EECE5554

Robotics Sensing & Navigation

FINAL PRESENTATION

Collaborative SLAM for Multi-Robot System

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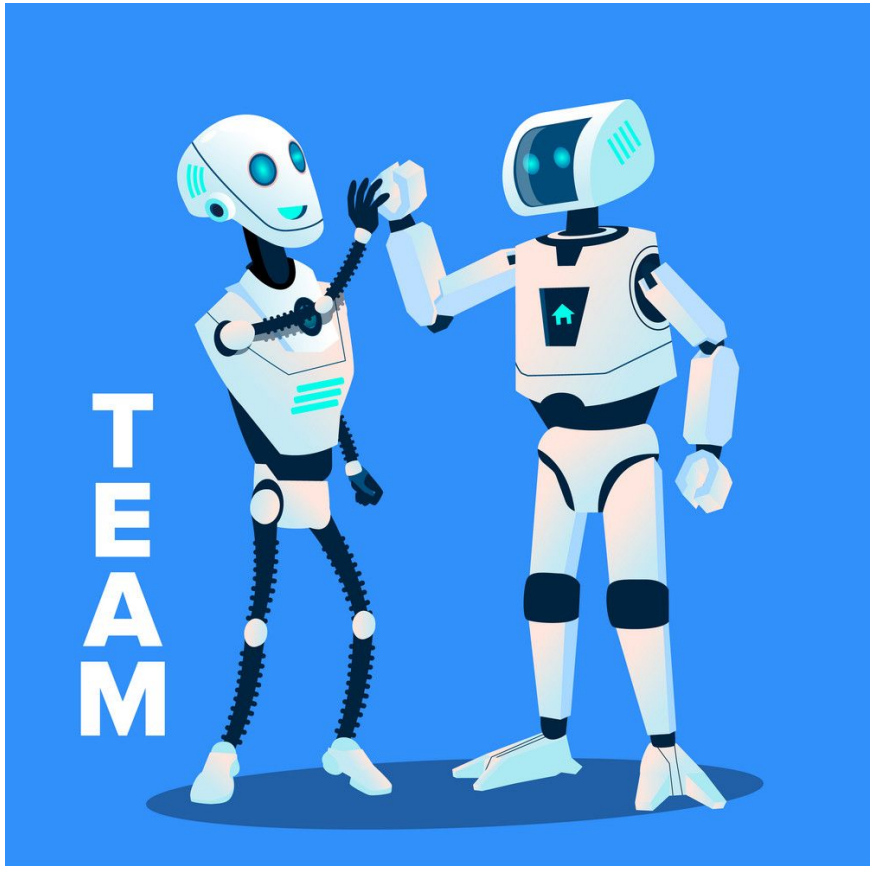
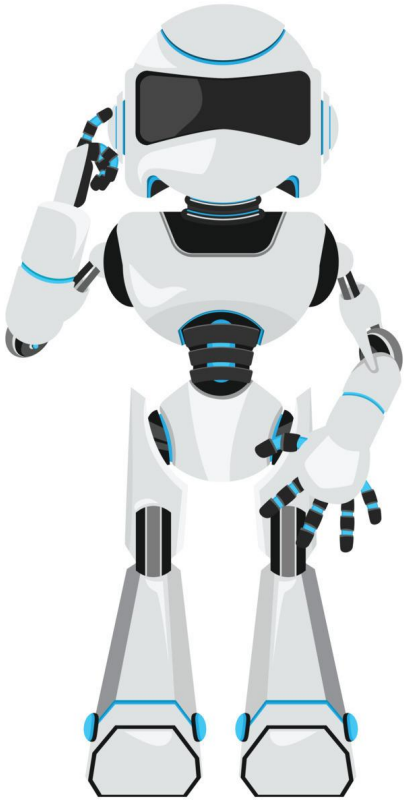


What is SLAM?

- A fundamental problem in mobile robotics
- Role in construction of autonomous robots
- Build a map of its surroundings while simultaneously localizing itself within the map



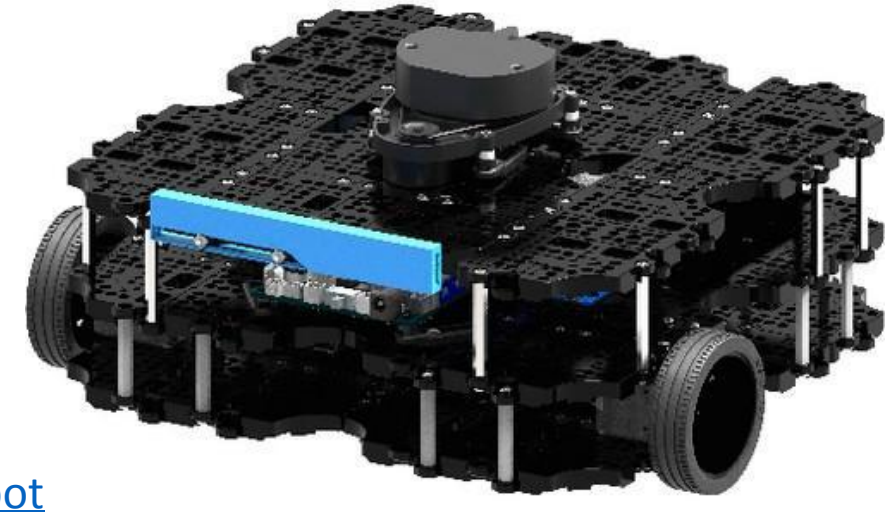
Proposal

- In the future, there will be multiple robots deployed in a space and will be expected to work collaboratively
- Collaborative perception is an important problem for the future of robotics
- Collaborative SLAM is a natural extension of both SLAM and collaborative robotics
- This project aims to create a package as a tool for multiple robots to build a shared map of the environment
- This can significantly improve the accuracy and speed of the mapping process

Method of Implementation

Turtlebot3 - Waffle Pie

- A modular differential drive robot
- LIDAR and camera for sensing
- https://emanual.robotis.com/docs/en/platform/turtlebot3/features/#specifications – for more information



ROS Package

- Create a ROS package to implement SLAM and autonomous navigation
- Implement multiple robots simultaneously.
- Builds local maps individually by each robot and merge them to create a new global map
- Simulate collaborative mapping in Gazebo and Rviz

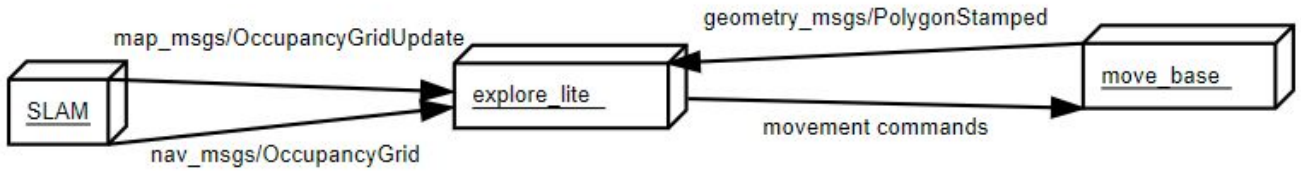
Mapping and Navigation

SLAM

- Gmapping - laser-based SLAM
- Create a 2D occupancy grid map from laser and pose data collected by a mobile robot
- Modified Rao-Blackwellized particle filters as effective means to solve the SLAM problem
- Subscribed topics
  1. /tf -Transforms necessary to relate frames for laser, base, and odometry
  2. /odom - Odometry from robot wheels
  3. /scan - Laser scans to create the map
- Published topics
  1. /map_metadata - Get the map data from this topic, which is latched, and updated periodically
  2. /map - Get the map data from this topic, which is latched, and updated periodically
  3. ~entropy - Estimate of the entropy of the distribution over the robot's pose (a higher value indicates greater uncertainty)

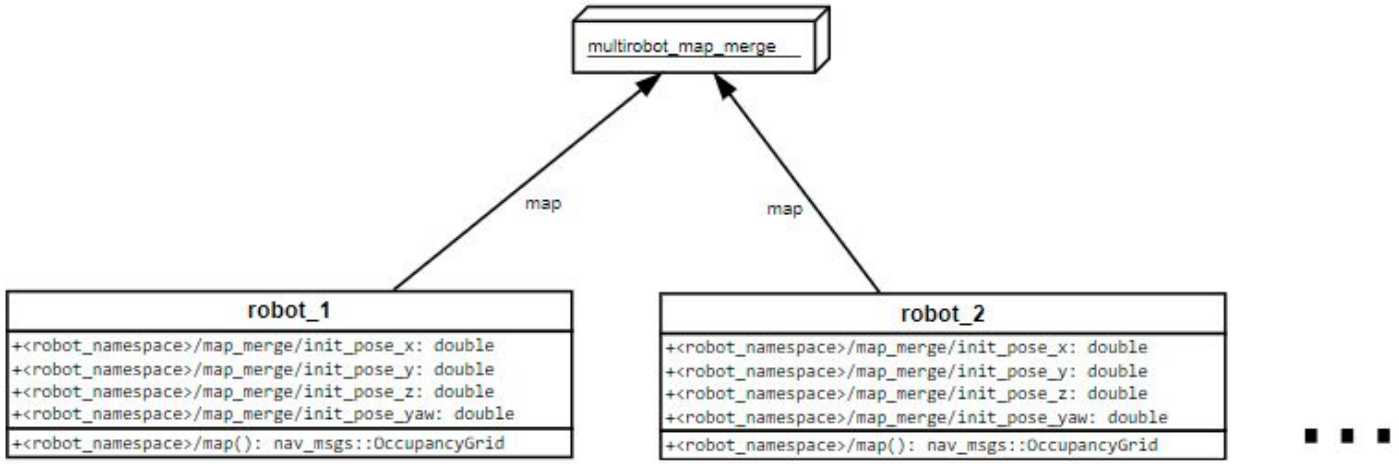
Exploration

- explore_lite - greedy frontier-based exploration
- Commands for robot movement are send to move_base node
- Subscribed topics
  1. /costmap - Map which will be used for exploration planning
  2. /costmap_updates - Incremental updates on costmap (usually not used)
- Published topics
  1. ~frontiers - Visualization of frontiers considered by exploring algorithm. Each frontier is visualized by frontier points in blue, size represents the cost
- Actions called
  1. move_base - API for posting goals



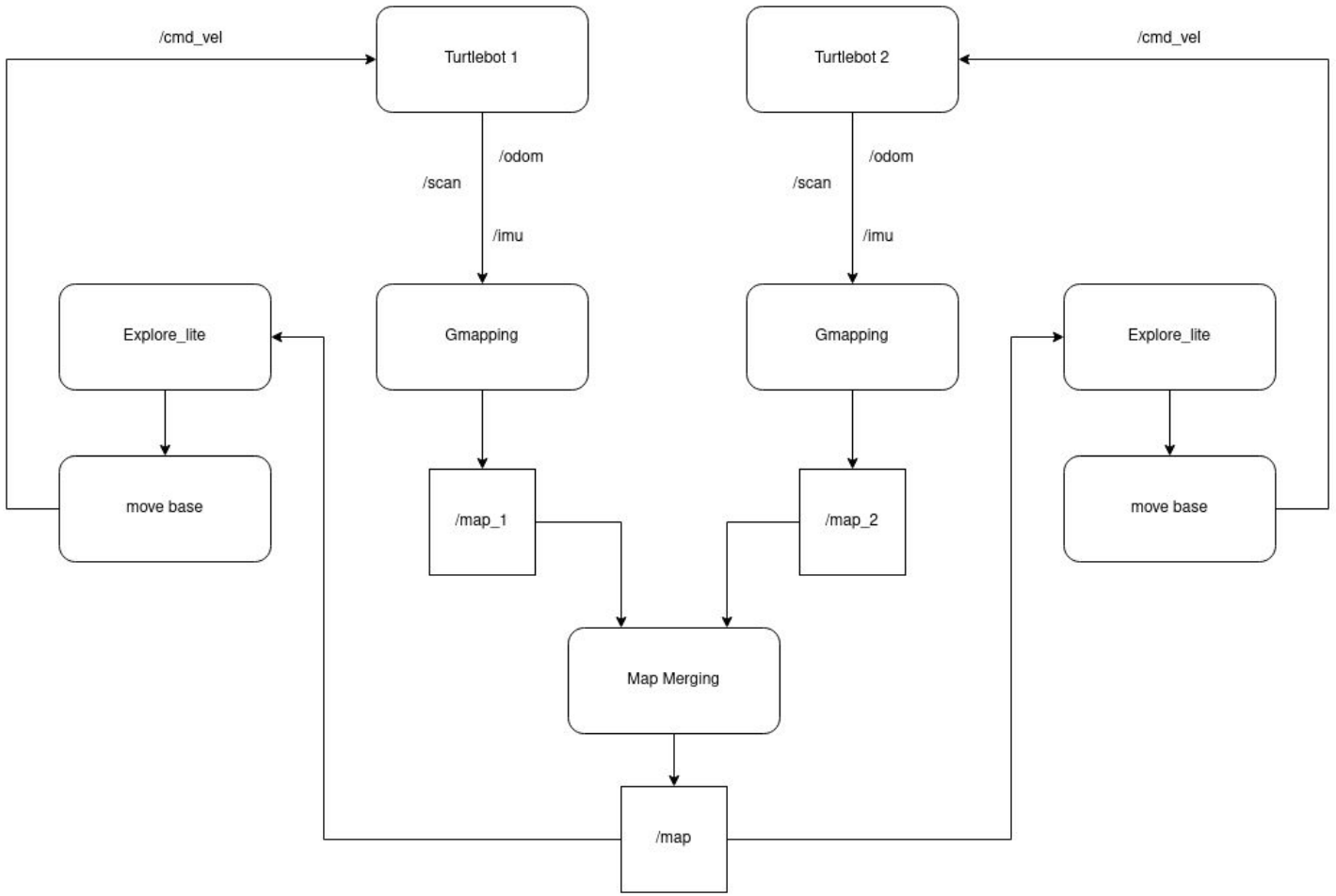
Map Merging

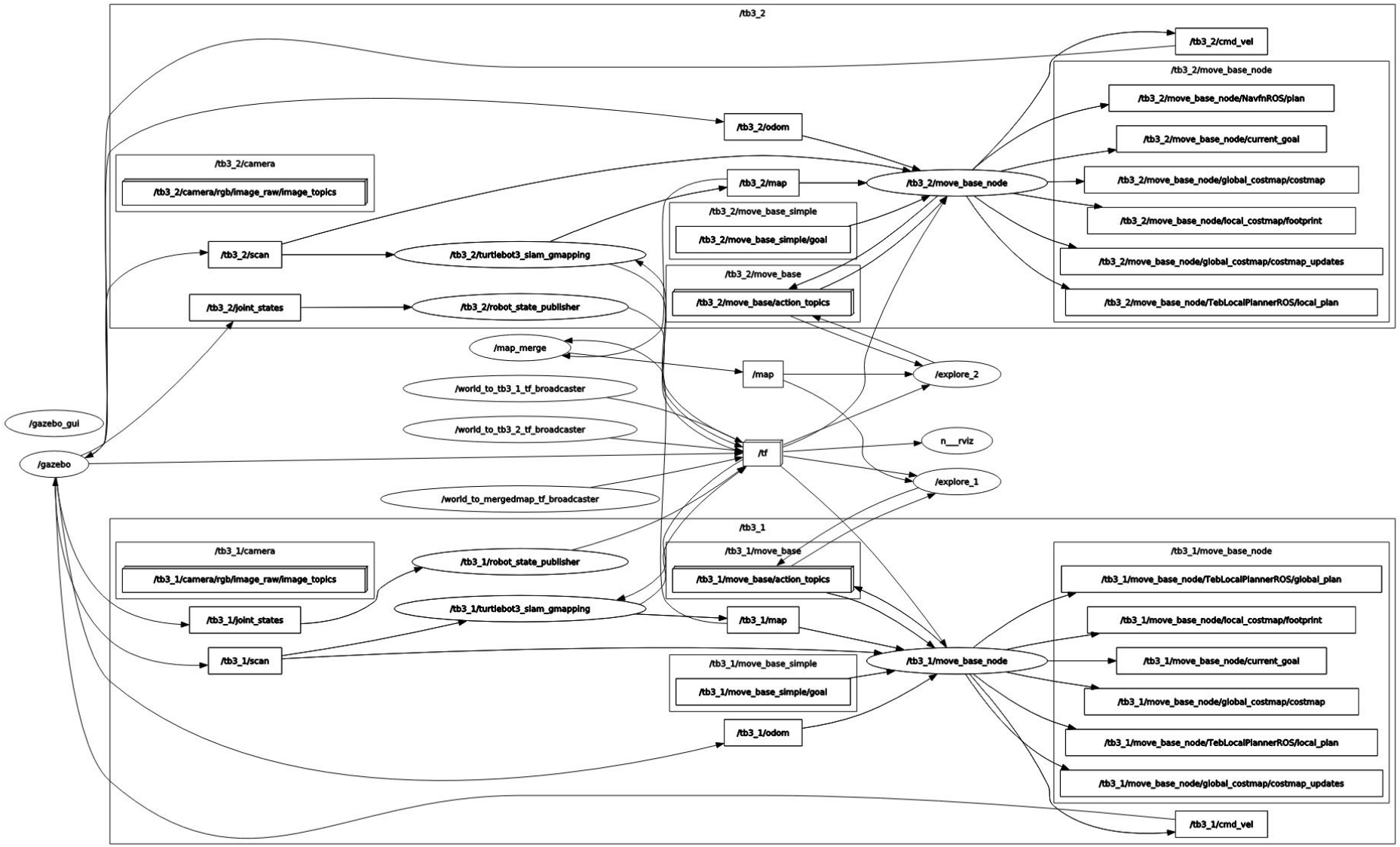
- multirobot_map_merge - provides global map for multiple robots
- Inspired by computer vision image stitching techniques for creating photo panoramas
- Subscribed topics
  1. <robot_namespace>/map - Local map for specific robot
- Published topics
  1. /map - Merged map from all robots in the system



ROS Software Structure

High Level Structure:




/tb3_2
/tb3_2/cmd_vel
/tb3_2/move_base_node
/tb3_2/move_base_node/NavfnROS/plan
/tb3_2/move_base_node/current_goal
/tb3_2/move_base_node/global_costmap/costmap
/tb3_2/move_base_node/local_costmap/footprint
/tb3_2/move_base_node/global_costmap/costmap_updates
/tb3_2/move_base_node/TebLocalPlannerROS/local_plan
/tb3_2/odom
/tb3_2/camera
/tb3_2/camera/rgb/image_raw/image_topics
/tb3_2/map
/tb3_2/move_base_node
/tb3_2/move_base_simple
/tb3_2/move_base_simple/goal
/tb3_2/move_base
/tb3_2/move_base/action_topics
/tb3_2/scan
/tb3_2/turtlebot3_slam_gmapping
/tb3_2/joint_states
/tb3_2/robot_state_publisher
/map_merge
/map
/explore_2
/world_to_tb3_1_tf_broadcaster
/world_to_tb3_2_tf_broadcaster
/gazebo_gui
/gazebo
/tf
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/explore_1
/world_to_mergedmap_tf_broadcaster
/tb3_1
/tb3_1/camera
/tb3_1/camera/rgb/image_raw/image_topics
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/tb3_1/move_base_node
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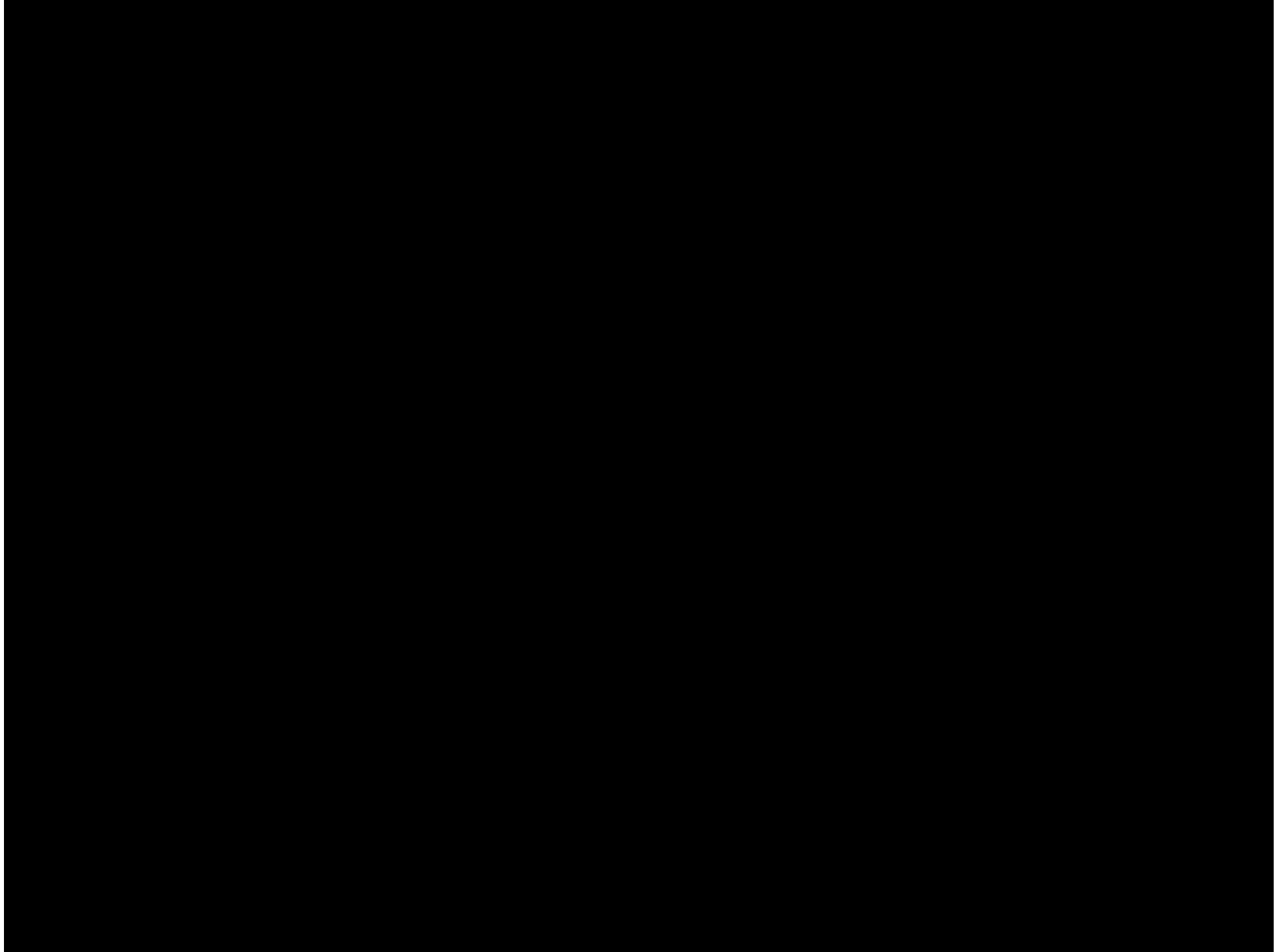
/tb3_1/move_base_node/TebLocalPlannerROS/local_plan
/tb3_1/move_base_node/global_costmap/costmap_updates
/tb3_1/cmd_vel

Result



Future Directions

TO IMPROVE THE PACKAGE TO MERGE MAPS WHEN THE INITIAL POSITION OF ROBOTS ARE NOT KNOWN

IMPROVE NAVIGATION USING LOCAL MAPS WHEN GLOBAL MAP IS UNAVAILABLE OR NOT MERGED YET

IMPROVE PATH PLANNING TO MAKE DIFFERENT ROBOTS EXPLORE DIFFERENT FRONTIERS

WORK ON LOCALIZATION PART OF THE SLAM

HOW TO USE LOCAL MAPS AND THE POSITION ON ONE ROBOT IN MAP TO IMPROVE THE LOCALIZATION OF OTHER ROBOTS

References

- https://github.com/ROBOTIS-GIT/turtlebot3
- http://wiki.ros.org/gmapping
- http://wiki.ros.org/explore_lite
- http://wiki.ros.org/multirobot_map_merge
- http://wiki.ros.org/move_base

THANK YOU