WWW.IJRPR.COM

International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

AUTONOMOUS ELECTRIC VEHICLES

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ABSTRACT

Autonomous Electric Vehicles run with a suite of sensors such as Camera, Radar and LiDAR. These are the market leading technologies that is present in present AEVs. This report describes how with sensor fusion the AEVs function.

I propose three points in this Use of thermal cameras, Solid state batteries and shed light on Govt. policy to support AEVs.

AEVs applications in present scenario will be discussed along with various intelligent application proposals where AEVs fit in perfectly.

1. INTRODUCTION

An An EV is a vehicle that uses electric motors for propulsion instead of internal combustion engines used in conventional vehicles. As such, EVs have batteries instead of fuel tanks. EVs are popular for three reasons. First and foremost they drastically reduce the Green House Gases emissions. This can be taken a step further if the energy is generated from renewable sources. Second is the running cost of EVs. [1]Their running cost can be four to seven times lesser than combustion engine vehicles. On comparing an EV (Mahindra e2o plus) to a traditional ICE(Internal Combustion Engine) car, the monthly expenditure of EV comes at Rs.1,095, whereas ICE car comes at a whopping Rs. 7,710.9, which is more than 7 times. Third is the energy dependency goal of a nation. Most nations including India depend on imported oil. Mobility and transportation play a major in the economy of a nation. But when the fuel used is imported from other nations then it defeats the purpose of improving the economy.

Autonomous and electric vehicles are two technologies that blend perfectly with each other. There are a plethora of reasons as to why these technologies should be implemented on a wide scale. There's no doubt that the future is electric. Electric vehicles simply are the evolved and apex version of all vehicles. An electric vehicle is already so advanced that it needs no retrofitting, add to that the autonomous feature and its possibilities become endless.

A future where all vehicles are autonomous EVs is what I'm proposing for. So in that context, an AV is a vehicle that can steer, accelerate and control itself without a human behind the wheels. [2]According to Society of Automotive Engineers (SAE) international there are six levels of automation for cars. It starts from level 0 (No automation) to level 5(complete automation), the features gradually transition from "driver assistance features" to "autonomous driving features." Level 5 EVs shall be the target vehicle for my report. AVs inputs data from multiple sensors such cameras, lidar, radar, etc. and safety and traffic rules from public road signs, this data is then processed for decision making which makes the vehicle make the right move.

[3]India ranked 24 this year in KPMG's 2019 Autonomous Vehicles Readiness Index (AVRI), a tool to help measure 25 countries' level of preparedness for autonomous vehicles. Given the right financial, technical and administrative support India has the potential to come in the top 10 of the AVRI index.

There are some AEVs in the market but they could increase their efficiency if there were certain sensors and their synchronization with other sensors according to the type of vehicle and the environment. This report will further illustrate on how it can be implemented.

2. LITERATURE REVIEW

India has many working prototype which could hit commercial launch soon if not done already. [4]Escorts, one of the tractor manufacturing giants, has developed a tractor which is able to auto steer and drive in a designated area with the help of a GPS system. They revealed their first prototype in September 2018. The vehicle has level 2 autonomy and currently requires a driver because it can't avoid obstacles automatically just yet. But this vehicle is a boon for farmers that have to work in large fields all day long. According to Mr. Ashwani Malik, CTO officer and head of R&D at Escorts this product will be commercially available by 2021.

Ati Motors is another Indian company building an autonomous cargo vehicle that can operate in huge factory environments. Their vehicle replaces trollies that carry heavy parts which are operated manually. They have supplied their prototype to two big automotive companies and is in talks with several other companies.

China's V2X (Vehicle To Everthing) model, facilitates technology driven automated and safe ecosystem. In compliance to that Baidu launched ACE (Autonomous driving, Connected road, Efficient mobility) Transportation engine. Under this Baidu has released 104 driverless vehicles in multiple cities across the country. These autonomous vehicles are helping carry out frontline anti-epidemic work such as cleaning, disinfecting, logistics, and transportation with support from partner companies. They provide the complete infrastructure and ecosystem required for the smooth functioning of AVs. These include connected platoon vehicle features, automated driving, decision making and auto park systems.

Apollo (Baidu's Autonomous vehicle line up) in partnership with Neolix(a self driving startup) provided autonomous vehicles that delivered food to the hospital staff amidst the maximum containment area. These AVs also served as disinfectant vehicles covering the entire road system in record breaking time. Apollo provided AVs that transported people and products during the pandemic across the whole town of 130 square kilometers. Also, In partnership with iDriverPlus they sent AVs to 16 hospitals throughout China. These vehicles had level 4 autonomy meaning the vehicle was capable of driving without drivers assistance.

On May 17 during the pandemic , due to lack of drivers and virus contraction risk a Chinese mine rolled a mining truck developed by the Baogang Group that could be operated fully by a remote driver at a base station connected via 5G using the V2X model. These vehicles were equipped with technologies like laser radar, millimeter-wave radar and 5G communication, the truck has various functions including remote control, precise parking and obstacle avoidance. There were option of new Vehicles and retrofitting existing vehicles with sensors. They greatly benefitted from it as replacing a giant mining vehicle would cost a fortune. Such vehicles act not only as advanced technological marvels but also help in stabilizing the economy.

But the world's first fully autonomous mine was Syama gold mine in Mali operated by Resolute Mining.

Another feat in this field is at Pilbara, Australia. Here around a third of their trucks are autonomous. These trucks are fully controlled from a remote base station in Perth which is 1200km away

3. METHODOLOGY

5.0 PCU system architecture

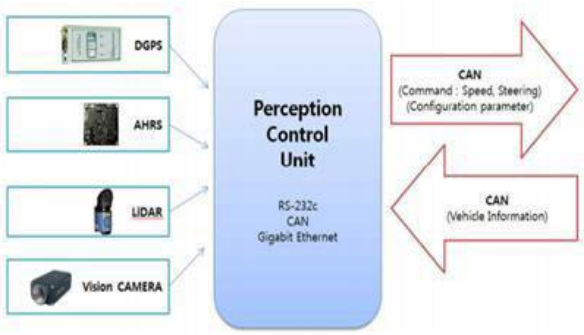

Figure 1 PCU system architecture

This control unit takes input from all the sensors of the vehicle and forwards it to the next sensor which helps to control the car. In general it works by constantly sending data of the lane and obstacles in front and sides of the vehicle. It also takes reverse command for selective input of sensors data. When in reverse mode it sends data of back camera and rear ultrasonic sensors. When in sentry mode in a Tesla, if there is any disturbance to the car, it will horn and start recording and live streaming the footage.

6.0 VCU system architecture

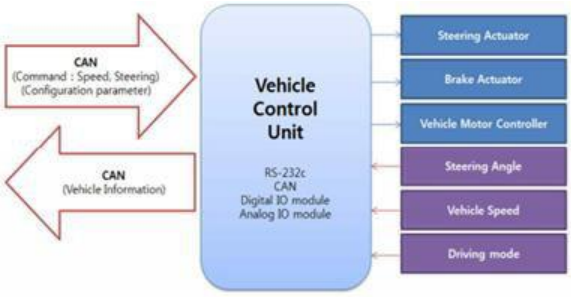

Figure 2 VCU system architecture

The VCU unit takes input from the PCU and controls the relevant gear. If the camera sees a right turn ahead, it will steer right. It can also demand specific input from particular sensors via PCU. When it is parking it requests data from all the cameras and ultrasonic sensors.

4. KEY COMPONENTS

Figure 3 Sensors placement on a Tesla.

Sensors are the key unit of an Autonomous EV. AEVs today have sensors such as LiDAR, cameras and radars. These sensors are what makes help in making the vehicles autonomous. All the hype and the limelight originated from these little components. AEVs have transported tons of products and people to their destinations. The benefits attract all the stardom. But there is still room for improvement. These sensors are also the cause of their imperfections. Recognizing an object makes use of sensors such as cameras which sends the pictures to the internal computer, here the data is processed instantly and gives command to different gears and motors.

CAMERA

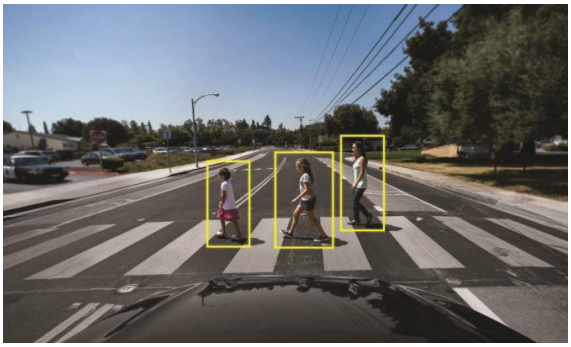

Figure 4 An autonomous vehicle uses camera data to perceive objects in its environment.

Cameras allow us to view and perceive our surroundings, this is widely used in autonomous cars. Autonomous vehicles use cameras as their main sensor. They are placed on the front, left, rear and right of the car. Together they cover 360 degrees around the car. Different cameras are used for this purpose. Some use wide angle view to capture large area but it gives shorter range of sight. Others provide narrow view but they give longer range of sight. Some even use fish eye cameras which give a super wide view of the environment with a panoramic view especially helpful in park assist. [12]Tesla Model X has eight surround cameras that provide 360 degrees of visibility around the car at up to 250 meters of range

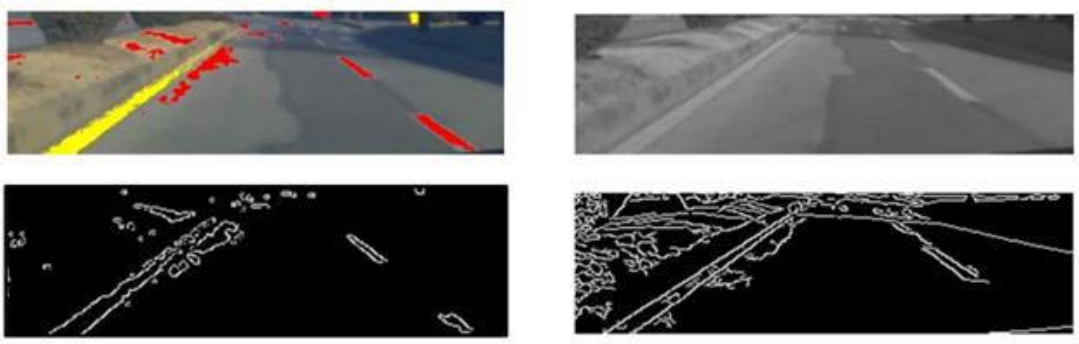

Figure 5 Pre-processing for lane detection

Lane Detection and Keeping algorithm:

The lane is the most common reference among various signs on the road, and it is detected using camera for autonomous driving. Lane details are found by recognizing lane edges with the help of Canny filter and lane information detected from color patterns are used together.

Those images are then applied with Hough transform to detect line features. Hough transform provides measurements of those line components-(r, θ). After going through these complex processes within milliseconds, the lane is detected.

RADAR

Figure 6 Tesla model S with live feed from radars

[11]Radars can compliment cameras when visibility is low, such as in night time. These were originally used in marine and aircrafts. They work by sending pulses of radio waves. When they hit an object they return to the sensor and provide necessary information like location and speed of the object. [12], [13]These are mostly used in sets so that they can cover the entire surrounding of the car. Tesla Model 3 and Mazda CX-9 use Radar to detect moving objects around them.

[14]Bosch has done a great job producing and testing Radars for Autonomous vehicles. Over the last 19 years they have produced and supplied 20 million car radar sensors. Their newest invention is a prototype that can draw out road pattern. With this mini map the vehicle can detect its location simply based on the GPS and radar. With these two components as inputs the system can compare the live data with the base map, after processing the data their accurate location can be determined with upto a few cm level.

[14]WaveSense, a Boston-based company has a very powerful radar system. It can literally see through the road and can create a personalized map consisting of all the details of the road surface type. Its radio waves penetrate the ground up to 10 feet. It can get great detail on soil type, its density, rocks pattern, hollow roads and much more.

This way the vehicle can be prepared for different terrains like snow, beach, desert, gravels and potholes. With the help of this tech if the vehicle is treading on a high altitude sandy road, it can automatically deflate the tires enough to make better traction with the ground. On snowy surfaces it can displace the weight of the vehicle so as to gain better speed and balance. Here in India it can crucially help in detecting potholes so it can warn the driver and avoid them.

LIDAR

Figure 7 Waymo AEV with LiDAR

[11]LiDAR, Light Detections And Ranging provide autonomous vehicles a 3d view of their surrounding. It provides details on depth and shape of all surrounding objects. It can also work well in low lighting just like radar. LiDar works by emitting lasers invisible to human eyes at very high speed and it continuously revolves. When these lasers bounce back they create a 3d picture of the surrounding in the system. These picture consists of thousands of dots called point clouds which together represent different objects around the car. This data is then used to navigate through tight spaces.

Figure 8 Obstacles using traffic cone

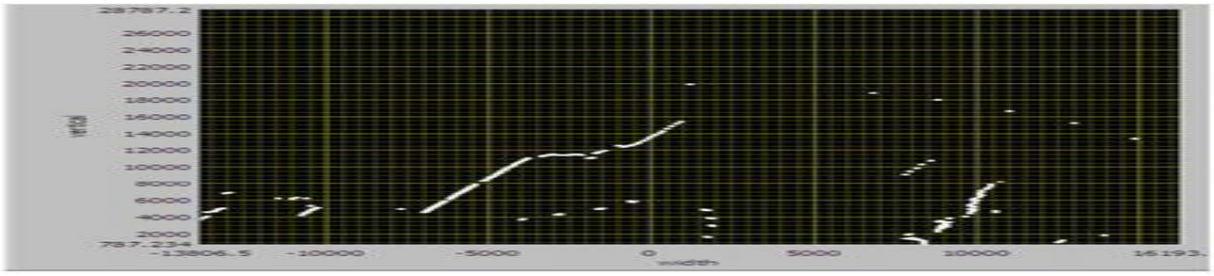

Figure 9 Raw data from LiDAR

[10]Obstacle Avoidance Algorithm :

It is important to develop an algorithm to detect and avoid obstacles such as road patterns, other humans, or cars. An object in front of the vehicle is detected through LiDar Distance and angle information is extracted from the feed. Information of distance and density of obstacles is converted into a histogram. Vector field histogram (VFH) algorithm is then applied to avoid the obstacles.

THERMAL CAMERA

Figure 11 View of a thermal camera detecting a person at a distant

[15]This is the magical sensor that only a single brand, FLIR, has adopted. It is "the missing link" that every sensor suite requires. Normal cameras faces difficulty in night drives, poor lighting environments, bad weather and sun glare these limitations have time and again resulted in fatal accidents. Thermal sensors can detect a longer wavelength as compared to normal cameras, the technology is not dependent on light availability in detecting live objects. They can accurately recognize potential hazards such as cars, humans, animals, cyclists, and other objects from as far as 200 meters away at earliest.

How is it different from Night Vision?

Technically, thermal imaging can be a form of night vision. But most thermal cameras use longer infrared wavelengths, allowing it to detect heat, while the normal night vision cameras use shorter infrared wavelengths, and are cheaper to produce. Thermal cameras also differ from near- IR cameras that need little light to function. These cameras have IR LEDs that light up the area in front of the camera. The camera sees this light only upto 50m beyond which it can't detect anything. This range is pretty much similar to a car's headlight. This reduces the available reaction time and space a driver may need to stop an accident from happening.

Traditional thermal cameras costed thousands of dollars. But now cost is no more a concern, thanks to FLIR systems for developing and launching two new portable and powerful products Thermal Vision ADK and Pathfindir II specifically of autonomous which are very cost effective.

5. PROPOSALS

I have three very string proposals to support autonomous electric vehicles. 1: Wide use of thermal cameras:

Referring to the above mentioned about the indispensability of thermal cameras. I feel this is the most under rated sensor and I personally feel it's a shame that No major commercial EVs use this sensor. When we talk about safety regaring AEVs the life of the pedestrian is of utmost importance. This camera actually sees whats alive and it can prioritise those beings. I propose that thermall cameras should be made standard on all EVs.

2: Battery:

As I have mentioned above about the battery technology available today, Solid State Batteries(SSB) are a ground breaking technology and answer to all the problems. No matter what features or sensors you add. You will most likely still have range anxiety. But how about you just extend the range 3 folds. SSBs do just that, their energy density can be at least 3 times more. Their charge cycle is much more than LiIon batteries at 1000 charge cycles which gives a life of 10 yrs compared to 2yrs in Li Ion batteries. These batteries should be made available as soon as possible.

3: Policy:

India is surely on the digital path. But as a critic and for the overall betterment of AEV development. I feel that India can learn a lot from other giants like China and Norway where the policies themselves are either so lucrative or compulsive that the EVs are adopted easily and the network grows rapidly. China and Norway both have impressive policies to support EVs. This is done by providing enticing subsidies and all the necessary infrastructure for adopting EVs. Even if we blatantly copy their policies it'll still be a sure shot to success. Therefore, I believe that the Govt. should focus in this filed.

6. APPLICATIONS

1: pandemic: We have learned from this pandemic how crucial transportation and mobility is in everyday and emergency services. They pretty much the backbone in connecting people and products. Humans risk their lives to transport people and goods. Our goal is only to go from A to B, then why is there a need for humans when AEVs are smart enough to do it on their own. This will save many lives and provide an even smoother and faster experience. Some countries have used it, but have only kept it to themselves. While others are still lagging behind in technology, infrastructure or policy. But AEVs could be the key tech in saving lives in pandemics.

2: military: When we say military we simply picture skilful armymen with heavy guns. They will defeat get in the enemies zone and defeat them. Soldiers do this job at the cost of their lives. There are so many skills that are needed such as strength, stealth, speed, accuracy, spontaneity, etc. But AEVs have these features already, they only need to be equipped with weapons. During missions the AEVs could be deployed to locate and shoot enemies and destroy their posts without risking a single life. As these machines are lifeless they can fight without fearing for their own. Thus eliminating the vulnerability of human life in battle fields. I believe this will be the ultimate trump card to win all battles in future.

3: Platoon vehicles: Platoon vehicles are the standard choice for delivering all the goods from factory to consumers. This plays an important role in the commercial world. Platoon vehicles are characterized by their ability to carry tons of goods in synced vehicles. However AEVs can be much efficient in this. As the vehicles will be in sync with the fleet. They travel like a train and not like different vehicles. This eliminates many human errors. Since they can drive with minimum distance between them so they also save tons of money lost in traction saving fuel. These will ultimately benefit the supply, demand, cost, profit and eventually reflect in the economy of the nation.

4: community(help infirm people, kids, people who don't drive): Not every person is capable of driving. Driving requires a certain degree of skill. Many simply don't know how to drive, some are just kids while others could be infirm. If mobility wasn't important for such people in the community then perhaps all the world leaders would be drivers. AEVs can help to move these people to and from their workplace/ school everyday and improve the life of the community.

5: delivery: Deliveries are now becoming the norm over daily shopping. The defliveries could be far or near. We have always chosen to have real drivers deliver these goods. But as matter of fact AEVs can deliver them much faster, safer and in a reliable manner. We must remember that it is the goods that we are transporting and not the driver. So AEVs can play a big role in delivering everyday goods.

7. FUTURE SCOPE

- All vehicles should be AEVs and run on a complex and managed network. Much like a railway network.
- Roads should come to life with the help of mixed reality technology. Much like aeroplane flying paths.
- EVs should run on sustainable renewable resources such as solar charging.
- All the AEVs should share a common database of localized maps. So that they can go anywhere anytime.
- After solid state batteries, graphene batteries should be used.
- AEVs should also be able to propel through air and water. Surprisingly they will have lesser obstacles here.
- Charging and maintenance station at every 500m.
- Regular drills to check safety of vehicles.

8. CONCLUSION

AEVs are definitely the future. They are better in many sectors than human driven fossil fueled cars. AEVs collection of sensors and features make them very safe and intelligent. They should have already dominated the roads by now. But due to delay or non adoption of certain sensors or technology we are lagging behind. The current policies also hinder the widespread of AEVs. I believe that in the near future all these obstacles will be taken care of. Through this seminar report I have also proposed few actions that can help in bringing AEVs to every street. I believe that the application of AEVs is very crucial to show its performance and make its place in the new era.

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