Applications of Computer Vision in Transportation Systems: A Systematic Literature Review

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Abstract—This research presents a bibliometric analysis focusing on practical applications of computer vision in transportation systems. The study offers a nuanced understanding of the topic, emphasizing its relevance to areas such as traffic surveillance, management, and road safety. By synthesizing insights from various studies, the analysis provides a comprehensive overview that serves as a valuable foundation for informed decision-making by policymakers and practitioners. The discussion not only highlights current applications but also identifies gaps and limitations in the existing literature. Furthermore, the study offers future directions for the integration of computer vision technologies into diverse transportation scenarios and suggests innovative ideas to overcome current limitations.

Index Terms—Computer Vision, Transportation System, CNN, YOLO, Image Recognition, Object Detection, Video Analysis

I. INTRODUCTION

In this paper, we discussed the applications of computer vision to solve transportation problems and focused on three fields: image recognition, object detection, and video analysis. This study aims to explore the multifaceted applications of computer vision (CV) in transportation systems. It assesses how CV, a subset of artificial intelligence, can significantly enhance the efficiency and security of transportation.

This comprehensive literature review delves into the realm of computer vision technology and its transformative applications in resolving transportation challenges. Examining insights from fourteen research papers, the focus spans real-time object detection and specific applications such as vehicle tracking, traffic flow estimation, and traffic sign recognition.

The introduction of the” You Only Look Once (YOLO)” real-time object detection system stands out as a pivotal advancement [1]. This technology showcases unparalleled potential by enabling swift and accurate detection and classification of objects in images or video through a single neural network forward pass. Practical implications extend to diverse sectors, including surveillance, security, and real-time traffic management systems.

A crucial aspect of our review encompasses a detailed survey titled” Computer Vision Algorithms and Hardware Implementations: A Survey” [2]. This survey offers a panoramic understanding of current computer vision algorithms and their hardware implementations. Serving as a cornerstone reference, it equips policymakers and practitioners with valuable insights for the seamless integration of computer vision technologies across diverse applications.

The application of the YOLO algorithm for vehicle tracking emerges as a beacon for effective traffic monitoring and management. Its prowess lies in real-time analysis of traffic flow, providing decision-makers with critical data for congestion management, incident detection, and overall traffic optimization.

Addressing urban traffic challenges, a method combining computer vision and deep learning techniques excels in accurately estimating the queue length of vehicles. This innovative approach empowers transportation planners to implement adaptive traffic signal control strategies, offering a practical solution for enhancing traffic flow and urban mobility [3].

Automated recognition of traffic signs, as explored in” Automatic Recognition of Traffic Signs Based on Visual Inspection,” contributes significantly to road safety and autonomous driving technologies. This research aids in developing systems that not only enhance driver awareness but also assist in navigation, contributing to advancements in overall road safety standards.

A pivotal benchmarking initiative is introduced in the research on the” Detection of Traffic Signs in Real-World Images: The German Traffic Sign Detection Benchmark.” This benchmark dataset evaluates different methods for detecting traffic signs in real-world images, fostering advancements in the development and assessment of robust traffic sign detection algorithms [{4, [5]}.

II. RESEARCH QUESTIONS

Computer vision has evolved rapidly over the last 50 years [6]. This field which encompasses the ability of computers to interpret and understand visual information from the world, plays a crucial role in modern transportation systems.
This technology has been instrumental in introducing groundbreaking changes in transportation, from enhancing the capabilities of autonomous vehicles to improving traffic management and ensuring pedestrian safety. The transformative impact of computer vision technologies is revolutionizing transportation networks’ operations, leading to more efficient, safe, and sustainable systems. Understanding the evolution and trajectory of research in this area is not only academically intriguing but also essential for policymakers, urban planners, and technologists. It is a field that combines aspects of artificial intelligence, machine learning, and data analytics to create systems capable of making real-time, informed decisions that significantly improve transportation management and safety.

A. Bibliometric Analysis

In this article, we used a systematic literature review using bibliometric analysis methods such as using VOSViewer software for analysis. Systematic literature reviews tend to include a lesser number of papers for review with a narrow scope of study. Since our topic here is very niche, we adopted a systematic literature review instead of a full-fledged bibliometric analysis or meta-analysis (Donthu et al., 2021). The next section outlined the choice of keywords that led us to a small number of articles of immediate relevance over a smaller period of time, instead of a full-fledged bibliometric analysis.

Bibliometric analysis stands as a pivotal tool in the realm of academic research, offering a quantitative approach to understanding the progression and impact of scientific literature [7]. In the context of computer vision, particularly in transportation systems, bibliometric analysis provides invaluable insights into the evolution of the field. This analytical technique facilitates the identification of key research trends, the most influential studies, and emerging areas of innovation. Employing this approach allows researchers and practitioners to comprehend the trajectory of the field, assessing its growth, diversification, and the interconnectivity of research efforts globally. By examining aspects such as citation dynamics, publication patterns, and collaborative networks, bibliometric analysis helps in constructing a comprehensive narrative of how computer vision has evolved, especially in its application to transportation.

This paper aims to provide a comprehensive overview of the research landscape in computer vision applications within transportation systems. By employing bibliometric analysis, the research seeks to uncover key trends, influential authors, and pivotal publications that have shaped the field. The purpose of this study extends beyond mere academic exploration; it is also about informing future research directions and assisting stakeholders, including technologists, urban planners, and policymakers, in making data-driven decisions that can shape the future of transportation.

The methodology of this bibliometric analysis involves a systematic examination of academic papers and publications related to computer vision in transportation. Utilizing various databases such as IEEE Xplore, Google Scholar, and analytical tools such as Elicit, and Research Rabbit. The study categorizes and evaluates the literature, focusing on metrics such as citation counts, publication frequency, and co-authorship networks. This meticulous approach allows for a deep dive into the intellectual structure of the field, highlighting influential regions, institutions, and researchers. It also provides insights into how interdisciplinary collaborations are driving innovations in this sector.

B. Measurable Insights of Transportation Systems

Preliminary findings indicate a significant surge in research activity in the past decade, with a particular emphasis on autonomous vehicles and real-time traffic monitoring systems. The analysis also reveals a global collaboration network, highlighting the interdisciplinary and international nature of this research field. These findings underscore the global interest and investment in developing computer vision technologies for transportation, reflecting a collective effort to address some of the most pressing challenges in urban mobility and traffic safety.

The insights derived from this bibliometric analysis have profound implications for the future of transportation systems. They provide a roadmap for emerging technologies, highlight potential areas for policy intervention, and identify gaps in the current research landscape. Looking ahead, the current study suggests several future research directions. These include a deeper exploration of artificial intelligence integration in traffic systems [8], the ethical considerations of autonomous vehicles [9], and the development of resilient infrastructure (e.g., deep learning) to support advanced computer vision technologies [10]. These areas represent the next frontier in transportation systems, where the integration of advanced technologies could lead to more efficient, safe, and environmentally friendly solutions.

Using bibliometric analysis of computer vision in transportation systems serves as a foundational piece for understanding the trend and impact of research in this dynamic field. It not only illustrates the past and present but also guides the future, ensuring that the evolution of transportation systems is informed by robust, data-driven insights. As the field continues to grow and evolve, this study will remain a critical reference point for understanding the directions and implications of future developments in computer vision and its application in transportation.
III. LITERATURE REVIEW THAT TALKS ABOUT THE TREND IN THE FIELD OF STUDY

A. Conduct a Literature Review

Exemplary discussions [11] such as the use of computer vision in autonomous vehicles suggest the importance of the integration of computer vision technology into transportation systems and symbolizes a critical shift in modern society’s approach to transportation and urban development.

This field, a subset of AI, is playing an increasingly critical role in reshaping transportation, a sector vital to the global economy and everyday life [12]. This section explains the approach of literature review and problems found in our literature review on computer vision in the field of transportation systems elaborates on the importance of artificial intelligence in the field of transportation, and deeply explores the applications, benefits, challenges, and prospects of computer vision in this field.

Literature reviews are critical to understanding the current state of a field, identifying advancements, and identifying gaps that guide future research and applications. The literature review offers a structured and data-driven overview, highlighting pivotal studies and emerging trends in CV applied to transportation systems. It plays a crucial role in identifying key research gaps and revealing the networks of research that shape this domain.

We identify several pivotal themes after conducting the literature review, including Autonomous Vehicle Technology, Vehicle Detection and Recognition, AI-driven Traffic Management, Predictive Maintenance in Transportation, Pedestrian Detection and Safety, etc. We also identified some major applications of CV in transportation systems, such as using image recognition in autonomous vehicles to automatically identify traffic lights or handle other tasks, using object detection to detect objects around the vehicle to avoid collisions, etc.

Key Findings and Research Trends

In the literature review, we found some major contributions of these technologies. In the paper titled “You Only Look Once: Unified, Real-time Object Detection” a vision algorithm called “YOLO” is proposed, which can handle some complex images or videos and then classify or object detected [1]. The YOLO algorithm has sparked a sustained surge in citations (cited by 44007 until 15th February 2024), indicative of its revolutionary impact in real-time object detection. Its ability to process images rapidly and accurately has not only garnered academic interest but also practical excitement, reflecting its significant contributions to the field. Beyond just academic citations, YOLO’s influence extends to various applications, notably transforming Advanced Driver-Assistance Systems (ADAS) and other areas where rapid and reliable object detection is crucial.

Its versatility and efficiency in different contexts underline its transformative role in computer vision technology. These trends and impacts showcase the YOLO algorithm’s significant role in shaping the landscape of computer vision, highlighting its ongoing influence and potential for future advancements in real-time object detection and beyond {[13], [14], [15], [16]}.  

B. Gaps and Limitations

One significant gap identified is the impact of varying lighting and weather conditions on computer vision systems. Current research often overlooks the performance of these systems under diverse environmental conditions. Given the considerable complexity and computational demands of the algorithm’s architecture, the associated implementation costs are significantly high. Furthermore, in the absence of sufficiently robust hardware capabilities, attaining real-time performance remains an unachievable objective. These gaps highlight the need for more comprehensive experiments and analyses that consider different lighting and weather scenarios. Understanding how these conditions affect computer vision accuracy and reliability is crucial for real-world applications, especially in transportation where safety and efficiency are paramount [17].

Recognizing these gaps has practical implications for businesses involved in transportation and smart city initiatives. For instance, improving computer vision systems to function reliably under varying conditions can lead to more robust and dependable transportation solutions. This advancement is essential for the development of smart cities, where transportation systems need to be efficient, safe, and adaptable to changing environments [18].

The identified gaps in the literature pave the way for future research to address these challenges. Future studies should focus on enhancing computer vision systems to overcome environmental limitations, leading to the evolution of smarter and more resilient urban transportation networks. This research trajectory not only addresses immediate practical concerns but also aligns with the broader goal of advancing toward smart city development, where technology and urban infrastructure work seamlessly to improve quality of life and environmental sustainability [19].

IV. METHODS

In conducting this research within the ambit of computer vision, a meticulous approach was adopted to aggregate and analyze scholarly articles. The corpus of literature foundational to this review was judiciously selected from eminent academic repositories, namely Google Scholar, IEEE Xplore, and the Web of Science (WoS). These platforms were specifically chosen due to their extensive archival of peer-reviewed scholarly communications, encompassing a wide range of disciplines pertinent to and encompassing computer vision.
The criteria for the selection of the articles were rigorously defined, and predicated on a keyword-based search strategy that encapsulated core dimensions of computer vision (e.g., keyword search from Advanced Google Scholar, Scopus Advanced Search, etc.). This encompassed terminologies such as “computer vision”, “object detection”, and “YOLO”. This methodological approach facilitated a refined filtration of the extensive literature, earmarking studies of paramount relevance to the research objectives delineated.

Table 1 demonstrates the advanced search in Google Scholar. The search was conducted in a way to allow a reasonable return of articles of relevance within a 10-year period (2014-2024).

Table 1: Find Articles from Google Scholar with the following criteria

<table>
<thead>
<tr>
<th>With all of the words</th>
<th>computer vision, object detection, Yolo, transportation</th>
</tr>
</thead>
<tbody>
<tr>
<td>With the exact phrase</td>
<td>“object detection”</td>
</tr>
<tr>
<td>With at least one of the words</td>
<td></td>
</tr>
<tr>
<td>Without the words</td>
<td>augmented reality, biological vision</td>
</tr>
<tr>
<td>Where my words occur</td>
<td>Anywhere in the article</td>
</tr>
<tr>
<td>Return articles authored by</td>
<td></td>
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<tr>
<td>Return articles published in</td>
<td></td>
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<tr>
<td>Return articles dated between</td>
<td>2014-2024</td>
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The above search returned 223 articles. This was a very specific area of study, with no results returned when the above criterion was searched as “in the title of the article”. This indicates not much research has happened over the last 10 years in this area of study. To keep the study manageable, we only added articles with citations in our analysis that appeared in the first 8 pages of Google search. We left out articles without any current citations. This enabled us to only look at articles with low-high impact.

![Image of top cited authors](image.png)

Figure 1. The top cited authors are identified based on the Google Scholar Data and the Overlay Visualization Shown
After the procurement of the initial dataset, VOSviewer was employed as a bibliometric tool of choice for its advanced capabilities in the visualization and analysis of bibliographic data. This application was instrumental in discerning the network of citations and the co-occurrence of keywords within the amassed literature, thereby illuminating the scholarly discourse’s structural and thematic contours. The research delineates the field’s intellectual lineage through this analytical lens, identifying seminal contributions and delineating emergent paradigms.

A. VOSviewer

VOSviewer significantly simplifies the interpretation of complex AI insights by offering advanced network analysis and visualization capabilities. VOSviewer is primarily a tool for bibliometric analysis, its applications in the realm of AI, especially for complex and specialized topics such as computer vision for transportation systems, are profound. It adeptly creates network visualizations, elucidating the intricate relationships among algorithms, technologies, or research areas within AI. Particularly valuable in fields like computer vision, where AI generates vast and complex datasets, VOSviewer excels in organizing and presenting this information coherently, thereby facilitating the recognition of underlying patterns and insights. It aids in mapping the intellectual structure of the field, identifying key players and collaborations, and understanding the evolution of research themes over time, thereby simplifying the otherwise overwhelming influx of data and research outputs.

Visualizing AI networks in business contexts, particularly within transportation systems, is paramount for several reasons. Tools like VOSviewer offer a clear depiction of how various AI components—such as image recognition, predictive analytics, and sensor data integration—interact, fostering a comprehensive understanding of the system. Such visualizations not only demystify the complex interconnections but also spotlight key technologies and trends, pinpointing emerging solutions poised to revolutionize transportation.

Furthermore, by mapping the AI landscape, VOSviewer facilitates collaboration and innovation, revealing potential synergies between organizations and researchers working on analogous challenges or technologies, thereby driving the field forward.

Importing AI business data into VOSviewer necessitates a stringent focus on clean and organized data. This ensures accuracy in network and trend analysis, foundational for strategic decisions. Clean data accelerates processing within VOSviewer, enhancing compatibility with automated updates and analyses. Moreover, it leads to clearer, more interpretable visualizations, crucial for stakeholder communication and minimizing misinterpretation risks. In essence, clean, organized data is pivotal for reliable, efficient, and clear data-driven insights in VOSviewer.

Fig. 2. Clustering AI themes.

Figure 2 shows the clustering of the AI themes, without any specific focus area. With our research direction, the aim is to zero in on computer vision, a subset of artificial intelligence (AI), with a specific interest in its applications in transportation and traffic management. To refine the search, we incorporated keywords like AI, transportation, and traffic. Given the rapidly evolving nature of AI, we further narrowed down the search results to include only articles from reputable conferences or those that have been extensively cited, ensuring the inclusion of cutting-edge and influential studies in the field. VOSviewer employs a unique approach to data analysis. It analyzes the frequency of keyword occurrence within the collected data. However, in its ‘binary count’ method, even if a term appears multiple times within an abstract, it is counted only once. This approach prevents overrepresentation of certain terms and maintains the integrity of the analysis.
To ensure the relevance and significance of the terms in the knowledge map, we set a specific threshold: only terms appearing more than 30 times in the dataset were considered. VOSviewer then performed a statistical analysis to determine the relevance of these terms. In this study, the software selected the top 60% of these terms based on their relevance, which amounted to 374 distinct terms.

V. FINDINGS

In this specific case, VOSviewer divided the terms into different categories. By examining any one of these categories, we can identify terms particularly pertinent to specific areas. This is a critical aspect of the study, as it directly relates to the application of our study topic in transportation. The knowledge map thus provides a visual and analytical representation of the key areas and terms within our research domain, facilitating a deeper understanding of the landscape of computer vision in traffic management. VOSviewer density visualization is an important technique for visualizing and analyzing scientific information, such as the distribution and density of scientific documents, citations, co-author relationships, and other related data. This method is widely used in the fields of econometrics and document analysis. It supports the creation and display of network diagrams and density diagrams based on literature data sets, providing a valuable tool for researchers to understand complex data environments.

Fig. 3. Density Visualization of computer vision.

As shown in Figure 3, first, we used keyword-specific computer vision. When applying this method, VOSviewer created a visual representation highlighting various interrelated research topics. It can be seen that the surrounding areas of the figure include these fields, such as object detection, recognition, machine learning, and classification. By analyzing these relationships and their strength, it becomes apparent that these studies are not only theoretical but have practical applications in our daily lives. In this case, density maps serve as a roadmap, providing insight into potential future directions in computer vision.

Fig. 4. Density Visualization of Transportation
Next, we conducted a keyword search on transportation issues to see related research areas and further explore the practical possibilities of the topic in the future. This is shown in Figure 4.

Color coding is a useful feature in this visualization. For example, yellow might represent areas of high research activity, while blue represents less explored areas. In the context of transportation research, topics such as rail, general highways, and vehicle diversion may arise. More importantly, such visualizations can reveal less obvious findings, such as the relative irrelevance of land uses, sectors, and transportation networks to core transportation tasks. This insight is critical for identifying gaps in research or potential new areas of research.

The advantage of density visualization through VOSviewer is that it provides a comprehensive and intuitive overview of the research area. By clearly identifying key research areas and their interrelationships, these visualizations contribute to a deeper understanding of the dynamics of scientific inquiry and development within a specific field.

VOSviewer allows the filtering of nodes based on attributes like the number of citations, the year of publication, or keywords. In a business context, filtering by keywords related to specific AI applications (e.g., computer vision, natural language processing) can help focus the network on areas most relevant to business interests.

This is shown in Figure 5, Figure 6, and Figure 7. Figures 5, 6, and 7 start from different reference points. The visualization produced by VOSviewer provides insights through various elements. The size of a node often indicates the number of citations or publications, reflecting the influence or prominence in the field. The distance between nodes suggests the strength of the relationship, while clusters usually represent thematically related groups of publications or authors. Identifying central nodes and dense clusters can reveal key trends, influential research, or emerging areas in AI.
For business presentations, clarity and relevance are paramount. This involves selecting a color scheme that is easily interpretable, ensuring labels are legible, and focusing on the most pertinent aspects of the network. Simplifying complex networks by focusing on key nodes or clusters can make the visualization more accessible to non-specialist audiences. Additionally, providing a brief explanation of how to read the map (such as interpreting node sizes and colors) can greatly enhance the audience’s understanding.

Fig. 7. The group of computer vision in map.

Fig. 8. Map of interpreting computer vision networks.

Briefly, VOSviewer’s settings and filters play a critical role in tailoring AI network visualizations for specific business needs. Understanding and effectively applying these features, users can extract valuable insights from large literature, and datasets, aiding in decision-making and strategy development in the specific domain. This is shown in Figure 7.
VI. DISCUSSION AND CONCLUSION

The bibliometric analysis conducted in this study sheds light on the research trends and methodological approaches in the field of computer vision in transportation systems. In the bibliometric analysis and literature review section, we mentioned the method of bibliometric analysis and guided a comprehensive examination of the current state and future directions, highlighting both the potential and challenges faced by practitioners and researchers. We highlight several key challenges identified in the literature and are as follows:

1. The transportation system might be affected by environmental factors necessitating the development of hardware with enhanced robustness to facilitate real-time operational capabilities.
2. Additionally, the role of lightweight structure cannot be understated in the development of computer vision algorithms, pointing towards areas that require further investigation and innovation.
3. With the rapid development of autonomous vehicles, a critical aspect that emerged from this study is the paramount importance of continuous learning strategies. The challenges associated with implementing continuous learning strategies in autonomous vehicles include ensuring data privacy, managing the computational demands of real-time processing, and developing algorithms that can learn effectively from incremental data without forgetting previous knowledge.

The bibliometric analysis and literature review have identified key trends, influential research, and potential future directions that are crucial for business strategies. Despite the challenges identified, the opportunities for advancement and impact on transportation systems are significant. The application of the YOLO algorithm has been identified as a crucial driver for advancements, offering novel solutions and enhancing the effects of transportation systems [15]. This paper contributes to a deeper understanding of applications of computer vision in transportation systems by mapping out the current landscape and delineating future research trajectories. Through a meticulous analysis of the YOLO algorithm, it has identified pivotal trends, key challenges, and potential areas for groundbreaking research. The insights gained underscore the transformative potential of applications of computer vision in transportation systems, despite the complexities and challenges that currently limit its full exploitation. For example, a layout-independent automatic license plate recognition system based on the YOLO detector is remarkable in the literature [20]. Future research should aim to transcend these limitations by adopting a more interdisciplinary approach, leveraging advancements in advanced algorithms to address the pressing challenges of this field. Additionally, the exploration of advanced algorithms could provide the necessary breakthroughs to overcome current obstacles, paving the way for more effective and sustainable solutions.

The journey ahead is both challenging and promising, with ample opportunities for significant contributions to this field. As this field continues to evolve, the research community must remain committed to innovation, collaboration, and the pursuit of knowledge that can drive real-world impact in the application of transportation systems. In conclusion, this study not only charts a course for future research but also highlights the critical role of computer vision in transportation systems in addressing some of the most pressing issues facing today. Examples of key research that might fast-track the movement toward intelligent transportation include video surveillance for road traffic monitoring [21] semantic scene segmentation in an unstructured environment with modified DeepLabV3+ [22], and estimation of road boundary for intelligent vehicles based on DeepLabV3+ Architecture [22], among many other such domains of application that are related to computer vision, or the strength of such relationships could be further explored through bibliometric analysis.

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VII. POTENTIAL FUTURE STUDIES

The future development of computer vision in transportation systems is expected to work in three directions.

The first is an effort to further improve the applicability of models. To create a workable model that is not affected by external factors, a variety of environments should be prepared in advance and a moderate amount of learning should be conducted in these environments. It is expected that with adequate learning, models can be created that are highly applicable to a greater variety of environments.

The second is an effort to optimize the models further. The equipment that integrates the created models must have sufficient performance and resources to process them in real time. This requires high costs. As a solution to this problem, the development of lightweight CNN and YOLO that reduce the computational complexity of algorithms such as traditional CNN and YOLO, while maintaining accuracy, is being discussed.

Third, efforts are underway to implement continuous learning strategies so that models can adapt to new environments and conditions. Tens of thousands of GPUs and supercomputers are used to continuously learn. However, this consumes a lot of power and time.
Broadly speaking, the following research areas about computer vision in transportation systems require in-depth bibliometric analysis to better comprehend the research directions in each of these domains of analysis within this specific field.

Autonomous Vehicles and Advanced Driver Assistance Systems (ADAS):
- Continued integration of computer vision for perception in autonomous vehicles and ADAS.
- Improvement in object detection, recognition, and tracking to enhance vehicle awareness of the surrounding environment.
- Pedestrian and Cyclist Detection:
  - Enhanced capabilities for detecting and predicting the behavior of pedestrians and cyclists, improving safety in urban environments.

Traffic Management:
- Implementation of computer vision for real-time traffic monitoring, congestion detection, and optimization of traffic flow.
- Integration with smart traffic lights and signal control systems to manage intersections efficiently.

Infrastructure Monitoring:
- Use of computer vision for monitoring and maintaining transportation infrastructure, such as bridges, roads, and tunnels, to detect structural issues and ensure safety.

Predictive Maintenance:
- Implementation of computer vision for predictive maintenance of vehicles and transportation infrastructure, reducing the likelihood of breakdowns and improving overall reliability.

Multi-Modal Transportation:
- Integration of computer vision in multi-modal transportation systems, including buses, trains, and other public transportation modes, to enhance safety and efficiency.

Smart Cities Integration:
- Collaboration with other smart city technologies, such as IoT devices and data analytics, to create a more integrated and responsive transportation ecosystem.

Data Privacy and Security:
- Continued focus on addressing privacy concerns related to the collection and use of visual data in transportation systems.

Implementation of secure and privacy-preserving computer vision solutions.

Customization and Adaptability:
- Development of computer vision systems that can adapt to diverse environmental conditions, including different weather and lighting scenarios.

Human-Machine Interaction:
- Advancements in human-machine interaction, such as improved gesture recognition and communication between autonomous vehicles and pedestrians.

Regulatory and Ethical Considerations:
- Development and refinement of regulations and ethical guidelines for the deployment of computer vision in transportation, addressing issues such as liability and accountability.

In summary, many different initiatives are being devised today to advance computer vision in transportation systems.

REFERENCES


