Autonomous Navigation using ROS 2

Introduction:

In the ever-evolving landscape of technology, the fusion of robotics and autonomous systems stands at the forefront of innovation. At this exclusive workshop, delve into the intricate world of Robot Operating System 2 (ROS2), the cornerstone of autonomous robotics. Have a deep dive into the theoretical foundations and practical applications, providing you with a unique opportunity to master the art of creating intelligent, self-navigating robots.

Abstract:

In Session 1, explore the fundamentals of ROS2 and learn to set up Nav2 and essential prerequisites for a robust development environment. Dive into AMCL, and SLAM, creating detailed environment maps in Gazebo. Experience autonomous rover navigation using these maps and understand the top-level architecture of the Nav2 stack, setting a solid foundation for advanced topics.

Session 2 delves into path planning algorithms: Breadth-First Search, Depth-First Search, Dijkstra, A*. Build your virtual world for navigation in Gazebo and interact programmatically with Nav2.

Duration: (2 sessions; 3 hours each)

Session 1	· Introduction to ROS2 and its elements · Setup and Installation of Nav2 and other requirements · Understanding Adaptive Monte Carlo Localization (AMCL) and Simultaneous Localisation and Mapping (SLAM) · Generating a Map of the Environment using SLAM in Gazebo

	5) Make the Rover Navigate with the Generated Map Autonomously 6) Understanding the Top level Architecture of Nav2 Stack
Session 2	7) Brief about Static and Dynamic Path Planning Algorithms in Robotics (Breadth First Search, Depth First Search, Dijkstra, A*) 8) Build your own world for Navigation in Gazebo 9) Interact Programmatically with Nav2 Stack

Prerequisites:

- Basic Programming Knowledge with Python
- Laptop running Ubuntu 22.04 with ROS 2 Humble Hawksbill installed

System Requirements:

- Operating System: Ubuntu 22.04 LTS
- Processor: Eight cores, x86_64 (64-bit x86 Instruction Set)
- HDD or SSD Storage Space: 30GB or more
- RAM: 8GB or more
- Dedicated graphics card: Preferable

Note: Ensure your laptop meets the specified requirements for a smooth workshop experience. You have two options for installing Ubuntu 22.04 on your laptop: using a **virtual machine or setting up a dual boot**. We **highly recommend dual booting** for stability, especially when using the Gazebo simulator in our workshop. Please check your laptop's available free space before proceeding with the dual boot installation.

Useful Links:

- Download Ubuntu 22.04 Desktop image
- Ubuntu 22.04 Dual boot reference video
- ROS 2 Humble installation guide
- Installation video guide
- Bonus Playlist: ROS2 Humble Basics

Please make sure to review these resources to prepare your system adequately for the workshop.

Detailed Plan

Session 1

1) Introduction to ROS2 and Its Elements:
In this segment, we will provide an overview of Robot Operating System 2, exploring its core concepts and architecture.

2) Setup and Installation of Nav2 and Other Requirements:
This section focuses on the installation of Nav2, a vital framework in ROS 2 for autonomous navigation. We will cover the installation of dependencies and other necessary components.

3) Understanding Adaptive Monte Carlo Localization (AMCL) and Simultaneous Localization and Mapping (SLAM):
Before delving into practical exercises, we will delve into localization and mapping algorithms, such as SLAM. This session will explore the theory behind SLAM and its practical applications.

4) Generating a Map of the Environment Using SLAM in Gazebo:
Utilizing the Gazebo Physics Simulator, we will simulate our robot and test the Nav2 stack for autonomous navigation. The session kicks off by creating a detailed environment map using the robot's onboard sensors, notably a 2-D LiDAR.

5) Autonomous Rover Navigation with the Generated Map:
Using the generated map, we will guide the robot autonomously. This section will cover specifying start and goal positions, as well as waypoint following techniques, enabling seamless autonomous movement.

6) Understanding the Top-Level Architecture of Nav2 Stack:
This session offers insights into the architecture of the Nav2 stack. We will explore key aspects such as Behavior Trees versus Finite State Machines, providing a comprehensive understanding of the system's high-level structure.

Session 2

1) Overview of Static and Dynamic Path Planning Algorithms in Robotics (Breadth First Search, Depth First Search, Dijkstra, A*):

Explore diverse path planning algorithms, delving into their distinctions and underlying mathematics. Gain insights into when and how to apply each algorithm effectively.

2) Create Your Custom Navigation Environment in Gazebo:

Engage in constructing personalized environments within Gazebo to challenge your robot. This hands-on session allows you to implement the knowledge acquired from Session 1

3) Programmatic Interaction with Nav2 Stack Using Python:

Utilize Python programming to interface with Nav2, crafting code snippets for defining initial and goal positions, as well as implementing waypoint following. This practical coding session enables you to automate interactions with the Nav2 stack efficiently.