EbyT Technologies

LASER SCANNER BASED EXPLORATION OF UNKNOWN INDOOR SPACE BY ROBOTIC SYSTEM.

MATLAB EXPO 2019
Bangalore

AGENDA

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ABOUT EBYT TECHNOLOGIES

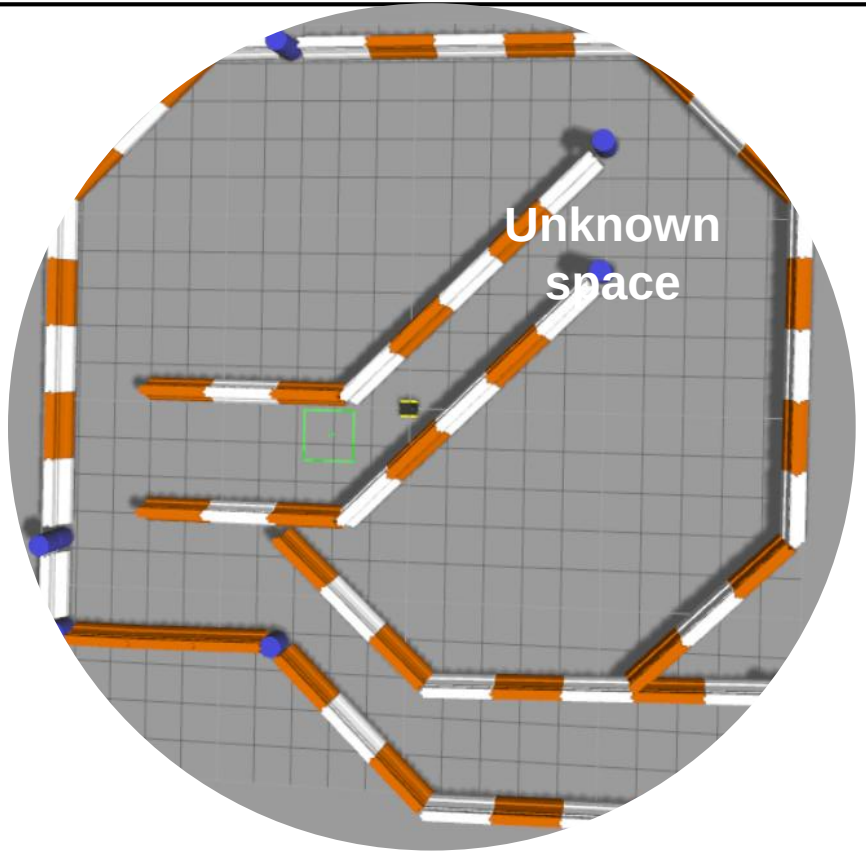
The EbyT Technologies is an Automotive and an Engineering consultancy company offering services to customers.

The core team of EbyT is having 45+years of experience in the field of powertrain development and calibration, benchmarking, engine and vehicle functional validation, automotive manufacturing.

We at EbyT work with the latest development tools and methodologies required for the successful execution and management of projects on automotive and Off-Highway engines, vehicles, transmissions, hybrid and electrification.

PROBLEM STATEMENT

- Robotic systems are often required to carry out given tasks in environments that are partially or completely unknown.
- Sensing, planning and motion execution must then be appropriately interlaced to discover and navigate the portions of the environment that are relevant to the assigned task.
- This presentation focuses on sensor-based motion planning that addresses the problem of finding a collision free path from a start configuration to a goal configuration in an unknown environment.



APPROACH
CONCEPT

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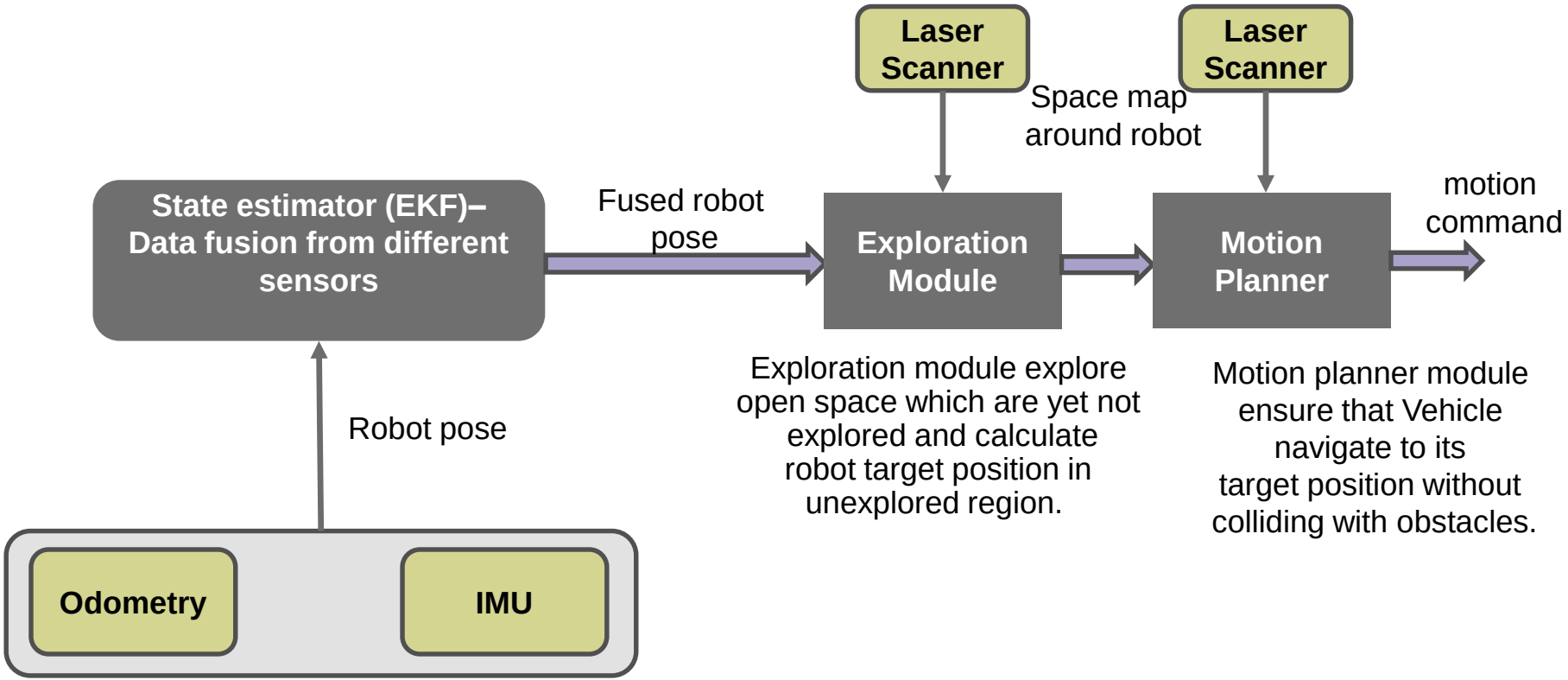
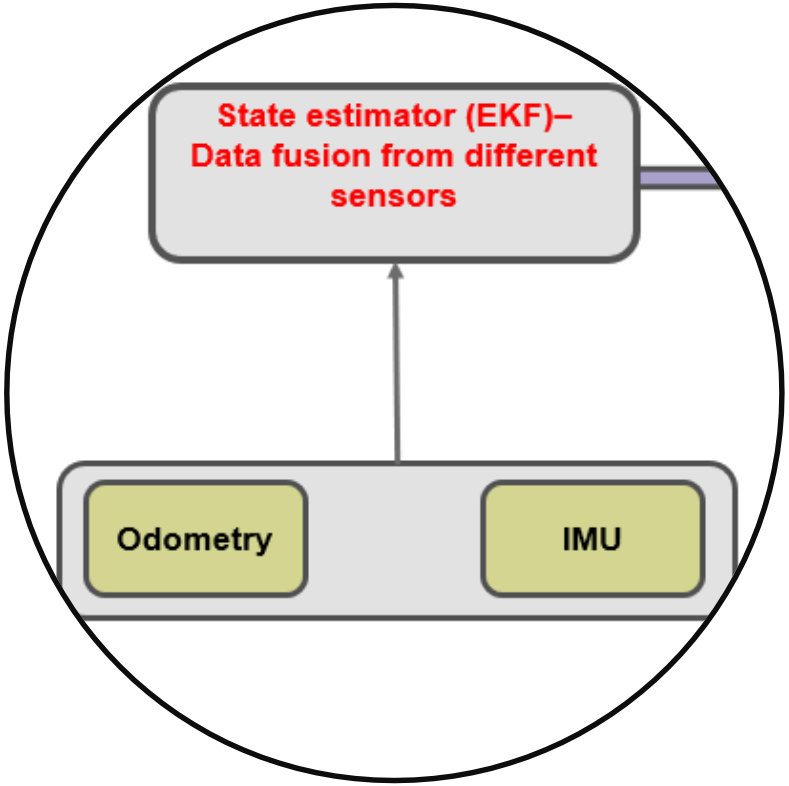


STATE ESTIMATION

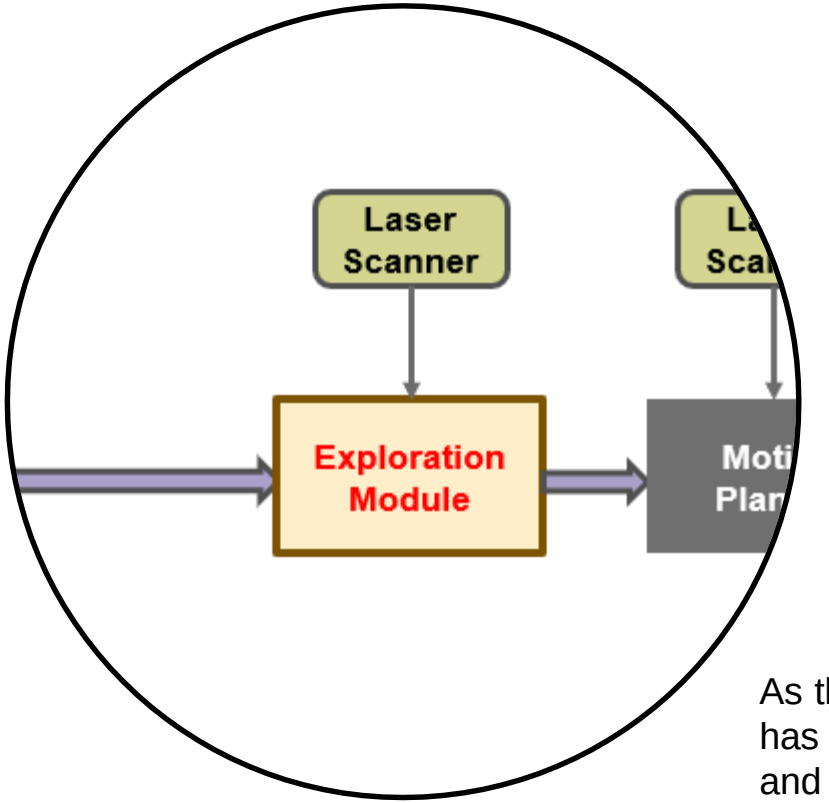
EXTENDED KALMAN FILTER- SENSOR FUSION



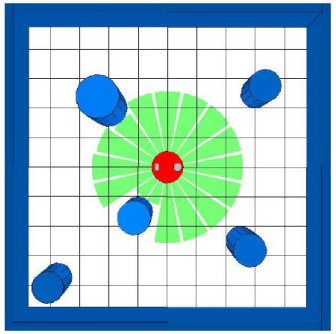
This is a ROS node (Robot Operating System) that takes robot pose information from different sensors such as odometry, IMU and fuse the data to get the final robot pose.

EXPLORATION MODULE

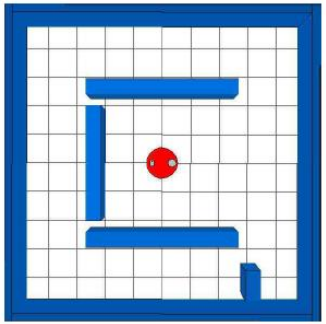
RANDOMIZED TREE ALGORITHM

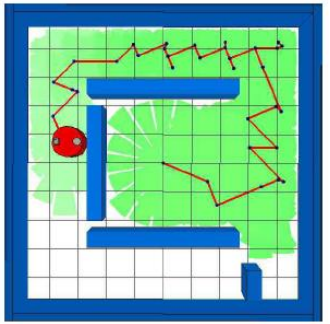


Source: The SRT Method: Randomized strategies for exploration



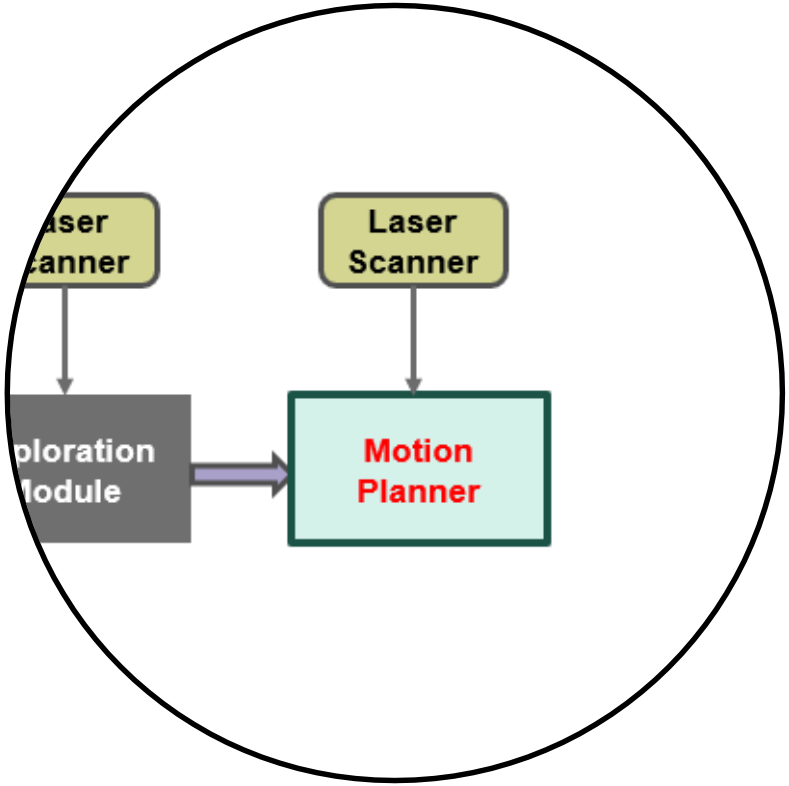
The method is based on the randomized incremental generation of a data structure called Sensor-based Random Tree (SRT), which represents a roadmap of the explored area with an associated safe region.

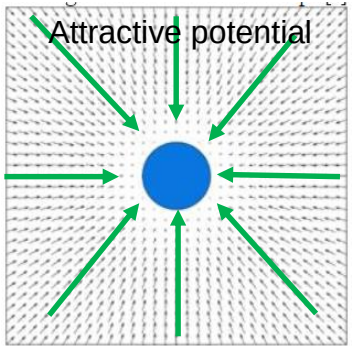


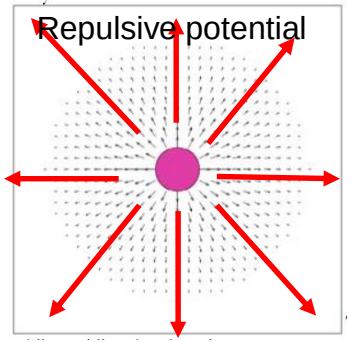


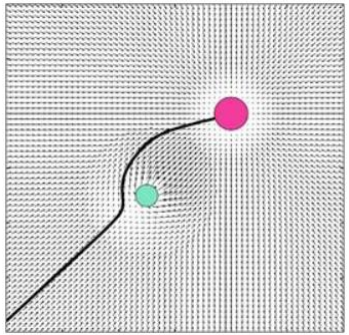
As the robot gets LS data it calculates the target position where it has to go next. At new position robot scans the area around it and calculates the new target position. until whole unexplored area is explored.

MOTION PLANNER
POTENTIAL FIELDS









The basic idea of the potential fields method is to fill the robot's workspace with the artificial potential field in which the robot is attracted to its target positions and is repulsed away from the obstacles.

CHALLENGES IN DESIGN & SIMULATION

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- The main challenge was to check the concept in simulation. Setting simulation environment in ROS is easy.
- ROS libraries are implemented in advance C++ language. Understanding the libraries and implementing the algorithms in C++ carries long lead time.
- The ease MATLAB provides in including equations, generating data pertaining to the equations helps ease the algorithm development process. MATLAB provided seamless experience of integrating ROS services and data structures into MATLAB.
- MATLAB scripting has reduced coding time of exploration and navigation modules.
- Lot of low level details required for coding in C++ has been avoided due to coding in MATLAB.
- MATLAB provides a platform wherein the entire simulation can be performed in short time.

MODELING IN MATLAB

HIGH LEVEL ARCHITECTURE

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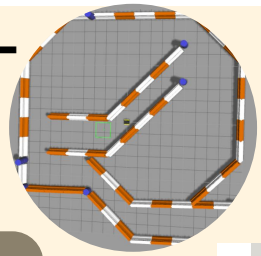
Robot Operating System – Simulation environment



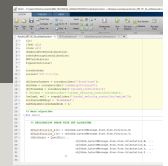
LIDAR

LIDAR

State estimator (EKF)– Data fusion from different sensors

Exploration Module

Motion Planner



Matlab – ROS toolbox

Odometry

IMU

- Exploration and navigation modules are coded in MATLAB.
- Modules interface with ROS is provided with MATLAB ROS toolbox.

MODELLING IN MATLAB

INTERFACING BETWEEN ROS & MATLAB

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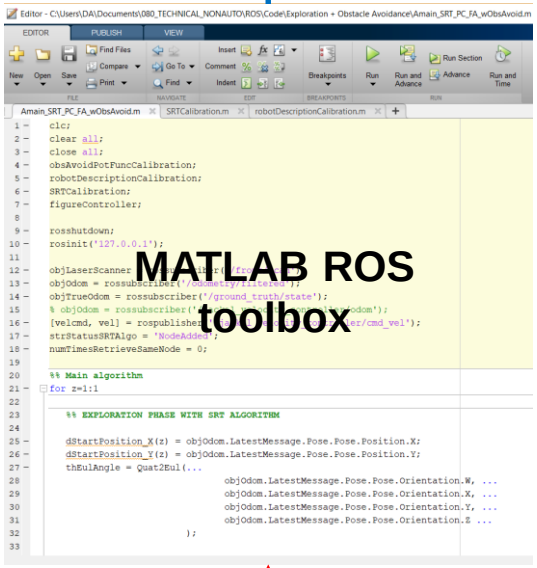
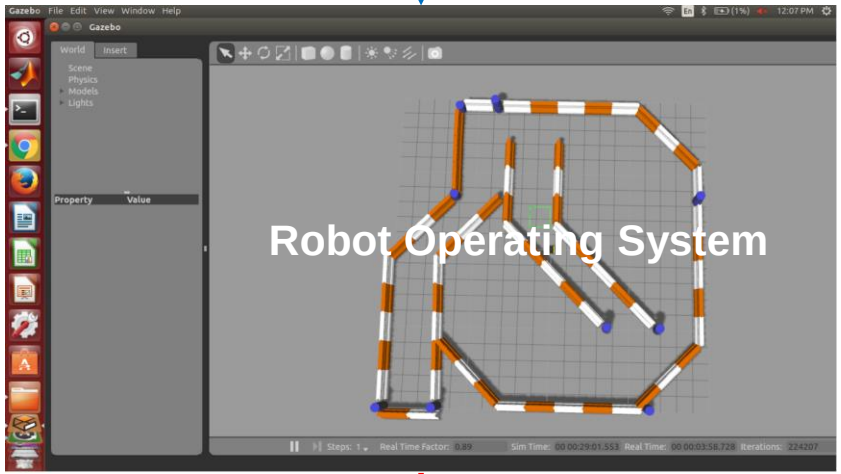
MATLAB

- **Target position**
- **Velocity**





ROS

- **Odometry**
- **Sensor – IMU, Laser scanner**

RESULTS
ROBOT PATH IN EMPTY SPACE

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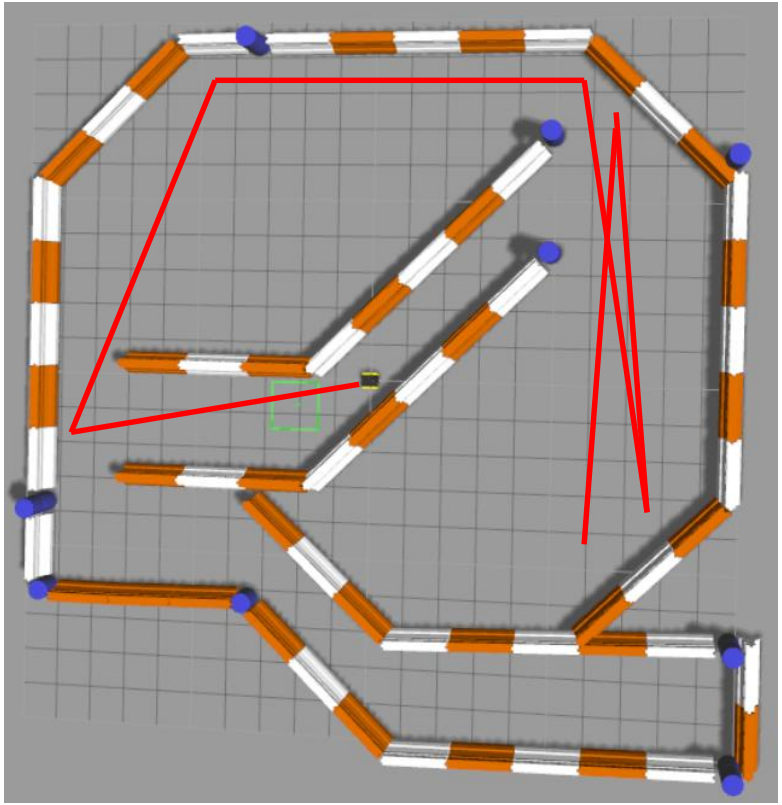

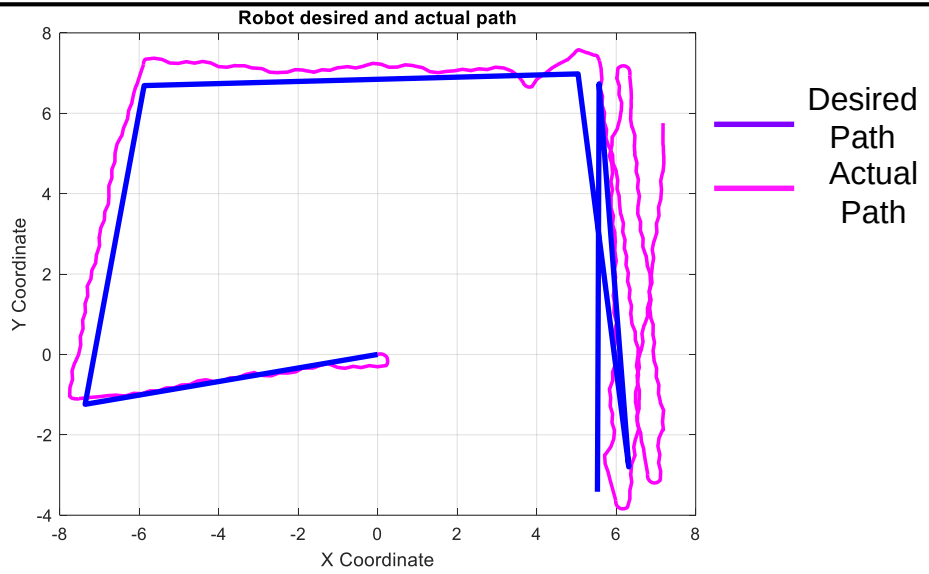

Exploration module calculates the robot target position based on laser scan data. The region which is not explored is selected to calculate the robot target position.

RESULTS
EXPLORED AREA BY ROBOT

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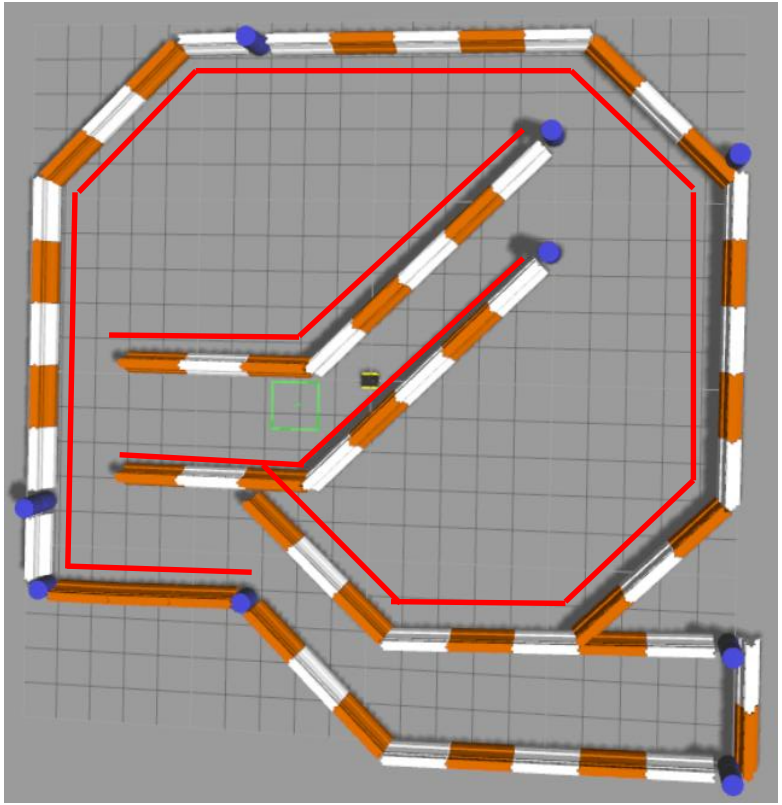

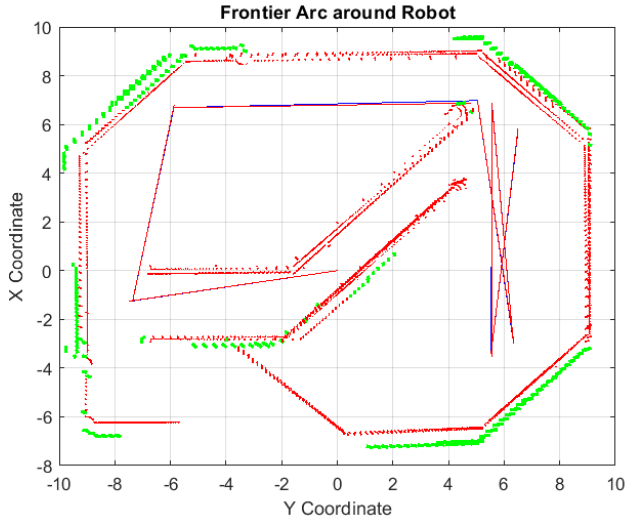

Above plot shows the explored region that is calculated from laser scan data. The area marked by red lines have been explored by robot.

FUTURE SCOPE

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The work presented in this presentation can be extended to different applications:

- The concept can be used to explore unknown indoor spaces such as warehouses, storages or places difficult for human exploration such as terrorist hideouts.
- The Lidar based exploration can be used to map out the free space for effective space planning and optimization mainly in offices, malls and warehouses.
- If the exploration module is combined with the SLAM module (Simultaneous Localization and Mapping) then the work can be extended to not only for autonomous exploration but also to develop the map of the indoor locations. The indoor maps are very helpful for space planning in big office buildings.

SUMMARY

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- If the exploration module has to be developed in C++ as a ROS node, it would have taken a long time.

- The use of MATLAB for application development has simplified the concept testing of robot navigation in unexplored space.

- MATLAB ease of integration with ROS through ROS toolbox simplified the algorithm development time by allowing team to focus only on application development rather than focusing on low level details.

- MATLAB coder can be used to develop ROS node thus saving time in writing code in C++.

Thank you