Development of autonomous driving-based radiation dosimeter transfer robot for real-time monitoring of highly radioactive areas

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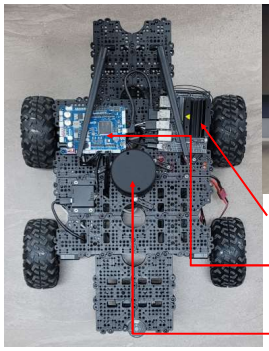
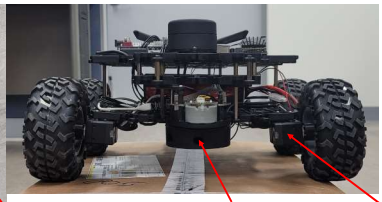
INTRODUCTION

- The autonomous driving-based radiation dosimeter transfer robots are needed to secure radiation safety in a high-radiation area or a narrow area before dismantling workers are put in, and to minimize the worker's radiation exposure as low as reasonably achievable(ALARA).
- Using the data from LiDAR, IMU sensors, and encoders, the robot can determine its location and create a map around it at the same time.
- The data collected from the radiation dosimeter using scintillation(SiPM, CsI(Tl)) mounted on the robot is wirelessly transmitted to the radiation management system in real time.

DEVELOPMENT OF ROBOT

[Framework of ROBOT]



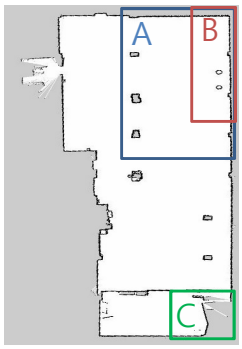


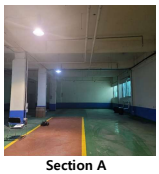
- SBC(Jetson nano)
- Control Board(OpenCR1.0)
- 2 LiDARs
- IMU
- Motor(XL430-W250-T)

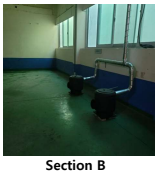
Jetson nano + [OpenCR1.0 + XL430-W250-T / A1M8 + G2]

Contents	Specification
Jetson nano	• SBC(single board computer) • Wireless communication with control PC • Send and Receive Topics with OpenCR1.0 and LiDARs
OpenCR1.0	• Receive Velocity Topics and Control Motors • Read and Send Encoder and IMU data
XL430-W250-T	• Send Encoder data • Get torque and move robot
YDLiDAR G2	• Main LiDAR • Range : 0.1~12 [m] • Localization and Mapping • Send Laser distance Topics
RPLiDAR A1M8	• Sub LiDAR • Range : 0.1~6 [m] • Restrict range and angle to avoid obstacles between wheel radius and main LiDAR • Range : 0.1~0.5[m] • Angle : -100~100[degree]

[SLAM(Simultaneous Localization And Mapping) and Navigation stack Test]

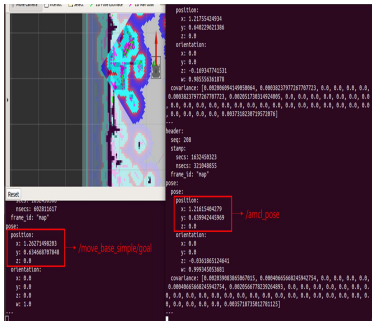



Section A


Section B


Section C

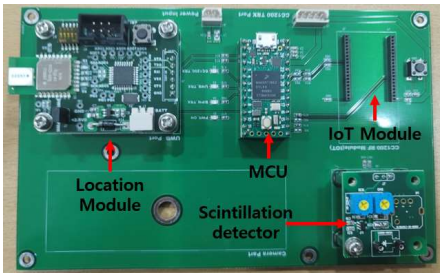
[SLAM Map File and Test Environment]



[Position Measurement Experimental Data]

	goal_x [cm]	pose_x [cm]	error [cm]	error_rate [%]
1	51.55	50.39	-1.16	-2.25
2	72.58	74.74	2.16	2.98
3	81.66	84.42	2.76	3.38
4	100	102.2	2.2	2.2
5	102	101.9	-0.1	-0.1
6	126.27	121.62	-4.65	-3.68
7	136.91	136.48	-0.43	-0.31

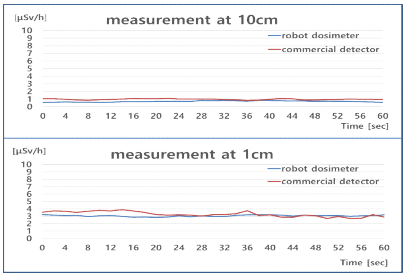
[Radiation Dosimeter mounted on the Robot]



[Radiation Dosimeter board]

Contents	Specification
Sensor type	• Scintillation detector • CsI(Tl)(6X6X10mm) + SiPM
MCU	• CoretaxM7
UWB	• 3.1Ghz ~10.6Ghz • TOA(Time of Arrival) • Indoor Positioning System
IoT Network	• Wireless communication technology

[Radiation Dosimeter board]



[Experimental Data of Radiation Dosimeter]

CONCLUSIONS

- The developed autonomous driving-based radiation dosimeter transfer robot can generate the map and smoothly move to the destination on the map and avoids unspecified obstacles.
- The detected radiation dose from the developed radiation dosimeter mounted on the robot has a similar pattern with a commercial detector.
- Currently, a two-wheel drive robot has been developed, and a four-wheel drive robot is being developed to improve obstacle avoidance and stable driving ability.
- Although the robot was developed to be put into dismantling work sites, it can also be applied to operating nuclear power plants in high-radiation areas.

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