A Novel Trajectory Optimisation and Joint Resource Allocation for Mobile Edge Computing with Multi-UAV-Assisted Multi-Access

Megha R
Post Graduation Student
Department of Computer Science and Engineering,
East West Institute of Technology Bangalore, India
Email: meghakrishnappa1993@gmail.com

Achyutha Prasad N
Professor
Department of Computer Science and Engineering
East West Institute of Technology, Bangalore, India
achyuth001@gmail.com

Rekha V S
Research Scholar
Dr. Ambedkar Institute of Technology, Bangalore, India
rekhasedam.vtu@gmail.com

Jagadeesh B N
Assistant Professor,
Department of Computer Science and Engineering
East West Institute of Technology, Bangalore, India
jagadeeshbn001@gmail.com

Dr. Manjula G
Associate Professor, Dept of CSE
BGS College of Engineering and Technology, Bengaluru, Karnataka
manjulayash1@gmail.com

Rekha H
Assistant Professor
Department of Computer Science and Engineering
Sri Siddhartha Institute of Technology, Tumkur, Karnataka
rekhah.girish@gmail.com

Abstract—

Given the absence of places to employ communication infrastructures, there are many coverage blind zones in maritime communication networks. Benefiting from the high flexibility and maneuverability, unmanned aerial vehicles (UAVs) have been proposed as a potential means of provide broadband maritime coverage for these blind zones. In this paper, a multi-UAV-enabled maritime communication model where UAVs are used is suggested provide the transmission service for maritime users. To enhance the effectiveness of the maritime communication systems, A problem for optimisation is formulated to maximize the minimum throughput required by all users by jointly optimizing the user association, power allocation, and UAV trajectory. To derive the solutions with a low computational complexity, we Break this issue down into three subproblems, namely user association optimization, power allocation optimization, and UAV trajectory optimization. Then, a joint iterative algorithm is developed to achieve the solutions according to the successive convex approximation and interior-point methods. Extensive simulation results verify the efficiency of the proposed algorithm and demonstrate that Using UAVs used to enhance the maritime coverage.

Keywords— **UAV, resource management, trajectory design**

DOINumber:10.48047/nq.2022.20.22.NQ10374 **NeuroQuantology2022;20(22):3660-3669**

I.INTRODUCTION

Unmanned aerial vehicles (UAVs) are anticipated to become a more significant component of civil aviation, economic, military and even daily fields over recent years [1], [2]. To satisfy the requirements of diversified applications, It is essential to integrate UAVs and mobile communication techniques. Hence, UAV-assisted communication networks have attracted continuous research attentions and interests from industrial and academic communities. The benefits of UAV-assisted communications mainly rely on the controllable maneuverability, which enables UAVs to establish line-of-sight (LoS) links by constructing intelligent and controllable aerial platforms. To further elaborate the potential applications of UAVs in the next generation network, they can be leveraged as aerial base stations for alleviating communication pressure of terrestrial networks [3], as relays for providing emergency support in disaster areas [4], and as data-collectors for monitoring remote zones.

Despite the considerable advantages, the development of the UAV technology is restricted by the limitations of the battery energy and communication bandwidth. Therefore, improving the transmission efficiency of the UAV communication networks is emergent. It is believed that the non-orthogonal multiple access (NOMA) is one of the most essential and cost-effective technologies to compensate these restrictions, on account of its advantages of massive connections and increased spectral efficiency [7]. In NOMA, the successive interference cancellation (SIC) is employed at the receivers, which allows UAVs serving different users simultaneously in a same resource block (RB) by multiplexing customers in other domains than frequency or time [8]. Since NOMA can support more connectivities in UAV networks, the resource scarcity problem is relieved and the UAVs are capable to complete various communication tasks within their endurance time. The combining of NOMA and UAVs has been widely proved to bring about predictable benefits, and can strike a healthy equilibrium between user fairness and system throughput [9]. Three case studies are carried out in [10] to understand the UAV-assisted NOMA networks comprehensively from fundamental theory to actual implementation, but further research and analysis are needed with more practical scenarios.

Despite many studies on UAV mobility and resource allocation in static user scenarios mentioned above, channel conditions of wireless communication systems can also be affected by user mobility, leading to dramatic fluctuation of communication channel conditions. There are only few recent researches on user mobility prediction in air-ground wireless networks. The impact of channel fading, terrestrial user mobility, and propagation environment air-to-ground communication outage performance were analyzed in [23]–[25]. To ensure timely delivery of data in mobile ad hoc networks where UAVs serve as message ferries, an opportunistic data delivery plan based on mobility prediction of users and UAV placement design was proposed in [5]. In addition, in realistic network scenarios, such as fleet transportation and disaster relief operations, the mobile users are often involved in group activities and exhibit common mobility behavior. A novel routing scheme was proposed in [26], which can obtain an efficient throughput-delay tradeoff for mobile group users (MGUs) in ad hoc mobile networks with reference point group mobility (RPGM). To predict network partitions and reduce the number of interrupts, a simple and effective data clustering algorithm was designed in [27], which can accurately determine the mobile groups and estimate the characteristic parameters of each group in the event that given mobile users' speed in wireless ad hoc networks. But these investigations on group mobility mainly accentuate the communication connections between users in mobile ad hoc networks. How to improve the communication performance in an air-ground system with dual mobility of the fixed-wing UAV and ground users has become an urgent problem to be solved.

The rest of this document is structured as follows. In Section II, we introduce the model and formulation of the system the optimization problem. In Section III, We suggest an efficient iterative optimization algorithm. In Section IV, we prove that the proposed algorithm has good convergence and effectiveness through simulation results. Finally, we summarize the work and propose some future work prospects in Section V.

I. Literature Survey

Recently, the UAV-enabled MEC significant research has been done on the network. [13]–[19]. Considering the low-power ground IoT devices and the limited onboard energy storage of UAV, it is of great importance dedicating to the energy consumption minimization issues in the UAV-enabled MEC networks. To this end, X. Zhang et al. in [13] suggest an effective iterative a jointly used algorithm optimize the Using resource allocation and trajectory design, the weighted sum of users' and UAVs' energy usage is minimised in the UAV-enabled MEC system. Considering the stochastic offloading scheme, J. Zhang et al. in [14] adopt the Lyapunov optimization technique to optimize the same objective. Simulation outcomes indicate that the proposed scheme can save more energy compared with that only considering the energy consumption of users. In addition, compared with the scheme that only minimizes the amount of energy that UAV, more backlogs of the job queues can be processed by tasking both users' energy use and UAV into consideration.

Furthermore, by simultaneously considering the quantity of completed job pieces and energy consumption, the energy efficiency problems in the UAV-enabled MEC are investigated in [16]–[18]. More specifically, the energy efficiency of smart mobile devices (SMDs) in The investigation of a multi-UAV aided MEC system [17], where an iterative optimization algorithm based on the Dinkelbach's method is proposed to tackle the formulated fractional programming problem. Different from [17], the energy efficiency of UAV is maximized in [16] by combining UAV optimisation trajectory, the user transmit power, and computation load allocation. Moreover, the node mobility estimation has been adopted in [16] to design a proactive UAV trajectory when the knowledge of user trajectory is limited, which offer valuable insights on UAV optimal trajectory design for providing on-demand edge computing service for remote IoT nodes.

B. RIS-Assisted Networks The general definition of RIS is first given in [20]. In order to realize the imagined setting for smart radio environment (SRE), RIS is regarded as a key enabler, which has received increasing research focuses on both industry and academia. For example, NTT DOCOMO designs a kind of smart glass, which can dynamically control the response of the impinging radio waves. Another practical example of RIS is called RFocus, which is designed by Massachusetts Institute of Technology (MIT), USA [21]. The elements of RFocus can adjust the reflect signals toward specified direction and locations. Although the smart glass and RFocus have provided some design insights for the development of RIS, the research of RIS is still at an early stage [22]. In academia, aiming to theoretically exploiting the benefits of RIS, there are much literature dedicates to the optimization problems in the RIS-assisted networks. For instance, in the RIS-assisted MEC networks, during a given mission period, the total completed task-input bits is maximized in [23]– [25]. From the simulation results, It is apparent that the computational performance of the MEC system is greatly improved using the aid of RIS. In an effort to reduce the energy consumption of all users in the RIS-assisted MEC, the phase shift, size of transmission data, transmission rate, power, transmission time and the decoding order are jointly optimized in [26]. Besides, the latency minimization and energy efficiency maximization problems in the RIS-assisted MEC are investigated in [27] and [28], respectively. In the RIS-assisted UAV networks, the RIS can be deployed for overcoming the blockages and enhancing the achievable rate. Due to this, in [29], number of users overall in the downlink is maximized by jointly optimizing UAV's trajectory, the change in phase of RIS, the distribution of THz sub-bands, and the strength control. As expected, One of the highest sum rates is achieved by the proposed joint optimization algorithm. Moreover, in order to guarantee the secure communication from the UAV to the legitimate user, the average secrecy rate is maximized by an iterative algorithm in [30]. Similarly, the secure transmission problem is investigated in the UAV and RIS assisted mmWave networks, where the near-optimal positions of RIS and UAV are obtained by an exhaustive searching method [31]. Besides, as a means of overcoming the highly dynamic stochastic environments also lessen the computational complexity, the machine learning (ML) approaches have been utilized in the RISassisted UAV networks. For instance, in [32], a decaying deep Q-network (D-DQN) based algorithm is proposed to minimize the energy consumption of the UAV by jointly optimizing the phase shift of RIS, UAV trajectory, decoding order, and power allocation. Simulation findings demonstrate that the suggested D-DQN algorithm can strike a balance between accelerating training speed and converging to the local optimal, as well as avoiding oscillation. Furthermore, with the aim to maximize the energy efficiency of the UAV, the joint trajectory-phaseshift problems are tackled by the Double DQN (DDQN) and Deep Deterministic Policy Gradient (DDPG) algorithms in [33]. It can be seen that the energy efficiency of the UAV is able to be greatly improved with the aid of RIS.

Resource Allocation

The area of resource allocation in IoT has seen a lot of research. Different researchers had provided various reviews and distribution methods. While some had provided an algorithm for a hybrid resource allocation technique in a network, others had employed scheduling algorithms for dynamic allocation. Below is a description of many study perspectives: An approach for load-balanced particle swarm optimisation was put forth by Krishnapriya.S. and Jobby P.P. in 2015 [16]. The algorithm is employed for load balancing and dynamic work assignment. IoT has significant QoS challenges. Quality is dependent on a number of variables, including latency, dependability, effective network use, and efficient use of processing resources. Different degrees of QoS for the heterogeneous have been defined in this. This proposed algorithm's major goal is to guarantee QoS while also allocating resources effectively.

Y. Choi, Y. Lim, 2016 [17] – identifies the allocation of resources as a significant difficulty for IoT in cloud computing (CC). Meeting Service Level Agreements (SLA) related to a user is the key challenge with resource allocation in the CC.A QoS agreement between the service provider and the end user is referred to as a SLA. Therefore, it suggests a winner determination mechanism in order to maximise the providers' profit and lessen the SLA violation constraints. It demonstrates that this process produces results significantly superior to those of already existing ones. Researchers from J. Li, Q. Sun, and G. Fan (2016) [18] described ways to increase network utilisation in this publication. The growth of IoT has a significant impact on network performance because more and more devices are connecting to the internet every day. Therefore, LTE-based IoT communication is used for uplink scheduling in order to guarantee better network performance. It suggests a resource allocation strategy for an uplink SC-FDMA that is QoS limited. Finally, a simulation model is employed to demonstrate how this technique enhances network data rate performance. A. Singh, Y. Viniotis, 2016 [19] – IoT message broker service definition. It functions as sort of a sender-to-receiver intermediate module and is controlled by SLA. SLA does not provide any more information about the message other than its volume. Researchers had introduced a brand-new, two-step SLA approach in this. Although it is comparable to the current one, it also gives providers more power to enforce it. Additionally, they ran simulations to see how the proposed solution compared to the current one, and they also looked at other system factors.. V. Angelakis, I. Avgouleas, E.

Fitzgerald, N. Pappas, Di Yuan, 2016 [20] – In this article, the author names an issue known as Service to Interface Assignment (SIA). According to this, it gets more challenging to assign services to each device with diverse and non-exchangeable resources as the number of IoT devices grows and they all employ various technologies. A mathematical approach known as Mixed Integer Linear Programming (MILP) is suggested to resolve this issue. This demonstrates that the overall cost of employing interface resources has decreased along with the demand for valuable services. Z. Zhou, M. Dong, K. Ota, G. Wang, L. T Yang, 2016 [21] – In this study, efforts are made to prevent energy loss and to preserve the quality of service, both of which are impacted by network communication. The architecture for device-to-device (D2D) communication is also addressed in this study and is represented in Fig. 6. D2D communication enables the establishment of communication between user equipments. Its primary goal is to provide the highest throughput and finest service. But interference and spectrum reuse lead to a decline in service quality. A hybrid resource allocation mechanism built on the Cloud Radio Access Network (C-RAN) has been provided to address this issue. In order to ensure QoS, it also included a centralised interference mitigation mechanism. It happens in the baseband unit pool. The outcome of the simulation verifies the algorithm's effectiveness.

II. System Model

IOT are small devices which sense data from it nearby environment and report to centralized server from further processing and this IOT can be anything like smart phones, sensors or any other devices which runs on battery and perform communication using internet. Due to limited battery this IOT cannot perform heavy computation task and need to offload this heavy computation task to nearby networks for mobile edge computing, if this edge network far away then IOT cannot offload task to edge servers. To overcome from this issue UAV (Unmanned aerial vehicle) was introduced which moves on fixed altitude nearer to IOT locations so IOT can easily offload to nearby UAV to get processed result.

All existing techniques were using SINGLE ACCESS UAV where all IOT will send or offload task to single UAV which leads to more usage of energy get more delay in response.

To overcome from above issue author the present paper employing Multi UAV Edge Assisted Mobile Access where single IOT allow task offloading between multiple UAV and those UAV will process task and send result back to IOT. Here by diving task between multiple UAV and selecting only those UAV which are free for communication to cut back on energy use and can get response faster.

In propose The energy consumption of users and UAVs can be significantly reduced by the multi-UAV-assisted multi-access MEC model, which enables each IoT user to offload task bits to several MEC servers deployed at UAVs simultaneously for parallel processing. The bit allocation, transmit power, CPU frequency, bandwidth allocation, and UAVs' trajectories are collaboratively optimised to reduce the weighted aggregate energy consumption of UAVs and users. The non-convexity of the formulated problem causes it to be divided into two smaller problems, and alternative optimisation then proposes a joint solution for resource allocation and trajectory planning.

III. Methodology

In this work, we considered a specific area include a smart home city, a small town, or forest fire alarm monitoring management. Therefore, the communication a place is a circle with a radius of 250 (m), where N users are served by a UAV-based network within this location. The UAV flies periodically at a constant height H = 50 m above the location with the maximum speed of UAV denoted by v set as v(max) = 50 m/s. The general parameters of the system setting and propagation channels appear in Table. 2, while several specific parameters are presented in each figure. Moreover, in order to demonstrate the higher the effectiveness of the indicated methods, Algorithm 3 will involve different baseline methods for comparison. The proposed solutions for sub-problems will be compared to different benchmarks.

Following modules are used to offload task

Communication Model: using this module vector will be created with values 0 and 1 and if user offloading task then vector will be filled with 1 else 0 and by using this vector system can know communication load on each UAV

Computation: to ensure all user/IOT task must be computed so Mobile EDGE CPU frequency will be assigned to each IOT request

UAV Model: using this module UAV will move from fixed altitude location and by using this locations IOT will find nearer UAV to offload tasks

Joint Resource Allocation and Trajectory Optimization: Based on vector of load the resource will be jointly allocated between multiple UAV'S. Each IOT will optimized UAV trajectory (movement) by analysing vector load.

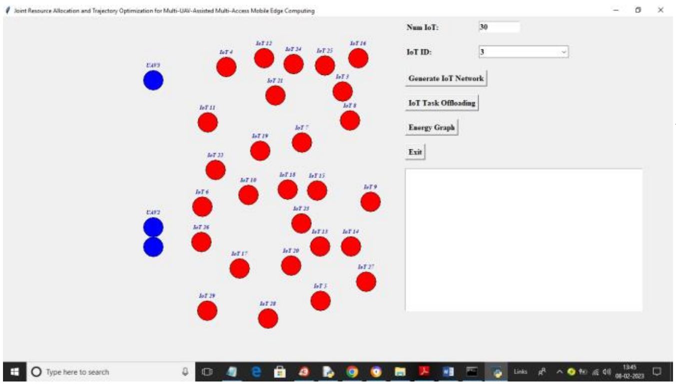
To implement this project we have designed IOT UAV simulation which consists of following modules

Generate IoT Network: using this module we will create virtual IOT and UAV devices. Each UAV will move from its location to another location to receive offload request from IOT devices

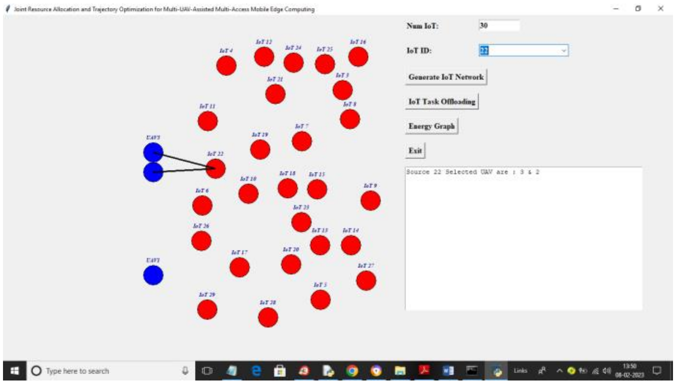
IoT Task Offloading: using this module we can select any IOT which will offload task to multiple nearby UAV'S which will process request and send result back to IOT. For each request energy consumption will be calculated based on single and multiple UAV access

Energy Graph: using this module we will plot energy consumption graph between existing single UAV access and propose multiple UAV access.

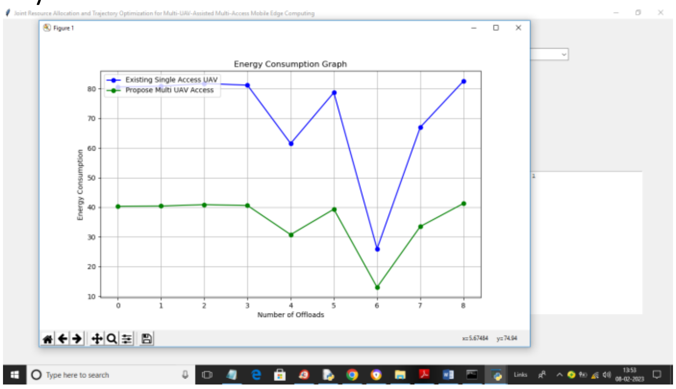
IV. Results And Analysis



In above screen I entered number of IOT as 30 and after pressing 'Generate IOT Network' we got above output where red colour nodes are the IOT and blue colour nodes are the UAV and we can see UAV are moving which we can see in below screen



In above screen we can see IOT22 offloading task between two UAV 3 and 2 and similarly you can select any IOT and offload task to UAV



In above graph x-axis represents number of task offload and y-axis represents energy consumption where blue line represents existing single access UAV energy consumption and green line represents propose multi access UAV energy consumption and in both techniques propose is taking less energy consumption compare to existing.

V. Conclusions

This paper includes considered a UAV-BS under in-band backhaul constraint, where the backhaul link together with access links share the same spectrum. To increase spectrum effectiveness of the UAV-BS and guarantee fairness among users being served, we have investigated maximizing the minimum rate among all users served by the UAV-BS jointly enhancing the bandwidths of the access links and the backhaul link, the transmit power allocated to all users, and the trajectory of the UAV-BS, and have proposed an efficient algorithm to address the considered problem. Computer simulation According to findings, the suggested algorithm achieves a significantly higher minimum user rate than the benchmark schemes, and demonstrate that jointly optimizing bandwidth, transmit power, and UAV trajectory can more efficiently use all the available resources to provide satisfactory rates for all users.

REFERENCES

[1]. Y. Zeng, Q. Wu, and R. Zhang, "Accessing from the sky: A tutorial on UAV communications for 5G and beyond," Proceedings of the IEEE, vol. 107, no. 12, pp. 2327–2375, 2019.

[2]. G, M.., P.. Deshmukh, U. K.. N. L., V. D. J.. Macedo, V.. K B, A. P.. N, and A. K.. Tiwari. "Resource Allocation Energy Efficient Algorithm for H-CRAN in 5G". International Journal on Recent and Innovation Trends in Computing and Communication, vol. 11, no. 3s, Mar. 2023, pp. 118-26, doi:10.17762/ijritcc.v11i3s.6172.

[3]. Prasad, A. K. ., D. K. . M, V. D. J. . Macedo, B. R. . Mohan, and A. P. . N. "Machine Learning Approach for Prediction of the Online User Intention for a Product Purchase". International Journal on Recent and Innovation Trends in Computing and Communication, vol. 11, no. 1s, Jan. 2023, pp. 43-51, doi:10.17762/ijritcc.v11i1s.5992.

[4]. Rekha, V.S., Siddaraju (2023). Goodness Ratio and Throughput Improvement Using Multi-criteria LEACH Method in Group Sensing Device Network. In: Kumar, A., Senatore, S., Gunjan, V.K. (eds) ICDSMLA 2021. Lecture Notes in Electrical Engineering, vol 947. Springer, Singapore.

[5]. Nirmala, G., Guruprakash, C.D. (2023). An Overview of Data Aggregation Techniques with Special Sensing Intelligent Device Selection Approaches. In: Kumar, A., Senatore, S., Gunjan, V.K. (eds) ICDSMLA 2021. Lecture Notes in Electrical Engineering, vol 947. Springer, Singapore.

[6]. X. Mu, Y. Liu, L. Guo, and J. Lin, "Non-orthogonal multiple access for air-to-ground communication," IEEE Transactions on Communications, vol. 68, no. 5, pp. 2934–2949, 2020.

[7]. Mohan, B. R., D.. M, V.. Bhuria, S. S.. Gadde, K.. M, and A. P.. N. "Potable Water Identification With Machine Learning: An Exploration of Water Quality Parameters". International Journal on Recent and Innovation Trends in Computing and Communication, vol. 11, no. 3, Apr. 2023, pp. 178-85.

[8]. Y. F. Chen, M. Liu, M. Everett, and J. P. How, "Decentralized non communicating multiagent collision avoidance with deep reinforcement learning," CoRR, vol. abs/1609.07845, 2016. [Online]. Available: http://arxiv.org/abs/1609.07845

[9]. Y. F. Chen, M. Everett, M. Liu, and J. P. How, "Socially aware motion planning with deep reinforcement learning," CoRR, vol. abs/1703.08862, 2017. [Online]. Available: http://arxiv.org/abs/1703.08862

[10]. M. Everett, Y. F. Chen, and J. P. How, "Motion planning among dynamic, decision-making agents with deep reinforcement learning," in 2018 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS), 2018, pp. 3052–3059.

[11]. Manjula G, Mohan H S," Constructing key dependent dynamic S-Box for AES block cipher system", 2nd IEEE International Conference on Applied and Theoretical Computing and Communication Technology, pp. 627-637,Bangalore,July 2016.

[12]. Manjula G, Mohan H S," Improved Dynamic S-Box generation using Hash function for AES and its performance analysis", 2nd IEEE International Conference on Green Computing and Internet of Things, pp. 109-115, Bangalore, August, 2018.

[13]. Manjula G, Mohan H S," A Secure Framework for Medical Image Encryption Using Enhanced AES Algorithm", International Journal of Scientific & Technology Research, Vol 9, Issue 2, pp. 3837-3841, ISSN 2277-8616.

[14]. Manjula G, Mohan H S," Probability based Selective Encryption scheme for fast encryption of medical images", Proceedings of the Third International Conference on Advanced Informatics for Computing Research June 2019 Article No.: 17 Pages 1–7.

[15]. Manjula G, Mohan H S," A study of Different methods of attacking and defending Cryptosystems", International Journal of Advanced Research in Computer and Communication Engineering, Vol 6, Issue 5, pp. 371-376, ISSN 2278-1021.

[16]. Achyutha Prasad N., Chaitra H.V., Manjula G., Mohammad Shabaz, Ana Beatriz Martinez-Valencia, Vikhyath K.B., Shrawani Verma, José Luis Arias-Gonzáles, "Delay optimization and energy balancing algorithm for improving network lifetime in fixed wireless sensor networks", Physical Communication,Volume 58,2023,102038,ISSN 1874-4907.

[17]. Hebbale, S., Marndi, A., Achyutha, P. N., Manjula, G., Mohan, B. R., & Jagadeesh, B. N. (2022). Automated medical image classification using deep learning. International Journal of Health Sciences, 6(S5), 1650–1667.

[18]. Manjula, G., and H. S. Mohan. "Probability based selective encryption scheme for fast encryption of medical images." In Proceedings of the ICAICR '19: Third International Conference on Advanced Informatics for Computing Research, Shimla, India, pp. 15-16. 2019.

[19]. N. A. Prasad and C. D. Guruprakash, "An ephemeral investigation on energy proficiency mechanisms in WSN," 2017 3rd International Conference on Applied and Theoretical Computing and Communication Technology (iCATccT), Tumkur, 2017, pp. 180-185.

[20]. P. N and C. D. Guruprakash, "A Relay Node Scheme for Energy Redeemable and Network Lifespan Enhancement," 2018 4th International Conference on Applied and Theoretical Computing and Communication Technology (iCATccT), Mangalore, India, 2018, pp. 266-274.

[21]. Achyutha Prasad, N., Guruprakash, C.D., 2019. A relay node scheme of energy redeemable and network lifespan enhancement for wireless sensor networks and its analysis with standard channel models. International Journal of Innovative Technology and Exploring Engineering 8, 605–612.

[22]. Achyutha Prasad, N., Guruprakash, C.D., 2019. A relay mote wheeze for energy saving and network longevity enhancement in WSN. International Journal of Recent Technology and Engineering 8, 8220–8227.

[23]. Achyutha Prasad, N., Guruprakash, C.D., 2019. A two hop relay battery aware mote scheme for energy redeemable and network lifespan improvement in WSN. International Journal of Engineering and Advanced Technology 9, 4785–4791.

[24]. Rekha VS, Siddaraju., "An Ephemeral Analysis on Network Lifetime Improvement Techniques for Wireless Sensor Networks", International Journal of Innovative Technology and Exploring Engineering, vol. 8, issue 9, 2278-3075, pp. 810–814, 2019.

[25]. Prasad N. Achyutha, Sushovan Chaudhury, Subhas Chandra Bose, Rajnish Kler, Jyoti Surve, Karthikeyan Kaliyaperumal, "User Classification and Stock Market-Based Recommendation Engine Based on Machine Learning and Twitter Analysis", Mathematical Problems in Engineering, vol. 2022, Article ID 4644855, 9 pages, 2022.

[26]. Achyutha, P. N., Hebbale, S., & Vani, V. (2022). Real time COVID-19 facemask

detection using deep learning. International Journal of Health Sciences, 6(S4), 1446–1462.

[27]. Kalshetty, J. N., Achyutha Prasad, N., Mirani, D., Kumar, H., & Dhingra, H. (2022). Heart health prediction using web application. International Journal of Health Sciences, 6(S2), 5571–5578.

[28]. R. V S and Siddaraju, "Defective Motes Uncovering and Retrieval for Optimized Network," 2022 6th International Conference on Computing Methodologies and Communication (ICCMC), 2022, pp. 303-313.

[29]. N. G and G. C. D, "Unsupervised Machine Learning Based Group Head Selection and Data Collection Technique," 2022 6th International Conference on Computing Methodologies and Communication (ICCMC), 2022, pp. 1183-1190.

[30]. Jipeng, T., Neelagar, M. B., & Rekha, V. S. (2021). Design of an embedded control scheme for control of remote appliances. Journal of Advanced Research in Instrumentation and Control Engineering, 7(3 & 4), 5-8.

[31]. Prakash, N. C., Narasimhaiah, A. P., Nagaraj, J. B., Pareek, P. K., Sedam, R. V., & Govindhaiah, N. (2022). A survey on NLP based automatic extractive text summarization using spacy. International Journal of Health Sciences, 6(S8), 1514–1525.

[32]. Prakash, N. C. P., Narasimhaiah, A. P., Nagaraj, J. B., Pareek, P. K., Maruthikumar, N. B., & Manjunath, R. I. (2022). Implementation of NLP based automatic text summarization using spacy. International Journal of Health Sciences, 6(S5), 7508–7521.

[33]. Ramkrishna, S., Srinivas, C., Narasimhaiah, A. P., Muniraju, U., Maruthikumar, N. B., & Manjunath, R. I. (2022). A survey on blockchain security for cloud and IoT environment. International Journal of Health Sciences, 6(7), 28–43.

[34]. Hebbale, S., Marndi, A., Achyutha, P. N., Manjula, G., Mohan, B. R., & Jagadeesh, B. N. (2022). Automated medical image classification using deep learning. International Journal of Health Sciences, 6(S5), 1650–1667.

[35]. Hebbale, S., Marndi, A., Manjunatha Kumar, B. H., Mohan, B. R. ., Achyutha, P. N., & Pareek, P. K. (2022). A survey on automated medical image classification using deep learning. International Journal of Health Sciences, 6(S1), 7850–7865.

[36]. S. Chaudhury, N. Achyutha Prasad, S. Chakrabarti, C. A. Kumar and M. A. Elashiri, "The Sentiment Analysis of Human Behavior on Products and Organizations using K-Means Clustering and SVM Classifier," 2022 3rd International Conference on Intelligent Engineering and Management (ICIEM), 2022, pp. 610-615.

[37]. Murthy, R. K., Dhanraj, S., Manjunath, T. N., Achyutha, P. N., Prasad, A. N., & Gangambika, G. (2022). A survey on human activity recognition using CNN and LSTM. International Journal of Health Sciences, 6(S7), 3408–3417.

[38]. Murthy, R. K., Dhanraj, S., Manjunath, T. N., Prasad, A. N., Pareek, P. K., & Kumar, H. N. (2022). A human activity recognition using CNN and long term short term memory. International Journal of Health Sciences, 6(S6), 10797–10809.

[39]. H. Rekha and M. Siddappa, “Hybrid deep learning model for attack detection in internet of things”, Service Oriented Computing Applications, vol. 16, No. 4, pp. 293-312, Oct. 2022.

[40]. H. Rekha and M. Siddappa, “Model Checking M2M and Centralized IOT authentication Protocols”. First International Conference on Artificial Intelligence, Computational Electronics and Communication System (AICECS 2021), October 2021.

[41]. H. Rekha and M. Siddappa, “Blockchain Mechanism-Based Attack Detection in IoT

with Hybrid Classification and Proposed Feature Selection”, Cybernetics and Systems, January 2023.

[42]. P. B.D, A. Prasad N, Dhanraj and M. T N, "Adaptive Voting Mechanism with Artificial Butterfly Algorithm based Feature Selection for IDS in MANET," 2023 IEEE International Conference on Integrated Circuits and Communication Systems (ICICACS), Raichur, India, 2023, pp. 1-7.

[43]. P. K. Pareek, A. P. N, C. Srinivas and J. B. N, "Prediction of Rainfall in Karnataka Region using optimised MVC-LSTM Model," 2023 IEEE International Conference on Integrated Circuits and Communication Systems (ICICACS), Raichur, India, 2023, pp. 1-8.

[44]. S. Chaudhury, N. Achyutha Prasad, S. Chakrabarti, C. A. Kumar and M. A. Elashiri, "The Sentiment Analysis of Human Behavior on Products and Organizations using K-Means Clustering and SVM Classifier," 2022 3rd International Conference on Intelligent Engineering and Management (ICIEM), London, United Kingdom, 2022, pp. 610-615.

[45]. Rekha, V.S., Siddaraju (2023). Goodness Ratio and Throughput Improvement Using Multi-criteria LEACH Method in Group Sensing Device Network. In: Kumar, A., Senatore, S., Gunjan, V.K. (eds) ICDSMLA 2021. Lecture Notes in Electrical Engineering, vol 947. Springer, Singapore.

[46]. Nirmala, G., Guruprakash, C.D. (2023). An Overview of Data Aggregation Techniques with Special Sensing Intelligent Device Selection Approaches. In: Kumar, A., Senatore, S., Gunjan, V.K. (eds) ICDSMLA 2021. Lecture Notes in Electrical Engineering, vol 947. Springer, Singapore.

[47]. Sagar, Y. S., and N. Achyutha Prasad. "Charm: a cost-efficient multi-cloud data hosting scheme with high availability." International Journal for Technological Research In Engineering 5.10 (2018).

[48]. Shinghal, Udit, Yashwanth AV Mowdhgalya, and Vaibhav Tiwari. "Achyutha Prasad N" Centaur-A Self-Driving Car." International Journal of Computer Trends and Technology 68 (2020): 129-131.

[49]. Shinghal, Udit, Yashwanth AV Mowdhgalya, and Vaibhav Tiwari. "Achyutha Prasad N" Home Automation using HTTP and MQTT Server." International Journal of Computer Trends and Technology 68 (2020): 126-128