Journal of Theoretical and Computationsl Advances in Scientific Research (JTCASR)
An International Open Access, Peer-Reviewed, Refereed Journal

Smart Street Lighting Infrastructure Development using IoT and Cloud Solutions

[1]C.E.Rajaprabha, [2]S.Srinithin, [3]M.P.Sanjay Dhanush, [4]S. Syed Althaf Hussain
[1]*Assistant Professor, Department of Computer Science and Engineering,*
Hindusthan Institute of Technology, Coimbatore
2,3,4, UG student, Department of Computer Science and Engineering,
Hindusthan Institute of Technology, Coimbatore

Abstract Street lighting plays a vital role in ensuring urban safety, visibility, and community well-being. However, traditional systems operate on fixed schedules, resulting in unnecessary energy usage, increased maintenance costs, and a lack of adaptability to environmental changes. To address these challenges, this project proposes a smart street lighting infrastructure powered by Internet of Things (IoT) and cloud solutions. The system utilizes microcontrollers (Atmega 328/2560), Wi-Fi modules (ESP8266/ESP32), and various sensors such as motion detectors, light sensors, and fault detectors. These components work together to enable dynamic lighting control based on real-time conditions like movement and ambient light levels. When no motion is detected, lights dim automatically to conserve energy and brighten only when needed. Through cloud integration, the system supports centralized monitoring and remote control, allowing authorities to receive live data, schedule operations, detect faults, and manage power usage efficiently. This reduces the need for manual intervention and enhances the reliability of the lighting network. The proposed solution aligns with smart city initiatives by offering a sustainable, cost-effective, and scalable infrastructure. It significantly reduces energy consumption, improves fault response time, and contributes to environmental conservation. This innovation not only modernizes public infrastructure but also improves the quality of life for urban residents.

Keywords: Smart Street Lighting, Internet of Things (IoT), Dynamic Lighting Control, Energy Efficiency, Real-Time Monitoring, Cloud-Based Infrastructure

1. INTRODUCTION

Urbanization is expanding rapidly across the globe, placing growing demands on city infrastructure and utilities. One of the critical aspects of urban development is public lighting, which plays a significant role in ensuring safety, enhancing visibility, and improving the overall well-being of communities. However, conventional street lighting systems are typically based on fixed schedules or manual controls, leading to inefficiencies such as unnecessary energy consumption, delayed fault detection, and increased maintenance costs. These outdated systems are neither energy-efficient nor adaptable to changing environmental conditions or real-time requirements. In response to these challenges, there is a growing shift toward the implementation of smart technologies in public infrastructure. This project proposes a Smart Street Lighting System powered by the Internet of Things (IoT) and cloud-based solutions. The proposed system is designed to optimize energy consumption, reduce operational costs, and enhance the responsiveness and reliability of urban lighting networks. It achieves this by leveraging modern microcontrollers such as Atmega 328/2560, wireless communication modules like ESP8266/ESP32, and a range of environmental sensors including motion detectors, light sensors, and fault detectors.

The system operates on a principle of dynamic lighting control, where street lights are dimmed when no movement is detected and brightened when motion is sensed in the vicinity. This significantly reduces energy

usage without compromising safety. Additionally, the integration of ambient light sensors allows the system to adjust lighting based on the natural light conditions, ensuring optimal illumination at all times. Fault detectors continuously monitor the health of individual street lights, providing real-time alerts to the central system in the event of a malfunction, which improves maintenance efficiency and reduces downtime.

A key feature of this solution is its cloud integration, enabling centralized monitoring and control of the entire street lighting network. Through a user-friendly dashboard, city authorities can access real-time data, adjust lighting schedules, detect and address faults, and analyze energy consumption patterns. This reduces the need for on-site manual inspections and interventions, thereby saving time and labor costs. The proposed system aligns with global Smart City initiatives, focusing on sustainability, automation, and data-driven governance. By significantly cutting down on energy wastage, the system contributes to environmental conservation and supports efforts to reduce carbon emissions. Its modular and scalable architecture makes it suitable for deployment in both small towns and large metropolitan areas.

2. Literature Survey

1. N. G. Bhavani et al. (2022) – IoT Integrated Monitoring and Control System for Renewable Energy in Smart Grids This paper presents the design and implementation of an IoT-based monitoring and control system for renewable energy integration in smart grids. The system utilizes microcontrollers, wireless communication modules, and various sensors to enable real-time monitoring and control of renewable energy sources within the smart grid infrastructure. The integration of IoT technologies enhances the efficiency and reliability of renewable energy utilization, contributing to sustainable computing networks.

2. Suddhasatwa Chakraborty et al. (2022) – Beam Controlled Lighting Design for Road Optimization In this study, the authors propose a beam-controlled lighting design approach aimed at optimizing road lighting systems. By utilizing advanced lighting technologies and control mechanisms, the system adjusts the illumination based on specific requirements, thereby enhancing energy efficiency and improving visibility on roadways. The approach contributes to the development of intelligent lighting solutions for urban infrastructure.

3. A. H. Al-Madhhachi et al. (2020) – Wireless Power Control System for LED Street Lighting Using ZigBee This paper introduces a wireless power control system designed for LED street lighting, employing ZigBee communication protocols. The system enables remote control and monitoring of street lighting, allowing for dynamic adjustment of illumination levels based on environmental conditions and traffic patterns. The implementation of ZigBee communication enhances the scalability and flexibility of the lighting system, contributing to energy savings and improved street lighting management.

4. W. A. Jabbar et al. (2019) – Smart and Green Street Lighting System Based on Arduino and RF Wireless Module The authors present a smart and green street lighting system that utilizes Arduino microcontrollers and RF wireless modules. The system incorporates sensors to detect ambient light levels and motion, allowing for adaptive lighting control. By integrating renewable energy sources and low-power LEDs, the system reduces energy consumption and minimizes environmental impact. The implementation of RF wireless communication facilitates remote monitoring and control, enhancing the efficiency and sustainability of street lighting infrastructure.

5. A. Ozadowicz and J. Grela (2017) – Energy Saving in Street Lighting Control System Based on EN-15232 Standard This study explores a new approach to street lighting control systems, focusing on energy savings through the application of the EN-15232 standard. The authors propose functional strategies for outdoor lighting systems based on efficiency classes defined in the standard. Experimental implementations demonstrate that these strategies can significantly reduce energy consumption, with reductions up to 45% compared to conventional systems. The integration of remote monitoring and control further enhances maintenance efficiency and operational effectiveness.

6. Cho and Kim (2018) – IoT-Based Intelligent Street Lighting System for Smart City Applications Cho and Kim propose an IoT-based intelligent street lighting system designed for smart city applications. The system integrates various sensors and communication technologies to enable adaptive lighting control, enhancing energy efficiency and public safety. By leveraging IoT capabilities, the system allows for real-time monitoring and management of street lighting infrastructure, contributing to the development of sustainable and intelligent urban environments.

7. Al-Haj, Al-Dubai, and Nasser (2020) – IoT-Based Smart Street Lighting System: A Comprehensive Review This comprehensive review examines the application of IoT technologies in smart street lighting systems. The authors analyze various IoT-based solutions, highlighting their benefits, challenges, and implementation strategies. The review provides insights into the integration of sensors, communication protocols, and data analytics in enhancing the efficiency and functionality of street lighting systems within smart cities.

8. Li et al. (2020) – Research and Application of Intelligent Street Lamp Control System Based on IoT Technology Li and colleagues explore the research and application of intelligent street lamp control systems utilizing IoT technology. The paper discusses the design and implementation of IoT-based control mechanisms, focusing on aspects such as energy efficiency, fault detection, and remote management. The integration of IoT technologies enables dynamic control and monitoring, improving the performance and sustainability of street lighting systems.

9. Guleria, Rani, and Kumar (2021) – IoT-Based Intelligent Street Lighting System: A Review This review paper provides an overview of IoT-based intelligent street lighting systems, examining various designs, technologies, and methodologies employed in their development. The authors discuss the integration of sensors, communication networks, and data analytics in creating adaptive and energy-efficient lighting solutions. The review highlights the potential of IoT technologies in transforming traditional street lighting into intelligent systems that contribute to smart city initiatives.

3. Proposed System

The Smart Street Lighting system is a comprehensive web-based solution designed for efficient management, monitoring, and automation of urban street lighting infrastructure. Developed using PHP, MySQL, Bootstrap, and hosted on Wampserver, the web application provides secure and user-friendly dashboards tailored for both municipality administrators and lighting operators. The system supports real-time monitoring, remote control, and intelligent automation of street lights, significantly improving energy efficiency and operational performance. Municipality admins can securely log in to access a centralized dashboard, where they can manage districts, areas, and individual streets. They are empowered to add and configure street lights, assign operators, manage STBot device settings, and visualize the street lighting network through interactive maps with color-coded indicators reflecting operational status. The dashboard also provides real-time fault notifications, energy consumption analytics, and detailed fault clearance reports for performance review and maintenance planning. Lighting operators, on the other hand, are assigned specific street lights and gain access to remote monitoring and fault update functionalities, ensuring fast and effective responses to any issues.

At the heart of the system is the STBot device, which integrates seamlessly with the web app via the MQTT protocol. This device includes an ESP8266 Wi-Fi module for wireless communication, a Current Sensor (ACS712) for real-time electrical monitoring, and an LDR sensor for adaptive lighting control based on ambient light levels. Through this integration, the system offers dynamic and responsive street lighting, reducing energy waste and enhancing sustainability. The Current Sensor continuously checks for anomalies in power consumption, enabling accurate fault detection, while the LDR sensor ensures that lighting adjusts automatically depending on the time of day or surrounding light conditions. These sensors send real-time data to the web app, allowing for instant alerts and updates.

The system also includes a powerful Street Light Visualization module that maps the entire lighting network for easy navigation and control. Operators can quickly identify the operational status of lights using graphical and color-coded indicators, facilitating efficient decision-making and proactive maintenance. Additionally, the Auto Lighting System works in tandem with the LDR sensor and ESP8266 to manage brightness levels dynamically, improving energy efficiency without compromising visibility. The Alert Generator module ensures that both admins and operators are promptly notified of any critical events, such as detected faults or scheduled maintenance, using predefined triggers that generate instant alerts. The Remote On/Off module allows lighting operators to control individual or grouped street lights directly from the web application, enabling precision in lighting control and rapid response in various urban scenarios.

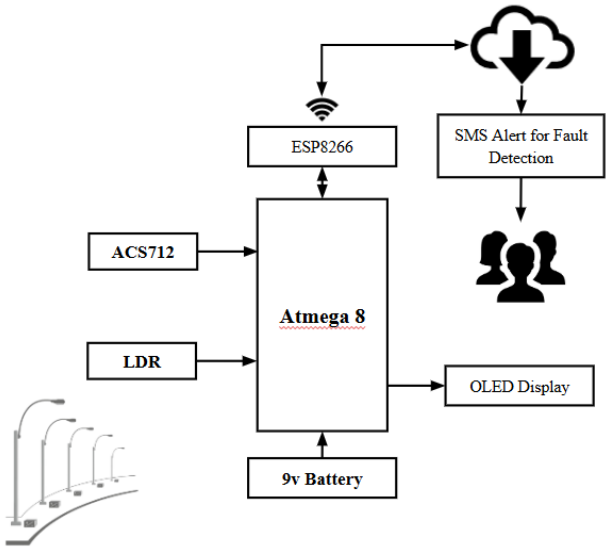

FIGURE 1: System Architecture

4. CONCLUSION

In conclusion, the proposed Smart Street Lighting system represents a transformative approach to urban illumination with numerous benefits. By integrating IoT technologies such as adaptive automation, fault detection, and remote control, the system offers unparalleled efficiency, sustainability, and cost-effectiveness. The real-time visibility provided by the Street Light Visualization module empowers administrators to make informed decisions, while the proactive maintenance features ensure minimal downtime and enhanced reliability. The user-friendly interface and scalability of the system make it adaptable to the dynamic needs of modern cities. Overall, this innovative solution not only addresses the challenges of traditional street lighting but also sets the stage for a smarter, more connected, and energy-efficient urban future.

REFERENCES

1. Sidharth, S. (2016). The Role of Artificial Intelligence in Enhancing Automated Threat Hunting

2. Sidharth, S. (2016). Establishing Ethical and Accountability Frameworks for Responsible AI Systems.
3. Sidharth, S. (2017). Cybersecurity Approaches for IoT Devices in Smart City Infrastructures
4. Innovations in Energy-Efficient Automation Systems –2025, Iris Publishers.
5. A New Energy-Efficient Approach to Planning Pick-and-Place Operations –2022, MDPI Energies, DOI: 10.3390/en15238795.
6. Robot Piece Picking Advances with Artificial Intelligence –2022, Automation World.
7. AI-Driven Warehouse Automation: A Comprehensive Review of Systems –2024, GSC Advanced Research and Reviews.
8. Energy-Efficient Control of Cable Robots Exploiting Natural Dynamics and Task Knowledge – Boris Deroo, Erwin Aertbeliën, Wilm Decré, Herman Bruyninckx, 2023, arXiv.
9. Intelligent Control of Robots with Minimal Power Consumption in Pick-and-Place Operations – Valery Vodovozov, Zoja Raud, Eduard Petlenkov, 2023, MDPI Energies, DOI: 10.3390/en16217418.
10. Booma Jayapalan,Sathishkumar, R.,Prakash, I.A.,Venkateswaran, M.”Optimizing wind energy efficiency in IoT-driven smart power systems using modified fuzzy logic control”AI Approaches to Smart and Sustainable Power Systems, 2024, pp. 250–273.
11. Sidharth, S. (2017). Access Control Frameworks for Secure Hybrid Cloud Deployments.
12. Sidharth, S. (2018). Post-Quantum Cryptography: Readying Security for the Quantum Computing Revolution.
13. Booma Jayapalan, Mahadevan Krishnan, Karunanithi Kandasamy & Kannan Subramanian, 2018, “Integrated Strategies for load demand management in the State of Tamil Nadu”, Journal of Electrical Engineering, vol. 18, edition 4, ISSN: 1582-4594, pp.151-160.
14. Booma Jayapalan, Mahadevan Krishnan, Karunanithi Kandasamy & Kannan Subramanian, 2017, “Renewable energy penetration and its impact on Reliability: A case study of Tamil Nadu”, Journal of Computational and Theoretical Nano science, vol. 14, no. 8, pp. 4036-4044, DOI: 10.1166/jctn.2017.6752.
15. Booma, J., Anitha, P., Amosedinakaran, S., & Bhuvanesh, A. (2025). Real-time electricity capacity expansion planning using chaotic ant lion optimization by minimizing carbon emission. Journal of the Chinese Institute of Engineers, 1–15. https://doi.org/10.1080/02533839.2025.2464575.
16. Sidharth, S. (2015). Privacy-Preserving Generative AI for Secure Healthcare Synthetic Data Generation.
17. Sidharth, S. (2015). AI-Driven Detection and Mitigation of Misinformation Spread in Generated Content.
18. Pandey, A., Shukla, K., Pandey, S. P., & Sharma, Y. K. (2007). Haemato-biochemical profile in relation to normal parturient buffaloes and buffaloes with retained fetal membranes. Buffalo Bull, 26(2), 46-49.
19. Jain, R., Pandey, A., & Pandeya, S. S. (2009). Mechanism of dissolution of delayed release formulation of diclofenac sodium. Chemistry, 18(4), 131-138.
20. Tripathi, S. K., Kesharwani, K., Kaul, G., Akhir, A., Saxena, D., Singh, R., ... & Joshi, K. B. (2022). Amyloid-β Inspired Short Peptide Amphiphile Facilitates Synthesis of Silver Nanoparticles as Potential Antibacterial Agents. ChemMedChem, 17(15), e202200251.
21. Sidharth, S. (2017). Real-Time Malware Detection Using Machine Learning Algorithms.
22. Rokade, U. S., Doye, D., & Kokare, M. (2009, March). Hand gesture recognition using object based key frame selection. In 2009 International Conference on Digital Image Processing (pp. 288-291). IEEE.
23. Kshirsagar, K. P. (2015). Key Frame Selection for One-Two Hand Gesture Recognition with HMM. International Journal of Advanced Computer Research, 5(19), 192.
24. Sidharth, S. (2018). Optimized Cooling Solutions for Hybrid Electric Vehicle Powertrains.
25. Sidharth, S. (2019). DATA LOSS PREVENTION (DLP) STRATEGIES IN CLOUD-HOSTED APPLICATIONS.
26. Kumbhar, K., & Kshirasagar, K. P. (2015). Comparative study of CCD & CMOS sensors for image processing. International Journal of Innovative Research in Electrical, Electronics, Instrumentation and Control Engineering, 3, 194-196.
27. Kshirsagar, K. P., & Doye, D. (2010, October). Object Based Key Frame Selection for Hand Gesture Recognition. In 2010 International Conference on Advances in Recent Technologies in Communication and Computing (pp. 181-185). IEEE.
28. Kshirsagar, K. P., & Doye, D. D. (2015). Comparing key frame selection for one-two hand gesture recognition using different methods. International Journal of Signal and Imaging Systems Engineering, 8(5), 273-285.

29. Baladari, V. (2024). Designing trustless identity: A multi-layered framework for decentralized verification in Web3 ecosystems. International Journal of Advanced Research in Science Communication and Technology, 4(1), 685-691.
30. Harini, P. P., & Ramanaiah, D. O. (2009). An Efficient Admission Control Algorithm for Load Balancing In Hierarchical Mobile IPv6 Networks. arXiv preprint arXiv:0912.1013.
31. Ramya, C. (2019). PB Shelley and Bharathidasan on the Miserable Lot of Women in Society: A Comparative Study. Language in India, 19(12).
32. Ramya, C. (2019). Arun Joshi's Art and Skill: Depicting East and West and Tradition and Modernity. Strength for Today and Bright Hope for Tomorrow Volume 19: 10 October 2019 ISSN 1930-2940, 21.
33. Harini, P. (2019). GESTURE CONTROLLED GLOVES FOR GAMING AND POWER POINT PRESENTATION CONTROL. GESTURE, 6(12).
34. Kumar, N. S., Harini, P., Kumar, G. D., & Rathi, G. (2017, June). Secured repertory of patient information in cloud. In 2017 International Conference on Intelligent Computing and Control (I2C2) (pp. 1-4). IEEE.
35. Harika, K. K. S., Harini, P., Kumar, M. K., & Kondaiah, K. (2012, July). A distributed CSMA algorithm for maximizing throughput in wireless networks. In Wireless Commun. (Vol. 4, No. 11, pp. 591-594).
36. Baladari, V. (2023). Intelligent Tier-Based Data Management: A Predictive Approach to Cloud Storage Cost Optimization. Framework, 1(6), 7.
37. Baladari, V. (2022). Cloud Without Borders: Software Development Strategies for Multi-Regional Applications. European Journal of Advances in Engineering and Technology, 9(3), 193-200.
38. Baladari, V. (2022). Evolving Cloud-Native Architectures: Leveraging Serverless Computing for Flexibility and Scalability in Applications. Journal of Scientific and Engineering Research, 9(9), 126-135.
39. Baladari, V. (2021). Monolith to Microservices: Challenges, Best Practices, and Future Perspectives. European Journal of Advances in Engineering and Technology, 8(8), 123-128.
40. RAMYA, C. (2020). Sri Aurobindo as 'The Pioneer of the New Age and the Spokesman of the New Truth': An Appraisal. International Journal on Multicultural Literature, 10.
41. Ramya, C. (2019). Concept and Emergence of Time in the Modernist novel: A Note.
42. Ramya, C. (2020). A House for Mr. Biswas VS Naipaul's Journey from Self-discovery to Search for Identity and Stability. Strength for Today and Bright Hope for Tomorrow Volume 20: 6 June 2020 ISSN 1930-2940, 68.
43. Ramya, C. (2019). Anita Desai-Psychological Exploration of the Inner Psyche of Her Existential Characters. Strength for Today and Bright Hope for Tomorrow Volume 19: 9 September 2019 ISSN 1930-2940, 27.
44. Ramya, C. (2019). Claude McKay and Black Diaspora. Strength for Today and Bright Hope for Tomorrow Volume 19: 6 June 2019 ISSN 1930-2940, 289.
45. Ramya, C. (2019). Ernest Hemingway's Portrayal of Female Characters. Strength for Today and Bright Hope for Tomorrow Volume 19: 5 May 2019 ISSN 1930-2940, 268.
46. Baladari, V. (2020). Adaptive Cybersecurity Strategies: Mitigating Cyber Threats and Protecting Data Privacy. Journal of Scientific and Engineering Research, 7(8), 279-288.
47. Baladari, V. (2021). The Role of Software Developers in Transitioning On-Premises Applications to Cloud Platforms: Strategies and Challenges. Journal of Scientific and Engineering Research, 8(1), 270-278.
48. Baladari, V. (2023). Building an Intelligent Voice Assistant Using Open-Source Speech Recognition Systems. Journal of Scientific and Engineering Research, 10(10), 195-202.
49. Ramya, C. (2020). Paule Marshall and Feminine Aesthetic. Language in India, 20(10).
50. Ramya, C. (2018). Anita Desai as an Existentialist Exploring the Emotional Turbulence and Chaotic Inner World. Language in India, 18(9), 197-202.
51. Bohrey, S., Chourasiya, V., & Pandey, A. (2016). Polymeric nanoparticles containing diazepam: preparation, optimization, characterization, in-vitro drug release and release kinetic study. Nano Convergence, 3(1), 3.
52. Chourasiya, V., Bohrey, S., & Pandey, A. (2016). Formulation, optimization, characterization and in-vitro drug release kinetics of atenolol loaded PLGA nanoparticles using 33 factorial design for oral delivery. Materials Discovery, 5, 1-13.

53. Dare, M., Jain, R., & Pandey, A. (2015). Method validation for stability indicating method of related substance in active pharmaceutical ingredients dabigatran etexilate mesylate by reverse phase chromatography. J Chromatogr Sep Tech, 6(263), 2.
54. Chourasiya, V., Bohrey, S., & Pandey, A. (2021). Formulation, optimization, and characterization of amlodipine besylate loaded polymeric nanoparticles. Polymers and Polymer Composites, 29(9_suppl), S1555-S1568.
55. Tripathi, S. K., Patel, B., Shukla, S., Pachouri, C., Pathak, S., & Pandey, A. (2021, March). Donepezil loaded PLGA nanoparticles, from modified nano-precipitation, an advanced drug delivery system to treat Alzheimer disease. In Journal of Physics: Conference Series (Vol. 1849, No. 1, p. 012001). IOP Publishing.
56. Naik, P. R., Pandeya, S. N., & Pandey, A. (1996). Anti-inflammatory and analgesic activities of 1-[2-(substituted benzothiazole)]-1, 3-diethyl-4-aryl guanidines. Indian Journal of Physiology and Pharmacology, 40(2), 189-190.
57. Pandey, A., Mishra, R. K., Mishra, S., Singh, Y. P., & Pathak, S. (2011). Assessment of genetic diversity among sugarcane cultivars (Saccharum officinarum L.) using simple sequence repeats markers. J. Biol. Sci, 11(4), 105-111.
58. Singh, N., Suthar, B., Mehta, A., Nema, N., & Pandey, A. (2020). Corona virus: an immunological perspective review. Int J Immunol Immunother, 7(10.23937), 2378-3672.
59. Bohrey, S., Chourasiya, V., & Pandey, A. (2016). Preparation, optimization by 23 factorial design, characterization and in vitro release kinetics of lorazepam loaded PLGA nanoparticles. Polymer Science Series A, 58(6), 975-986.
60. Ramya, C. (2020). Kanthapura Protagonists as Representation of Gandhi. Strength for Today and Bright Hope for Tomorrow Volume 20: 1 January 2020 ISSN 1930-2940, 130.
61. Ramya, C. (2020). Sri Aurobindo‟ s Poetry as The Imprint of Mighty Imagination and Philosophical Contemplation: An Appraisal. DYNAMICS OF LANGUAGE, LITERATURE & COMMUNICATION, 51.
62. Reddy, D. B. E., Harini, P., MaruthuPerumal, S., & VijayaKumar, D. V. (2011). A New Wavelet Based Digital Watermarking Method for Authenticated Mobile Signals. International Journal of Image Processing (IJIP), 5(1), 13-24.
63. Baby, M., Harini, P., Slesser, Y. E., Tejaswi, Y., Ramajyothi, K., Sailaja, M., & Sumantha, K. A. (2013). Sms based wireless e-notice board. International Journal of Emerging Technology and Advanced Engineering, 3(3), 181-185.
64. Kesavulu, O. S. C., & Harini, P. (2013). Enhanced packet delivery techniques using crypto-logic riddle on jamming attacks for wireless communication medium. Int. J. Latest Trends Eng. Technol, 2(4), 469-478.
65. Harini, P., & Ramanaiah, D. O. (2008). An Efficient DAD Scheme for Hierarchical Mobile IPv6 Handoff. IJCSNS, 8(8), 182.
66. Karunya, L. C., Harini, P., Iswarya, S., & Jerlin, A. (2019). Emergency Alert Security System for Humans. Int. J. Commun. Comput. Technol, 7, 1-5.
67. Ramachandran, V., Kumari, Y. S., & Harini, P. (2016). Image retrieval system with user relevance feedback. Computer Science Engineering, St. Anns College of Engineering, Chirala.
68. Nandan, M. J., Sen, M. K., Harini, P., Sekhar, B. M., & Balaji, T. (2013, December). Impact of urban growth and urbanization on the environmental degradation of Lakes in Hyderabad City, India. In AGU Fall Meeting Abstracts (Vol. 2013, pp. B31E-0452).
69. Sahithi, D., & Harini, P. (2012). Enhanced hierarchical multipattern matching algorithm for deep packet inspection. IRACST-International Journal of Computer Science and Information Technology & Security (IJCSITS), ISSN, 2249-9555.
70. Harini, P. (2011). A novel approach to improve handoff performance in hierarchical mobile ipv6 using an enhanced architecture. IJCST, 2(1).
71. Singh, A., Santosh, S., Kulshrestha, M., Chand, K., Lohani, U. C., & Shahi, N. C. (2013). Quality characteristics of Ohmic heated Aonla (Emblica officinalis Gaertn.) pulp.
72. Thakur, R. R., Shahi, N. C., Mangaraj, S., Lohani, U. C., & Chand, K. (2020). Effect of apple peel based edible coating material on physicochemical properties of button mushrooms (Agaricus bisporus) under ambient condition. International Journal of Chemical Studies, 8(1), 2362-2370.

73. Kumar, S., Singh, A., Shahi, N. C., Chand, K., & Gupta, K. (2015). Optimization of substrate ratio for beer production from finger millet and barley. 国际农业与生物工程学报, 8(2), 110-120.