A Study on Car Parking Occupancy Detection Using Smart Camera Networks and Deep Learning

Manisha Sharma[1], Anshu Sharma[2], Pooja Dahiya[3*], Komal Malik[4]
[1]Department of Computer Application, Panipat Institute of Engineering And Technology, Samalkha, Kurukshetra University Kurukshetra
[2]Department of Computer Application, Panipat Institute of Engineering And Technology, Samalkha, Kurukshetra University Kurukshetra
[3]Department of Computer Science and Engineering (Cyber Security), Panipat Institute of Engineering and Technology, Samalkha, Kurukshetra University Kurukshetra
[4]Department of Computer Science and Engineering, Arya Kanya Mahavidyalaya Gurukul Mor Marja, Karnal, Kurukshetra University
*pujadahiya88@gmail.com

* Corresponding author
doi: https://doi.org/10.21467/proceedings.7.6.9

ABSTRACT

Car parking occupancy detection is a crucial system required at numerous parking facilities. The suggested method is automobile Parking Detection with deep learning. This study aims to address the problem of automobile parking by capturing photos and videos from surveillance cameras to ascertain the occupancy status of parking spaces, determining whether they are empty or occupied. It employs the Convolutional Neural Networks (CNN) algorithm, as it yields the most promising results compared to classic parking detection methods such as Dijkstra's and Ant Colony algorithms. This work uses a smart camera system and deep learning module to improve accuracy of system. The detection is dependable, even when tests are conducted with photos obtained from a perspective distinct from that utilized during training. Furthermore, it exhibits its robustness when training and testing are conducted in various parking lots. As smart city initiatives advance, it is essential for policymakers to stay informed and adapt to the changing technology landscape to cultivate a more livable and resilient urban environment for everyone.

Keywords: Car Parking Model, Deep Learning Models, Smart Cameras, Image Classification etc.

1 Introduction

Numerous detective technologies for parking spaces now exist. The selected sensors can be categorized into visual and non-visual detecting methods. Vision-based detection approaches primarily utilize monocular cameras, binocular cameras, or RGB-Depth (RGB-D) cameras. Cameras are utilized for picture acquisition, and computer vision algorithms are employed to identify parking spaces based on the acquired images. These methodologies offer real-time visual support and comprehensive image data; yet, they may be significantly influenced by ambient conditions. As the population expands, the proliferation of private vehicles has resulted in significant challenges for individuals seeking parking in congested places such as retail malls, restaurants, and university parking lots. This leads to time wastage for drivers seeking vacant parking spaces, resulting in atmospheric pollution and driver discontent. The Smart Parking System comprises an on-site IoT module that monitors and indicates the availability status of each individual parking place. A smartphone application is available that enables users to verify parking space availability and reserve a parking slot accordingly. Parking sensors are employed to identify parking spaces in a certain region and provide this information to the user via a mobile application [1]. Intelligent parking solutions can yield economic advantages for municipalities by generating income through parking charges and penalties. This supplementary cash might be reinvested into the community to finance more sustainability efforts or enhance public services. Moreover, the implementation of intelligent parking systems enables cities to collect significant data on parking trends and utilization, facilitating better informed decisions about urban planning and transportation infrastructure. In summary, intelligent parking is an essential element in fostering a more efficient, sustainable, and habitable urban landscape for everyone. A comprehensive counterexample can be observed in a city where the smart parking system suffers from recurrent technical failures, resulting in the transmission of erroneous information to the mobile application. This may result in vehicles being led to nonexistent parking spaces or being unable to find vacant places, so escalating annoyance and potentially exacerbating traffic congestion as drivers circulate in search of parking [2].

Proceedings DOI: 10.21467/proceedings.7.6; Series: AIJR Proceedings; ISSN: 2582-3922; ISBN: 978-81-989164-9-5

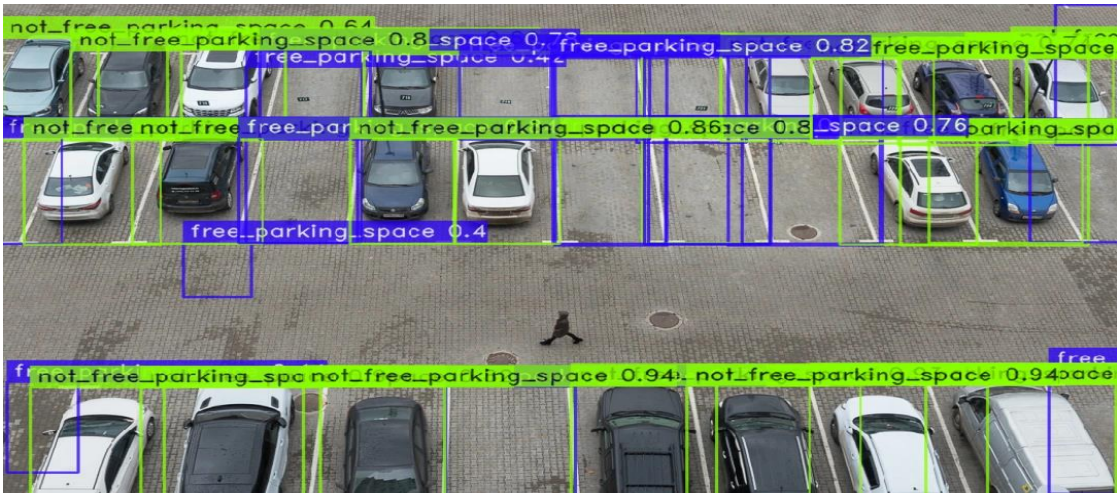

Fig 1: Parking Space Detection using Smart System [3]

Reliance on a smart parking system may result in reduced flexibility for drivers who prefer to locate space autonomously rather than depending on technology (Fig 1). Some drivers may view the system's recommendations as restrictive, preferring the autonomy to choose their parking place based on personal preference or convenience. This may lead to a reduced sense of autonomy and control for drivers, ultimately impacting on their overall satisfaction with the parking experience. Furthermore, the implementation of a smart parking system may provoke concerns about privacy and data security, as drivers might be hesitant to share their location information with a third-party application due to apprehensions about potential data breaches or the misuse of their personal data [3].

1.1 Overview of Current Challenges in Car Parking Occupancy Detection

The shift to a smart parking system presents both benefits and challenges for drivers. While the technology can improve the parking process and boost efficiency, it concurrently raises substantial concerns over privacy and control. As advancements in auto parking occupancy detection technology occur, it is essential for developers to address these challenges and guarantee that drivers trust the security of their data. Ultimately, attaining a balance between convenience and privacy will be essential in shaping the future of parking technologies. Developers can alleviate specific privacy issues associated with smart parking systems by utilizing strong encryption methods and rigorous data security protocols. Furthermore, clarifying the processes of data collection, storage, and utilization enhances trust among drivers [4]. As technology progresses, identifying innovative solutions to address these challenges will be essential for creating a seamless and secure parking experience for all users. By emphasizing ease and privacy, developers can enable a future where smart parking solutions enhance the whole driving experience. Developers can enhance data security in smart parking systems by implementing encryption methods to protect important information. By encrypting data during transport and storage, developers may ensure that unauthorized users cannot access or modify the data. Furthermore, the implementation of multi-factor authentication can offer an extra layer of security to prevent unauthorized access to the system. Through the implementation of these proactive steps, developers can demonstrate their commitment to protecting user privacy and security in smart parking systems. An intelligent parking system could utilize encryption to protect license plate numbers and payment data during communication between the user's device and the parking management system. Furthermore, requiring users to authenticate with a password and a unique code sent to their mobile device can impede hackers from obtaining critical information, even if they succeed in intercepting it [5].

1.2 Introduction to smart camera networks and deep learning as potential solutions

Developers must perform routine security audits and updates to ensure system protection against evolving threats. By staying abreast of the latest security techniques and technologies, smart parking systems can continuously enhance their defenses against potential intrusions. Furthermore, educating users on effective strategies for protecting their personal information while using the system can improve overall security measures. By implementing these strategies, developers can create a safer and more dependable environment for users of smart parking systems. Furthermore, developers can use technologies such as two-factor authentication and encryption to bolster the security of user data. By maintaining constant surveillance and promptly addressing security issues, developers may demonstrate their commitment to protecting user data. By implementing a proactive security approach and continually improving security standards, developers can enhance user confidence and establish a reputation for providing secure and reliable smart parking solutions [6].

Proceedings DOI: 10.21467/proceedings.7.6
ISBN: 978-81-989164-9-5

Series: AIJR Proceedings
ISSN: 2582-3922

This commitment to security protects users' personal data and ensures the smooth and efficient operation of smart parking systems. Due to the increasing frequency of cyber-attacks and data breaches, it is essential for developers to be vigilant and proactive in safeguarding user data. Regularly performing security audits and staying informed about contemporary security developments will empower developers to foresee potential dangers and maintain user trust. In a digital environment, security must be crucial for developers to ensure the long-term profitability and sustainability of smart parking systems. Developers can encrypt user data to protect it from unauthorized access and install two-factor authentication to bolster security. By routinely updating software and mitigating vulnerabilities, developers may prevent future cyberattacks and maintain the integrity of their smart parking systems. Furthermore, the deployment of intrusion detection systems allows engineers to notice and respond to suspicious activity in real-time, thereby enhancing the system's overall security. Regular security audits and penetration testing can help identify vulnerabilities within the system before they are exploited by malicious actors [7].

2 Research Methodology

A fuzzy reactive navigation architecture was created, and an alternate training technique to the EEM-based method was proposed. The novel training method achieved a learning speed 270 times greater than the EEM method, incurring only 4% of its learning cost. It exhibited significant flexibility, an elevated rate of acquired rules (98.8%), and exceptionally reliable learning convergence. The proposed fuzzy reactive navigator, whose adaptability is achieved through an environmental evaluator, integrates goal-seeking and obstacle avoidance behaviors to dictate its control actions based on a rule basis acquired through an innovative technique [8, 9]. The acquisition of control rules to improve the efficacy of control systems has garnered significant attention recently. This study illustrated the capability of fuzzy neural networks (FNs) to directly extract such rules from observational data. A fuzzy reactive navigation architecture was created, along with an alternative training strategy to the EEM-based method, resulting in a novel training methodology that is 270 times faster and incurs only 4% of the EEM method's learning cost [10]. It exhibited significant flexibility, an impressive 98.8% of acquired rules, and very reliable learning convergence. The proposed fuzzy reactive navigator, which achieves flexibility through an environmental evaluator, integrates goal-seeking and obstacle avoidance behaviors to inform its control actions based on a rule base acquired using an innovative method.

2.1 Previous Studies on Car Parking Occupancy Detection Methods

Highlighted the importance of safe and reliable technologies to ensure accurate data collection. Research demonstrates that a combination of sensors, cameras, and machine learning algorithms produces the most effective parking occupancy detection. Furthermore, research has emphasized the imperative of encryption methods to protect the data transmitted between sensors and the central parking management system. The research demonstrates that a strong focus on security protocols is essential for the successful deployment of smart parking systems. Utilizing these secure technologies enables parking operators to ensure the integrity and protection of the acquired data, hence improving dependability and efficiency in parking management. Furthermore, security measures can impede unauthorized access and hacking attempts, safeguarding vital information and maintaining the integrity of the parking system. In conclusion, prioritizing security protocols in smart parking systems is crucial for providing a seamless and dependable parking experience for both operators and users [11].

Improving security in smart parking systems can be accomplished by utilizing encryption methods to protect data transmission and storage. Encrypting essential information, such as user credentials, payment information, and occupancy data, allows parking firms to prevent unauthorized access and data breaches. Moreover, the application of multi-factor authentication methods can offer an extra layer of security to verify the identity of those using the system. This improved security protocol can reduce fraudulent activities and ensure that only authorized individuals access the parking system. Incorporating rigorous security standards into smart parking systems is essential for maintaining user trust and ensuring the effective operation of the parking facility. An intelligent parking system could utilize license plate recognition technology to oversee vehicle ingress and egress, so ensuring that only authorized vehicles gain access. Furthermore, real-time monitoring of parking spaces and occupancy data allows operators to promptly identify any irregular activities or potential security threats. This technology can also be utilized to enforce parking regulations and prevent unauthorized vehicles from entering, so enhancing the security of the parking area. Implementing these security measures allows smart parking systems to provide a safe environment for users, hence improving the overall user experience [12].

Proceedings DOI: 10.21467/proceedings.7.6
ISBN: 978-81-989164-9-5

Series: AIJR Proceedings
ISSN: 2582-3922

2.2 Review of Existing Smart Camera Networks and Deep Learning Applications in Other Industries

These solutions have exhibited considerable effectiveness in enhancing security protocols. Intelligent parking systems can accurately monitor and track vehicles entering and exiting the facility by utilizing advanced technologies such as facial recognition and license plate identification. This level of surveillance not only deters criminal activity but also ensures that only authorized cars gain access. In the event of a security breach, operators can swiftly respond and execute necessary procedures to ensure the safety of all users. In conclusion, the integration of intelligent parking systems with advanced security features is essential for creating a secure and user-focused parking environment. Intelligent parking systems offer a comprehensive solution for the administration of parking facilities through the integration of sophisticated technology and proactive security protocols. By utilizing real-time monitoring and alerts, operators can swiftly address any concerns and maintain a safe atmosphere for all clients. The integration of security measures into smart parking systems enhances user experience and ensures vehicle protection [13]. Furthermore, these security features can assist in preventing theft and vandalism while improving overall traffic flow within the parking facility. Operators can effectively monitor and manage access to the parking facility by utilizing advanced surveillance cameras, license plate recognition technology, and access control systems. This not only deters unwanted entrance to the premises but also ensures that only authorized vehicles are allowed to park in designated areas. Furthermore, the integration of intelligent parking systems with mobile applications and web platforms allows clients to easily track their vehicle's location and receive notifications in case of any security breaches. This level of transparency and regulation enhances the user experience while fostering trust and dependability in the parking facility [14, 15].

2.3 Research Gap

Additional efforts are required to enhance the accuracy and reliability of sensors for detecting parking occupancy. Modern technologies, such as infrared sensors and cameras, may not reliably provide real-time data on parking space availability. Moreover, it is necessary to examine the incorporation of these sensors with existing parking management systems to improve overall efficiency. Addressing these research deficiencies will be crucial for the further advancement of smart parking systems and the improvement of parking facilities. The integration of these sensors with advanced data analytics and artificial intelligence algorithms could markedly enhance the accuracy and reliability of parking occupancy detection. Improving the integration of sensor technology with existing parking management systems allows cities and businesses to optimize parking facilities, reduce congestion, and enhance the overall user experience. This research will be essential in enhancing smart parking systems and ensuring the effective functioning of parking facilities in the future. Furthermore, the implementation of real-time data monitoring and predictive analytics may enhance the forecasting of parking demand, allowing for modifications in pricing or availability as required. The implementation of AI allows municipalities and businesses to oversee parking facilities, thereby reducing emissions and mitigating traffic congestion. This proactive parking management technique can provide a more sustainable and efficient urban environment for all stakeholders. The integration of smart parking systems with other smart city initiatives can improve the connectedness and efficiency of the urban experience for residents and visitors alike.

3. Research methodology

The intelligent camera network setup for vehicle parking occupancy detection will involve the strategic placement of cameras within parking facilities to monitor and evaluate parking space availability in real-time. These cameras will utilize AI technology to accurately identify and track vehicles entering and exiting parking spaces. By collecting and analyzing this data, governments and organizations can gain valuable insights into parking patterns and trends, allowing them to develop informed parking management policies. This technology will enable a more efficient and sustainable method of parking management, benefiting both the environment and the community. The implementation of this modern technology allows communities and businesses to reduce traffic congestion, decrease emissions from vehicles searching for parking, and improve the overall parking experience for residents and visitors. Additionally, real-time data about parking availability can be communicated to drivers using mobile applications, streamlining the search for parking spaces. This innovative approach to parking management has the potential to revolutionize urban mobility and create a more efficient and sustainable transportation system for everyone. Through the utilization of data and technology, municipalities may enhance parking efficiency and augment the overall effectiveness of their transportation systems (fig 2). The shift to intelligent parking systems benefits both drivers and the broader environment. Reducing the time spent searching for parking enables vehicles to remain on the road for lesser durations, thereby decreasing carbon emissions and improving air quality. Furthermore, the implementation of intelligent parking systems can aid communities in optimizing curbside space management, ensuring its consumption is both effective and equitable.

Proceedings DOI: 10.21467/proceedings.7.6
ISBN: 978-81-989164-9-5

Series: AIJR Proceedings
ISSN: 2582-3922

Fig 2: Car Parking Dataset

This may lead to less traffic congestion and a reduction in accidents resulting from vehicles circling the block in search of parking. Furthermore, intelligent parking systems can provide critical data insights to urban planners, assisting them in making educated decisions about infrastructure improvements and potential development projects. The use of smart parking technology can markedly improve urban sustainability and elevate the quality of life for residents and visitors alike. A city may implement sensors in parking areas to determine when a vehicle is stationed, enabling real-time monitoring and management of available parking spaces. This technology pertains to mobile applications that inform drivers of available parking spaces, thus reducing the time spent searching for parking. By optimizing parking usage and reducing traffic congestion, governments may improve efficiency and the overall experience for individuals navigating urban environments.

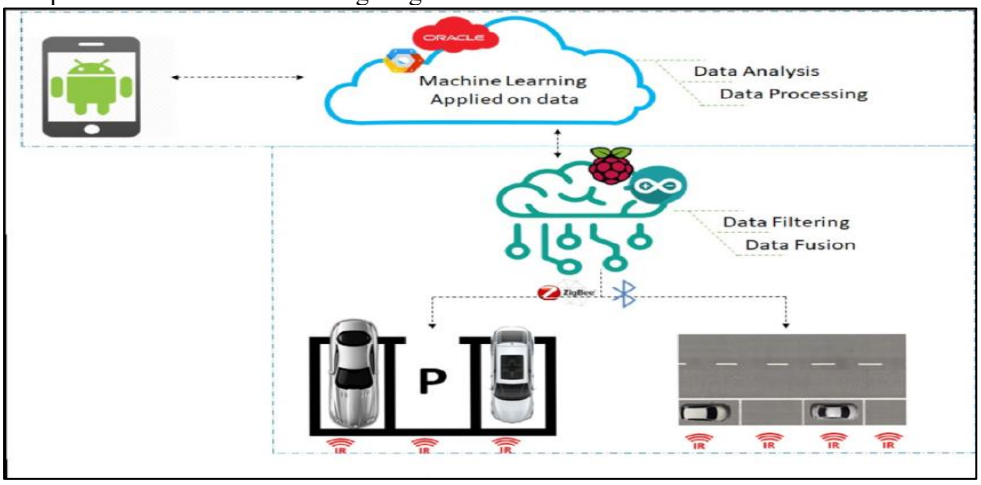

Fig 3: Smart Parking System using Deep Learning

Use of Deep Learning Algorithms

Deep learning techniques can be employed for image processing and analysis to precisely detect and classify automobiles in parking areas. These algorithms can be trained on extensive image datasets to enhance their accuracy and efficiency over time. Utilizing deep learning, municipalities can automate the monitoring of parking spaces and deliver real-time updates to drivers, thereby improving the entire parking experience in urban environments. This technology could transform urban parking management and mitigate the hassles commonly linked to locating a parking space in congested locations. Beyond enhancing parking management efficiency, deep learning algorithms can assist cities in mitigating traffic congestion and emissions by directing drivers to available parking spaces more swiftly. By optimizing the parking procedure, municipalities may establish a more sustainable and eco-friendly transportation framework. As technology progresses, the potential for employing deep learning in urban planning and management is limitless, providing novel answers to enduring difficulties. The implementation of smart parking systems enables communities to provide a more efficient and convenient experience for both inhabitants and visitors. These systems can enhance traffic flow and diminish emissions while also provide essential data for urban planners to make informed decisions on infrastructure and transportation

Proceedings DOI: 10.21467/proceedings.7.6
ISBN: 978-81-989164-9-5

Series: AIJR Proceedings
ISSN: 2582-3922

policies. Utilizing deep learning algorithms, municipalities can examine patterns and trends in parking behavior to enhance the distribution of parking spaces and minimize the duration spent searching for a spot. This not only advantages drivers but also enhances the optimal utilization of urban space and resources. Moreover, intelligent parking systems can be incorporated with other smart city projects, like public transit and energy management, to foster a more interconnected and sustainable urban ecosystem. The integration of deep learning technology in urban planning will be essential for the future of transportation and sustainability as cities expand and develop.

By perpetually updating and refining these models with real-time data, municipalities can make educated decisions and swiftly adjust to evolving conditions. Engaging with specialists in data science and machine learning can enable towns to utilize their data efficiently and optimize the advantages of smart city technologies. By leveraging data and advanced technology, cities can develop more sustainable, efficient, and habitable urban environments for their inhabitants. Moreover, through the application of predictive analytics and artificial intelligence, municipalities may foresee future trends and strategize accordingly to optimize resources and improve citizen satisfaction. By integrating feedback from citizens and stakeholders, municipalities can guarantee that their smart city efforts align with the needs and expectations of the community. In conclusion, data-driven decision-making is crucial for the success of smart city initiatives, and collaboration with field specialists will be vital for attaining long-term sustainability and prosperity in metropolitan regions.

4. Conclusions

The research highlights the need of utilizing intelligent technology and deep learning techniques to enhance automotive parking management, hence promoting the sustainability and growth of metropolitan areas. The anticipated benefits of using the suggested system include improved allocation of parking spaces, reduced carbon emissions from idling vehicles, and increased revenue for municipalities through more effective use of parking resources. The system can enhance the user experience by providing real-time information about available parking spaces, hence reducing the time spent searching for a spot. The integration of this technology into urban planning methodologies can yield a more sustainable and efficient transportation system, ultimately benefiting both residents and visitors. The proposed system utilizes data and analytics to identify patterns and trends in parking demand, enhancing decision-making for future urban development projects. This may lead to improved spatial efficiency, reduced traffic congestion, and more seamless vehicular mobility around the city. The implementation of this technology has the potential to revolutionize urban parking management and transit planning, providing prospects for more revenue and improved user experience. The integration of intelligent technology into parking management can enhance overall efficiency and user convenience. Real-time data on available parking spaces, automated payment systems, and customized parking recommendations based on user preferences can improve efficiency and user-centricity. By employing technology in this manner, cities can improve the efficiency of their transportation systems while promoting a more sustainable and environmentally friendly urban environment. The benefits of deploying such a system are numerous and substantial, with the potential to transform urban operations and development in the future. This innovative methodology enhances efficiency and contributes to the creation of more sustainable and livable cities for the future. As technology advances, the potential for enhancing urban transportation through intelligent solutions like automated parking occupancy detection is boundless

REFERENCES

[1] A. Dogan, G. Korkmaz, Y. Liu, F. Ozguner, U. Ozguner, K. Redmill, O. Takeshita, and K. Tokuda (2004), Evaluation of intersection collision warning system using an inter-vehicle communication simulator, In *Intelligent Transportation Systems, Proceedings. The 7th International IEEE Conference'*, pp. 1103–1108.

[2] Aijaz, B. Bochow, F. D6tzer, A. Festag, M. Gerlach, R. Kroh and T. Leinmulller (2006), Attacks on Inter-Vehicle Communication Systems – An Analysis, _T*he 3rd International Workshop on Intelligent Transportation (WIT06), March 2006'*, pp. 187-194.

[3] Ahmed Soomro, I., Hasbullah, H., and AbManan, J. L. (2010), _Denial of Service (DOS) Attack and Its Possible Solution in VANET.2010', *International Journal of Electrical, Computer, Energetic, Electronic and Communication Engineering*. World Academy of Science, Engineering and Technology, **4**(5), 813-817.

[4] A. Taeihagh and H. S. M. lim, "Governing autonomous vehicles: emerging responses for safety, liability, privacy, cybersecurity, and industry risks," *Transport Rev*, vol. 39, no. 1, pp. 103–128, JAN. 2019

[5] Anh-Tu Nguyen, "Driver-Automation Cooperative Approach for Shared Steering Control under Multiple System Constraints: Design and Experiments", *IEEE Transactions on Industrial Electronics*, 2016.

[6] Akihito Nakamura, "Short-Term Multi-Vehicle Trajectory Planning for Collision Avoidance", *IEEE Transactions on Vehicular Technology*, 2020, 1-12.

[7] Britt, J. J. (1994). Case study: Applying formal methods to the traffic alert and collision avoidance system (TCAS) II. *Proceedings of the Ninth Annual Conference on Safety, Reliability, Fault Tolerance, Concurrency and Real Time, Security* (pp. 39-51). Computer Assurance, 1994. COMPASS'94.

[8] Bianchi, G.,et al. (1996). Performance evaluation and enhancement of the CSMA/CA MAC protocol for 802.11 wireless LANs. *Sevnth IEEE International Symposium on Personal, Indoor and Mobile Radio Communications* (pp. 392-396).

[9] Brenner, P. (1997). A technical tutorial on the IEEE 802.11 protocol. *BreezeCom Wireless Communications,* 1-24.

[10] Basant Kumar Sahu, "Flocking Control of Multiple AUVs Based on Fuzzy Potential Functions", *IEEE Transactions on Vehicular Technology*, 2017, PP.1-15.

[11] Coelingh, E., Jakobsson, L., Lind, H., & Lindman, M. (2007). Collision warning with auto brake: a real-life safety perspective. *Innovations for Safety: Opportunities and Challenges.*, 1-9.

[12] C. Chauvin, S. Lardjane, G. Morel, J.-P. Clostermann, and B. Langard, Human and organizational factors in maritime accidents: Analysis of collisions at sea using the HFACS," *Accident Anal. Prevention*, vol. 59, pp. 26–37, Oct. 2013.

[13] C. Tam and R. Bucknall, "Collision risk assessment for ships," *J. Mar. Sci. Technol.*, vol. 15, no. 3, pp. 257–270, Sep. 2010.

[14] D. Kim, "Lane-Level Localization Using an AVM Camera for an Automated Driving Vehicle in Urban Environments," *IEEE/ASME Trans. Mechatro.,* vol. 22, no. 1, pp. 280–290, FEB. 2017.

[15] D. K. M. Kufoalor, E. F. Brekke, and T. A. Johansen, "Proactive collision avoidance for ASVs using a dynamic reciprocal velocity obstacles method," in *Proc. IEEE/RSJ Int. Conf. Intell. Robots Syst. (IROS)*, Oct. 2018, pp. 2402–2409.

Proceedings DOI: 10.21467/proceedings.7.6
ISBN: 978-81-989164-9-5

Series: AIJR Proceedings
ISSN: 2582-3922