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Autonomous Vehicle Using Machine Learning

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Abstract: More advanced technologies in the field of automobles had come up recently. The main focus is on making the vehicles automated. There are various aspects in the field of automobile industry which makes the vehicle automated. This autonomous vehicle is based on the idea of using fewer resources and less cost to develop a highly efficient self-driving vehicle. It is a mix of Robotics, Machine learning, and AI and using an ARM-based low-power Low-cost CPU (P.C) which is mainly found on Mobile architecture by replacing a CPU of X86 architecture which is having high cost and needed high power consumption. The vehicle is trained using Machine Learning and it detects not only simple obstacles but also understands several kinds of signs, stopped vehicle, take a turn when a parked vehicle or comes in front of it, understands the road line and follow it, only by using a simple camera and a low power low-cost simple CPU. When an obstacle/sign captured by the camera, vehicle takes a needed decision by sending the data into the Machine learning algorithm in PC. Thus, the vehicle will be trained enough to navigate safely by relaxing the driver.

Keywords: IoT, Robotics, Autonomous Vehicle, Machine Learning

I. INTRODUCTION

Autonomous vehicles are the ones that run without human input. There are a lot of automatic vehicles running in the industrial market these days. But every projects are overloaded with many expensive sensors like lidar, sonar, etc. Over that to run all these sensors, one need an expensive high-cost, high power consuming PC inside the vehicle to process all the data in real-time. So, overall expense of the project is already skyrocketed. There comes our project. This project is based on the idea of replacing all the sensors and high cost, high power consuming PC with a single camera and ARM PC. It processes the give data using machine learning and takes the needed decision. A normal autonomous vehicle that is currently available in the market today cannot be affordable by every people. In this project, the vehicle not only detects simple obstacles but also understands more obstacles, traffic lights, traffic signs and take needful decision accurately. for all this, we are only using simple cameras and a low power low-cost simple CPU. By reducing the sensors and by replacing the expensive CPU, the vehicle can be affordable to normal people and hence autonomous vehicles are going to be the vehicles of future.

II. THEORY

A. ARM architecture CPU

In computer processors, ARM is a family of reduced instruction set computing (RISC) architectures. These processors are mainly found on mobile architectures. In this project we are using Raspberry Pi 4. It is the master working brain of the entire Robot. All the processing, calculations are done inside Raspberry pi. All the software requirements are installed inside the Raspberry pi, and then the Raspberry pi does the calculations and processing to further forward the actions into the next module. Since the Pi 4 being faster, it is able to decode any 4K video, and faster storage through USB 3.0, and also faster network connections through true Gigabit Ethernet, and there are other options as well. The Pi can run a very variety of systems, including the official Raspbian OS, Ubuntu Mate, Snappy Ubuntu Core and it can run Windows 10 IoT Core, which is very different to the desktop version of Windows. In this project we are using ubuntu. Mainly in autonomous cars CPU with X86 architecture is used. But that is of high cost and also it is highly power consuming. But the Raspberry Pi 4 has ground-breaking and increased processor speed.

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B. A low-cost standard resolution camera

Camera is used to capture the input images. The entire system works with the help of the input image got from the camera. Here we are using pi cam. The Pi camera is light weight and a portable module that supports mainly in the Raspberry Pi. It communicates with Pi using the MIPI camera serial interface protocol. The entire robot works with the help of image processing and these images are captured using pi cam. This module when purchased comes along with the ribbon cable, this cable is connected to the CSI (Camera Serial Interface) port of the Raspberry Pi. Thus, the camera is connected to the system.

C. Driver Board

The driver board is the hardware component which decides the degree and angle the wheels, steering etc of the vehicle has to be turned. Here we are using Arduino Uno as driver board. Arduino is a platform which is mainly based on easy-to-use hardware and software. Arduino boards are capable of converting an input which is already read by the board into an output. Here the driver board receives the output of the processed data from the ARM CPU and hence the board determines the actions to be forwarded. The board consists of 14 digital input/output pins out of which there are 6 analog inputs, and also other functionalities such as USB connection, a power jack, a reset button etc. It contains everything needed to support the microcontroller. It can be simply connected to the Raspberry Pi with a USB cable or power it with a AC-to DC adapter or battery to get started.

D. Internet of things

The Internet of Things (IoT) is a network which consists of hardware and software technologies mainly embedded with various sensors, a media for the purpose of connecting various devices and for exchanging data and other information. The IOT mainly focuses on connecting various physical devices one another and also with the user so that the device can be controlled by the users and one another. There are various applications of IOT in the daily life including Home Automation, Smart medical field etc. In this project there are Arduino UNO, which is the micro controller convert the output coming from Raspberry Pi and make the desired output actions.

E. OpenCV

In this project, the important aspect is image processing. The image processing is done using OpenCV. OpenCV (Open-Source Computer Vision Library) is a software library mainly focusing on image processing. Since the library has more than 2500 optimized algorithms, these algorithms can be used to detect and recognize faces, identify various objects, classify human actions with the recorded videos, track the movements of camera, tracks various moving objects, etc. OpenCV will be one of the best options that can be used in our case. Using OpenCV library the image classification is done on the basis of trained data. Thus, various objects are detected and the further decisions is taken based on these processing.

F. Cascade Classifier

In the projected system, numerous objects square measure detected in OpenCV exploitation Haar Cascade classifier. Cascading could be a style of learning supported symptom numerous different classifiers, exploitation the {information} and different info collected from the output from another given classifier as extra information for consecutive classifier within the cascade. For this, initial we have a tendency to capture numerous signboards, traffic lights in addition as different obstacles for the aim of coaching. we want 2 styles of information. Positive samples and negative samples. the 2 styles of information square measure positive samples and negative samples. each the positive samples and negative samples of information square measure captured and singly keep in folders. when the classifier is trained it is applied to a vicinity of a picture and notice the thing in question. to look for a selected object within the entire frame, the search window is affected across the whole image. These information square measure given for coaching in Cascade classifier. The cascade classifier uses Feature extraction technique and at last detects the kind of obstacle, traffic lights, signboards etc.

G. Machine Learning

Machine Learning is basically about learning itself. With an input trained data, the algorithm trains itself with the trained data and when a new data is found, it then again trains itself, thus the system gets improved by itself. The more experienced the system is, the more accurate result the algorithm predicts. In this project there are two sets of data given for training. Positive samples and negative samples. With these samples the system gets trained and then the vehicle starts to capture various images and other obstacles. Machine Learning is the best option for Autonomous Vehicles.

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III. RELATED WORK

Various papers describing different technologies used in automobile field is explained below.

The aim of this paper [1] is an autonomous car which works Convolutional Neural Network. There are a lot of Vehicle to infrastructure correspondence related projects existing already. But the inaccessibility of these V2I frameworks resulted in moving into other technologies in the field of autonomous vehicles. Again, Traffic Light recognition and path identification are yet to be a complicated task in the scenario of autonomous vehicles. In this paper, using Convolutional Neural Network these tasks are done. Neural networks can take more highlights form a raw picture. For image processing YOLO (You Only Look Once) image processing algorithm is used. YOLO proves to be one of the fastest image processing algorithms. Rather than classifying a single class of object, it identifies different classes so that driver only needs less attention while driving. With the help of ultrasonic sensors, distance from the vehicle to an object is calculated. For lane detection, Canny edge detection algorithm is used in this paper.

The aim of the paper [2] is an Automatic Incident Detection method using V21 communications. Here, there will be RSUs (Road Side Infrastructure Units) placed at equal distances on the road. RSUs will collect information from the vehicles and sent the distance from the vehicle to the traffic light and other traffic signs to the vehicle. RSUs will always act as wireless access points. When vehicles enter to the corresponding coverage area of an RSU, it gets connected to RSU like mobile terminals. The connection is established between RSUs and vehicles using beaconing mechanisms. The problem with this paper is that, it is limited to only certain scenarios. That is, these RSUs must be placed at regular intervals on the road which is only limited to a particular highway infrastructure or the road infrastructure of a particular area.

This paper [3] is reviewing and comparing the different vision-based algorithms used for detecting road lines in autonomous vehicles. Lane detection and tracking are always considered as an important task in autonomous vehicles. Vision based approaches and strategies are very simple for detecting road lines. In this approach, camera is used for the purpose of lane detection. Lane detection mainly indicate as the way of locating the road markers and then interpreting this information to any intelligent system. It mainly includes in searching and locating the white or yellow horizontal markings on the painted road's surface and then marking the boundaries on them for the purpose of limiting these lanes. Then comes lane tracking. These already detected lane markers are adjusted themselves in accordance with the movement of the model and then uses the temporal coherence for the purpose of tracking the boundaries in a frame sequence. After that Vehicle Orientation is done. It means detecting the orientation of the vehicle and position of the vehicle inside these lane boundaries. Light detection & Ranging (LIDAR) are the most commonly used solutions for the purpose of lane & road detection. The global positioning information are also widely used.

This work [4] is aimed on traffic light & sign detection using image processing technique for autonomous vehicle. Traffic sign recognition systems are used for various purposes like regulating the traffic, warn the drivers etc. This is a visual based project where the input is video data, in which these input images are captured from the webcam continuously. The webcam is interfaced to the PC which is Raspberry Pi here. Hue, saturation & value (HSU) color space model are the techniques used here for the purpose of image processing in traffic light detection. For detecting traffic signs region of internet (ROI) is selected. And also, for the same purpose, HSV color space model and Contour Algorithm is also used. This paper is mainly focused to assist the driver & to give audio commands. It accurately detects traffic light colors, ie. Red, Green & different signs like foreword, turn left, turn right & turn back. Also works accurately when the vehicle needs to take diversions & start/stop according to traffic lights. After the experiment, the result shows that the system works in highly accurate manner even in complex situations.

In this work [5] An autonomous vehicle is designed to perform required task such as pedestrian detection. It is always a complicated task for detecting human being like pedestrians on the road in the case of autonomous vehicles. For better safe road navigation, this paper presents a pedestrian detection in autonomous vehicles through inter – vehicle communication systems. It is mainly achieved by pedestrian detection which is implemented by using Histogram of Oriented Gradients (HOG) descriptor with the linear Support Vector Machine (SVM) classifier and vehicle recognition which is implemented by using Haar feature-based cascade classifier. Intended detectors are also implemented for the purpose of pedestrian detection. When a pedestrian's presence is detected a warning notification is sent which is through an inter-vehicle communication system, based on an In-Car Gateway. Finally, the system accurately detects around 90% for pedestrian and 88% for vehicle in simulation.

This paper [6] discusses a technology in the field of automobiles is discussed which is based on Multi-hop V2I Communications. This paper is a Feasibility Study, Modelling and Performance Analysis. Generally, In wireless networks, multi-hop communication is based as a means to establish connectivity between distant nodes. But establishing this in vehicular networks are a difficult task. In case of vehicles which is on V2I communication has a limitation of limiting the connectivity of a faraway vehicle with RSU. This technology of multihop connectivity can overcome this limitation. It also focuses on increasing the connectivity of vehicles navigating on highway. Here Vehicular Adhoc Networks are used (VANETs). These includes V2I (Vehicle to Infrastructure) as well as Vehicle to

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vehicle communications. Here the intermediate vehicles between an isolated vehicle and faraway RSU acts as intermediate relays. A mathematical framework is also required for the purposes like determining the availability of a connectivity path between the faraway source vehicle and the destination RSU and also for evaluating the end-to-end delivery delay of a packet and multi-hop throughput of the system. A packet undergoes various hopping and reaches the final destination. Various simulation results are done and found the probabilistic relation of establishing the connectivity path between faraway vehicles and RSU. It is found that the probability of having a path available is directly proportional to the vehicular density and also inversely proportional to the distance between the source vehicle and the destination RSU.

In this paper [7], obstacle avoidance solution is solved for autonomous vehicles. Obstacle avoidance is one of the majour issues in automatic vehicles and various miniature models and simulations had done for the purpose of experimenting with various solutions to obstacle avoidance problems. In this paper, a solid solution is introduced using a Raspberry Pi and a LIDAR module such that, the vehicle is capable of navigating in an unknown environment by avoiding obstacles and works in a very efficient manner. Here for the obstacle detection, instead of using any Computer Vision techniques, only a single LIDAR sensor is used. It helps to safely navigate from a starting point to a destination point to avoiding obstacles. The vehicle is also having a Wi-fi infrastructure to locate its position in the environment. The vehicle also includes various sensors like LIDAR, GPS, radars etc which are capable to respond very quickly and also the vehicle includes a processing unit, which is capable of interpreting all this data in real time. Among these sensors are cameras, radars, Global Positioning System (GPS), LIDARs and infrared modules. Over all these, LIDAR is used to collect the measurement information from the surrounding for the purpose of obstacle detection. A novel algorithm is also required for driving the vehicle in the real-time by processing all these data. But modification of an algorithm is to be made to predict obstacle movement and navigate in more efficient manner.

This paper [8] provides a solution for the existing problems related to improper recognition of traffic lights and signs in autonomous vehicles. According to many statistics, most of the road accidents are occurring due to less attention or less response time in the traffic events. So autonomous vehicles should have automatic modules for detecting such traffic events. In this paper, an automatic system is implemented mainly to recognize traffic events in self-driving vehicles which monitor and manoeuvre through real-time traffic events. For that identification and classification of data has to be done. Image recognition is done for capturing images and the data are classified using Convolutional Neural Network. All the responses are provided through Arduino controlled Autonomous vehicle model used here. The vehicle is trained with Belgium Traffic signs dataset. This paper mainly proposes a hardware integration using Arduino which is connected to the car model used here to perform real-time response to various traffic signs and events which is already trained to the vehicle. The system also includes distance calculation from road sign to the capturing camera. For following the road lane, an algorithm is also implemented and applied to detect curves on the road and respond to that in real time. The experiment was done and found the system with an accuracy of 83.7%.

In this work [9] an image processing technique associated in image processing toolbox in LabVIEW is used in order to solve the traffic light recognition problem for colour-blind individuals. Color blind people will be having difficulty in normal lighting conditions or some people will see colors differently. In the proposed system, a fixed mobile camera is used uses to capture traffic light images which is taken in different roads and streets in Jordan and Kuwait. Traffic lights are detected by comparing the candidate traffic light with the already collected traffic light templates. All the comparisons are based on correlation. The collected templates consist of 22 different shapes of traffic lights which are in Jordan and Kuwait. An algorithm is designed which extracts the green and the red planes of traffic lights and recognizes their colors. Experiments are done on this idea and found out that the experimental results have high accuracy in the implemented algorithm in identifying the colors of traffic lights in various situations and cases which shows that the proposed algorithm is very helpful for colorblind drivers.

This paper [10] discusses the challenges and difficulties that researchers needed to overcome in traffic light recognition (TLR) research in automobile industry and gives an overview of the current works based on these. The main aim is to discover the improvements by comparing the areas which has thoroughly researched and not. Various Traffic Light Recognition algorithms has been studied in depth, evaluated through a a common procedure with public datasets which includes various video sequences that had captured in different lighting and weather conditions with the help of a stereo camera. This will help the researchers to compare algorithms more efficiently. Overall, the paper is divided into different parts. First part is the color space detection. Most approaches focus on finding the color and shape for finding the candidate region of traffic lights and also on. For removing bad candidate regions, BLOB analysis is mainly used. Some approaches are based on trained features such as HOG, LBP, and 2D Gabor wavelets, which is classified using SVM. Some of the approaches focuses on template matching or neural networks using the color and/or shape.

The system [11] is mainly based on building a robust, detector of traffic lights which captures traffic light and detects them and classifies them in real-time for autonomous vehicles. In this paper, using the publicly available LISA and LARA and Daimler dataset, a multi-scale and multi-phase detector is proposed which is based on aggregate channel features and boosted trees classifier. The datasets Daimler, LISA and LARA is mainly used for evaluation, through

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which high average-recall and speed can be estimated. In general, the paper is divided into two parts. First the main focus is on Blob Analysis method. In this method color segmentation is used which is considered to be a noisiest step, to cluster all candidate pixels within the current frame followed by applying any of the heuristic rules to filter the connected regions. Second part discusses Classifier based methods like Haar like features, SVM classifier etc. The proposed algorithm performs the red-light detector and green light detector one another in consecutive frames. To enhance the performance, a tracking module is also used. Then the experiments is done using the three publicly available Daimler, LISA and LARA datasets and evaluated the performance.

This paper is [12] about building an autonomous car using raspberry pi. Software part is done by usng libraries in python. These python-based libraries can be used for controlling the car and for communicating with the car over a network or locally within the car. Environment learning is also required. For that, two methods are used. Supervised learning and Reinforcement learning. In supervised learning the car is drove on an environment and collected around 30,000 datapoints. Based on this data, a CNN model is trained. The results showed that this CNN model has achieved the test accuracy of 73%. For supervised learning, image pre-processing, image resize and rescaling, image equalisation, image labelling, class labelling, class weights and deep learning has to be done. In reinforcement learning, the car is trained with three road signs such as stop, No left and also traffic lights are trained using with existing CNN model in deep Q - learning. Using these CNN model and cascade classifiers, road signs and traffic lights are detected. It is said that CNN makes use of patterns and more structural information from an image. This is a customised car in a customised environment created from scratch.

A vision-based traffic light detection may be not always accurate for automatic vehicles. This paper [13] is based on a complementary detection approach which is based on completely new set of information. Here, the main working is based on the movement pattern of vehicles. It is found that this approach is robust to all previously found means of errors, and may even be a supplemental detection method. There are various different classification models presented for traffic light status detection based on these patterns. All of these method's performance is evaluated over real time and with simulated data sets, and found a result of 97% accuracy in each set. Overall the current state of traffic light is accurately detected by analysing the spatial movement of nearby vehicle with respect to target vehicle. By testing in three classifiers like feedforward neural network, in a nearest neighbour classifier and in a bidirectional long short-term memory network, nearest neighbour classifier had obtained maximum best result in classification. BLSTM classifier is used if the data is noisy.

This paper [14] will present solution for the problem of detecting traffic lights in complex urban environment along with recognizing them. For this, a method of integrating HOG features with Visual Selective Attention (VSA) model is used. For getting the candidate regions, VSA model is used. Then to precise regions of these traffic lights, HOG features of traffic lights and SVM classifier is used in those candidate regions. First of all candidate regions has to be first selected and to reduce the time consumed for computing HOG features and SVM classifier. SVM classifier will identify wheather the image in the detected window is traffic light or not. Then bounding boxes will be obtained followed by converting the image to grey scale and mapping these bounding boxes into the grey scale image of the channel. After performing the experiment, system evaluation is done. Evaluating the result is done by checking the overlap ratio of the detection bounding box and ground truth bounding box. If the overlap ratio is greater than 50%, the result will be considered as correct decision. A baseline algorithm is implemented for the purpose of validating the method and also for making comparisons. Finally concluded that the proposed method is capable of meeting the real-time detections in more efficient manner than baseline algorithm

The main purpose of this work [15] is to propose a reliable traffic light detection and classification. For smooth urban driving, it is a crucial task to implement an efficient traffic light detection in real-time. The system in this paper proposes a traffic light detector, tracker and a classifier for traffic light detections in real-time. All these are based on deep learning, vehicle odometry and stereo vision. There are three major sections contributed in this paper. First contribution is a labelled traffic light dataset which is accurately detected with the help of 5000 trained images and 8334 frames of trained video sequences. This result is taken as baseline and the data set is also published as Bosch Small Traffic Lights Dataset which is largest publicly available dataset which has labelled traffic lights which includes 1 pixel width of labels down. Traffic light detector which runs at 10 frames per second on 1280×720 images is the second contribution. The third contribution is the light tracker which is to compute the motion estimate of traffic lights which is based on vehicle odometry and stereo vision. A neural network is trained for traffic light detection which detects traffic lights for equal error rates down to the size of 4 × 12 pixels at the IOU of 0.5. Then comes the second neural network which determines false positive detections and different states of traffic lights. Then finally for any misses and time constraints a supplementary detector based on stereo vision, odometry, and deep learning based approach to tracking of traffic lights is described. Thus the system runs in any challenging conditions in more efficient manner.

This work [16] is a traffic light detector which works on frame-by-frame execution based on temporal information. For efficient and real-time traffic light detection a camera-based system is proposed using deepTLR. For visual based object detections, always deep convolutional neural networks is the best option which accurately does detection and classification. Without any prior segmentation, the system can detect traffic light. In each fine grain pixel region of the

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input image, classification is done. Then classes are identified in the image along with forming bounding boxes. It is found that the proposed algorithm can be run on real-time applications with more accuracy and efficiency with single frame evaluation even in complex datasets.

The paper[17] proposed a traffic light detection which is robust that works based on vision is implemented. It is mainly for on-vehicle camera applications. The paper mainly focuses on three aspects. The first one is to reduce the redundancy in computations, next is aspect ratio, area, location, and context of traffic lights which is utilized as prior information. Second focus is to improve the accuracy. To improve the accuracy by aggregate channel feature method, a serious of improved methods are established. This includes establishing a structure of fusion detectors and modifying the channel feature for each types of traffic light. In third aspect, a method is introduced for improved accuracy. This includes introducing inter-frame information analysis, making use of information from detection of previous frame to make modifications in original proposal regions. With VIVA dataset, this model achieves comparatively good results even for complex backgrounds. The detection model will detect the candidate regions with statistics of shapes, location and context of traffic lights. Normally it is a difficult task for detection for small luminous objects especially with poor quality. In this system by establishing the model which combines prior feature with statistic learning, the solution for that problem is also solved.

The paper[18]thinks about strikingness map generation for real time traffic mistreatment convolutional neural networks. ordinarily vision primarily based sensors square measure used for this purpose. however there square measure challenges like reduced look info in low illumination conditions, poor quality of pictures etc. during this system, a spatially forced region of-interest within the image containing the stoplight is known mistreatment visual camera primarily based period stoplight detection rule that is given during this paper. Even for adverse surroundings, by distinguishing the region of interest high stoplight detection accuracy with few false positive is achieved. For obtaining this result with high accuracy, the rule that is planned consists of 2 steps. initial one is off-line strikingness map generation and second may be a period stoplight detection. In offline step, the stoplight is detected mistreatment deep learning framework. This info is found mistreatment Region of interest and aboard GPS detector. These detected traffic lights is employed to come up with strikingness map. The strikingness map are having changed multi-dimensional density-based abstraction bunch of applications with noise (M-DBSCAN) rule. This map are indexed mistreatment the data got from vehicle GPS. within the second technique, detection of traffic lights square measure achieved by retrieving relevant strikingness maps so by performing arts example matching with the assistance of color info. The present planned rule is finally valid with the datasets that is taken in variable conditions and from totally different countries.

In this paper [19] implementation of road sign detection ANd management of an autonomous Vehicle exploitation Haar Cascade Classifier rule. System mechanically detects road signs management vehicle and command bound actions. The system consists of Raspberry Pi three processor and net camera. The camera can capture video knowledge and converts them into range of frames ar processed by the rule. Open CV to observe road sign and management the vehicle. Vehicle management 2 DC motors interfaced with Raspberry Pi. System offers a lot of correct results with higher PSNR price compared to Hough Transformation.

This paper [20] gift, associate economical methodology for police investigation the standing of the traffic lights from visual data. (versus wishing on light localization via GPS, radar, lidar, or map-based previous knowledge). The control signal head lightweight detection is a vital drawback for driver- help system. The system in the main focuses on shaping the various light colours, at the side of group action a several fail-safe technique that area unit designed to stop errors within the detection. The algorithmic rule may be simply worked by adding the system over to associate embedded good camera platform and additionally by CVD at the side of windshield-mounted driver-assistance device by people. this method is intended in such how that it's capable of characteristic the standing of the sunshine even at four hundred linear unit away in associate correct manner at the side of dependably police investigation solid, arrow, and high-visibility signal lights. The system is tested with fifty h of video (over 2000 intersections) that containing intersections with one to four traffic and resulted with ninety seven.5% accuracy.

IV. CONCLUSION

This project is mainly based on the purpose of reducing the expenses of manufacturing an autonomous vehicle. A normal autonomous vehicle that is currently available in the market cannot be affordable by all people. By reducing the sensors and by replacing the expensive CPU, the vehicle can be affordable to normal people and hence autonomous vehicles are going to be the vehicles of future. Thus, we are able to build an autonomous vehicle that not only work like any other autonomous vehicle, but also with less expense.

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