Design and Integration of a Radiation Detector Module for Robot Operating System (ROS)

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Introduction

- In nuclear and radiation industries, robots can help reduce the risk of radiation exposure to workers.
- Automation of 3D process - dull, dirty, and dangerous
- To make a robot capable of radiation inspection and monitoring, integration with radiation detector module is required.

Introduction

- Robot Operating System (ROS):
  - Open-source software with extensive libraries and tools for building robotics applications
  - Diagnostic and visualization tools like Gazebo and RViz
  - Accelerates algorithms development
  - Evaluate algorithms in simulations and real-world experiments

Jackal - Clearpath Robotics

RR100 - Generation Robots

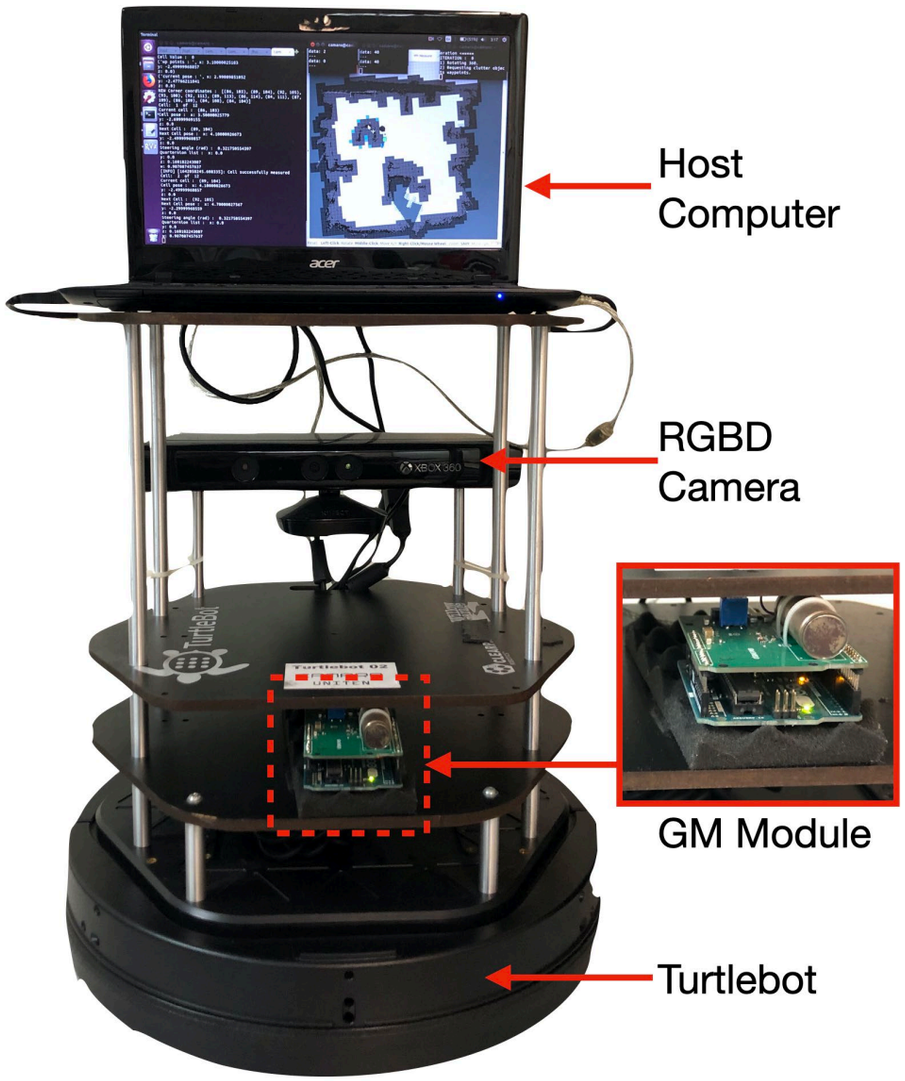
ROSbot 2 PRO - Husarion

Scout 2.0 - Agilex

Spot - Boston Dynamics

Objectives

- To design and implement a ROS-enabled radiation detector module.
- To verify the functionality of the module.



Motivations

- Serves as a fundamental building block for robots operating in radiation environments
- Can be adapted for various applications; e.g surveillance, emergency response, and monitoring
- Valuable resource for students learning ROS and working on robotics projects.

System Overview

Physical Setup and Block Diagram

Host computer running ROS

Check source

GM Module

USB connection

Host Computer

Robot Operating System

Serial node

Data Visualizer

Data Logger

/RadiationData

GM Module

GM Shield

High Voltage

GM

Pulse Shaper

Arduino Uno Shield

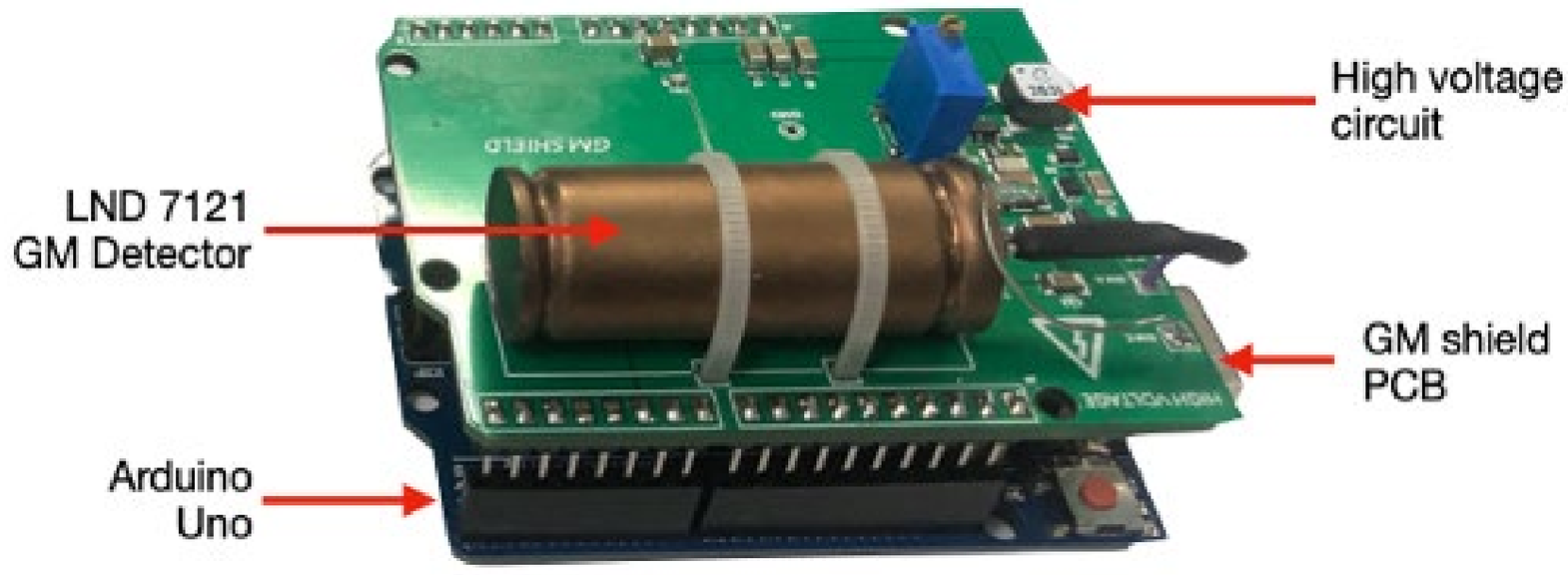
Firmware

Counter/Timer

ROS Publisher

GM Module Hardware

GM shield and Arduino Uno



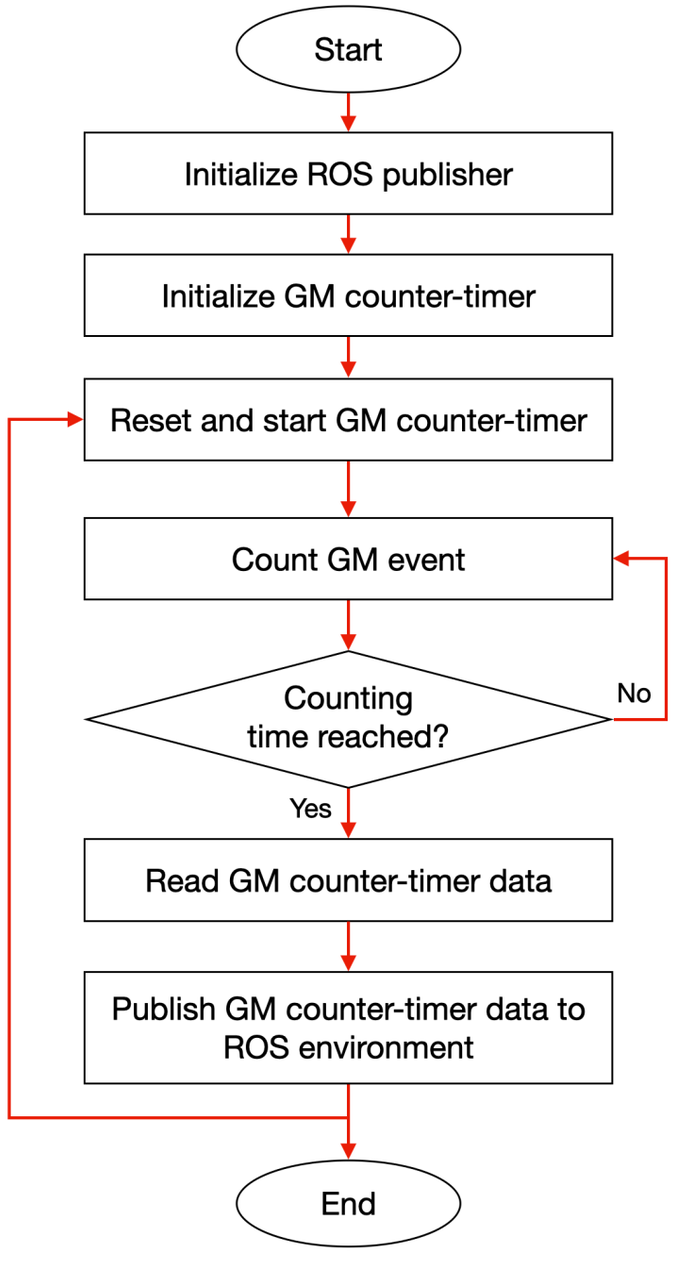
GM Module Firmware

Codes and Flowchart

GMpublish | Arduino 1.8.8

GMpublish

```
#include <ros.h>
#include <std_msgs/Int32.h>

long count, cpm;
float cph, uSvHr;
String cpmdata;
long count_dummy = 0;

ros::NodeHandle  nh;

std_msgs::Int32 radcount;
ros::Publisher mapper("RadiationData", &radcount);

void setup()
{
  nh.initNode();
  nh.advertise(mapper);

  pinMode(5, INPUT);
  TCNT1 = 0x00;
  TCCR1A = 0x00;
  TCCR1B = 0x07;
}

void loop()
{
  TCNT1 = 0x00;
  delay(1000);
  count = TCNT1;

  radcount.data = count;
  mapper.publish( &radcount );
  nh.spinOnce();
}
```



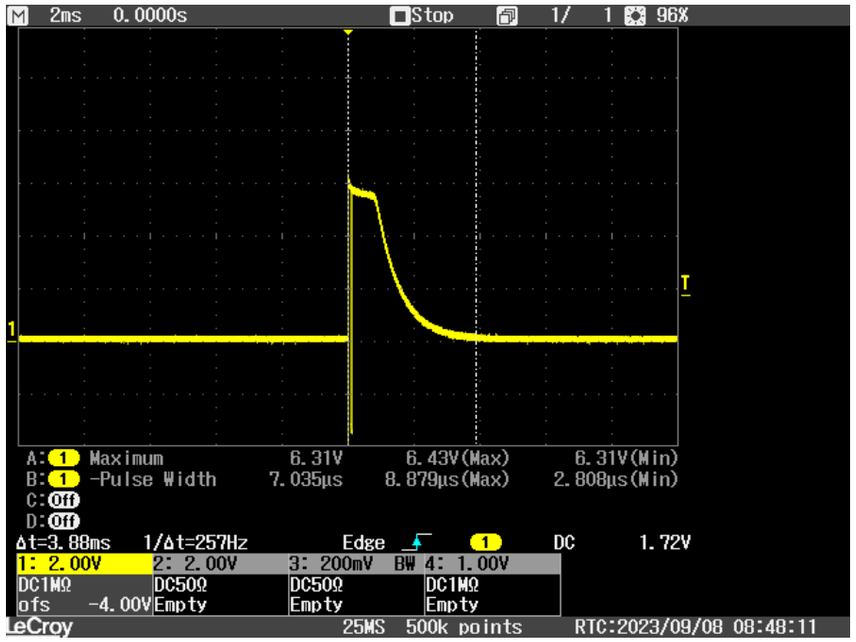
Setup on Host Computer

- On the host computer, the *rosserial_python* package was run to set up a serial node.
- Subsequently, the serial node could subscribe to the ROS topic */RadiationData* published by the GM module.
- The measured radiation data can be monitored in real-time and further manipulated or analysed from this point.
- The pose of the robot on 2D occupancy map is referred as the detector position.
- This data is acquired from the ROS *tflistener* which maintains the relationship between the *map, odom*, and *base_footprint* coordinate frames.

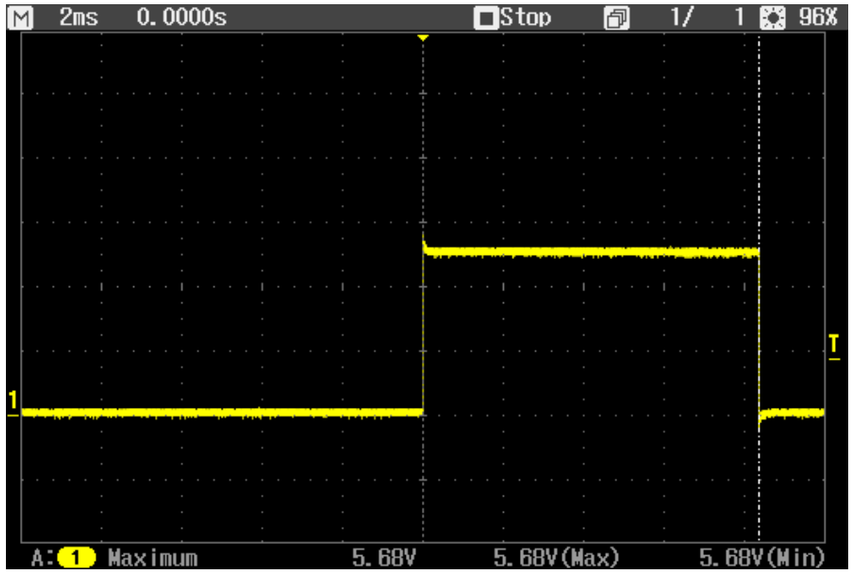
Results and Discussion

GM Module Basic Functionality Tests

High voltage = 500 V

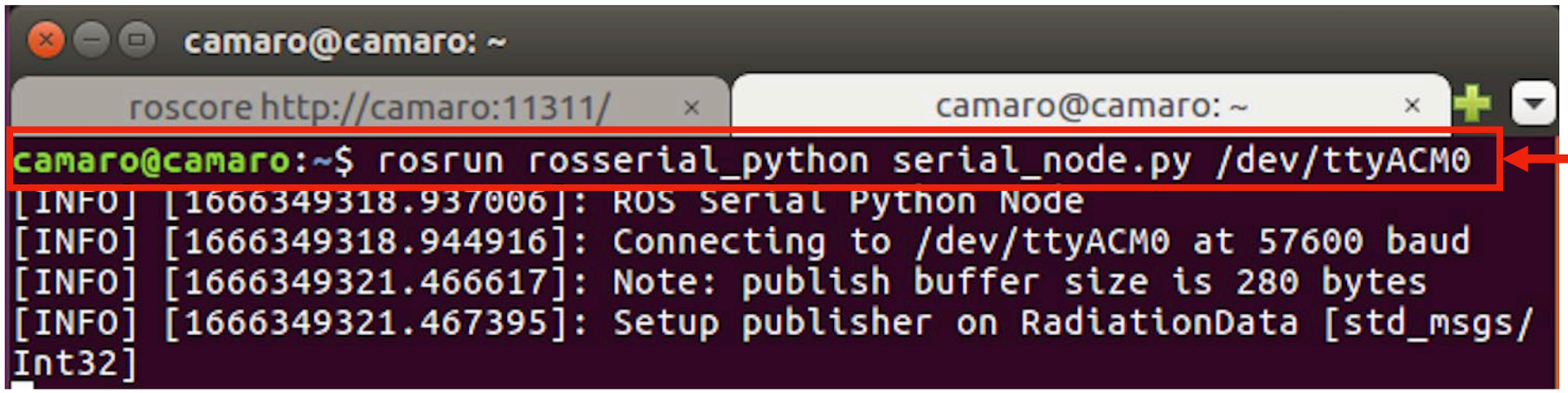


Analog output of GM detector

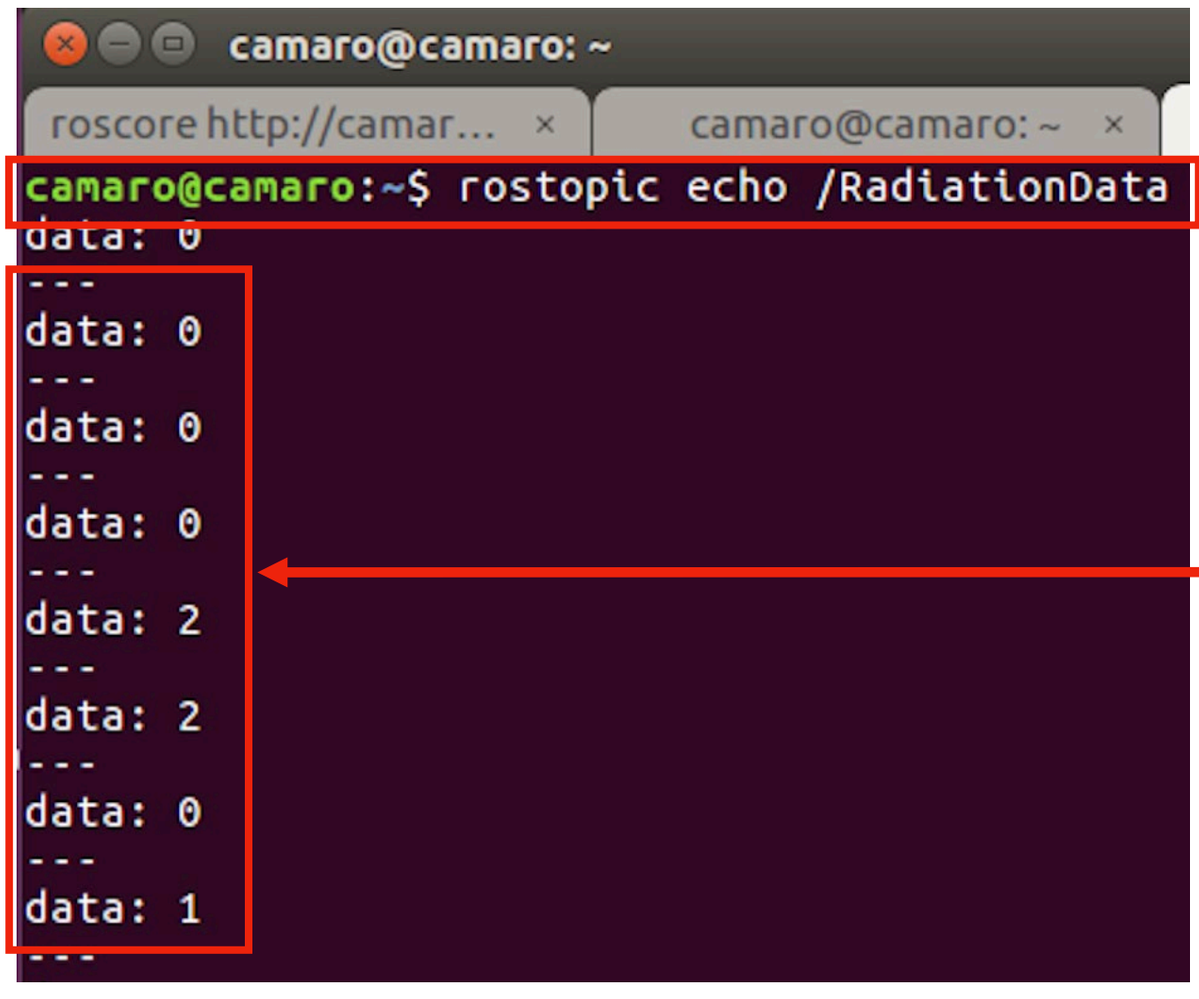


Digital output of pulse shaper

Ros Topic Publish and Subscribe : /RadiationData



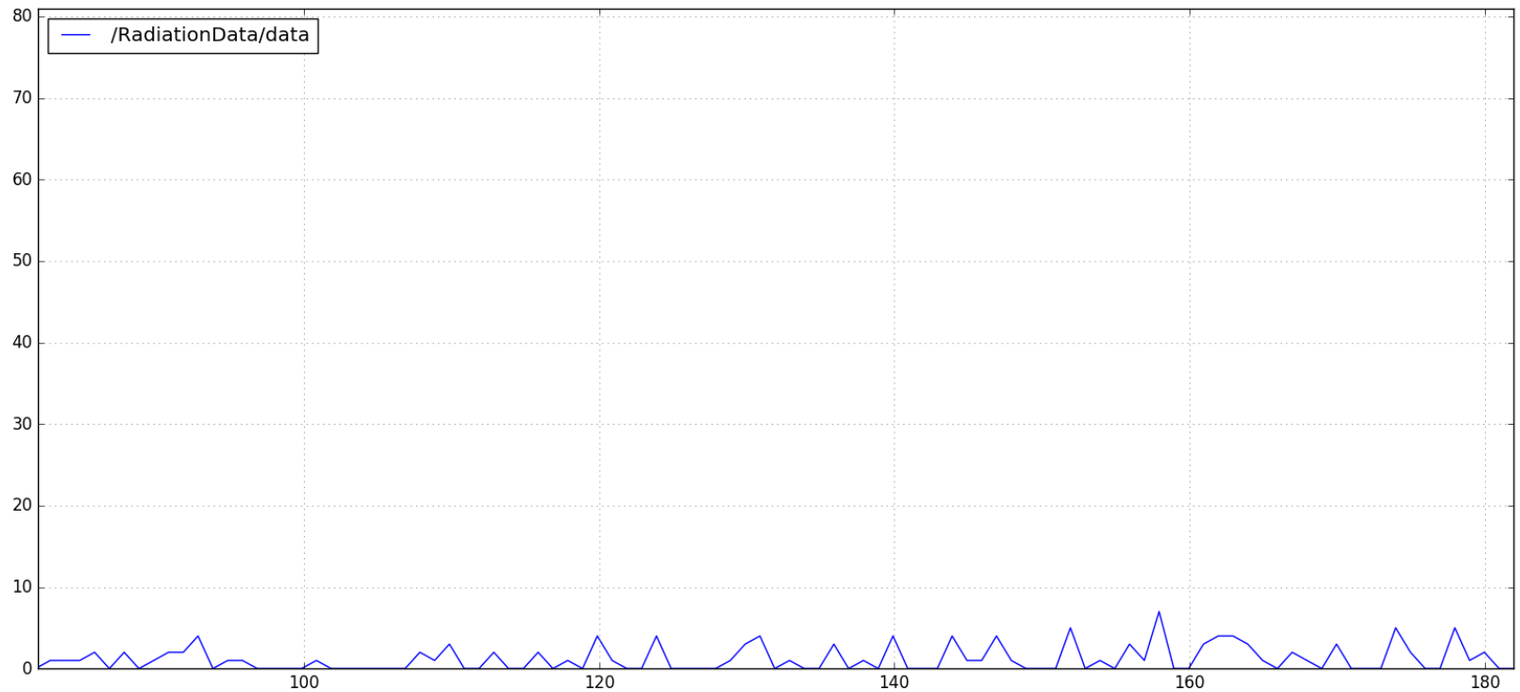
Command to run serial_node



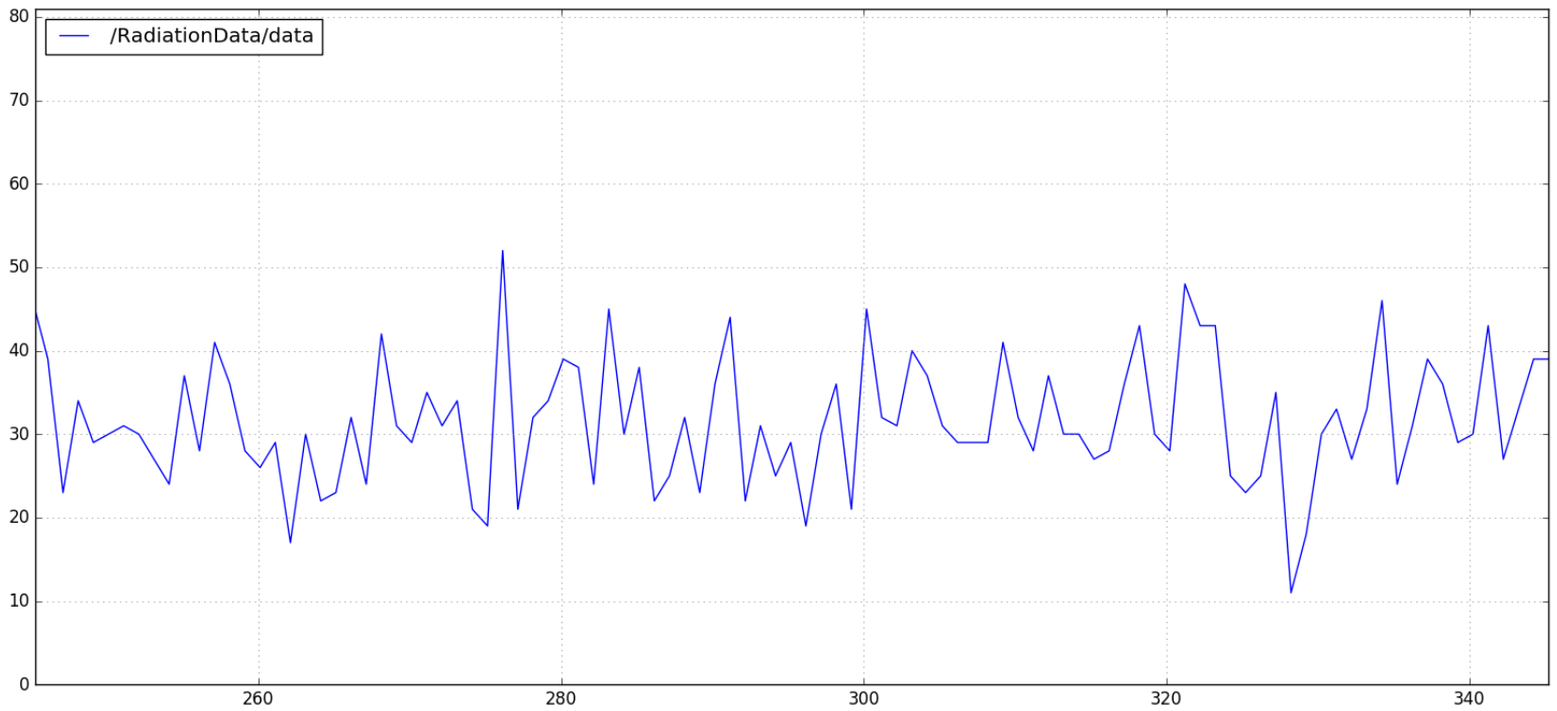
Command to echo data published to terminal

Data published by GM module

ROS rqt viewer : Background and Checksource

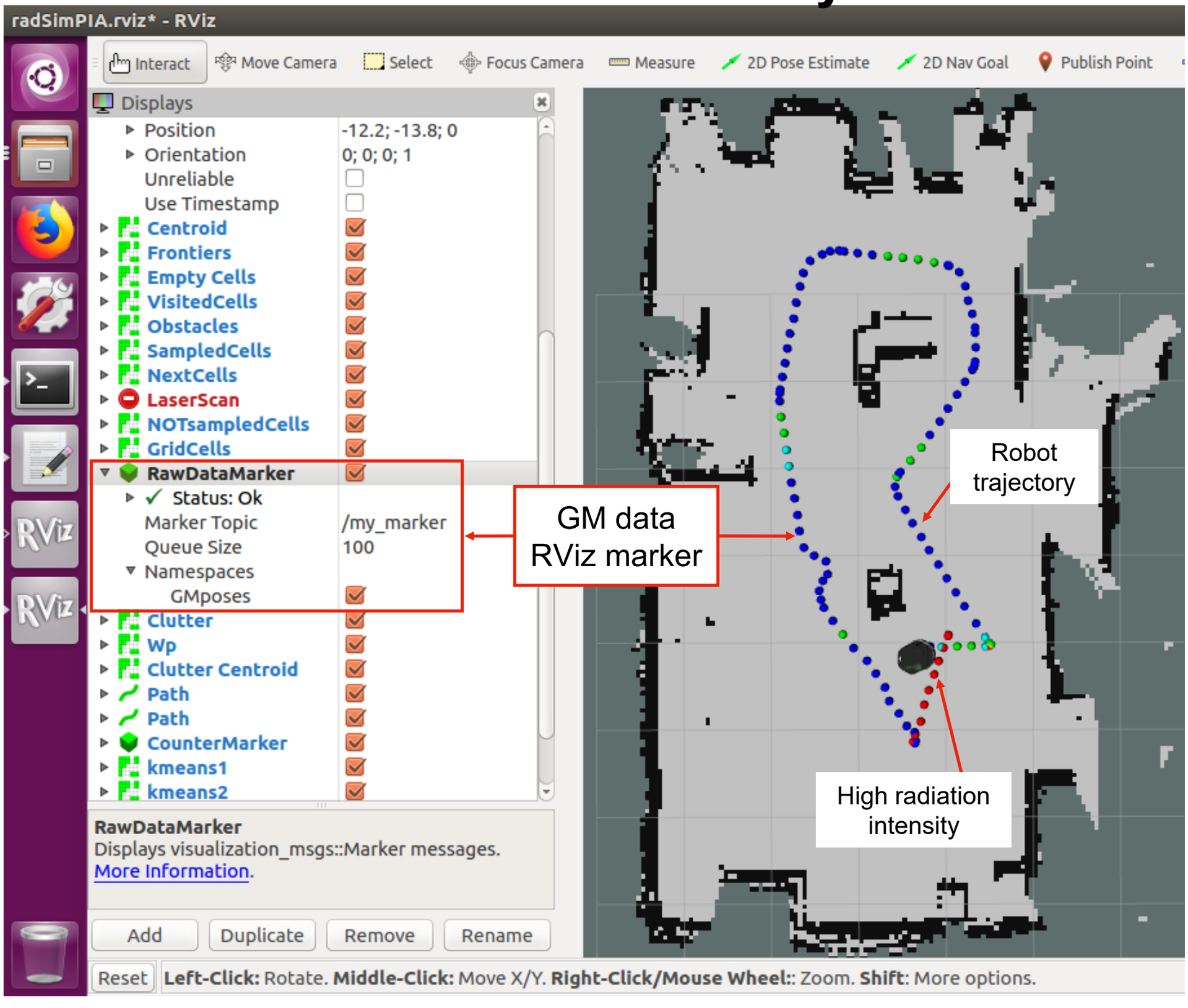


Background data

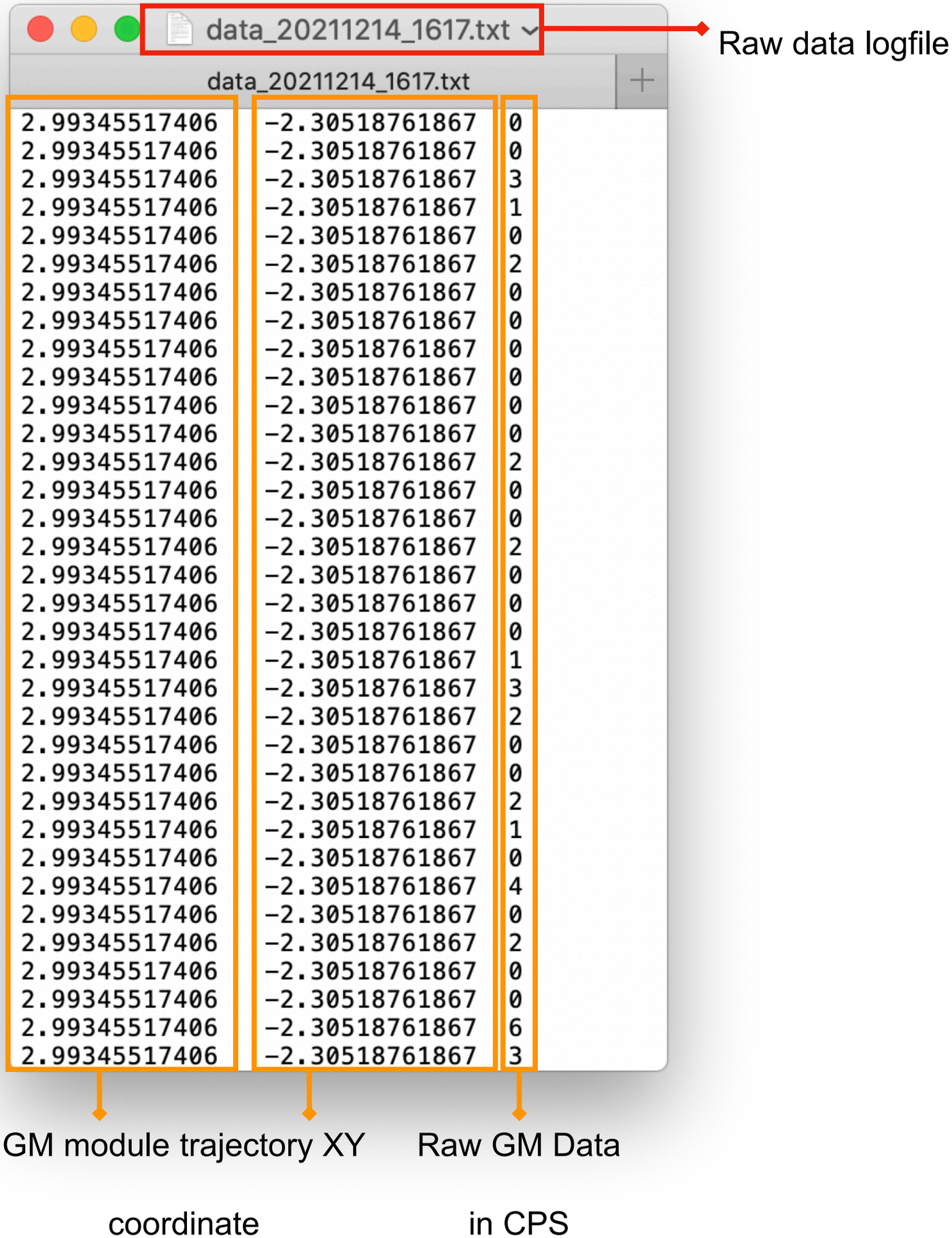


Checksource data

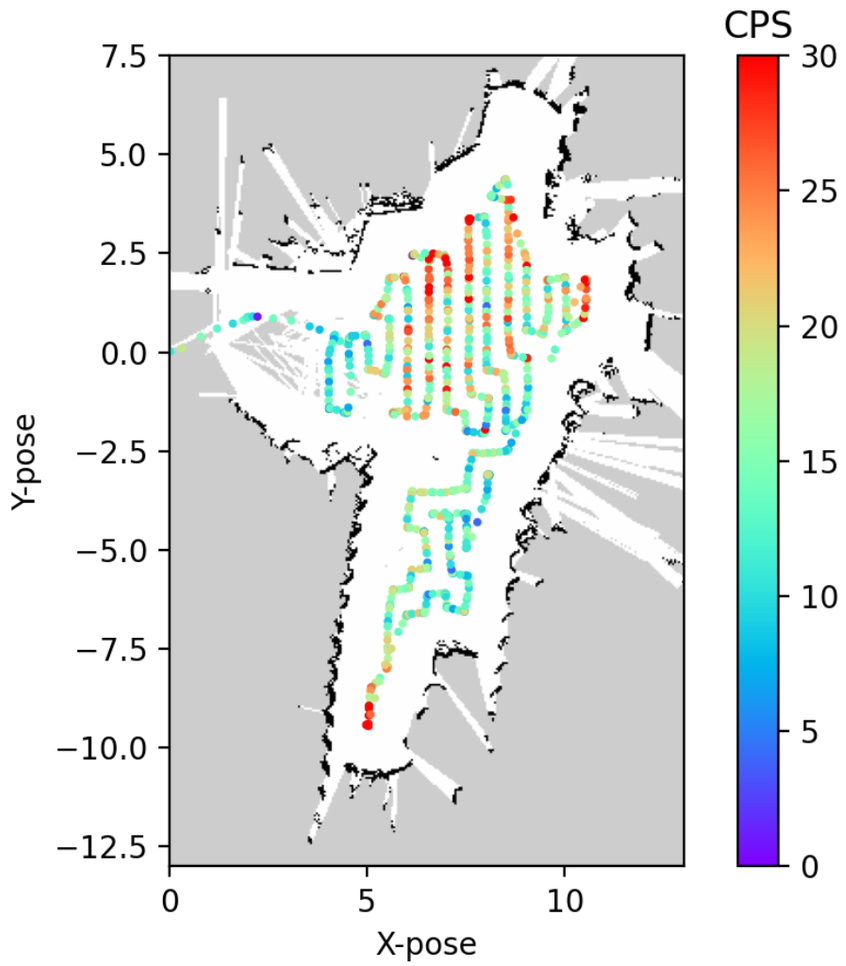
RViz visualisation of GM module trajectory and measured intensity

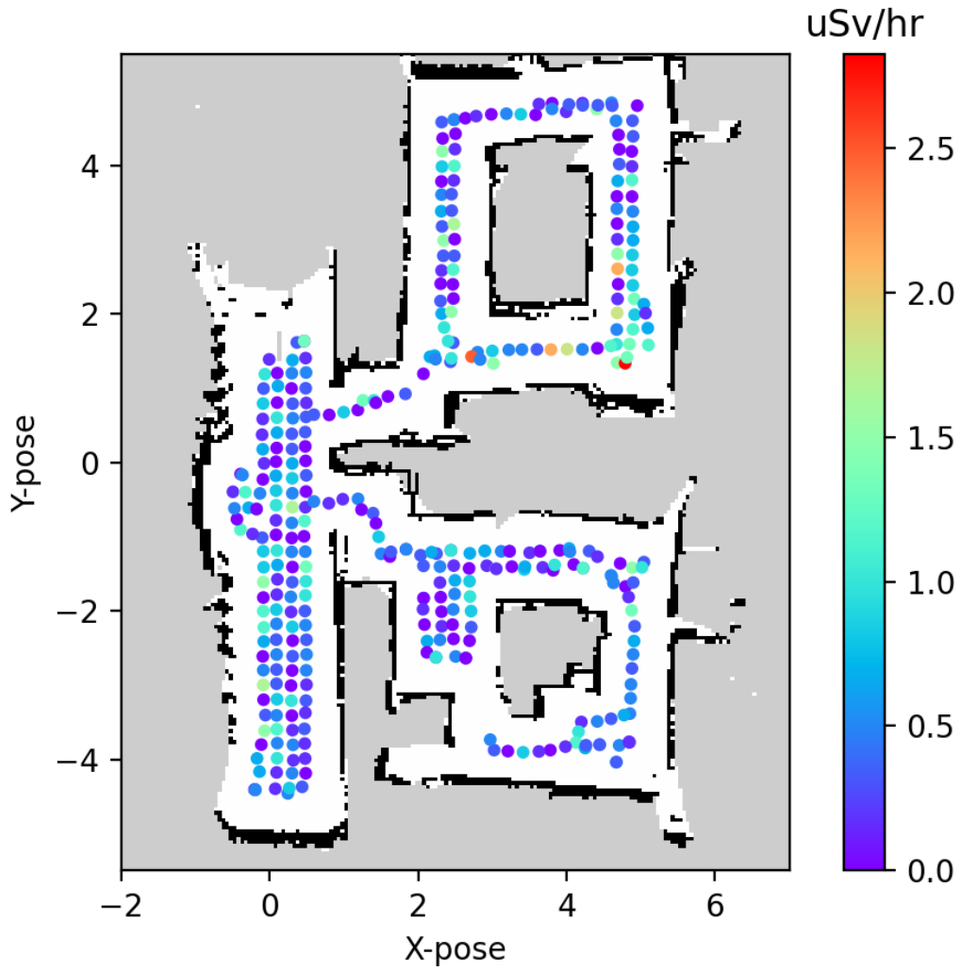


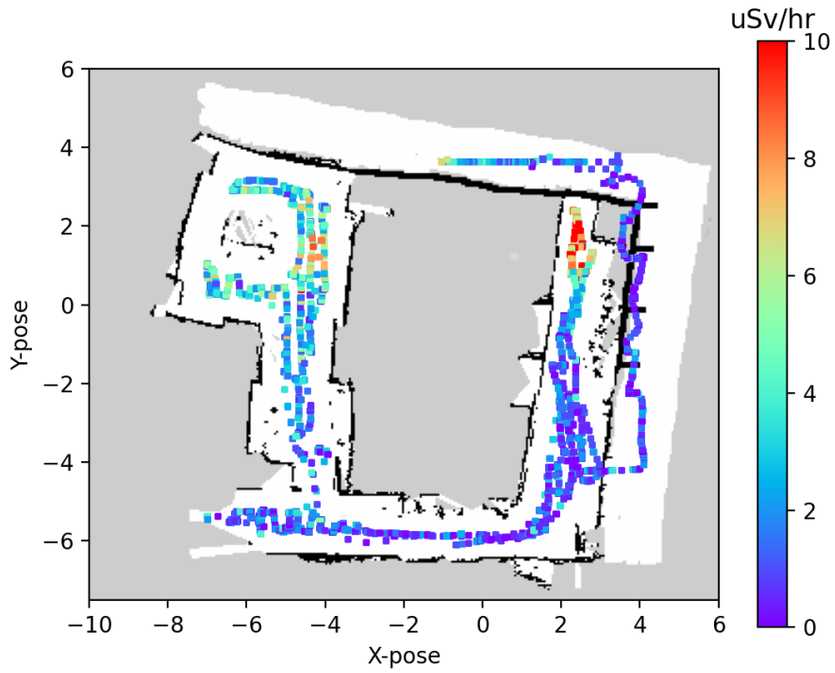
Log files created by the data logger

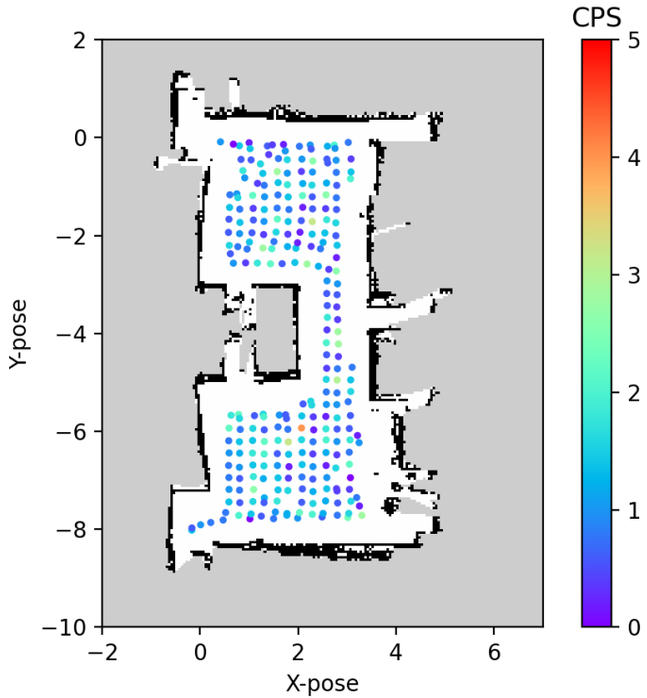


Application: Radiation Survey and Inspection









Conclusion

- In conclusion, this paper presented the design and integration of a radiation detector module with the Robot Operating System (ROS).
- The GM module incorporates a GM shield compatible with Arduino PCB.
- The Arduino firmware publishes data into the ROS environment, enabling the effortless visualization of radiation measurements within a 2D occupancy map.
- The presented knowledge in this paper could serve as the basis to enable robot to autonomously conduct radiation surveys and inspections.
- This advancement not only enhances the efficiency and safety of radiation workers but also contributes to safeguarding the environment against potential radiation hazards.

Thank You For Your Attention