Foreword from the Core of '20-'21

It's been quite a unique journey this year, with a completely online mode of interaction and collaboration. Initially, the transition was a bit hard as some of our projects were entirely hardware-based, and we had to find ways to work around by importing them to a simulation platform and rework on them. But as we progressed through the year, we revamped our workflow to adapt to the circumstances.

This year, we continued some of the long-term research projects started in the previous years that are feasible to be worked on online. A couple of them would be resumed on campus. Along with these, we have started new projects and were able to reach the goals set for this academic year for most of them.

We plan to extend the objectives for some of these projects and continue working on them. We have also submitted some of our works to international conferences for publication. Our works are documented on our website and GitHub so that interested people can check them out. In addition to our projects, we have participated in several competitions this year with the advantage of being online. We are happy to say that we have won most of those we participated in.

As every year, we conducted many events to engage the student community in robotics, and technology. We introduced quizzes with ice-breakers and fun-filled questions to engage students in these times of distress.

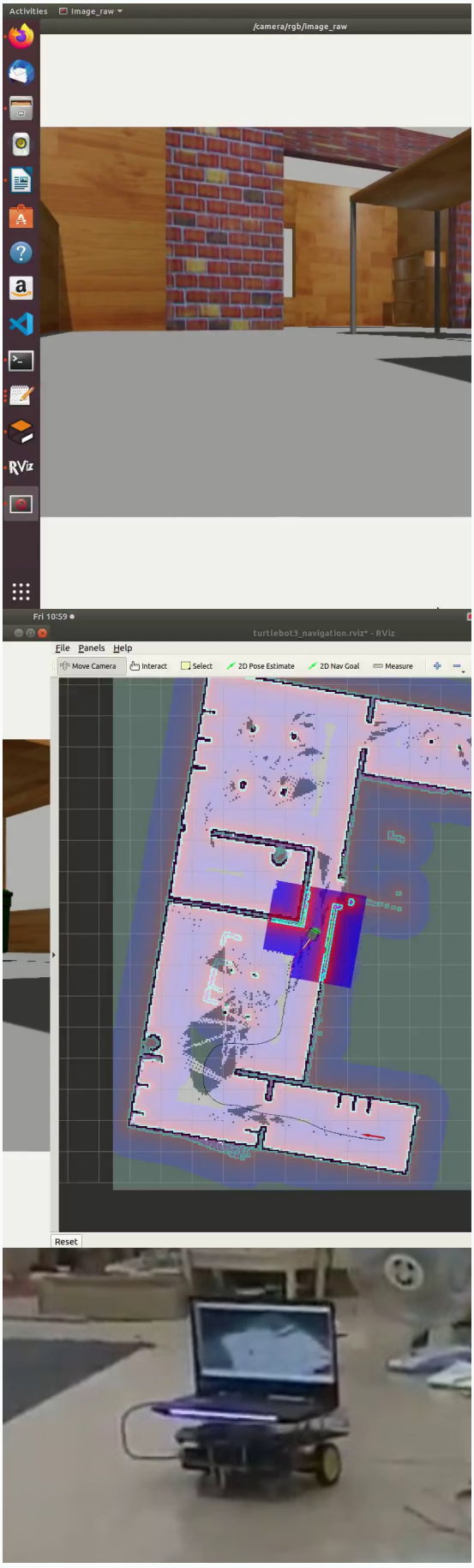
For the first time, we conducted the Genesis workshop entirely online for free and documented the sessions to introduce the freshers to robotics. Several competitions have been conducted in collaboration with the Student Council, Pragyan and independently throughout the year. We made efforts to be inclusive of students with limited resources and facilities wherever possible while coming up with our events. Students are also provided with resources required for gaining knowledge and preparing for their club inductions.

The induction process is designed by keeping the present situations, student experience and our requirements in mind. So, even those who are venturing into the field for the first time can find comfort in solving the tasks while learning with the resources and guidance of RMI members when needed. And lastly, we had knowledge sharing sessions, webinars and discussions with our alumni who have provided us with valuable guidance and suggestions. In the following years, we plan to extend these to the rest of the student fraternity as well.

INITIATIVES

Project PEPPER

Pepper is a mobile robotics framework implementing machine learning and AI techniques in multi-agent systems to map and interact with a dynamic environment. We established decentralized multi-agent coordination and implemented exploration of agents, and implemented path planning in an explored environment. Formulated a decentralised policy for multiple agents to explore the given map in an efficient manner. Created an environment in which we have a map and agents in it. We have various options to alter this environment. Currently, we have used reinforcement learning combined with imitation learning to get the best policy. The A3C algorithm is implemented, and LSTM (RNN) is used for temporal dependencies. We ran simulations of multi-agent systems (including cloud computing platforms) implementing the above modules.



Open Quad

The project was designed as a platform for implementing various deep learning and computer vision algorithms such as person tracking, Gesture recognition, Optical flow stabilization, Human Pose estimation, obstacle avoidance, and depth estimation using monocular vision. The drone uses a pixhawk flight controller with RaspberryPi as a single board computer. DJI flame wheel is used for the quadcopter structure with custom mountings for safety measures. Serial communication is used to communicate between Pixhawk and RaspberryPi. RaspberryPi runs a ROS node that communicates with the ROS node running on the host PC to transfer videos over Wi-Fi. To make the project open-source, easy to develop, and reproducible, the simulation environment setup has been dockerized using docker containers. The gazebo is used for simulation. This year, the focus was on the vehicle to infrastructure communication (V2I) of the quad. In this mode, messages from the open quad could be broadcasted to the cloud directly. And this information can be enriched with other systems in the surrounding like weather management systems etc. And the cloud, using its petabytes and zettabytes of data, can predict the weather conditions and other situational events in real-time, and send the information back to the quad/ central server. To simulate this scenario of smart technology using the Internet of things, we have utilised AWS IoT suite of services. We Created Openquad instances and connected them to the AWS IoT Core service to send the real-time information captured by the quad to the cloud, which can be utilised in multiple ways. Create a trigger message using a sequel query following AWS IoT rules when there is an obstacle in the path, such as a tree, bird etc., during its aerial flight. The information reaches all the corresponding team members (at different locations) if there is any obstacle in the path, and necessary actions can be taken soon.

MARKO - Machine Assisted Rehabilitation of Knee Osteoarthritis(Research paper under review by iNaCoMM conference):

Knee-osteoarthritis is one of the most common forms of arthritis that people above the age of 40 and even a few youngsters suffer from. Physiotherapy, pain relief, anti-inflammatory medications are the few available treatments. The permanent solution is to do surgeries like osteotomy, knee-joint replacement. Post-surgery rehabilitation can be divided into two stages - Stage 1 (THERAPY): To gain control over the knees; Stage 2 (TRAINING): To strengthen the muscles around the knees. Robotic therapeutic tools such as CPM (continuous passive motion) machines exist, cutting down the huge expenditure of frequent consultations, but they support only stage 1 of rehabilitation and not stage 2, which requires a trainer to guide the person to do heavy exercises such as cycling.

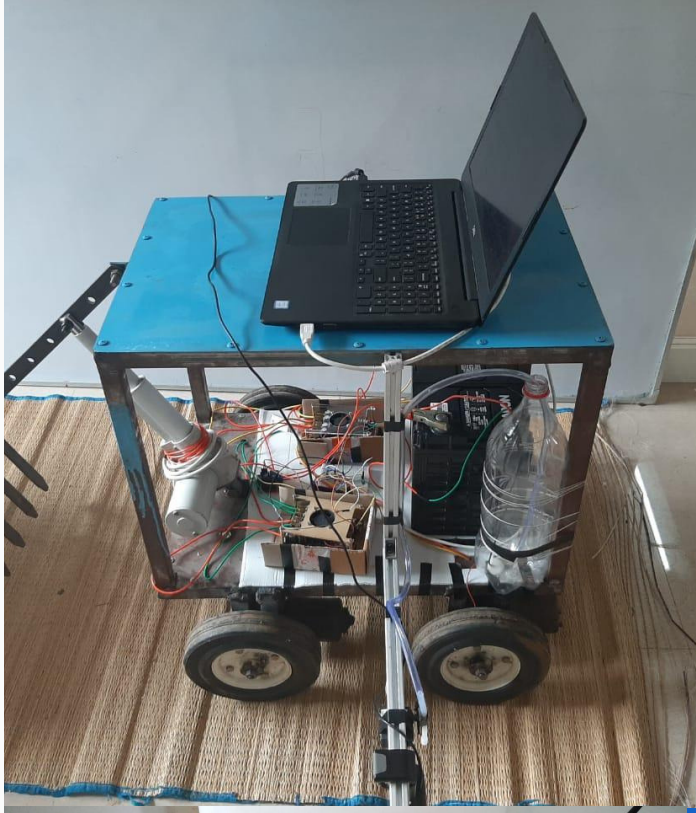
MARKO aims to Automate both stages of rehabilitation, integrate them in the same device and make the recovery process interesting and motivating by interfacing stage 2 with a gaming context. The electric linear actuator controls the motion of the leg, which is attached to links connecting to the actuator. For stage 1, a four-bar linkage slider-crank mechanism assists the leg, performing physiotherapy in a CPM. For stage 2, EMG signals are taken to know the intent and direction in which the person puts the effort to move his/her leg, which is a parameter of control for the game, allowing the person to train while gaming.

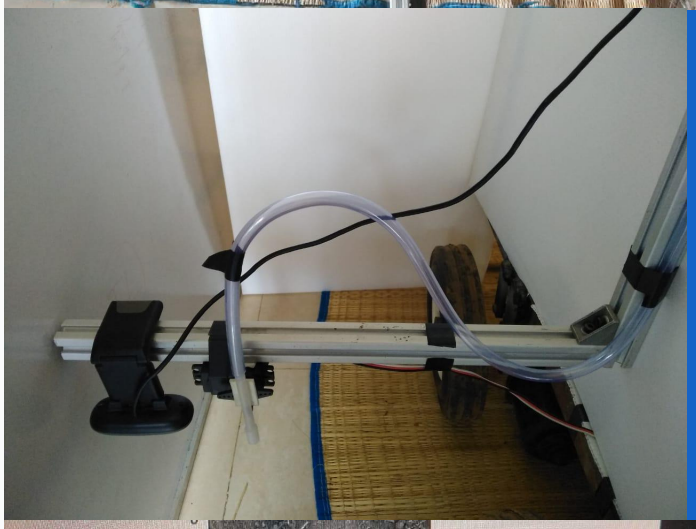
Precision Agriculture Bot (PAB)

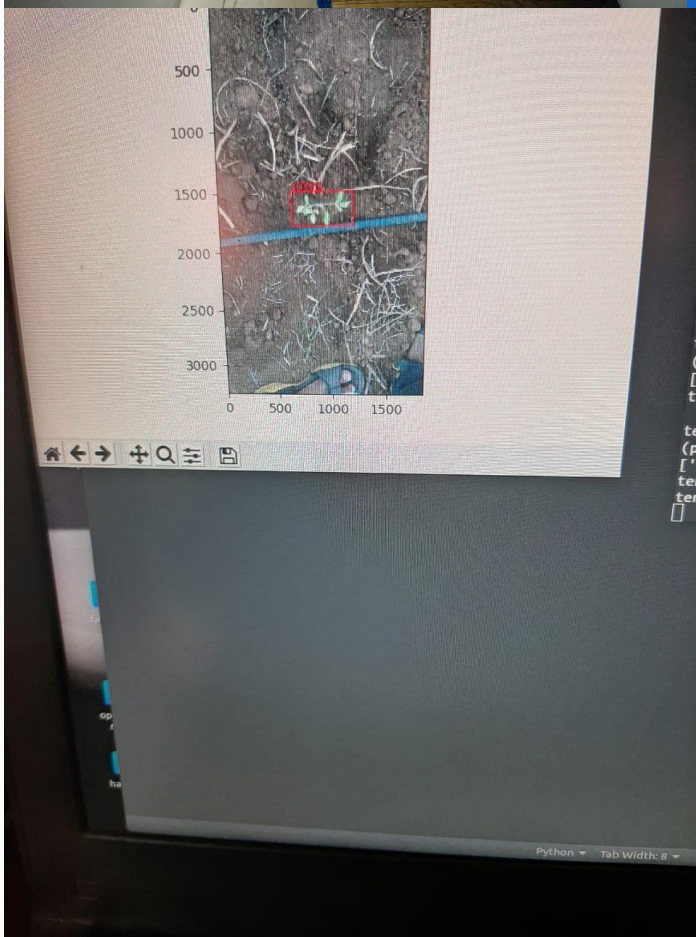
PAB is a robot that aims to automate the laborious process of removing weeds and spraying fertilizers. The de-weeding process is a crucial process that should be performed manually every 3-4 weeks so that weeds don't overrun the farms. Spraying farms with fertilizer is very important to have higher yields in farms. Both these processes are very labour intensive and time-consuming. Current robotic solutions try solving both these independently by employing two different robots, one for de-weeding and one for spraying fertilizers. Our proposed robot can solve both at the same time.

The proposed solution is a lightweight four-wheel-drive robot platform to traverse farms. It is mechanically actuated by hoeing ploughs to remove weeds. Computer vision enables a spraying mechanism to spray microdoses of fertilizers directly on crops. For weed detection, we developed a Deep Learning model for the task of object detection. We used FRCNN architecture to detect crops out of the images.

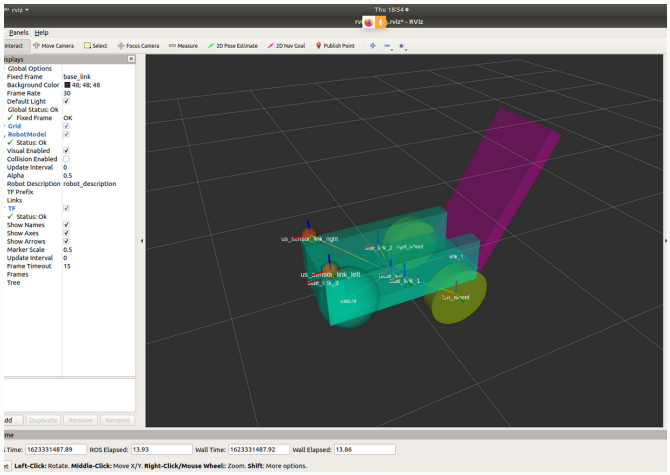
The current method of employing manual labourers is getting expensive, as labour wages are steadily increasing. Pesticides and fertilizers prices are increasing, and the traditional way uses a lot of chemicals than needed. Hence, robotic solutions are a viable alternative.





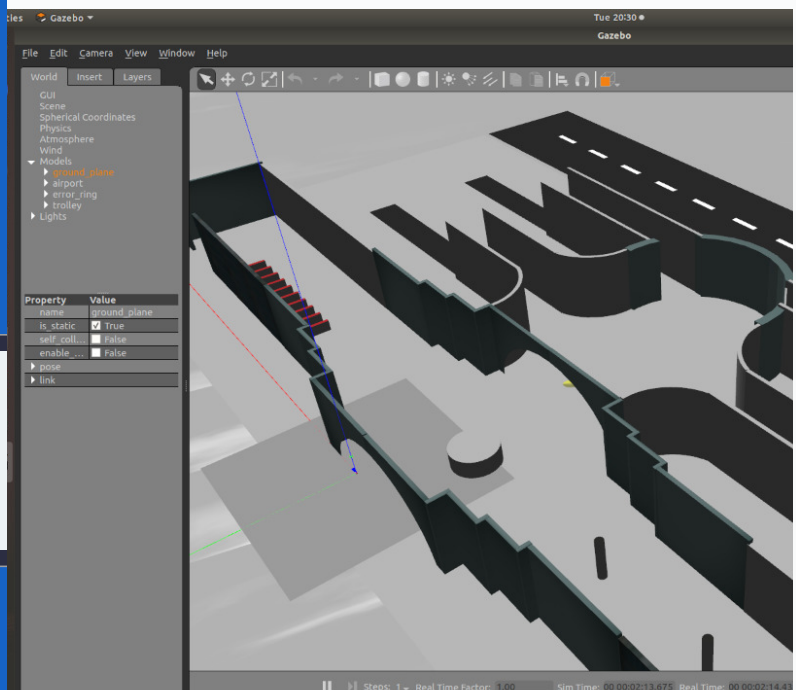


Automated Trolley



The availability of trolleys at the right place in airports and shopping centres is a big concern for authorities, and often, a huge human force is employed to deal with the same concern. Through this project, we propose building an automated system which after being used by customers returns into its parking point without needing any human intervention. The other problem which we are dealing with is avoiding accidents while taking back these trolleys with humans and surroundings using obstacle avoidance.

The proposed design uses ultrasonic sensors to get information of obstacles and using the trilateration data, we will localize our system within the environment, and a relative coordinate is fetched using the same. Gmaping is used to mark system position within the static map of the airport, and using A star (A*), we get the required path to return back to the parking lot. ArUco markers are used to increase the precision by acting as a landmark. The airport camera is used for the input to the dl model. A Convolution Neural Network-based DL model is used to get the driving instructions which will alsotake care when any dynamic obstacle (for, eg. Humans) interfere with the path, and the DL model is fetched with the image to decide on path planning by avoiding all obstacles.



H.I.D.Q - Hybrid Inspection Drive Quadcopter

Typical human inspection has constraints in narrow spaces, dangerous environments and does not always ensure precision. Thereby the damages at inaccessible areas are left unnoticed, which leads to heavy collateral damage. The use of robots for inspection and quality assurance provides dependable results with high precision. This predominant issue calls for the need to build an efficient and innovative method to inspect remote regions. A convertible hybrid drive quadcopter is manually controlled to move across inaccessible places as a drone or a 4-wheeler convertible using a self-transforming mechanism, equipped with a camera to inspect various industrial systems and check for defects and anomalies using Machine Learning and Image Processing algorithms at the controller side. The same BLDC motors power both the wheels and the propellers in each model and a novel idea for power engaging disengaging mechanism. Automated crack and rust detection using integrated Image processing and Deep Learning using Convolutional Neural Network are implemented.

HuRoS - Humanoid Robotic System

HuRoS is aimed at mimicking two-legged animals. It's a developmental platform for building humanoid robots and prosthetics. A model of the robot mimicking the functionality of the hardware with appropriate appropriate joint constraints have been developed. The kinematic mathematical model of the robot has been developed. Additional constraints are to be framed to control the over-actuated system.

CHAOS - Crop Harvesting's Automated and Optimal Solution

Automation is an important current trend and development in the field of agriculture. The agriculture industry worldwide is facing many problems, including labour shortage and increasing costs. Currently, much of the work in the field of fruit harvesting is manually done (labour-intensive), time-consuming and an expensive process. Moreover, existing robots are customized only for a particular crop, are slow and bulky. Therefore, employing robotics to automate the multi-crop harvesting/picking process of fruits/vegetables becomes an essential requirement to solve such issues. n intelligent and efficient robotic system that utilises a camera feed to identify ripe crops using AImage-Processing algorithms. A Robotic manipulator (4DOF) with a soft gripper as its end effector is used to pluck the crop using Inverse Kinematics. We developed a prototype of 4DOF robotic Arm and mobile base utilising the required hardware, 3D printed the mould for the soft gripper and built the prototype for the same. We collected the images of fruits and vegetables (dataset) for training and testing the YOLO deep learning CNN Model for Object detection and localization. We utilised find object 2D for object detection in Gazebo Simulation.

Vitarana Drone (eYantra)

Package delivery and return using a drone over an area in Gazebo. Location of pickups are given, and drop locations are either given directly, or marker detection must be performed to drop the package. The final solution includes PID control over position and attitude, integrated bug algorithm, marker detection, dynamic grid mapping using floating numbers, hybrid A* path planning with smoothening, unique height control navigation algorithm for obstacle avoidance and variable yaw control to optimise the drone's trajectory and speed.

EVENTS

RMI Quiz (5th October 2020)

The RMI 30-minute quiz, which was conducted online on 5th October, saw a massive response from all years and various departments. The quiz contained a good mixture of different domains of robotics to test one's technical and problem-solving skills, which intrigued the minds of fellow robotics enthusiasts. Not just robotics, it also included some fun elements which the participants found engaging and exciting to solve with such massive participation. We received fantastic feedback from all the participants. This event was conducted in collaboration with the Student Council, with prizes worth Rs 3000.

RMI Hybrid Hackathon (28th January 2021)

It was a free online event conducted exclusively for NITT first years in Microsoft Teams. Around 50 students participated in this event. First years were introduced to the basics of Robotics through this event.

Genesis'21 (20 - 25 April 2021)

Genesis is the annual workshop of Robotics and Machine Intelligence (RMI). This year, the workshop was conducted online through Microsoft Teams for free of cost to introduce 1st years to various domains of Robotics. Around 200 students registered for the workshop.

COMPETITIONS

- **1st place** in **eYantra** 2020-21, All India Robotics competition held by **IIT Bombay** with over 35,000 competing teams. Project - Vitarana Drone
- **NITT, Pragyan '21**:
  - **2nd place** in **Circuitrix**
  - **2nd place** in **Sangam**, Healthcare and Agriculture - Team MARKO
  - **3rd place** in **Sangam**, Healthcare and Agriculture - Team CHAOS
- **IIT Madras, Shaastra 2021**: **1st place** in ARDRILLO
- **IIT Hyderabad, Elan and ηvision**:
  - **2nd place** in Paper Presentation
  - **4th place** in Code Arduino challenge
- **IIT Bhubaneswar, Wissensire**: **1st place** in Mech colloquia
- **NIT Durgapur, AAROHAN '21**: **3rd place** in Innovare
- **SRM University, Xion**:
  - **1st place** in Robo-Dock competition
  - **1st place** in Quizzard contest
- **SSN College**:
  - **1st place** in each of CSE, EEE, Mech and Biomedical Paper presentations
  - **1st place** in Papyrus IT Presentation event
  - **1st place** in Inventino contest
  - **1st place** in Mech Technical Jam
  - **2nd place** in e-Biomart Biomedical contest
- **BITS Pilani, APOGEE**: **2nd place** in Paper presentation
- **DDUC**, Delhi: **3rd place** in Technix Tinker contest
- **IIT Roorkee, Cognizance**:
  - **1st place** in CSE paper presentation
  - **2nd place** in ECE paper presentation

- **NITT, Synergy**: **1st place** in Paper presentation
- **NITT, Currents: 1st place** in Colloquium Paper presentation
- **NITT, Probe**:
  - **1st place** in Paths and holes
  - **2nd place** in Embedtronix
- **Sardar Patel College of Engineering** (SPCE), Mumbai: **3rd place** in project presentation and technical paper presentation.

CAMPUS DEVELOPMENT

The Open Quad project has been made open-source, easy to develop, and reproducible by dockerising the simulation environment setup using docker containers. Anyone who is interested can learn from the existing GitHub repository and also contribute to that if they wish to, even if they're not a part of the club. The project has been added as a part of the GitHub externship program.

The RMI 3D printer has been upgraded for campus-wide utilisation. Anyone who requires a part to be printed can send the STL file and pay the material charges to utilise the 3D printing services.