Synergizing Cloud in Autonomous Vehicles.

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***Abstract*— This study sets about to uncover the symbiosis between two exciting technologies; connected vehicles and cloud computing, with emphasis on the role autonomous driving technology plays. The research focuses on the divergent issues of cloud and edge computing integration, which are presented to be the main driving forces in the industry acceleration through IoV causing the advanced data transmission and high level of responsiveness in vehicular networks. An important element of the research is the role of edge computing that is brought out which shows the potential of edge computing for meeting the strict resource and latency requirements of real-time applications such as augmented reality and autonomous driving. The paper provides more details about certain cloud-based services like dynamic vehicle recognition algorithms, path segmentation procedures for autonomous navigation, and lane detective technologies, and so on. Utilizing the processing power of edge computing the data quality that will be assimilated is improved even on the instances where resources are very scarce. Moreover, in the technological sphere, the research deals with the multifaceted domain of the security and the privacy in the case of the autonomous vehicles, as a result proposing a robust approach to identify and fix the weaknesses at different layers of the autonomous vehicle systems. It is through the continuous vigilance and the application of numerous security measures and privacy measures that the study aspires equilibrium and security in the operation of the autonomous vehicles, foreseeing a future in which the innovative, efficient and safe cloud-based solutions are the driving force in the transportation industry. Academic collaboration with industry professionals and policymakers emerges as the necessary factor in guiding the transportation sector, which is increasingly relying on technologically-honed and reasonably safe modes of transport.**

INDEX TERMS: Cloud Computing, Autonomous Vehicles, Artificial Intelligence, Internet of Vehicles, Lane Detection, Resource allocation, Security and Privacy.

I. INTRODUCTION

The assimilation of cloud and fog computing managed a wisely swift transformation in IOT. Which deserves the description that aims to solve the growing need for data transfer and improve the reaction times of the vehicles undergoing the integration of the connected devices. The significance of Edge computing in the Internet of Vehicles is as a result of their capacity to satisfy the resource and latency requirements of sensitive vehicle applications, due to where they are located. On the other hand, the previously reasonable edge computing systems are challenged to support the needs of the next generation of internet things due to recent development of intensive-compute and latency-sensitive applications, such as augmented reality and autonomous driving.[1]

When thinking of technological advancements, the Internet of Vehicles is moving into a new paradigm line as it is getting scheduled blending of edge computing and clouds. In-vehicle network integration is central for the overcome of resource allocation and processing delays for domain of connected vehicles on time sensitive applications. The coming of the field of IoV and the development of compute-intensive and low latency applications such as AR and driverless vehicles is a brainstorming for information processors and their allocating strategies. The novel resource provisioning scheme for the time critical situations dedicated to the local operations is going to be brought with the creating the cooperation between the Cloud and the Edge computing. Certain systems of autonomous navigation for vehicles need to segment a path, which helps the machine to move in a precise way and without causing an accident [2].

The collaborative cloud-edge cluster resource provisioning framework suggested for vehicular edge computing focuses on handling the challenges emerged due to the growing volume of applications in IoV. This framework gets to capitalize on the hybridity between cloud and edge computing to meet the growing demand for resource distribution and delay resistant processing while in the era of connected cars. Next, we will expand our topic to address the significance of path segmentation in autonomous navigation and the positive influence of a cloud service smart management algorithm on vehicular clouds. The two discussions to follow will thereafter illuminate the intricate priority-based resource allocation and computation system that is the heart of vehicular multimedia cloud computing, thus providing equal attention to the abstract features and implications of this system [3].

II. CLOUD-BASED SERVICES FOR AVS

In the quest of developing advanced autonomous driving, the functionality of dynamic vehicles detection and tracking by means of 2-D point clouds is an important factor. Discovering and staying with 3-D dynamic vehicles after 2-D point data means the fulfillment of the process of safe and efficient driving in autonomous cars. The traditional method to get those updated vehicle detections and tracking relies on the complexity of the algorithms that needs the total computational resource possess. Edge computing, on the other hand, through the provision of a more efficient and real-time computing platform than any one other technology holds out a hope of resolving this challenge. Leveraging the edge node computational power for decentralized peer to vehicle detection also assures that the latency is within the expected levels and that the quality of data is better.[5]

Autonomous navigating which is one of the basic elements of self-driving vehicles is responsible for them being able to cruise safe and smoothly through the different surrounds. Path segmentation is a crucial feature in the autonomous navigation as it provides the required information for crafting path from the point cloud data. The function of path segmentation helps the autonomous vehicles tackle different regions of the environment and distinguish them, such as roads, walks and obstacles. Such assistance helps considerably in choosing a particular route and clearing the way to potential risks. Path segmentation methods utilizing point cloud data, which provides accurate 3D geometry information about the nearby environment in order to discern and group different objects and surfaces, use a series of steps in the identification and classification of similar elements from the point cloud dataset. These steps could be preceded by preprocessing the range data in order to clean up the cloud of points by filtering the noise and outliers, segmenting the cloud of points in distinct groups based on the proximity or their combining properties, and lastly, an assignment of these groups to specific categories, like roads, curbs and buildings. The fashion of segmenting the path is by using voxelization, in which 3D space is split into tiny volumetric elements nicknamed voxels, to allow for the grouping and classifying, Machine learning algorithms, such as clustering algorithms or neuronal networks, can be used to further improve the segmentation process and increase classification accuracy.

Cloud-based solutions play a crucial role nowadays while building computing models because of their flexibility and scalability that meet a wide range of application demands. It examines the Cloud-Edge Cluster Collaboration in Internet of Vehicle (IoV), emphasizing the cluster collaboration as one of the strategies to improve the delay and profit parameters. Distribute a reliable infrastructure for offloading the work from vehicles to edge servers or distant clouds, which will enable better use of resources and successful task monitoring. The document establishes the most reasonable criteria for equipment renting and IoV system optimization with the help of cloud computing pool unification and communication of Edge Service Providers (ESPs). A planned implementation of the cloud-based services will allow for a substantial improvement of computing performance and be able to cope with the dynamics of vehicular environment [1].

III. LANE DETECTION

The perception technologies required for the improvement of the reliability and speed of the autonomous driving systems need to be tuned. Visualize autonomous cars that are capable of "seeing" the road better than humans. In the recent past studying, automated driving technology has strongly focused on the perception, the mapping, and the localization as the central research domains. This example firstly looks like a car that can read lane lines which are basically road signs that have been drawn on the pavement. The detection of lane marking plays a pivotal role in the environmental perception setup that the autonomous vehicles use the lane markings become a reference system and send a clear sign to the car that it is in the right lane. Accordingly, we, retain the balance and do not go astray. The effectiveness of detecting the lane marking not only ensure the road safety but also has high possibility to apply in other transportation areas like vehicle positioning, mobile mapping technology, and route optimization. It is not only tracking the car's position but also generating the road map for better driving experience which makes it equivalent to a super-GPS that guides on the way [7].

This paper focuses on the image to lidar point cloud data transfer with semantic segmentation in the roads of the Berkeley campus by explaining the highly complex algorithm. Categorization and segmentation types are employed to allow acquiring semantic categories of objects as well as a LiDAR test dataset, before the development of new segment data dataset. As the last step, each point is symbolized with an SS class which is aimed at improving the visualization of objects within the 3D position tracking system for Wireless Sensor Networks, WSNs. The article then introduces the novel framework called PointSeg which comprises of three layers namely - the Rapid Segmentation Layer, Feature Generation Layer and the Background Detection Layer. RI-U-Net can also be used to classify each point on two-dimensional terrain maps or three-dimensional point cloud data. In this case, mobility is faster since we can use heuristics and also prior terrain navigation experience to improve trafficability and search speed. This requires a LiDAR sensor for autonomous system locations that are added on cameras. The method in practice guarantees using labeled data, yet with the primacy in mind to develop unsupervised schemes and handle data scarcity. The bigger focus is brought on to semantic segmentation process, which opens the system to experience and receives the knowledge base [6].

The introductory part of the document is going to focus on the critical role of LiDAR sensors in permitting the correct perception and navigation through the encompassing environment by autonomous vehicles and robotics. It pinpoints the use case of LiDAR point clouds in adding the desired exactness and detailed shape features to the sensing system of autonomous vehicles through precise measurements and provision of the real sense of the world for more accurate perception. LiDAR sensors constitute a major element that assists us in knowing our environment very well so that the vehicles can take decisions based on 3D maps in which they will navigate using spatial data. More importantly, section 1 states that this tedious operation with numerous LIDAR point clouds, especially in the case of weak communication lines can generate issues. No adequate data managing brings costs and delays that impede live launching of robotic devices/system. Hence, it is necessary to find fresh ways that would consume less data storage and movement without affecting the quality and integrity of collected information. The study describes SA-LPCC as the new processing algorithms which can solve the problem of poor data processing from LiDAR for Autonomous Vehicles. As this study aims to develop a new point cloud compression and reconstruction method that uses semantics and task demands in the coding frame, it can contribute to the enhancement of the existing point cloud compression and reconstruction methods. This framework has been developed to give a capability of fulfilling requirements of autonomous systems like environment recognition precision, obstacle detection, and routing planning through employing advanced compression and storage methods [3].

IV. SECURITY

The automation of vehicles has re-defined the very industry of transportation. These vehicles play the fundamental role of improving both road safety and efficiency while reducing congestion, and are able to provide the commuters with a more enjoyable travel experience. While these technologies can definitely add many benefits, they also have areas which need to be looked after concerning security and privacy. In the advent of increasing number of self-driving vehicles, it is essential to carry out investigations to establish privacy and security of such vehicles. This paper is entirely devoted to researching and classifying the security and privacy issues in vehicles that are autonomous and applying a sequential approach. Under this method, the paper will be able to assess the various layers of an autonomous vehicle and determine different attacks as well as the weaknesses at each layer. Besides, the paper will put forward the countermeasures and discuss other research fields for minimizing the impact of security and privacy issues. Through the review of security and privacy pitfalls in autonomous vehicles, this paper serves as a great source for knowing about the possible threats in this budding technology. Finally, it promotes taking serious security measures and putting in place privacy safeguards to ensure smooth and safe autonomous vehicle operations. The presented analysis emphasizes the necessity for taking into account the safety and data privacy risks while using self-driving cars. Then again, the face that calls for the continuous updating of security measures, as new exploitation methods are discovered and the technology evolves, is a given as well [10].

Transportation sector is now changing dramatically at a fast pace as the new technical domain of the vehicles with connectivity and automation appears. The CAVs integration might serve as a launchpad for a more efficient and time-saving transportation system due to features such as higher safety, embedded traffic management, and better accessibilities. The process of decrypting and getting rid of the hurdles that affect CAVs is very crucial. The endpoint and the purpose of this research are to describe in detail all roads to the detection of deviations in networked and autonomous vehicles. The paper analysis of the current concepts, the problems faced, and the possible solution are going to be the best contribution to the building of resilient anomaly detection systems tailored to the safe operation of CAVs. The rapid adoption of autonomous and connected vehicles is shaped a new transportation paradigm that provides more safety and super-performing level of efficiency. Complex technologies such as artificial intelligence and Internet of things now bring CAV features unthinkable just a few years ago. Consequently, as vehicles are becoming more and more complex and interconnected, it comes in handy to analyze and react to the faults of those systems. It is worth noting that studying anomaly detection in connection with a partially autonomous vehicle implies the striking interconnection of numerous technical parts and the continuous enhancement of the live environment overall quality, what eventually results in the increase of complexity. Data interoperability as well as the massive data generated by CAV's are, the principal the issue we are up against. In order to quickly acquire and understand large pixels of data that come from a variety of sources such as vehicle sensors, communication networks and external information sources, advanced algorithms will be essential. Moreover, there will be a need for a great awareness in the detection process due to deviation of routine conditions such as different weather conditions, different types of road designs and different types of traffic patterns [11].

V. RELATED WORKS

The core aspect of RT3D (Real-Time 3D) being the apt transformation of raw data from LiDAR sensors, which are point clouds in 3D, in a 2D configuration while retaining significant height information. This let the system utilize the 3D surroundings utilizing the 2D convolutional neural networks (CNNs). In the RT3D, we use bilayer CNN detector because it resembles human visual recognition processes. In the first place, the Region Proposal Network (RPN) performs an analysis of the reprogrammed point cloud data to locate any possible vehicle locations. These areas are next classified as Regions of Interest (RoIs). The following block of CNN will focus on each RoI individually using the pose-sensitive mappings of feature vectors to pinpoint the localization, orientation, and dimensions of all vehicles within the aforementioned region more accurately. RT3D uses a pre-RoI pooling, convolutional step which makes the figure smaller in size and then passes it to the second stage of CNN which increases the processing speed and also maintains the accuracy. The next line of RT3D technical development concerns the addition of pose-sensitive features. The classical operation encounters problems in taking into account the alignment of the vehicle at point cloud. RT3D has come up with a solution to this impediment, which is using responsive mapping of features to the vehicle's orientation. As a result, the network will achieve increased precision of the car's 3D space coordinate, orientation, and dimensions when predicting its position. In addition, RT3D integrates the application of OHEM in the training stages and choosing perplexing instances within every mini-batch of data for training purpose. Through such training the system will be able to monitor and manage the often-demanding situations happening during the real-world driving [8].

The primary problem of keeping autonomous vehicles safe and efficient under different situations mostly depends on how elements that are mobile are correctly distinguished and separated. Unlike the conventional approach that employs static images or those that are point clouds, there is a need to so as to identify objects that are moving from those that are stationary. Semantic Scene Flow - that is a breakthrough technology which conceptually changes how autonomous cars perceive dynamic environment. With the integration of semantic understanding along with 3D motion estimation, the SSF-MOS presents a relatively robust solution for motion separation and positioning with utmost accuracy. By means of this technique the limitations of existing methodologies are eliminated and moving objects are identified as such through the application of highly advanced algorithms. Integrating the autonomous driving vehicle(s) system with SSF-MOS helps it become more competent and be able to move around even the most complex and dynamic environments with high accuracy and efficiency. By virtue of modern algorithm and deep learning processing, MOS-SSF cars improve their decision-making and rapid adaption. And in addition, SSF-MOS provides room for implementation of the segments other than autonomous vehicles by resolving the uncertainties related to moving objects categorization and depiction of the dynamics of the scene.

This may be the most revolutionary invention that can boost the advancement and use of intelligent systems in multiple real-life applications [9].

VI. CONCLUSION

The combination of cloud computing and connected vehicles form the basis of a technological transformation in the transportation industry and therefore provides an array of advantages in the future. Here, the most accessible route for establishing the degree of the interplay of these two fields is approved; the gains, new technologies and massive business opportunities is found out. The occurrence of cloud computing can be identified as the fueling of developments in vehicles driven autonomously offering them with flexibility, high effectiveness, and high performance. The use cloud-based solutions allow implementing Ai and machine learning models for the main server for the real time reactivity which, in turn, provides an improvement of vehicles perception, decision making, and control ability. Through this alliance, the AVs have been able to go through the most complex and endless surroundings and achieve high precision and adaptability which are unsurpassable. Besides that, cloud-based platforms comprise functions on storing, sustaining fleets and data, as well as fleet optimizations, which in turn forms a way for centralized tracking, monitoring and updating of software versions for AV fleets. Lanes marking is no less important than environmental perception technology, which primarily provides vehicles' security and enable the diverse applications of positioning and routes optimization, mobile mapping technology. It is also important to mention the significance of the spatial segmentation methods providing the route plan support with the help of the points density cloud and in that way reducing the possibilities of getting lost and result with the navigation error free. This paper has developed the basic functions of lane detection and path segmenting in the autonomous vehicle navigation. A key component of the technology for environmental perception is lanes detection being its primary function for ensuring the safety of vehicles and offering wide range of applications that include positioning, mobile mapping and route optimization among others. The segmentation of path using point cloud data is considered one of the tasks which can extract the meaningful information from the environment," therefore, it is able to identify and classify different areas eventually. Therefore, effective and safe maneuvering is achieved.

Security and privacy are given the priority in the system of an autonomous vehicle. The paper has taken a layered approach in inspecting potential attacks and weaknesses in every level of autonomous car components. Furthermore, it presented. Countering measures and the adoption and utilization of security measures, as well as privacy safeguards to make sure that we have secure and safe making use of autonomous vehicles. Moreover, the article also highlights the problem spots and complexities of judging CAVs accuracy as well.

Finally, Cloud computing tied with the autonomous cars makes a milestone in transportation innovation, efficiency and safety.

This is one of the industries of the future. Therefore, the collaboration among researchers, stakeholders, and decision-makers will provide the keys to the doors of new possibilities.

ABBREVIATIONS:

AVs - Autonomous Vehicles.

AI - Artificial Intelligence.

IoV - Internet of Vehicles.

RPN - Region Proposal Network.

RoIs - Regions of Interest.

OHEM - Online Hard Example Mining.

CNNs - Convolutional Neural Networks.

LiDAR - Light Detection and Ranging.

RI - Range-Image.

UNet - U-Net (neural network architecture).

WSNs - Wireless Sensor Networks.

SA-LPCC - Framework name.

CAVs - Connected and Autonomous Vehicles.

ESPs - Edge Service Providers.

RT3D - Real-Time 3D.

SSF-MOS - Semantic Scene Flow.

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