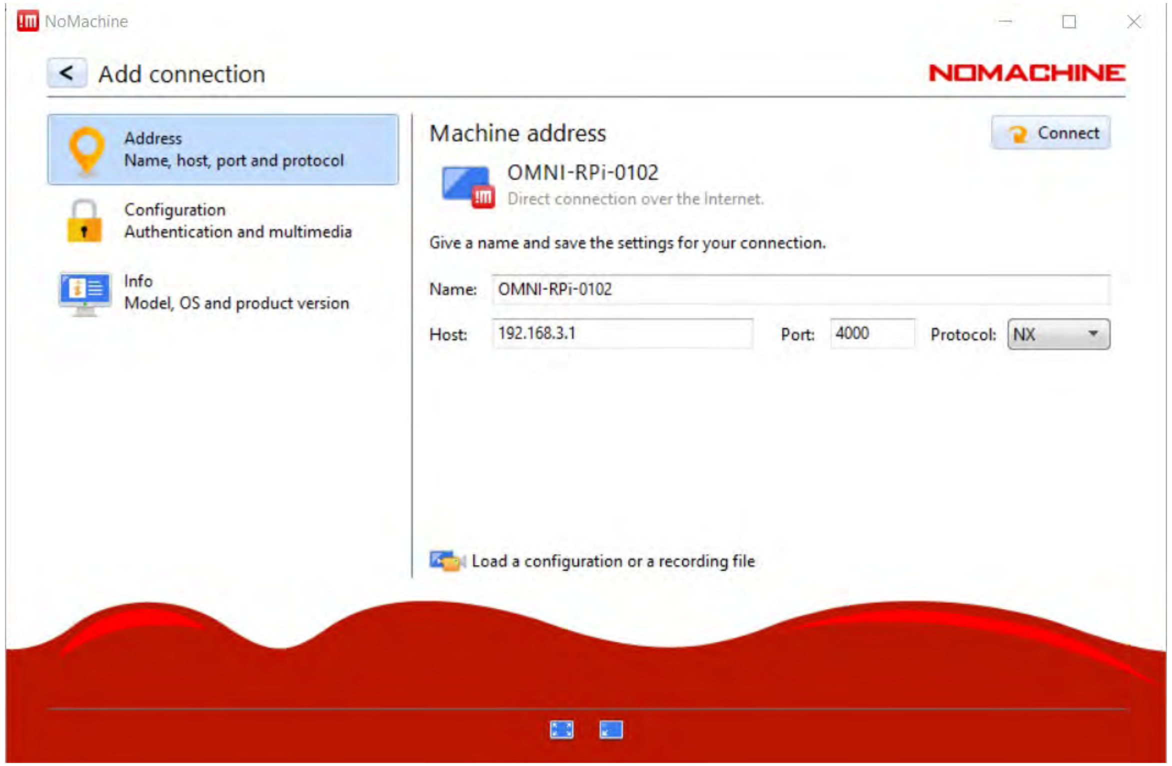
include/autonomous_navigation/utils/graph_utils.h

The GridGraph struct represents the map data.

Building a Map on the Robot

Download the program NoMachine: https://www.nomachine.com/

Create a new connection to the Raspberry Pi.



Building a Map on the Robot

You will see the robot's desktop!

Building a Map on the Robot

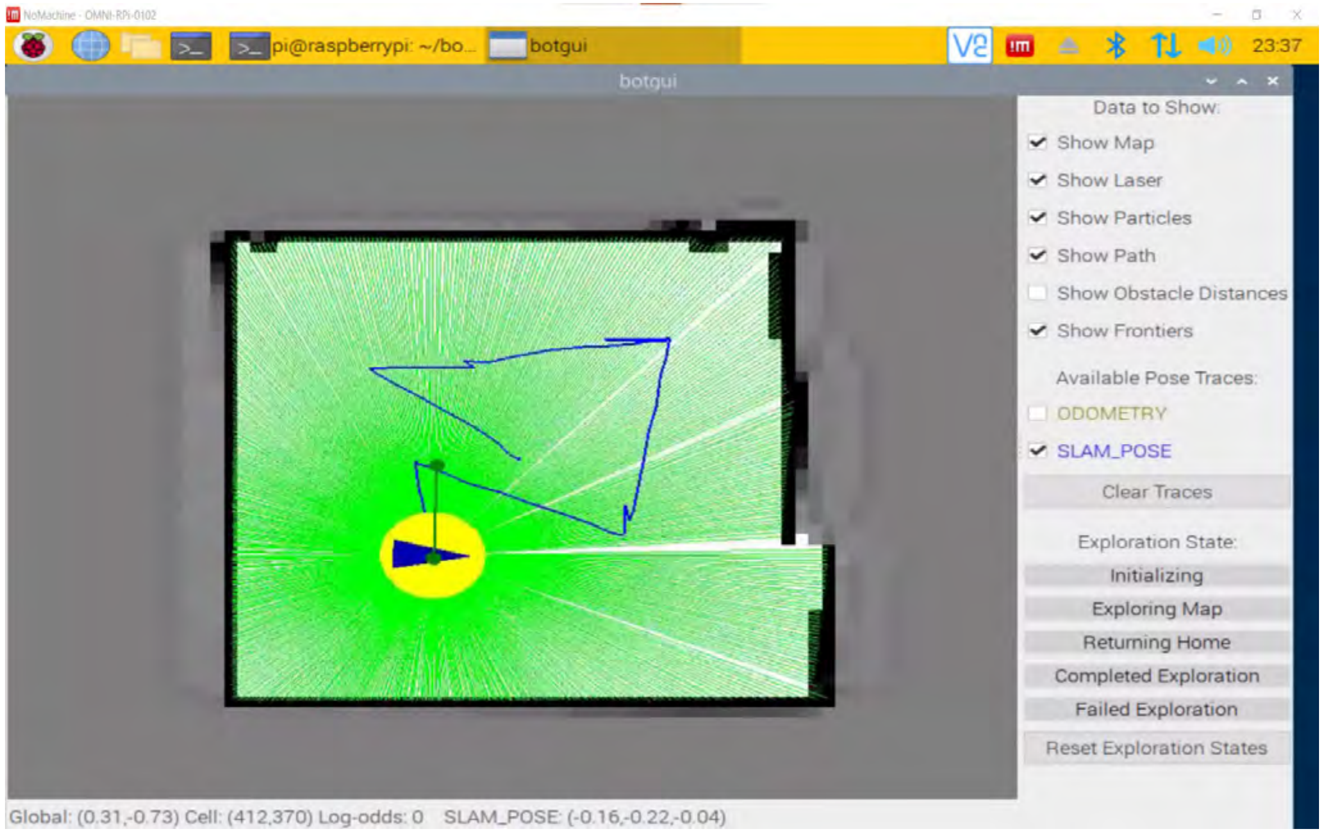
Open a terminal on the robot.
Run:

```
./botlab-bin/launch_botlab.sh
```

Then run:

```
./botlab-bin/bin/botgui
```

Use Ctrl+Click on the GUI to move the robot.



TODO Today:

1. Clean up robots from Project 1
   a) Make sure all your code is pushed to GitHub
   b) Remove your code and any other data
2. Get Docker and the web app running
   a) Accept the assignment on GitHub (find the link on Slack)
   b) Clone it onto your computer (all teammates should do this!)
   c) Build & run the Docker and look at the web app
3. Build a map on the robot