ABSTRACT

An Autonomous robot is one that can perceive its environment, make decisions based on what it perceives and has been programmed to recognize, and then actuate a movement or manipulation within that environment. Several vital functions of robots such as Autonomous Navigation, Object Recognition, Speech Recognition & Synthesis, etc. are increasingly AI driven. This technical report prepared as an outcome of the internship, describes the methodologies to create a general purpose user-interface that helps to acquire labeled datasets for performing several of these AI features by navigating a real service robot in an indoor environment.

BACKGROUND

An Autonomous Robot is a machine that has the capability to sense, make decisions and perform actions in the real world environment in which it operates. Robotics applications vary greatly and a robot can be designed to carry out various tasks desired for its application. Broadly robots can be grouped into 6 categories:

1. Autonomous Mobile Robots (AMRs)

An Autonomous mobile robot can function completely independently and can understand and make decisions in real time as it moves through its environment. It is equipped with sensors and cameras which provides the robot with data needed for decision making and navigation. AI makes an important impact in decision making. Advanced AI algorithms enable the robot to perceive and navigate through its environment. AMR robots are capable of constructing a floor plan or a map for navigation and localisation purposes with respect to their environment. They can operate in any environment and are not restricted to pre-defined tracks or paths. A self-driving car is an example of AMR. It can autonomously navigate through its environment and is capable of detecting and avoiding obstacles on its way. A delivery robot which is used for delivering food or other items is also an example of AMR.

Fig 1: Robot in a factory automation

2. Automated Guided Vehicles(AGVs)

AGVs operate under a controlled environment specified by tracks or pre-defined paths and hence differ from AMRs. They can obey only simple programming instructions and are guided by magnetic strips or sensors for their navigation. Therefore, they require extensive facilities for their operation and are more expensive as compared to AMRs. They are usually used for restricted applications like in a warehouse or factory floor for moving items and delivering materials. They can sense obstacles but are unable to move past them and hence stop when they encounter obstacles.

Fig 2: Robot in a factory automation – Compact

3. Pre-Programmed Robots

As the name suggests, a pre-programmed robot is programmed to do a specific task and it simply executes that task. It cannot do other tasks and does not require human intervention. Such robots find extensive usage in automobile industry and medicine. Pre-programmed robotic arms are used in industries today to handle entire automobiles and perform certain operations on them such as spraying paint or making small welds, ext. They have very high accuracy and precision and reduce human effort greatly. In medicine, presently these robots are used for performing high accuracy and precise operations such as delivering radiations in order to kill tumors in cancer patients.

Fig 3: Robot with arm movement

4. Humanoid Robots

A humanoid robot is a robot which resembles a human body in shape or even a part of human body and can mimic human behavior and actions. Since the goal of a humanoid robot is to closely resemble a human, it needs to take decisions and perform certain actions or tasks like a human. Therefore, humanoid robots may also fall under the category of AMRs. A humanoid robot can perform human-like actions like walking, lifting loads and speaking as well. They can be used for interacting with humans such as guiding or helping old people, for entertainment purposes and also for teaching and medical use cases like performing a surgery. Typically a humanoid robot has a head, torso, two arms and two legs. A popular example of a humanoid robot is Hanson Robotics' Sophia.

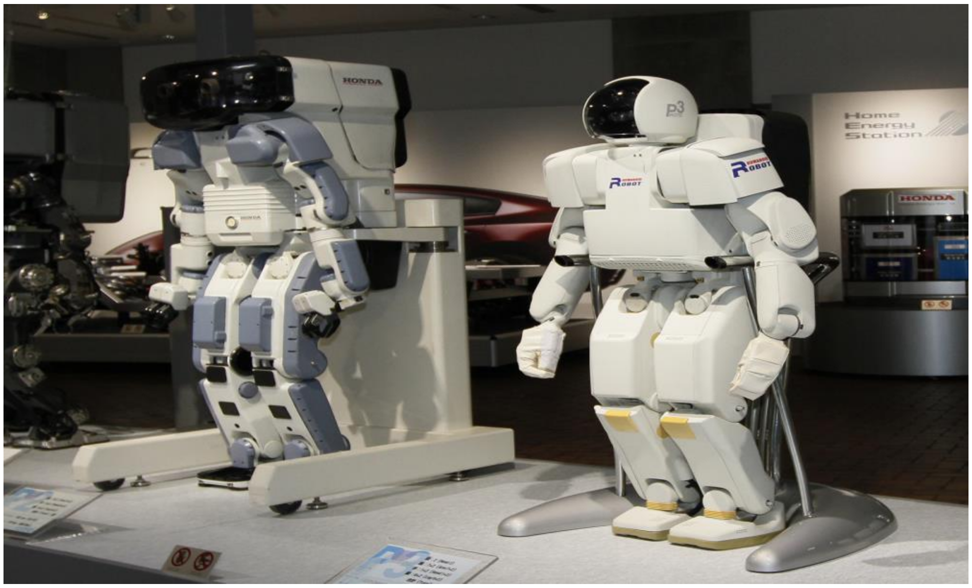

Fig 4: Humanoids

5. Augmenting Robots

Augmenting robots, also known as cobots, are designed to work alongside humans. These robots are not completely autonomous or independent and are remotely controlled by humans.They also learn from human behavior and can be used to perform manual or strenuous day to day tasks. Presently, cobots are for lifting heavy weights, diffusing bombs, performing surgery, stopping gas leaks, ext.

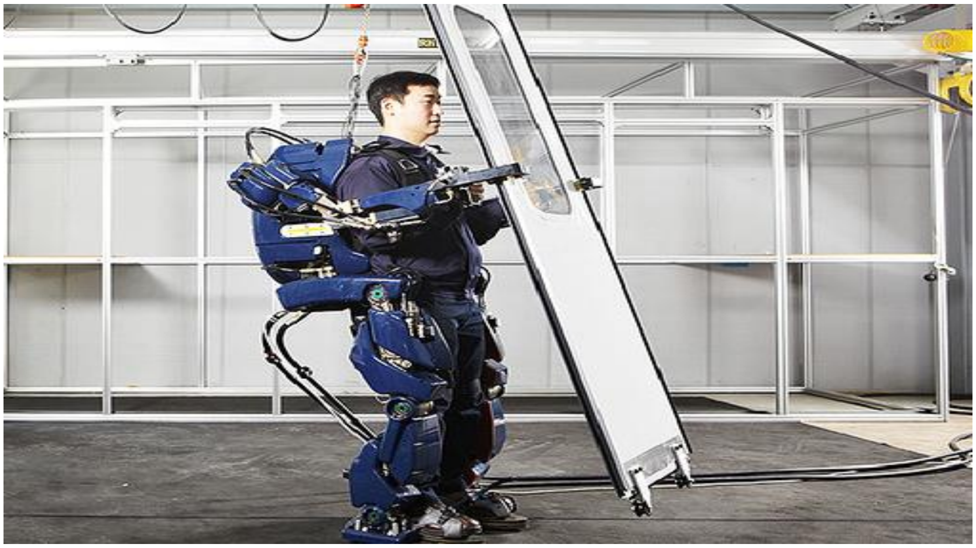

Fig 5: Cobots

6. **Hybrid Robots**

The various types of robots which are already discussed, can be combined together to design a hybrid robot. For example, pre-programmed robots or AMRs can be combined with humanoid robots to create a hybrid robot. Since the functions of various robotic types are combined into a single unit, hybrid robots can perform many functions which single robotic types are unable to. General AI can be realized through hybrid robots and therefore hybrid robots can be seen as future prospects.

List of Sensors

Navigation Control	Vision	Audio
LiDAR	Fixed cameras	6 Channel Mic
Accelerometer	Servo cameras (Pan and Tilt): Front and Back	Speaker
Magnetometer	Depth camera (RGB-D and IR)	
Gyroscope		

Robotic Platform

Our robot is a lab version of a service robot. It is built as a general platform for experimentation. It can be customized for a number of applications. It is equipped with a variety of sensors and actuators which produce multimedia data and permit development of different AI Algorithms.

Sensors and actuators belong to the following categories:

- Navigation
- Vision
- Audio

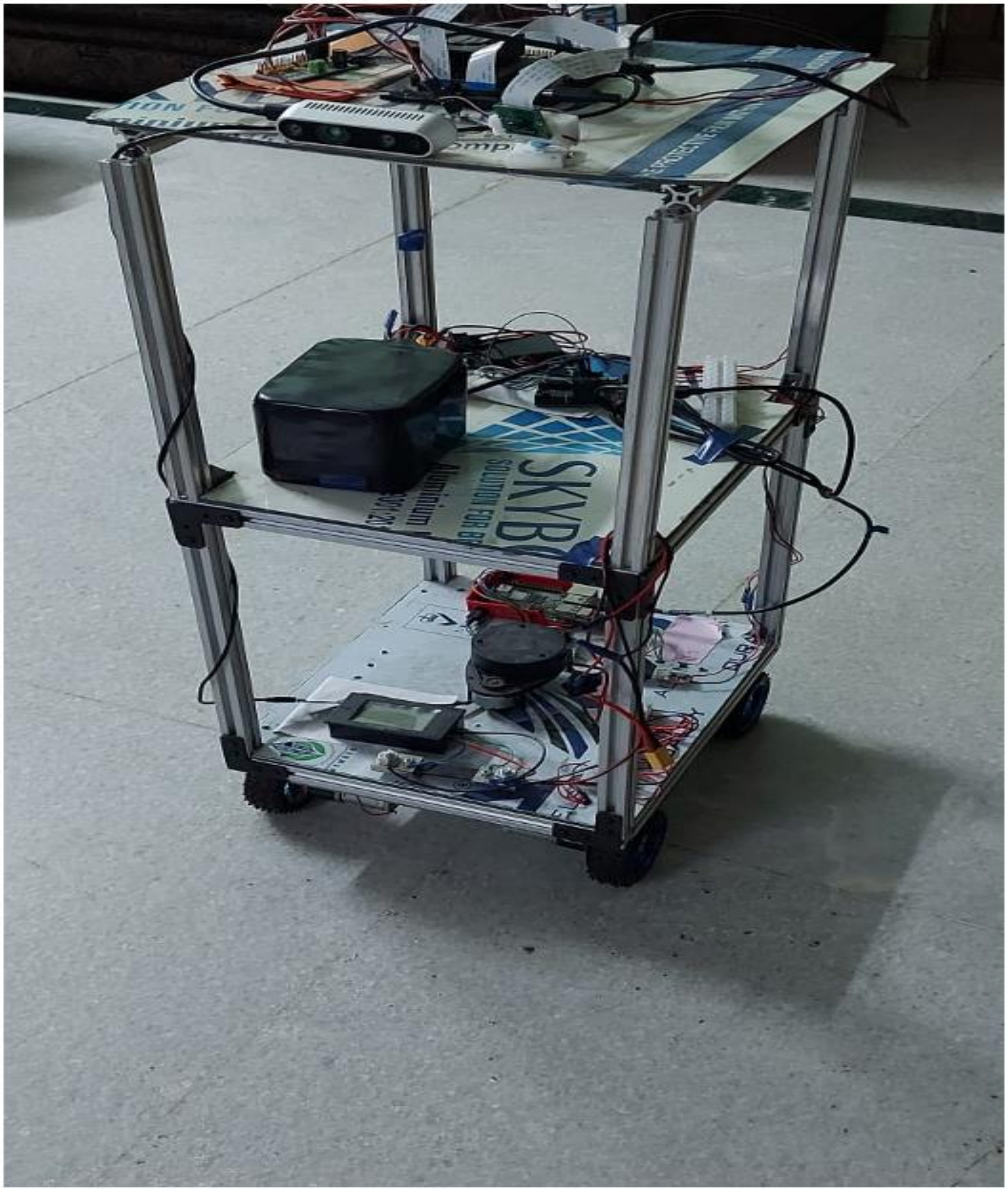

Fig 7: Our service robot

Joystick Control Interface

A joystick controller acts as a general purpose user-interface that facilitates in navigating real robots and helps in acquisition of data to enable development of various AI Algorithms.

It has 2 main functionalities:

1. Provides high flexibility and easy-to-use user interface for controlling / navigating the robot.
2. Acts as a single super controller enabling control of various sensors and actuators present in the robot, not just limiting to navigation but also audio(mic, speaker) and vision(cameras) control.

Fig 8: Joystick Interface

The following keys of the joystick control specialized robotic features.

Navigation Control

L3: Velocity control

R3: Direction control

Start: Start recording

Select: Stop recording

Vision Control

R1: Enable servo-camera(rear)

R2: Enable servo-camera(front)

L1: Click Photo

X: Tilt down

Triangle: Tilt up

Circle: Pan right

Square: Pan left

Architecture

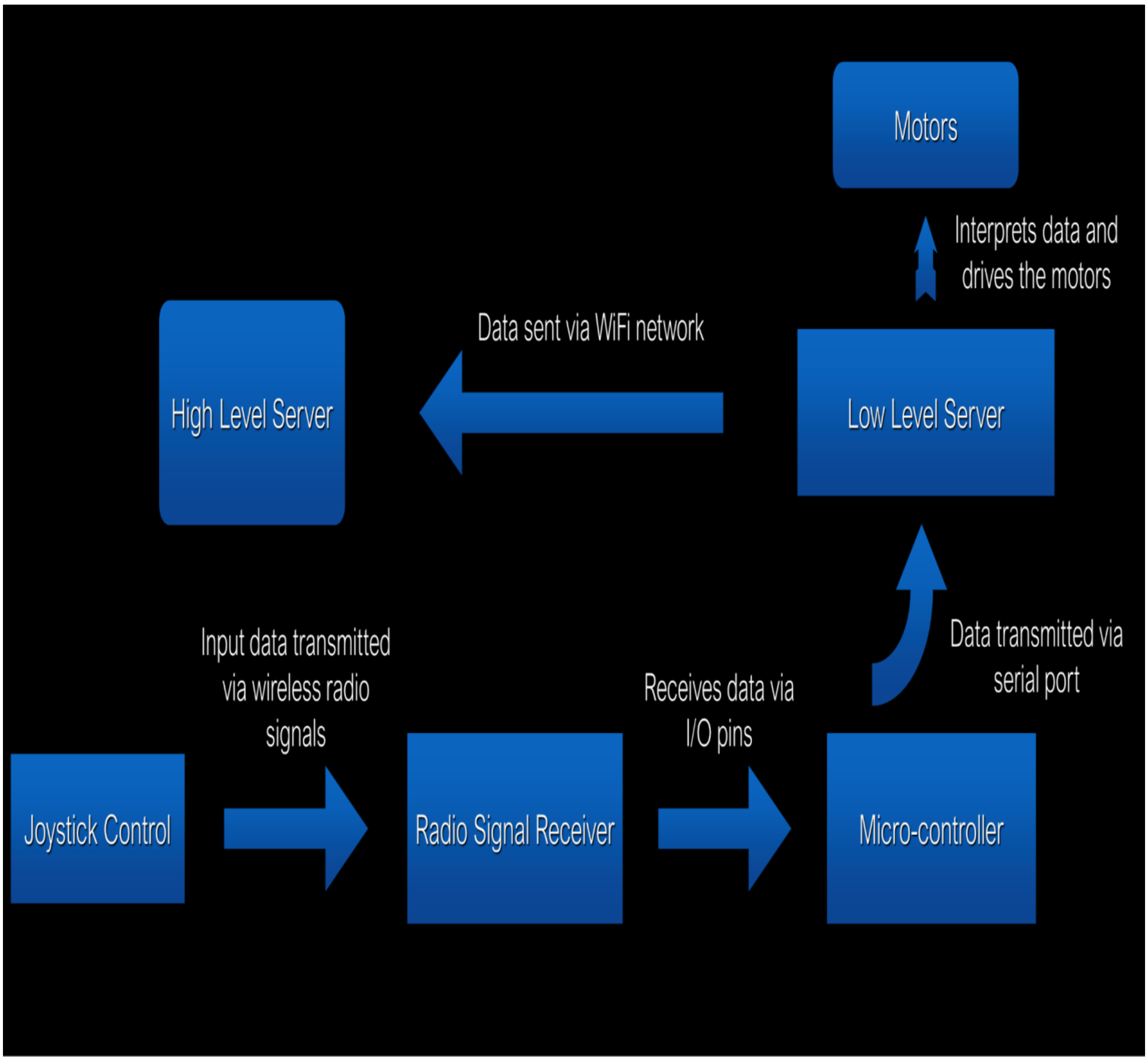

Fig 9: High Level Architecture

Client Design

The key elements in the client design are listed as follows:

1. Joystick Control
2. Radio Signal Receiver
3. Microcontroller

As the user starts controlling the joystick, the joystick interface interprets the logic and transmits the input data to the radio signal receiver board present in the robot. The data is transmitted to the radio signal receiver in the form of radio signals. The design architecture can be visualized using the above diagram.

As the signals are being transmitted in real time, the radio signal receiver board receives these input signals and transmits these signals to the microcontroller through I/O pins.

The microcontroller reads the I/O pins and interprets the data. It converts the input data into a Python Data Structure and sends the data to the server.

Server Design

The key elements of the server design are as follows:

1. Low Level Server
2. High Level Server

The Low Level Server receives the input data from the microcontroller through the serial port. The Low Level Server interprets and manipulates the logic and performs the navigation.

The data is transmitted to a High Level Server through WIFI Network.

The High Level Server is responsible for performing high level functions such as controlling Vision and Audio features. The High Level Server stores all the data into a database and runs the Deep Learning model. The model, after training through all the data, performs the Autonomous Navigation.

RESULTS

Indoor Robot Navigation Dataset(IRND)

Data was collected by operating the robot using a Joystick control over 2 surfaces with varying surface characteristics and the results are compiled as below:

Each file of the dataset is a *json file* that stores a sequence data recorded from one episode of robotic control, i.e, data collected from robotic sensors and actuators while controlling the robot from an initial position at rest to the target position. The data collected at each time step of an episode contains the following records:

- **num_records**: no. of records in an episode
- **direction**: clockwise/counter-clockwise depending upon the direction of movement of robot
- **pose**: current location/position of robot
- **brake**: 1 if brake is applied, 0 otherwise
- **angles**: obtained from LiDAR. Ranges from -180 degrees to +180 degrees
- **dists**: obstacle distances obtained from LiDAR corresponding to respective LiDAR angles
- **horn**: 1 if pressed, otherwise 0
- **counts_left**: speed of left wheel. Max speed = 2000 counts
- **counts_right**: speed of right wheel. Max speed = 2000 counts

References

1. S Russel and Peter Norvig, "Artificial Intelligence: A Modern Approach", 4th Edition
2. Jonatan E. Salinas-Avila et al, "Assistant Delivery Robot for Nursing Home using ROS"
3. Aniketh Gujarathi et al, "Design and Development of Autonomous Delivery Robot", Btech project report, Visvesvaraya National Institute of Technology (VNIT), Nagpur India