UV Robot Design Challenge

IIT DELHI

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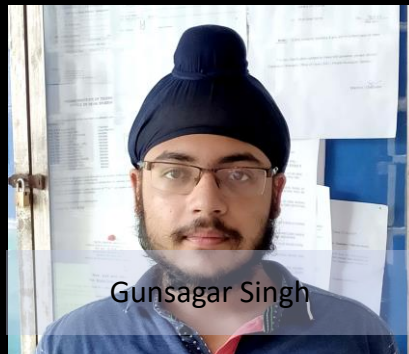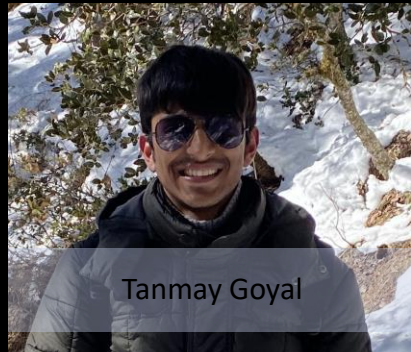
Outline of presentation

- Modern Design
- Integration of UV lamps
- Powerful Drive System
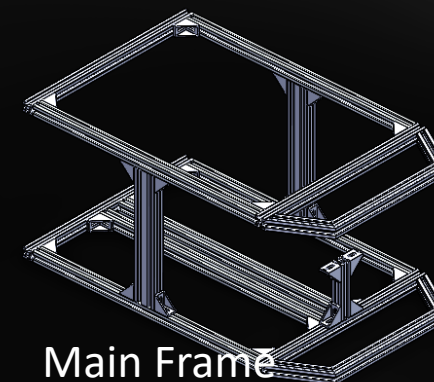- Light Weight Aluminium Frame
- Energy consumption & Battery Life Estimate
- Intuitive User Interface
- Reliable – Open source Backend

RPLIDAR A3
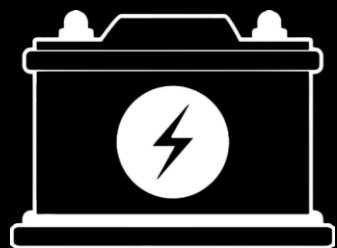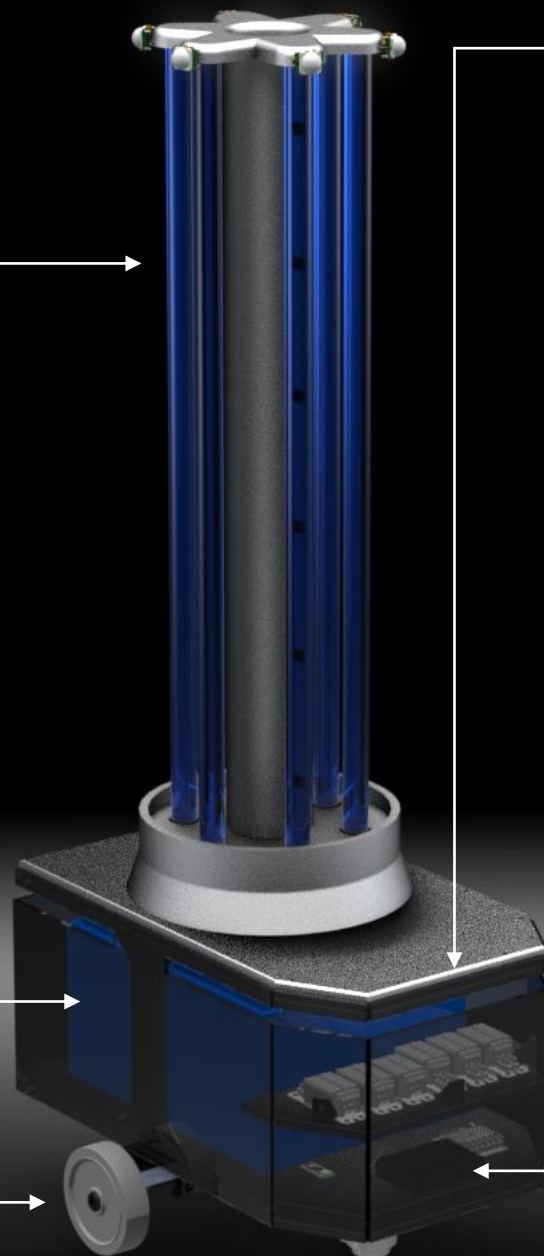360 Degree Laser Range Scanner for Indoor and Outdoor Applictaion

11.2W UV-C Lamps

Battery 1.3kWh

Main Frame

Motors

Nvidia Jetson

UV Lamps

A MATLAB program was coded to carry out calculation and provide a visual output of the irradiation pattern

This program can calculate the expected irradiance for multiple lamp configurations at various distances

We used this program to choose the wattage of our lamp model, their configuration and the time it will take to irradiate surfaces at various distances

Values indicated show the time it takes to disinfect surfaces at a height 2.4 meters above the ground with an irradiation dose of 25mJ
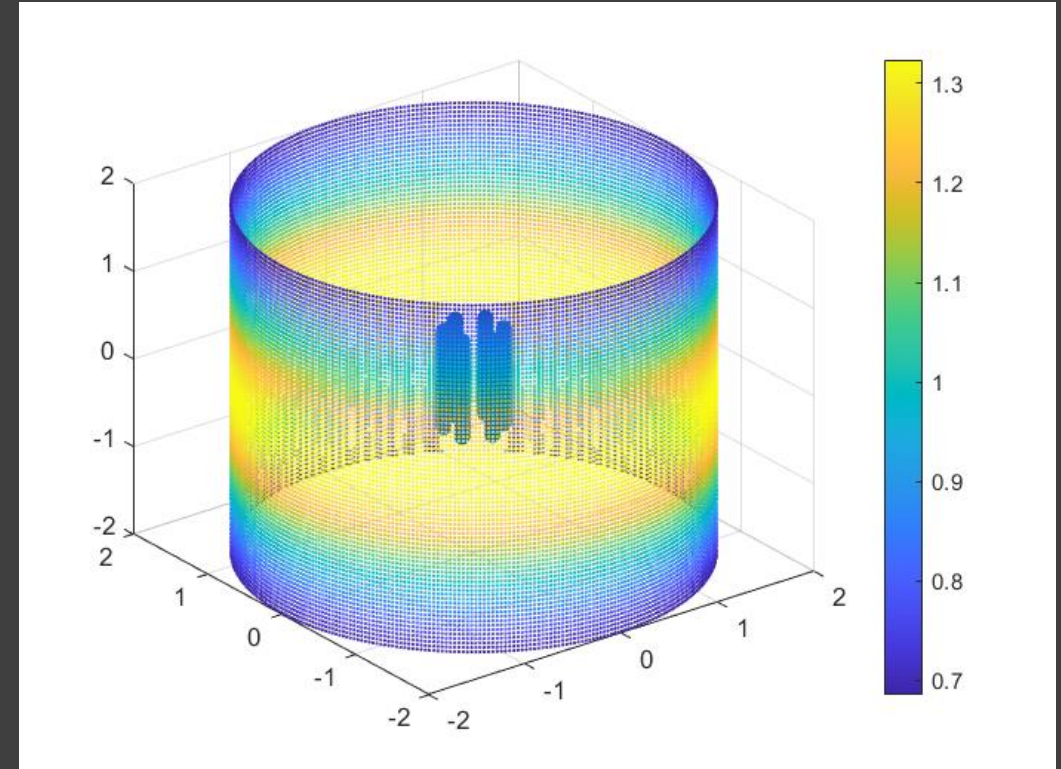
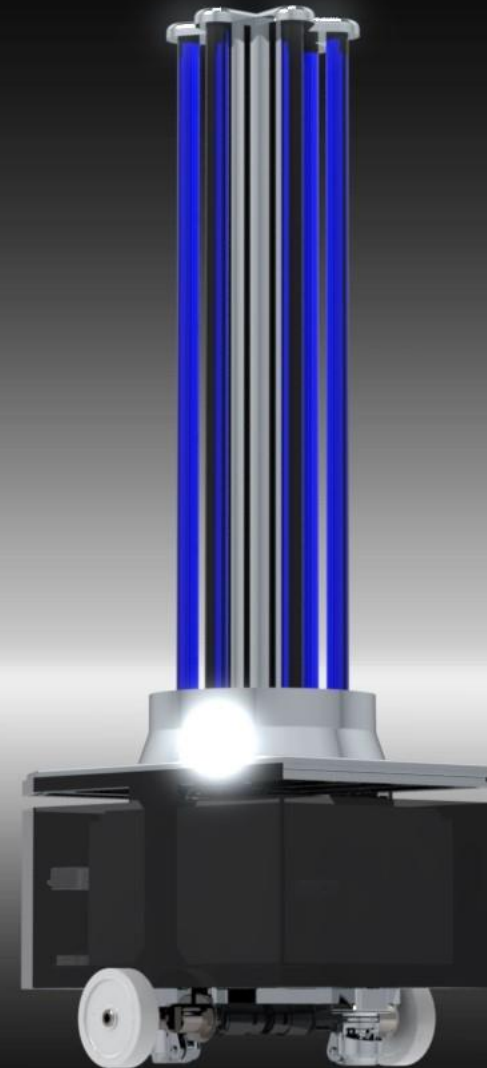| Power (W)	Distance (m)	Irradiance (μW/cm^2)	Time (sec)	Energy (Wh)
255	1	169	147.9	10.4
	2	85	294.1	20.8
	3	48	520.8	36.9

UV lamps

STER-L-RAY's CC48T5L Cold Cathode 11.2-Watt UV lamp

6 UV lamps arranged uniformly in a circle

360-degree coverage

Germicidal UV-C with wavelength 254nm

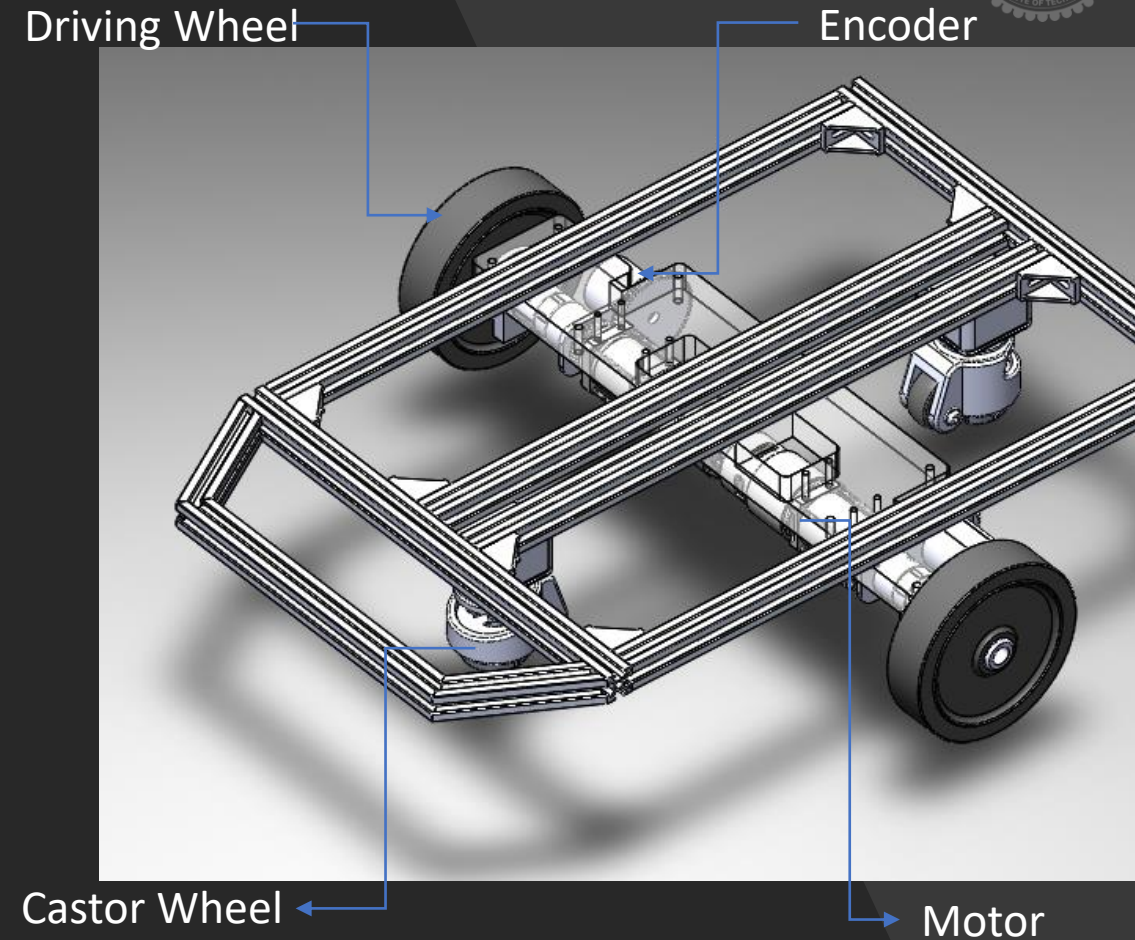Long life (20,000 hrs) and unaffected by frequent starting

Drive System

Why differential drive system?

- Statistically Stable
- Zero Turning Radius
- Low Cost
- Light Weight

Specifications

- Achieves a speed of 1.4 m/s in 3 seconds
- Can traverse a grade of 7.5°

Driving Wheel

Encoder

Castor Wheel

Motor

Mechanical Frame (Chassis)

- Made from Aluminium Profiles

- Aluminium Plates at each level to distribute the load

- The chassis can bear a load of up to 60kg

- Modular design ensures placement of components utilizing minimum volume

- Specifications
  - Weight = 55Kg
  - Dimensions: 60cm x 37.2cm x 138.7cm
  - Tipping force: 70 N

BOM and part drawings are documented which provides the manufacturing route of the Robot
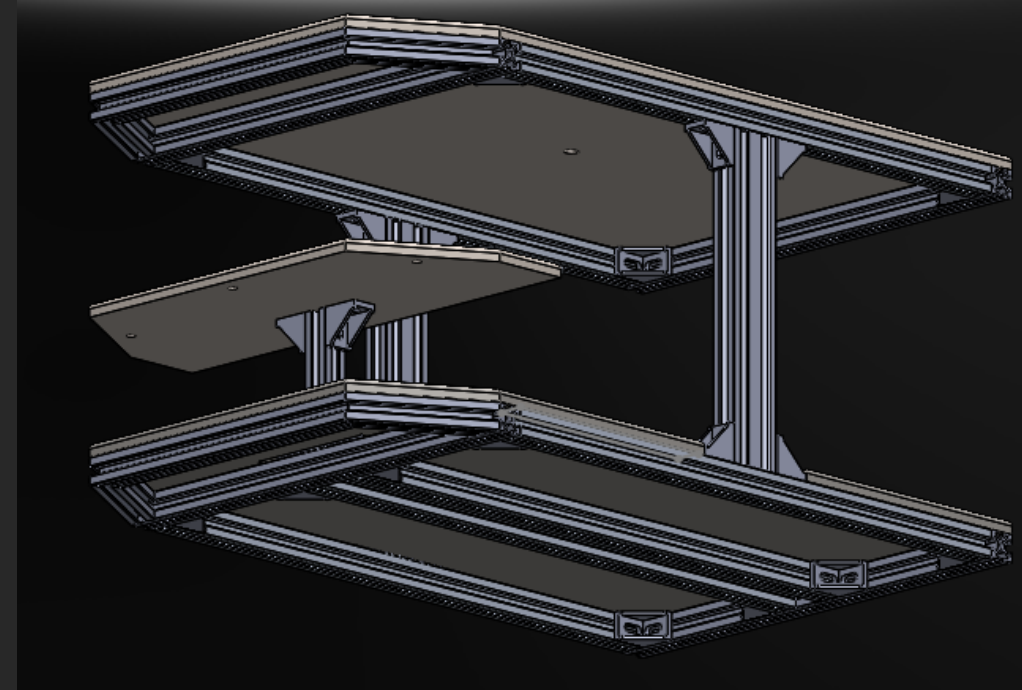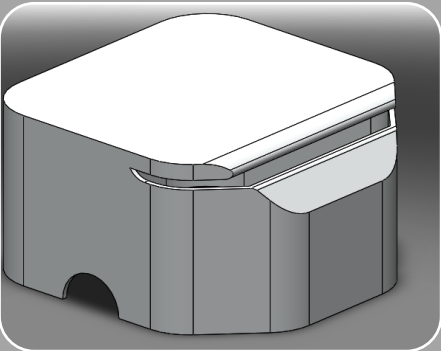
Outer body
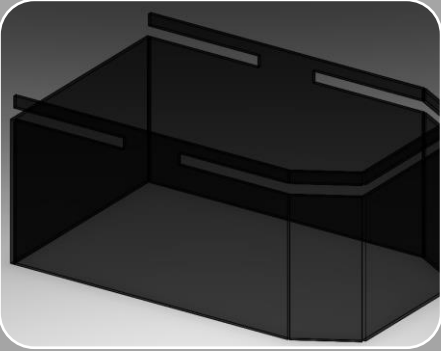
Acrylic plates on all sides

- Suitable for prototyping version

Single mould enclosure

- Suitable for mass manufacturing
- Design can be custom made

Power Source

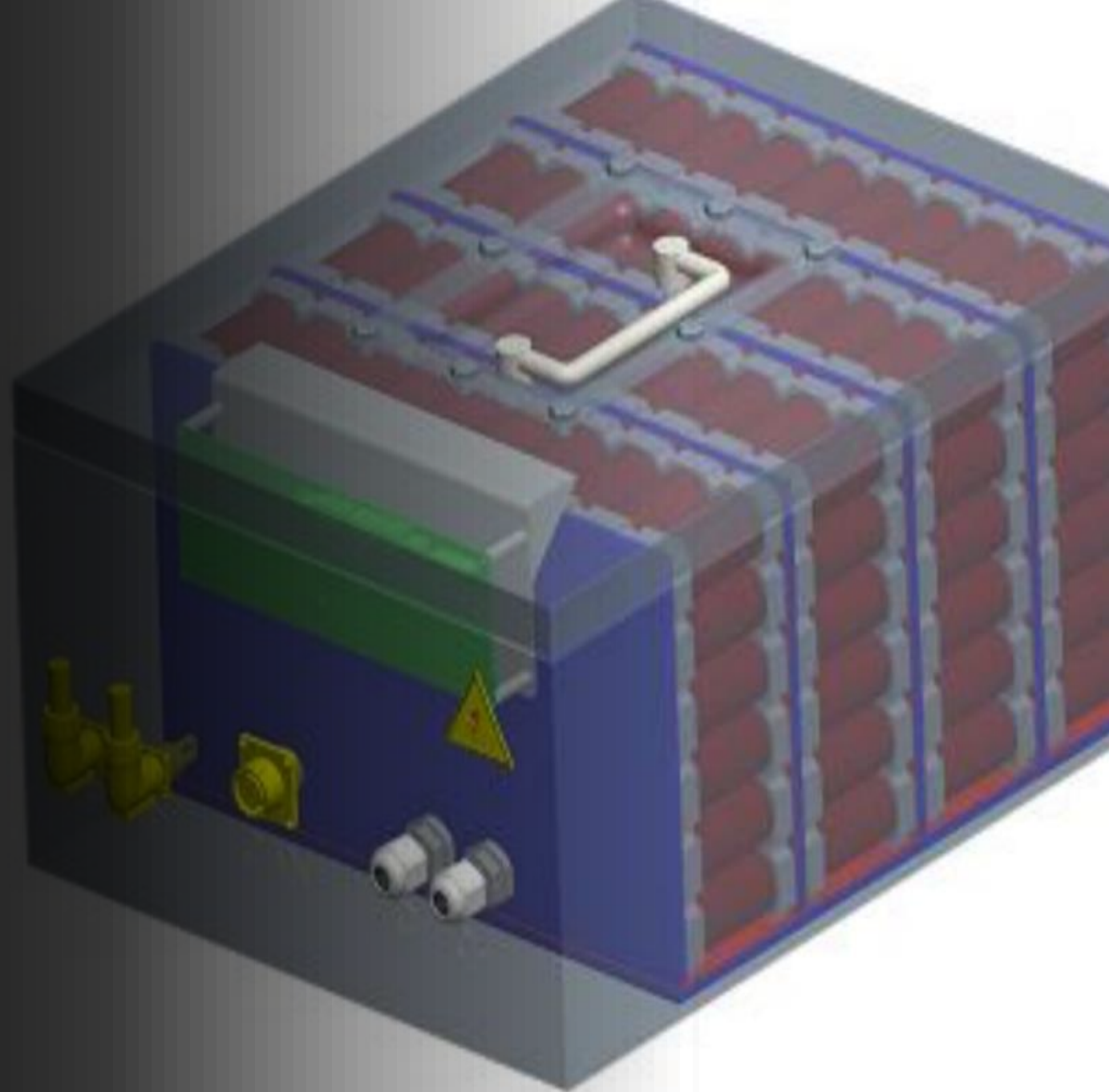1.3 kWh 25.6 Volt LiFePO4 battery manufactured by UltraLife Corporation
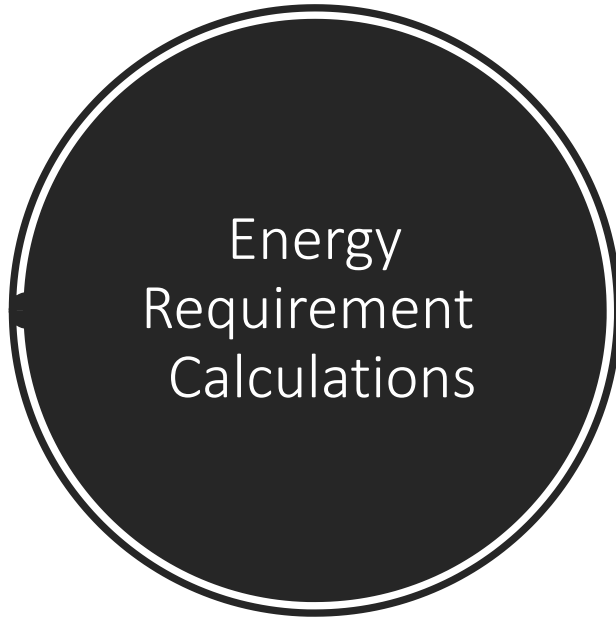
Safest Lithium-ion based battery chemistry

Long life with 2000+ charge cycles

Inbuilt Battery Management System for safe operation

CAN communication for reporting battery health and state of charge

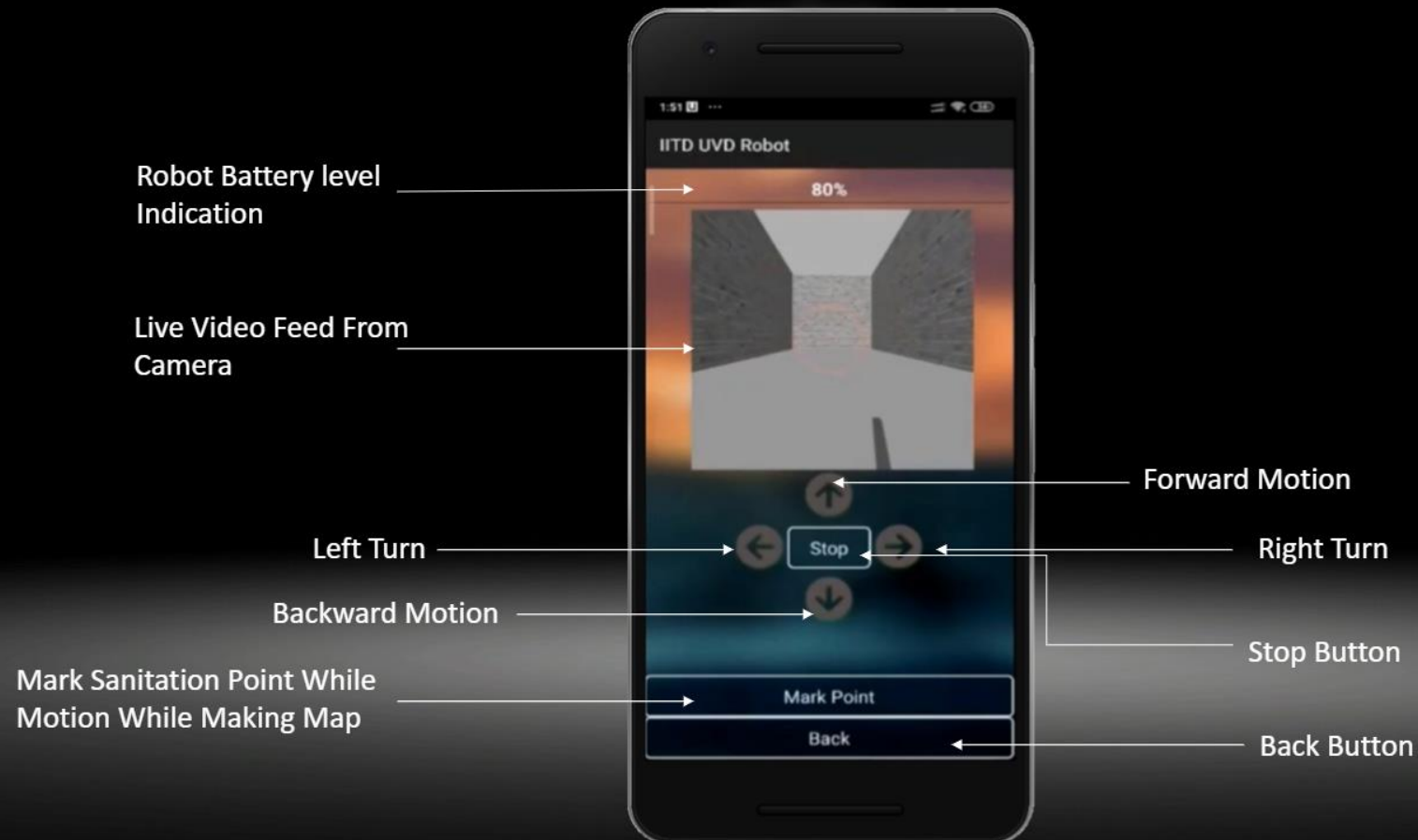Enclosed in a fireproof ABS enclosure

Energy Requirement Calculations

#	ROOM TYPE	DIMENSIONS (m)	AREA (sqm)	# OF 1m CIRCLE	# OF 2m CIRCLE	TOTAL ENERGY (Wh)	T.E. PER sqm
1	Office	4 by 4	16	4	1	62.75	3.92
2	Office	3 by 4	12	2	1	41.79	3.48
3	Lab	6.1 by 5.8	35.38	0	5	104.17	2.94
4	Operating Room	7.1 by 8.7	61.77	0	9	187.50	3.04
5	Floor plan of a building	17 by 11	184	0	22	458.33	2.49
					Average	170.91	3.17

- 0.11Wh energy consumed by drive system per <u>meter</u> of travel
- Can cover 250 sqm / 12 rooms on a single charge
- Worst Case Scenario: 50 sqm of area covered with 70% overlap with a runtime of 3 hours

Android Application

Manual Mode Button → Manual Mode

Autonomous Mode Button → Autonomous Mode

Create Mission button → Create Mission

IITD UVD Robot

Manual Mode

Robot Battery level Indication

Live Video Feed From Camera

Forward Motion

Left Turn

Right Turn

Backward Motion

Stop Button

Mark Sanitation Point While Motion While Making Map

Back Button

Map created by driving robot using the app

Sanitation point selection done while mapping or after the map is made
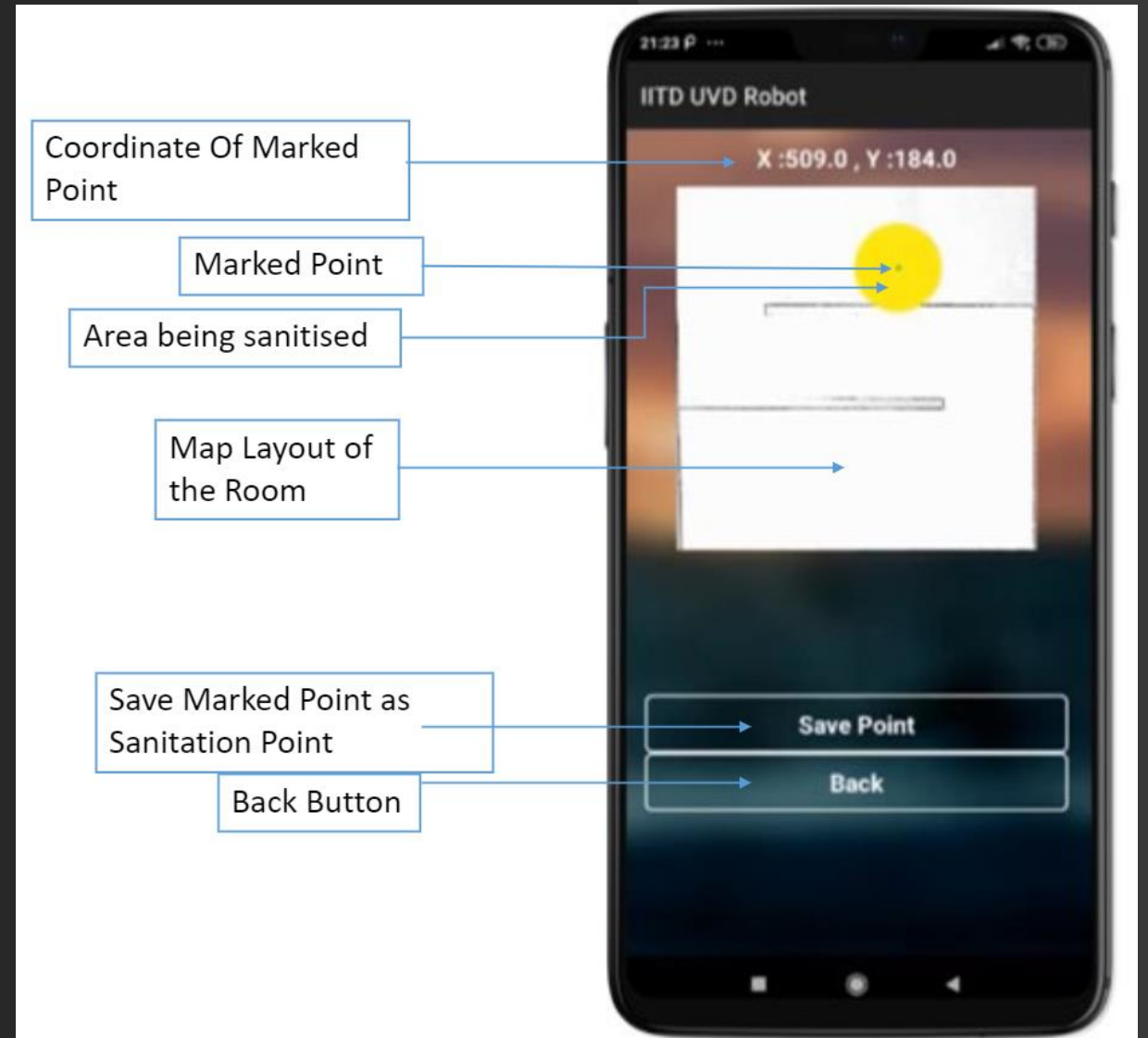
Initial Mapping
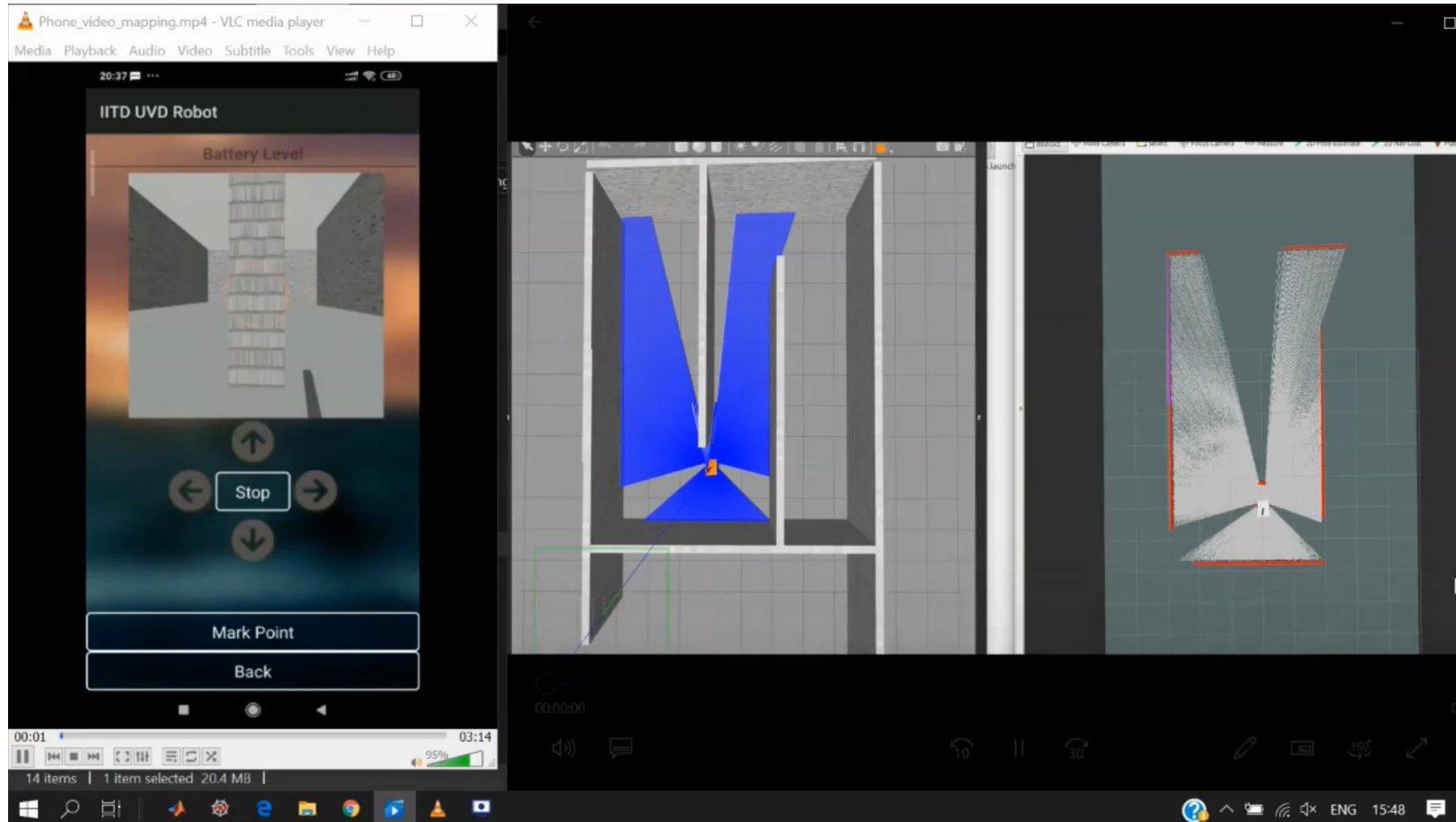
Creating Missions

Create and save multiple missions within the app

Add sanitation points by merely touching the location on the picture of the mapped area

See the sanitised area and set the desired sanitation distance

IITD UVD Robot

Coordinate Of Marked Point

X :509.0 , Y :184.0

Marked Point

Area being sanitised

Map Layout of the Room

Save Marked Point as Sanitation Point

Save Point

Back Button

Back

While Starting Mission

DETERMINE MOST EFFICIENT PATH (TSP)

CALCULATE ENERGY REQUIREMENTS

**DETERMINE TIME TO COMPLETION**

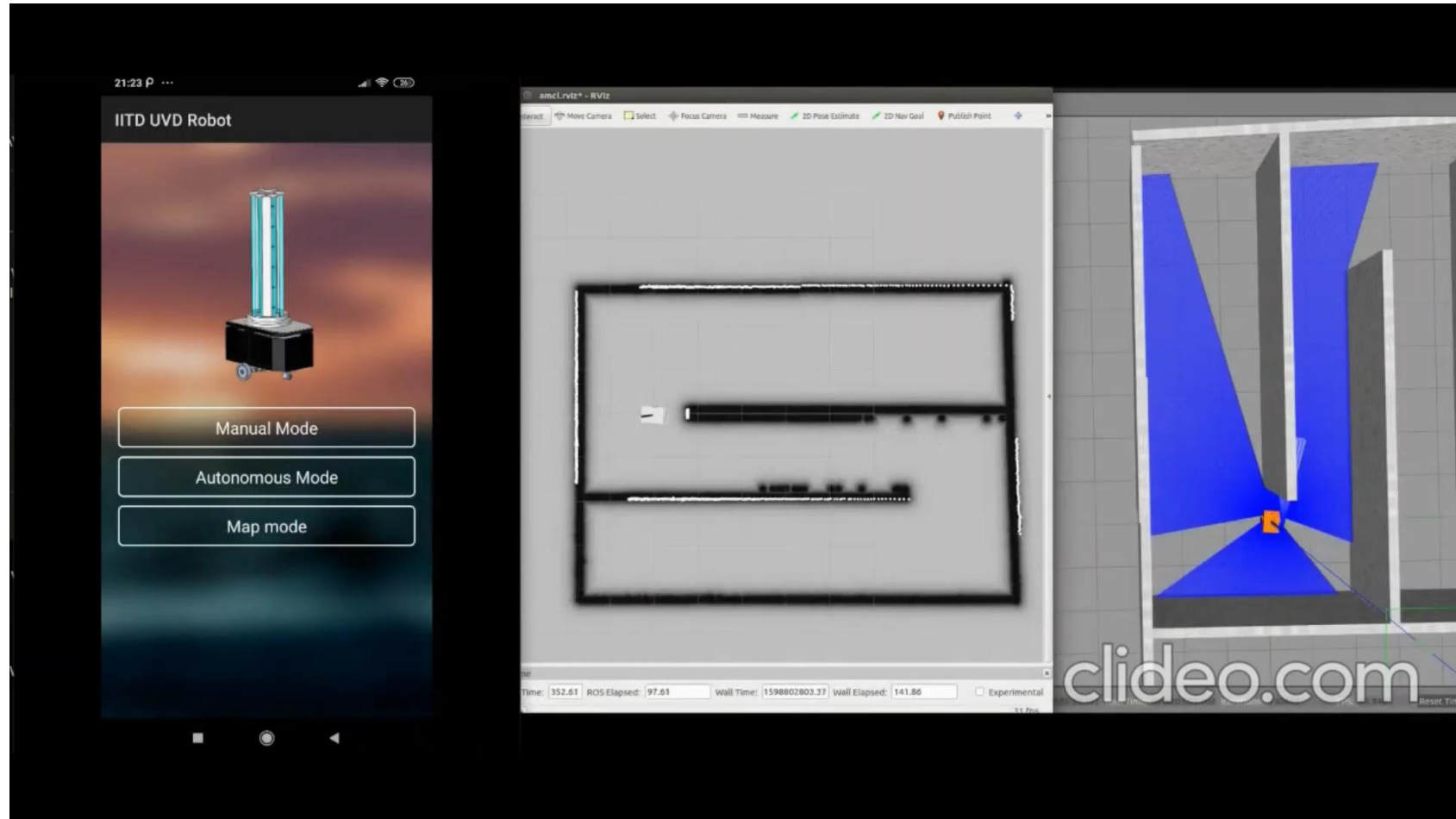**USER NOTIFICATION AND CONFIRMATION**

During Missions

- See the location and a live camera feed of the robot

- Easily keep track of the robot including battery level, time remaining in sanitation during current mission

- Receive notifications whenever the mission is interrupted due to any safety event

- Control robot movement and UV lights easily
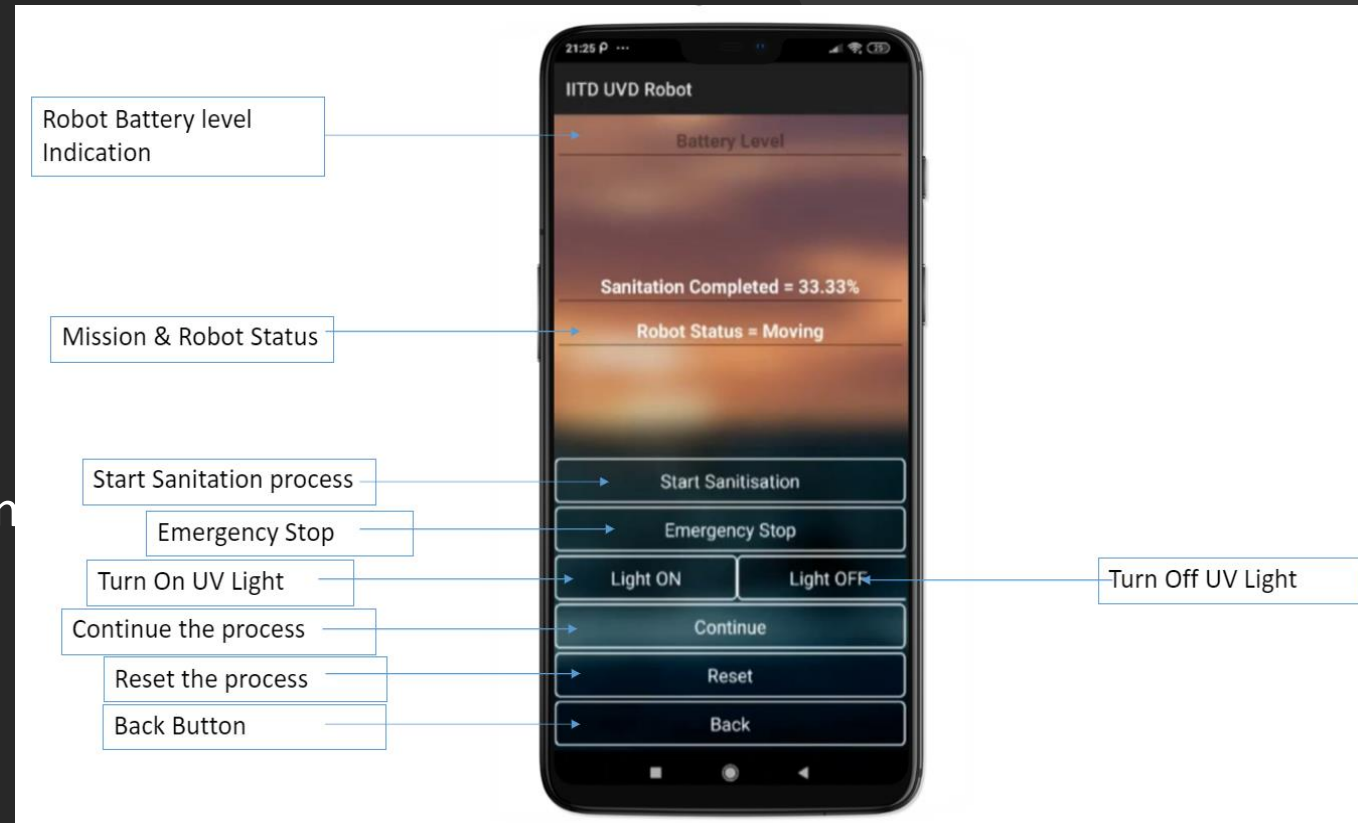
Mission Demo

Emergency Stop

Safety Features
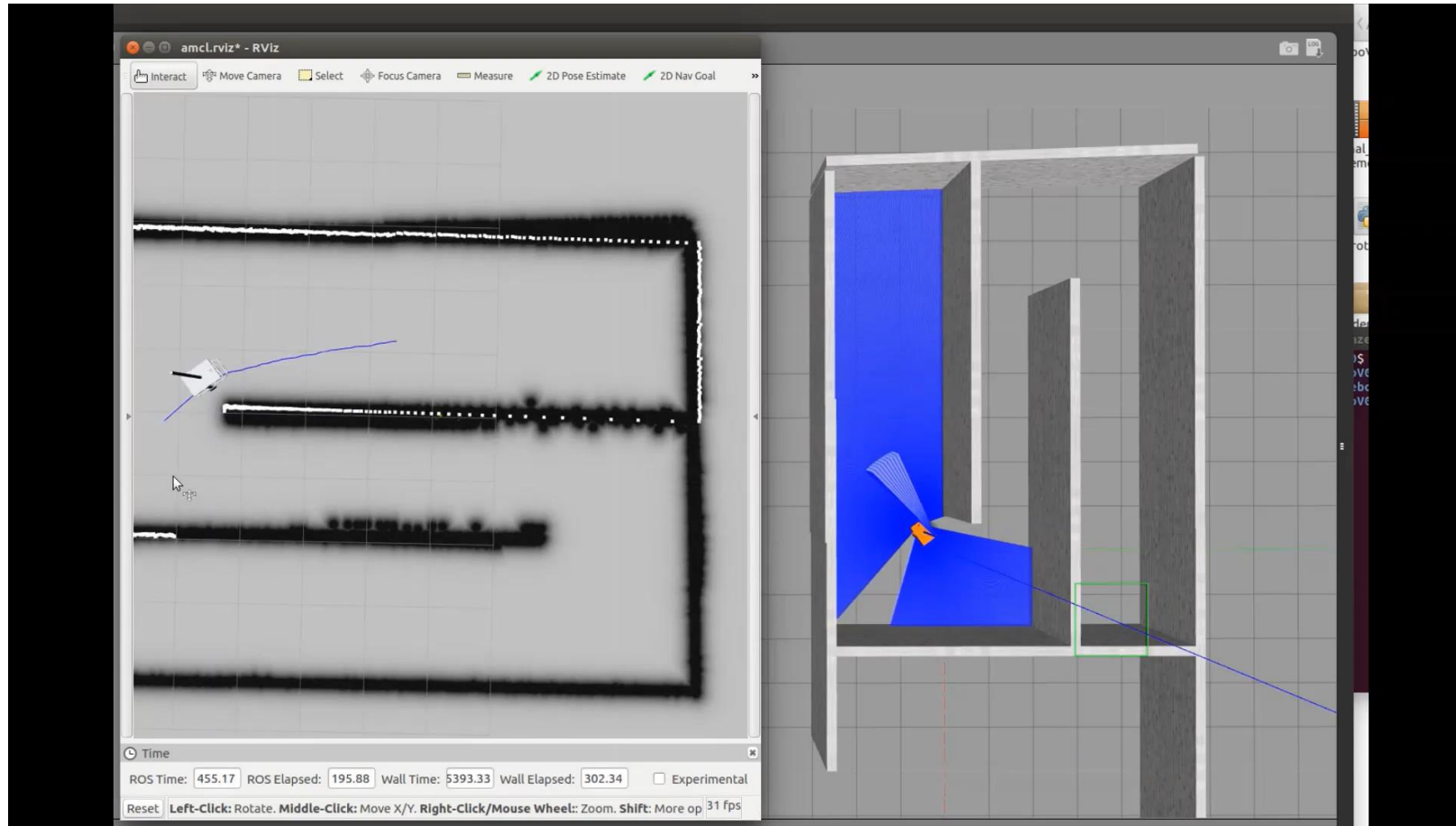
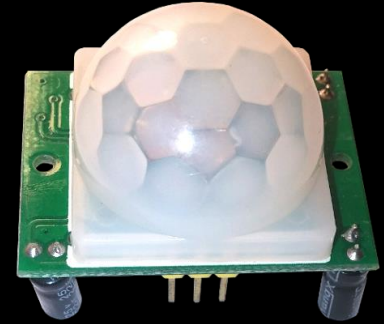
Infrared based human detection with range up to 7 meters

ML based voice enabled control for emergency stop

Multiple ToF sensors for object detection along the height of the robot (TeraRanger by Terabee)

Wireless communication with android app

Voice Based Safety Feature

Introducing a voice-based command system to stop the robot while disinfecting

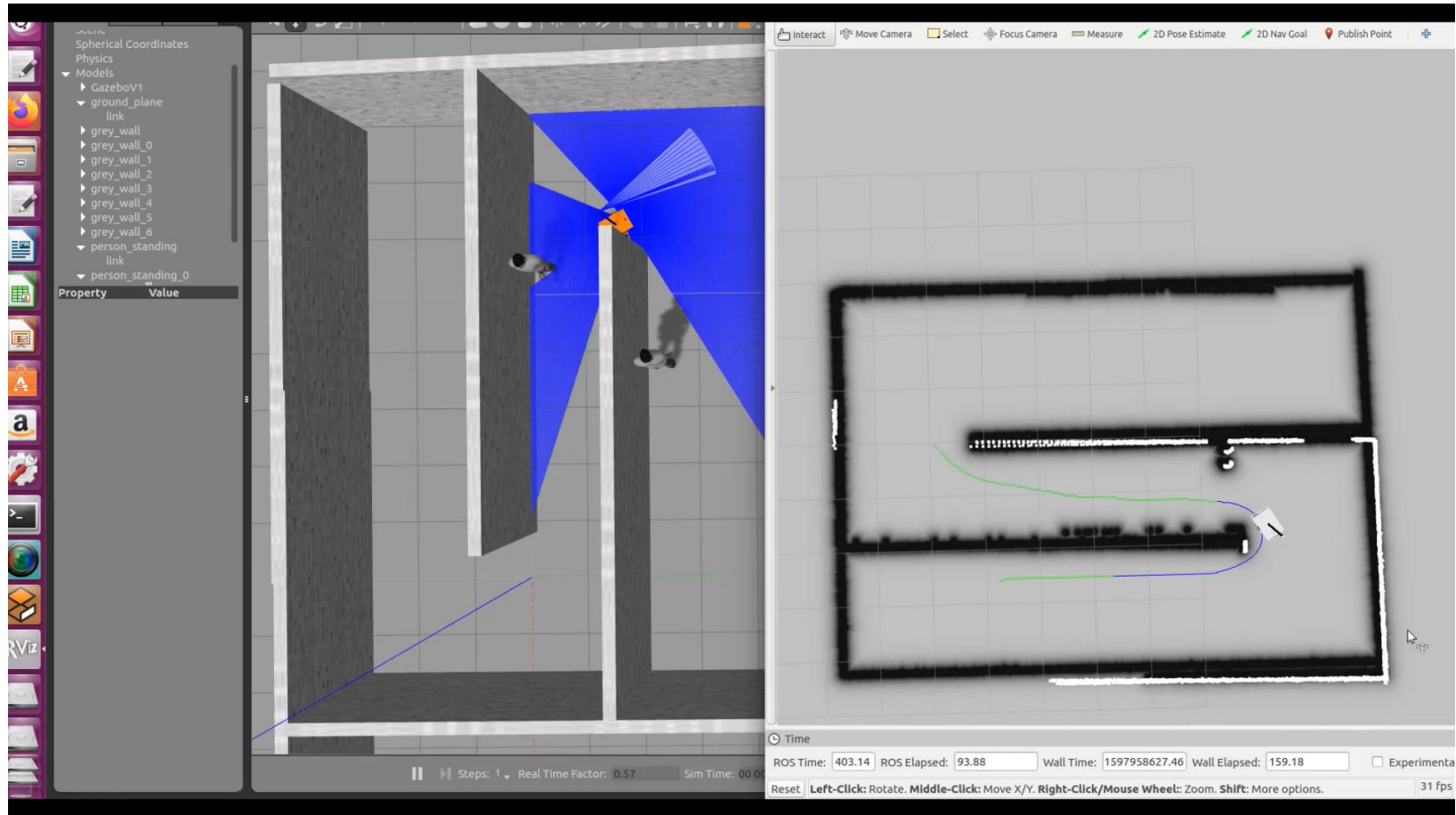Extensive and open source Google Speech Commands Dataset used for reliability

Trained for words: STOP, NO, OFF

Capable of distinguishing between background noises thereby reducing false positives

Detection accuracy of 88%

Obstacle Avoidance

Software Stack

Robot driven via the ROS differential drive controller

ROS packages by Terabee used for obstacle detection

Localisation within the building using LiDAR scanner

Robot navigates and avoids obstacles via the ros navigation stack

Bill of Materials

| #	Item	Price ($)
1	Nvidia Xavier NX	399
2	Battery + Power Supply	1500
3	Chassis	145
4	RP LiDAR A3	599
5	TeraRanger Multiflex	115
6	PIR HC-SR501	10
7	UV Light holder	69
8	UV Light ballast	660
9	UV Light Lamp	690
10	Banebot DC Motors	35
11	Gearbox- P61 16:1	92
12	Optical Rotary encoder 2500ppr	108
13	RoboClaw 2x30A Motor Controller	125
14	Wi-60 Auto Castor Wheels	30
15	Colson Wheel	7
16	Colson Series 2 Hub	14
17	SSR-40DA Solid State Relay Module	7
18	Arduino Nano 33 BLE Sense Header	34
19	Raspberry Pi Camera Module V2	35
20	Speaker	4
21	Fast LED WS2812B	4
	Total	4682

Video Demo of product Design

Summary

- Elegant & Modern design

- Sanitise 12 large rooms on a single charge

- Intuitive control via Android app
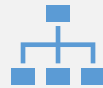
- Multi-tiered safety system

- Open-Source Backend