International Journal of Engineering and Science Invention (IJESI)
ISSN (Online): 2319-6734, ISSN (Print): 2319-6726
www.ijesi.org ||Volume 10 Issue 12 Series II December 2021 || PP 40-45

Intelligent Traffic Monitoring and Signaling for Smart Cities: A Review

Manoranjan Jena*, Issa Mishra, Monalisa Mohanty
Department of Computer Science and Engineering
Ajay Binay Institute of Technology, Cuttack, Odisha, India

Abstract: *With the rapid urbanization and increasing vehicular density, traditional traffic management systems struggle to ensure efficient mobility and reduce congestion. Smart cities leverage emerging technologies such as the Internet of Things (IoT), Artificial Intelligence (AI), and machine learning to enhance traffic monitoring and intelligent signaling. This review explores various techniques and frameworks used in modern traffic management, focusing on real-time traffic data collection, adaptive signal control systems, and vehicle-to-infrastructure (V2I) communication. The study highlights advancements in sensor-based monitoring, edge computing, and predictive analytics to optimize traffic flow and minimize delays. Furthermore, challenges such as data privacy, scalability, and integration with existing infrastructure are discussed. The review aims to provide insights into the future of intelligent monitoring &signalling systems, fostering sustainable and efficient urban mobility in Smart cities.*
Keywords:*Intelligent Traffic Monitoring & Signalling (ITMS), IoT,Smart City, V2I Communication.*

I. INTRODUCTION

The increasing traffic volume over the past decade has highlighted the need for a safer and more efficient transportation system. Conventional networks struggle with congestion, long queues, and accidents. Advance notifications about obstacles or traffic conditions can help drivers take precautions, choose alternate routes, and regulate speed at intersections to prevent collisions. The integration of mobile wireless technologies with vehicles has led to various applications, including collision detection, driver alerts, disaster warnings, emergency coordination, and traffic management. Additionally, these technologies enhance navigation, data sharing, routing, smart services, and multimedia streaming, improving overall traffic efficiency, safety, and commuter experience.Intelligent Traffic Monitoring & Signalling (ITMS) create a self-organizing network to enhance traffic management and road safety. Over time, ITMS has proven effective in addressing traffic congestionand improving efficiency of transportation. A key application is in smart cities, where the Internet of Things (IoT) connects vehicles, infrastructure, and communication systems. IoT integration enables ITMS to manage traffic, control lanes, issue emergency alerts, monitor the environment, and provide infotainment services.Rising vehicle usage has intensified traffic congestion, resulting in accidents, delays, pollution, and road obstructions. To mitigate these issues, researchers, transportation agencies, and academicians are developing real-time solutions. Analyzing real-time data, such as images and videos, helps in understanding traffic patterns and improving commuter safety[1], [2]. Various communication technologies and systems have been explored to advance ITMS solutions, with Figueiredo et al. being among the first to study ITMS[3]. ITMSemphasizes vehicle connectivity and automation, which, along with mobility, contribute to smart city development and ITMS implementation[4]–[7] . Vehicles act as communication nodes, enabling interactions like V2V, V2I, and V2X. By detecting road conditions and pedestrian activity, they exchange data wirelessly to enhance safety and reduce accidents. The advanced 4G-LTE support Cellular V2X (C-V2X) communication which enhances the vehicular networks, enabling applications like collision prevention, driver assistance, eco-friendly traffic management, and regulatory compliance.

II. SYSTEMS FOR MONITORING & SIGNALLING

This review highlights recent applications in Intelligent Traffic Monitoring & Signalling (ITMS), analyzing their effectiveness in meeting various demands. This analysis offers insights into traffic-related objectives and emerging trends.

Every year, approximately 50 million injuries and 1.25 million fatalities occur due to road traffic accidents worldwide [8]. These accidents result in severe injuries, loss of life, and significant financial and social consequences for individuals, families, and the state[9], [10]. Despite enforcing speed limits, strict traffic regulations, mandatory seat belts, airbags, and improving vehicle durability, road accidents continue to rise[11] . Researchers have developed various electronic and computerized safety mechanisms encompass intelligent braking, speed regulation, collision prevention, adaptive cruise control, lane recognition, and object positioning, and electronic stability control, to mitigate these incidents[12]. The advancement of the Internet and ICT has facilitated vehicle connectivity, leading to the development of smart vehicles in Intelligent Traffic Monitoring & Signalling (ITMS). These technologies enable vehicles to share real-time data, helping to prevent unforeseen incidents. Early warnings about potential hazards assist drivers in avoiding accidents. Additionally, providing route and event updates improves traffic flow, reducing congestion and enhancing overall road safety and efficiency.Several studies have explored different ITMS applications to develop intelligent transportation systems enhance traffic flow, optimize lane usage, detect and prevent collisions, and provide real-time alerts to improve road safety and efficiency. Broadly, ITMS features are categorized into seven types based on functionality and application, as illustrated in Figure 1.

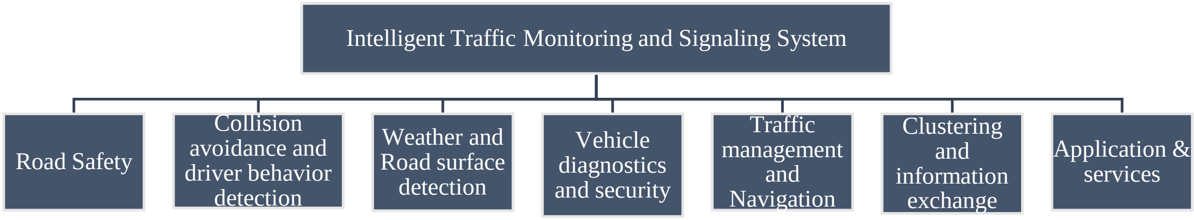

Fig. 1 Features of Intelligent Traffic Monitoring and Signaling System

III. ITMS FOR ROAD SAFETY

The primary function of safety related ITMS is to enhance road safety, security, and monitoring for commuters. These systems include driver behavior analysis, collision detection and prevention, environmental and road surface monitoring, emergency management, diagnostics for vehicles and infrastructure, along with security and privacy protocols.

IV. ITMS FOR COLLISION AVOIDANCE AND DRIVER BEHAVIOR DETECTION

Collision-avoidance mechanism utilize sensors for location and speed to evaluate potential collision risksand alert drivers through in-vehicle communication via windshield displays. These systems use different techniques to detect and prevent collisions while in motion. Timely transmission of warning messages can help avoid potential accidents. Examples include cross-point crash avoidance, rear-end, and front-end collision prevention. This section reviews various Collision Detection/Avoidance systems proposed by researchers.A prediction-based Cross Point Collision Avoidance (CCA) model is investigated to detect nearby vehicles and prevent collisions at road intersections[12]. Their approach, designed for urban environments, utilizes both static and dynamic sensor and beacon deployments. Speiran et al. [13]proposed an android phone-based collision detection mechanismwhich minimizes the need for cloud-based applications. However, it is ineffective at intersections and junctions to address pedestrian accidents, especially in obstructed or blind areas, as proposed a preventive approach by Goncalves et al. [14]. Their approach uses to warn vehicles, leveraging IEEE 802.11p for vehicle communication and LTE with cloud support for walkers. Similarly, system for detecting abnormal driving behavior using a differential deviation approach, and driver distraction detection system by integrating in-vehicle and image data are proposed for efficient driving[15],[16].

V. ITMS FOR DETECTION OFWEATHER AND ROAD SURFACE CONDITIONS

Weather and surface condition detection mechanism play a crucial role in monitoring and assessingenvironmental disorder. These systems gather data through surveillance, monitoring, and weather prediction, often utilizing infrared sensors in vehicles. Siems-Anderson et al. [17]developed an adaptive big data-based weather system for surface transportation, utilizing real-time data from connected vehicles to improve road safety and efficiency. Their model efficiently handled big data challenges in forecasting and provided timely warnings to motorists. Yoneda et al. [18]focused on enhancing automated driving in adverse weather conditions and characterized weather into sun glare, rain, fog, and snow, identifying navigation and traffic evaluation as primary challenges. Their approach utilized self-localization via GNSS/INS and map matching, environmental recognition, motion prediction with digital maps, driving route assistance, trajectory generation, and control.Iancu et al. [19] developed a pollution monitoring application using vehicles as probes to assess environmental conditions. Infrared sensors play a crucial role in detecting infrared radiation from road surfaces, which is then processed using intelligent algorithms to determine surface conditions. Key indicators for road surface detection include potholes, pedestrians, temperature variations, water, ice, and snow.Bansal et al. [20] introduced Deep Bus, a machine learning-based pothole detection system leveraging IoT to identify road surface irregularities. Bibi et al. [21] introduced an Edge AI and VANET-based system for automated road anomaly detection. Their approach employs high-resolution cameras to capture real-time road conditions, using trained images to mitigate accidents caused by poor infrastructure for detecting and classifying anomalies like potholes, bumps, and cracks.An intelligent accident prevention system is developed using the KNN algorithm witheye aspect-ratio, to detect driver drowsiness[22]. Chellaswamy et al. [23]designed a CNN-based approach for identifying and reporting road hazards like humps and potholes to improve safety.Their approach enables warning messages for high-speed vehicles and transmits pothole data to a central authority for further action.

VI. VEHICLE DIAGNOSTICS AND SECURITY SYSTEM

Vehicle diagnostics focuses on identifying component failures that could lead to breakdowns. Sensors utilizing I2V and V2V communication relay data to the cloud, enabling support in remote regions. Liu et al. [24]developed a model for detecting failures by predicting vehicle movement.They introduced a dead reckoning-based method to predict vehicle failures and prevent link disruptions. Yu et al. [25]proposed an strategy for effective traffic management and fault diagnosis in urban road networks.Liu et al. [26]proposed a hierarchical failure detection model for VANETs, utilizing an RSU grouping strategy to efficiently identify and disseminate alerts while minimizing packet loss and overhead. Their approach, designed for a linear road network, demonstrated a high detection rate even for fast-moving vehicles but did not consider vehicle dynamics.Security systems play a crucial role in authenticating users and onboard devices in vehicles. These systems are broadly categorized into intrusion detection, authentication, and countermeasure mechanisms. A deep learning-based interruption detection system is proposed to identify hacking attempts in vehicles[27]. A distributed-authentication mechanism to alleviatethe collision attacks is investigated in [28].

VII. ITMS FOR TRAFFIC MANAGEMENT AND NAVIGATION SYSTEM

This ITMS applications focuses on traffic management, aiming to deliver essential traffic-related information. It encompasses traffic data management, flow prediction, navigation, clustering, routing, and data dissemination. These systems utilize sensors,cameras,and surveillancesystem to control traffic flow and inform the users. Abdoos et al. [29] introduced a short period traffic forecast model using neural network. It demonstrated greater accuracy compared to existing approaches. In article[30] a distributed traffic forecasting system is proposed using an anticipatory routing approach. Navigation system under ITMS provide real-time vehicle location information, enhancing navigation through GPS and map-matching algorithms integrating road maps. Similarly, a path-planning is proposed to reduce travel time in cooperative ITMS, utilizing a shortest-path routing technique by Regragui et al. [31].Tasgoankar et al. [32] introduced a sensor-based vehicle detection and traffic estimation system for ITMS, leveraging sensor fusion to improve tracking and detection accuracy.

VIII. APPLICATIONS AND SERVICES

8.1 Clustering and information exchange applications

Clustering is a technique used for data transmission by grouping vehicles within a region to facilitate efficient information exchange. It enhances energy efficiency, data transfer, and network security. Nedham et al. [33] introduced an energy-efficient clustering protocol for WSNs, utilizing a centralized clustering phase with distributed cluster heads based on k-means clustering to lower consumption of energy and extend network lifecycle. Mukherjee et al. [34]projected a backpropagation neural network method for identifying cluster heads in MIMO sensor networks within ITS. Their approach employed the distributed gradient drop technique to minimize distance estimation errors, while particle swarm optimization tuned network weight and threshold for improved localization and energy efficiency. Abdulzahra et al. [35] presented an unequal clustering and sleep scheduling approach for energy optimization in WSN-based IoT, using fuzzy c-means for cluster formation and head selection to balance energy usage and transmission distance. Asim Saleem et al. [36] developed a deep learning-based dynamic cluster selection method that leverages adaptive spectrum sensing with LSTM, achieving 80% accuracy in signal detection under varying noise conditions while improving cluster stability and reducing communication overhead.

8.2 Routing and scheduling applications

Routing determines the optimal path for data transfer within a specific timeframe while managing traffic flow and scheduling in public networks. It also addresses key challenges such as energy efficiency, security, scalability, density, and coverage. Al-Qurabat et al. [37] explored the integration of WSN with IoT, particularly for periodic applications, addressing key challenges such as energy-efficiency, security, node density and routing.Elhoseny et al. [38] developed an energy-efficient VANET routing method using k-medoids clustering and an Enhanced Dragonfly Algorithm (EDA), reducing energy consumption by 83%.In Ref.[39]a traffic routing approach is developedfor connected vehicles using ant colony optimization combined with collective learning-based negotiation to enhance traffic flow. Similarly in Ref.[40]a 3D localization technique for mobile WSN nodes is presented integrating the Savarese algorithm to address singularity issues and enhance accuracy.

8.3 Crowd- sensing applications

Crowd sensing, also called mobile crowd sensing, involves collective data gathering and analysis to extract insights through crowdsourcing applications. Wang et al. [41] proposed a hybrid crowd-AI approach for urban tracking, improving safety in theft, crime, and investigations. Their method, addressing the NP-hard nature of the problem, minimizes data offloading costs using graph-optimized offloading, trajectory prediction, and task allocation. While AI-driven offloading enhances efficiency, cost reduction and accuracy remain challenges. Bock et al. [42] developed a smart parking system utilizing taxis for crowd sensing to detect available street parking. Yang et al. [43] addressed crowdsourcing issues in transportation, such as diverse sensor data and low participation incentives, by introducing an edge-based hierarchical vehicular crowdsourcing framework with deep reinforcement learning to optimize engagement.

8.4 Energy efficiency and Smart grid services

Advancements in intelligent connected vehicle technology have driven the development of hybrid electric- vehicles which address pollution, energy transmission, and fuel efficiency issues. Research on smart grid services has explored various solutions in this field. Kazemi et al. [44]introduced a predictive powertrain optimization method for hybrid electric vehicles to enhance traffic safety. They employed the Adaptive Equivalent Consumption Minimization Strategy to refine energy optimization within ITS, reducing fuel and power consumption, particularly during braking and at intersections. However, their approach still faces challenges in traffic prediction accuracy. Yang et al. [45] proposed an Energy Management Strategy to optimize energy distribution between the fuel tank and electric storage.

IX. PERFORMANCE ANALYSIS OF ITMS

Table 1 Performance analysisofITMS and applications

Type	**Connectivity**	**Accuracy**	**Latency**	**Complexity**	**Precision**	**Energy**
Systems for collision-avoidance and detection of driver-behavior	Yes	Yes	Yes		Yes	
Systems for weather and surface condition detection	Yes	Yes			Yes	
Systems for vehicle-diagnostics and security	Yes			Yes		Yes
Systems for traffic-management and navigation	Yes	Yes	Yes			
Clustering and information exchange	Yes		Yes	Yes	Yes	
Routing and scheduling	Yes	Yes	Yes		Yes	
Crowd sensing	Yes		Yes	Yes	Yes	
Energy efficiency and Smart grid	Yes					Yes

X. CONCLUSION

This review explores Intelligent Traffic Monitoring and Signaling (ITMS) for smart cities, focusing on road safety, traffic efficiency, and collision prevention. It provides a detailed analysis ofITMS applications, comparing them based on challenges, key features, benefits, and limitations. The study also identifies research gaps and offers insights into existing works in ITMS. Additionally, future directions are highlighted to enhance ITMS effectiveness. Further research is needed on security and safety aspects, as well as advancements in monitoring and signaling, crowd sensing, vehicle diagnostics, and road surface condition detection to drive future ITMS innovations.

REFERENCES

[1] Wan, S., Gu, Z., and Ni, Q., "Cognitive computing and wireless communications on the edge for healthcare service robots," Computer Communications, **Vol.149**, pp. 99–106, 2020.

[2] Chen, M., Leung, V. C., Mao, S., and Yuan, Y., "Directional geographical routing for real-time video communications in wireless sensor networks," Computer Communications, **Vol.30**, **No.17**, pp. 3368–3383, 2007.

[3] Figueiredo, L., Jesus, I., Machado, J. T., Ferreira, J. R., and De Carvalho, J. M., "Towards the development of intelligent transportation systems," in ITSC 2001. 2001 IEEE intelligent transportation systems. Proceedings (Cat. No. 01TH8585), 2001, pp. 1206–1211. [Online]. Available: https://ieeexplore.ieee.org/abstract/document/948835/

[4] Alberio, M. and Parladori, G., "Innovation in automotive: A challenge for 5G and beyond network," in 2017 International Conference of Electrical and electronic technologies for automotive, 2017, pp. 1–6. [Online]. Available: https://ieeexplore.ieee.org/abstract/document/7993223/

[5] Schaefer, K. E. and Straub, E. R., "Will passengers trust driverless vehicles? Removing the steering wheel and pedals," in 2016 IEEE International Multi-Disciplinary Conference on Cognitive Methods in Situation Awareness and Decision Support (CogSIMA), 2016, pp. 159–165. [Online]. Available: https://ieeexplore.ieee.org/abstract/document/7497804/

[6] Jones, L., "Driverless when and cars: where?[automotive autonomous vehicles]," Engineering & Technology, **Vol.12**, **No.2**, pp. 36–40, 2017..

[7] Organization, W. H., "World health statistics 2010." World Health Organization, 2010. [Online]. Available: Online.

[8] Mohamed, H. A., "Estimation of socio-economic cost of road accidents in Saudi Arabia: Willingness-to-pay approach (WTP)," Advances in Management and Applied Economics, **Vol.5**, **No.3**, p. 43, 2015.

[9] Al Turki, Y. A., "How can Saudi Arabia use the Decade of Action for Road Safety to catalyse road traffic injury prevention policy and interventions?" International Journal of Injury Control and Safety Promotion, **Vol.21**, **No.4**, pp. 397–402, 2014.

[10] Wenger, J., "Automotive radar-status and perspectives," in IEEE Compound Semiconductor Integrated Circuit Symposium, 2005. CSIC'05., 2005, pp. 4-pp. [Online]. Available: https://ieeexplore.ieee.org/abstract/document/1531741/

[11] De Souza, A. M., Brennand, C. A., Yokoyama, R. S., Donato, E. A., Madeira, E. R., and Villas, L. A., "Traffic management systems: A classification, review, challenges, and future perspectives," International Journal of Distributed Sensor Networks, **Vol.13**, **No.4**, p. 155014771668361, 2017.

[12] Mohapatra, H., Rath, A. K., and Panda, N., "IoT infrastructure for the accident avoidance: an approach of smart transportation," International Journal of Information Technology, **Vol.14**, **No.2**, pp. 761–768, 2022.

[13] Speiran, J. and Shakshuki, E. M., "A smartphone VANET based forward collision detection system," Procedia Computer Science, **Vol.198**, pp. 33–42, 2022.

[14] Gonçalves, F., Ribeiro, B., Santos, J., Gama, O., Castro, F., Fernandes, J., Costa, A., Dias, B., Nicolau, M. J., and Macedo, J., "Enhancing VRUs Safety with V2P communications: an experiment with hidden pedestrians on a crosswalk," in 2022 14th International Congress on Ultra-Modern Telecommunications and Control Systems and Workshops (ICUMT), 2022, pp. 96–103. [Online]. Available: https://ieeexplore.ieee.org/abstract/document/9943508/

[15] Ucar, S., Hoh, B., and Oguchi, K., "Differential deviation based abnormal driving behaviour detection," in 2021 IEEE International Intelligent Transportation Systems Conference (ITSC), 2021, pp. 1553–1558. [Online]. Available: https://ieeexplore.ieee.org/abstract/document/9564620/

[16] Omerustaoglu, F., Sakar, C. O., and Kar, G., "Distracted driver detection by combining in-vehicle and image data using deep learning," Applied Soft Computing, **Vol.96**, p. 106657, 2020.

[17] Siems-Anderson, A. R., Walker, C. L., Wiener, G., Mahoney III, W. P., and Haupt, S. E., "An adaptive big data weather system for surface transportation," Transportation research interdisciplinary perspectives, **Vol.3**, p. 100071, 2019..

[18] Yoneda, K., Suganuma, N., Yanase, R., and Aldibaja, M., "Automated driving recognition technologies for adverse weather conditions," IATSS research, **Vol.43**, **No.4**, pp. 253–262, 2019.

[19] Iancu, B., Illyes, I., Peculea, A., and Dadarlat, V., "Pollution Probes Application: the impact of using PVDM messages in VANET infrastructures for environmental monitoring," in 2019 IEEE 15th International Conference on Intelligent Computer Communication and Processing (ICCP), 2019, pp. 443–449. [Online]. Available: https://ieeexplore.ieee.org/abstract/document/8959532/

[20] Bansal, K., Mittal, K., Ahuja, G., Singh, A., and Gill, S. S., "DEEPBUS: Machine learning based real time pothole detection system for smart transportation using IoT," Internet Technology Letters, **Vol.3**, **No.3**, p. e156, 2020.

[21] Bibi, R., Saeed, Y., Zeb, A., Ghazal, T. M., Rahman, T., Said, R. A., Abbas, S., Ahmad, M., and Khan, M. A., "Edge AI‐ Based Automated Detection and Classification of Road Anomalies in VANET Using Deep Learning," Computational Intelligence and Neuroscience, **Vol.2021**, **No.1**, p. 6262194, 2021.

[22] Guria, M. and Bhowmik, B., "IoT-enabled driver drowsiness detection using machine learning," in 2022 Seventh international conference on parallel, distributed and grid computing (PDGC), 2022, pp. 519–524, 2025. [Online]. Available: https://ieeexplore.ieee.org/abstract/document/10053235/

[23] Chellaswamy, C., Saravanan, M., Kanchana, E., and Shalini, J., "Deep learning-based pothole detection and reporting system," in 2020 7th International conference on smart structures and systems (ICSSS), 2020, pp. 1–6.. [Online]. Available: https://ieeexplore.ieee.org/abstract/document/9202061/

[24] Liu, J., Chen, S., Gui, G., Gacanin, H., Sari, H., and Adachi, F., "Failure detector based on vehicle movement prediction in vehicular ad-hoc networks," IEEE Transactions on Vehicular Technology, **Vol.72**, **No.9**, pp. 11657–11667, 2023.

[25] Yu, H., Liu, R., Li, Z., Ren, Y., and Jiang, H., "An RSU deployment strategy based on traffic demand in vehicular ad hoc networks (VANETs)," IEEE Internet of Things Journal, **Vol.9**, **No.9**, pp. 6496–6505, 2021.

[26] Liu, J., Ding, F., and Zhang, D., "A hierarchical failure detector based on architecture in VANETs," IEEE Access, **Vol.7**, pp. 152813–152820, 2019.

[27] Ashraf, J., Bakhshi, A. D., Moustafa, N., Khurshid, H., Javed, A., and Beheshti, A., "Novel deep learning-enabled LSTM autoencoder architecture for discovering anomalous events from intelligent transportation systems," IEEE Transactions on Intelligent Transportation Systems, **Vol.22**, **No.7**, pp. 4507–4518, 2020.

[28] Tolba, A. M. R., "Trust-based distributed authentication method for collision attack avoidance in VANETs," IEEE Access, **Vol.6**, pp. 62747–62755, 2018.

[29] Abdoos, M. and Vajedsamiei, T., "Short-Term Traffic Flow Prediction Based on a Recurrent Deep Neural Network: a Study in Tehran," in 2021 12th International Conference on Information and Knowledge Technology (IKT), 2021, pp. 150–156. [Online]. Available: https://ieeexplore.ieee.org/abstract/document/9685122/

[30] Krishnan, V. G. and Ram, N. S., "Analyze traffic forecast for decentralized multi agent system using I-ACO routing algorithm," Journal of Ambient Intelligence and Humanized Computing, pp. 1–8, 2018.

[31] Regragui, Y. and Moussa, N., "A real-time path planning for reducing vehicles traveling time in cooperative-intelligent transportation systems," Simulation Modelling Practice and Theory, **Vol.123**, p. 102710, 2023.

[32] Tasgaonkar, P. P., Garg, R. D., and Garg, P. K., "Vehicle detection and traffic estimation with sensors technologies for intelligent transportation systems," Sensing and Imaging, **Vol.21**, **No.1**, p. 29, 2020.
[33] Nedham, W. B. and Al-Qurabat, A. K. M., "An improved energy efficient clustering protocol for wireless sensor networks," in 2022 International Conference for Natural and Applied Sciences (ICNAS), 2022, pp. 23–28.. [Online]. Available: https://ieeexplore.ieee.org/abstract/document/9944716/
[34] Mukherjee, A., Jain, D. K., Goswami, P., Xin, Q., Yang, L., and Rodrigues, J. J., "Back propagation neural network-based cluster head identification in MIMO sensor networks for intelligent transportation systems," IEEE Access, **Vol.8**, pp. 28524–28532, 2020.
[35] Abdulzahra, A. M. K. and Al-Qurabat, A. K. M., "A clustering approach based on fuzzy C-means in wireless sensor networks for IoT applications," Karbala International Journal of Modern Science, **Vol.8**, **No.4**, pp. 579–595, 2022.
[36] Saleem, M. A., Shijie, Z., Sarwar, M. U., Ahmad, T., Maqbool, A., Shivachi, C. S., and Tariq, M., "Deep Learning-Based Dynamic Stable Cluster Head Selection in VANET," Journal of Advanced Transportation, **Vol.2021**, pp. 1–21, 2021.
[37] Al-Qurabat, A. K. M. and Abdulzahra, S. A., "An overview of periodic wireless sensor networks to the internet of things," in IOP conference series: materials science and engineering, 2020, **Vol.928**, **No.3**, p. 032055. [Online]. Available: https://iopscience.iop.org/article/10.1088/1757-899X/928/3/032055/meta
[38] Elhoseny, M. and Shankar, K., "Energy Efficient Optimal Routing for Communication in VANETs via Clustering Model," in Emerging Technologies for Connected Internet of Vehicles and Intelligent Transportation System Networks, **Vol.242**, M. Elhoseny and A. E. Hassanien, Eds. Cham: Springer International Publishing, 2020, pp. 1–14.
[39] Nguyen, T.-H. and Jung, J. J., "ACO-based traffic routing method with automated negotiation for connected vehicles," Complex Intell. Syst., **Vol.9**, **No.1**, pp. 625–636, 2023.
[40] Javed, I., Tang, X., Saleem, M. A., Sarwar, M. U., Tariq, M., and Shivachi, C. S., "3D Localization for Mobile Node in Wireless Sensor Network," Wireless Communications and Mobile Computing, **Vol.2022**, pp. 1–12, 2022.
[41] Wang, P., Pan, Y., Lin, C., Qi, H., Ren, J., Wang, N., Yu, Z., Zhou, D., and Zhang, Q., "Graph optimized data offloading for crowd-ai hybrid urban tracking in intelligent transportation systems," IEEE Transactions on Intelligent Transportation Systems, **Vol.24**, **No.1**, pp. 1075–1087, 2022.
[42] Bock, F., Di Martino, S., and Origlia, A., "Smart parking: Using a crowd of taxis to sense on-street parking space availability," IEEE Transactions on Intelligent Transportation Systems, **Vol.21**, **No.2**, pp. 496–508, 2019.
[43] Yang, X., Gu, B., Zheng, B., Ding, B., Han, Y., and Yu, K., "Toward incentive-compatible vehicular crowdsensing: An edge-assisted hierarchical framework," IEEE Network, **Vol.36**, **No.2**, pp. 162–167, 2022.
[44] Kazemi, H., Fallah, Y. P., Nix, A., and Wayne, S., "Predictive AECMS by utilization of intelligent transportation systems for hybrid electric vehicle powertrain control," IEEE Transactions on Intelligent Vehicles, **Vol.2**, **No.2**, pp. 75–84, 2017.
[45] Yang, C., Zha, M., Wang, W., Liu, K., and Xiang, C., "Efficient energy management strategy for hybrid electric vehicles/plug- in hybrid electric vehicles: review and recent advances under intelligent transportation system," IET Intelligent Trans Sys, **Vol.14**, **No.7**, pp. 702–711, 2020.