1. Introduction

1.1. Autonomous Vehicle

Transportation had played an important role in the mankind since early age. The invention of rotary wheel had been a groundbreaking innovation in the human history. It facilitates the long-distance commutation ultimately, paves ways to trading and sharing knowledge. However, the field of transportation had been evolved rapidly in the last century in particular after the invention of steam engines which is initially used for goods transportation, but soon it had a direct impact on civilians in the form of road cars. After 1930s proper road infrastructures are developed to cope up with the rapid improvements in vehicle performance. The fourth industrial revolution had taken the science field by strom, where the machines are controlled by intelligent systems reducing manual errors and increased performance. The automotive field is not an outlier to this fact, various driver assistance system such as ADAS not only reduces the human effort in driving but also ensures the safety of the occupants and the vehicle. Engineers and scientist around the world are working keenly to develop the performance of the intelligent system. The big target for this community is to achieve complete autonomous driving, where no human is needed to guide the car to reach its destination. The concept of Autonomous driving has it’s origin in 1926, where a radio controlled car is developed by Houdini Radio control of new York city. The components of the car operate using the commands received from another car following it, thus achieving a first driverless car. In 1960 at Transport and road research laboratory in the United Kingdom, Magnetic cables are laid beneath the road which serves as a path detection tool for the car running on the road. The car uses the magnetic cables for its navigation and drove without human aid and delivered better performance even at high speeds. However, the first self sufficient autonomous was achieved by Mercedes in 1995 where a retro fitted Mercedes S class equipped with efficient cameras and exclusive processors aiding parallel computing was developed in the aim of autonomous vehicle. The car had clocked the maximum speed of 175 kmph and drove 1500 kms from Munich, Germany to Copenhagen, Denmark. This car had performed various overtakes and drove in traffic. This had been a significant milestone in field of autonomous driving. In late 2010s various carmakers like Toyoto, volvo had developed their own prototypes of Avs. In addition, Tech companies like Google, Waymo and universities had initiated research in autonomous vehicle. The parallel development in Artificial Intelligence and hardware such as Processors and sensors had catalysed the research on self driving. Notably, development in camera and GPUs enabled fast and efficient processing. On other hand intelligent algorithms like neural networks laid foundation for AV’s. In 2014, Tesla had launched it functional semi autonomous driving car with various assistance features like Lane detection, autonomous breaking and parking and speed limit recogonization using computer vision. This had been a significant leap in the community. In the same year Society of automotive engineers (SAE) had drafted the 6 level taxonomoy for Autonomous driving. Several countries like United states of America, united kingdom Japan had decided to draft a law for autonomus driving.

Currently various leading carmakers like Mercedes Benz, BMW, Volvo had also launched their own commercial full/semi autonomus vehicle for public and improving their levels of automation as classified by SAE. For example, in 2022 Mercedes Benz had reached SAE level 3 automation with its S class and EQS models, which features advanced driving tech like automated lane keeping system. However, Tesla Motors had been the leader in this domain with better performance.

The six level of automation in Autonomous vehicle classified by SAE as J3016, Taxonomy and Definitions for Terms Related to On-Road Motor vehicle Automated Driving Systems ranges from fully manual driving to fully automated.

Level0 : No Driving automation :

This Levels adopts no driving assistance system and the entire process of driving is controlled manually

Level 1: Assisted

Vehicles with a single automated system under driver’s monitor are categorized as Level 1

Level2 : Partially automated

Multiple automated systems like automated steering, braking works simultaneously under drivers attentation, where the driver should be ready to take the control at any time

Level3: conditional driving automation

This level encapsules a system with intelligent algorithm that can take decisions such as overtaking navigation. However, the human attentation is required

Level4: Highly automated

At this level, the vehicle can could take optimistic decision in case of a failure, which further reduces the human interaction, but still attentation is needed, which could mostly be used in a confined area/region

Level5: Full driving automation

At this level the vehicle can perform all driving task than an experienced driver does without the human interaction.

**CLEAN**

**TEXT**

1. Introduction

1.1. Autonomous Vehicles

Transportation has played an important role in the human history, evolving from the invention of the rotary wheel to the modern road cars. The invention of fuel engines in the last century marked a significant revolution, initially impacting goods transportation and later extending to civilian life with the introduction of road cars. This period also witnessed the development of proper road infrastructures to accommodate the advancements in vehicle performance.

The fourth industrial revolution mark a start of new era where intelligent systems-controlled machines are developed which reduces the manual errors and enhancing performance. The automotive industry is also undergone this transformation with various intelligent driver assistance systems like Advanced Driver Assistance Systems (ADAS) which not only reducing human effort in driving but also ensuring safety. Engineers and scientists globally are working to enhance the capabilities of intelligent systems, aiming for complete autonomous driving, eliminating the need for human guidance.

The concept of autonomous driving dates back to 1926, with the development of a radio-controlled car in New York City. In 1960s, the Transport and Road Research Laboratory in the United Kingdom laid magnetic cables beneath the road, serving as a path detection tool for self-driving cars and tested its performance. Later, in 1995 Mercedes Benz achieved a significant milestone with the development of first self-sufficient autonomous vehicle, a retrofitted Mercedes S class equipped with efficient cameras and exclusive processors for parallel computing. This vehicle reached a maximum speed of 175 kmph, covering 1500 kms from Munich, Germany, to Copenhagen, Denmark, performing various manoeuvres in traffic without human assistance. In the late 2000s, carmakers like Toyota and Volvo, along with tech companies such as Google and Waymo, developed their prototypes of Autonomous Vehicles (AVs).

The parallel advancements in the field of Artificial Intelligence and efficient hardware accelerated research in self-driving technology. Notably, improvements in cameras and GPUs facilitated fast and efficient processing, while intelligent algorithms like neural networks laid the foundation for Autonomous Vehicles (AVs). In 2014, Tesla Motors launched Model S, a semi-autonomous driving car. This vehicle featured a various assistance feature, including lane detection, autonomous braking and parking, and speed limit recognition using computer vision. Tesla's entry into functional semi-autonomous driving represented a notable advancement in the field. During the same year, the Society of Automotive Engineers (SAE) had drafted a 6-level taxonomy for autonomous driving. This framework provided a standardized and structured classification system for assessing the level of autonomy in vehicles. Recognizing the growing impact of autonomous driving, several countries, including the United States of America, the United Kingdom, and Japan, made decisions to formulate laws addressing autonomous driving in the next few years. Various leading car manufacturers, including Mercedes Benz, BMW, and Volvo, have introduced their commercial fully or semi-autonomous production vehicles. They are continually enhancing their automation levels, as classified by the Society of Automotive Engineers (SAE). For instance, in 2022, Mercedes Benz achieved SAE Level 3 automation with its S-Class and EQS models, equipped with advanced driving technologies like an automated lane-keeping system. However, Tesla Motors has been a leader in this field, showcasing superior performance.

The SAE J3016 classifies autonomous vehicles into six levels, ranging from fully manual driving to fully automated systems.

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| Level 0 | No driving automation | This level involves no driving assistance system, and the entire driving process is manually controlled. |
| Level 1 | Driver assistance | Vehicles at this level feature a single automated system under the driver's supervision. |
| Level 2 | Partial driving automation | Multiple automated systems, such as automated steering and braking, work simultaneously under the driver's attention. The driver must be ready to take control at any moment. |
| Level 3 | Conditional driving automation | This level involves a system with an intelligent algorithm capable of making decisions like overtaking navigation. However, human attention is still required. |
| Level 4 | High driving automation | At this level, the vehicle can make optimistic decisions in the event of a failure, reducing the need for human interaction. This level is often suitable for confined areas or regions |
| Level 5 | Full driving automation | Here, the vehicle can perform all driving tasks without human interaction, comparable to an experienced human driver. |