Cairo University
Faculty of Engineering
Cognitive Robotics

Project Document

1. Project Overview

This project aims to apply the concepts of cognitive robotics to implement a **S**imultaneous **L**ocalization **a**nd **M**apping(**SLAM**) algorithm, and then apply it on **Gazebo** and **RViz** simulation tools using a real-life robot model in a realistic environment from scratch.

2. Robot Overview

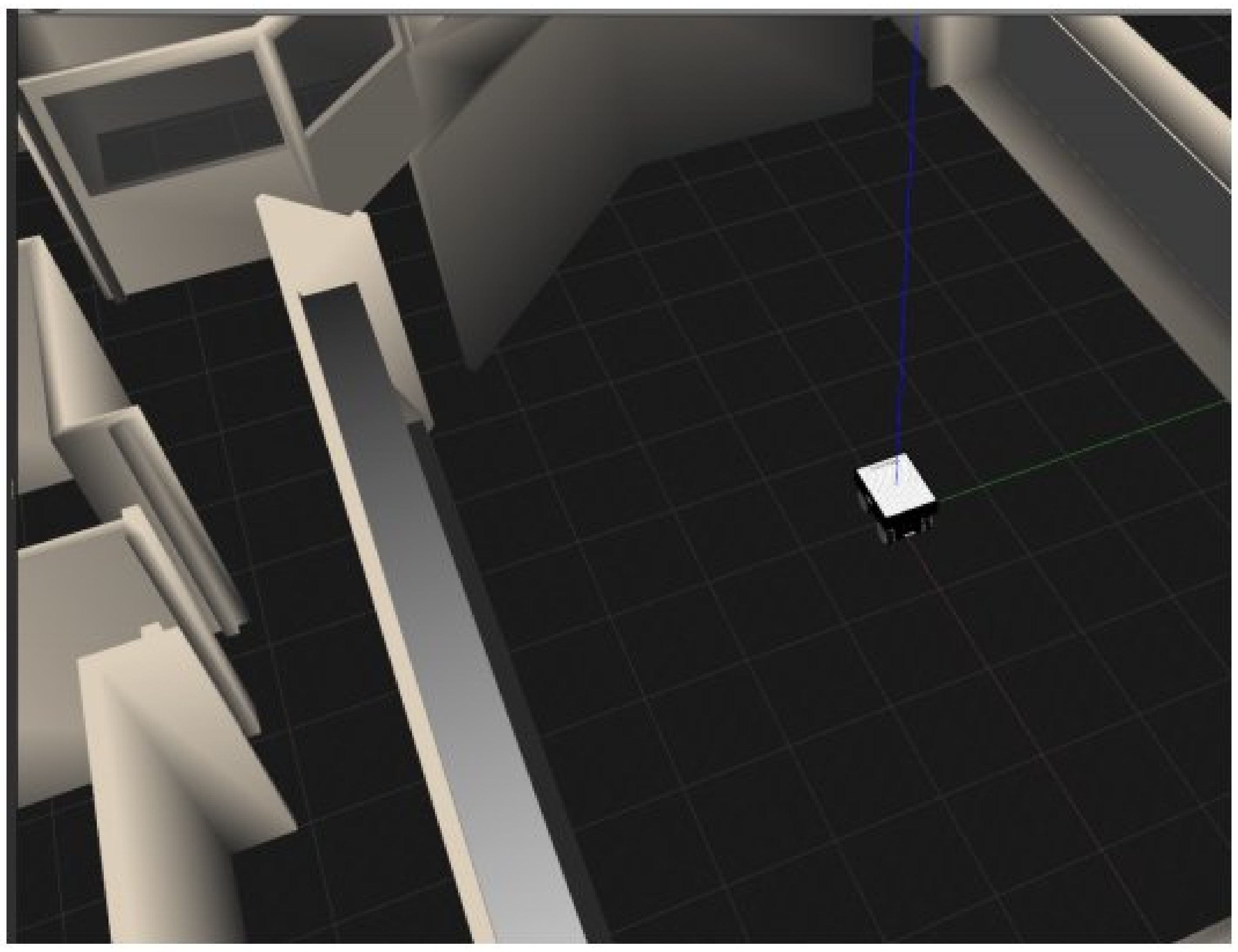
SUMMIT-XL is a highly versatile Autonomous Mobile Robot (AMR) capable of carrying loads of up to 65 Kg. The platform allows two types of configurations: with mecanum wheels or with rubber wheels. The former are recommended for indoor places while the latter are appropriate for outdoor environments. This makes the robot an agile and highly mobile vehicle. The common sensor options include a **Hokuyo laser scanner** and a range of RTK-DGPS kits . Likewise, it has internal and external connectivity to easily connect all kinds of components. SUMMIT-XL uses the ROS[1] open architecture in order to implement algorithms that make the robot operate autonomously, the manufacturer also provides a **gazebo model** that exactly operates like the real one in the simulation world.

Summit_XL robot

[1] Robotnik SUMMIT-XL in ROS

3. Environment Overview

Willow garage is one the most popular indoor simulation environments in Gazebo. It consists of many walls that are put together to form multiple rooms. Willow garage is commonly used for testing SLAM and path planning algorithms.



Willow garage in Gazebo

Willow garage top view

4. Requirements

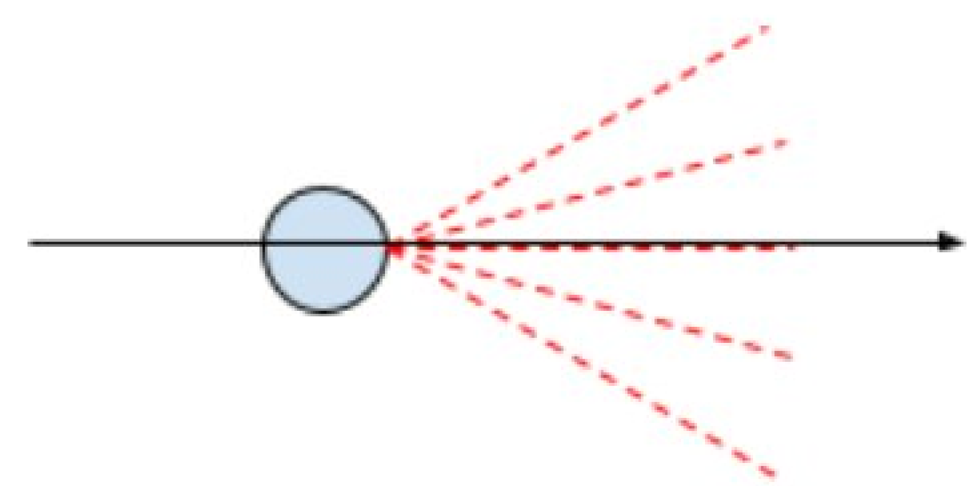
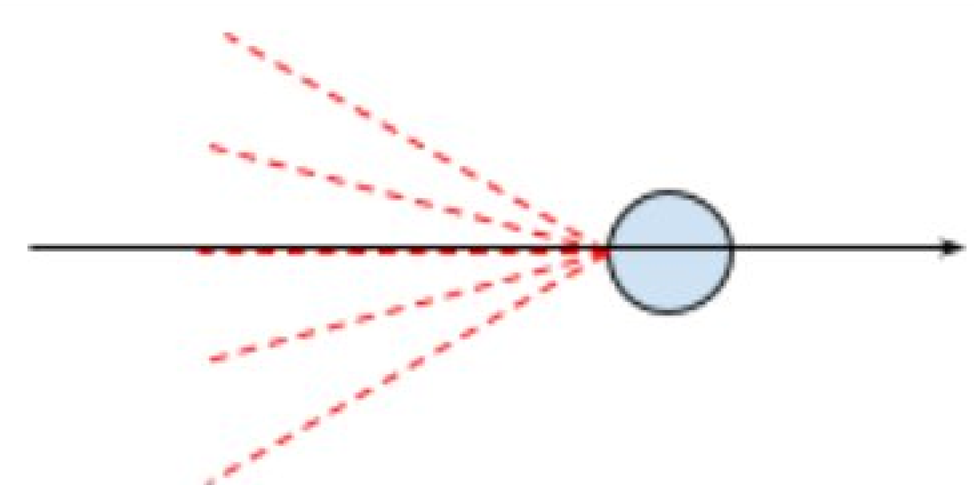
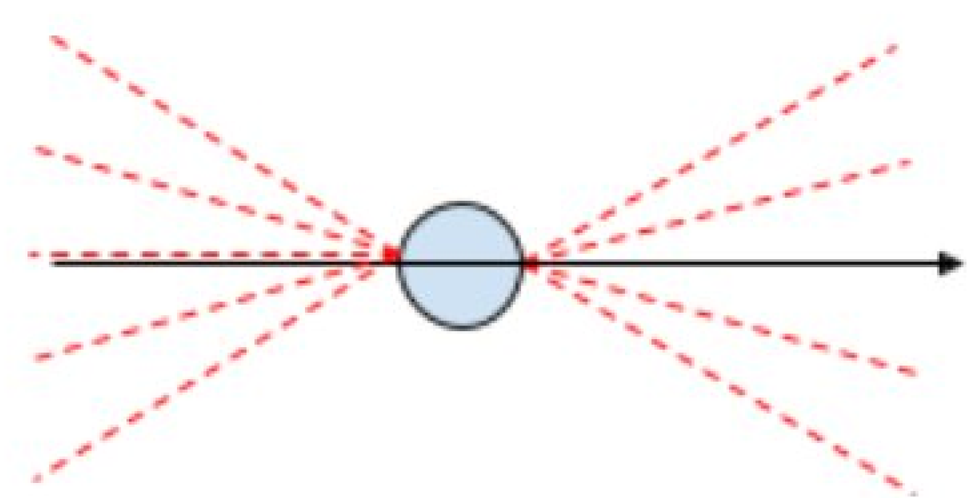
The main goal of this project is to implement a SLAM algorithm from scratch that takes as input the odometry and laser readings, and gets the current pose and map of the environment at any given time in the simulation. In order to implement this, you will need to follow these steps:

a. Robot Control

It is required to be able to control your robot in-order to test any next implementations. Controlling a robot in real-life usually requires a joy-stick or keypad. It is required to implement an algorithm from scratch to control the robot's linear and angular velocities using the keys [W A S D]. W and S keys should only move the robot forward and backward when pressed (increase or decrease linear velocity), A and D keys should rotate the robot's heading to left and right (increase or decrease angular velocity). When no keys are pressed, the robot should not be moving after a short time period.

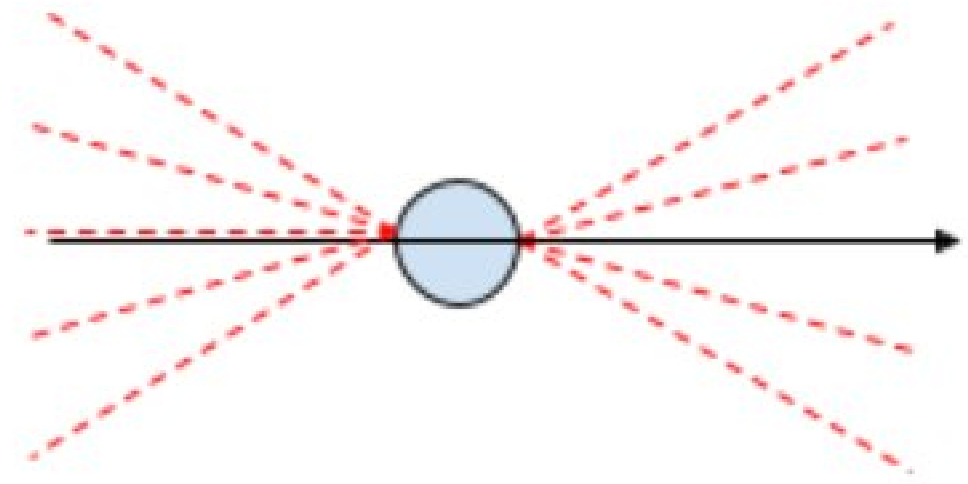
b. Sensor Incorporating and Alignment

Summit_XL has front laser sensor, rear laser sensor and odometry. At any given time, the robot needs to be aware of all its behind and front surroundings in the environment. In order to get such knowledge, a sensor incorporation between front and rear lasers is required. The inputs and outputs of this requirement are:

Input	Front laser readings at time t	
Input	Rear laser readings at time t	
Input	Odometry readings at time t	
Output	All around laser readings + odometry readings at time t	

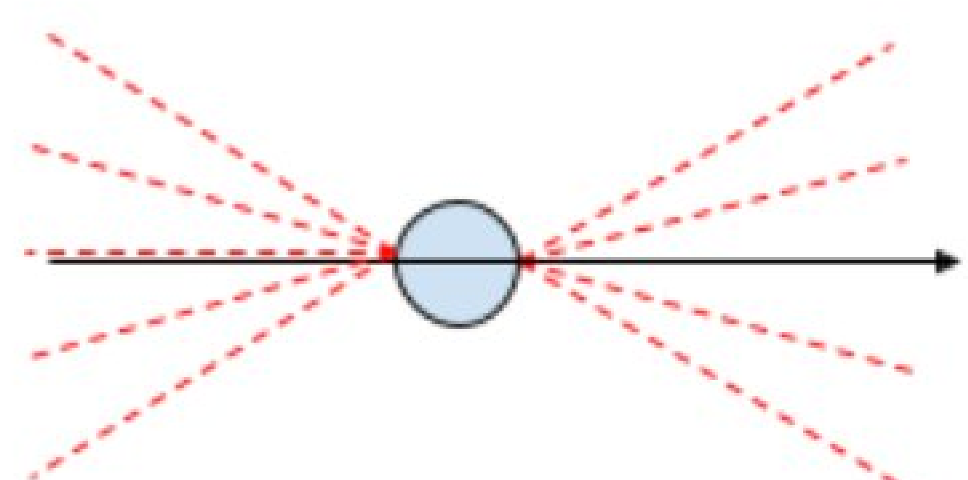
c. Mapping with known poses

Mapping can be built using the resulting **sensor readings** from the above requirement along with the **ground truth position**. Assuming you have the ground truth position, build the map of the environment as the robot navigates it. The inputs and outputs of this requirement are:

Input	All around laser readings + odometry readings at time t	
Input	Ground truth position at time t	
Output	Estimated Map at time t	

d. Simultaneous localization and mapping

After being able to build a map with known poses, the assumption of knowing the ground truth is removed, and you have to build the map and estimate your pose simultaneously with only laser and odometry readings. The inputs and outputs of this requirement are:

Input	All around laser readings + odometry readings at time t	
Output	Estimated position at time t	

Output	Estimated map at time t	

5. Suggested Plan

Phase 1	1. Simulation contains Summit_XL and willow garage environment 2. Robot control module 3. Sensor incorporation and alignment module 4. Mapping with known poses module 5. Map visualization on rViz or any visualization library	Week 11
Phase 2	SLAM module	Week 13

6. Deliverables

1. Simulation contains Summit_XL and willow garage environment 2. Robot control module 3. Sensor incorporation and alignment module 4. Mapping with known poses module 5. Map visualization on rViz or any visualization library 6. SLAM module	Week 13