Prototype of an Autonomous Robot with Variable Crawler Mechanism Using RFID-SLAM

JaeRyeong Lee
Dept. of Electronic Engineering
Soongsil University
Seoul 06978, Republic of Korea
now0@soongsil.ac.kr

Hae-Min Kang
Dept. of Electronic Engineering
Soongsil University,*)*
Seoul 06978, Republic of Korea
goals0211@soongsil.ac.kr

Hong-Ju Kim
Dept. of Electronic Engineering
Soongsil University,*)*
Seoul 06978, Republic of Korea
ju5394@soongsil.ac.kr

Overview

These days, the need for autonomous robots is increasing in narrow spaces that are difficult for humans to directly access, such as underground power districts and high-rise building ducts. However, in such a GPS limited environment, cumulative errors occur when estimating a location using only SLAM, and driving stability deteriorates in narrow spaces and irregular terrain. Existing studies have proposed RFID-based destination setting and LiDAR-based obstacle detection, but they lacked a mechanism to correct accumulated location errors and adjust hardware to operate reliably in the long run. To solve this problem, this study proposes an autonomous robot that integrates a variable caterpillar structure and RFID-SLAM-based location correction technology.

Proposed Method

The proposed robot can adjust the length of the caterpillar to 25 cm and 40 cm, and the length switching is performed either manually or automatically by the navigation module. Fig. 1 shows the prototype of the proposed robot in both 25 cm and 40 cm crawler configurations. The real-time map is created with the Hector SLAM using RPLIDAR-R6 and IMU, and the cumulative error is corrected even in an environment where communication with the outside is unstable by using the 902-928 MHz band RFID tag. In addition, RGB and thermal imaging cameras and YOLOv5 object recognition models are integrated to detect various wire damages such as cladding damage and cracks in real-time. Data augmentation techniques such as MOSAIC, left-right inversion, and color transformation were applied to the learning to reflect various lighting and background changes in the real environment. The system supports multi-user monitoring, abnormality detection, and log analysis through a web-based interface, as illustrated in Fig. 2, and mapping and navigation control is possible through RQT visualization. Path planning combines a Dijkstra-based global planner and a local obstacle avoidance algorithm to create and visualize candidate paths and perform autonomous driving according to the selected paths, as shown in Fig. 3.

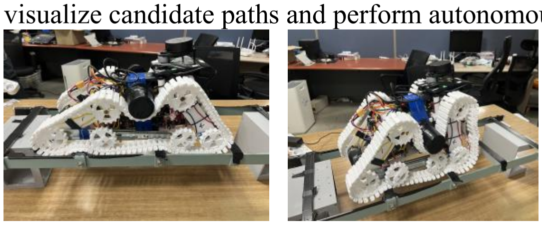

Fig. 1. Robot prototype in 25 cm and 40 cm crawler modes

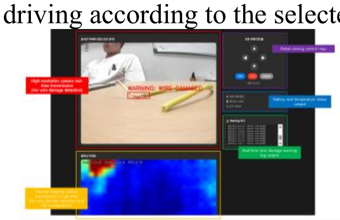

Fig. 2. Web-based monitoring interface

Fig. 3. Navigation screen with RFID

Conclusion

This study achieved GPS limited area precise position estimation by solving cumulative errors in driving through RFID-corrected SLAM, and through variable caterpillars, unstable terrain
It has proven that stable driving is possible. YOLO-based wire damage recognition technology uses thermal imaging and RGB cameras to detect overheating and damage points, which is more effective than visual inspection
It showed a new academic and industrial significance in robot research in that it integrates precision driving and real-time monitoring to minimize user intervention and to integrate mission performance
It presents directions. This technology can be extended to various fields such as maintenance and disaster response.

References

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