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Autonomous Car with Optimized Dynamic Range using Machine Learning: A Review

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Abstract: In this paper, we have done a comprehensive study of the technology and algorithms that are used in self-driving autonomous cars. We have discussed how machine learning models and artificial intelligence play a crucial role in these vehicles. With the automobile technology booming with the increase in people's standard of living, delivering an efficient and cost-effective self-driving module is the need of the hour. We have also mentioned the importance of the dynamic range of the optical sensors that are popularly used in self-driving cars. There are two ways to increase the dynamic range of the sensors which are mentioned in the topics below. Accordingly, as the level of automation in cars increases, a network of autonomous cars will be groundbreaking as the cars will be able to communicate and share essential information which can help them to learn and analyze different situations. We have also discussed how a smart city can have this ability to make the day to day operations more efficient. Lastly, we have mentioned the technical challenges that are faced and will be faced by autonomous cars.

Keywords: Machine Learning, Dynamic Range, Automation level, Sensors, Smart City, Connected Cars

I. INTRODUCTION

The full driving exercise is too unpredictable a movement to be completely formalized as a sense-acting mechanical autonomy framework that can be unequivocally settled through model-based and learning-based methods to deal with accomplishing fully compelled vehicle self-governance. This is true for unconstrained, real word operation where the number of edge cases is extremely large, and allowable error is extremely small. The belief that people are poor drivers is all around archived in mainstream society since we are now and again diverted, tired, alcoholic, sedated, and irrational. Today, the issues of geopositioning, trajectory augmentation, and more significant level choices stay loaded with open difficulties to be completely tackled by the frameworks consolidated to a production stage. A lot of intelligence is required to understand the world of predictable but irrational humans. The aftereffect of utilizing profound learning-based automated annotation is that it can dissect the driving which allows the coordination of complex interactions with a human's viewpoint. The improved dynamic range of the sensors can add more to record and observe the real-world dynamics. Keeping the data loss to a minimum, the data collected will be run through the machine learning model to make the swift edge cut decisions that the drivers experience in real life. The ultimate goal is to make fully autonomous vehicles that can make their own decisions and do not require any supervision from the driver. Additionally, with an increase in these "intelligent vehicles", it is possible to build a network along with these individual vehicles which in turn will create an information network to be utilized for progressive measures. Now, when we add so much to the system of existing vehicles, there are bound to be challenges and obstacles in implementing such diverse and advanced technology. We have also discussed those challenges in this paper. We will now discuss the various topics that constitute building the desired self-driving cars.

II. REVIEW OF LITERATURE

The First Step towards shaping the modern automated driving system began in the 1920s. Houdina Radio Control exhibited the radio-controlled vehicle, called Linriccan Wonder[1] which was a 1926 Chandler comprising of a transmitting antenna on its back compartment. Radio bursts sent by another vehicle tailing it was received by the transmitting antennas to circuit breakers which controlled the vehicle's motion using electric engines. Japan's Tsukuba Mechanical Engineering Laboratory built up the first semi-autonomous vehicle in 1977, the vehicle attained speeds up to 30 kmph (19mph) which had two cameras on it and an analog computer which deciphered specifically tagged streets. Ernst Dickmanns, a German Pioneer, bought a Mercedes van in the 1980s to travel many miles autonomously on roadways, a gigantic accomplishment particularly with the processing ability of the time.

United States Defense Advanced Research Projects Agency (DARPA) [2], in the mid-2000s, sorted out Grand Challenges where groups assembled to contend with self-driving vehicles. The Self Driving car venture of Google began in 2009, including different aides who effectively contributed to the innovation which took years.

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By 2012, Google car hits the road for testing which was further developed and modified with Global Positioning System (GPS), multiple sensors, lasers, radars that use heavily detailed maps and features to navigate itself with no human interaction. Cameras are used to detect and find objects which are further processed by the computer in it, the car has the capability of getting parked on its own and can go on freeways. In 2015, Navlab's accomplishment stood unparalleled, when Delphi extemporized it by guiding an Audi, with Delphi innovation which drove more than 5472 kilometers staying in the autonomous mode for almost 100% of the time through 15 states in the US.

Over the past recent years, there has been rapid progress in technology for the development of Advanced Driver Assistance Systems (ADAS). These new types of vehicles are expected to improve safety, efficiency, sustainability, and comfort. However, automated or autonomous cars bring new technical and non-technical challenges that have to be addressed to ensure safe adoption of these new types of cars. We studied over 20 technical papers looking for the relevant information, the past attempts that were made in developing autonomous cars, the algorithms that were used in machine learning, and the resulting outcome of such attempts. Out of which we have referred the most relevant and appropriate ones. The technology and the methods used in these attempts reflect their greatest achievements and their failures as well from which we can rectify ourselves and get a better understanding of the development of these self-driving vehicles.

III.MACHINE LEARNING

Machine learning has progressed rapidly over the years, and machine learning algorithms have now achieved human-level accuracy, even superior to humans in several tasks, including facial recognition, optical character recognition, and object recognition. Data analysis, search algorithms, self-driving vehicles are for the most part subject to different AI calculations that decipher their contributions to give astute yields that guide the dynamic procedure of automated frameworks [3].

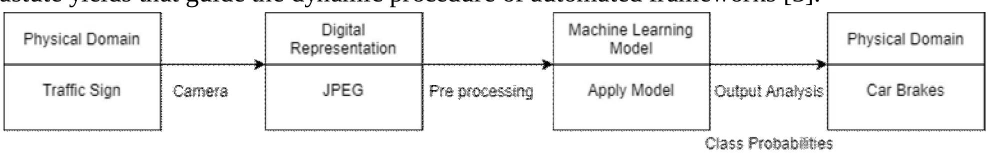

Fig. 1 Machine Learning Pipeline

Machine learning models are generally utilized as a component of a data pipeline. The inputs to the model are obtained from an array of preprocessing phases, and outputs of the model are then used to decide the later stages of the complete system. For example, a traffic-sign classifier could be set up in an autonomous vehicle. The model would be given inputs in the form of pictures from a camera surveying the road and coalesced with a detection mechanism for traffic signs. The class anticipated by the machine learning model could then be used to determine the action to be taken by the automobile (such as coming to a stop if the traffic sign is classified as a "STOP" sign) [3]. The Machine Learning Algorithms can be classified as shown below:

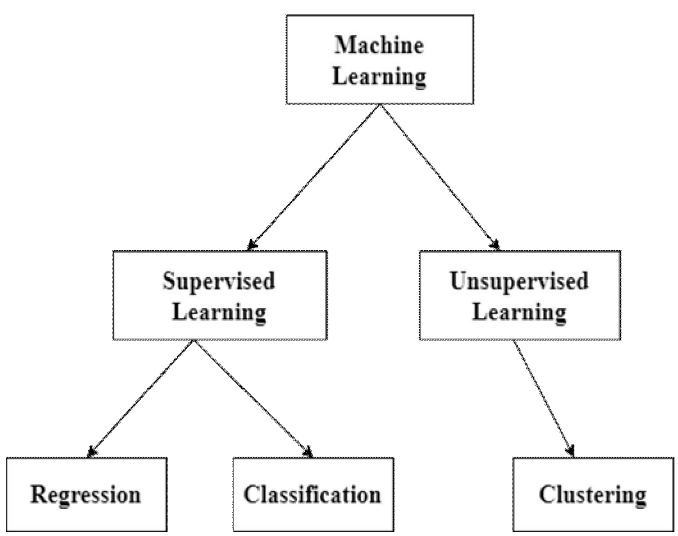

Fig. 2 Classification of Machine Learning Algorithms.

A. Supervised Learning

These algorithms use predetermined training data-set to learn. They continue learning until they arrive at the desired level that guarantees negligible errors. Supervised ML algorithms can furthermore be assorted into Regression and Classification algorithms [4].

1) *Regression:* Regression algorithms utilize the monotonous aspects of the environment to set up a factual model of the connection between a specific image and the situation of a specific object within the image. The statistical model can provide prompt online detection of the object by the process of image sampling. Gradually, it can be developed to identify other objects as well, without involving any human intervention. Regression analysis essentially relies on three core metrics:

a) The total number of independent variables
b) The nature of dependent variables
c) The shape of the regression line

2) *Classification:* Classification is the means of categorizing some unknown items or objects into a discrete set of categories or "classes". It learns the relationship between a set of feature variables and the target variable. Classification determines the class label for an unlabeled test case for a given set of training data points along with the target labels. They are also referred to as Pattern Recognition Algorithm. Usually, the pictures acquired from the Advanced Driver-Assistance Systems (ADAS) are loaded with information from the surroundings. This data is filtered using pattern recognition algorithms or data reduction algorithm. Pattern recognition algorithms are designed to eliminate unwanted data points. These algorithms help in refining the data obtained from the sensors. Because of this feature, this algorithm is also called a data reduction algorithm. Pattern Recognition Algorithm also supports:

a) Support Vector Machines
b) Discriminant Analysis
c) Bayes Decision Rule
d) Neural Networks
e) Histogram of Oriented gradients
f) K-nearest neighbor

B. Unsupervised Learning

These algorithms learn by understanding the current information. No predetermined training datasets are utilized here. They attempt to discover identifiable patterns within the dataset and afterward separate them into classes/groups as per the degree of similarity between them. Clustering is a type of unsupervised ML algorithm [4].

1) *Clustering:* Cluster algorithms are exceptional at discovering the structure of the object from data points. It is possible that the images acquired by the ADAS are blurry, or it may also occur that an object is not identified correctly, thereby failing to classify the object. Clustering algorithms are used in such scenarios. Generally, clustering techniques are based on hierarchical modeling and centroid based approaches. All clustering techniques focus on arranging basic structures in the data into groups having the highest commonality. K-means and multi-class neural networks are the two most commonly used clustering algorithms for autonomous cars. Automobiles get into many different situations on the road. The drivers need to be sure that the autonomous cars can handle any situation before entrusting their lives to these cars. An automobile can't be restricted to dealing with a few basic situations. The vehicle has to understand and adapt to the constantly changing behavior of the other vehicles on the road. Machine learning algorithms make autonomous vehicles efficient in making decisions in real-time. This makes the vehicle safe and trustworthy.

C. Machine Learning Algorithms

Many algorithms are trained for self-driving cars developed by different companies and start-ups for their ventures. They mostly implement a basic framework. Some of them are discussed below.

1) *Scale Invariant Feature Transform (SIFT):* Scale-invariant feature transform (SIFT) algorithm allows image matching and object recognition for partially visible objects. The algorithm uses an image database to derive key points of the objects. These are the features of the object that don't change with scaling, rotation, or noise. The algorithm compares every new image of the object with the SIFT features that are already stored in the image database [5]. It detects similarities between them to identify the objects.

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2) *AdaBoost:* AdaBoost is a decision matrix algorithm that takes the output of regression and classification algorithms and examines how their performance correlates to successful predictions [6]. AdaBoost fuses the performance of numerous algorithms so they work together and perfect each other. It's particularly useful for face and vehicle detection.
3) *TextonBoost:* TextonBoost extends image recognition based on the labeling of groups of visual data that have identical characteristics and respond to filters in the same style. These groups are called as Textons. TextonBoost combines data from appearance, shape, and context [7]. It's excellent because individually these parameters may not lead to correct outcomes. TextonBoost incorporates several classifiers to give the most accurate object recognition.
4) *Histogram of oriented gradients (HOG):* Histogram of oriented gradients (HOG) is one of the most primitive machine learning algorithms for autonomous driving and computer vision. HOG represents images as a distribution of intensity. It develops a coded and compressed version of an image, which is an image gradient [8]. Autonomous vehicles benefit from HOG because it plays a vital role in image recognition. HOG performs excellently at human detection. This region is precarious for self-driving vehicles on account of the various appearances of individuals. Strikingly, the HOG algorithm settles this issue for self-driving cars.
5) *You Only Look Once (YOLO):* YOLO (You Only Look Once) is an algorithm used for categorizing objects into various categories like cars, trees, people, etc. YOLO examines the entire image and then divides it into segments. The algorithm then comes up with bounding boxes and predictions for each segment [9]. It applies network evaluation only once as it deals with each prediction in the context of the whole image. The accuracy and speed of YOLO are much more than HOG. It guarantees quick processing and response of the vehicle in real-world scenarios.

The fate of the automobile industry will be controlled by machine learning and autonomous vehicles. And they're a perfect match. There are a lot of machine learning algorithms that are yet to be discovered to use them in autonomous cars for perception and decision-making. For example, machine learning can be used for autonomous navigation and identifying the state of the driver.

IV. LEVELS OF AUTOMATION

SAE International known as the Society of Automotive Engineers classified the automation system into six levels. In SAE's automation level "driving mode" is when the machine drives the vehicle in such a scenario which follows dynamic driving task requirements those dynamic driving tasks can be a low-speed traffic jam, parallel parking, etc[10, 11].

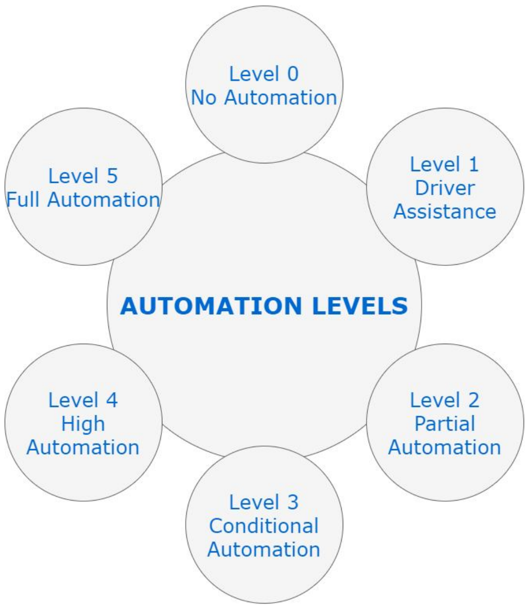

Fig. 3 Levels of Automation

A. Level 0: No Automation

Here your vehicle has no control over your journey. The driver is responsible for his or her driving. Here the vehicle can give a particular warning, but even then the human is the sole controller of the vehicle. Hence it is called no automation. Stage 0 is typically every motor vehicle out there with no control system.

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B. Level 1:Driver Assistance

Here the vehicle's control is shared between the driver and the automated system. Here the driver has to stay focused to take complete supervision of the vehicle anytime. Level 1 automation is common nowadays in the new optimized vehicle where the vehicle has features such as Cruise Control where the steering is controlled by the driver and the speed is controlled by the automated system. One more new feature that we can find in new vehicles is Parking Assistance here the speed is manually controlled by the driver and the steering is automated. Hence Level 1 automation is also called "Hands-On" Automation.

C. Level 2:Partial Automation

Here the vehicle's control is fully managed by the automated system. That means the system controls braking, acceleration, and steering. The driver will sit still during the journey but he or she has to have his or her full attention throughout the journey, as the driver has to intervene immediately if the automated system fails to respond in some way or the other. Here the system might monitor the eyes throughout the journey to ensure the driver is having proper attention over the traffic. As the driver can sit freely without the control of the vehicle during the journey hence it is called "Hands Off" Automation. The Autopilot system in Tesla comes under Level 2 Automation.

D. Level 3:Conditional Automation

Here the automation system controls the vehicle just like the Level 2 Automation but here the driver is not supposed to watch the drive throughout the journey. Hence the driver can read a book or text in their mobile or could make a call if they wish. But like Level 2 here the driver is not fully free, even though he or she can take their eyes off during their journey, they still have to be prepared if the automated system fails. Hence it is also called "Eyes Off" Automation.

E. Level 4:High Automation

Level 4 automation enables the automation system to fully control the vehicle irrespective of whether the driver is giving any attention. Hence a driver can sleep and still there will be a safe and efficient journey that can be achieved. This kind of Automation is known as "Mind Off" Automation. Here the vehicle can perform this in limited areas

F. Level 5:Full Automation

Level 5 Automation is a milestone if achieved we can have an efficient Autonomous Car journey. Level 5 is similar to Level 4 but here the vehicles can transport under all roadways and the environmental condition that can be managed by a human driver.

TABLE I
Levels Of Automation

<table>
<tr><th>SAE Level</th><th>Name</th><th>Execution Of The Vehicle</th><th>Monitoring Of Driving Environment</th><th>Backup</th></tr>
<tr><td>0</td><td>No Automation</td><td>Human Driver</td><td rowspan="3">Human Driver</td><td rowspan="3">Human Driver</td></tr>
<tr><td>1</td><td>Driver Assistance</td><td>Human Driver and System</td></tr>
<tr><td>2</td><td>Partial Assistance</td><td>System</td></tr>
<tr><td>3</td><td>Conditional Automation</td><td rowspan="3">System</td><td rowspan="3">System</td><td>Human Driver</td></tr>
<tr><td>4</td><td>High Automation</td><td rowspan="2">System</td></tr>
<tr><td>5</td><td>Full Automation</td></tr>
</table>

V. TYPES OF SENSORS

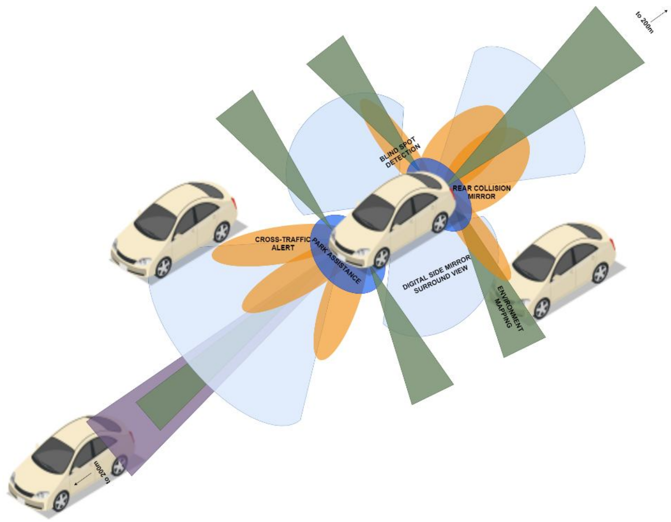

Fig. 4 Types of Sensors

A. Camera

Most of the data for the human driver is provided by video images. Additionally, they are also used as input parameters for highly automated driving. The back and 360° cameras present the driver with a superior portrayal of the environmental factors outside the vehicle. Nowadays, two-dimensional cameras are extensively used to display pictures and occasionally superimpose additional data on the display like the steering wheel angle. For the appropriate representation of the three-dimensional image, the input signals from four to six cameras are required, and to avoid data loss or formation of ‘ghost images’, it is necessary to take into attention the 'image stitching'. Both 2-D and 3-D cameras need image sensors with a very high dynamic range greater than 130 dB. Such a large dynamic range is crucial to produce a clear image even with sunlight directly hitting the lens.

Nowadays, automobile rear and 360° video systems commonly have a centralized architecture. The processor faces tough requirements as the processing is done in software. Additional FPGAs are necessary for specific hardware acceleration, which causes a high power loss. Modern data compression techniques need a large amount of storage.

Front aligned Camera Systems are medium to high range systems, somewhere in the range of 100 and 275 yards. These cameras utilize the algorithms to consequently recognize objects, characterize them, and figure the distance from them. For instance, the cameras can recognize people on foot, cyclists, vehicles, bridges, street edges, traffic signs, and signals. Medium range cameras caution the driver about traffic, walkers, crisis emergency braking in the vehicle ahead, just as street and signal light recognition. High range cameras are used for traffic sign recognition, distance control, and road guidance.Since the immediate raw information of the optical sensor is utilized, color-accurate signal generation is not described for these camera systems[12]. A color filter with an RCCC (Red Clear Clear Clear) matrix is used, which provides a better light intensity than the traditional RGB filter (Red Green Blue) used in most of the cameras. 'Red Clear Clear Clear' indicates a pixel with a red color filter and three with a neutral (clear) filter. The major difference between medium and high range cameras is the aperture angle of the lenses or field of view (FoV). For medium-range frameworks, a horizontal FoV of 70 ° to 120 ° is utilized, while cameras with a wide scope of aperture utilize horizontal edges of around 35°.

B. LiDAR

LiDAR represents Light Detection and Ranging. It is a laser-based framework. The framework requires a laser transmitter and a profoundly susceptible receiver. The main purpose of this system is to measure distances of moving as well as stationary objects. It enforces special modes to provide 3-D images of the detected objects [13].

A driver assistance system has to ensure that it will function under any environmental conditions (sunlight, darkness, rain, snow) and mainly, detect objects up to 300 yards away. Along with this, large-scale production at the lowest possible cost and scaled down to the smallest possible dimensions should be possible. Lidar systems have been used in industry and the military for many years. Since they are very expensive, it is not feasible for large-scale deployment of these systems in the automotive sector.

C. RADAR

RADAR represents Radio Detection and Ranging, which means object recognition with the help of radio waves. Present-day radar systems are either established on 24 GHz or 77 GHz. The 77 GHz system has higher accuracy for distance and speed measurements. It also has a precise angular resolution. Another advantage of the 77 Ghz system is that the antenna size is smaller and interference between signals is less. SRR (Short-range radar) and MRR/LRR (mid-range radar/long-range radar) are the various sorts of radar.

1) Short-range radio applications incorporate Vulnerable Blind Spots, the Lane-change assistant, Parking Assist, Cross-traffic observing, Crash cautioning, or Impact evasion.
2) Mid-range radar/ long-range radar applications are Brake Assist, Emergency braking, Automatic distance control.

D. Ultrasonic Sensor

An ultrasonic sensor is an electronic gadget with the assistance of which we can determine the separation of target by transmitting ultrasonic sound waves and convert the reproduced sound into an electrical pulse [14]. Ultrasonic sensors have two fundamental parts: the transmitter (which will produce the ultrasonic sound utilizing piezoelectric gems) and the receiver (which will experience the sound after it has gone to and from the object). Ultrasonic sensors being cheap, they have been utilized in vehicles since the 1990s as parking sensors.

Their range can be constrained to only a couple of meters, yet they are perfect for giving increased detecting competence to help low-speed use cases. Ultrasonic sensors can be used in self-parking technologies, anti-collision safety systems, and obstacle detection systems.

VI. DYNAMIC RANGE

Traditionally, the criteria for selecting a suitable optical camera for automotive sensors was the frame rate(speed) and the resolution of the camera but to tackle the real-world problems, Sensitivity and Dynamic Range are becoming essential.

The amount of variation in the brightness in the real-world could benefit from the advantages of cameras having a wide dynamic range.

For instance, a car coming out of a tunnel will have a substantial variation in the brightness. A camera/sensor with a low dynamic range will not be able to acquire the details due to under or overexposed images, which means data loss. As the autonomous system in the car that depends on this information, it could be disastrous. It is clear that we have to increase the dynamic range of cameras to avoid such circumstances [15].

There are two methods to contrive this. One is the hardware enhancements to the sensors to increase the dynamic range and effectively scaling down the stress on software due to processing. The second method is to use software algorithms to ameliorate the collected data which can be applied to the existing hardware.

A. Hardware Approach

In a CMOS Sensor, the number of electrons a sensor’s pixels can hold, until saturation, determines the sensor’s dynamic range. The dark noise of the pixel which is the noise that appears when examining the charge also contributes to the overall dynamic range. If we have to increase the dynamic range, we have to minimize the dark noise or maximize the saturation capacity. The dark noise reception of a sensor depends on the electronics used in the sensor.

However, we can increase the saturation capacity by increasing the pixel size thereby increasing the exposure to a larger number of photons and achieving abundant charge[16]. We can also increase the saturation capacity by inherently improving the pixel structure. Such an example of the increased dynamic range sensor is the Sony Pregius sensor. They have made enhancements in the pixel structure which leads to a phenomenal reduction in dark noise. To properly quantize this enlarged dynamic range, it delivers a 12-bit quantized signal as opposed to the traditional 8-bit signal.

B. Software Approach

The dynamic range can also be increased using different software algorithms. The main advantage of algorithmically increasing the dynamic range is it can be applied to the existing hardware rather than replacing valuable and expensive hardware sensors on the car. The most popular approach to increase the dynamic range is using time-varying exposures which essentially means getting images with different exposure durations as a data basis [16].

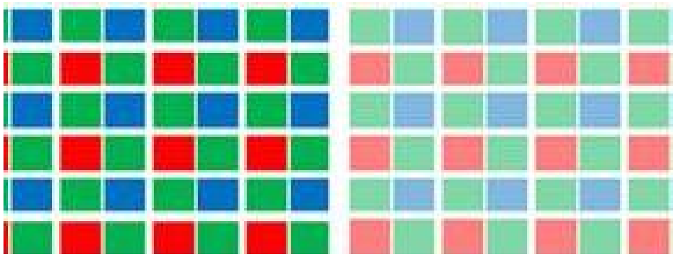

Fig. 5 Time-Varying Exposure

These images are stitched together by the software which gives a complete reference of the actual data. This process is used in many smartphones, photography, and image processing programs as well. The pixel value of the sensor is dependant on the amount and energy of the incident light as well as the exposure time. Thus the energy of the incident light for a particular exposure time can be calculated by the pixel value. We can know about the quantity of light over a large area without any resolution loss. However, the problem with multiple exposure times is that it leads to undesirable artifacts especially in our case of autonomous cars. This is called ghosting

To avoid ghosting, “Spatially Varying Exposure” technology is used. This procedure exposes certain pixels for a longer duration to get an optimized image. Customarily, a typical strategy is to expose two picture lines utilizing exchanging exposure times however there is no 1:1 correspondence of the captured pixels which likewise contributes to the loss of goal.

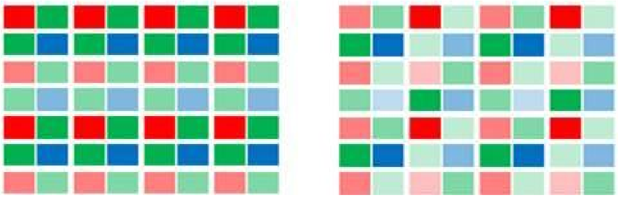

Fig. 6 Spatially Varying Exposure using 2 lines and Spatially Varying Exposure using different pixel exposures

Thus by using high dynamic range sensors the real-world challenges can be efficiently tackled by creating a well-furnished dataset depicting the problems that were not addressed before and training the Machine Learning and AI modules accordingly. Thereby increasing the adaptability and performance of autonomous cars

VII. TESTING

In the last decade, there has been a commodious development in automated driving technology. Since the DARPA[1] Challenge of 2006, many industrial companies and Tech companies have tested their autonomous cars which have encouraged many manufacturers. We will recapitulate the state-of-the-art Autonomous Driving Systems tested and analyze the most viable substitute which counters the real-world challenges and prove to be beneficial for society. As the advancement of self-driving vehicles rises at a fast clasp, various organizations have expressed their intent to market and sell self-driving cars. In any case, there's beginning to be a contrast between those organizations that are just "talking the talk" and those that are testing their vehicles on open streets. Some of the companies are mentioned below

A. Google parent Alphabet's Waymo auxiliary is by a wide margin in front of other organizations as estimated by the number of vehicles working, the number of kilometers driven (32 million in reality and over 16 billion in testing), and the advancement of its innovation. Along with cameras, it also uses LiDAR and RADAR sensors. It also integrates a microphone to detect sirens from emergency services. At present, Waymo functions a fleet of Society of Automotive Engineers (SAE) Autonomy level 4 Robo-Taxis in Phoenix, Arizona most of which have a backup driver. Prototype testing of completely driverless with SAE Autonomy of Level 5 is also taking place simultaneously.

B. General Motors’ Cruise division has the world’s second-biggest self-driving line—180 vehicles— going through testing; up until this point, they’ve driven more than 1 million miles. The heritage of General Motor’s has given it a headstart over other tech companies like Apple which have a very little experience of the real-world challenges

C. Ford’s Argo AI startup has tested over 100 of its self-driving vehicles in six cities in the USA. Unlike Alphabet’s Waymo or General Motor’s, ArgoAI intends to produce self-driving technology for other automobile companies.

D. Tesla has a greater number of automated vehicles on the roads than any other manufacturer. Tesla uses ultrasonic sensors, 2D camera sensors for automation in its cars whereas LiDAR is the most popular and efficient technology used. Tesla was able to get more than 600,000 Tesla production vehicles worldwide and is still increasing that number, altogether having driven more than 3.2 billion kilometers. Tesla started from SAE Level 2 autonomy and is building up to Level 5 in prototypes which are believed to be rolled out at the end of 2020.

E. China's Baidu has more than 300 autonomous vehicles on the streets of China. Like Google's Waymo, Baidu started as a search engine and branched out to other industries. It likewise plans to turn out Robo-Cabs in China. Till date, Baidu's Autonomous Cars have covered more than 3 million kilometers in 23 cities of China

Besides the above-mentioned companies, other players which have participated in the autonomous cars race are Apple, Daimler, Audi, Lyft, BMW and Uber. Many tech startups are also inclined towards this field like Zoox, Nuro, Aptiv, Autox, and DiDi.

VIII. SMART CITY

A smart city is an urban city that is much more efficient and convenient for the people of the society. Here the city is said to be a smart city if the Internet of Things sensors are used to collect data. The information that we get from the data is used to manage assets and services efficiency, in return, the data is used to improve society[17]. In smart cities, the innovations that are utilized are the Internet of Things sensors, Big Data frameworks, and Mobility as a Service (MaaS) platforms. An important aspect of this infrastructure is the connected car[17].

A. Connected Cars

A connected car is a vehicle that enables communication which will access to Internet and Wireless Local Area Networks (WLAN). Connectivity hear means a communication channel between the vehicles and their surroundings, through ad hoc networks and advanced management systems. Thus a connected vehicle is a vehicle that can "talk" to different vehicles, street sensors, traffic structures, and different systems. The transmission of the information is done through a connected car network and used for remote diagnostics, telematics, informant, and parking allocation.

B. Technology-Enabled Connected Cars

Four main technologies used for the connection of connected cars:

1) *Connectivity, 5G, and DSRC:* Cars get access to the internet by connecting it to 4G LTE and WiFi, which enables sharing and receiving data from other networks. Internet connectivity can be increased by using a 5G once it gets fully developed. Direct ShortRange Communication encourages vehicles to impart data to one another to forestall any mishaps, streamline routes, and improve wellbeing.
2) *Autonomous driving and computer vision:* With the help of Artificial Intelligence (AI) the driver gets a flood of information on how to operate a vehicle. Drivers working semi-autonomous vehicles with the assistance of AI can show the vehicle how to drive securely, and AI is growing completely self-driving vehicles.
3) *Telematics:* Telematics system collects, stores, monitors, and analyzes the information collected by sensors, networks, programs, vehicles, and the driver. Telematics screens the driver's behavior and examines vehicle diagnostics for smart upkeep.
4) *Cloud platforms:* Connected cars use technologies such as hardware, data management, and IoT. Platforms as a Service (PaaS) for example, Pivotal and Location World fill in as the reason for modifying the innovation answer for the demand of the connected vehicle. PaaS platforms can aid all product lifecycle stages, from improvement to CRM management and billing.

C. Types of Connectivity

A vehicle can interface with and speak with its environmental factors in different manners. The primary models of communication include:

1) *Vehicle-to-Infrastructure (V2I):* Here vehicles and street frameworks are empowered to correspond through the specially appointed system. Street frameworks oversee data from RFID readers and cameras, traffic signals, streetlights, and parking meters
2) *Vehicle-to-vehicle (V2V):* Here vehicles are interconnected with a network forming a channel, so they can exchange information about their direction, speed, location, and information. Vehicles rigged with V2V communication and security applications have a 360-degree perspective on different vehicles and can anticipate risk and notify the driver.

3) *Vehicle-to-Pedestrian (V2P):* Alarms vehicles and drivers of pedestrian proximity, and the other way around. For instance, forward collision warning & blind-spot gives in-vehicle alarms about objects and individuals around the vehicle. The Mobile Accessible Pedestrian Signal System lets people on foot with sight impairment alert close by drivers of their propinquity.
4) *Vehicle-to-X (V2X):* Vehicle-to-everything: Makes a smart vehicle system by joining distinctive communication types, for example, V2I, V2P and V2V. The platforms build an administration system that gives precise traffic data and empowers streamlining for better routes, low CO2 discharge, and fewer vehicle mishaps.

D. Connected Cars in Smart City

Information and Communication Technology (ICT) and the Internet of Things (IoT) developments are essential for arranging and keeping up the smart city transport framework. A network of sensors, applications, devices, and services, supports car connectivity. IoT gadgets enable urban communities to frame a smart, consolidated mobility framework to improve gridlock, energy utilization, and vehicle security [17].

In smart cities, connected vehicles can combine with the state-of-the-art traffic administration system to make a consistent driving experience for daily travelers. The data about roads, pedestrians, surrounding vehicles, and cyclists are collected by connected cars and shared in real-time. Smart cities can utilize this data to give people improved transportation administrations, for example, active accident response, traffic optimization, and re-routing drivers. To empower self-driving cars, the innovation behind associated vehicles has created [17].

IX. TECHNICAL CHALLENGES

There are various frameworks that help the person driving the vehicle to control it. Frameworks that need improvement incorporate the vehicle route framework, the area framework, the electronic guide, the guide coordinating, the worldwide way arranging, the earth discernment, the laser recognition, the radar observation, the visual recognition, the vehicle control, the impression of vehicle speed and course, and the vehicle control method. The test for driverless vehicle originators is to create control frameworks equipped for breaking down tangible information to give precise discovery of different vehicles and the street ahead. Control frameworks on mechanized vehicles may utilize Sensor Combination, which is a methodology that coordinates data from an assortment of sensors on the vehicle to create a progressively steady, precise, and helpful perspective on the environment. Substantial precipitation, hail, or snow could block the vehicle sensors.

Driverless vehicles require some type of machine vision with the end goal of visual item acknowledgment. Robotized vehicles are being created with profound neural networks, a kind of profound learning design with numerous computational stages, or levels, in which neurons are recreated from the condition that enacts the network. The neural system relies upon a broad measure of information removed from genuine driving scenarios, empowering the neural system to "realize" how to execute the best course of action [3][18].

Most Machine learning models are structured, in any event halfway, in light of the suspicion that the information at test time is drawn from a similar conveyance as the preparation information, a presumption that is frequently abused. It is normal for the exactness of the model to corrupt because of some generally favourable change in the conveyance of test information. For instance, if a diverse camera is utilized at test time from the one used to gather preparing pictures, the prepared model probably won't function admirably on the test pictures. Significantly, this marvel can be misused by adversaries fit for controlling contributions before they are introduced to the Machine learning model. The adversary inspiration for "controlling" the model's conduct along these lines originates from the ramifications of AI forecasts on ensuing strides of the information pipeline. In our running case of an independent vehicle, an enemy prepared to make STOP signs named “yield” signs may make the self-driving vehicle resist transit regulations and conceivably cause a mishap.

Increasing dynamic range by using advanced hardware can be very efficient and straight forward from a programming point of view, but it increases the cost of the hardware enhancements which effectively increases the cost of the car. Due to an increase in dynamic range, it can require a lot of processing power and thus increasing load on the main processor [16].

Connected cars create a seamless driving experience for commuters by pairing with advanced traffic management systems. Connected vehicles gather and offer ongoing information about streets, pedestrians, surrounding vehicles, and cyclists. To provide improved transportation services, such as efficient incident response, traffic optimization, and re-routing citizens, Smart cities can use this information.

The connected car is exposed more to attack, as car manufacturers integrate to more networks. Similar risks are communicated by semi-autonomous vehicles with V2V and V2I frameworks [17].

X. CONCLUSION

The rapid growth of autonomous cars has brought the need to increase autonomy and also ensure the safety of the driver in real-world problems. The improbable and unpredictive nature of the surrounding environment makes the idea of a fully autonomous car nothing more than just a sheer illusion or a distant possibility. However, it can be achieved by an assured system with negligible data loss.

This review attempts on shedding some light on the issues about achieving total autonomy and the challenges faced in doing so. The various machine algorithms discussed gives us the option to choose which might be efficient and can be implemented on a large scale with maximum accuracy.

This will play a major role in increasing the level of automation in the existing system. The process for building a self-driving car starts right from choosing the correct data source it will be learning from. But it is equally important to have the appropriate sensors which collect the data on which these machine learning models are implemented. By ensuring minimal data loss, self-driving cars can be more adaptable and decisive for cutting through the sharp edges of reality. Optimization of the dynamic range of sensors on which our capable machine learning models depend on is the next step towards achieving the goal of increased autonomy. This paper discusses the methods to increase the aforementioned issue of dynamic range by minimizing the cost of those implementations.

There are still other ways than the ones discussed above to enhance the dynamic range of sensors. Self-driving cars can be the greatest boon in creating a smart city that was just a vision. This review paper discusses all the issues in modern self-driving cars and how they can be overcome to some extent.

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REFERENCES

[1] K. Bimbraw, "Autonomous cars: Past, present and future a review of the developments in the last century, the present scenario and the expected future of autonomous vehicle technology," 2015 12th International Conference on Informatics in Control, Automation and Robotics (ICINCO), Colmar, 2015, pp. 191-198.

[2] L. Fridman et al., "MIT Advanced Vehicle Technology Study: Large-Scale Naturalistic Driving Study of Driver Behavior and Interaction with Automation," in IEEE Access, vol. 7, 2019

[3] Ian Goodfellow, Patrick McDaniel, Nicolas Papernot, “Making machine learning robust against adversarial inputs,” Communications of the ACM Volume 61, Number 7 (2018).

[4] Williams, Nigel & Zander, Sebastian & Armitage, Grenville, “A preliminary performance comparison of five machine learning algorithms for practical IP traffic flow classification.” Computer Communication Review. 36. 5-16 (2006).

[5] David Lowe, “Method And Apparatus For Identifying Scale Invariant Features In An Image And Use Of Same For Locating An Object In An Image”, U. S. Patent 6711293, March 23, 2004.

[6] Ruihu Wang, “AdaBoost for Feature Selection, Classification and Its Relation with SVM, A Review”, Physics Procedia, Volume 25, 2012.

[7] Shotton, Jamie & Winn, John & Rother, Carsten & Criminisi, Antonio, “TextonBoost for Image Understanding: Multi-Class Object Recognition and Segmentation by Jointly Modeling Texture, Layout, and Context”, International Journal of Computer Vision 81. 2-23, Jan. 23, 2009.

[8] Forczmański, Paweł & Markiewicz, Andrzej, “Two-stage approach to extracting visual objects from paper documents. Machine Vision and Applications”, Machine Vision and Applications, August 2016.

[9] Corovic, Aleksa & Ilic, Velibor & Đurić, Siniša & Marijan, Mališa & Pavkovic, Bogdan, “The Real-Time Detection of Traffic Participants Using YOLO Algorithm”, November 2018.

[10] Bagloee, Saeed & Tavana, Madjid & Asadi, Mohsen & Oliver, Tracey, “Autonomous Vehicles: Challenges, Opportunities and Future Implications for Transportation Policies,” Journal of Modern Transportation, 24. 284-303, August (2016).

[11] Inagaki, T., Sheridan, T.B., “A critique of the SAE conditional driving automation definition, and analyses of options for improvement,” Cogn Tech Work 21, 569–578 (2019).

[12] Francisca Rosique, Pedro J. Navarro, Carlos Fernández and Antonio Padilla, “A Systematic Review of Perception System and Simulators for Autonomous Vehicles Research”, Perception Sensors for Road Applications, Feb. 5, 2019.

[13] Daniel Gruver, Pierre-Yves Droz, Gaetan Pennecot, Anthony Levandowski, Drew Eugene Ulrich, Zachary Morriss, Luke Wachter, Dorel Ionut Iordache, Rahim Pardhan, William McCann, Bernard Fidric, Samuel William Lenius, "Vehicle with multiple light detection and ranging devices (LIDARs)," United States Patent Gruver et al., Patent No.: US 9.625,582 B2, Date of Patent: Apr. 18, 2017.
[14] Xu, Wenyuan & Yan, Chen & Jia, Weibin & Ji, Xiaoyu & Liu, Jianhao, "Analyzing and Enhancing the Security of Ultrasonic Sensors for Autonomous Vehicles," IEEE Internet of Things Journal (2018).
[15] S. Nuske, J. Roberts and G. Wyeth, "Extending the dynamic range of robotic vision," Proceedings 2006 IEEE International Conference on Robotics and Automation, 2006. ICRA 2006., Orlando, FL, 2006, pp. 162-167,(2006).
[16] Zhiyong Pan, Mei Yu, Gangyi Jiang, Haiyong Xu, Zongju Peng, Fen Chen, "Multi-exposure high dynamic range imaging with informative content enhanced network," Neurocomputing, Volume 386, 21 April 2020.
[17] H. Samih," Smart cities and internet of things", Journal of Information Technology Case and Application Research,Volume 21, NO. 1, 3–12, 02 April 2019.
[18] Mengnan Du, Ninghao Liu, Xia Hu, "Techniques for interpretable machine learning," Communications of the ACM, Volume 63, Number 1 (2020).