KAIT International Program
Final Presentation

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K1 Bldg, Room 1201
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Rev.8

A Remote Call System for Autonomous Round Robots based on Visual Landmarks

Intouch Visaruthaphong, Pimolkan Piankitrungreang [1)]
Haruki Isono, Shota Arai, Ryo Saegusa [2)]
1) Mechanical Engineering, Chulalongkorn University
2) Information Technology, Kanagawa Institute of Technology

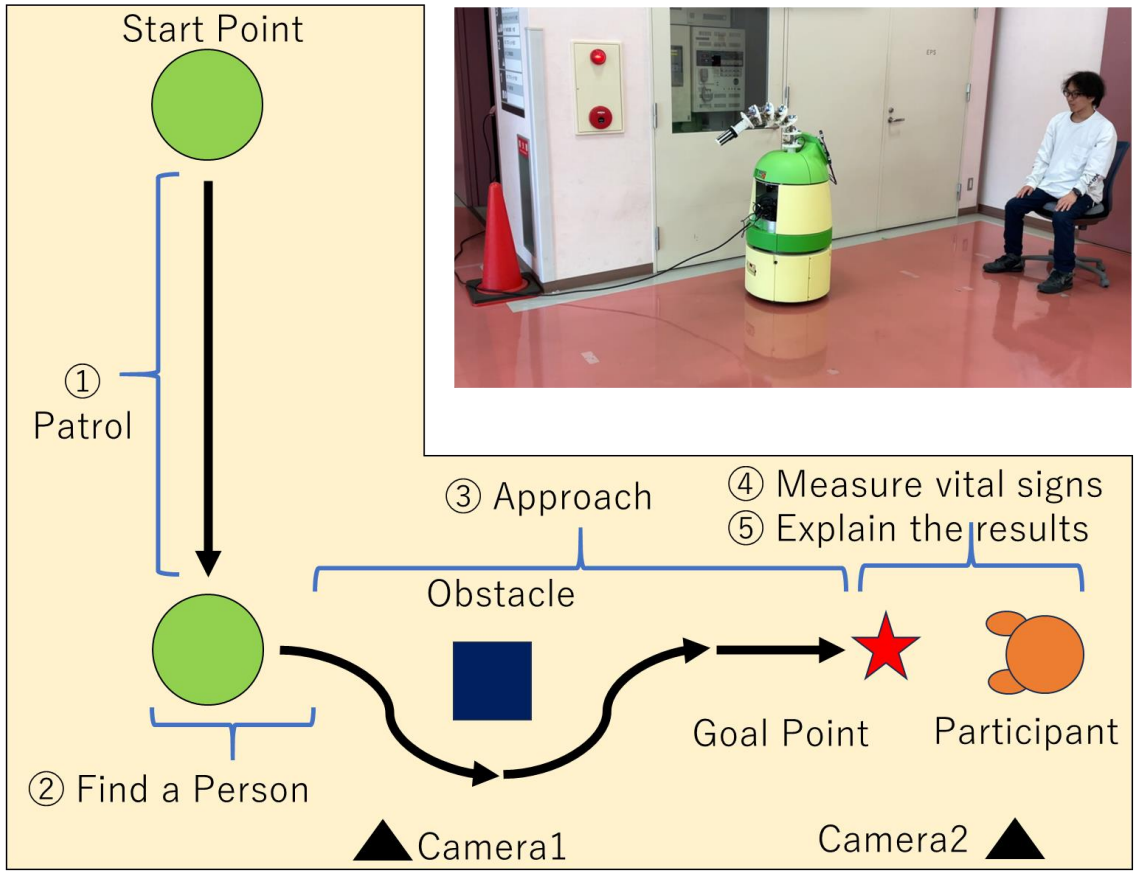
Background

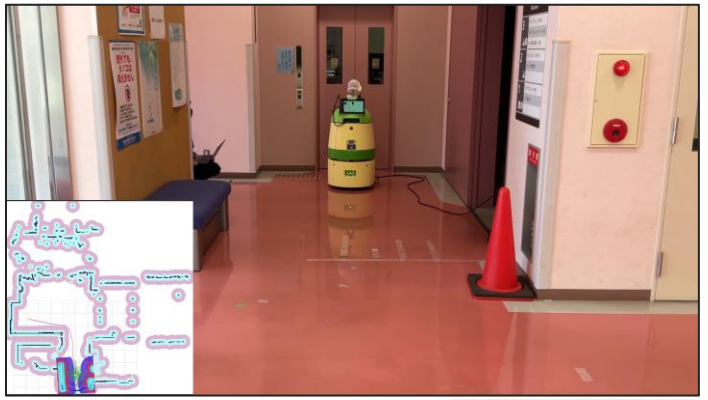
- **Lucia** is a mobile robot designed to assist medical doctors in clinical environments. It is capable of **autonomous navigation**, including **obstacle detection and avoidance**.
- Lucia's main role is to **support disabled patients** by measuring vital signs such as **heart rate, blood pressure, and oxygen levels**.
- The robot is built on **ROS2**, which controls its behavior, and **YARP**, which enables modular communication between software and hardware components.
- It also uses **Simultaneous Localization and Mapping (SLAM)** to navigate by building and updating a map of its environment in real time.



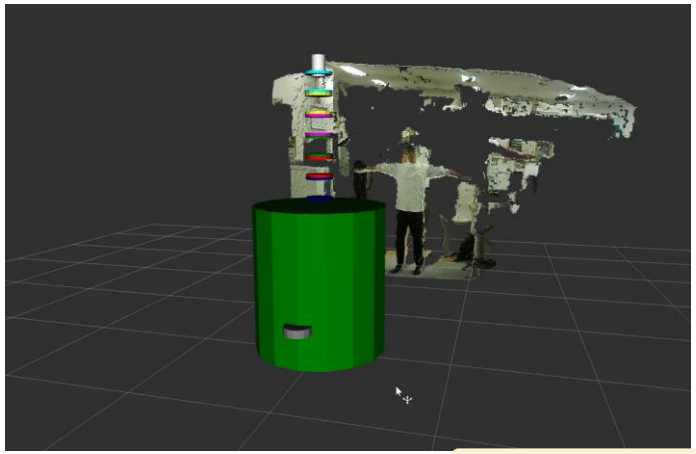
Previous Studies

- Lucia: Autonomous round and vital sign collection.





lucia_vital.25.06
https://youtu.be/0Q4QJuZeVQ8
Video: 3:13
Autonomous round and vital sign collection



lucia_3d.25.06
https://youtu.be/F8daknI57Hs
Video: 0:27
Spatial perception

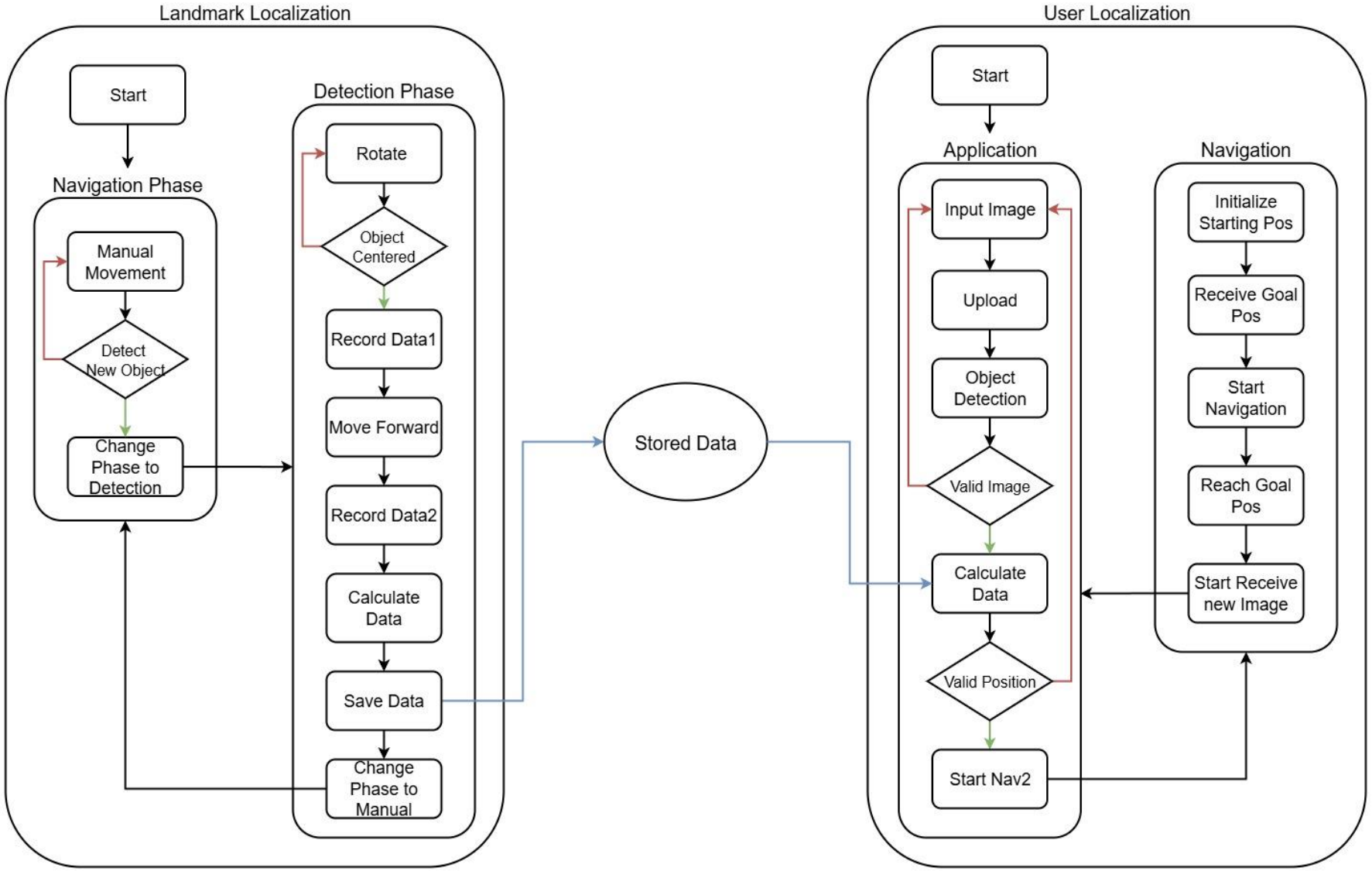
Problem Statement

- While Lucia is capable of autonomously navigating from one point to another and able to follow patients, it currently **cannot respond to patients who need assistance but are not in motion**.
- Since many patients requiring Lucia's support are **not mobile**, this causes a problem where the target user of Lucia cannot utilize its functions.
- Lucia's current design does not fully **address the practical needs of real-world clinical environments**. Not meeting the basic needs of patients would not allow Lucia to be **fully usable** in actual medical environments and restricting the potential help it can bring.
- A new system must be implemented to make the robot truly practical in real-world healthcare settings.

Objective

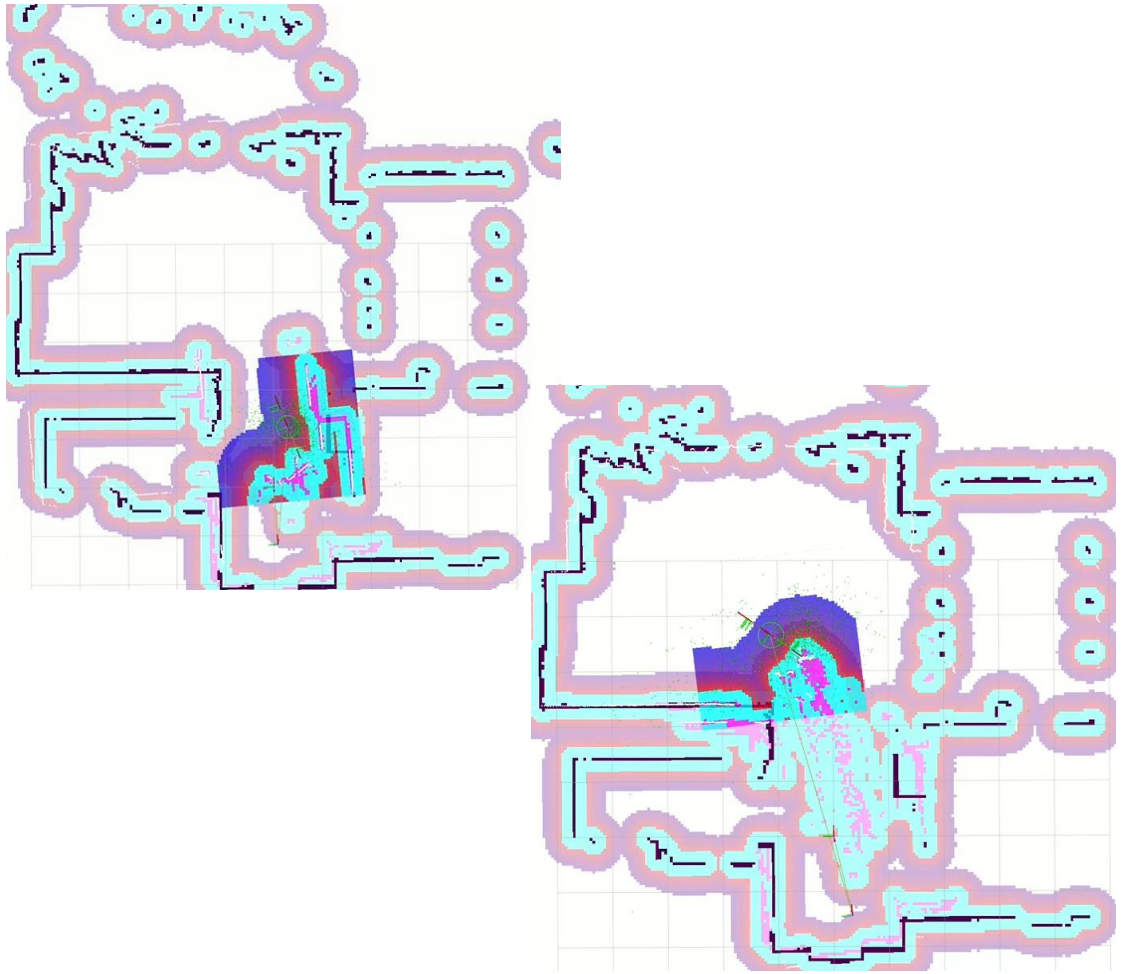
- The main goal is to make Lucia accessible and usable by **immobile patients**.
- Implementing a patient-initiated call system would solve this problem by empowering users to easily and independently **request assistance**, improving **accessibility and responsiveness**.
- This system must be:
  - **Simple and intuitive** for patients to use
  - **Easily deployable** in a variety of medical facilities
  - **Low-preparation**, requiring minimal setup and staff training
- This enhancement will transform Lucia into a more **practical and reliable healthcare assistant**, bridging the gap between advanced robotics and everyday clinical application.

System Overview



Landmark Localization System - Navigation Phase

- Main purpose of the Navigation Phase is for Lucia to **navigate** around the room and **detect key objects**.
- Uses **manual controls** to control movements by changing the speed of forward/backward movement and rotation.
- Localizes by first **initializing** and **sending initial position**, including coordinates and yaw to match with position on map.
- Visualization of robot on Rviz2 by showing robot position on map which uses data from odometry and lidar sensors to localize.



Landmark Localization System - Detection Phase

- Main purpose of the Detection Phase is for Lucia to **record data** and **localize key objects** as landmarks.
- Enters detection phase when object of interest in detected.
- Rotate until object is **centered** -> **record** height1 -> **move forward** distance -> **record** height2
- Calculations:

  K $= {}^{\Delta d}/_{\frac{1}{h1}-\frac{1}{h2}}$ (Variable used to fine object distance)

  $xO = xL + K \cdot height2 \cdot \cos(\theta)$ (x coordinate)

  $yO = yL + K \cdot height2 \cdot \sin(\theta)$ (y coordinate)

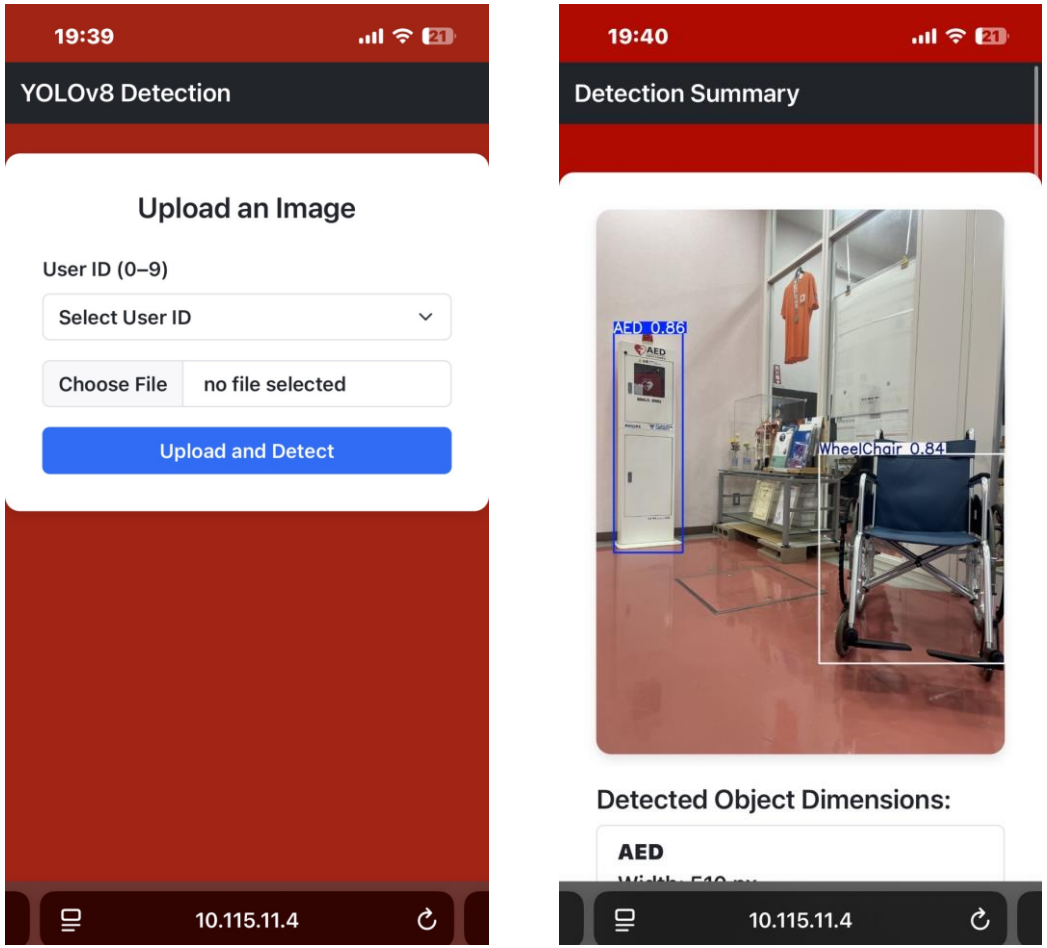
- Return to Navigation Phase after data is recorded to continue the process.


```
{
  "Cone": {
    "K": 288.1124999999999,
    "position": [
      2.174412228229322,
      -0.623000459196581
    ]
  },
  "WheelChair": {
    "K": 598.5573770491802,
    "position": [
      6.544579425041917,
      1.4593723572077846
    ]
  },
  "AED": {
    "K": 829.0071942446043,
    "position": [
      5.859464929039424,
      3.259999868887085
    ]
  }
}
```


Stored data

User Localization Application - Communication

- The app uses **HTTP** (HyperText Transfer Protocol) to send and receive data between the PC and the phone.
- When using the app, the pc will **request an image** from the user which can be either taken or chosen from an image gallery.
- When sent, the image will run through the object detection model trained before which give us the result of the detection.
- The results will be sent back to the phone.
- If needed, the app can **request** for a new photo to be taken.



Application interface

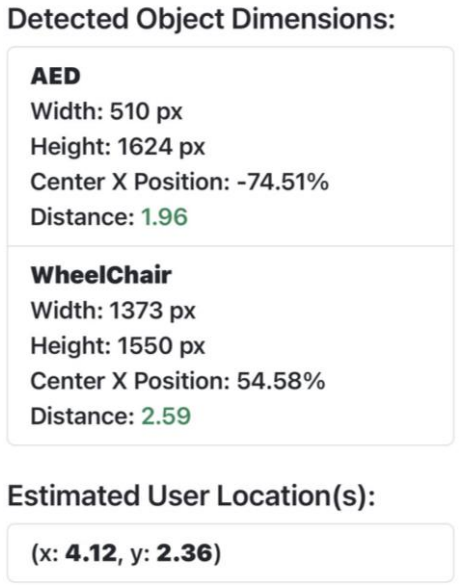
User Localization Application – Localization

- When image is sent, object detection will **detect for objects** and use its data.
- Localization is done by using preexisting **K values** and **coordinates** to calculate approximate locations.
- Calculations:

  $d = {}^{h}/_{k}$ (object distance from camera)

  $ro^2=(x-x0)^2+(y-y0)^2$ (radius1)

  $r1^2=(x-x1)^2+(y-y1)^2$ (radius2)
- **Solutions** of the equation are potential location of the user. Use the map to select best location and **send navigation goal** to Lucia.



Application showing user data

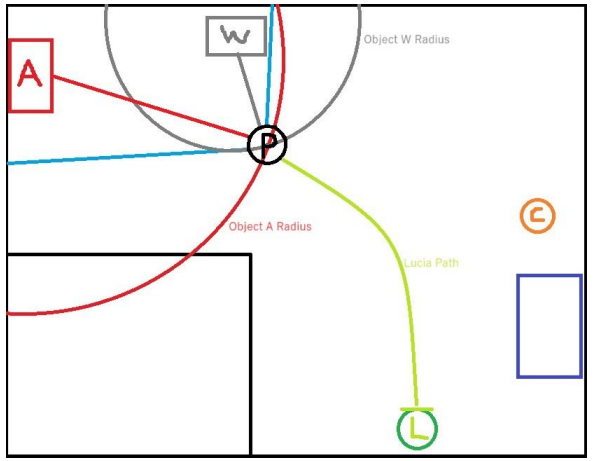
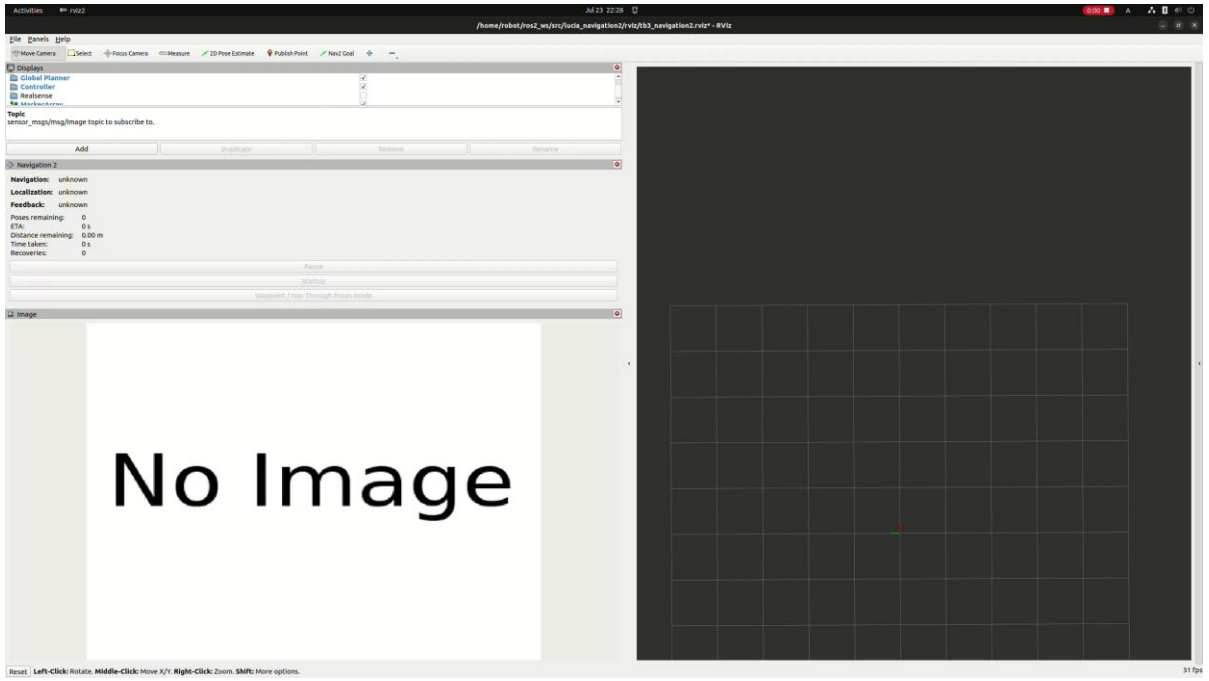


Diagram Visual of User Positioning Calculation

Demo Video – Landmark Localization



Rviz2 Interface showing Lucia's current position on the map and camera footage.



Video footage of Lucia moving around and localizing key objects.

Demo Video – Patient Localization



Rviz2 Interface showing Lucia's current position on the map.



Video footage of Lucia navigating to position of user based on image sent.

Problems Faced

- Communication with Japanese students are sometimes **not clear** enough causing **misunderstand** about some parts of the project. This causes some plans to have to be **changed** or entirely **ignored** to complete this work on time.
- Object detection model is not working properly in some parts and will need to be **more accurate** with a much **larger detection range** than what it is currently. Testing shows that the model is **not well trained** enough to be used in this type of project.
- **Automation** logic which was planned in the start became too complicated that it had to be left out and changed to **manual control** instead. This is due to underestimation of the **complexity** of the automation **algorithm**.
- Scope of the project is still far too small to be usable. Will have to continue develop and fine tune.

Future Improvements

- Implement the use of the **depth camera** to more accurately localize objects.
- Utilize a better format to **store data** so that it is usable in multiple formats.
- Fix and improve on the object detection model for a more **stability** and **accuracy**.
- Implement in the **automation algorithm** for Lucia be usable in unique areas with low maintenance and interference from people.
- Perform more testing on the system to **calibrate** specific parameters so that it will result in better localization accuracy.
- Integrate the use of the **Lidar system** and **object avoidance** is all parts of the process.
- Improve on the user **location calculation** to be able to utilize **map coordinates** and **boundaries** when selection coordinates.

References

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- https://docs.nav2.org/
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- https://jinja.palletsprojects.com/en/latest/templates/
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- https://storage.googleapis.com/openimages/web/visualizer/index.html?type=detection&set=train&c=%2Fm%2F052lwg6
- https://github.com/iHaruruki/Lucia_and_Spina?tab=readme-ov-file

Q&A…?