Team NA-SARATHY

Team NA-SARATHY is powered by Humanitarian Technology (HuT) Labs, Amrita Vishwa Vidhyapeetham, India. The team consists of talented and passionate individuals, who have 5 years of experience in different fields of Robotics and automation. The team is led by Dr. Rajesh Kannan Megalingam, director of Humanitarian Technology Labs. He has seven and a half years of work experience and ten years of research experience. He has published more than 160 research papers at various international conferences, journals and book chapters. He has won several awards including the 2020 IEEE Undergraduate Teaching Award, Best Outstanding Branch Counselor and Advisor Award from IEEE, NJ, USA, Outstanding Branch Counselor Award from IEEE Kerala Section, and Award of Excellence from Amrita University. The NA-SARATHY team consists of 2 senior staff, 2 full-time researchers, 2 Ph.D scholars and 23 bachelor students, who participated in reputed international competitions like Robo cup German open 2018-19, and World robot summit, Japan, 2018.

History with automation

Autonomous cart: Intelligent automated shopping cart, shown in Fig. 1. which leads customers inside a supermarket to products specified by them without the need for the customers to search for the products on their own. We have used a variety of packages provided by ROS (Robot Operating System) as well as sensors like LiDAR (Light Detection And Ranging), IMU (Inertial Measurement Unit) and rotary encoders to solve the problem of SLAM (Simultaneous Localization and Mapping). LiDAR is used for obstacle detection whereas IMU and rotary encoders give the position and orientation of the cart. An android application has been developed to simplify the user interface for the navigation of the cart. The communication between the cart and the application is realized using Bluetooth technology. Once the app is connected to the cart via Bluetooth, it provides the customer's provision for controlling the cart in three different modes. Furthermore, the app provides the feature of electronic payment which contributes to faster checkouts. The entire system has been first tested in a simulation software called Gazebo which offers conditions equivalent to a real-time environment to ensure the accuracy and precision of the packages, codes and the robot model. The prototype of the cart was designed and tested in real-time environments. The smart cart can improve the overall shopping experience of the customer by decreasing the shopping time.

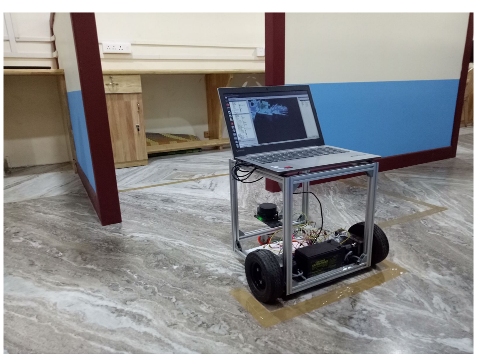

Fig. 1. Autonomous cart

Fig. 2. Chetak, with team members

CHETAK is a self-governing and multi-tasking home assistance robot to support the old, crippled and impaired individuals to do their daily life activities or regular tasks at home and hospital environments. CHETAK has a highly integrated architecture with features like Object Vision, Speech Recognition, Autonomous Navigation with Obstacle Avoidance and a 6 Degree of Freedom Robotic Arm to make the robot serviceable. Team members working on Chetak are shown in Fig. 2. The robot can perceive the trained objects or persons and can differentiate among objects dependent on class and can foresee the qualities like Gender, Age and Posture. It can listen to commands from a person and perform the tasks accordingly in an autonomous way.

The robot can be navigated either manually or autonomously in an environment that resembles a house. While navigating autonomously, the robot always chooses the shortest path to reach the destination by avoiding any dynamic obstacles and can also navigate through extended waypoints. It uses the robotic arm integrated with the end-effector to pick and place the objects by utilizing the vision information. The whole system is implemented using the Robot Operating System (ROS) on the Ubuntu platform to integrate individual nodes to achieve complex operations. The robot can perform complex tasks such as Human-Robot interaction, Object Manipulation and Gesture recognition. CHETAK helps the disabled and physically handicapped people in serving them drinks, fruits etc.. It helps the visually impaired people to find an object or a person and also serves them.

Self-E - Autonomous wheelchair: Self-E is an advanced wheelchair system capable of autonomous navigation at a low cost and having advanced technology. It was created to serve people with disabilities for walking. It can be also used for travelling and transport of old age and the patients in the hospital and other places. It uses the SLAM method for mapping the environment along with an algorithm for computing the shortest path. Programmed in the ROS platform, Self-E is unique by the way that it is having its own navigation stack for its working purpose. Mapping is done using the LiDAR sensor which helps both in mapping and object detection and avoidance. The wheelchair is a leap ahead in technology on having an app for controlling the wheelchair. An app inclusive for wheelchair control has been made which helps in autonomous navigation; the same app can also be used for navigating it manually through the control buttons for its manual operation. The team members involved in the project development are shown in Fig. 3. Self-E was tested in Amrita Institute of Medical Sciences, with patients having a disability. Fig. 4. shows self-E with a patient.

Fig. 3. Team self-E

Fig. 4. Testing with patient

Rescue robot: Two different search and rescue robots developed in Humanitarian Technology labs (HuT labs), Paripreksya, shown in Fig. 5. and Fig. 6. and Vijayanta is shown in Fig. 7. Paripreksya is a teleoperated UGV (Unmanned Ground Vehicle) developed at HuT Labs. It is a lightweight robot capable of doing complex manoeuvring, mobility and dexterity tasks. The robot typically consists of a mobile base and a manipulator. The mobile base is responsible for the manoeuvring and mobile ability of the robot while the manipulator can reach difficult places where humans cannot reach. A lot of sensors and cameras are placed on the robot so that they aid in the rescue process of disaster-affected areas. The sensors placed include CO2 sensor, IMU, cameras, LiDAR etc. All these sensors and cameras help the operator to identify victims and to gather information on the surroundings. Kinect and LiDAR sensors help in mapping the environment in which the robot glides and to mark the location of detected victims on the map. The first use of the rescue robots was actually during the World Trade Centre(WTC) collapse in 2001 though the research was going on in this field in the past for many years. The main goal of these robots is to reduce the number of deaths during disasters by surveying the areas in which humans are not permitted until the fire is off. HuT Labs has built a search and rescue robot called Vijayanta to help and save many lives of the victims after natural disasters such as earthquakes. Many technologies and many algorithms are utilized to develop this disaster category robotic system. Mapping, image processing, advanced sensor technologies, human-machine interface, victim identifications and rescue etc. We have designed a robust and rigid robotic system with an effective flipper mechanism which makes it move with ease in any kind of uneven terrains like sand, gravel, step fields, etc. The rescue robot can even detect hazardous signs and QR codes too. 3D Mapping of the whole unknown environment is done using LiDAR which helps in the localization of the robot. It can identify and carry the victim to safety. In addition, it can retrieve dead bodies too.

Fig. 5. Pariprekshya

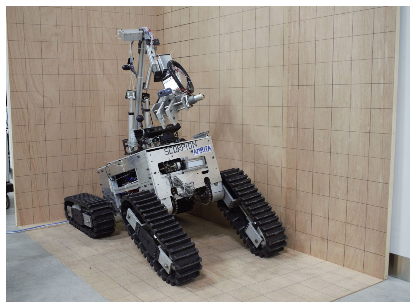

Fig. 6. Pariprekshya 2.0

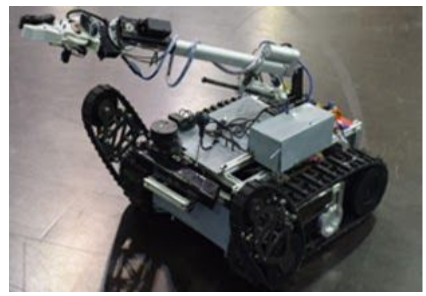

Fig. 7. Vijayanta

Projects from HuT lab:-

“AMARAN” - A Robotic Coconut Tree Climber: There is an acute shortage of human coconut tree climbers to harvest coconuts. Coconut tree farmers, individuals who own a few coconut trees and the coconut industry suffer a lot due to this shortage. Coconuts could not be harvested on time. The price of coconuts and coconut products are increasing day by day and consumers are unhappy.

Fig. 8. Amaran

We propose Amaran, an unmanned robotic coconut tree climber and harvester with IoT enabled and can be controlled remotely using wireless technology. India got the tag as the second largest coconut producer in the world. Until recently coconut plucking jobs conventionally was taken up by socially and economically backward people in these areas. Due to various government welfare programs and increase in literacy, the number of people taking up this job has dwindled a lot which is one of the main reasons resulting in increase in the price of coconuts. Another reason is the risk involved in coconut tree climbing. These factors led to the increase in the rise of coconut and coconut based products. First version we developed is the wired climber with one DOF arm for cutting coconuts. The second version is wireless smart phone based control with 3 DOF arms for cutting coconuts. This version has a camera attached to the climber which can send the live video of the coconuts at the top of the tree, which helps the user in positioning the cutter precisely to cut the coconuts. A patent has been filed for this innovation and is expected approval any time this year.

"MARUTI" - A Remote Controlled Wheelchair during COVID-19 Pandemic Social Distancing: Maruti is a wheelchair that allows a health-worker to transport patients to and from isolation wards without physically touching either the patient or the wheelchair. The operator/caretaker using a Bluetooth application that can be installed in any smartphone or using a wireless joystick controller can operate the wheelchair at a safe distance of 1m up to 4m. Patients in isolation wards can be transported without the need for the operator to touch the wheelchair or the patients.

Fig. 9. Maruti

"ANNAPOORNA" - Food & Drug Delivery Tele-Operated Robot during COVID-19 Pandemic Lockdown: Need a robot to serve food and water and deliver medicines to quarantined patients? Annapoorna does all that as well as facilitates remote communication between the patients and healthcare professionals. It is also operated either by a joystick or by using a smartphone app, either with Bluetooth or WiFi. This remotely operated robot using WiFi can serve food, water and medicine to patients in isolated wards. It also has a telemedicine facility and enables patients in isolated wards to interact with doctors/nurses remotely. It will be very useful for front line workers who supply food, water and medicine to the patients during the pandemic/ epidemic in hospitals.

Fig. 10. Annapoorna

"BODHI" - Surveillance & PA system Self-Driving Robot During COVID-19 Lockdown: Bodhi, a robot that can patrol streets during the lockdown and broadcast messages if necessary. Operated remotely via smartphone at up to a distance of 500 meters and fitted with a 360° camera, Bodhi was designed for use by police and security personnel. It can be used in containment areas on streets where even police/security personnel can't access it. Police/security personnel can play recorded messages or even give live instructions from the control station.

Fig. 11. BODHI

"PRABHA" - Ultraviolet Room Disinfection Tele-Operated Robot During COVID-19 Pandemic: Prabha, a robot that cleans rooms by systematically disinfecting the area with UV light. It can clean a 12'X12' room, killing any COVID-19 virus that may be lurking, in 30 minutes to one hour depending upon how many lamps are connected to it. Prabha also cleans restrooms and medical equipment. The operator manipulates the robot remotely via Bluetooth.

Fig. 12. PRABHA

Publications

1. ROS based Autonomous Indoor Navigation Simulation Using SLAM Algorithm” R Kannan Megalingam, C Ravi Teja, Sarath Sreekanth, Akhil Raj 2018, Journal: Int. J. Pure Appl. Math
2. Jeeba M Varghese and Rajesh Kannan Megalingam, "Study And Analysis Of Embedded System Based Indoor Navigation on Multiple Platforms", International Conference on Communication and Signal Processing ICCSP 2016, April 2016, Chennai, India, IEEE Xplorer Pages: 1203 - 1207, DOI: 10.1109/ICCSP.2016.7754343
3. Rajesh Kannan Megalingam, Ananthakrishnan Ponnileth Rajendran, Deepak Dileepkumar, Abhiram Thejus S and Venkat Rangan, "Embedded System Based Auto Navigation Platform for Paralyzed People", IEEE ISCO 2016, Karapagam College of Engineering, Coimbatore, Jan 8 and 9, 2016
4. Rajesh Kannan Megalingam, Meera Pillai, Athul Balan E A, Aparna Jayakumar, Arsha Anil, Jeeba Varghese, " FPGA Based Wheelchair Autonavigation for People with Mobility Issues", IEEE International Women in Engineering (WIE) Conference on Electrical and Computer Engineering 2015 (WIECON-ECE 2015), BUET, Bangladesh, Dec 19 - 20, 2015, IEEE Xplorer, Pages: 74 - 77, DOI: 10.1109/WIECON-ECE.2015.7444002
5. Rajesh Kannan Megalingam, Vishnu G B, Meera Pillai, " Development of Intelligent Wheelchair Simulator for Indoor Navigation Simulation and Analysis", IEEE International Women in Engineering (WIE) Conference on Electrical and Computer Engineering 2015 (WIECON-ECE 2015), BUET, Bangladesh, Dec 19 - 20, 2015
6. Rajesh Kannan M, Ananthakrishnan Rajendran, Deepak Dileep, Abhiram Tejas, “LARN: Indoor Navigation for Elderly and Physically Challenged”, Oct 21-23, San Jose, USA, 2013 Global Humanitarian Technology Conference, IEEE Xplorer Digital Object Identifier: 10.1109/GHTC.2013.6713705, Publication Year: 2013 , Page(s): 326 - 330
7. Rajesh Kannan Megalingam, Ananthakrishnan Rajendran.; Dileep, D, “LARN: Implementation of Automatic Navigation in Indoor Navigation for Physically Challenged”, INDICON 2012, Dec 7 – 9, 2012, IEEE Xplorer Digital Object Identifier: 10.1109/INDCON.2012.6420755, Publication Year: 2012 , Page(s): 956 - 961

8. Megalingam, Rajesh Kannan; Nammily Nair, Ramesh; Manoj Prakhya, Sai, “Automated voice-based home navigation system for the elderly and the physically challenged”, Proceedings of 2011 13th International Conference on Advanced Communication Technology (ICACT), 13-16 Feb. 2011, IEEE Xplorer Page(s): 603 - 608
9. Autonomous path guiding robot for visually impaired people Megalingam, R.K., Vishnu, S., Sasikumar, V., Sreekumar, S. 2019 Advances in Intelligent Systems and Computing 768, pp. 257-266.

Achievements

1. Award: ‘Best Demo’ Award for the project ‘Intelligent Home Navigation System (IHNS) for the elderly and the physically challenged', at the International Conference on Wireless Technologies for Humanitarian Relief. (ACWR2011), from December 18th to 21st 2011, Kerala, India.
2. Humanitarian robot competition -International category best mechanical design award winner, RAHA 2016

PATENTS APPROVED

1. Method and Apparatus for Wireless Network-Based Control of a Robotic Machine, US Patent No. US10674667

PATENTS FILED

1. A System and A Method Thereof to Control A Robotic Machine for Climbing And Harvesting Coconut Trees Using Mobile Device, 2017 - Appln No. 201741031217 India, Appln No. 15/868,197 USA
2. Robotic Machine for Climbing Coconut Trees And Harvesting Coconuts, 2014 - Appln No. 4794/CHE/2013
3. An Automatic Pancake Preparing Machine, 2018 - Appln No. 201941005584
4. Novel Gesture Recognition System to Operate Light Duty Vehicles and Methods Thereof, 2014 - Appln No. 685/CHE/2014
5. Hand Orthosis Control Using Electro-Oculography 2014 - Appln No. 1200/CHE/2015
6. A Novel Approach to Depth Estimation Using Mouse Click Method 2018 - Appln No. 201841041778
7. Multi-Mode Control (Manual, Fixed and Self-driving) ROS Based Wheelchair 2018 - Appln No. 201841029066
8. Medical Caregiver Robot 2020 – Appln No. 202041021030
9. A System For Public Surveillance And Awareness 2020 – Appln No. 202041021103
10. Door Keeper Sanitizer Robot – Appln No. 202041021028
11. Auto Navigation Vehicle System And Method Of Operating The Same 2020 – Appln. No. 202041021163

Participated competitions

1. Finalist of CISCO Global Problem Solver Challenge 2020 for "Unmanned Robotic Coconut Tree Climber and Harvester”
2. Semifinalist of CISCO Global Problem Solver Challenge 2020 for “Crop Protection from Animal Attacks”
3. Semifinalist of CISCO Global Problem Solver Challenge 2020 for "Hand Orthotic Device for Stroke Patients"
4. Robocon 2019 at MIT - First Prize for best design contest
5. RoboCup German Open 2019 - Disaster Robot Category
6. RoboCup German Open 2019 - Home Service Robot category
7. RoboCup German Open 2018 - Disaster Robot Category
8. World Robot Summit 2018, Japan Tokyo - Standard Disaster Challenge
9. Robocon 2018 at Tokyo - First prize for best design contest

News & reports

http://www.embracingtheworld.org/news/self-e-wheelchair/

https://yourstory.com/2018/07/students-wheelchair-amrita-vishwa-vidyapeetham

https://indiaeducationdiary.in/amrita-vishwa-vidyapeetha-students-develop-indias-first-self-driving-wheelchair/

https://www.edexlive.com/news/2018/jul/05/these-students-from-amrita-vishwa-vidyapeetham-developed-a-self-driven-wheelchair-that-costs-less-th-3359.html

https://www.photonics.com/Articles/Lidar_App_Make_Auto_Wheelchairs_Possible/p1/v150/i1018/a63829

Software Architecture Proposal

Inorder to accomplish the task of auto navigation, architecture was differentiated into 3 parts, as shown in Fig.13. Extracting data from sensors, Processing data, Publishing electric signals to the hardware. First we will take the inputs from sensors to understand the situation. LiDAR and camera are used for range finding tracking obstacles and monitoring opponents. Short-Range navigation will be done using these sensors. Since GPS is available, long-range localization and navigation will be done using GPS data along with odometry and orientation data from the accelerometer. We need to constantly monitor the tyre pressure and there will be a pressure sensor for that. RADAR data will also contribute to localization and obstacle detection, but the main aim is to monitor opponents. The detailed description of the sub-systems explained below.

Path Planning

Path-planning is an important primitive for autonomous vehicles that let cars to find the fastest or otherwise optimal path. Otherwise optimal paths could be paths that minimize the amount of turning, the amount of braking or whatever a specific application requires. It is also defined as a task of finding a continuous path that will drive the car from the start to the goal point. As path planning takes place only in the free path, we need the sensor data to find the area to navigate. The internal architecture of path planning is shown in Fig 14. Prior to navigation, the track is mapped using LiDAR and Odometer. This map is considered as a global map. For navigation, we will be considering the goal position and the vehicle tracking using GPS.

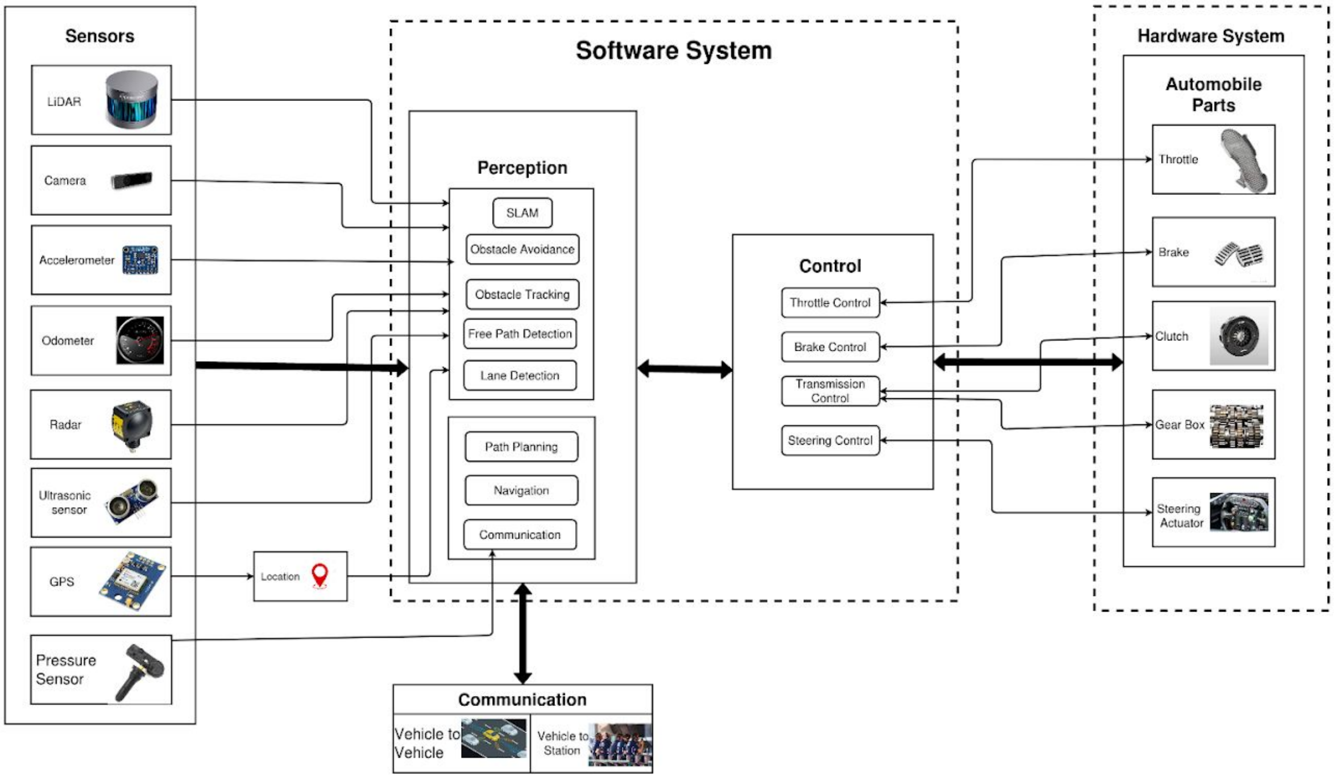

Fig. 13. Software Architecture

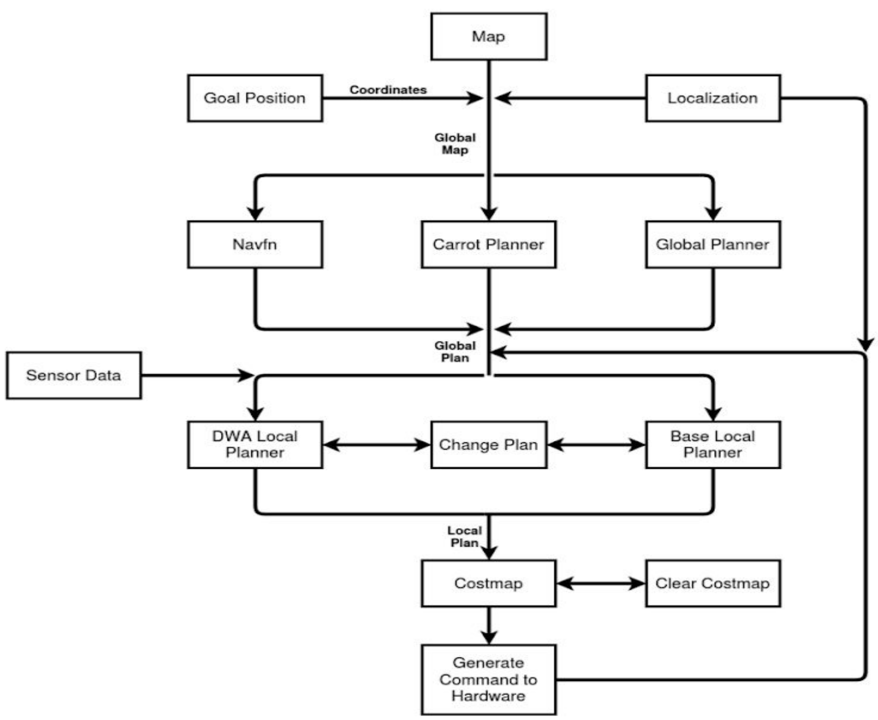

Fig. 14. Internal architecture of Path Planning

By taking a global map into the account, the global plan was calculated with respect to the goal position. After creating a global plan, the data from Radar, LiDAR and Ultrasonic sensors are taken into account for calculating local plans. Using Sensor data, costmap is calculated. In any case of occurrence of obstacles, the free path is again calculated and the flow continues. If no obstacles are found, both costmap and clear costmap are considered and the signal command is generated to hardware. Detecting the obstacles and changing path place an important role in projects like Self-E to avoid injury for the patient. Our team had worked on path planning algorithms and we successfully implemented various projects like Self-E, Autonomous cart, Chetak, and in Pariprekshya.

Other Technical Specifications and Insights

The vehicle will be equipped with a variety of sensors, such as Cameras, LiDARs, Radars, IMU, GPS, tyre pressure sensor and Ultrasonic sensors. Since the vehicle is going very fast, the sensors should be capable of reading the surroundings at a very high frequency. A normal LiDAR has to rotate to get the data in different angles, so a Wide Angle Scanning Sensor similar to ScaLa B2 LiDAR will be used. Data from multiple LiDAR will be combined to a single point cloud of the surroundings of the detection of obstacles. The camera output is directly sent to an image-processing engine for further calculations. The combination of multiple sensors like camera, radar and Lidar will be used for Lane detection, Object detection and free space detection. Machine learning techniques will be applied in path planning and obstacle avoidance. The control will be based on a high-performance GPU based ECU similar to the Nvidia Drive AP2X.

In multi-car racing, vehicles must communicate with each other to avoid a collision. The cars will provide information like track location, ground speed, heading, acceleration, braking rate and vehicle fault states. When a car is nearby, the information from the car will be used for avoiding a collision. For better perception, the control system has to behave like a real driver. The system has to evaluate the surroundings for every scenario with the help of the integrated sensors. Controlling a car going high-speed needs a high-performance ECU which can collect all the sensor data and convert it to control signals in a very short time. Even a small delay in the control will affect the performance of the car. The control system of the car has to control the steering, throttle control, shifting, braking, and clutch operation by implementing a hardware interface. The feedback from the hardware will be given to the controller for better performance. The communication system will be used for vehicle condition monitoring by participants in the pit lane. which can also be used for the emergency stop if something goes wrong. The pit crew will have an option to call the car to the pit stop at any point in time. When the pit crew calls the car to the pit stop, the car will calculate the path to the pit stop in the same direction the car is heading.

Simultaneous localization and mapping (SLAM)

We published a paper, "*ROS based Autonomous Indoor Navigation Simulation Using SLAM Algorithm*" in Int. Journal for Pure Appl. Mathematics in 2018. This method is mostly applied to our projects. In an autonomous racing car The mapping, localization and their corresponding computing algorithm should be fast enough to work within a vehicle moving at 200km/hr. For localization we can mainly rely on GPS, considering the size of the track. Mapping can be done by utilizing the sensor input from LiDAR, IMU, as shown in Fig. 15. The use of LIDAR sensors is favourable in the given scenario as they enable the direct measurement of the distance to the walls on one side of the track. We need a good pose prior or odometry prior is crucial to enable the SLAM process.

We are planning to use Google Cartographer instead of Gmapping, because it is able to create 3D maps of the environment. Furthermore, it can deal with a greater variety of data input. Furthermore, it can deal with point clouds represented by their x, y and z coordinates directly. It is further possible to input several sources of lasers or point clouds into the algorithm. The Cartographer can use pose and velocity measurements for the movement estimation to the algorithm. Furthermore, it can use readings from an IMU. In the 2D case, these measurements are used to stabilize the scan aligned to the horizontal plane. In the 3D SLAM case, the availability of an IMU is necessary for the algorithm to function. In 3D mode, the Cartographer can also process GPS signals directly to stabilize the drift of the pose estimation. The Cartographer found it to be computationally more efficient than Gmapping.

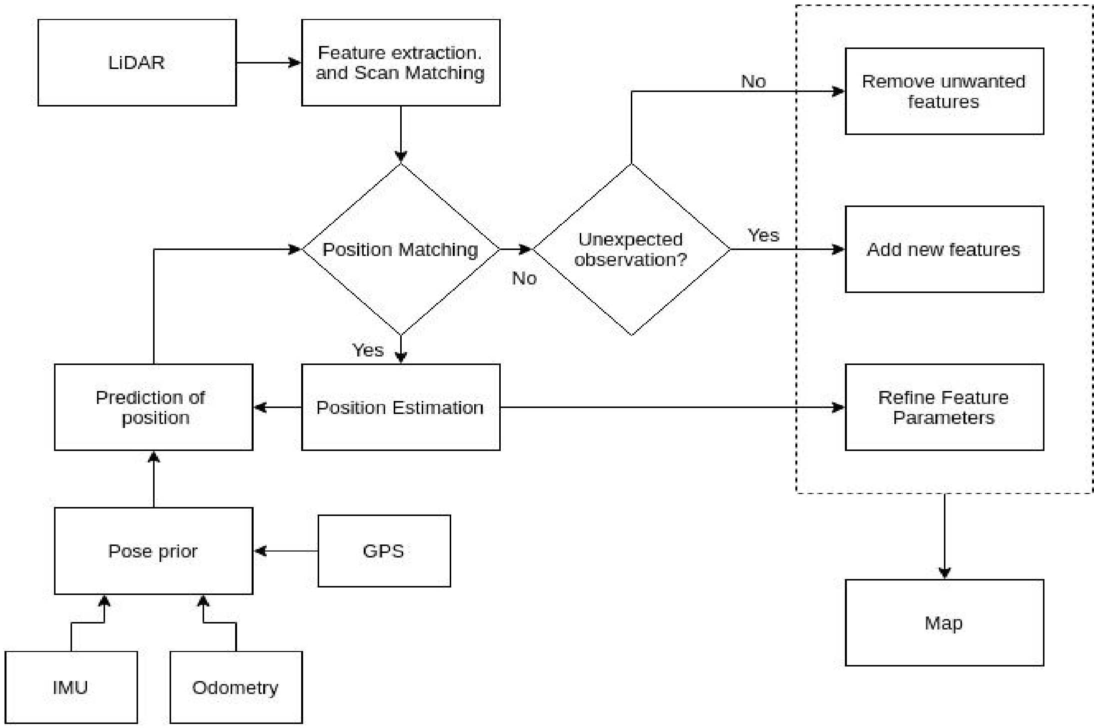

Fig. 15. Mapping and Localization using SLAM

Testing

Testing procedures are planned on a virtually created track and the environment in Unity or Gazebo which is a ROS based simulation platform. Different testing procedures like speed evaluation for turnings, Obstacle avoidance, overtaking algorithm etc. will be evaluated. Perception tests will help the ability to collect data while moving fast, ability to keep safe distance from opponents etc. Simulation races will be conducted with virtual opponents with similar specifications. Plugins for different sensors will be added in the Gazebo virtual environment. As per the test bench shown in Fig. 16. simulated sensor data will be compared with expected data or golden data and the performance will be evaluated.

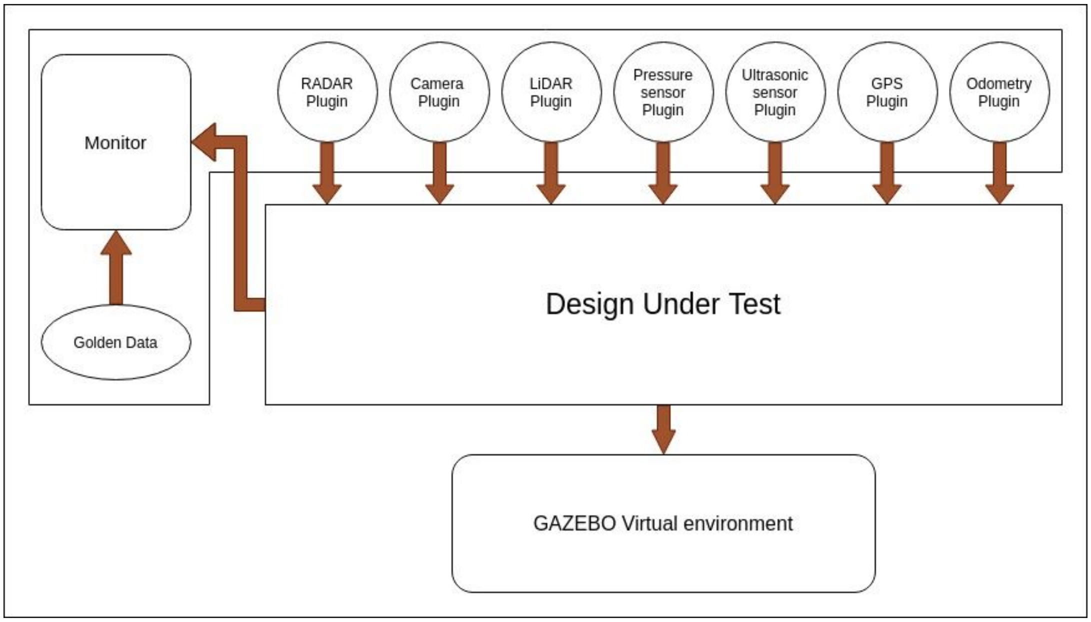

Fig. 16. Test Bench

Team Members and Details

No.	Team Members	Expertise
1	**Dr. Rajesh Kannan Megalingam** PhD in "Multi-Modal Control, Analysis and Evaluation of Automatic/Semi-Automatic Navigation Platform for Rehabilitation of People with Mobility Issues", 2015, Amrita Vishwa Vidyapeetham, India. Director, Humanitarian Technology (HuT) Labs, Asst. Professor, Department of Electronics and Communication,Amrita Vishwa Vidyapeetham, India	● Low Power VLSI Design for Manufacturing and Embedded Systems ● Robotics and automation ● Agricultural Robotics ● Rehabilitation Robotics
2	**Dhananjay Raghavan** M.S. Aerospace Engineering, 2003 University of Texas at Arlington Assistant Professor, Mechanical Engineering, Amrita Vishwa Vidyapeetham, India	● Static and Dynamic Systems Modeling ● Finite Element analysis ● Experimental Stress analysis ● Virtual Instrumentation
3	**Shankar Srinivasan** M.S in Mechatronics, 1999 National University of Singapore	● Robotics and Automation ● Technology Transfer ● Design and commissioning at autonomous, semiconductor and Solar industries.
4	**Sakthiprasad Kuttankulangara Manoharan** Ph.D Scholar, Department of Electronics and Communication, Amrita Vishwa Vidyapeetham, India	● Robotics ● Computer Vision, Image Processing, and Power Efficient Solar ● Energy Systems
5	**Sreekanth Makkal Mohandas** Ph.D Scholar, Department of Electronics and Communication, Amrita Vishwa Vidyapeetham, India	● Haptics ● Robotics and automation ● PCB Design

6	**Anandu Rajendraprasad** Master of Technology in Embedded Systems, A.P.J Abdul Kalam Technological University, India. Research Assistant, HuT Labs, Amrita Vishwa Vidyapeetham, India	● Autonomous Navigation Using Robot Operating System(ROS) ● Embedded Systems ● Mathematical Modeling in Robotics
7	**Akhil Raj** Bachelor of Technology in Electronics and Communication Engineering Research Assistant, HuT Labs, Amrita Vishwa Vidyapeetham, India	● Autonomous Navigation Using Robot Operating System(ROS) ● System-level integration using ROS ● Sensor Interface and Control
8	**Nikhil Chowdary** Final year, Bachelor of Technology in Electronics and Communication Engineering Amrita Vishwa Vidyapeetham, India Participated in RoboCup GermanOpen 2019 @ Home league	● Autonomous Navigation Using Robot Operating System(ROS) ● Simultaneous Localisation and Mapping(SLAM) ● Sensor Interface and Control ● System-level integration using ROS
9	**Jahnavi Yannam** Final year, Bachelor of Technology in Electronics and Communication Engineering Amrita Vishwa Vidyapeetham, India Participated in RoboCup GermanOpen 2019 @ Home league	● Speech Synthesis Algorithms. ● Simultaneous Localisation and Mapping (SLAM). ● Autonomous Navigation in Robotics using Robot Operating System (ROS). ● Power management and circuit design.
10	**Raviteja Geesala** Final year, Bachelor of Technology in Electronics and Communication Engineering Amrita Vishwa Vidyapeetham, India Participated in RoboCup GermanOpen 2018/19 @ Rescue league	● Mathematical Modeling in Robotics ● Hardware design, testing and evaluation in robotics ● Microprocessor, Microcontroller and sensor interface ● Power management and circuit design
11	**Rohith Raj RV** Final year, Bachelor of Technology in Electronics and Communication Engineering, Amrita Vishwa Vidyapeetham, India Participated in RoboCup GermanOpen 2019 @ Home league	● Mathematical Modeling in Robotics ● Hardware design, testing and evaluation in robotics ● Microprocessor, Microcontroller and sensor interface ● Power management and circuit design
12	**Manaswini Motheram** Final year, Bachelor of Technology in Electronics and Communication Engineering Amrita Vishwa Vidyapeetham, India Participated in RoboCup GermanOpen 2019 @ Home league	● Mathematical Modeling in Robotics ● Hardware design, testing and evaluation in robotics ● Microprocessor, Microcontroller and sensor interface ● Power management and circuit design
13	**Akhil Masetti** Final year, Bachelor of Technology in Electronics and Communication Engineering Amrita Vishwa Vidyapeetham, India Participated in RoboCup GermanOpen 2019 @ Home league	● Object recognition and manipulation algorithms ● Sensor interface with microcontroller and microprocessor ● Integrator of the whole system using the ROS platform ● System-level integration using ROS ● Integrated Graphical User Interface(GUI) development for system-level using electron Platform
14	**Akhil Tammana** Final year, Bachelor of Technology in Electronics and Communication Engineering Amrita Vishwa Vidyapeetham, India	● Applications of Robotic arm by adapting different interfaces ● Testing and evaluation in robotics ● Microprocessor, Microcontroller and sensor interface ● Power management and circuit design

	Participated in RoboCup GermanOpen 2019 @ Home league	
15	**Ravi Kiran Pasumarthi** Final year, Bachelor of Technology in Electronics and Communication Engineering Amrita Vishwa Vidyapeetham, India Participated in RoboCup GermanOpen 2019 @ Rescue league	● Mathematical Modeling in Robotics ● Hardware design, testing and evaluation in robotics ● Microprocessor, Microcontroller and sensor interface ● Power management and circuit design
16	**Santosh Tantravahi** Third-year, Bachelor of Technology in Electronics and Communication Engineering Amrita Vishwa Vidyapeetham, India Participated in RoboCup GermanOpen 2019 @ Rescue league	● Mathematical Modeling in Robotics ● Hardware design, testing and evaluation in robotics ● Microprocessor, Microcontroller and sensor interface ● Power management and circuit design
17	**Hemanth Sai Surya Kumar Tammana** Third-year, Bachelor of Technology in Electronics and Communication Engineering Amrita Vishwa Vidyapeetham, India Participated in RoboCup GermanOpen 2019 @ Rescue league	● Mathematical Modeling in Robotics ● Hardware design, testing and evaluation in robotics ● Microprocessor, Microcontroller and sensor interface ● Power management and circuit design
18	**Nagasai Thokala** Third-year, Bachelor of Technology in Electronics and Communication Engineering Amrita Vishwa Vidyapeetham, India Participated in RoboCup GermanOpen 2019 @ Rescue league	● Mathematical Modeling in Robotics ● Hardware design, testing and evaluation in robotics ● Microprocessor, Microcontroller and sensor interface ● Power management and circuit design
19	**Sreevatsava Reddy Musani** Third-year, Bachelor of Technology in Electronics and Communication Engineering Amrita Vishwa Vidyapeetham, India Participated in RoboCup GermanOpen 2019 @ Rescue league	● Mathematical Modeling in Robotics ● Hardware design, testing and evaluation in robotics ● Microprocessor, Microcontroller and sensor interface ● Power management and circuit design
20	**Rahul Puram** Third-year, Bachelor of Technology in Electronics and Communication Engineering Amrita Vishwa Vidyapeetham, India Participated in RoboCup GermanOpen 2019 @ Rescue league	● Mathematical Modeling in Robotics ● Hardware design, testing and evaluation in robotics ● Microprocessor, Microcontroller and sensor interface ● Power management and circuit design
21	**Naveen Samudrala** Third-year, Bachelor of Technology in Electronics and Communication Engineering Amrita Vishwa Vidyapeetham, India Participated in RoboCup GermanOpen 2019 @ Rescue league	● Mathematical Modeling in Robotics ● Hardware design, testing and evaluation in robotics ● Microprocessor, Microcontroller and sensor interface ● Power management and circuit design
22	**Hemanth Sai Venkata Srinivasa Kumar Nidamanuru** Third-year, Bachelor of Technology in Electronics and Communication Engineering Amrita Vishwa Vidyapeetham, India Participated in RoboCup GermanOpen 2019 @ Rescue league	● Mathematical Modeling in Robotics ● Hardware design, testing and evaluation in robotics ● Microprocessor, Microcontroller and sensor interface ● Power management and circuit design

23	**Lokesh Gadde** Third-year, Bachelor of Technology in Electronics and Communication Engineering Amrita Vishwa Vidyapeetham, India Participated in RoboCup GermanOpen 2019 @ Rescue league	● Mathematical Modeling in Robotics ● Hardware design, testing and evaluation in robotics ● Microprocessor, Microcontroller and sensor interface ● Power management and circuit design
24	**Avinash Hegde Kota** Second year, Bachelor of Technology in Electronics and Communication Engineering Amrita Vishwa Vidyapeetham, India	● Robot Operating System (ROS) ● Circuit Design ● Autonomous Navigation
25	**Vijaya Krishna Tejaswi P** Second year, Bachelor of Technology in Electronics and Communication Engineering Amrita Vishwa Vidyapeetham, India	● Robot Operating System (ROS) ● Circuit Design ● Autonomous Navigation
26	**Vineeth Prithvi Darla** Second year, Bachelor of Technology in Electronics and Communication Engineering Amrita Vishwa Vidyapeetham, India	● Robot Operating System (ROS) ● Circuit Design ● Autonomous Navigation
27	**Chaitanya N** Second year, Bachelor of Technology in Electronics and Communication Engineering Amrita Vishwa Vidyapeetham, India	● Robot Operating System (ROS) ● Circuit Design ● Autonomous Navigation
28	**Anirudh Dasari** Second year, Bachelor of Technology in Electronics and Communication Engineering Amrita Vishwa Vidyapeetham, India	● Robot Operating System (ROS) ● Circuit Design ● Autonomous Navigation
29	**Sriram Chowdary** Second year, Bachelor of Technology in Electronics and Communication Engineering Amrita Vishwa Vidyapeetham, India	● Robot Operating System (ROS) ● Circuit Design ● Autonomous Navigation
30	**Muneesh Puligundla** Second year, Bachelor of Technology in Electronics and Communication Engineering Amrita Vishwa Vidyapeetham, India	● Robot Operating System (ROS) ● Circuit Design ● Autonomous Navigation
31	**Rohit Inti** Third-year, Bachelor of Technology in Electronics and Communication Engineering Amrita Vishwa Vidyapeetham, India	● Mathematical Modeling in Robotics ● Hardware design, testing and evaluation in robotics ● Microprocessor, Microcontroller and sensor interface ● Power management and circuit design