Int. J. Advanced Networking and Applications 6275
Volume: 16 Issue: 01 Pages: 6275– 6280 (2024) ISSN: 0975-0290

The Recent Variants of OLSR Routing Protocol in MANET: A Review

Md. Zahid Hassan
Department of Computer Science and Engineering, Bangladesh Army University of Science and Technology, Bangladesh
Email: zahidhassan956@gmail.com
Md. Mamun Hossain
Department of Computer Science and Engineering, Bangladesh Army University of Science and Technology, Bangladesh
Email : mamunsust12@gmail.com
S. M. Jahangir Alam
Department of Computer Science and Engineering, Bangladesh Army University of Science and Technology, Bangladesh
Email : jahangir@baust.edu.bd

ABSTRACT

The dynamic topology of a mobile ad hoc network (MANET) distinguishes it as a decentralized kind of wireless network. When it comes to performance, a routing protocol is crucial. It is employed to ascertain and to find route that is both accurate and effective between two source and destination nodes to ensure that messages are delivered on time. We have examined the OLSR (Optimized Link State Routing) protocol in this research. Multi-point relays (MPRs), which are chosen nodes that forward broadcast messages throughout the flooding process, are the main idea employed in the protocol. MPRs are used to reduce routing cost by limiting the spread of control messages across the network. Many efforts have been made in the last few years to choose MPRs efficiently, which leads to improved routing performance. We provide a state-of-the-art assessment of the various MPR selection processes used in recent years in this work.

Keywords – **MANET, Routing Protocols, OLSR, MPRs**

Date of Submission: May 12, 2024 Date of Acceptance: June 2, 2024

1. INTRODUCTION

A mobile ad hoc network, or MANET [1], is a type of computer network that forms instantaneously without a set architecture using mobile nodes. Nodes are freely and readily inserted and withdrawn. An ad hoc network [2] is sometimes known as an infrastructure-less network since it lacks the base infrastructure of conventional networks. It lets the user interact without a physical network, no matter where they are in the world. An ad hoc network lacks a central management that handles communication [3]. Typically, the nodes' transmission range is limited. In order to forward packets, each node must ask its nearby mobile nodes for assistance. These kinds of networks are usually the best option when a fixed network cannot be created or there is no fixed infrastructure.

MANETs enable communication between devices and the sharing of helpful data even in challenging circumstances and remote locations lacking conventional network infrastructures. These characteristics have led to the widespread usage of MANETs in many fields, including education, search and rescue [4] [5], military operations [6], and disaster management systems [7]. To carefully select and improve the most adaptable MANET protocol for real-world applications, it is crucial to simulate several MANET protocols [8] [9] [10] and assess how well they work under diverse scenarios. It is generally recommended to take into account a number of important factors while assessing the effectiveness of ad-hoc network protocols. They must first be tested in real-world scenarios [11] [12], such as a variety of delicate transmission scenarios, a small buffer size to hold messages, relevant data traffic models, and an actual mobility model, among others.

Proactive, reactive, and hybrid routing protocols [13] are the three types of MANET routing protocols. Each node in proactive maintains a routing table to keep track of topology changes and to maintain route information accessible to packet transfers. However, reactive lacks a routing table and creates a route only when communication is required. The best elements of proactive and reactive routing protocols are combined in hybrid protocols, which include methods with a natural inspiration. In this paper, only different variations of the standard OLSR protocol [14] [15], a proactive routing protocol, have been discussed.

The rest of the article is organized as follows. A brief introduction to OLSR is given in Section 2. Section 3 discusses several OLSR extensions and provides an overview of their key features, advantages, and disadvantages. The paper's conclusion is given in Section 4.

2. OPTIMIZED LINK STATE ROUTING (OLSR)

One of the most widely used wireless routing protocols, OLSR performs comparably better on MANETs and is developed by optimizing the traditional link state routing technique. Since OLSR is a proactive protocol, it always ensures previous route availability. It can surpass its corresponding benchmarks in terms of packet delivery ratio (PDR), throughput, and end-to-end delay because of the previously available routes [16].

Through a frequent or sporadic exchange of Hello and TC messages, nodes in a MANET can build and maintain necessary pathways. Performance degradation may result from message collisions, traffic jams, and increased energy consumption, all of which can be brought on by the increase in TC communications, particularly in congested networks. Only the chosen MPR nodes are allowed to forward TC messages, allowing OLSR to regulate or optimize the broadcasting of TC messages. Two or more TC messages may be contained in a single TC packet sent by an MPR node. This helps to reduce routing overhead and the possibility of packet collisions between nodes. Consequently, fewer TC messages can be sent by lowering the MPR set. The basic MPR selection strategy of OLSR protocol has been given in Algorithm 1.

Algorithm 1: MPR selection strategy of OLSR [17]

1: Start with MPR(u) ← N (u) where willingness of y ∈ N (u) is WILLALWAY S
2: Compute D (y) for all y ∈ N (u)
3: for Each y ∈ N (u) do
4:   if y is the only node to reach some w ∈ N2(u) then
5:     Add y to MPR(u) and Remove w from N2(u)
6:   end if
7: end for
8: while N2(u) remains not empty do
9:   if Only y ∈ N (u) has highest reachability and willingness for some w ∈ N2(u) then
10:     Add y to MPR(u) and Remove w from N2(u)
11:     if More y ∈ N (u) with same reachability and willingness then
12:       Find y ∈ N (u) where D (y) is maximum
13:       Add y to MPR(u) and Remove w from N2(u)
14:     end if
15:   end if
16: end while
17: Integrate MPR(u) for all interfaces of u

(MPRs) nodes are essential for limiting the transmission of control TC signals. Heuristic in nature, the standard MPR selection process requires a node (u) to preserve its one-hop and two-hop neighbor sets, N(u) and N2(u), respectively [17]. Nodes that are accessible to members of one-hop neighbors N(u) and whose willingness is not WILLNEVER are included in N2(u). Every node keeps track of the "willingness" parameter, which is an integer number between 0 and 7 that expresses how eager it is to transfer traffic for other nodes. WILLNEVER(0) indicates any node that is not interested in forwarding traffic for other nodes, possibly due to resource constraints. A node with WILLALWAYS(7) indicates that it is constantly prepared to forward traffic on behalf of other nodes. Every node has WILLDEFAULT as its default willingness (3). Any node y that belongs to N(u) has its degree shown as D(y). D(y) is the number of symmetric neighbors of node y minus the node u doing the computation and any other nodes that are also members of N(u).

By dispersing different kinds of control signals including Hello, TC, MID, and HNA, OLSR facilitates proactive routing to find the optimal path. Through the control messages, the MANET nodes share neighbor and routing information. The nodes create and maintain the topology data in their routing tables using the control packets.

OLSR performance in MANET is largely dependent on the effectiveness of the MPR selection technique [18]. Researchers have worked hard in recent years to develop an MPR selection approach that takes into account several performance metrics, including throughput, packet delivery ratio, end-to-end delay, secured routing, and energy-efficient OLSR, among others.

3. SEVERAL IMPROVEMENTS ON OLSR

To ensure good performance in MANET, several works have been done in the recent years. In this study, the main purpose is to introduce the most recent works and improvements on OLSR so that researcher can extend these works for further improvements.

Table 1 illustrates the major improvements of OLSR that enable it to show better performance in terms of different performance metrics such as throughput, end-to-end delay and packet delivery ratio.

Table 1: Protocols related to the improvements in terms of throughput, end-to-end delay and packet delivery ratio.

Protocol Name, Year	**Contribution**	**Future Scope**
Efficient OLSR [17], 2024	MPRs have been selected based on heuristic approach and considering only 1-hop neighbors. This process enables OLSR to reduce routing overhead without degrading the other performance metrics. By choosing approximately 55%, 28%, and 49% (on average) fewer MPR nodes than the conventional OLSR, SSTB, and M-OLSR protocols, respectively, the suggested methodology lowers the routing overhead without compromising packet	The normalization factor and willingness factor can be improved considering transmission region and power. In order to implement the suggested MPR selection approach, more repositories and Hello and TC message header additions are needed. The method is based on a heuristic

Volume: 16 Issue: 01 Pages: 6275– 6280 (2024) ISSN: 0975-0290

	delivery ratio, throughput, or time.	function based on Euclidean distance.
M-OLSR [19], 2023	Gives more weight to nodes with more consistent energy and movement. Adding a mobility metric to the conventional MPR selection process is the aim of this strategy, which aims to enhance the overall network performance. In this methodology, less mobile candidate MPR nodes are given preference based on the mobility degree captured or the node with the biggest residual energy. While OLSR's throughput is 79%, M-OLSR's total average throughput is 86%.	The parameter, or coefficient of flow, has been set at one of three values, which are dependent on the motion around the node (0.25, 0.5, and 0.75). However, the routing overhead is not sufficiently reduced by M-OLSR.
FF-MPR OLSR [20], 2023	To choose the best MPRs, the ant colony algorithm has been enhanced, and the fruit fly algorithm has been suggested. If the best solution is not identified in each iteration, the algorithm will continue to optimize the collection based on prior decisions and random variables introduced by crossover and mutation until the iteration is finished. The FF-MPR OLSR algorithm outperforms the MMYQ-MPR method in terms of time savings, saving about 30%.	Using a greedy approach, the suggested method can be optimized; the outcomes should be compared while taking other performance measures into account.
LS-OLSR [21], 2023	Based on connection survival time, traditional OLSR has been enhanced for use in micro-nano satellite constellation networks. In order to estimate link survival time, HELLO messages are utilized to capture and exchange satellite location data at various times. These messages are also used to update the nearby link survival time. Link survival time is added to the Dijkstra method to improve it, and a new MPR selection algorithm has been presented that takes node connectivity and link survival time into account. LS-OLSR has a data transmission success rate of roughly 88.5%.	According to this protocol, the shortest path with the longest minimum survival time is chosen as the routing path. The minimum value of the link survival time in each path is recorded as the minimum survival time of the path. Other variables, such willingness and link security, can be taken into account when determining the graph's weight.
PSO-GA OLSR [22], 2023	A hybrid strategy that combines the benefits of PSO and GA has been presented to perform a more thorough and efficient search of the solution space. The customizable hybrid model uses two driving factors, one of which prioritizes GA and the other PSO, to change the OLSR performance. When the suggested technique is combined with an efficient dynamic component, it eliminates the need to construct the path each time a node or link fails.	It is possible to boost throughput and compare it to the most recent works. because throughput is not as improved in this study as it is when compared to regular OLSR. When comparing with different protocols, extra performance parameters like overhead and MPRs should be taken into account.

Table 2 enlists some OLSR protocols showing good performance in term of energy.

Table 2: Energy efficient OLSR protocols.

Protocol Name	**Contribution**	**Future Scope**
AC-OLSR [23], 2022	In order to calculate pheromone concentration and enhance network performance in a wireless context, link quality approaches have been combined. Heuristic elements are also introduced to deterministic methods utilizing the link's ETX measure to calculate pheromone concentration in order to further reduce the network's performance.	AC-OLSR has somewhat more routing overhead. When routing decisions are based on broadcasted link cost, there is an increase in routing overhead since data transmission duplication leads in greater energy costs.
WOA-OLSR [24], 2021	The authors proposed optimized link state routing based on the whale optimization algorithm as the optimal routing method for a secure and energy-efficient FANET. Through the use of the WOA algorithm and single or multi-key encryption, WOAOLSR	Time complexity arises to O(n4). Using additional bio-inspired techniques such as Fruit Fly Optimization, Moth-Flame Optimizer, Dragonfly Optimization, and

Volume: 16 Issue: 01 Pages: 6275– 6280 (2024) ISSN: 0975-0290

	provides energy efficiency together with security across flying ad hoc networks.	Grey Wolf Optimization for next systematic investigations further enhances FANET's routing mechanism.
EEM-OLSR [25], 2021	In order to improve energy management and extend the network lifetime based on willingness without performance losses, this research presents a new mechanism for choosing the MPR in the OLSR protocol. The EEM-OLSR protocol greatly extends the network lifetime compared to the traditional OLSR.	EEM-OLSR's performance can be evaluated by comparing it to other routing protocols with varying parameters in large network sizes and mobility models.
JPASR [26], 2020	Combining safe routing with joint power allocation has been proposed to maximize routing security while reducing uplink power usage. Energy-first multipoint relays set selection mechanism (EFMSS) is used to pick the backbone nodes for messages to be broadcast in the down-link, and the same level-by-level sleeping scheduling technique that is used for the uplink transmission is utilized to wake them up.	Layer by layer, nodes wake up when the sink node uses the MPR set that EFMSS chose during the 2k-th duty cycle to transmit the control message to the whole network. Other performance metrics can be taken under consideration besides energy consumption.
EMA-MPR [27], 2017	In order to improve QoS, prolong node lifetime, and increase route stability, an innovative energy and mobility-aware multi-point relay selection technique has been proposed, extending the existing MP-OLSRv2 protocol. It modifies the willingness setting of the traditional MPR selection process to guarantee the ideal number of nodes added to the MPR set.	Comparisons based on various network sizes have not been thought of. The MPR set is selected from the most mobile and stable nodes in terms of energy reserves by the proposed EMA-MPR selection process.

Table 3 demonstrates some OLSR protocols showing comparatively better performance in terms of security.

Table 3: Secured OLSR.

Protocol Name	Contribution	Future Scope
DBN-OLSR [28], 2023	In order to minimize the needless transmission of beacon messages during route selection, multipoint relay nodes are chosen based on real-time node parameters such as hop-count and residual energy. By employing machine learning-based Deep Belief Networks and Naive Bayes classifiers to thwart single black hole attacks, safe data transmission is accomplished. Through the choice of MPRs, the DBN-OLSR lowers routing overhead and enhances security.	Another enhanced classifier may be employed, and the outcomes ought to be contrasted with the most recent iteration of OLSR as well. The receiving node's willingness to participate in the MPR selection process can also be computed to enhance the other performance measures such as throughput, packet loss, overhead.
ST-OLSR [29], 2023	To enhance MPR selection in OLSR, a trust-based security solution is put forth in this study. The degree to which nodes are willing to become MPR is used to determine trust, while an aggregate of recommendations from other nodes is used to calculate their reputation. When ST-OLSR is used, the loss rate is lowered by 60%.	It is more critical problem to assess the reliability of a received feedback in order to avoid misjudging a possible MPR. Another more crucial problem is choosing the threshold value.
QoS-OLSR [30], 2021	Blockchain is included to improve the QoS-OLSR protocol for VANET, which is implemented off-chain and provides for trustworthy relay selection, end-to-end incentive payments for relays, and verification of nodes' transferred reputations.	Extension can be done by taking some other performance metrics under consideration such as throughput, delay, packet delivery ratio and overhead.
FT-OLSR [31], 2021	Enhances the security of communications within the VANET. Blockchain technology has been applied in order to eliminate tedious computations and isolate dangerous vehicles detected by FT-OLSR by improving collaboration between VANET components in a dynamic environment with limited resources.	Future research will concentrate on blockchain revocation, or the situation where an attacker shifts from being evil to being trustworthy, or vice versa. Energy efficiency as well as overhead can also be taken under consideration.
New-OLSR	This work aims to verify the existence of every 2-	End-to-end delay-based performance

[32], 2021	hop neighbor that has been declared by sending an ACK−HELLO routing control message upon each 2-hop neighbor's successful receipt of the forwarded HELLO message with a TTL of 1.	is not consistent with different node speeds. Throughput, delay and packet delivery ratio can be improved.

4. CONCLUSION

The current advancements made by the OLSR routing protocol are the main topic of this study. Researchers are interested in improving OLSR's performance in various aspects because it performs better in wireless scenarios. Based on the aforementioned works, it is evident that most of the works helped choose more dependable nodes to be MPR nodes because MPRs are crucial for improving the performance of OLSR. To get better results, researchers are urged to use more effective algorithms for the MPR selection procedure in the future.

REFERENCES

[1] M D. Ramphull, A. Mungur, S. Armoogum, and S. Pudaruth, A review of mobile ad hoc network (manet) protocols and their applications, *5th international conference on intelligent computing and control systems (ICICCS)*, Madurai, India, 2021, 204–211.

[2] M. Sharma, M. Singh, K. Walia, and K. Kaur, A comprehensive study of performance parameters for manet, vanet and fanet, *IEEE 10th Annual Information Technology, Electronics and Mobile Communication Conference (IEMCON)*, Vancouver, BC, Canada, 2019, 0643–0646.

[3] Z. Hassan and Asaduzzaman, Advanced Recursive Best-First Search (RBFS) based Routing Protocol for Multi-hop and Multi-Channel Cognitive Wireless Mesh Networks, *Journal of Computer Science and Technology Studies, 6*(1), 2024, 1-10.

[4] M. H. Hassan, S. A. Mostafa, H. Mahdin, A. Mustapha, A. A. Ramli, and M. A. Jubair, Mobile ad-hoc network routing protocols of time-critical events for search and rescue missions, *Bulletin of Electrical Engineering and Informatics, 10*(1), 2021, 192–199.

[5] F. T. Al-Dhief, N. Sabri, S. Fouad, N. A. Latiff, and M. A. A. Albader, A review of forest fire surveillance technologies: Mobile ad-hoc network routing protocols perspective, *Journal of King Saud University-Computer and Information Sciences, 31*(2), 2019, 135–146.

[6] S. Lee, J. Youn, and B. C. Jung, A cooperative phase-steering technique in spectrum sharing-based military mobile ad hoc networks, *ICT Express, 6*(2), 2020, 83–86.

[7] U. Aliyu, H. Takruri, M. Hope, and A. G. Halilu, Ds-olsr–disaster scenario optimized link state routing protocol, *12th International Symposium on Communication Systems, Networks and Digital Signal Processing (CSNDSP)*, Porto, Portugal, 2020, 1–6.

[8] V. K. Quy, V. H. Nam, D. M. Linh, N. T. Ban, and N. D. Han, A survey of qosaware routing protocols for the manet-wsn convergence scenarios in iot networks, *Wireless Personal Communications, 120*(1), 2021, 49–62.

[9] K. Raghavendra Rao and B. Jagadesh, Routing protocols: A survey, *Proc. of the International Conference on Computer Vision, High Performance Computing, Smart Devices and Networks*, Singapore, 2022, 85–94.

[10] P. Shah and T. Kasbe, A review on specification evaluation of broadcasting routing protocols in vanet, *Computer Science Review, 41*, 2021, 100418.

[11] A. Kurniawan, P. Kristalina, and M. Z. S. Hadi, Performance analysis of routing protocols aodv, olsr and dsdv on manet using ns3, *International Electronics Symposium (IES)*, Surabaya, Indonesia, 2020, 199–206.

[12] N. Gupta, A. Jain, K. S. Vaisla, A. Kumar, and R. Kumar, Performance analysis of dsdv and olsr wireless sensor network routing protocols using fpga hardware and machine learning, *Multimedia Tools and Applications, 80*(14), 2021, 22301–22319.

[13] R. R. Chandan, B. S. Kushwaha, and P. K. Mishra, Performance evaluation of aodv, dsdv, olsr routing protocols using ns-3 simulator, *International Journal of Computer Network & Information Security, 10* (7), 2018, 59-65.

[14] L. Maccari, M. Maischberger, and R. L. Cigno, Where have all the mprs gone? On the optimal selection of multi-point relays, *Ad Hoc Networks, 77*, 2018, 69–83.

[15] M. Usha and B. Ramakrishnan, A robust architecture of the olsr protocol for channel utilization and optimized transmission using minimal multi point relay selection in vanet, *Wireless Personal Communications, 109*, 2019, 271–295.

[16] S. A. H. Belkhira, S. Boukli-Hacene, P. Lorenz, M. Belkheir, M. Gilg, and A. Zerroug, A new mechanism for mpr selection in mobile ad hoc and sensor wireless networks, *IEEE International Conference on Communications (ICC)*, Dublin, Ireland, 2020, 1–6.

[17] Z. Hassan, S. M. A. Iqbal and Asaduzzaman, An Efficient OLSR Routing Protocol to Minimize Multipoint Relays in MANET, *International Journal of Intelligent Engineering and Systems, 17*(2), 2024, 489-500.

[18] A. Boushaba, A. Benabbou, R. Benabbou, A. Zahi, and M. Oumsis, Multi-point relay selection strategies to reduce topology control traffic for olsr protocol in manets, *Journal of Network and Computer Applications, 53*, 2015, 91–102.

[19] Y. Hamzaoui, M. Chekour and M. Amnai, Enhanced MPR Selection Algorithm Based on Metrics for the OLSR Routing Protocol, *Proc. 6th International Conference on Advanced Communication*

Technologies and Networking (CommNet), Rabat, Morocco, 2023, 1-6.

[20] Z. Xiang and J. Li, Multi point relay set selection algorithm based on fruit fly inspired optimizers, *3rd International Conference on Algorithms, High Performance Computing, and Artificial Intelligence (AHPCAI 2023),* Yinchuan, China, 2023, 120–128.

[21] W. Fu, Y. Yao, X. Guo, L. Fan, X. Zhang, Z. Wang, S. Shi, An improved OLSR protocol for micro-nano satellite Ad Hoc Networks, *6th International Conference on Intelligent Computing, Communication, and Devices (ICCD 2023),* Hong Kong, China, 2023, 421-429.

[22] U. K. Addanki, and B. H. Kumar, Hybrid optimization of OLSR routing protocol in MANETs: Uniting genetic algorithm and particle swarm optimization. *International Journal of Intelligent Systems and Applications in Engineering, 11*(3), 2023, 131-141.

[23] R. Jain, Ant colony inspired energy efficient OLSR (AC-OLSR) routing protocol in MANETS, *Wireless Personal Communications, 124*(4), 2022, 3307-3320.

[24] M. Namdev, S. Goyal, and R. Agarwal, An optimized communication scheme for energy efficient and secure flying ad-hoc network (fanet), *Wireless Personal Communications, 120*(2), 2021, 1291–1312.

[25] S. Laqtib, K. Yassini, K. Oufaska, & M. Hasnaoui, A New Energy Efficient Mechanism to Enhance MPR Selection in OLSR: EEM-OLSR, *Proc. International Conference on Industrial Engineering and Operations Management*, Rome, Italy, 2021.

[26] W. Feng, F. Wang, D. Xu, Y. Yao, X. Xu, X. Jiang, and M. Zhao, Joint energy saving scheduling and secure routing for critical event reporting in wireless sensor networks, *IEEE Access, 8*, 2020, 53281–53292.

[27] W. A. Jabbar, M. Ismail, R. Nordin, and R. M. Ramli, Ema-mpr: Energy and mobility-aware multi-point relay selection mechanism for multipath olsrv2, *IEEE 13th Malaysia international conference on communications (MICC),* The Puteri Pacific, Johor Bahru, Malaysia, 2017, 1–6.

[28] S. Shafi, and D. Ratnam, New Energy Aware MPR Selection for Securing OLSR Routing Scheme Under Black Hole Attack: A Machine Learning Approach, *Wireless Personal Communications, 132*(3), 2023, 1917-1931.

[29] F. Lakrami, M. Kamili, N. Elkamoun, H. Sounni and O. Labouidya, A secure based trust model for Optimized Link State Routing protocol (OLSR), *10th International Conference on Wireless Networks and Mobile Communications (WINCOM),* Istanbul, Turkiye, 2023, 1-5.

[30] M. Kadadha and H. Otrok, A blockchain-enabled relay selection for qos-olsr in urban vanet: A stackelberg game model, *Ad Hoc Networks, 117*, 2021, 102502.

[31] Y. Inedjaren, M. Maachaoui, B. Zeddini, and J.-P. Barbot, Blockchain-based distributed management system for trust in vanet, *Vehicular Communications, 30*, 2021, 100350.

[32] A. Nabou, M. D. Laanaoui, and M. Ouzzif, New mpr computation for securing olsr routing protocol against single black hole attack, *Wireless Personal Communications, 117*, 2021, 525–544.

AUTHORS BIOGRAPHY

Md. Zahid Hassan: completed his B.Sc. and M.Sc. Engineering degree in Computer Science and Engineering (CSE) from the Department of CSE, CUET, Bangladesh. Alongside, he is a Lecturer in the Department of CSE at Bangladesh Army University of Science and Technology (BAUST), Bangladesh. His major research interest includes Ad hoc Networks, Cloud Computing, Cognitive Radio Networks, IoT, Network Security, etc. He can be contacted at email: zahidhassan956@gmail.com.

Md. Mamun Hossain: is currently pursuing his PhD in Computer Science and Engineering at Rajshahi University of Engineering Technology (RUET), Bangladesh. He holds M.Sc. and B.Sc. Engineering degrees in Computer Science and Engineering from Shah Jalal University of Science and Technology. He is working as an Associate Professor in the Department of Computer Science and Engineering at Bangladesh Army University of Science and Technology. His research interests encompass AI, machine learning, NLP, data mining, computer vision, and biomedical engineering.

S.M. Jahangir Alam: has completed his PhD in engineering (AI & Robotics) from Xiamen University in China. He was previously an associate professor and foreign expert at South China University of Technology in China, as well as a visiting assistant professor at the University of British Columbia in Canada. In addition, he holds a visiting professorship at Leading University in Bangladesh. He is currently employed with Bangladesh Army University of Science and Technology as a professor and head of the CSE department. His research area encompasses Brain Science & Neural Network, Control Engineering, Deep Learning, Image Processing, Intelligent Systems & Robotics, IoT & Data Science, Machine Vision, and Time Series Analysis.