Literature Review in the Domain of Research (PPD-103)

Guided By

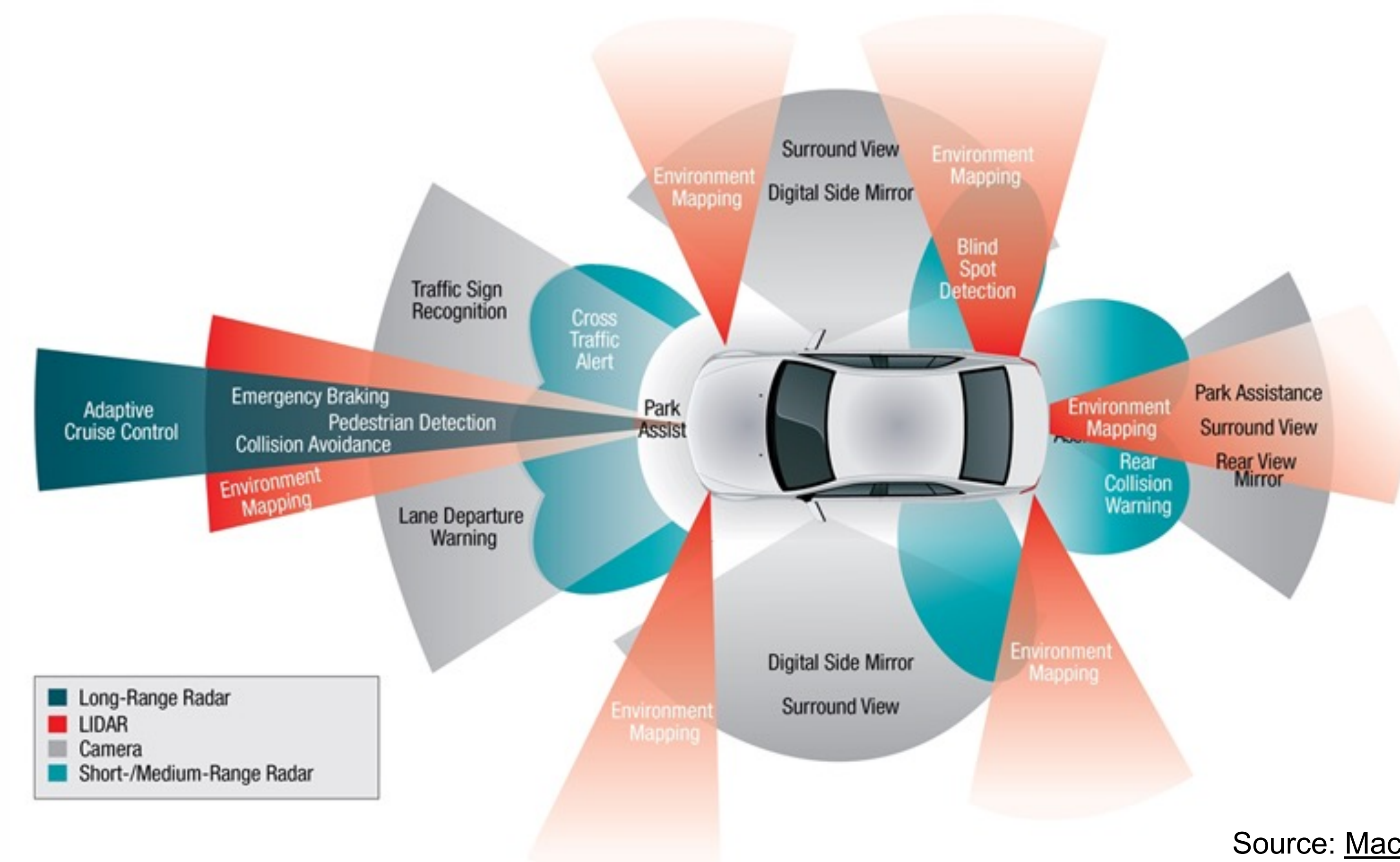
Dr. Suraj Kumar Singh
Associate Professor and Head,
Centre for Climate Change and Water Research, Suresh Gyan Vihar University

Presented By

Shrikrishna Manjrekar
PhD in Geoinformatics
Enrolment No. - PRORS019102319842
SID – 23181828

CONTENTS

"Deep Learning in Digital map for navigation of autonomous vehicles with computer vision and LiDAR information"

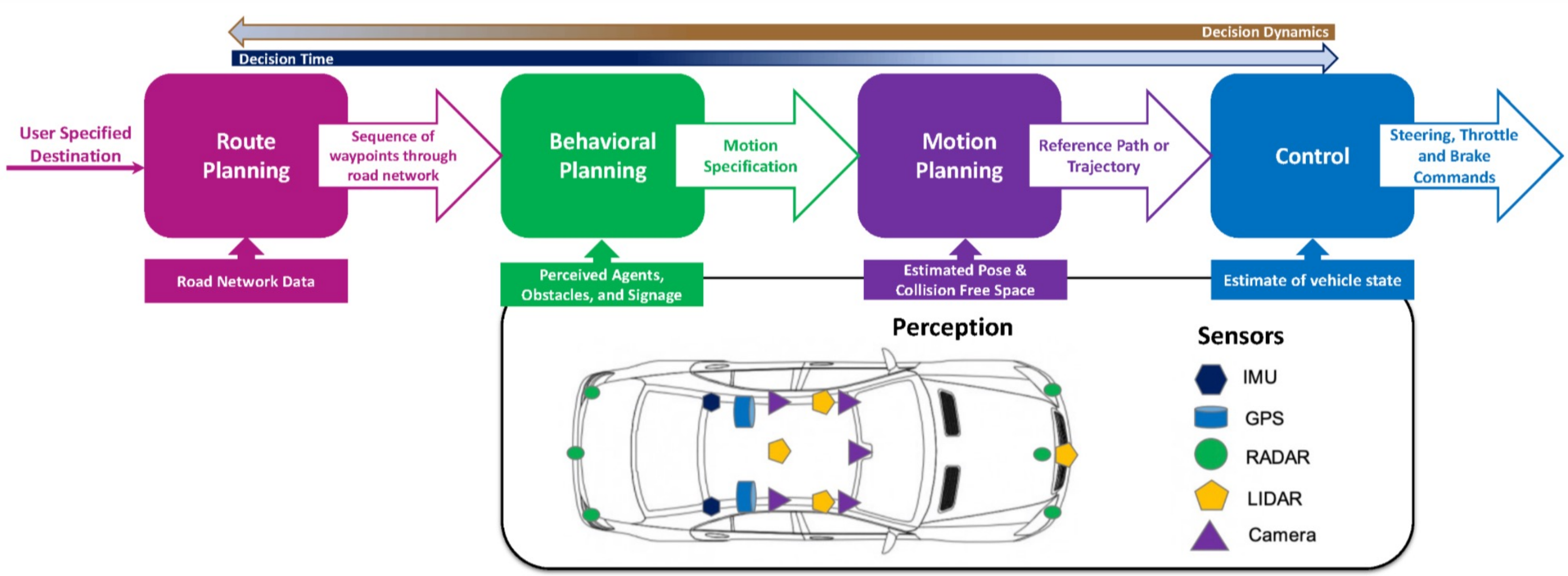


Source: Machine Design

INTRODUCTION

The topic is related to ***"Deep Learning in Digital map for navigation of autonomous vehicles with computer vision and LiDAR information"*** can improve the thorough analysis of deep learning applications in autonomous vehicles for scene perception and object detection.

The use of deep learning has been investigated in several autonomous driving stack components, including perception, prediction, and planning. Additionally, deep learning can be applied to mapping, which is essential for more advanced autonomous driving.



Source: Software Architecture of Autonomous Vehicle

RESEARCH GAP

The literature review suggests several areas where further research can contribute to advancing the field of deep learning in digital maps for the navigation of autonomous vehicles using computer vision and LiDAR information. Some potential research gaps identified are:

1. **Real-time Map Updates:** While the importance of real-time map updates for autonomous vehicles is recognized, there is a lack of research focusing on developing efficient and scalable methods for continuous map updates. Future research could explore novel algorithms or frameworks that enable autonomous vehicles to update high-definition (HD) maps in real-time with minimal latency and computational resources.
2. **Integration of Sensor Data:** The literature emphasizes the integration of various sensors, such as LiDAR, cameras, IMUs, and GPS, for creating HD maps. However, there is a need for research addressing the seamless integration and fusion of heterogeneous sensor data to improve the accuracy and reliability of HD maps. Investigating fusion techniques, sensor calibration methods, and data synchronization algorithms could be fruitful directions for future research.
3. **Adaptation to Dynamic Environments:** Autonomous vehicles operate in dynamic and unpredictable environments, where changes in road conditions, weather, and traffic patterns occur frequently. Existing research mainly focuses on static environments, and there is a gap in understanding how deep learning-based mapping systems can adapt to dynamic environments in real-time. Future research could explore dynamic mapping techniques that can effectively handle changes in the environment and update HD maps accordingly.
4. **Robustness and Generalization:** Deep learning models used for scene perception and object detection in autonomous vehicles need to be robust and generalize well across diverse driving scenarios. However, current research often lacks robustness testing across various environmental conditions, such as different lighting conditions, weather conditions, and road layouts. Future research could focus on developing robust deep learning models that generalize well across different driving scenarios and are less susceptible to environmental variations.
5. **Cost-effective Mapping Solutions:** Creating and maintaining HD maps can be expensive, mainly due to the high costs of sensor equipment and data processing. There is a gap in research exploring cost-effective methods for HD map creation and updates without compromising the accuracy and quality of the maps. Investigating low-cost sensor technologies, data compression techniques, and crowdsourced mapping approaches could be potential avenues for future research.

Addressing these research gaps can significantly advance the field of deep learning in digital maps for autonomous vehicle navigation, ultimately contributing to the development of safer, more efficient, and more reliable autonomous driving systems.

AIMS AND OBJECTIVES OF RESEARCH WORK

Based on the literature review provided, here are tentative aims and objectives for research work in the domain of deep learning in digital maps for the navigation of autonomous vehicles with computer vision and LiDAR information:

Aims:

1. To enhance the accuracy and reliability of High-Definition (HD) maps for autonomous vehicles through the integration of deep learning techniques with computer vision and LiDAR data.
2. To develop efficient methods for real-time map updates, addressing the dynamic nature of the environment and ensuring that autonomous vehicles have access to up-to-date spatial information.
3. To investigate robust deep learning models for scene perception and object detection that generalize well across diverse driving scenarios, including different lighting conditions, weather conditions, and road layouts.
4. To explore cost-effective solutions for HD map creation and maintenance, aiming to reduce the overall cost of autonomous driving systems while maintaining high-quality spatial data.

Objectives:

1. To review and analyze existing deep learning techniques for scene perception and object detection in the context of autonomous vehicle navigation using computer vision and LiDAR data.
2. To develop novel algorithms or frameworks for integrating heterogeneous sensor data (LiDAR, cameras, IMUs, GPS) to improve the accuracy and reliability of HD maps.
3. To design and implement a real-time map updating system that can efficiently incorporate new spatial information into HD maps and distribute updates to autonomous vehicles in the field.
4. To evaluate the performance and robustness of deep learning models for scene perception and object detection across a wide range of driving scenarios, including both simulated and real-world environments.
5. To investigate cost-effective sensor technologies, data compression techniques, and crowdsourced mapping approaches for reducing the cost of HD map creation and maintenance.
6. To validate the effectiveness of the proposed research work through simulations, experiments, and real-world deployment in collaboration with industry partners or autonomous vehicle manufacturers.

These aims and objectives outline a comprehensive research agenda aimed at advancing the state-of-the-art in deep learning-based mapping solutions for autonomous vehicles, addressing key challenges and contributing to the development of safer, more efficient autonomous driving systems.

REVIEW OF LITERATURE

Sr, No.	Publication Year	Date	Area	Title (Name of Paper)	Author	Title (Publication in)	Observation	Specification	Application	Remarks
1	2024	2024-04	Digital Map	**Review and Challenge: High Definition Map Technology for Intelligent Connected Vehicle**	Yang, Mengmeng; Jiang, Kun; Wijaya, Benny; Wen, Tuopu; Miao, Jinyu; Huang, Jin; Zhong, Cao; Zhang, Wei; Chen, Huixian; Yang, Diange	Fundamental Research	This article examines High Definition (HD) map technology, which is essential for Intelligent Connected Vehicles (ICVs). It discusses the current state of HD maps, their technical hurdles, and future outlook. The article highlights the importance of HD maps in improving the accuracy and safety of autonomous driving.	The article discusses HD map creation, update mechanisms, data management, and integration with vehicle systems. It identifies technical challenges such as accuracy, real-time updating, data storage, and security.	**H**D maps are crucial for autonomous driving, providing accurate environmental data essential for navigation and decision-making. HD maps enable real-time data exchange between vehicles and infrastructure, improving traffic management and safety through V2X communication. HD maps enhance the functionality of ADAS by offering precise road geometry, traffic signs, and obstacle information.	The article highlights advancements in sensors, machine learning, and data processing that have driven HD map development. Key challenges include maintaining map data accuracy and timeliness, ensuring data security, and managing the massive data volume generated.
2	2024	2024-05	Autonomous Vehicle	**Autonomous driving system: A comprehensive survey**	Zhao, Jingyuan; Zhao, Wenyi; Deng, Bo; Wang, Zhenghong; Zhang, Feng; Zheng, Wenxiang; Cao, Wanke; Nan, Jinrui; Lian, Yubo; Burke, Andrew F.	Expert Systems with Applications	The article comprehensively surveys autonomous driving systems (ADS), covering their current status, underlying technologies, and future outlook. The study examines key ADS aspects like perception, decision-making, control, and system architecture. It also discusses ADS integration with other technologies and the challenges in developing fully autonomous vehicles.	The article explores the ADS components, including sensors, algorithms, computing platforms, and connectivity. It emphasizes the importance of machine learning, computer vision, and sensor fusion in advancing ADS capabilities.	The survey highlights the use of sensors and algorithms for perception, including object detection, recognition, and tracking, which are crucial for vehicle awareness and navigation. It discusses how ADS employs AI and machine learning for path planning, obstacle avoidance, and real-time decision-making.	The article highlights the complexity of ADS, requiring advancements across hardware, software, and networking domains. It identifies challenges such as ensuring robustness and reliability in diverse conditions, real-time processing, and addressing ethical and regulatory issues.

REVIEW OF LITERATURE

Sr. No.	Publication Year	Date	Area	Title (Name of Paper)	Author	Title (Publication in)	Observation	Specification	Application	Remarks
3	2023	2023-06	Digital Map	**A review of high-definition map creation methods for autonomous driving**	Bao, Zhibin; Hossain, Sabir; Lang, Haoxiang; Lin, Xianke	Engineering Applications of Artificial Intelligence	The article reviews the methods used to create high-definition (HD) maps for autonomous driving. It examines the techniques, technologies, and processes involved in generating accurate and detailed maps, which are critical for the safe and efficient operation of autonomous vehicles.	The article explores the methods and technologies for creating HD maps, including data collection, processing, fusion, and validation. It also discusses the challenges and future prospects of HD map creation for autonomous driving.	HD maps are crucial for autonomous vehicle navigation, providing detailed information about road geometry, lane markings, traffic signs, and infrastructure. HD maps assist in path planning, route optimization, and real-time decision-making by offering accurate and up-to-date environmental data.	The article discusses mapping techniques, including surveying, mobile mapping, LiDAR-based mapping, and crowdsourcing, highlighting their advantages and limitations. It emphasizes the importance of integrating data from multiple sources, such as LiDAR, cameras, GPS, and satellite imagery, to create comprehensive and accurate HD maps
4	2023	2023-12	Computer Vision	**A comprehensive study on lane detecting autonomous car using computer vision**	Gajjar, Henil; Sanyal, Stavan; Shah, Manan	Expert Systems with Applications	The article presents a comprehensive study on developing and implementing a lane-detecting autonomous car system using computer vision. It investigates various lane detection algorithms, their performance in different conditions, and the integration of these algorithms into an autonomous driving framework.	The article focuses on using computer vision techniques for lane detection in autonomous vehicles, covering topics like image processing, feature extraction, machine learning, and the challenges of real-world implementation.	Lane detection is a crucial component of autonomous driving, enabling accurate identification and tracking of lane markings for safe and reliable navigation. Lane detection algorithms can also be used in advanced driver assistance systems (ADAS) to provide warnings and assistance to human drivers, enhancing overall road safety.	The article evaluates various lane detection algorithms, including traditional computer vision and deep learning approaches, comparing their accuracy, robustness, and computational efficiency. It discusses the challenges of deploying lane detection systems in real-world scenarios, such as varying lighting, road markings, weather, and occlusions

REVIEW OF LITERATURE

Sr, No.	Publication Year	Date	Area	Title (Name of Paper)	Author	Title (Publication in)	Observation	Specification	Application	Remarks
5	2022	2022-07	Object recognition	**Object recognition datasets and challenges: A review**	Salari, Aria; Djavadifar, Abtin; Liu, Xiangrui; Najjaran, Homayoun	Neurocomputing	The article provides a thorough analysis of object identification problems and datasets. It explores several facets of datasets used for training and assessing object identification systems in the field of computer vision.	The article focuses on object recognition datasets from tasks such as semantic segmentation, object detection, and image classification that are utilized in computer vision research.	Algorithm Development: For a variety of tasks like picture classification, object detection, and semantic segmentation, object recognition datasets are essential resources for training and assessing computer vision algorithms, including deep learning models.	Features of the Dataset: The review talks about the features of widely used datasets for object identification, such as their size, diversity, quality of annotations, number of classes, and domain specialization.
6	2022	2022-07	Computer Vision	**Vision-based mapping of lane semantics and topology for intelligent vehicles**	Tian, Wei; Ren, Xiaozhou; Yu, Xianwang; Wu, Mingzhi; Zhao, Wenbo; Li, Qiaosen	International Journal of Applied Earth Observation and Geoinformation	The article focuses on mapping methods based on vision that are specifically designed for intelligent cars. In particular, it investigates how computer vision techniques might be used to map lane semantics and topology. This entails recognizing and comprehending the layout and properties of lanes in road environments to support autonomous cars' navigation and decision-making.	The focus of the essay is on the creation and implementation of vision-based mapping approaches to enable intelligent vehicle navigation systems by comprehending lane semantics (like lane markings and types) and topology (like lane connections and intersections).	Autonomous Driving: To enable safe and effective navigation in a variety of traffic circumstances, autonomous cars must be able to precisely perceive and interpret lane markings, traffic laws, and road geometry. This requires vision-based lane mapping. Advanced Driver Assistance Systems (ADAS): By offering real-time lane information for features like adaptive cruise control, lane-keeping assistance, and lane departure warning, lane semantics and topology mapping can improve ADAS functionality.	Vision-Based Mapping Techniques: Image processing, feature extraction, lane identification algorithms, and semantic segmentation techniques are some of the computer vision techniques covered in this article for lane semantics and topological mapping. Obstacles: It tackles obstacles related to vision-based mapping, like changes in illumination, occlusions, deteriorating lane markings, and the existence of dynamic objects (like pedestrians and other cars) in the scene.

REVIEW OF LITERATURE

Sr. No.	Publication Year	Date	Area	Title (Name of Paper)	Author	Title (Publication in)	Observation	Specification	Application	Remarks
7	2022	2022-07-06	Deep learning	**Vision-Based Autonomous Vehicle Systems Based on Deep Learning: A Systematic Literature Review**	Pavel, Monirul Islam; Tan, Siok Yee; Abdullah, Azizi	Applied Sciences	This paper reviews the literature systematically with an emphasis on deep learning-based vision-based autonomous driving systems. It thoroughly reviews the body of research on the topic, evaluating deep learning-based approaches' performance, algorithms, and methods in relation to several facets of autonomous car systems.	The paper presents a thorough analysis of the literature on vision-based autonomous car systems, with a particular emphasis on deep learning methods. It addresses subjects like mapping, perception, localization, control, and path planning.	Autonomous Driving: Vision systems based on deep learning are essential to autonomous driving because they allow cars to see their environment, recognize objects, comprehend traffic signals, and travel effectively and securely. Advanced Driver Assistance Systems (ADAS): These systems, which include functions like automated emergency braking, adaptive cruise control, lane departure warning, and pedestrian recognition, are also essential to ADAS applications.	Methodological insights: The paper offers information on the methodology, training plans, network topologies, and data augmentation tactics employed in the development of deep learning-based autonomous car systems. Performance Evaluation: This section addresses the methods and performance measures used to evaluate the dependability and efficiency of deep learning models for a range of autonomous driving applications.
8	2021	2021-07	Deep learning	**Deep learning for object detection and scene perception in self-driving cars: Survey, challenges, and open issues**	Gupta, Abhishek; Anpalagan, Alagan; Guan, Ling; Khwaja, Ahmed Shaharyar	Array	An extensive survey of the use of deep learning approaches for object recognition and scene perception in self-driving automobiles is included in this paper. It explores a number of topics, such as approaches, difficulties, and unresolved problems with using deep learning to improve autonomous cars' perceptive abilities.	In the context of self-driving automobiles, the article focuses on the use of deep learning techniques for object recognition and scene perception. It addresses issues including sensor fusion, model designs, data preprocessing, and practical difficulties.	Autonomous Driving: The key components of autonomous driving technology are deep learning-based object identification and scene perception systems, which allow cars to recognize and understand objects, people, traffic signs, and other important environmental aspects.	Overview of Deep Learning Techniques: This paper offers a thorough overview of the deep learning techniques, such as convolutional neural networks (CNNs), recurrent neural networks (RNNs), and their variations, that are employed in self-driving cars for object detection and scene perception.

Sr. No.	Publication Year	Date	Area	Title (Name of Paper)	Author	Title (Publication in)	Observation	Specificatin	Application	Remarks
9	2021	2021-12	LiDAR	**Positioning and perception in LIDAR point clouds**	Benedek, Csaba; Majdik, Andras; Nagy, Balazs; Rozsa, Zoltan; Sziranyi, Tamas	Digital Signal Processing	The essay focuses on using LIDAR point clouds for positioning and perception problems. It investigates strategies and tactics for precisely locating things and comprehending their spatial relationships using information from LIDAR sensors.	This paper focuses on using LIDAR point clouds for perception and positioning tasks such as tracking, localization, object detection, and mapping.	Autonomous cars: In order for autonomous cars to recognize and comprehend their environment, LIDAR point cloud data is essential. It makes obstacle recognition, environment localization, and navigational mapping of the surrounding area possible.	Data Processing Methods: Point cloud segmentation, feature extraction, and clustering algorithms are just a few of the data processing methods that are covered in this article for studying LIDAR point clouds.
10	2021	2021-12	Deep learning	**Autonomous Driving Architectures: Insights of Machine Learning and Deep Learning Algorithms**	Bachute, Mrinal R.; Subhedar, Javed M.	Machine Learning with Applications	The paper by offers insights into architectures for autonomous driving with a particular emphasis on the use of deep learning and machine learning techniques. It investigates different architectures, approaches, and algorithms that are employed in autonomous car systems to facilitate perception, control, and decision-making.	The paper focuses on architectures for autonomous driving and offers information on how machine learning and deep learning algorithms are used for different tasks in these systems.	Autonomous Driving Systems: The article's observations are relevant to the creation of autonomous driving systems, which depend on sophisticated algorithms to perform tasks including perception, judgment, and control. Advanced Driver Assistance Systems (ADAS): The concepts covered here can also be used to create ADAS systems, which help human drivers with lane-keeping assistance, adaptive cruise control, and collision avoidance, among other driving-related tasks.	Algorithm Insights: Convolutional neural networks (CNNs), recurrent neural networks (RNNs), and reinforcement learning algorithms are just a few of the machine learning and deep learning algorithms covered in this article that are utilized in autonomous driving frameworks. The design and structure of autonomous driving architectures, including perception modules, sensor fusion, localization, mapping, planning, and control, are covered in this section on architectural design.

METHODOLOGY / LABORATORY WORK

Based on the literature review provided and the identified aims and objectives, here's a tentative methodology for conducting laboratory work in the domain of deep learning in digital maps for the navigation of autonomous vehicles with computer vision and LiDAR information:

Methodology:

1. **Data Collection and Preprocessing:**
   - Gather diverse datasets containing LiDAR point cloud data, camera images, IMU data, GPS data, and corresponding ground truth annotations for scene perception and object detection tasks.
   - Preprocess the collected data to remove noise, perform sensor calibration, synchronize timestamps, and align coordinate systems for fusion.

2. **Algorithm Development:**
   - Develop deep learning models for scene perception and object detection tasks using computer vision techniques.
   - Experiment with various network architectures such as Convolutional Neural Networks (CNNs), Recurrent Neural Networks (RNNs), and Transformer-based models to optimize performance.
   - Explore techniques for multi-sensor fusion to integrate information from LiDAR, cameras, IMUs, and GPS for improved accuracy.

3. **Real-time Map Updating System:**
   - Design and implement algorithms for real-time map updates, considering the dynamic nature of the environment and the need for continuous spatial information.
   - Develop mechanisms for efficiently processing incoming sensor data, identifying changes in the environment, and updating the HD maps accordingly.
   - Investigate strategies for distributing map updates to autonomous vehicles in the field, considering bandwidth constraints and latency requirements.

4. **Performance Evaluation:**
   - Conduct comprehensive evaluations of the developed algorithms and systems using benchmark datasets and simulation environments.
   - Assess the accuracy, reliability, and robustness of HD maps and scene perception/object detection models across various driving scenarios.
   - Analyze performance metrics such as precision, recall, F1 score, and processing time to quantify the effectiveness of the proposed solutions.

5. **Cost-effective Mapping Solutions:**
   - Investigate cost-effective sensor technologies, such as low-cost LiDAR sensors and consumer-grade cameras, for data collection.
   - Explore data compression techniques and sparse representation methods to reduce the storage and transmission costs of HD maps.
   - Evaluate crowdsourcing approaches for map creation and maintenance, leveraging data contributed by autonomous vehicles and other sources.

6. **Validation and Deployment:**
   - Validate the effectiveness of the developed methodologies through simulations, experiments in controlled environments, and real-world testing.
   - Collaborate with industry partners or autonomous vehicle manufacturers to deploy the research findings in prototype autonomous driving systems.
   - Collect feedback from end-users and stakeholders to iteratively improve the proposed solutions and address practical challenges.

By following this methodology, we can conduct laboratory work to advance the state-of-the-art in deep learning-based mapping solutions for autonomous vehicles, addressing key challenges identified in the literature review and contributing to the development of safer and more efficient autonomous driving systems.

FORMULATION OF RESEARCH HYPOTHESIS WITH EXPECTED OUTCOMES

When conducting research on deep learning in mapping for autonomous driving, several research questions and hypotheses has guided the investigation. Here are some examples:

1. *Research Question: Can deep learning models accurately and robustly detect and classify different objects in the environment for mapping in autonomous driving?*
   Hypothesis: Deep learning models, such as convolutional neural networks (CNNs), can achieve high accuracy and robustness in object detection and classification tasks, enabling accurate mapping in autonomous driving systems.

2. *Research Question: How can deep learning models effectively leverage multimodal sensor data for mapping in autonomous driving?*
   Hypothesis: By fusing and integrating data from multiple sensors, such as cameras, LiDAR, radar, and GPS, deep learning models can improve the accuracy and reliability of mapping, enabling more comprehensive perception of the environment.

3. *Research Question: Can deep learning models efficiently perform real-time semantic segmentation for mapping in autonomous driving?*
   Hypothesis: Deep learning models, specifically designed for real-time performance, can accurately and efficiently perform semantic segmentation tasks, enabling precise mapping of different objects and regions in the environment.

4. *Research Question: How can deep learning models handle uncertainty estimation and propagate uncertainties in mapping tasks for autonomous driving?*
   Hypothesis: By incorporating probabilistic modeling and uncertainty estimation techniques, deep learning models can provide more reliable and robust mapping results, accounting for uncertainties in sensor measurements and environmental variations.

5. *Research Question: Can deep reinforcement learning be applied to learn and adapt mapping strategies in complex and dynamic environments for autonomous driving?*
   Hypothesis: Deep reinforcement learning algorithms can enable autonomous driving systems to learn and adapt mapping strategies in real-time, allowing them to navigate complex and dynamic environments effectively.

6. *Research Question: How can deep learning models be made more interpretable and explainable for mapping decisions in autonomous driving?*
   Hypothesis: By developing methods to interpret and explain the decisions made by deep learning models, users can gain a better understanding of the mapping process and trust the decisions made by autonomous driving systems.

These research questions and hypotheses has provided a starting point for investigating various aspects of deep learning in mapping for autonomous driving. We can design experiments, develop novel algorithms, and analyze results to validate or refute these hypotheses, thereby advancing the understanding and capabilities of deep learning in this domain.

SIGNIFICANCE OF RESEARCH

The significance of research in the domain of deep learning in digital maps for the navigation of autonomous vehicles with computer vision and LiDAR information is multifaceted and crucial for the advancement of autonomous driving technology. This research holds the potential to:

1. **Enhance Autonomous Vehicle Safety and Reliability:**
   - Deep learning-based mapping solutions enable autonomous vehicles to perceive and understand their environment with unprecedented accuracy and reliability. By integrating computer vision and LiDAR information into high-definition (HD) maps, autonomous vehicles can make informed decisions in real-time, leading to safer navigation and reduced accident rates.

2. **Enable Higher Levels of Autonomy:**
   - Advanced mapping technologies empower autonomous vehicles to operate at higher levels of autonomy (e.g., Level 4 and Level 5), where human intervention is minimal or unnecessary.
   - By leveraging deep learning techniques, autonomous vehicles can navigate complex road scenarios, including urban environments, highways, and challenging weather conditions, without human intervention.

3. **Improve Efficiency and Convenience:**
   - Accurate HD maps, continuously updated in real-time, streamline autonomous vehicle navigation and optimize route planning, leading to more efficient and time-saving transportation.
   - Enhanced scene perception and object detection capabilities enable autonomous vehicles to anticipate and react to dynamic traffic conditions, reducing congestion and travel times for passengers.

4. **Pave the Way for Mass Adoption of Autonomous Vehicles:**
   - This research addresses critical challenges hindering the widespread adoption of autonomous vehicles, such as safety concerns, regulatory hurdles, and technological limitations.
   - By advancing the capabilities of autonomous driving systems, this research contributes to building public trust and confidence in autonomous vehicle technology, accelerating its integration into mainstream transportation networks.

5. **Facilitate Innovation and Industry Growth:**
   - Continued research in this domain fosters innovation and drives technological advancements in the automotive industry, spurring economic growth and creating new opportunities for businesses and entrepreneurs.
   - Collaboration between academia, industry, and government stakeholders facilitates knowledge exchange, technology transfer, and the development of standardized practices and protocols for autonomous driving systems.

6. **Address Societal Challenges and Environmental Impact:**
   - Autonomous vehicles have the potential to address societal challenges such as mobility access for the elderly and disabled, urban congestion, and road safety.
   - By promoting the adoption of electric and shared autonomous vehicles, this research contributes to reducing greenhouse gas emissions and mitigating the environmental impact of transportation.

In summary, research in deep learning-based mapping solutions for autonomous vehicles holds significant promise in revolutionizing the way we perceive, interact with, and benefit from transportation systems. By addressing key challenges and harnessing the power of emerging technologies, this research has the potential to reshape the future of mobility, making transportation safer, more efficient, and more accessible for all.

BIBLIOGRAPHY

1. Adnan Yusuf, Syed, Arshad Khan, and Riad Souissi. “Vehicle-to-Everything (V2X) in the Autonomous Vehicles Domain – A Technical Review of Communication, Sensor, and AI Technologies for Road User Safety.” Transportation Research Interdisciplinary Perspectives 23 (2024): 100980. https://doi.org/10.1016/j.trip.2023.100980

2. Aggarwal, Shubhani, and Neeraj Kumar. “Path Planning Techniques for Unmanned Aerial Vehicles: A Review, Solutions, and Challenges.” Computer Communications 149 (2020): 270–99. https://doi.org/10.1016/j.comcom.2019.10.014

3. Ahmad, Khlood, Mohamed Abdelrazek, Chetan Arora, Muneera Bano, and John Grundy. “Requirements Engineering for Artificial Intelligence Systems: A Systematic Mapping Study.” Information and Software Technology 158 (2023): 107176. https://doi.org/10.1016/j.infsof.2023.107176

4. Bachute, Mrinal R., and Javed M. Subhedar. “Autonomous Driving Architectures: Insights of Machine Learning and Deep Learning Algorithms.” Machine Learning with Applications 6 (2021): 100164. https://doi.org/10.1016/j.mlwa.2021.100164

5. Balaska, Vasiliki, Loukas Bampis, and Antonios Gasteratos. “Self-Localization Based on Terrestrial and Satellite Semantics.” Engineering Applications of Artificial Intelligence 111 (2022): 104824. https://doi.org/10.1016/j.engappai.2022.104824

6. Bao, Zhibin, Sabir Hossain, Haoxiang Lang, and Xianke Lin. “A Review of High-Definition Map Creation Methods for Autonomous Driving.” Engineering Applications of Artificial Intelligence 122 (2023): 106125. https://doi.org/10.1016/j.engappai.2023.106125

7. Bellusci, Matteo, Paolo Cudrano, Simone Mentasti, Riccardo Erminio Filippo Cortelazzo, and Matteo Matteucci. “Semantic Interpretation of Raw Survey Vehicle Sensory Data for Lane-Level HD Map Generation.” Robotics and Autonomous Systems 172 (2024): 104513. https://doi.org/10.1016/j.robot.2023.104513

8. Benedek, Csaba, Andras Majdik, Balazs Nagy, Zoltan Rozsa, and Tamas Sziranyi. "Positioning and Perception in LIDAR Point Clouds." Digital Signal Processing 119 (2021): 103193. https://doi.org/10.1016/j.dsp.2021.103193

9. Chan, Kit Yan, Bilal Abu-Salih, Raneem Qaddoura, Ala' M. Al-Zoubi, Vasile Palade, Duc-Son Pham, Javier Del Ser, and Khan Muhammad. "Deep Neural Networks in the Cloud: Review, Applications, Challenges and Research Directions." Neurocomputing 545 (2023): 126327. https://doi.org/10.1016/j.neucom.2023.126327

10. Chintalapati, Bharadwaj, Arthur Precht, Sougata Hanra, Rene Laufer, Marcus Liwicki, and Jens Eickhoff. "Opportunities and Challenges of On-Board AI-Based Image Recognition for Small Satellite Earth Observation Missions." Advances in Space Research, 2024, S0273117724002886. https://doi.org/10.1016/j.asr.2024.03.053

11. Damaj, Issam W., Dina K. Serhal, Lama A. Hamandi, Rached N. Zantout, and Hussein T. Mouftah. "Connected and Autonomous Electric Vehicles: Quality of Experience Survey and Taxonomy." Vehicular Communications 28 (2021): 100312. https://doi.org/10.1016/j.vehcom.2020.100312

12. Damsgaard, Hans Jakob, Antoine Grenier, Dewant Katare, Zain Taufique, Salar Shakibhamedan, Tiago Troccoli, Georgios Chatzitsompanis, et al. "Adaptive Approximate Computing in Edge AI and IoT Applications: A Review." Journal of Systems Architecture 150 (2024): 103114. https://doi.org/10.1016/j.sysarc.2024.103114

13. De La Torre, Gonzalo, Paul Rad, and Kim-Kwang Raymond Choo. "Driverless Vehicle Security: Challenges and Future Research Opportunities." Future Generation Computer Systems 108 (2020): 1092–1111.https://doi.org/10.1016/j.future.2017.12.041

14. Elallid, Badr Ben, Nabil Benamar, Abdelhakim Senhaji Hafid, Tajjeeddine Rachidi, and Nabil Mrani. "A Comprehensive Survey on the Application of Deep and Reinforcement Learning Approaches in Autonomous Driving." Journal of King Saud University - Computer and Information Sciences 34, no. 9 (2022): 7366–90. https://doi.org/10.1016/j.jksuci.2022.03.013

15. Elliott, David, Walter Keen, and Lei Miao. “Recent Advances in Connected and Automated Vehicles.” Journal of Traffic and Transportation Engineering (English Edition) 6, no. 2 (2019): 109–31. https://doi.org/10.1016/j.jtte.2018.09.005

16. Fernandez, Felipe, Angel Sanchez, Jose F. Velez, and Belen Moreno. “Associated Reality: A Cognitive Human–Machine Layer for Autonomous Driving.” Robotics and Autonomous Systems 133 (2020): 103624. https://doi.org/10.1016/j.robot.2020.103624

17. Flores-Fuentes, Wendy, Gabriel Trujillo-Hernández, Iván Y. Alba-Corpus, Julio C. Rodríguez-Quiñonez, Jesús E. Mirada-Vega, Daniel Hernández-Balbuena, Fabian N. Murrieta-Rico, and Oleg Sergiyenko. “3D Spatial Measurement for Model Reconstruction: A Review.” Measurement 207 (2023): 112321. https://doi.org/10.1016/j.measurement.2022.112321

18. Fontana, Simone, Daniele Cattaneo, Augusto L. Ballardini, Matteo Vaghi, and Domenico G. Sorrenti. “A Benchmark for Point Clouds Registration Algorithms.” Robotics and Autonomous Systems 140 (2021): 103734. https://doi.org/10.1016/j.robot.2021.103734

19. Gajjar, Henil, Stavan Sanyal, and Manan Shah. “A Comprehensive Study on Lane Detecting Autonomous Car Using Computer Vision.” Expert Systems with Applications 233 (2023): 120929. https://doi.org/10.1016/j.eswa.2023.120929

20. Gouda, Maged, Ishaat Chowdhury, Jonas Weiß, Alexander Epp, and Karim El-Basyouny. “Automated Assessment of Infrastructure Preparedness for Autonomous Vehicles.” Automation in Construction 129 (2021): 103820. https://doi.org/10.1016/j.autcon.2021.103820

21. Gupta, Abhishek, Alagan Anpalagan, Ling Guan, and Ahmed Shaharyar Khwaja. “Deep Learning for Object Detection and Scene Perception in Self-Driving Cars: Survey, Challenges, and Open Issues.” Array 10 (2021): 100057. https://doi.org/10.1016/j.array.2021.100057

BIBLOGRAPHY

22. Jawad, Aqeel Thamer, Rihab Maaloul, and Lamia Chaari. “A Comprehensive Survey on 6G and beyond: Enabling Technologies, Opportunities of Machine Learning and Challenges.” Computer Networks 237 (2023): 110085. https://doi.org/10.1016/j.comnet.2023.110085

23. Keshari, Niharika, Dinesh Singh, and Ashish Kumar Maurya. “A Survey on Vehicular Fog Computing: Current State-of-the-Art and Future Directions.” Vehicular Communications 38 (2022): 100512. https://doi.org/10.1016/j.vehcom.2022.100512

24. Khan, Manzoor Ahmed, Hesham El Sayed, Sumbal Malik, Muhammad Talha Zia, Najla Alkaabi, and Jalal Khan. “A Journey towards Fully Autonomous Driving - Fueled by a Smart Communication System.” Vehicular Communications36 (2022): 100476. https://doi.org/10.1016/j.vehcom.2022.100476

25. Kirişci, Murat. “Interval-Valued Fermatean Fuzzy Based Risk Assessment for Self-Driving Vehicles.” Applied Soft Computing 152 (2024): 111265. https://doi.org/10.1016/j.asoc.2024.111265

26. Limbasiya, Trupil, Ko Zheng Teng, Sudipta Chattopadhyay, and Jianying Zhou. “A Systematic Survey of Attack Detection and Prevention in Connected and Autonomous Vehicles.” Vehicular Communications 37 (2022): 100515. https://doi.org/10.1016/j.vehcom.2022.100515

27. Meng, Xiaofeng, Yong Li, Ke Liu, Yu Liu, Bin Yang, Xuan Song, Guoqiong Liao, et al. “Spatial Data Intelligence and City Metaverse: A Review.” Fundamental Research, 2023, S2667325823003527. https://doi.org/10.1016/j.fmre.2023.10.014

28. Miglani, Arzoo, and Neeraj Kumar. “Deep Learning Models for Traffic Flow Prediction in Autonomous Vehicles: A Review, Solutions, and Challenges.” Vehicular Communications 20 (2019): 100184. https://doi.org/10.1016/j.vehcom.2019.100184

29. Mora, Luca, Xinyi Wu, and Anastasia Panori. "Mind the Gap: Developments in Autonomous Driving Research and the Sustainability Challenge." Journal of Cleaner Production 275 (2020): 124087. https://doi.org/10.1016/j.jclepro.2020.124087

30. Pavel, Monirul Islam, Siok Yee Tan, and Azizi Abdullah. "Vision-Based Autonomous Vehicle Systems Based on Deep Learning: A Systematic Literature Review." Applied Sciences 12, no. 14 (July 6, 2022): 6831. https://doi.org/10.3390/app12146831

31. Perumal, P. Shunmuga, M. Sujasree, Suresh Chavhan, Deepak Gupta, Venkat Mukthineni, Soorya Ram Shimgekar, Ashish Khanna, and Giancarlo Fortino. "An Insight into Crash Avoidance and Overtaking Advice Systems for Autonomous Vehicles: A Review, Challenges and Solutions." Engineering Applications of Artificial Intelligence 104 (2021): 104406. https://doi.org/10.1016/j.engappai.2021.104406

32. Qiao, Liang, Yujie Li, Dongliang Chen, Seiichi Serikawa, Mohsen Guizani, and Zhihan Lv. "A Survey on 5G/6G, AI, and Robotics." Computers and Electrical Engineering 95 (2021): 107372. https://doi.org/10.1016/j.compeleceng.2021.107372

33. R, Dhinesh Kumar, and Rammohan A. "Revolutionizing Intelligent Transportation Systems with Cellular Vehicle-to-Everything (C-V2X) Technology: Current Trends, Use Cases, Emerging Technologies, Standardization Bodies, Industry Analytics and Future Directions." Vehicular Communications 43 (2023): 100638. https://doi.org/10.1016/j.vehcom.2023.100638

34. Salari, Aria, Abtin Djavadifar, Xiangrui Liu, and Homayoun Najjaran. "Object Recognition Datasets and Challenges: A Review." Neurocomputing 495 (2022): 129–52. https://doi.org/10.1016/j.neucom.2022.01.022

35. Shao, Sihua, and Abdallah Khreishah. "Harnessing Retroreflective Transportation Infrastructure for Intelligent Vehicle Positioning." Vehicular Communications 24 (2020): 100246. https://doi.org/10.1016/j.vehcom.2020.100246

36. Sheth, Karan, Keyur Patel, Het Shah, Sudeep Tanwar, Rajesh Gupta, and Neeraj Kumar. "A Taxonomy of AI Techniques for 6G Communication Networks." Computer Communications 161 (2020): 279–303. https://doi.org/10.1016/j.comcom.2020.07.035

37. Shit, Rathin Chandra. "Precise Localization for Achieving Next-Generation Autonomous Navigation: State-of-the-Art, Taxonomy and Future Prospects." Computer Communications 160 (2020): 351–74. https://doi.org/10.1016/j.comcom.2020.06.007

38. ———. "Precise Localization for Achieving Next-Generation Autonomous Navigation: State-of-the-Art, Taxonomy and Future Prospects." Computer Communications 160 (2020): 351–74. https://doi.org/10.1016/j.comcom.2020.06.007

39. Singh, Pranav Kumar, Sunit Kumar Nandi, and Sukumar Nandi. "A Tutorial Survey on Vehicular Communication State of the Art, and Future Research Directions." Vehicular Communications 18 (2019): 100164. https://doi.org/10.1016/j.vehcom.2019.100164

40. Thakur, Abhishek, and Sudhansu Kumar Mishra. "An In-Depth Evaluation of Deep Learning-Enabled Adaptive Approaches for Detecting Obstacles Using Sensor-Fused Data in Autonomous Vehicles." Engineering Applications of Artificial Intelligence 133 (2024): 108550. https://doi.org/10.1016/j.engappai.2024.108550

41. Tian, Wei, Xiaozhou Ren, Xianwang Yu, Mingzhi Wu, Wenbo Zhao, and Qiaosen Li. "Vision-Based Mapping of Lane Semantics and Topology for Intelligent Vehicles." International Journal of Applied Earth Observation and Geoinformation 111 (2022): 102851. https://doi.org/10.1016/j.jag.2022.102851

42. Wang, Xiong, Tianpeng Wei, Linghe Kong, Liang He, Fan Wu, and Guihai Chen. "ECASS: Edge Computing Based Auxiliary Sensing System for Self-Driving Vehicles." Journal of Systems Architecture 97 (2019): 258–68. https://doi.org/10.1016/j.sysarc.2019.02.014

43. Wu, Zhenyu, Kai Qiu, and Hongbo Gao. "Driving Policies of V2X Autonomous Vehicles Based on Reinforcement Learning Methods." IET Intelligent Transport Systems 14, no. 5 (2020): 331–37. https://doi.org/10.1049/iet-its.2019.0457

44. Yang, Mengmeng, Kun Jiang, Benny Wijaya, Tuopu Wen, Jinyu Miao, Jin Huang, Cao Zhong, Wei Zhang, Huixian Chen, and Diange Yang. "Review and Challenge: High Definition Map Technology for Intelligent Connected Vehicle." Fundamental Research, 2024, S2667325824000268. https://doi.org/10.1016/j.fmre.2024.01.006

45. Yoneda, Keisuke, Naoki Suganuma, Ryo Yanase, and Mohammad Aldibaja. "Automated Driving Recognition Technologies for Adverse Weather Conditions." IATSS Research 43, no. 4 (2019): 253–62. https://doi.org/10.1016/j.iatssr.2019.11.005

46. Zaidan, R.A., A.H. Alamoodi, B.B. Zaidan, A.A. Zaidan, O.S. Albahri, Mohammed Talal, Salem Garfan, et al. "Comprehensive Driver Behaviour Review: Taxonomy, Issues and Challenges, Motivations and Research Direction towards Achieving a Smart Transportation Environment." Engineering Applications of Artificial Intelligence 111 (2022): 104745. https://doi.org/10.1016/j.engappai.2022.104745

47. Zali, Nader, Sara Amiri, Tan Yigitcanlar, and Ali Soltani. "Autonomous Vehicle Adoption in Developing Countries: Futurist Insights." Energies 15, no. 22 (November 12, 2022): 8464. https://doi.org/10.3390/en15228464

48. Zhang, Yuxiao, Alexander Carballo, Hanting Yang, and Kazuya Takeda. "Perception and Sensing for Autonomous Vehicles under Adverse Weather Conditions: A Survey." ISPRS Journal of Photogrammetry and Remote Sensing 196 (2023): 146–77. https://doi.org/10.1016/j.isprsjprs.2022.12.021

49. Zhao, Jingyuan, Wenyi Zhao, Bo Deng, Zhenghong Wang, Feng Zhang, Wenxiang Zheng, Wanke Cao, Jinrui Nan, Yubo Lian, and Andrew F. Burke. "Autonomous Driving System: A Comprehensive Survey." Expert Systems with Applications 242 (2024): 122836. https://doi.org/10.1016/j.eswa.2023.122836

50. Zhuang, Yuan, Xiao Sun, You Li, Jianzhu Huai, Luchi Hua, Xiansheng Yang, Xiaoxiang Cao, et al. "Multi-Sensor Integrated Navigation/Positioning Systems Using Data Fusion: From Analytics-Based to Learning-Based Approaches." Information Fusion 95 (2023): 62–90. https://doi.org/10.1016/j.inffus.2023.01.025


Thank you