Vidhyayana - ISSN 2454-8596
An International Multidisciplinary Peer-Reviewed E-Journal
www.vidhyayanaejournal.org
Indexed in: Crossref, ROAD & Google Scholar

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A Review on Future Safety Mechanisms in Automated Vehicle Management Systems

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Abstract

This Concept is totally based on maximum safety provisions in future vehicles. The Main idea behind this concept is to provide such features with a lot of daily incidents which can be Fatal or Non-Fatal that can be easily avoided with the help of AI and the overall system. With an overall analysis most of the accidents take place with minor human errors and turn out to be fatal. The Basic idea behind this concept is to connect all cars/vehicles together via GPS, AI within a certain radius and the car can itself detect any incoming vehicles towards it from any direction and the AI can take the necessary controls of the car if the driver is not able to detect the car.

Keywords: Self-driving cars, Artificial Intelligence, GPS, auto-pilot, blind turn.

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1. Introduction

As we know GPS is inbuilt in every modern vehicle these days so using this data any car or vehicles within the range of say 300 meters in any direction (360 degree) can be monitored. This technology is more useful in Ghat sections and blind turns as humans cannot see through any natural barriers and there using the help of GPS the car coming from the opposite direction can be detected the second it gets entered in the radius provided by the technology, As the car is detected a message or display on animated car can be shown on the display of the car speedometer hence the driver getting an idea about the car and necessary actions can be taken prior to the meet point of the both vehicles. If somehow the driver is not able to control the vehicle although getting the notification or alert message of the opposite vehicles then the technology of self driving vehicles using AI gets into action. By measuring the opposite vehicle's distance and speed with the help of GPS and sensors which are in the vehicle the AI can easily maneuver the car by getting the control of steering wheel and assisting the driver hence avoiding the collision.

As self driving cars are already available in the market currently, they are mostly precise on the straight patches and on slow speeds so we are using this self driving technology to use on the blind turns and difficult patches a human can find. In heavily populated countries like India, China etc where auto-pilot/self driving technology in cars is very difficult as people tend to not follow the traffic rules is high. So at least such technology can be used in a smaller area with the given radius and used precisely.

We are aiming for such technology in the future where GPS and AI are easily loaded and compatible with the vehicles. Artificial intelligence is the next big thing which will reduce human work and enhance security. India being a heavy traffic country needs a technology where accidents can be avoided. So, we've come up with an idea of using AI and GPS combined and using it in a way to avoid accidents by detecting the oncoming cars or any vehicles.

2. Literature Review

Road traffic accidents remain a significant public health concern, with millions of people injured or killed each year worldwide. To mitigate this issue, automobile manufacturers and

researchers are continuously striving to improve vehicle safety through advancements in technology and design. This literature review examines the current research and developments related to future safety in cars, focusing on three key areas: active safety systems, passive safety features, and emerging technologies.

2.1 Active Safety Systems

Active safety systems are designed to prevent accidents or mitigate their severity by assisting the driver in avoiding or mitigating collisions. One of the most significant advancements in active safety systems is the implementation of advanced driver assistance systems (ADAS), which use sensors and cameras to monitor the vehicle's surroundings and provide real-time feedback to the driver. For example, lane departure warning systems, adaptive cruise control, and forward collision warning systems are increasingly being incorporated into modern cars to assist drivers in avoiding potential collisions (Kusano, Gabler, & Fitzpatrick, 2017). Research studies have shown that ADAS can significantly reduce the number and severity of crashes (Braitman et al., 2010), and their further development and widespread adoption are expected to have a significant impact on future vehicle safety.

2.2 Passive Safety Features

Passive safety features are designed to protect vehicle occupants in the event of a crash. Traditional passive safety features, such as seat belts, airbags, and crash structures, have been effective in reducing injuries and fatalities in crashes. However, ongoing research aims to improve the performance of these features and develop new technologies to enhance occupant protection. For example, advanced airbag systems that adjust the deployment force and direction based on occupant position and crash severity are being developed to further reduce the risk of injury (Forman, Kent, & Kang, 2016). Additionally, research is focusing on improving crashworthiness by using advanced materials and structural designs to absorb and distribute crash energy more effectively, thereby reducing the risk of severe injuries (Grundy et al., 2019).

2.3 Emerging Technologies

Emerging technologies have the potential to revolutionize vehicle safety in the future. One area of research is the development of connected vehicle technology, which allows vehicles

to communicate with each other and with infrastructure to share information about their position, speed, and intentions. This can enable advanced safety applications, such as intersection collision warning and cooperative adaptive cruise control, which can enhance situational awareness and prevent collisions (Liu et al., 2019). Another area of research is the integration of artificial intelligence (AI) and machine learning algorithms into vehicle safety systems. AI-based systems can analyze vast amounts of data from various sources, such as sensors, cameras, and traffic patterns, to predict and prevent potential accidents [ ] (Acharya, Chen, & Ganganath, 2018). However, the ethical and regulatory implications of using AI in vehicle safety systems are still being debated, and further research and development are needed to ensure their safe and responsible use.

2.4 Smart Roads and Road Safety

Electronic technologies are integrated into smart roads and highways. These technologies are utilized to enhance the functionality of connected and autonomous vehicles (CAVs), manage traffic lights and street lighting, monitor road conditions, as well as traffic volume and vehicle speeds. These smart roads will be using solar energy to function, which will also be potentially used to power LED lights for marking lanes on road or warning boards like “Slow Down” signs. These smart roads can also incorporate vehicle tracking technologies in them which will be used by the drivers to know if a vehicle is going to crash into them. This vehicle tracking can be very useful for long cargo trucks because they have bigger bling spots as compared to normal passenger cars.

These tracking technologies can provide real-time information to drivers, enabling them to be alerted if another vehicle is on a collision course. By integrating vehicle tracking technologies into the road infrastructure, smart roads can enhance safety by helping drivers avoid potential collisions, especially in critical areas such as intersections or merging lanes. This innovation has the potential to greatly reduce the risk of accidents and improve overall road safety for all types of vehicles on the road. The information released by the American Highway Safety Insurance Association indicates that in 2019, there were a total of 4,119 recorded fatalities in crashes involving large commercial trucks in the United States [16]. The significant inertia of large trucks, resulting from the heavy goods they carry, poses a substantial risk to life,

property, and the economy. Thus, it is crucial to prioritize truck safety and conduct further research in this field to address this pressing issue. Smart roads in India refer to the implementation of advanced technologies and intelligent infrastructure solutions in the construction, management, and maintenance of roads and highways to improve safety, efficiency, and sustainability.

These smart roads may include features such as integrated traffic management systems, smart lighting, sensors for monitoring traffic flow and conditions, intelligent transportation systems (ITS), and other innovative solutions. Some of the initiatives undertaken in India to develop smart roads include the Bharatmala Pariyojana, which is a flagship highway development program aimed at enhancing connectivity, economic growth, and infrastructure development across the country. Under this program, smart elements such as electronic toll collection (ETC) systems, variable message signs (VMS), and advanced traffic management systems (ATMS) are being deployed to improve road safety and traffic management. Additionally, various cities in India are implementing smart city projects that include smart road components, such as intelligent traffic management systems, adaptive traffic signaling, smart parking solutions, and smart street lighting, to optimize traffic flow, reduce congestion, and enhance road safety.Smart roads in India are expected to bring numerous benefits, including improved traffic management, reduced congestion, enhanced road safety, increased sustainability, and economic growth through improved connectivity and transportation efficiency. However, challenges such as the need for standardization, interoperability, and adequate infrastructure investments remain to be addressed in the widespread implementation of smart road technologies in the country.

2.4 Human Factors in Vehicle Accidents in Ghats

Human factors play a crucial role in vehicle accidents that occur in ghats, which are mountainous and hilly areas. Factors such as driver behavior, skill level, experience, fatigue, and distraction can significantly impact the occurrence of accidents. Additionally, the road design and condition, visibility, weather conditions, and lack of proper signage and safety measures can also contribute to accidents. Ghats are known for their challenging terrain and winding roads, which demand higher levels of driver concentration, skill, and caution.

Therefore, understanding and addressing the human factors involved in vehicle accidents in ghats is crucial in order to improve road safety and reduce the incidence of accidents in these areas. Human factors are significant contributors to vehicle accidents in ghats, which are known for their unique topography and challenging road conditions. One key human factor is driver behavior, including speeding, reckless driving, and overtaking on blind curves, which can lead to fatal accidents.

Driver skill level and experience are also crucial, as navigating through steep slopes, narrow roads, and sharp bends requires advanced driving skills. Fatigue, distraction, and impaired driving due to alcohol or drugs can further increase the risk of accidents in ghats. In addition to driver-related factors, the road design and condition in ghats can also contribute to accidents. Poorly designed or maintained roads, lack of proper signage, and inadequate safety measures such as guardrails and crash barriers can increase the risk of accidents. Limited visibility due to fog, mist, or darkness, especially during the monsoon season, can further challenge drivers and increase the chances of accidents. Weather conditions, such as landslides, rockfall, and slippery roads due to rain or snow, are also important human factors that can contribute to accidents in ghats.

Lack of awareness and preparedness for such weather-related challenges can lead to accidents, especially for drivers who are not familiar with driving in mountainous areas. Addressing human factors in vehicle accidents in ghats requires a multi-faceted approach, including improving driver education and training, enforcing traffic regulations, enhancing road design and maintenance, installing proper signage and safety measures, and promoting awareness about weather-related challenges. Additionally, encouraging responsible driving behavior, avoiding fatigue and distraction, and adopting defensive driving techniques are essential in reducing the incidence of accidents in ghats and improving overall road safety in mountainous regions.

2.5 Road Safety Measures for Driving in Ghats

Driving in ghats, which are characterized by hilly regions with steep slopes, narrow roads, sharp bends, and challenging road conditions, requires special attention to road safety measures to prevent accidents and ensure safe travel. Ensuring safe driving speeds is of

utmost importance in ghats. Due to the steep gradients and sharp bends, it is essential to maintain an appropriate speed that allows for proper control, braking, and maneuvering. Adhering to posted speed limits, adjusting speed based on road conditions, visibility, and traffic flow, and avoiding overspeeding can prevent loss of control and reduce the risk of accidents in ghats. Maintaining a safe following distance is critical in ghats. Given the sudden slowdowns of vehicles in front due to the steep slopes and narrow roads, having adequate reaction time is crucial to avoid rear-end collisions. It is recommended to maintain a minimum of three seconds of distance from the vehicle in front, and even more in adverse weather or road conditions, to allow for better visibility, maneuverability, and reaction time. Proper lane usage is another essential road safety measure in ghats.

Staying in designated lanes, avoiding overtaking on blind curves or unsafe locations, and using overtaking lanes or designated passing zones, if available, is important. Overtaking should be done with caution, considering road visibility, traffic conditions, and vehicle capability. Having a clear view of the road ahead before attempting to overtake another vehicle can prevent accidents and ensure safe driving in ghats. Using appropriate vehicle lights is crucial for road safety in ghats, especially during adverse weather conditions or low visibility situations. Proper use of headlights or fog lights ensures visibility to oneself and other road users. High beam lights should be used judiciously to avoid blinding oncoming traffic. Keeping the windshield, mirrors, and headlights clean and clear is also important for proper visibility while driving in ghats. Adequate lighting can help drivers anticipate potential hazards, navigate sharp bends, and maintain safe distances from other vehicles. Regular vehicle maintenance is essential for safe driving in ghats.

Ensuring that the brakes, tires, suspension, and other vehicle components are in good condition can prevent accidents caused by vehicle failures. Adequate tire tread depth, proper tire inflation, and functional brakes are crucial for safe driving in ghats, where road conditions can be challenging. Regular vehicle inspections, maintenance, and timely repairs can prevent accidents caused by vehicle failures and ensure safer driving in ghats.Being aware of weather conditions and planning accordingly is another critical road safety measure for driving in ghats. Ghats are often prone to fog, mist, rain, or snow, which can reduce visibility and increase the risk of accidents. Monitoring weather forecasts, checking road

conditions, and carrying necessary equipment such as chains for snow driving can help drivers be prepared and make informed decisions while driving in ghats. Adjusting driving behavior, speed, and following distances based on weather conditions can help prevent accidents and ensure safer driving in ghats. Avoiding distractions while driving is crucial for road safety in ghats.

Distractions such as using mobile phones, adjusting music, eating, or engaging in other activities can take away the driver's attention from the road, increasing the risk of accidents. It is important to stay focused on driving, keep both hands on the steering wheel, and minimize distractions to ensure safe driving in ghats. In conclusion, driving in ghats requires special attention to road safety measures due to the challenging road conditions. Maintaining appropriate speeds, safe following distances, proper lane usage, using appropriate vehicle lights, regular vehicle maintenance, being aware of weather conditions, and avoiding distractions are crucial for ensuring safe driving in ghats.

2.6 Vehicle-to-Vehicle Communication

Vehicle-to-Vehicle (V2V) communication is an innovative technology that has the potential to revolutionize road safety by allowing vehicles to communicate with each other, sharing real-time information about their location, speed, and direction. This technology enables vehicles to exchange critical data, such as their position, speed, acceleration, and braking status, which can help prevent accidents and improve overall road safety. One of the key advantages of V2V communication is its ability to enhance situational awareness for drivers. With V2V communication, vehicles can exchange information about their location and movements, allowing them to "see" around corners or beyond obstacles. For example, if a vehicle ahead suddenly applies its brakes or makes a sudden lane change, it can send a signal to nearby vehicles through V2V communication, alerting them to the potential danger and giving them time to react accordingly.

This can help prevent collisions in situations where drivers may not have had sufficient time to react based solely on their own visual perception. Moreover, V2V communication can also provide information about traffic conditions, road hazards, and other relevant data, helping drivers make more informed decisions while on the road. For instance, if a vehicle up ahead

encounters a pothole or a slippery patch of road, it can transmit this information to nearby vehicles through V2V communication, allowing other vehicles to adjust their speed or route accordingly. This can help prevent accidents caused by sudden maneuvers or unexpected road conditions. In addition to improving situational awareness, V2V communication can also enhance the effectiveness of other safety technologies, such as Advanced Driver Assistance Systems (ADAS). For example, V2V communication can complement ADAS technologies, such as automatic emergency braking, by providing additional information about the position and speed of nearby vehicles, allowing ADAS systems to better anticipate and respond to potential collision risks.

This can help prevent accidents and reduce the severity of crashes, potentially saving lives and reducing injuries. Another key advantage of V2V communication is its potential to address human error, which is a major reason for accidents occurring on the road. According to the National Highway Traffic Safety Administration (NHTSA), human error is a factor in over 90% of all crashes. V2V communication can mitigate human errors, such as misjudging distances, failing to see other vehicles, or making sudden maneuvers, by providing real-time information and alerts to drivers. For example, if a driver attempts to change lanes without realizing that there is a vehicle in their blind spot, V2V communication can alert both the driver and the driver of the adjacent vehicle, helping to prevent a potential collision. Furthermore, V2V communication can also benefit vulnerable road users, such as pedestrians and cyclists. For instance, V2V communication can enable vehicles to detect pedestrians or cyclists in close proximity, even if they are not directly visible to the driver due to obstructions or poor visibility. This can help prevent accidents involving pedestrians or cyclists and improve their safety on the road. Despite the potential benefits of V2V communication, there are also challenges that need to be addressed.

Ensuring standardization and interoperability presents a significant hurdle in addressing the challenge at hand. For V2V communication to be effective, all vehicles on the road need to be able to communicate with each other, regardless of make, model, or manufacturer. This requires the development of standardized communication protocols and interoperability standards to ensure seamless communication among different vehicles and systems. Another challenge is related to cybersecurity and privacy. V2V communication involves the exchange

of sensitive data, such as location and speed, which could be vulnerable to cyber-attacks or misuse. Ensuring the security and privacy of V2V communication is crucial to prevent unauthorized access or malicious activities that could compromise the safety and integrity of the system.

2.7 Motorcycle-to-Motorcycle Communication

Vehicle-to-vehicle (V2V) technology, also known as motorcycle-to-motorcycle (M2M) communication, refers to systems that allow motorcycles to communicate with other vehicles, including motorcycles and cars, using wireless communication protocols. V2V technology in motorcycles is aimed at improving safety, situational awareness, and communication among riders on the road. V2V technology in motorcycles typically utilizes wireless communication protocols, such as Dedicated Short-Range Communications (DSRC) or Cellular Vehicle-to-Everything (C-V2X), to enable communication between motorcycles and other vehicles in close proximity.

Safety Alerts: V2V systems in motorcycles can provide real-time safety alerts to riders, warning them about potential hazards, such as nearby vehicles, sudden braking, or other safety-related information. These alerts can help riders to be more aware of their surroundings and potentially avoid accidents.

Cooperative Collision Avoidance: V2V technology can enable cooperative collision avoidance, where motorcycles can communicate with each other to detect and prevent potential collisions. For example, if two motorcycles are approaching an intersection from different directions, their V2V systems can exchange information and provide alerts to both riders if a collision is imminent.

Group Communication: V2V technology can facilitate communication among riders within a group, allowing them to share information about routes, destinations, or other messages. This can be particularly useful for group rides or motorcycle clubs to stay connected and coordinated on the road.

Traffic Information: V2V systems can also provide real-time traffic information to riders, such as traffic congestion, road closures, or detours, helping them to plan their routes more effectively.

Emergency Assistance: V2V technology can include emergency assistance features, such as automatic crash detection, which can alert emergency services with the location of the accident in case of a crash, enabling faster response times and potentially saving lives.

Interoperability: V2V systems are typically designed to be interoperable, meaning they can communicate with other V2V-equipped vehicles regardless of the make, model, or brand. This allows for widespread adoption and effectiveness of the technology across different types of motorcycles and vehicles.

V2V technology in motorcycles has the potential to enhance safety, communication, and situational awareness on the road, helping to reduce the risk of accidents and improve overall riding experience. However, it's important to note that V2V technology is still in the early stages of development and deployment, and regulatory frameworks, standardization, and widespread adoption may still be evolving. Riders should always prioritize safe riding practices and follow local traffic laws and regulations, regardless of the presence of V2V technology.

2.8 Key Challenges

The development and integration of advanced safety technologies in vehicles can present technical challenges. This may involve the requirement for sophisticated sensors, communication systems, and computing power to enable functions such as autonomous driving, collision avoidance, and driver-assistance systems. It is crucial to ensure the reliability, accuracy, and robustness of these technologies for successful implementation. Regulatory frameworks and standards play a critical role in implementing safety mechanisms in vehicles. Complying with existing regulations and standards, as well as navigating the complex legal and regulatory landscape surrounding emerging technologies, can be challenging. Addressing compliance with relevant laws, regulations, and standards for safety mechanisms, and managing potential conflicts or gaps, may pose challenges. Future safety mechanisms in vehicles may raise ethical concerns, such as issues related to privacy, data security, and liability. For instance, autonomous vehicles may collect and process large amounts of data, which raises questions about data usage, storage, and protection.

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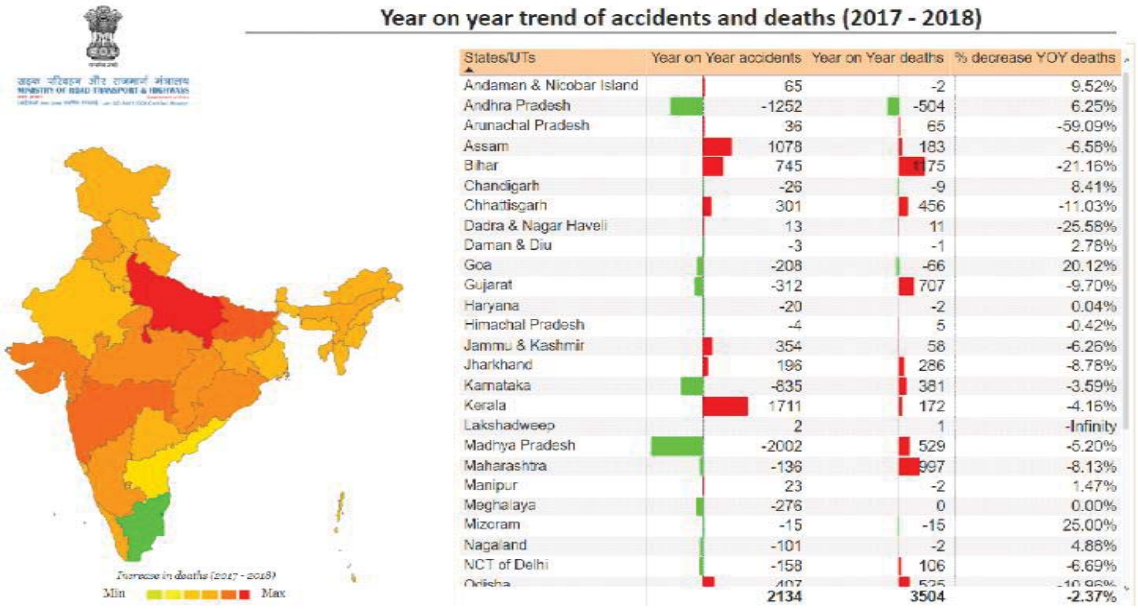
Determining liability and responsibility in accidents involving autonomous vehicles or other advanced safety technologies may also present challenges. The human element plays a crucial role in vehicle safety. Human factors, including human behavior, perception, and decision-making, can impact the effectiveness of safety mechanisms. Addressing proper usage and interaction of these technologies by drivers and passengers, mitigating potential misuse or over-reliance, and managing the transition between automated and manual driving modes can pose challenges. Implementing advanced safety mechanisms in vehicles may entail significant costs, which can affect affordability and accessibility for consumers. Developing, manufacturing, and maintaining complex safety technologies can add to the overall cost of vehicles. Ensuring cost-effectiveness and accessibility of safety mechanisms to a wide range of consumers, including those in low-income communities, may present challenges.



Year on year trend of accidents and deaths (2017 - 2018)

States/UTs	Year on Year accidents	Year on Year deaths	% decrease YOY deaths
Andaman & Nicobar Island	65	-2	9.52%
Andhra Pradesh	-1252	-504	6.25%
Arunachal Pradesh	36	65	-59.09%
Assam	1078	183	-6.58%
Bihar	745	175	-21.16%
Chandigarh	-26	-9	8.41%
Chhattisgarh	301	456	-11.03%
Dadra & Nagar Haveli	13	11	-25.58%
Daman & Diu	-3	-1	2.78%
Goa	-208	-66	20.12%
Gujarat	-312	707	-9.70%
Haryana	-20	-2	0.04%
Himachal Pradesh	-4	5	-0.42%
Jammu & Kashmir	354	58	-6.26%
Jharkhand	196	286	-8.78%
Karnataka	-835	381	-3.59%
Kerala	1711	172	-4.16%
Lakshadweep	2	1	-Infinity
Madhya Pradesh	-2002	529	-5.20%
Maharashtra	-136	997	-8.13%
Manipur	23	-2	1.47%
Meghalaya	-276	0	0.00%
Mizoram	-15	-15	25.00%
Nagaland	-101	-2	4.88%
NCT of Delhi	-158	106	-6.69%
Odisha	407	525	-10.86%
	2134	3504	-2.37%

Fig.1. Year on year trend of accidents and deaths (2017-2018)

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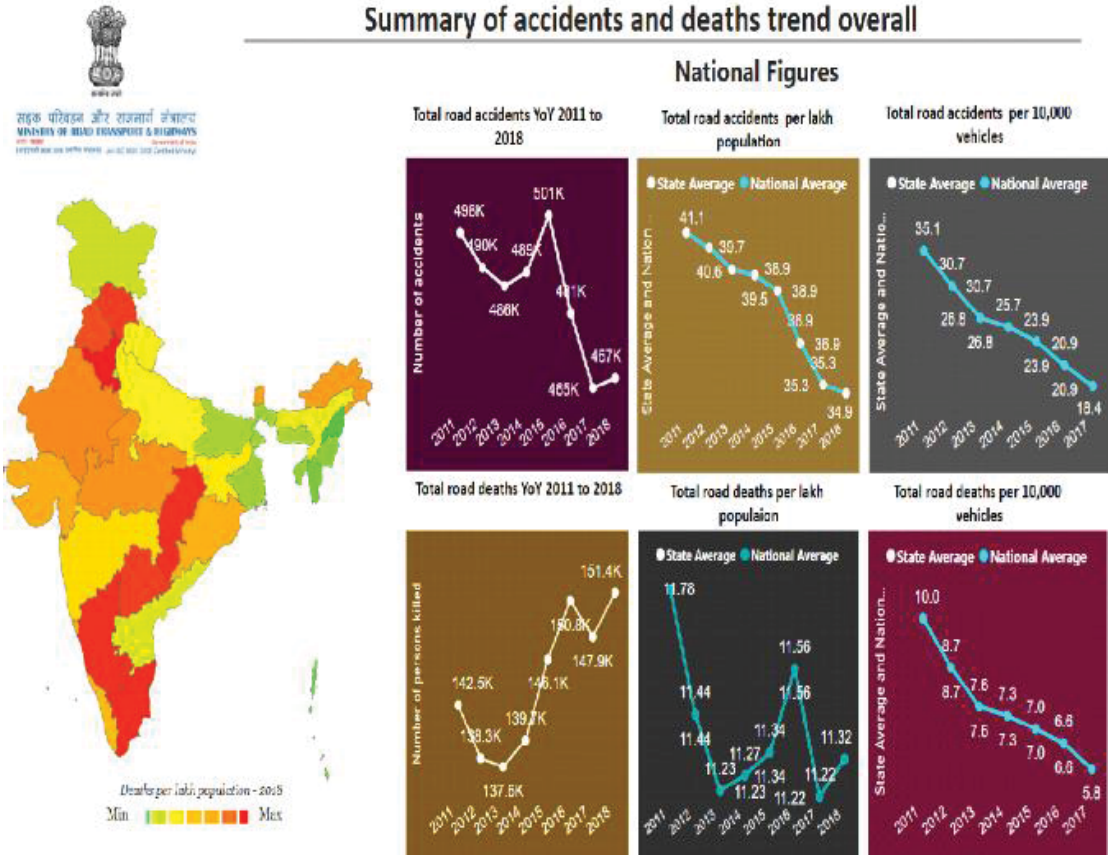

Fig.2. Summary of accidents and deaths trend overall

As you can see in the above table Assam, Bihar and Kerala are top three states where most of the accidents and deaths have happened, these states will see a major fall in deaths due to accidents if the proposed technology is incorporated into the vehicles. As well as the amount of infrastructure, labor and cost which will be saved is also huge. In Ghat Sections the accident risk factor is doubled due to which our system comes into play and drivers can detect oncoming vehicles even on blind turns.

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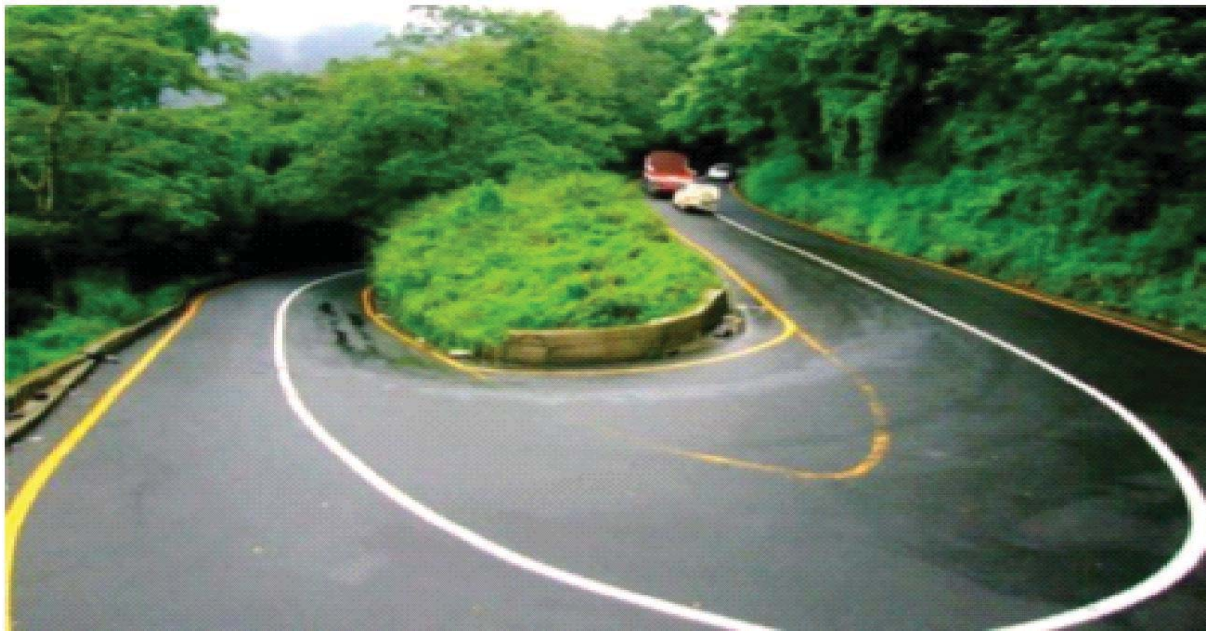

Fig.3. Ghat section

4. Future Proposition

Our first future scope of this project will be to design 3d animated models which will be displayed instead of images which is our current technology right now. Right now, we are providing messages or notifications if any kind of overspeeding is done by driver then our next goal will be that if a driver is drunk or overspeeding or sleepy while driving then using AI a sudden/slight change in vehicle and overall body gestures of the driver we will be able to detect all of it and give control to AI for controlling the car's speed or direction to avoid any fatal accidents. This same technology or features can also be implemented in motorcycles as they are also prone to accidents and they have even less safety as compared to cars and trucks. Using GPS based geo-location or advanced bluetooth communication between vehicles and motorcycles we can immensely improve proximity awareness among drivers and riders on the road.

4. Conclusion

As self driving cars are already available in the market currently, they are mostly precise on the straight patches and on slow speeds so we are using this self driving technology to use on the blind turns and difficult patches a human can find. In heavily populated countries like

India, China etc where auto-pilot/self driving technology in cars is very difficult as people tend to not follow the traffic rules is high. So at least such technology can be used in a smaller area with the given radius and used precisely. We are aiming for such technology in the future where GPS and AI are easily loaded and compatible with the vehicles.

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