Freedom Rover Units – Low-Cost Multi-agent Swarm

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I. Introduction

- Multi-agent robot swarms present potentially useful applications in hazardous environments and are capable of cheap large-scale monitoring: e.g., search and rescue operations and in environmental monitoring, respectively.
- Eventual future where robot swarms can work alongside professionals to perform delicate tasks such as in healthcare.
- Simultaneous Localization and Mapping (SLAM) leverages distance detecting sensors like LiDAR to map unknown environments and smooth robot navigation.
- Simulation tools like Gazebo reduce development time by providing a means for software, firmware, and hardware integration testing.
- Open-source robotics software such as ROS2 allow for cheap and reusable implementations.
- The ROS2 framework facilitates integration of multi-agent systems and development of state-of-the-art intelligence software.

II. Methods

- **Robot Kinematic Model** – Two-wheel Differential Drive.
- **Hardware**
- Refer to Table 1. for a general parts breakdown per robot.
- Wi-Fi router for telecommunication between rovers and laptop running agent software.
- Metal cage and misc. materials for map creation.
- **Firmware**
- FreeRTOS – Espressif and MicroROS (PID, Kinematics, Data Distribution Service (DDS), etc).
- Wireless messaging via UART (Wi-Fi).
- Driver software for sensors and hardware interfaces.
- **Software**
- Implementation and integration via ROS2.
- Robot and sensor data visualization with rViz2.
- Hardware and software simulation via Gazebo.
- Robot localization through *robot_localization* package.
- Autonomous navigation and SLAM features via Nav2 stack.

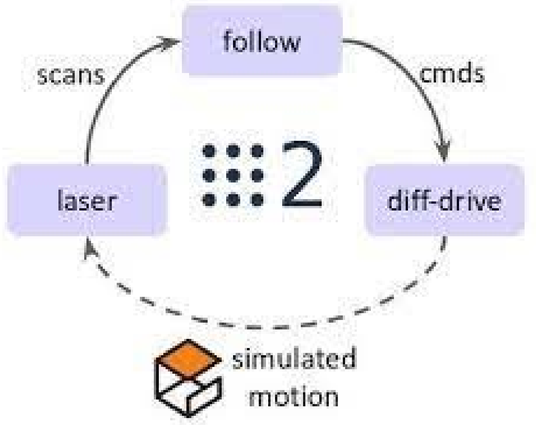

Figure 2 – Simplified diagram of a simulated two-wheel differential drive robot.

Part	Quantity	Cost
LDS-01 LiDAR	1	$39.99
7.4V 2000mAh li-ion	1	$11.99
ESP32-WROOM-DevKitC	1	$10.00
Rotary Encoders	2	$1.60
TT Motor	2	$1.37
Dual Motor Driver	1	$1.37
Caster Wheel	1	$1.06
Power Interface Board	1	~$12.99
3D Printed Chassis	1	~$5.00
Misc. Hardware	NA	~$5.00
Total Cost Per Robot		~$94.61

Table 1 – Approximate cost per robot parts breakdown.

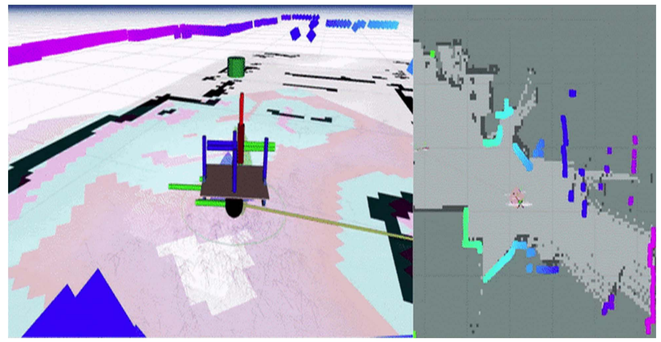

Figure 2 – Visualization of a rover utilizing the SLAM toolbox for navigation.

Figure 1 – Visualization of our workflow during the FALL 2023 semester (left to right): robot design and simulation, hardware integration, prototype building and system validation, real time testing, and finally full system integration with multiple agents.

III. Conclusion

- Lots of potential for further development on useful and applicable collaborative tasks.
- Custom PCB and individual components can cut down on weight, cost, and unnecessary power dissipation.

Our Github Organization

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