Preliminary Results of the Autonomous Radiation Mapping in Malaysian Nuclear Agency

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CONTENTS

01 INTRODUCTION

- Radiation in the workplace originates from various sources and exposure to it can pose health risks to employees **if not properly managed**.

- Some common **sources of workplace radiation** are coming from nuclear reactor and nuclear research facilities, radioactive materials, X-ray machines and radiation therapy equipment.

- On top of that, there is a **regulation** that specifies that each licensee and employer engaged in activities associated with regular or potential occupational exposure is required to ensure the safety of their workers from occupational hazards.

- In order to protect the workers from the harmful effects of radiation, it is imperative to implement safety measures and practices.

- These measures and practices encompass conducting risk assessments, monitoring radiation levels in the workplace and regularly inspecting and maintaining radiation-emitting equipment to ensure safety.

01 INTRODUCTION

IOP Conference Series: Materials Science and Engineering

PAPER • OPEN ACCESS

Spatial interpolation of gamma dose in radioactive waste storage facility

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The primary objectives of this work include acquiring the radiation dose distribution, creating a dose database and producing a dose map within the facility.

01 INTRODUCTION

The work has been implemented in the waste storage facility using the Ludlum Model 2241-3 survey meter with 118 sampling points were recorded.

The process of manually measuring radiation doses for each grid was time consuming and posed a significant safety risk to the workers responsible for this task.

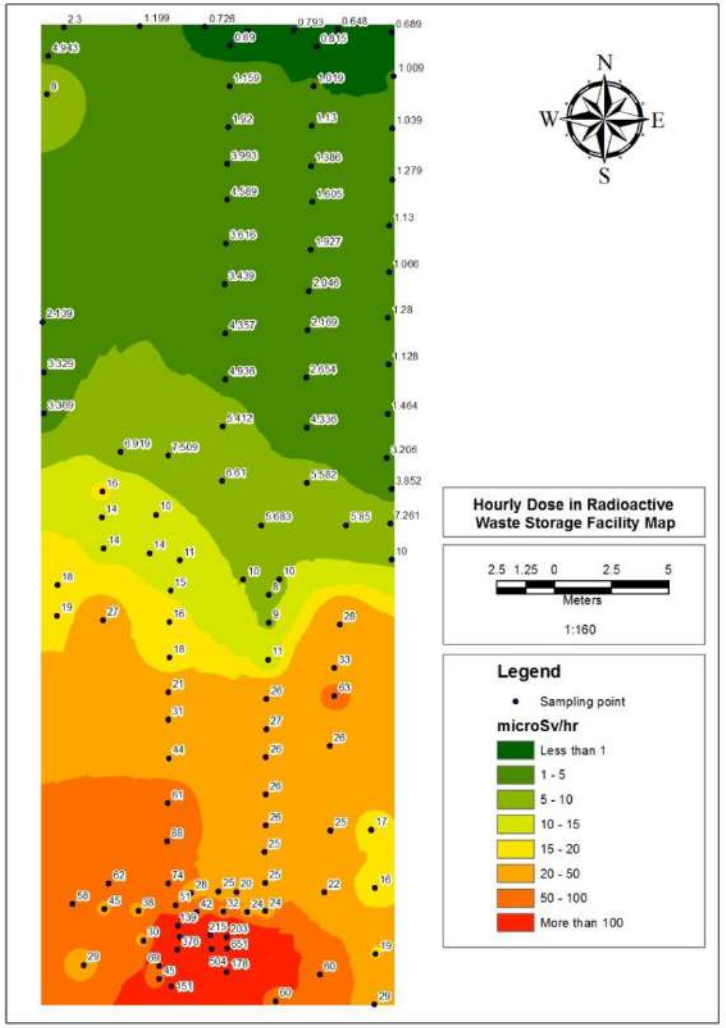
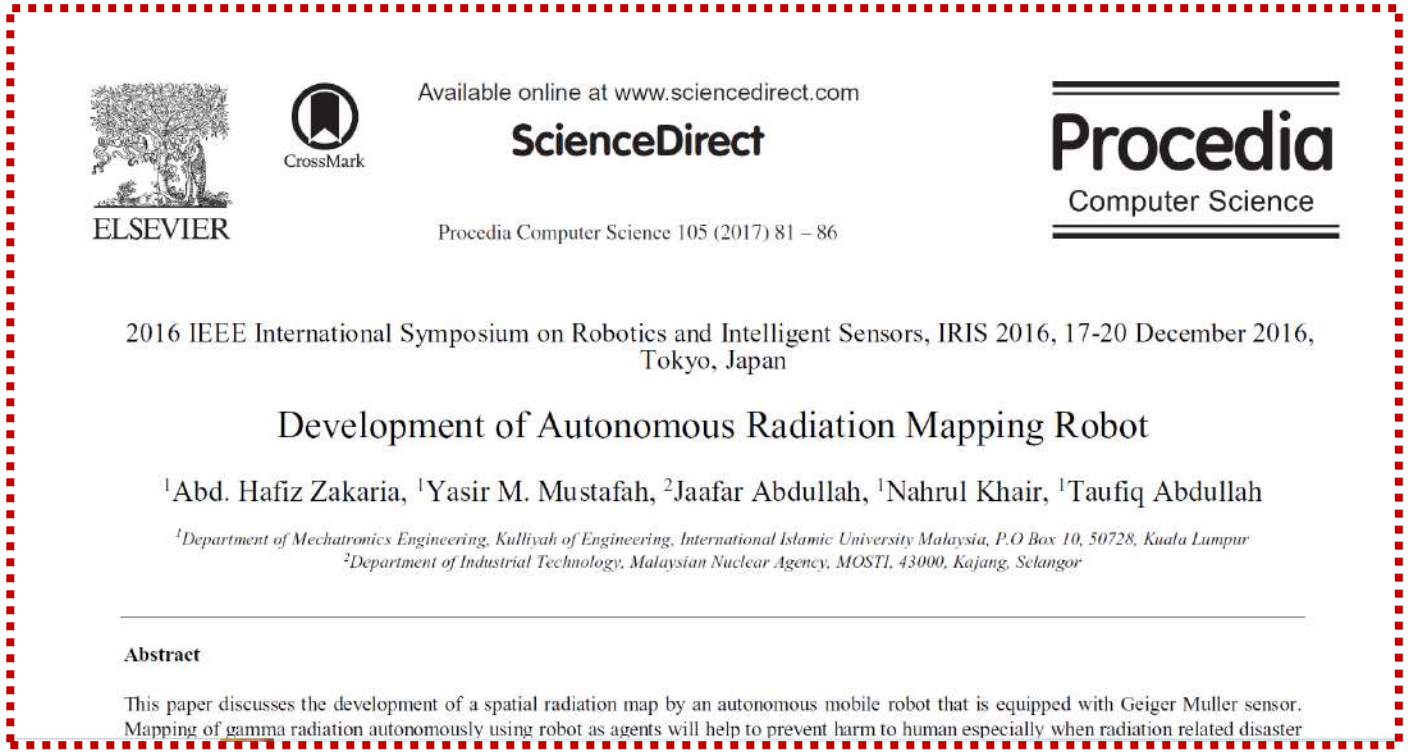


Figure 1: The data grid for the manually recorded radiation readings at the waste storage facility (Harun et. al., 2018)

01 INTRODUCTION



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Development of Autonomous Radiation Mapping Robot

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Abstract

This paper discusses the development of a spatial radiation map by an autonomous mobile robot that is equipped with Geiger Muller sensor. Mapping of gamma radiation autonomously using robot as agents will help to prevent harm to human especially when radiation related disaster

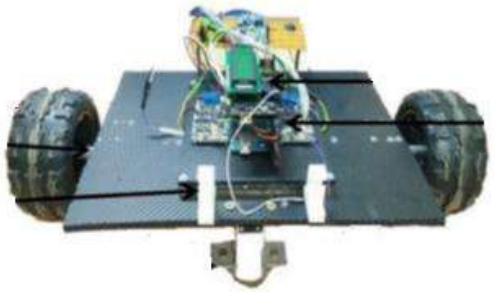
There is a study from Zakaria et al. (2017) that explores the development of a spatial radiation map by an autonomous mobile robot that is equipped with a Geiger Muller sensor.

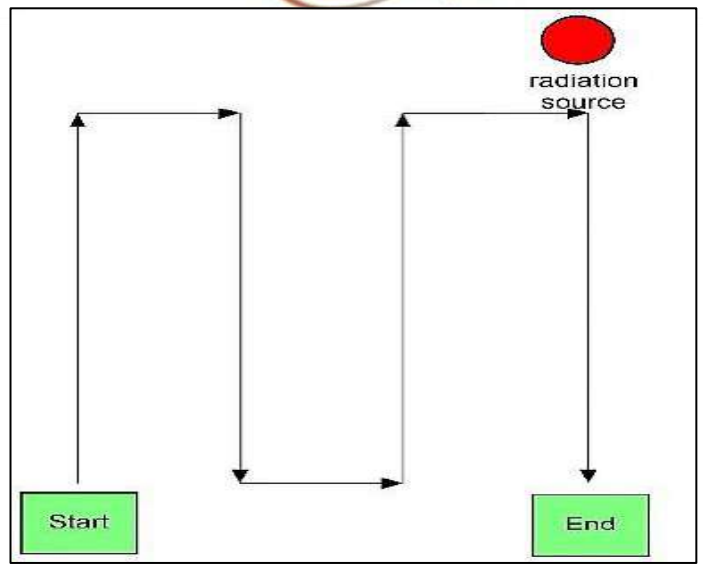
01 INTRODUCTION

The study was intended to develop a gamma radiation mapping system that reads and process location data of a mobile robot with encoder as well as the radiation data transmitted by the Geiger Muller sensor on the mobile robot.

The study was conducted with the zigzag waypoints sweeping pattern and the radiation source is placed at a certain point of the designated waypoint.

As shown in Figure 2, the result of the experiment conclude that higher radiation activity is recorded when the robot moves near the sources and the radiation activity decreases when the robot is far from the sources which satisfy the **inverse square law theorem.**





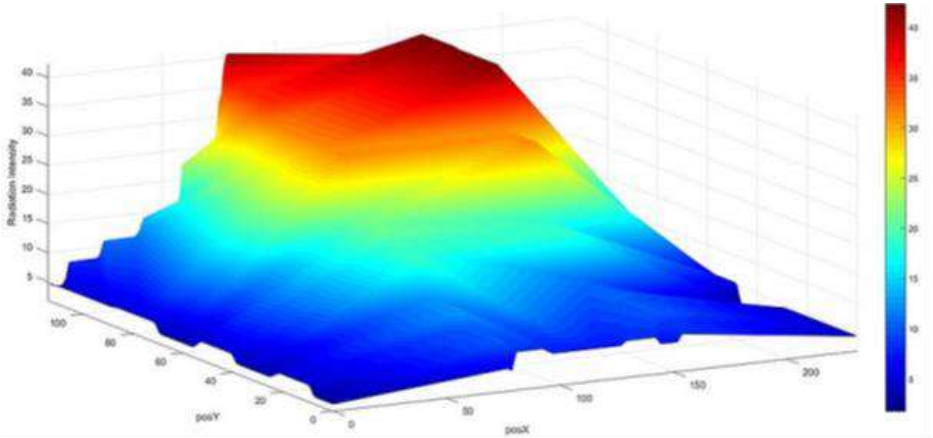


Figure 2: Radiation map with radiation sources (Zakaria et al, 2017)

01 INTRODUCTION

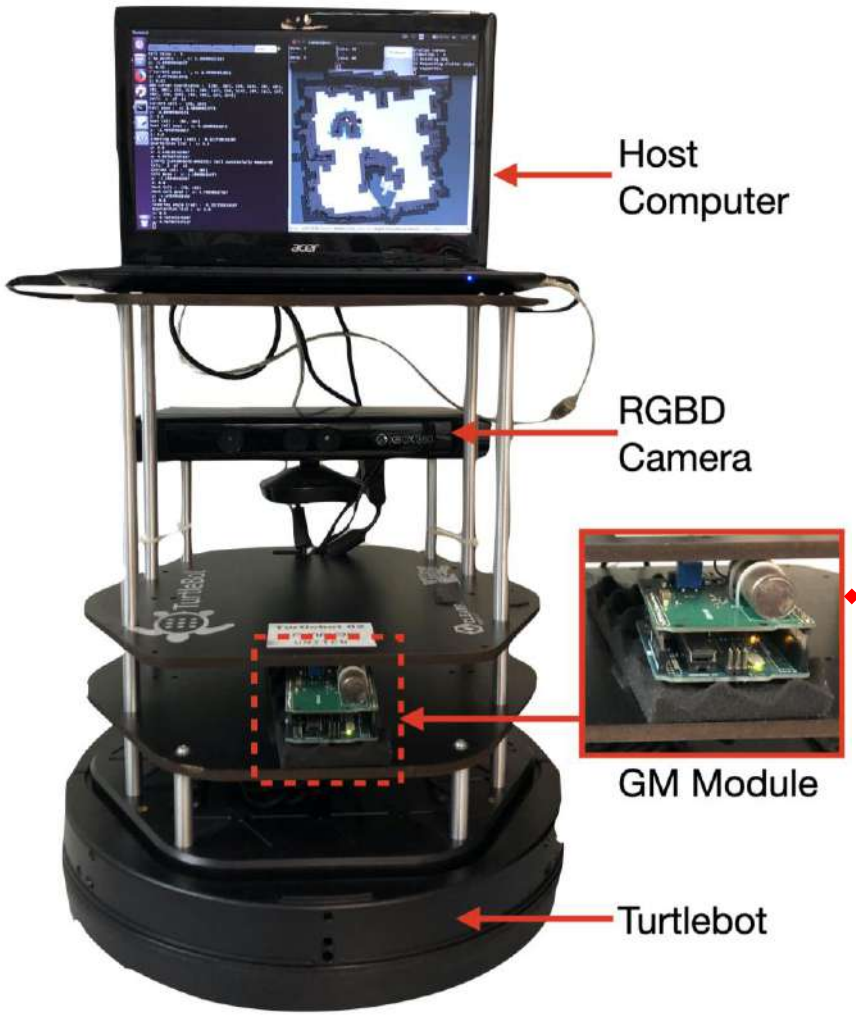


Figure 3: Complete set of AMoRA used in this study.

- AMoRA ensures measurement accuracy by indicating hotspots on the **physical map**
- This autonomous radiation measurement capability offered by AMoRA can **effectively decrease exposure time** to radiation

AMoRA

Autonomous Mobile Robot for Accurate Radiation Detection and Mapping

AMoRA were developed to map the distribution of radiation in the area.

01 INTRODUCTION

The **primary goal** of this study are:

- to observe AMoRA performance in producing the radiation mapping autonomously.
- to assess radiation distribution, enabling the identification of areas with higher radiation levels to be avoided during work at these facilities.

This approach ensures that work activities in the selected areas can be more efficiently coordinated in accordance with the ALARA (As Low As Reasonably Achievable) principle.

02 RADIATION MAPPING

INTERNATIONAL NUSTEC 2023

Site survey

Selected for Mapping?

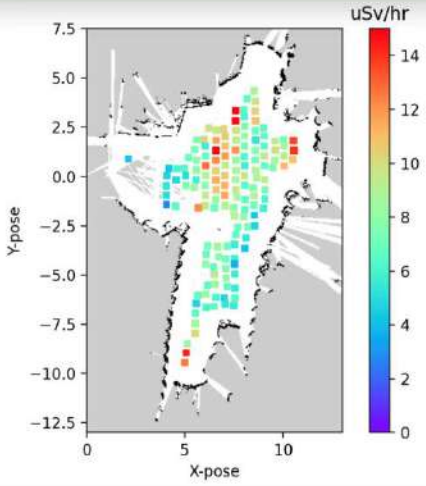
YES

NO

2D Mapping

Autonomous Radiation Mapping

Generate Radiation Map



Generate Report

RADIATION MAPPING REPORT

Project code : NM-R&D-23-02

Location: Reactor Hall Blok 20

Date/Time: 1 Mac 2023 / 0930 am - 1200 pm

PIC (person-in-charge):

Nur Aira Binti Abdul Rahman
Nabilah Binti Ramli
Muhammad Izzuan Bin Mohd Ghazali

Radiation type/source:

a) Fission product from Uranium-238
b) Activation product
c) Irradiation sample
d) Annihilation (energy), Ar-41, N-16

Radiation range:

In operation – i) at 0 meter = ~1 – 195uSv/hr
ii) at 1 meter = ~1 - 70uSv/hr
Off operation – 0.2 – 0.5 uSv/hr
Background -

Location condition:

Indoor / Outdoor / Others (specify): Indoor at the ground level of reactor hall

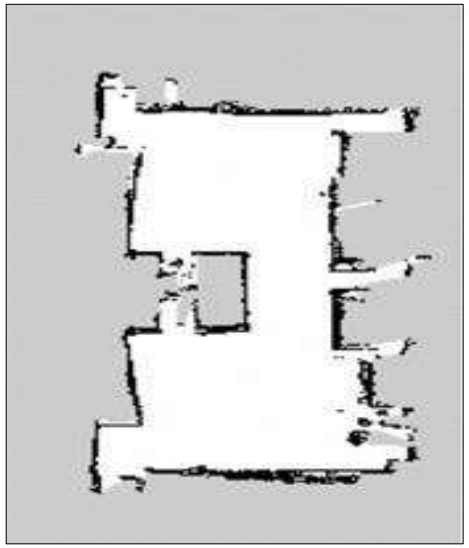
Mapping observations:

Problem encounter and limitation:

1) The floor surface condition that have bumper and holes on the floor made the mapping not accurate
2) Mapping program terminated unexpectedly
3) The location coordinate during manual data collection inaccurate
4) Code – No partition settings cause the robot skip the cell/area to measure the radiation reading
5) Speed robot in autonomous mode – potentially overturn when there are a bump and hole because the robot moved too fast

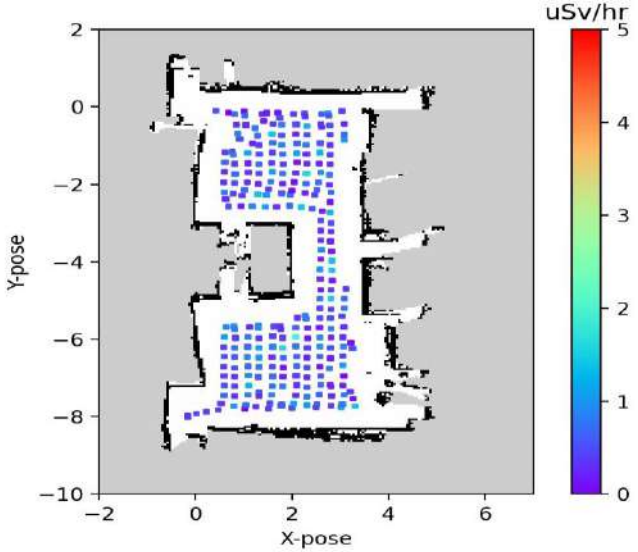
02 RADIATION MAPPING

1) The AMoRA was manually deployed to create a 2D mapping operation



2) The generated 2D map of the area. It was created with Simultaneous Localisation and Mapping (SLAM) by running the Robot Operating System (ROS) *gmapping* package

3) AMoRA is deployed to perform autonomous radiation mapping by executing the ROS *rad_mapper* package developed in the previous work



4) The rad_mapper divides the 2D map into a grid and generates sampling points at the centroid of each unoccupied grid. The counting time for data collection can be configured manually

03 RESULTS AND DISCUSSION

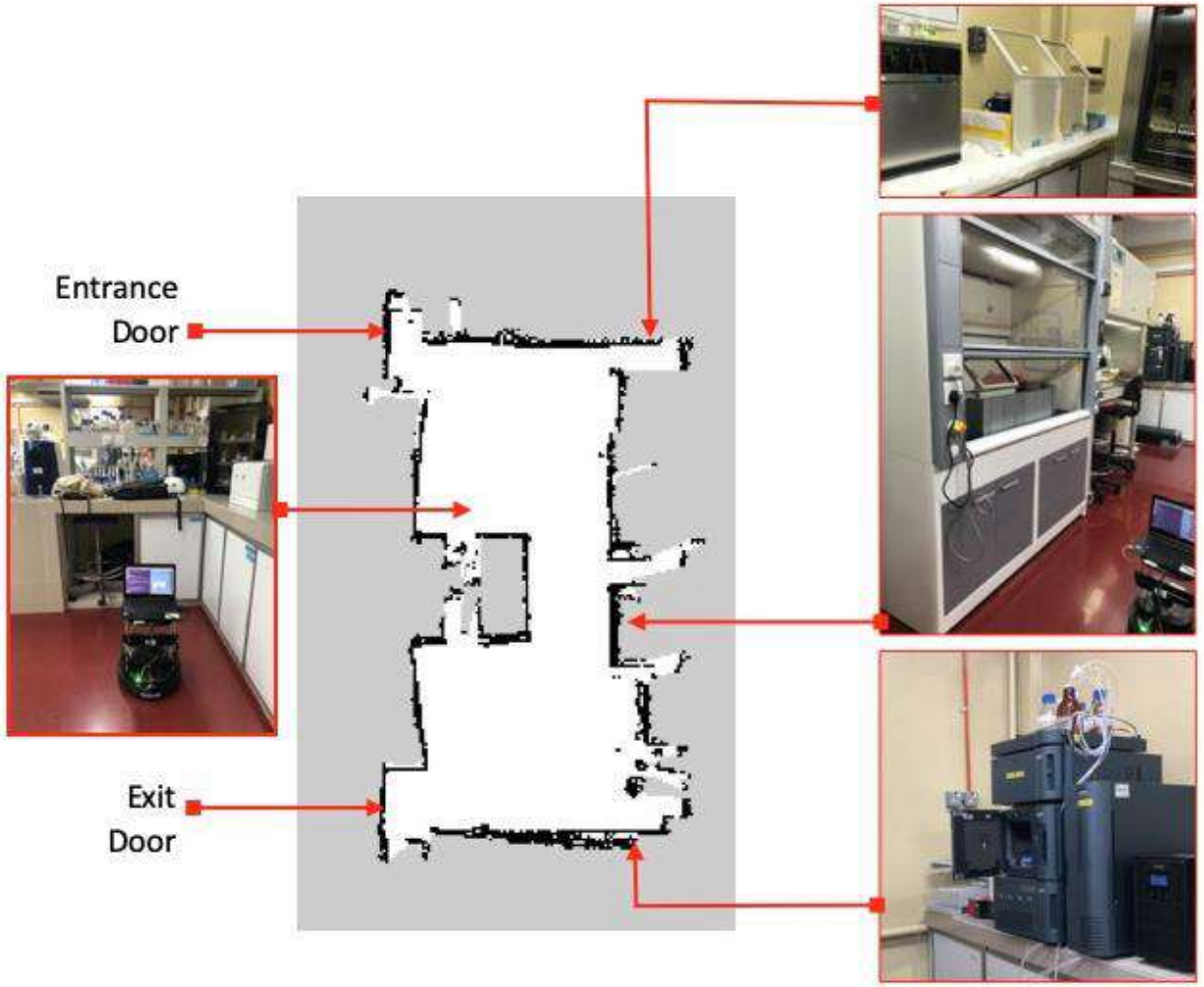
- In this study, AMoRA was employed to grid the radiation exposure levels at specific facilities. The facilities were chosen based on the **operational activities and associated risk factors.**

- The experiment was carried out at the facilities of the Malaysian Nuclear Agency under the guidance of professional supervision.

- There are three of the results presented in this work which are BTP Development Laboratory, Interim Storage Facility and Reactor TRIGA PUSPATI.

03 RESULTS AND DISCUSSION

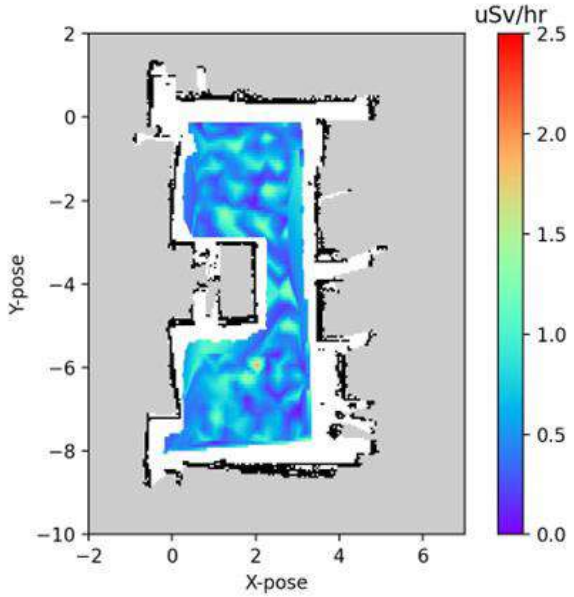
1) BTP Development Laboratory



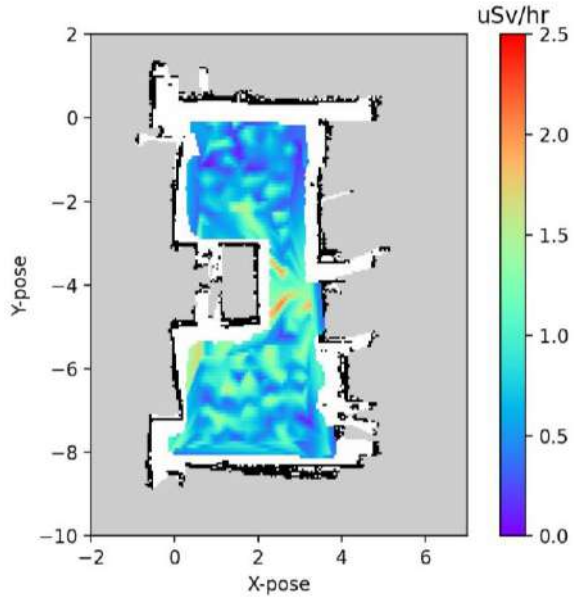
- There is a concern from the employer regarding the effectiveness of the shielding in preventing radiation exposure to personnel

03 RESULTS AND DISCUSSION

1) BTP Development Laboratory



At rest state :
The result demonstrate only background reading was detected

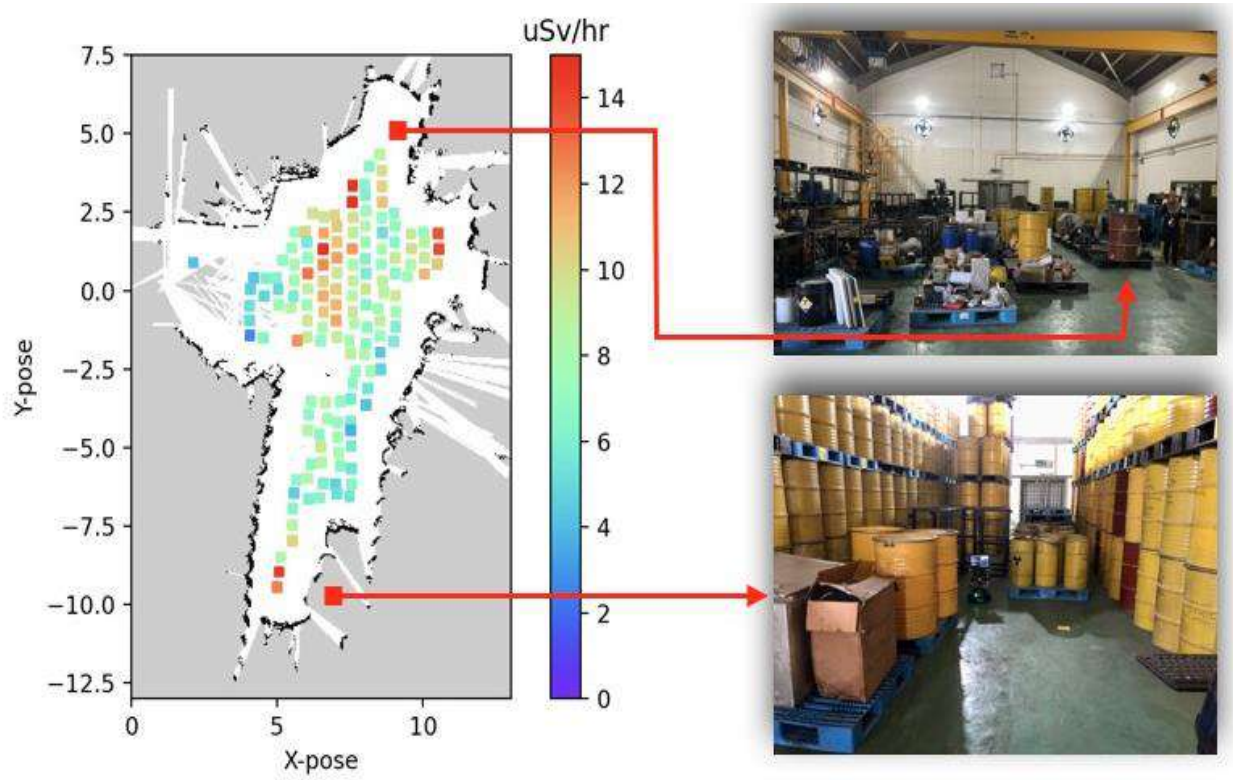


At workload state :
Clearly demonstrate the presence of radiation distribution

- ✓ It proves that the radiation around the working area is slightly elevated.
- ✓ Finding of this is useful for facility personnel to evaluate and coordinate the activities to ensure that the radiation exposure is within permissible limits.

2) Interim Storage Facility

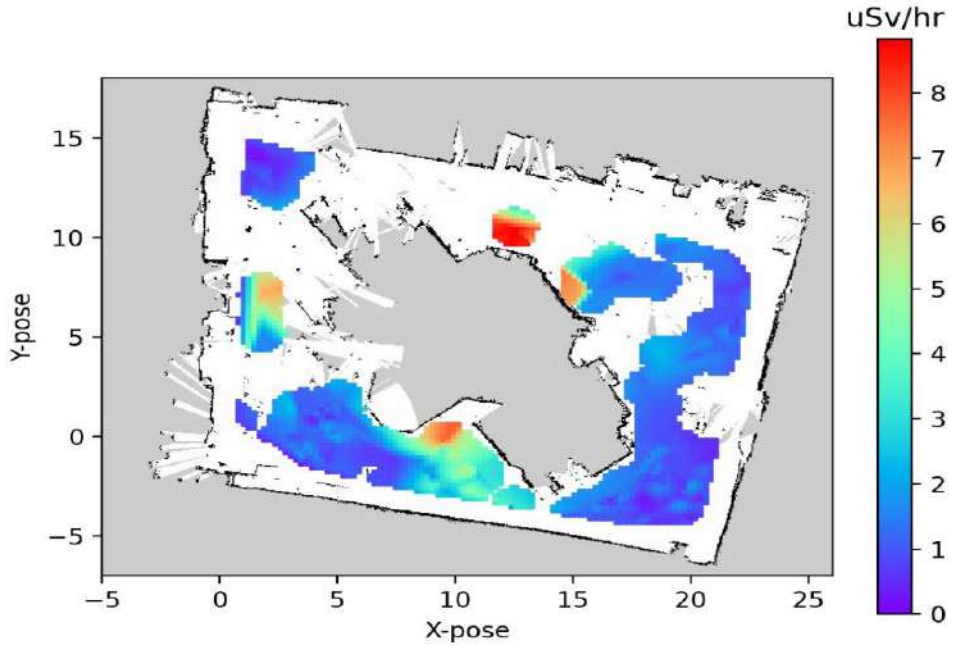
- Serves as a storage site for low-level radioactive material originating from reactor operations, medical, academic, industrial and other commercial uses of radioactive materials.
- The configuration of radioactive material within this facility is constantly changing.
- Radiation mapping is carried out to observe scattered radiation and detect areas with elevated levels of radiation.



- ✓ The results obtained clearly reveal hotspots in various areas within the facility.
- ✓ This contour map allows for the precise identification of hotspot regions because the mapping is conducted on the actual location map.
- ✓ In contrast, manual mapping by Harun et al., (2018) only offers a general location estimate for the hotspot.
- ✓ The exposure to radiation workers during the radiation mapping process is minimised by the autonomous operation.

3) Reactor TRIGA PUSPATI

- Research Reactor TRIGA PUSPATI equipped with the facilities such as Neutron Radiography (NUR), Small Angle Neutron Scattering Neutron (SANS) and Diffraction and Thermal Column for Boron Neutron Capture Therapy (BNCT).
- The radiation levels inside the reactor hall were monitored by area monitoring instruments in each corner of the building.
- However, despite all the facilities having shielding in place, scattering radiation remains a concern.
- To provide a detailed view of radiation distribution inside the reactor hall



✓ This contour map precisely pinpoints the location of these hotspots.

CONCLUSIONS & FUTURE WORK

- As a conclusion, the results presented in this paper have demonstrated AMoRA capabilities to perform autonomous radiation mapping and produce comprehensive radiation maps of the target areas.

- These radiation maps can be referred to effectively manage and minimise radiation exposure in the workplace, to ensure the safety compliance with local regulations and standards.

- Based on issues and challenges observed during AMORA deployment at the selected site, the design and algorithm will be improved in the future.

05 ACKNOWLEDGEMENT

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Thanks.

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