Development of Advance Driver Assistance System using Artificial Intelligence

Mohini Tomar
Dept. of CSE
FET Agra College
Agra

Amit Yadav
Dept. Of ECE
RBSETC Bichpuri
Agra, UP

R.K. Sharama
Dept. of CSE
FET Agra College
Agra

Aseem Chandel
Dept. of EE
REC, Mainpuri
UP

Dushyant K Singh
Dept. of CSE
MNNIT Allahabad
Prayagraj, UP

Rajeev Agrawal
Dept. of ME
MNIT Jaipur
Rajasthan

ABSTRACT

Today, the technology moving towards to artificial intelligence to adapt the changes according to the environment. Autonomous vehicle has always been a part of human life they assist in various activities. The number of different vehicles is increasing day by day which brings ease in daily life, along with the comfort there are certain negative effects of the growing number of collisions on-road, such as congestion, and accidents, which eventually have an impact on human's social, economic, and environmental elements of life that must be overcome. Incidents in driving can occur on a daily basis with uncertain causes that the driver was sleep deprived. One form of accident causes the driver to sleep while driving, and it can lead to severe damage to the vehicle and it could be life-threatening for the driver. Advance driver assistance system (ADAS) technology can cure these kinds of incidents. In India, on an average among all accidents, there are 40% of accidents happen because of sleep-deprived drivers.

Decision-making ability in a vehicle using artificial intelligence is an active safety system created to eliminate human errors while driving a car. This system uses cutting-edge technology to aid the driver while they are driving and so enhance their performance. It makes use of a variety of sensors to collect the environmental data surrounding a car and in necessary situations, either inform the driver or take action itself. Through automated systems and early warning mechanisms, this system improves safety and response times to hazards. Some of these systems are standard on vehicles, while others can later be customized for the driver with features or even whole systems.

Keywords

Vehicle, Mathematical modeling, Artificial intelligence based expert system.

1. INTRODUCTION

These days the field of intelligent and smart machines is getting a wide popularity. Industries have huge demand of such like autonomous robot's, arms and humanoid robots. The nineteenth century, a big change in industry and research programs came up towards the development of high-performance man like machines. The man like machines has a smaller number of faults and delivers better outcome. Indian National Laboratories have developed remote automatic manipulators complete. These systems were of the "master-slave" type and to replace faithfully rotation and motions made by a manual operator. The smart/intelligence machine was guided by the researcher through a sequence of motions, while the slave manipulator demonstrate the master unit as nearly as possible. In 1950 the manual coupling was replaced by hydraulic power and electrical energy in manipulators such as General Electric's (GE) Handyman.

While an intelligent vehicle has referred to as an autonomous entity in the field of artificial intelligence. It acts for achieving the desired goals. It perceives from the environment (by using sensors) and performs using actuators. It can possess additional powers which categorize them in the following categories as discussed 1) Simple Reflexive Agents. 2) Model-based Reflexive Agents. 3) Goal-based Agents. 4) Utility-based Agents. 5) General Learning Agents. 6) Cognitive Agents. These are the most straightforward agents who work on the principle of "If-Then" rules. The knowledge is hardcoded, and they perform according to the defined standards. These agents cannot handle undefined situations effectively. They are merely taking the input and act according to set rules. These systems have no memory element.

These agents maintain or contain a kind of model within itself, which allows the agent to perform by considering the current state of the agent. These agents have a memory element which helps in storing the current state of the agent, afterwards consult the model, select the defined rule, and then perform accordingly. These agents can handle unseen situations partially. Perception acts sensing perception rules action agent environment unlike simple reflexive agents, these are more powerful in handling the cases [2-3]. In fact, a cognitive vehicle should have the power of (i) Sensing, (ii) Comprehension, and (iii) Action. It perceives from the environment through sensors or via direct text input, understands the situation, finds the best solution (with justification), and performs in the background. These robots are autonomous and have a self-learning nature. Instead of finding the answer to the situation, they find out the best solution and the architecture is known as "Cognitive Robot". Now in early day's Google autonomous vehicle has been designed for completing many tasks in daily life. This vehicle is known as "Smart Car", which is driverless and takes all decision by self-intelligence [4]. Smart Google car technology was innovative and all the actions are based on real time situation. The smart car has been designed fully automated and used various types of sensors. The most common problem in motions is of the vehicle and whenever it is loaded should not strike with the obstacles or objects either indoor or outdoor. In brief review there are many obstacle avoidance algorithms and approaches have been designed and developed in past. The hypothesis and test approach were the earliest technique for real time obstacle avoidance. The main advantage of the hypothesis and test is its simplicity and easy formation. The second class of algorithm for obstacle avoidance is based on derived a penalty variable on manipulator design. In penalty configuration obstacle collision and fall off sharply with range from the objects. The proposed idea is an intermediate approach between these two extremes. This approach uses penalty function which satisfies the definition of potential field at a point on the vehicle is interpreted as repelling force acting on that point. The third approach of obstacle avoidance is explicit demonstration of subsets of manipulation vehicle manufacturing that is collisions free in outdoor space. The disadvantage is that the computation of the free space is expensive and complex [5].

2. VEHICLE CONTROL LEARNING APPROACH

Now a days' market is demanding general purpose systems. This innovation is based on the design and development of vehicle which has the capability to avoid obstacle in real-time. These obstacles may be known or unknown, static or dynamic. The vehicle which should have the following capabilities in terms of:

1. It should be able to navigate itself from one point to another on X-Y plane.
2. It should be able to avoid the obstacles in real time.
3. While avoiding one obstacle it should not lose control over itself.

Mathematical Modelling of Obstacle Avoidance System

Obstacle avoidance algorithm mathematical representation and generate a fine response at the output in same manner this was the challenging task for us. So, for autonomous vehicle act according to the environmental situation which can adapt the change. In this research paper the techniques which is discussed about the obstacle avoidance is known as virtual vector field (VFF). The advantage of algorithm, it takes quick decision in indoor or outdoor environment. The obstacles can be categorized into two types.

1). Stationary/ Static Obstacles

House walls, pillar, wood furniture, door etc. comes into this category.

2). Dynamic Obstacles

These obstacles have unknown behavior in the nature. The motion coordinates or direction of vehicle velocity of these hurdles keeps on moving or changing. The vehicle will detect the moving obstacles which come in front of the path and take decision to move forward. Thus, the dynamic or moving obstacle can also be taken concern by smalltime allowing for them as static obstacle. The vehicle must accept a path of a moving object in the cartesian space from a given initial concept. This research paper gives the idea of advance virtual force-based obstacle/ hurdle avoidance technique best with the ultrasonic distance finder. The modification technique takes benefit of the glacial organize based facts transmit by the feeler by map the surroundings in a glacial organize scheme. The technique as well utilizes a Gaussian meaning base confidence principles to notice obstruction. The technique productively navigates from side-to-side multifaceted obstacle and reach goal waypoints. The functional block diagram of the vehicle is shown in figure 1.

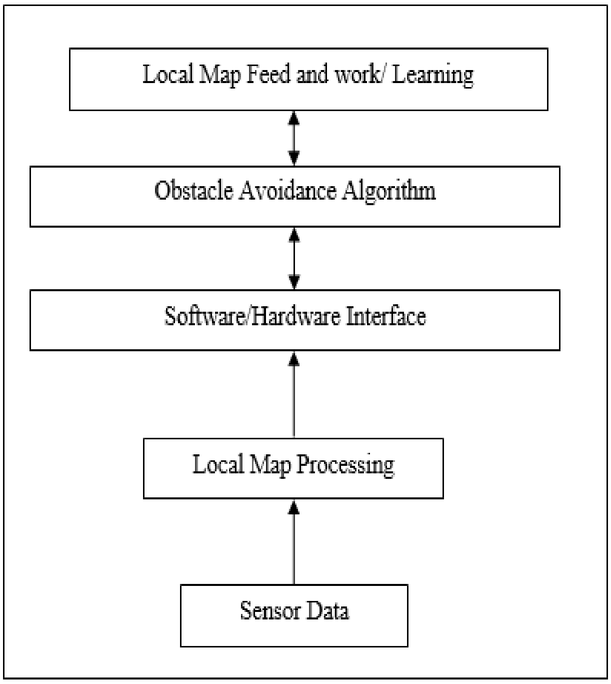

Fig1: Functional block diagram of the vehicle

The virtual force field (VFF) technique of matter theoretically exerts pressure onto vehicle has been optional by smart actions of artificial machine. The execution treats every ultrasonic sensor with variety of interpretation as a revolting strength vector. If the scales of the amount of the revolting forces exceed a sure entry, the vehicle stops, turn into the way of the ensuing compel vector, and move on. This technique has saved the instance of computing and it resolves the 'local-minimum' difficulty. The scale of this strength is relative to the goal point contents, C (i, j), and inversely relative to the quadrangle of the reserve between the conclusion and robot.

$$F(i,j) = \frac{F_{cr} C(i,j)}{d^2(i,j)} \left(\frac{x_t - x_0}{d(i,j)} \hat{x} + \frac{y_t - y_0}{d(i,j)} \hat{y} \right)$$

…. (1)

Where, F_{cr} = Force

$d(i,j) =$ Detachment between cell (i,j) and vehicle

$C(i,j) =$ Conviction level of point (i,j)

(x_0, y_0) = coordinate of vehicle

(x_i, y_j) = coordinate of target

The ensuing revolting force, is the vector addition of the entity forces from all the conviction point.

$$F_{cr} = \sum_{i,j} F(i,j) = F_r$$

At one occasion through the movement of vehicle, a constant-magnitude attracts force pull vehicle in the direction of the goal. The goal attract force, is given by

$$F(t) = F_{ct}\left(\frac{x_t - x_0}{d(t)}\hat{x} + \frac{y_t - y_0}{d(t)}\hat{y}\right) \quad \text{.... (2)}$$

Where,

F_{ct} = Force (towards to the goal)

d_t = Distance between the target and the vehicle

x_t, y_t = Target coordinates of the vehicle

$F(t)$ is autonomous of the complete remoteness to the target.

The vector addition of all forces, revolting since engaged point and striking from the goal location, produce a resulting force vector R,

R = F_t + F_r… (3)

The behavior of the vehicle can be experienced if it can get the route of the trajectory, when subjected to a given place of circumstances. The path representation for the vehicle is developed with the modeling and simulation in the MATLAB software and the path planning is tough for vehicle to arrive at unlike purpose point in every four dissimilar quadrants. In the modeling simulation the curriculum has been built-in which explain the constants k1 and k2. Specified a worldwide orientation equation flat surface in which the early location and direction of the vehicle is given by (q_1, q_2, q_3) with deference to the position scheme. The vehicle is to start from a point (x, y) and has to attain a specified spot with esteem to the limited position plane. Since, this position flat surface position change constantly with high opinion to the stage location, the initial or starting location from the derivation of the vehicle is shown in figure 2, and the vehicle is starting from the source. There is no obstacle in the route, therefore the vehicle moves below a stable striking force from the origin to the objective. Hence the route of vehicle is a straight line. The goal is in the 2nd quadrant at (-100,100). But as quickly as the ultrasonic sensor map the blockage come together, the revolting forces start performing. Thus, vehicle a then calculate the resulting of the striking and the revolting energy force and traverse in the way of the resulting force. The rate of movement depends on the extent of the resulting force F. The observation of the wind which is shown in figure 3. This is a blunder, which can be rectify by adjust the principles of the parameter k_1 and k_2.

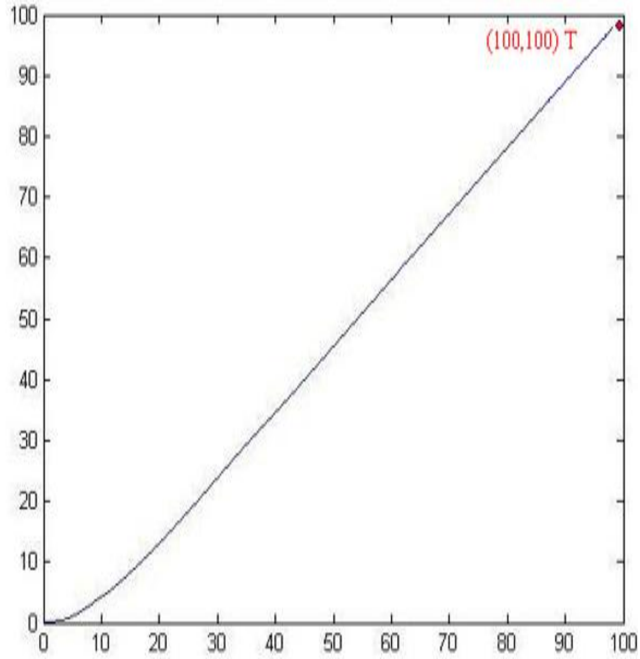

Fig2: When no obstacle in the path

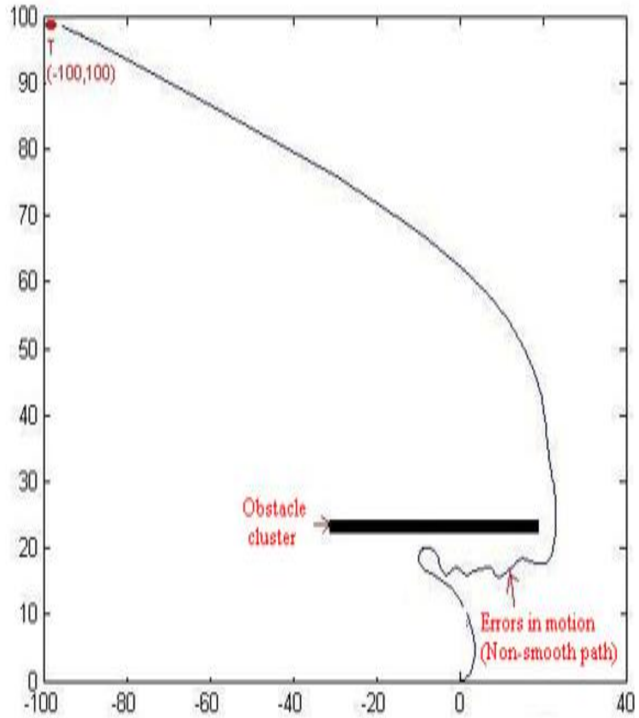

Fig 3: The vehicle reaching to the target, which comes in second quadrant

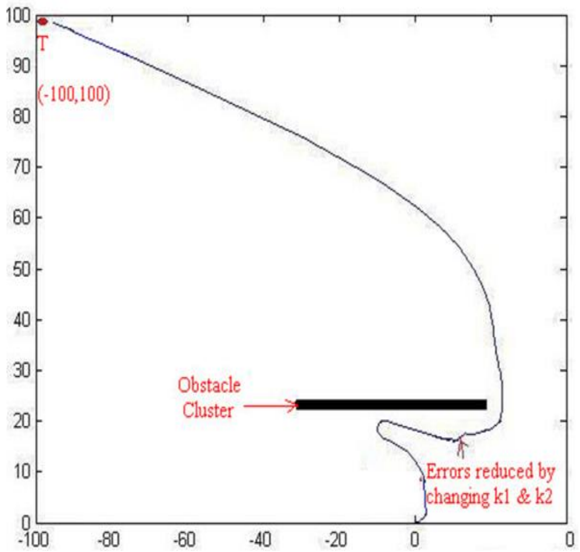

Fig 4: The route of vehicle among k_1=7 and k_2 =5

The most favorable standards of the parameter k_1 and k_2, in figure 4 are known as,

k_1= Onward speed

k_2= Pointed deflection of the wheel

Geometric modeling of the vehicle considers immediately single obstacle huddle. Yet, a figure 4 of obstacle cluster can be measured by modify the programing code. With the purpose of, allowing for two obstruction group expressions. The obstacle of every form and dimension can be describing with the help of suitable equations. The vehicle is moving smoothly and avoiding the obstacles like static or dynamic which are coming in his path. The results are showing the response according to the situation. Here in figure 5 shown that the vehicle is moving from starting point to target point after avoiding the obstacles in his path.

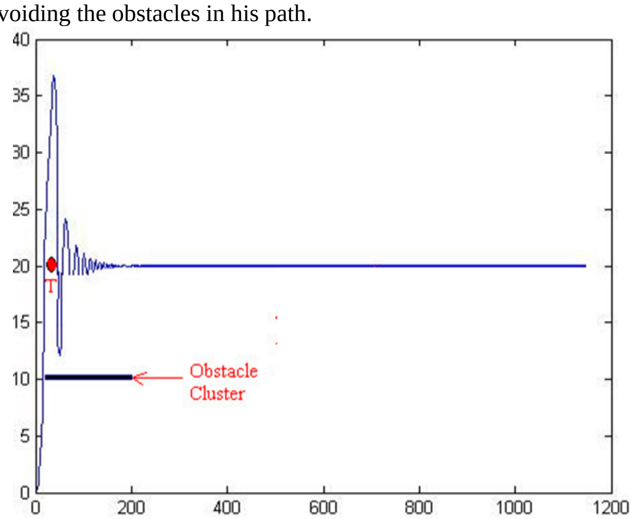

Fig 5: The vehicle achieves the target without any collision

3. Obstacle avoidance algorithm using artificial intelligence

Artificial intelligence method consists of very attractive and repulsive field of obstacle avoidance, which are used to represent targets and obstacles. For each moving obstacle there is, a dynamic constraint of the form can be employed:

$fj(n) = |n - Qj| - |n - Qj|2 - |n - Qj|3 - M3obs \geq$ 0......(5)

Where, n is the actual position of the robot, *Qj* is representing the position of obstacles, and *Mobs* is the defending distance of each spotted obstacle.

3.1 Active Collision Avoidance Using Expert System

The intelligence of human brain as we know that the decision-making capability in human is very fast and correct according to the situation. Therefore, the development of an expert system to face these real time situations and avoid accident with the obstacle in its path. There are some rules-based algorithms has been developed with the help of artificial intelligent technique which are known as expert-based algorithm for the system.

These expert-based rules based on the behavior of the real time situation in the workspace of the vehicle (KHR signifies the distance between the obstacle and robot), which is minimum KHR_min the unsafe space):

Case (a): When the obstacle is moving fast, consider the obstacle is moving fast then rn>rn_ m/s (in which unhazardous is the unsafe speed), the best decision is to make the vehicle keep away from the obstacles, instead of planning a new path at once.

Case (b): When obstacle is approaching slowly. When the obstacle approaches in a slow motion the speed (*0 <sn ≤ sn danger* m/s), by using artificial intelligence potential field method, the system needs to predict the motion trajectory and generate a new path to avoid the obstacles.

Case (c): The obstacle is static. At the beginning, the system makes a judgment whether the obstacle will block the movement of the vehicle or not. If the impediment exists, a new path should be generated by using artificial potential field method. If the obstacle moved at the speed *sn>sn_danger* m/s all of a sudden, the vehicle should react with case (a). While the speed (*sn>sn danger* m/s), the vehicle should react with case (b).

3.2 Decision making capability in a crowded space

Here we took a case that vehicle will run for long path where object A through a crowded location as shown in figure 6. To plot the movement of the object once it is detected by vehicle, the state space representation (x, y, a).

Were,

x = is the horizontal coordinate of the object = $1 < x < 6$

y = is the vertical coordinate of the object = $1 < y < 3$

a = is the orientation of the object

$$a = \begin{cases} 0 \text{ if object A is parallel to x axis} \\ 1 \text{ if object A is parallel to y axis} \end{cases}$$

Both position and orientation of the object are quantized. The vehicle commands are:

Move ± x direction one part

Move ± y direction one part

Rotate 90^0

The physical space appears in Figure 6. That assume for graphic that each movement can be specify (2, 2, 1) and the final state is (3, 3, 0). All of this path is not representing the straight path for vehicle but all are complex route for turning and follow the target.

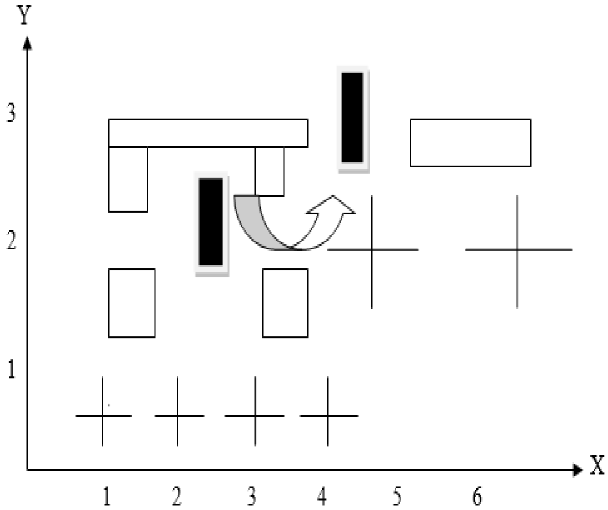

Fig 6: Physical space for the vehicle in parking

Here, the crowded environment where vehicles are near around vehicle and it makes the best possible decision to overcome from this problem. The vehicle is capable to avoid the collision to the vehicle with his decision-making capability. As it is seen from the figure 6, the vehicle stops one step before its collision and back steps in the same path to move forward. It tries to avoid the obstacle and collision to other vehicle unless and until it reaches to its final destination point.

3.3 Hardware Development

The vehicle development has been completed in research lab. So, that the vehicle has been tested in both indoor and outdoor and the outcome was as per the desire. The configuration of all software module and parameters are checked and tested in the lab. Selection of modules and customization of parameters for particular system run. The developed vehicle is shown below in figure 7.

Fig 7: The vehicle development in the research lab

4. CONCLUSION

The design and development of an autonomous vehicle with such kind of intelligence is a challenging task and comes under the domain of "Artificial Intelligence". The prototype of the vehicle is developed in the lab as per the objectives and tested in real time indoor/outdoor environment. The real-time obstacle detection systems will be crucial to minimizing accidents and it will be helpful technique for upcoming driverless vehicle. The artificial intelligence technique will increase the range of decision-making capability in real-time operation or performance. The research would identify and classify the over-all development of the vehicle with advanced learning techniques using simulated and actual experimental data. The development of control algorithms could be adopted for similar problems in other obstacle avoidance as well. The government is emphasizing on development of smart driverless vehicle with artificial intelligence technology. The proposed research would be applicable mainly for the transportation applications.

5. REFERENCES

[1] Awad. F and Shamroukh.R , " Electric Vehicle Detection by Intelligent Machine Urban Search and Rescue Using Image Processing and Neural Networks" International Journal of Intelligent Science , pp.4 39-53, 2014.

[2] Gold.J and Koren.K, "Obstacle Avoidance with Ultrasonic Sensors". IEEE Journal of Robotics and Automation, vol. RA-4, No.2, pp. 213-218, 2018.

[3] Hook.A, and Koren. K, "The fast obstacle avoidance for autonomous vehicle, IEEE Trans. on Robotics and Automation, pp.501-518, 2022.

[4] Harrol. J and Latombe .J.C, "Hybrid Machine motion planning: a distributed representation Approach", International Journal of Robotics Research, vol.10 no.6, pp. 628-649, 2018.

[5] Mongin.A.K , Chatterji.B.N , Ray A.K . "Design of a real-time tracking system for fast-moving objects with Solar EV" IETE J. Res 43, pp.359-369, 2017.

[6] Motai, Y. "Visual-based human-robotic interaction for extracting salient features of An industrial object for an automated assembly system, special issue on Machine Vision", International Journal of Computers in Industry 56

(8-9) pp.943-957, July 2021.

[7] Nick.D and Forsyth.A, "Finding and tracking people from the autonous electric machine", in Proceeding of Computer Vision and Pattern Recognition (CVPR), Madison Wisconnin , June 2019.

[8] Nian, X. Peng, F. and Zhang, H. "Regenerative braking system of electric vehicle driven by brushless DC motor," IEEE Trans. Ind. Electron., vol. 61, no. 10, pp. 5798–5808, Jan. 2014.

[9] Prassler, E. Bank, D. Kluge, B. and Hagek, H. "Key technologies in robot assistants: Motion co-ordination between a human and a mobile robot," proc. 30thint .sym. Robotics, 2001, pp. 410-415, Mar. 2001.

[10] Schulz, W. Burgard, D. and Fox, "People tracking with mobile robots using Sample-based joint probilistic data association filters", International Journal of Robotics Research pp.99-116, Sept. 2003.

[11] Urzelai, J. and Ezkerra, J, M. "Fuzzy controller for wall-following with a non- holonomous mobile robot" FUZZY-IEEE / IFES, BARCELONA, July, 2022.

[12] Yadav, A. Chaturvedi, D, K. "Design and development of safe intelligent moving machine". International Journal of Electrical Machines & Drives(IJEMD). vol.2, pp 16-21, Feb. 2016.

[13] Yadav, A. Chaturvedi, D, K. "Mathematical Model for Ground Electric Vehicle Using Matlab-Simulink". International Journal of Automatic Control System (IJACS). Vol. 2, pp 26-34, April 2016.

[14] Yadav, A. Yadav, N. Chaturvedi, D, K. "An Intelligent Electric Vehicle (IEV) Using LabVIEW". IEEE 2nd International Conference on Communication, Control and Intelligent Systems (CCIS) vol.2, ISSN 978-5090 Nov. 2016.

[15] Yadav, A. Chaturvedi, D, K. "An Autonomous Ground Electric Vehicle using LabVIEW". National Systems Conference on Super Intelligent Man and Machines sponsored by IEEE (NSC-17), DEI, Agra, Dec. 2017.