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LiDAR-S LAM based Autonomous Rover

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ABSTRACT-
An autonomous rover is a robot capable of navigating through unknown environments without human intervention. One of the most common methods for autonomous navigation is Simultaneous Localization and Mapping (SLAM), which allows the robot to map its surroundings while simultaneously localizing itself within that map. SLAM is often combined with Light Detection and Ranging (LIDAR) sensors to create highly accurate and detailed maps of the environment. LIDAR sensors emit pulses of laser light that bounce off objects in the environment and return to the sensor. By measuring the time it takes for the light to return, LIDAR can determine the distance and location of objects in its field of view. This information is then used by the SLAM algorithm to construct a map of the environment.
Keywords- LiDAR, SLAM, Autonomous

I. INTRODUCTION-

An autonomous rover is a robotic vehicle that can navigate and explore the environment without human intervention. One of the key technologies that will enable rovers to operate autonomously is light detection and ranging (LiDAR) and simultaneous localization and mapping (SLAM). LiDAR is a remote sensing technology that uses lasers to measure the distance to surrounding objects, and SLAM is a computational technology that enables rovers to map and locate within their environment.

Using LiDAR and SLAM, the rover can also avoid obstacles and navigate complex terrain. LiDAR sensors can detect obstacles and provide the rover with a 3D map of the environment. The SLAM algorithm, on the other hand, allows the rover to create a map of its environment while moving and use that map to navigate.In summary, his use of LiDAR and SLAM on autonomous rovers has revolutionized the field of planetary exploration and opened up new possibilities for scientific research. As technology advances, we can expect to see even more sophisticated and capable rovers that continue to push the boundaries of what is possible in space exploration.

Background and Motivation-

Autonomous rovers equipped with LIDAR (Light Detection and Ranging) sensors and SLAM (Simultaneous Localization and Mapping) algorithms have gained significant attention in recent years due to their ability to navigate and map unknown environments without human intervention.

The motivation behind the development of autonomous rovers with LIDAR and SLAM capabilities is to enable safer and more efficient exploration of remote and hazardous environments, such as other planets, disaster zones, and industrial sites. By using autonomous rovers equipped with LIDAR sensors and SLAM algorithms, researchers and engineers can gather data and perform tasks in these environments without putting human lives at risk.

II. PROBLEM STATEMENT-

An autonomous rover using LIDAR and SLAM is to develop a complete system that can accurately localize the rover, create a map of its surroundings, detect and avoid obstacles, plan a safe and efficient path, and integrate all the necessary components. Addressing these challenges will enable the development of autonomous rovers that can operate in a wide range of environments, from planetary exploration to industrial inspection.

The key challenges to be addressed in this problem statement include:

1. Localization
2. Mapping
3. Obstacle avoidance.
4. Path planning
5. System integration

III. RELATED WORK

There have been several research works in the field of autonomous rovers with LIDAR and

SLAM (Simultaneous Localization and Mapping) technology, which have contributed to improving the capabilities and performance of these robots. Here are some related works:

1. "Laser-Based SLAM for Autonomous Exploration and Mapping of Planetary Environments" (2018) by R. Podolak, et al. This paper presents a laser-based SLAM algorithm that can be used for autonomous exploration and mapping of planetary environments. The algorithm uses a LIDAR sensor to create a 3D map of the environment and estimates the rover's position and orientation in real-time.
2. "Autonomous Exploration with a LIDAR-Equipped Rover Using Visual SLAM" (2019) by M. Zolghadri, et al. This paper presents a method for autonomous exploration using a LIDAR-equipped rover and visual SLAM. The method uses a LIDAR sensor to detect obstacles and create a map of the environment, and a camera to detect landmarks and estimate the rover's position.

3.1 Literature review-

Autonomous rovers that use LIDAR and SLAM (Simultaneous Localization and Mapping) technology are becoming increasingly popular due to their ability to navigate through complex environments and unknown terrains. In this literature review, we will explore some of the recent research in this field.

1. "Real-Time Trajectory Generation and Control of an Autonomous Rover with 2D LiDAR SLAM" by N. Thomas and A. Akın (2019): This paper presents a real-time trajectory generation and control system for an autonomous rover using LIDAR and SLAM. The system uses a particle filter for localization and a rapidly-exploring random tree (RRT) algorithm for path planning. The authors demonstrate the effectiveness of their system in simulations and real-world experiments.

2. "A Survey of Simultaneous Localization and Mapping with Application to Autonomous Rover Exploration" by S. Elbanhawi et al. (2019): This paper provides a comprehensive survey of SLAM techniques and their application to autonomous rover exploration. The authors review the various types of sensors used for SLAM, including LIDAR, and discuss the challenges and limitations of each approach. They also provide an overview of the different SLAM algorithms and their performance in different environments.

3. "Autonomous Planetary Exploration with a Mobile Robot using LIDAR-based SLAM and Online Path Planning" by Y. Qiao et al. (2020): This paper presents an autonomous planetary exploration system using LIDAR and SLAM for localization and mapping, and an online path planning algorithm based on a potential field method. The authors demonstrate the effectiveness of their system in experiments using a simulated Mars environment.

4. "Autonomous Robot Navigation using LIDAR-based SLAM and Deep Reinforcement Learning" by M. Kucukdemiral et al. (2018): This paper presents a navigation system for an autonomous robot using LIDAR and SLAM for localization and mapping, and a deep reinforcement learning algorithm for decision-making. The authors demonstrate the effectiveness of their system in simulations and real-world experiments.

5. "An Integrated LIDAR-SLAM Navigation and Object Detection System for Autonomous Robot Exploration" by Z. Zhang et al. (2019): This paper presents an integrated LIDAR-SLAM navigation and object detection system for autonomous robot exploration. The system uses a feature-based SLAM algorithm for localization and mapping, and a convolutional neural network (CNN) for object detection. The authors demonstrate the effectiveness of their system in simulations and real-world experiments.

IV. DESIGN AND CONSTRUCTION-

An autonomous rover with LIDAR and SLAM (Simultaneous Localization and Mapping) technology involves several key steps, which build on the design and construction of an autonomous rover with LIDAR technology. The following steps should be taken:

1. System requirements
2. Platform selection
3. Sensor integration
4. SLAM algorithm development
5. Control and navigation system
6. Power and communication systems
7. Testing and validation

Designing and constructing an autonomous rover with LIDAR and SLAM technology requires a multi-disciplinary approach, combining expertise in robotics, sensor technology, control systems, and mechanical engineering. The process may involve significant time and resources but has the potential to create a powerful tool for exploration, inspection, and research.

4.1 Components and materials

An autonomous rover using LIDAR and SLAM depends on various factors such as the application, environment, size, weight, power consumption, and cost. Here are some key components and materials to consider:

1. LIDAR Sensor
2. Microcontroller/ Processor
3. Motor and Motor Driver
4. Battery
5. Chassis
6. Wheels/Tires

4.2 Software development

Here are some of the essential software components and programming techniques for autonomous rovers:

1. LIDAR Data Processing: LIDAR data processing involves converting the raw data from the LIDAR sensor into a usable format for SLAM processing
2. SLAM Algorithm: The SLAM algorithm processes the LIDAR data and creates a map of the environment. There are several SLAM algorithms, such as EKF SLAM, FastSLAM, and GraphSLAM..
3. Motion Planning: Motion planning involves generating a path for the robot to follow. The path is generated based on the SLAM-generated map and the robot's current position. The path planning can be done using algorithms such as A* or Dijkstra's algorithm.
4. ROS (Robot Operating System): ROS is a popular software framework used in robotic systems, including autonomous rovers. ROS provides a standardized architecture for robotic systems and includes tools for building, testing, and deploying software modules.

V. RESULTS AND DISCUSSION-

Fig 1: Turtlebot

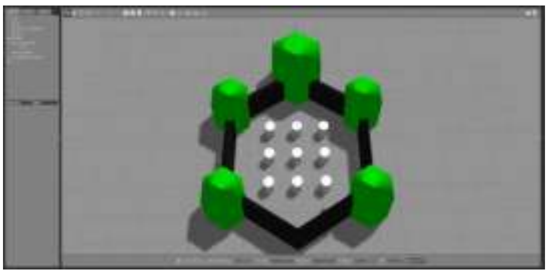

Fig 2: Maze Environment

Fig 3: Rover movement

Fig 4: Rover avoiding Obstacles

5.1 Interpretation of results

Proper interpretation of the results can help identify areas for improvement and ensure the success of future autonomous rover missions.Here are some key factors to consider when interpreting the results of an autonomous rover mission:

1. Map Accuracy:
2. Environment Analysis
3. Localization Accuracy.
4. Path Planning
5. Sensor Data Quality
6. Mission Success

VI. CONCLUSION

In summary, SLAM and LIDAR autonomous rovers have emerged as promising technologies for exploring unknown or hazardous environments, conducting inspections, and conducting search and rescue missions. It can navigate unfamiliar environments autonomously, create accurate maps of the environment, and avoid obstacles and potential hazards. The combination of SLAM and LIDAR technology enables accurate and efficient mapping and navigation even in complex environments.

However, autonomous rovers using SLAM and LIDAR also have some limitations that need to be considered: B. High cost, limited detection range, limited computing power, sensitivity to environmental conditions, and limited terrain adaptability. These restrictions may limit its use in certain applications.

6.1 Limitations

Autonomous rovers with LIDAR and SLAM have some limitations that can affect their performance and effectiveness. Here are some of the key limitations of autonomous rovers with LIDAR and SLAM:

1. Limited Sensing Range: The sensing range of LIDAR sensors is limited, and the resolution of the generated map decreases with distance.
2. Limited Processing Power: SLAM algorithms require significant computational resources, which can limit the rover's processing power and slow down the mapping and navigation process.
3. Sensitivity to Environmental Conditions: Autonomous rovers with LIDAR and SLAM can be sensitive to environmental conditions, such as dust, rain, or fog, which can affect the accuracy of the LIDAR sensor and map generation process
4. High Cost: Autonomous rovers with LIDAR and SLAM can be expensive due to the cost of the LIDAR sensor and other hardware components, as well as the high processing power required for SLAM algorithms.
5. Limited Battery Life: Autonomous rovers with LIDAR and SLAM require a significant amount of power to operate, which can limit their battery life and overall mission duration.

6.3 Future Scope

As technology continues to improve, the scope of autonomous rovers with SLAM and LIDAR is expected to expand further, with increased capabilities and applications in various fields. The future of autonomous rovers with SLAM and LIDAR is promising, and ongoing research and development in this area will continue to drive innovation and expand their capabilities.

REFERENCES

[1]. Ren C. Luo, Yi T. Chou and Chung T. Liao, "NCCU security warrior: An Intelligent security robot system", IECON 2007–33 rd Annual conference of the IEEE industrial electronics society , 2007.

[2]. Wenjiang Huang, Qingsong Guan, Juhua Luo, Jingcheng Zhang, JinlingZhao, Dong Liang, et al., "New Optimized Spectral Indices for Identifying and Monitoring Winter Wheat Diseases", IEEE journal of selected topics in applied earth observation and remote sensing, vol. 7, no. 6, June 2014.

[3]. P. Viola and M. Jones, "Robust Real-time Object Detection", Proceeding of IEEE Workshop on Statistical and Computational Theories of Vision (SCTV 2001).

[4]. Ming-Hsuan Yang, D.J. Knegman and N Ahuja, "Detecting faces in images: a survey", IEEE Transactions on Pattern Analysis and Machine Intelligence, vol. 24, no. 1, pp. 34-58, Jan. 2002.

[5]. Howie Choset, Kevin Lynch, Seth Hutchinson, George Kantor, Wolfram Burgard, Lydia Kavraki, et al., Principles of Robot Motion Theory Algorithms and implementation, 2005.

[6]. Y. Sakagami, R Watanabe, C Aoyama, S. Matsunaga, N Higaki and K. Fujimura, "The intelligent ASTMO: system overview and integration", International Conference on Intelligent Robots and System 2002. IEEE/RSJ, vol. 3, pp. 2478-2483, 30 Sept.-5 Oct. 2002.