AMR final project report

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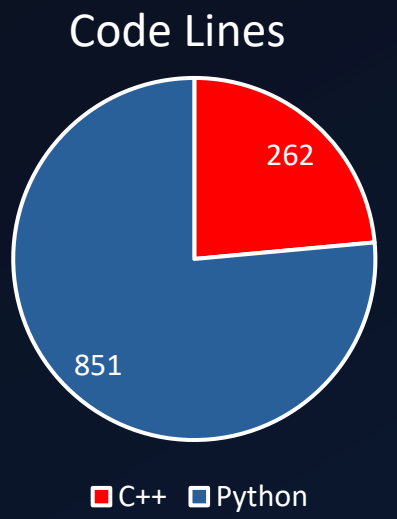
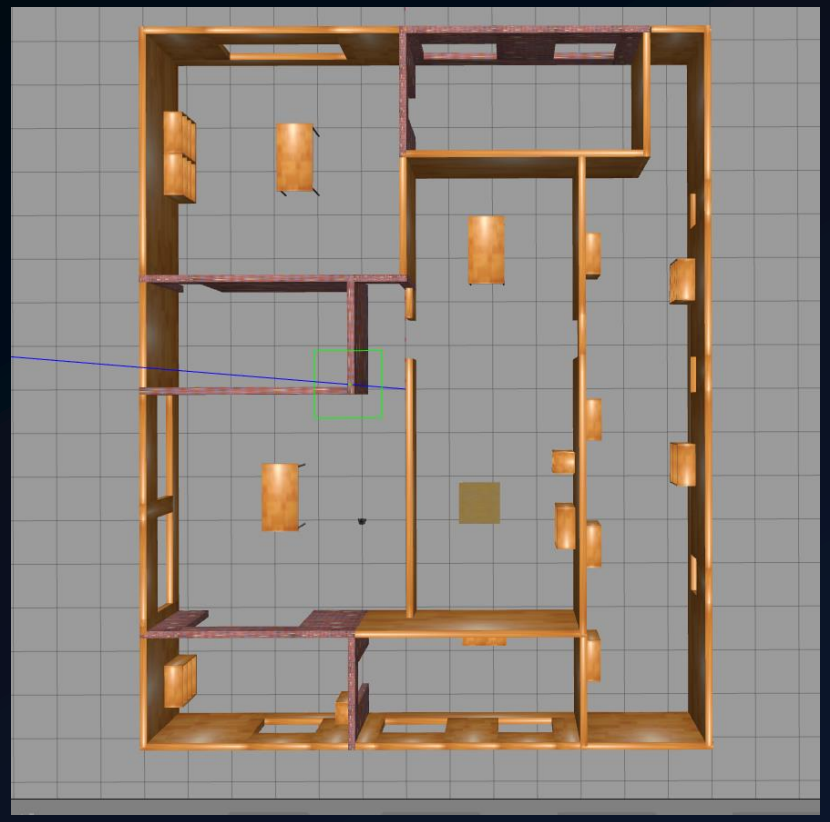
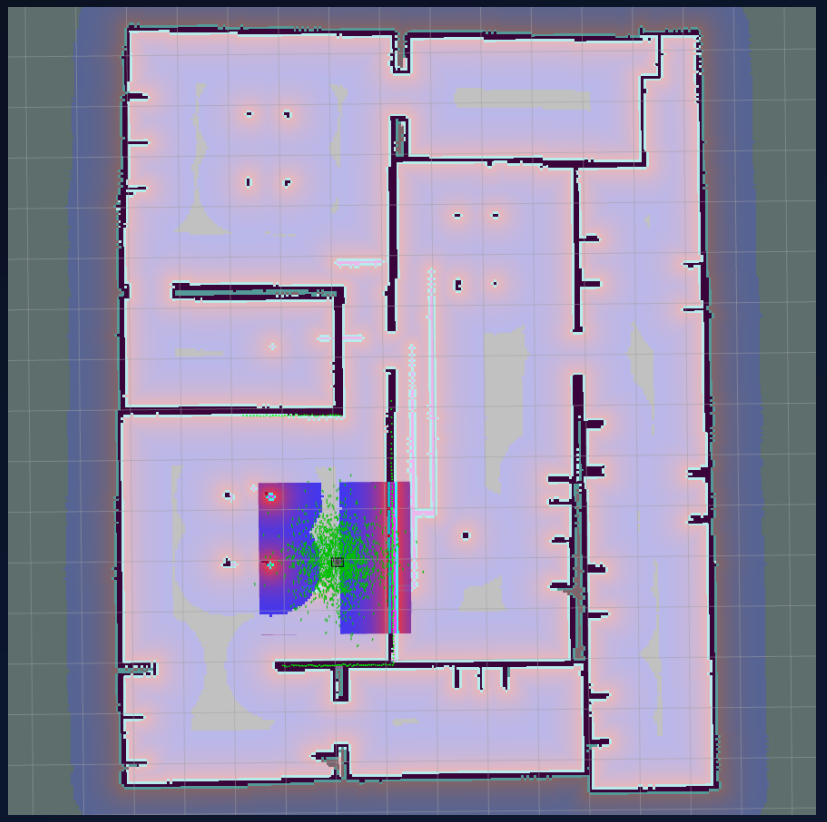


Task 1- *Gazebo and Rviz*

- Gazebo and Rviz simulation in Big house environment.





Task 2

- We used the *SLAM* node to create the map as an image by moving the robot in the environment.
- To move the robot, we used e*xplore_lite package* with the parameter *min_frontier_size* set to 0.3.

Task 2 – *Map creation video*

Task 2 – *Map manipulation*

- We used OpenCV and Python in Jupyter Notebook environment to manipulate the image of the map in order to obtain a discretized binary map with resolution 0.2m/px.

Original image (0.05m/px)

Binary image (0.05m/px)

Binary image (0.2m/px)

Task 3 - Localization

- We developed *Turtlebot3_project_localization* package (C++) to localize the robot.
- Localization scheme:

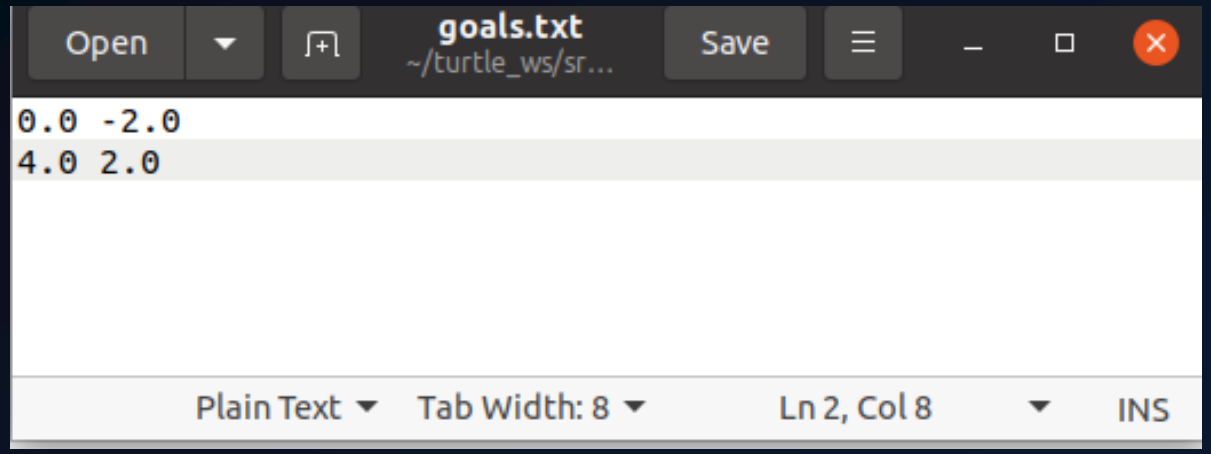
Task 3 – *Localization video*

Task 3 – *Localization results*

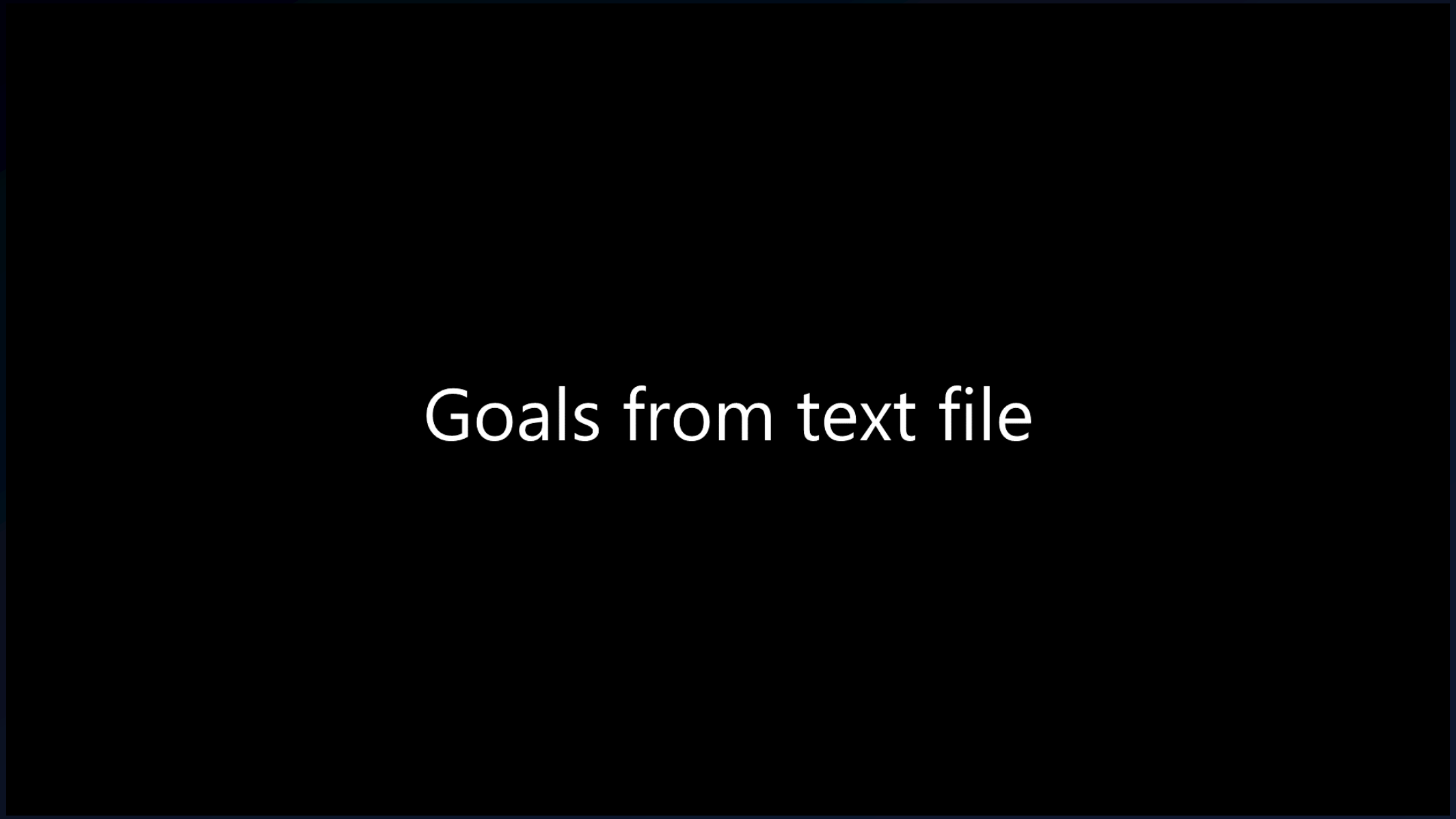
```
orenzo@MSI-Lorenzo:~/turtle_ws$ rosrun turtlebot3_project_localization turtlebot3_project_localiza
on
 INFO] [1643630403.097433559]: INITIALIZING LOCALIZATION NODE
 INFO] [1643630403.099718872]: Stop
 INFO] [1643630403.150400555]: AMCL particles redistributed!
 INFO] [1643630403.326262148, 232.024000000]: Costmaps cleared!
 INFO] [1643630405.731302318, 233.024000000]: Turning around...
 INFO] [1643630445.843576324, 253.958000000]: Stop
 INFO] [1643630445.843968102, 253.958000000]: Moving forward...
 INFO] [1643630461.077506962, 261.958000000]: Stop
 INFO] [1643630461.077980802, 261.958000000]: Moving backward...
 INFO] [1643630476.076363722, 269.958000000]: Stop
  INFO] [1643630476.076700456, 269.958000000]: Is the robot successfully localized? (y/n)

  INFO] [1643630483.340802864, 273.909000000]: AMCL particles redistributed!
  INFO] [1643630483.481137830, 273.966000000]: Costmaps cleared!
  INFO] [1643630485.275690707, 274.966000000]: Turning around...
  INFO] [1643630524.286289997, 295.900000000]: Stop
  INFO] [1643630524.286407552, 295.900000000]: Moving forward...
  INFO] [1643630539.247581299, 303.900000000]: Stop
  INFO] [1643630539.247787901, 303.900000000]: Moving backward...
  INFO] [1643630553.995034260, 311.900000000]: Stop
  INFO] [1643630553.995313605, 311.900000000]: Is the robot successfully localized? (y/n)

  INFO] [1643630556.761378966, 313.387000000]: AMCL particles redistributed!
  INFO] [1643630556.914701331, 313.476000000]: Costmaps cleared!
  INFO] [1643630558.867307957, 314.477000000]: Turning around...
  INFO] [1643630598.974040328, 335.412000000]: Stop
  INFO] [1643630598.974915881, 335.412000000]: Moving forward...
  INFO] [1643630614.151281678, 343.412000000]: Stop
  INFO] [1643630614.151705470, 343.412000000]: Moving backward...
  INFO] [1643630629.390216887, 351.412000000]: Stop
  INFO] [1643630629.390516517, 351.412000000]: Is the robot successfully localized? (y/n)

  INFO] [1643630631.188664838, 352.400000000]: LOCALIZATION SUCCESSFUL
```

Task 3 – Navigation from a text file

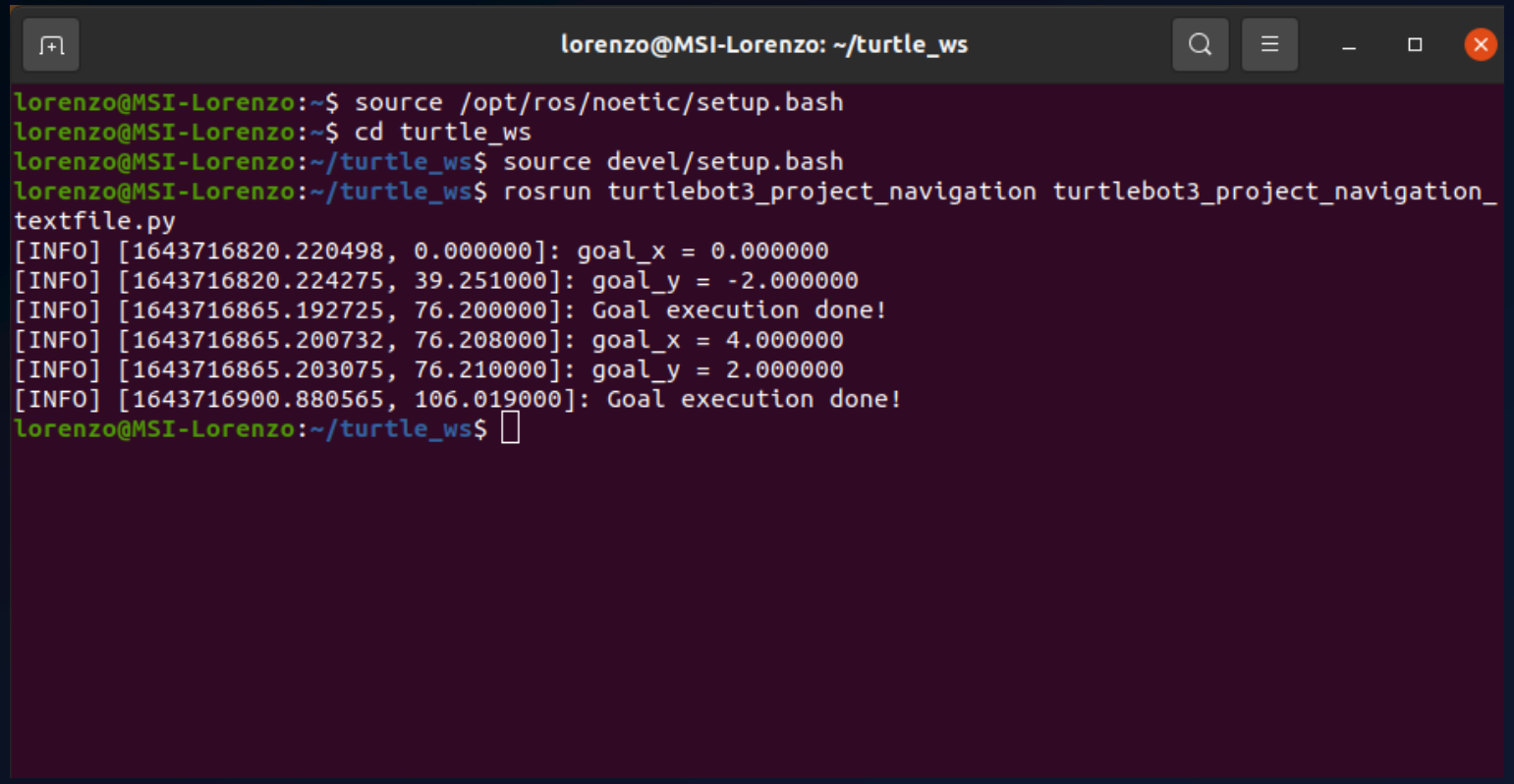
- We developed *Turtlebot3_project_navigation_textfile* (Python) to reach goals written in a given text file.



Task 3 – *Goals from text file video*



Task 3 – *Goals from text file results*

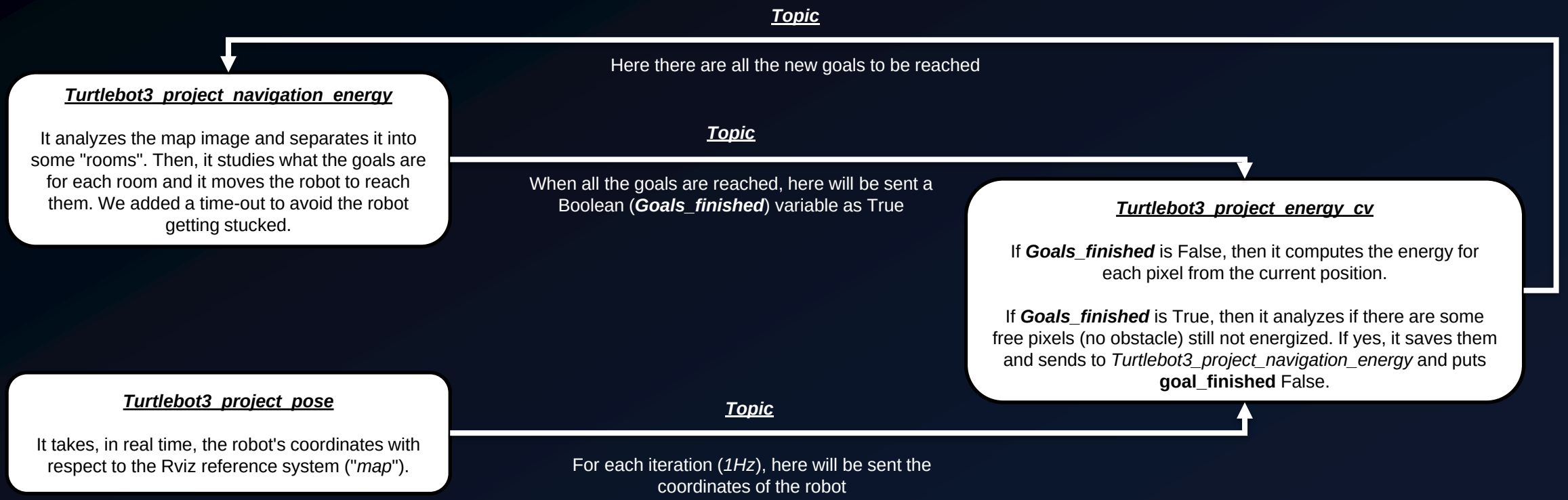


Task 4

We developed the package *turtlebot3_project_navigation* to perform navigation from text file and Task 4. It consists of the nodes:

- *Turtlebot3_project_navigation_textfile (Python)*
- *Turtlebot3_project_pose* (C++)
- *Turtlebot3_project_energy_cv* (Python).
- *Turtlebot3_project_navigation_energy* (Python).

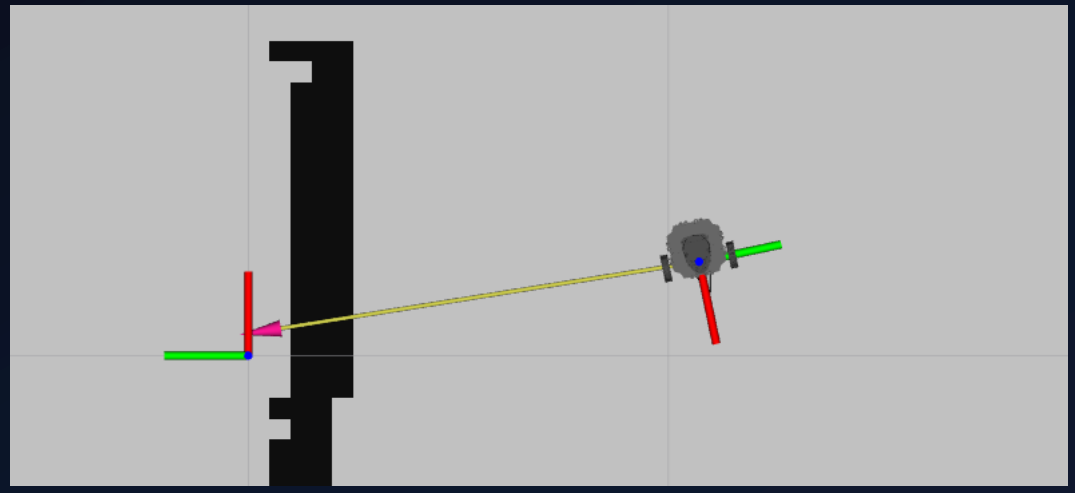
Task 4 – Algorithm



Task 4 - *Turtlebot3_project_pose*

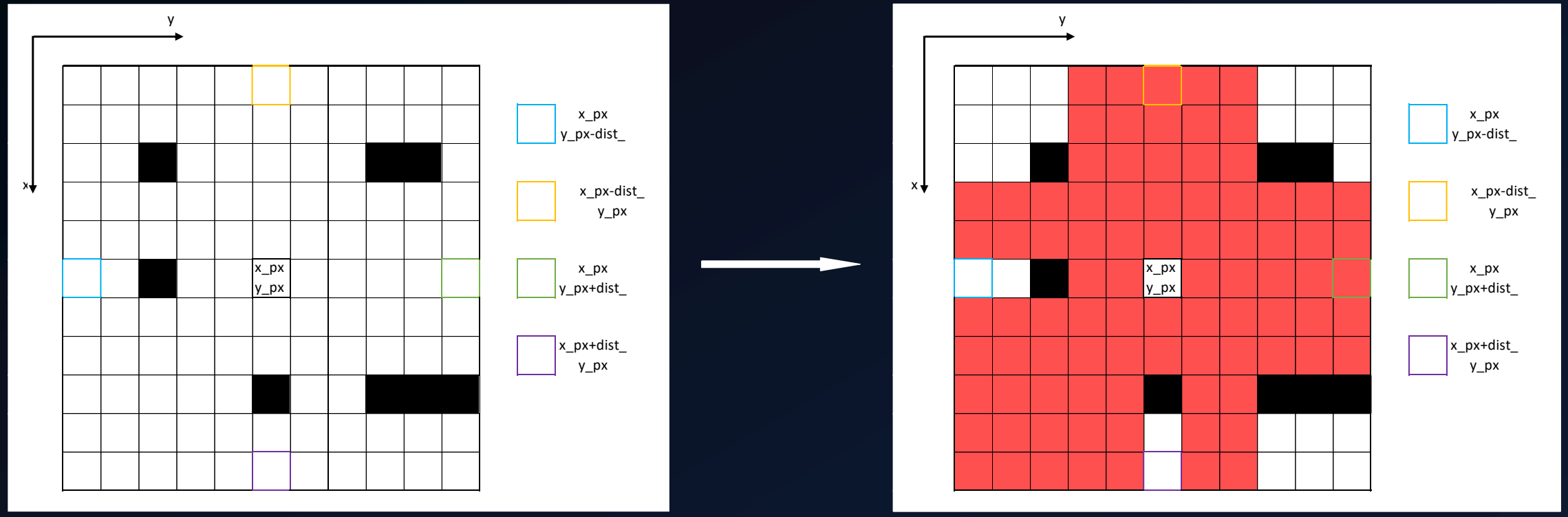
This node finds the transformation between the map frame and the robot frame. The robot coordinates (in meters) are then published.

```
INFO] [1643716993.091984016, 28.778000000]: tf is good; current pose is:
INFO] [1643716993.092304480, 28.778000000]:    frame id = map
INFO] [1643716993.092445425, 28.778000000]:    origin: -1.23715, 0.865022, 0.0121372
INFO] [1643716993.092553109, 28.778000000]:    quaternion: 0.000334013, -7.76199e-05, -0.270884, 0.962612
INFO] [1643716993.097747398, 28.780000000]: x_pose of the robot = -1.23715, y_pose of the robot = 0.865022
INFO] [1643716993.097818209, 28.780000000]: Publishing robot pose on 'robot_pose' topic
```



Task 4 - *Turtlebot3_project_energy_cv*

- Algorithm based on the research of «free» pixels in an image.

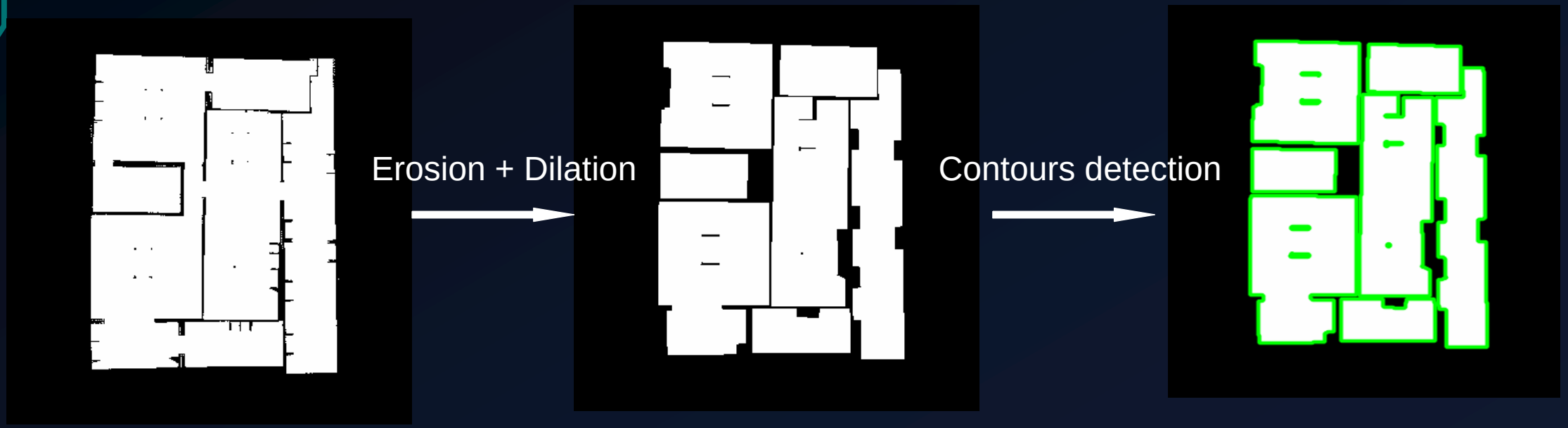


Task 4 - *Turtlebot3_project_energy_cv results*

```
lorenzo@MSI-Lorenzo:~/turtle_ws$ rosrun turtlebot3_project_navigation turtlebot3_project_energy_cv.py
(80, 80, 3)
(80, 80, 2)
[INFO] [1643717837.847928, 48.469000]: ENERGY NODE
[INFO] [1643717837.952846, 48.562000]: I heard x_pos = 1.009686
[INFO] [1643717837.958387, 48.567000]: I heard y_pos = -3.253614
[INFO] [1643717837.968285, 48.570000]: x_pos in pixels = 32
[INFO] [1643717837.975583, 48.578000]: y_pos in pixels = 54
[INFO] [1643717839.203659, 49.592000]: I heard x_pos = 0.993868
[INFO] [1643717839.206019, 49.593000]: I heard y_pos = -3.474297
[INFO] [1643717839.210830, 49.604000]: x_pos in pixels = 32
[INFO] [1643717839.215728, 49.609000]: y_pos in pixels = 55
[INFO] [1643717840.476593, 50.624000]: I heard x_pos = 0.981165
[INFO] [1643717840.488617, 50.629000]: I heard y_pos = -3.693503
[INFO] [1643717840.492961, 50.633000]: x_pos in pixels = 32
[INFO] [1643717840.497236, 50.635000]: y_pos in pixels = 56
[INFO] [1643717841.683086, 51.649000]: I heard x_pos = 0.979890
[INFO] [1643717841.686404, 51.652000]: I heard y_pos = -3.909733
[INFO] [1643717841.694756, 51.655000]: x_pos in pixels = 32
[INFO] [1643717841.702528, 51.662000]: y_pos in pixels = 58
```

Task 4 – *Rooms detection algorithm*

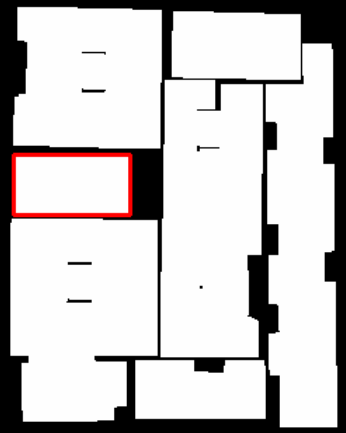
- The rooms detection algorithm consists of a sequence of image processing operations and gives as output the coordinates of the upper left corner, the height and the width of each detected room. We developed it using OpenCV in Jupyter Notebook environment and we successively implemented it in the *turtlebot3_project_navigation_energy* node.

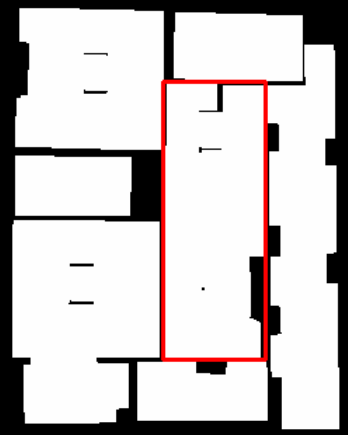


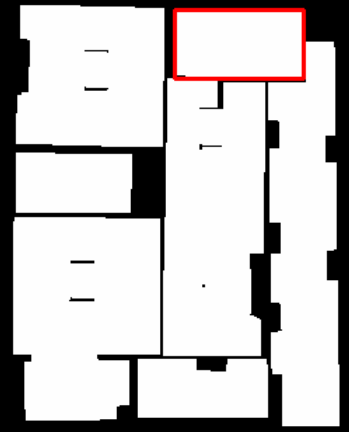
Task 4 – *Room detection algorithm results*

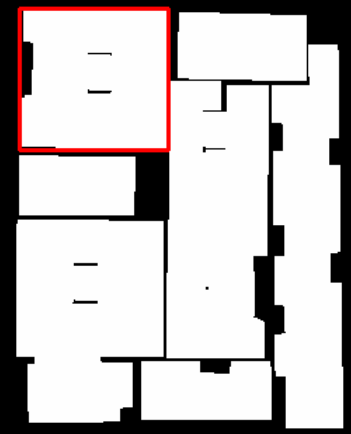
→ Find bounding rectangle, discard if area < threshold


```
lorenzo@MSI-Lorenzo: ~/turtle_ws
lorenzo@MSI-Lorenzo:~$ source /opt/ros/noetic/setup.bash
lorenzo@MSI-Lorenzo:~$ cd turtle_ws
lorenzo@MSI-Lorenzo:~/turtle_ws$ rosrun turtlebot3_project_navigation turtlebot3_project_navigation_energy.py
[INFO] [1643718618.837641, 172.468000]: ROOMS DETECTION AND NAVIGATION NODE
Published!
[INFO] [1643718620.013210, 173.477000]: Map imported successfully!
(384, 384)
[INFO] [1643718620.024009, 173.483000]: In this house I found 7 rooms.
[INFO] [1643718620.028003, 173.485000]: Processing room number 1...
Goals: [303, 198, 325, 198, 325, 245, 303, 245]
303
198
[INFO] [1643718620.030324, 173.489000]: Sending goal: -5.550000, -0.300000
[INFO] [1643718672.682192, 217.127000]: Goal execution done!
```



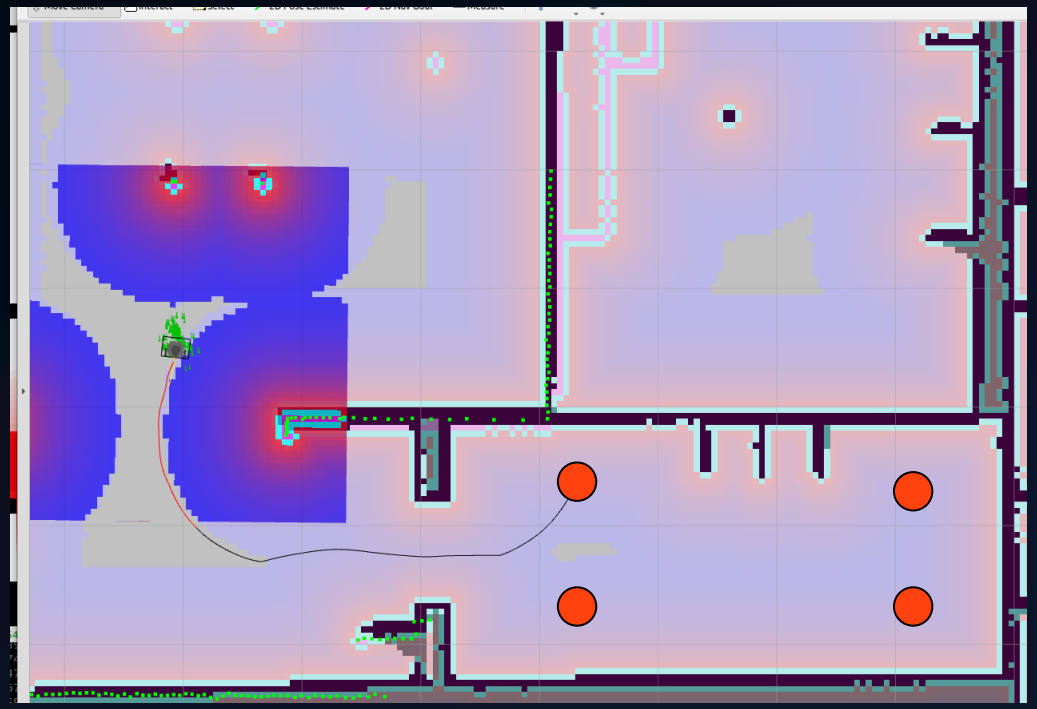






Task 4 - *Turtlebot3_project_navigation_energy*

- This node implements the rooms detection algorithm and sends 4 goals for each detected room, once checked they are not obstacles.



```
lorenzo@MSI-Lorenzo: ~/turtle_ws
orenzo@MSI-Lorenzo:~$ source /opt/ros/noetic/setup.bash
orenzo@MSI-Lorenzo:~$ cd turtle_ws
orenzo@MSI-Lorenzo:~/turtle_ws$ rosrun turtlebot3_project_navigation turtlebot3_project_navigation_energy.py
INFO] [1643718618.837641, 172.468000]: ROOMS DETECTION AND NAVIGATION NODE
ublished!
INFO] [1643718620.013210, 173.477000]: Map imported successfully!
384, 384)
INFO] [1643718620.024009, 173.483000]: In this house I found 7 rooms.
INFO] [1643718620.028003, 173.485000]: Processing room number 1...
oals: [303, 198, 325, 198, 325, 245, 303, 245]
03
98
INFO] [1643718620.030324, 173.489000]: Sending goal: -5.550000, -0.300000
INFO] [1643718672.682192, 217.127000]: Goal execution done!
25
98
INFO] [1643718672.685777, 217.131000]: Sending goal: -6.650000, -0.300000
INFO] [1643718679.438270, 222.738000]: Goal execution done!
25
45
INFO] [1643718679.444751, 222.742000]: Sending goal: -6.650000, -2.650000
INFO] [1643718697.923247, 237.947000]: Goal execution done!
03
45
INFO] [1643718697.928488, 237.954000]: Sending goal: -5.550000, -2.650000
INFO] [1643718714.078954, 251.057000]: Goal execution done!
INFO] [1643718714.085368, 251.062000]: Reached all goals!
INFO] [1643718714.097311, 251.070000]: Checking if sanification complete...
ublished!
```

Task 4 - *Turtlebot3_project_energy_cv*

Pixels to energize

Goals

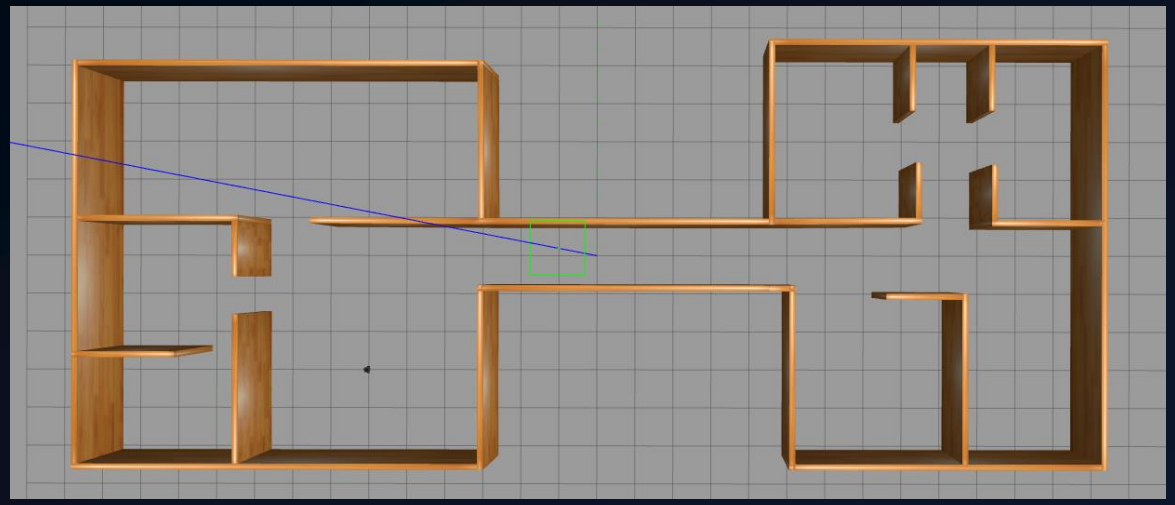
Task 4 – *Navigation and sanification video*

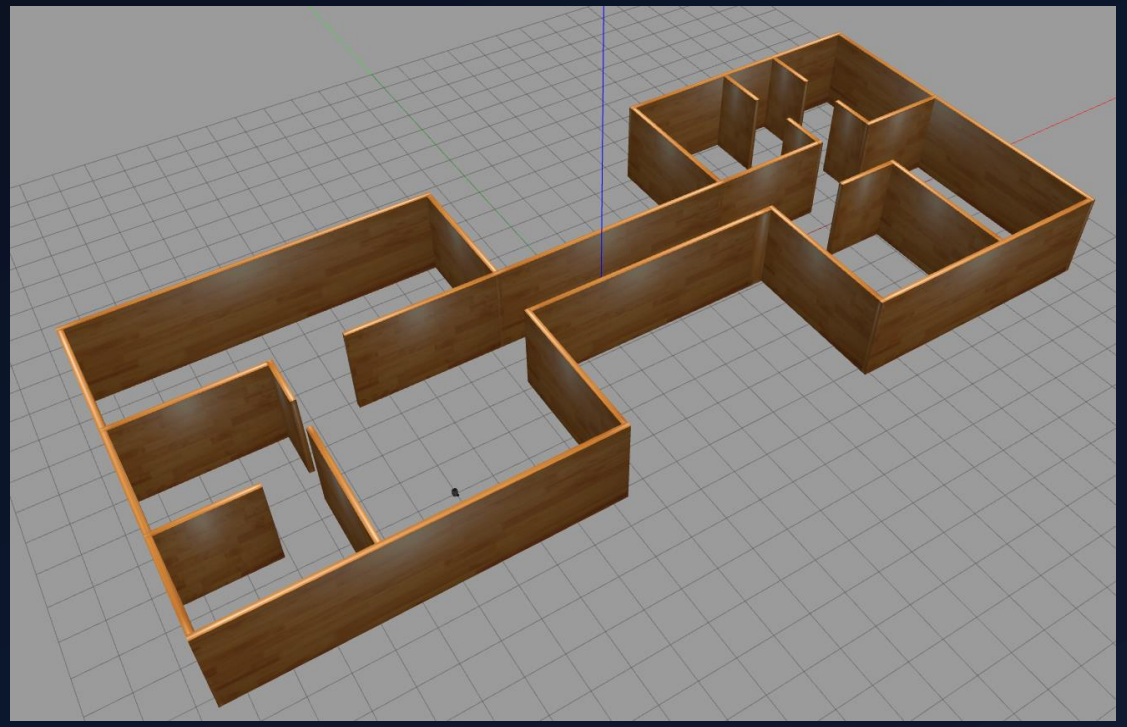
Results

```
lorenzo@MSI-Lorenzo: ~/turtle_ws 63x11
-5.2
[INFO] [1643635629.141529, 2652.168000]: Sending goal_: -7.2000
00, -5.200000
[INFO] [1643635645.277528, 2664.373000]: Goal execution done!
-7.4
-5.800000000000001
[INFO] [1643635645.289509, 2664.380000]: Sending goal_: -7.4000
00, -5.800000
[INFO] [1643635657.916245, 2673.589000]: Goal execution done!
[INFO] [1643635657.927259, 2673.594000]: Map sanified!
```

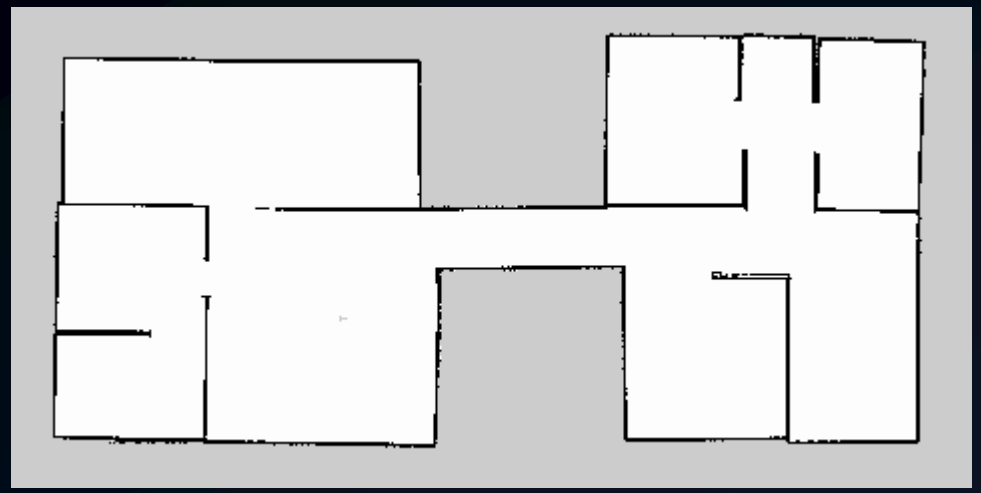
Extra – *Project_house environment*

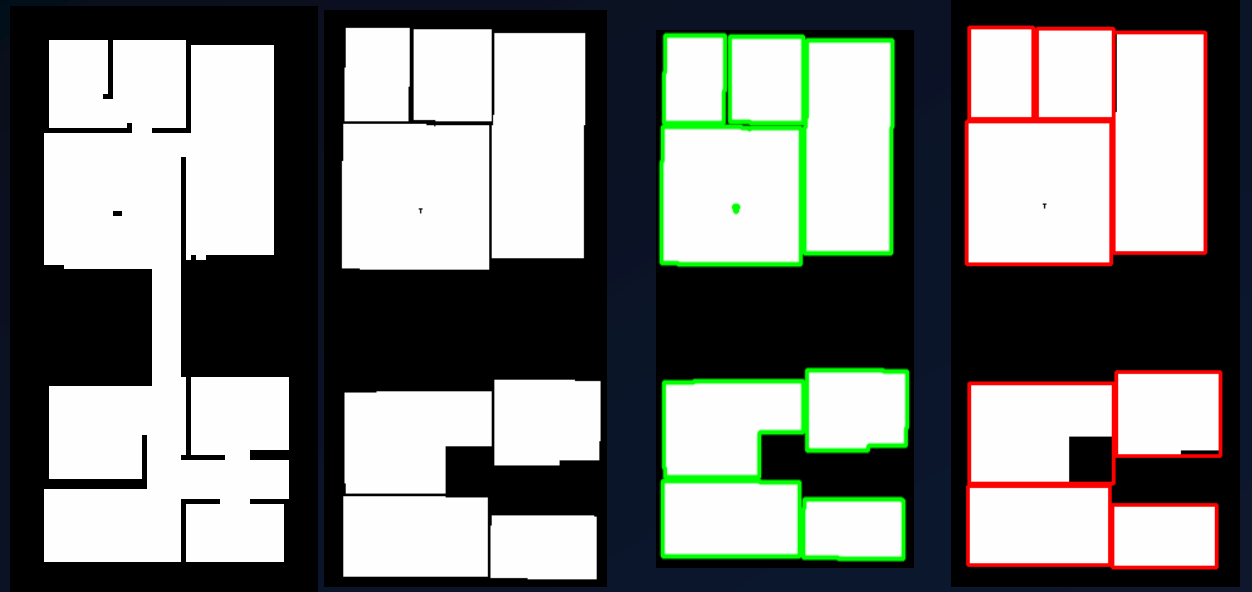
- We created the package turtlebot3_project_house containing a different environment that we used for tests.

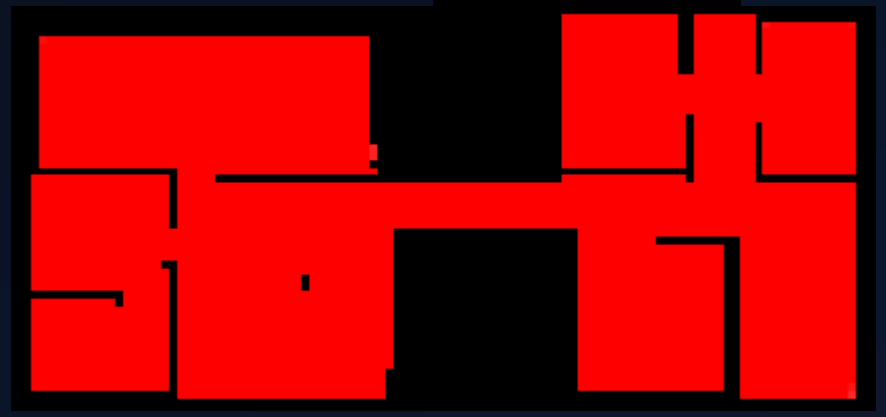




Extra – *Project_house environment* results







Thank You for Your Attention!