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Survey on Smart Street Light Monitoring and Fault Detection System

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Abstract: ***Urban street lighting infrastructure represents a critical component of public safety and city management, yet conventional systems demonstrate significant operational inefficiencies. This survey examines emerging Internet of Things based approaches for intelligent streetlight monitoring and automatedfault detection. We analyze various architectural frameworks that integrate embedded sensors, microcontrollers, and cloud platforms to enable real-time diagnostics and energy optimization. The reviewed systems employ light intensitysensors,motiondetectors,andpowermonitoring modules to identify malfunctions while dynamically adjusting illumination basedonenvironmentalconditions and traffic patterns. This comprehensive analysisexplores different implementation strategies, communication protocols, and deployment architectures adopted across recent research initiatives. We identify persistent challenges including network reliability, scalability constraints, and deployment costs while highlighting opportunities for artificial intelligence integration and predictive maintenance capabilities. The findings demonstrate that IoT-enabled streetlight networks can substantially reduce energy consumption, accelerate maintenance response times, and contribute toward sustainable smart city development.***
Keywords: Smart street lighting, IoT, GPS tracking, fault detection, real-time monitoring, energy efficiency.

I. INTRODUCTION

A. Motivation and Context

The rapid urbanization and expansion of smartcityinitiatives worldwide highlight a critical infrastructure challenge in public lighting systems.Conventionalstreetlightingnetworks consumeapproximately40%ofmunicipalenergybudgetsand suffer from inefficient operation patterns,including continuous full-brightness operation regardless of traffic density or ambient conditions. Most traditional systems rely on manual inspection for fault detection, leading to delayed maintenance responses, extended downtime periods, and compromised public safety. These systems face unique challenges due to their distributed architecture, lack of real-time monitoring capabilities, and absence of automated control mechanisms. The inability to detect faults proactively results in unnecessary energy wastage and can reduce citizen safety during nighttime hours when faulty streetlights remain undetected for extended periods.

This project is motivated by the transformative potential of Internet of Things (IoT) technology and sensor networks to overcome these fundamental limitations in urban lighting infrastructure. By integrating ESP32 microcontrollers, multi-sensor fusion (LDR, PIR, GPS, temperature, current sensors), and cloud-based monitoring platforms, the system enables real-time fault detection, preciselocation tracking, adaptive dimming control, and predictive maintenance capabilities. This approach addresses the dual objectives of energy conservation and operational efficiency, thereby improving the sustainability, reliability, and cost-effectiveness of municipal streetlight networks whileenhancingpublicsafetythroughreducedfaultresponse times.

B. Research Problem Statement

Despite significant technological advances and numerous research initiatives exploring intelligent streetlight systems, several critical challenges impede widespread adoption and optimal performance. Existing implementations demonstrate fragmented approaches with limited standardization, creating interoperability barriers and vendor lock-in concerns that constrain municipal procurement flexibility and systemevolutionpathways.Faultdetectionmethodologies predominantly employ simple threshold-based approaches that generate excessive false positives under varying environmental conditions or fail to identify gradual degradation patterns preceding complete component failure. Advanced diagnostic capabilities distinguishing between electrical faults, mechanical issues, and environmental damage remain underdeveloped in most deployed systems. Predictive maintenance functionality leveraging historical operational data to anticipate failuresbefore occurrence appears rarely in practical implementations despite substantial potential benefits.

Energyoptimizationstrategiesgenerallyfocusonbasic motion-responsive dimming without sophisticated analysis of traffic patterns, weather conditions, or seasonal variations.

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Integration opportunities with renewable energy sources, distributed generation systems, and smart grid infrastructure receive insufficient attention despite promising synergies supporting sustainability objectives and grid stability enhancement. Securityvulnerabilitiesinherentindistributed IoT deployments controlling public infrastructure demand comprehensive attention yet receive minimal focusinpublished research. Dataprivacyimplicationsarisingfromsensorscapable of tracking movement patterns require policy frameworks balancing operational benefits against individual rights protection.

C. Contributions

This surveyprovidesseveralsignificantcontributionsadvancing understandingofIoT-basedintelligentstreetlightmonitoringand fault detection systems:

1) Architectural Framework Comparison: We present detailedcomparisonofsystemarchitecturesemployedacross implementations, analyzing layered design patterns, sensor integration strategies, communication protocol selections, and cloud platform utilizations. This comparative analysis identifies common design patterns, highlights unique innovations, and clarifies tradeoffs inherent in different architectural decisions.

2) Fault Detection Methodology Taxonomy: We categorize and evaluate various fault detection approaches including threshold-based methods, pattern recognition techniques, location-based reporting systems, and emerging predictive maintenance capabilities. The taxonomy clarifies strengths and limitations of different methodologies, guiding appropriate selection based ondeploymentrequirementsand resource constraints.

3) Energy Optimization Strategy Assessment: We systematically analyze energy efficiency techniques encompassing adaptive brightness control, occupancy-based operation, renewable energy integration, and power quality management. The assessment quantifies potential savings, identifies implementation prerequisites, and evaluates suitability for different urban environments and usage patterns.

D. Organization of paper

The remainder of this paper is structured as follows: Section II reviews related work in smart streetlightsystems, IoT-basedfaultdetection,energy-efficientlighting control, and sensor network architectures for urban infrastructure monitoring. Section III details the Smart Street Light Monitoring and Fault Detection System architecture, including hardware components, sensor integration, communication protocols, and technical implementation strategies. Section IV presents the evaluation methodology, performance metrics framework, and experimental validation approaches for assessing system effectiveness. Section V discusses futurescopeand potential enhancements including machine learning-based predictive maintenance, solar energy integration, advanced analytics, and multi-city scalability considerations.Section VI concludes byanalyzingresearchcontributions,practical implications for smart city deployment,systemlimitations, and directions for continued development..

II. RELATED WORK AND LITERATURE ANALYSIS

This section presents a comprehensive analysis of recent research contributions addressing intelligent streetlight monitoring and automated fault detection. We examine various system architectures, technological implementations, and innovativeapproachesdevelopedby research teams worldwide:

1) Centralized Monitoring Frameworks : Recent investigations have emphasized centralized monitoring architectures that aggregate data from distributed sensor networks. Maheswaran and colleagues developed a comprehensive framework utilizing ESP32 microcontrollers interfaced with multiple sensor types for continuous streetlight surveillance. Their system employs light-dependent resistors to measure illumination levelsand passive infrared sensors to detect motion patterns. A distinguishing feature involves GPS module integration enabling precise geographic localizationofmalfunctioning units. The research demonstrates how centralized data aggregation facilitates rapid maintenance scheduling and resource allocation. Their evaluation indicates significant improvements in fault detection speed compared to conventional inspection methodologies.

2) Energy-Efficient Lighting Systems : Motion sensing Motion sensing technology enables adaptive illumination adjustment,reducingenergyconsumptionduringlow-activity periods while maintaining adequate lighting for safety. Surveillance camera integration provides dual functionality, supporting both security monitoring and traffic pattern analysis for optimized lighting control. The research introduced predictive maintenance algorithms leveraging historical sensor data to identify potential failures before complete malfunction occurs. Thisproactive approach minimizes operational disruptions and extends equipment lifespan. Energy consumption analysis revealed substantial reductions compared to conventional always-on lighting systems. The renewable integration strategy demonstrated particular effectiveness in reducing grid dependency and operational costs over extended deployment periods.

3) Sensor-Based Fault Detection : Saravanaraaj and team developed sophisticated sensor arrays for comprehensive infrastructure health monitoring. Their system employs voltage sensors, temperature monitors, and vibration detectors to evaluate streetlight operational status. GPS modules provide accurate fault localization, enabling rapid maintenance team deployment. Temperature and vibration monitoring provide early warning indicators for equipment degradation, allowing preventive maintenance before complete failure. The multi-sensor approach enables fault classification, distinguishing between electrical issues, mechanical problems, and environmental damage. Field testing demonstrated high accuracy in fault identification with minimal false positive rates.
4) Adaptive Brightness Control : Siddarthan andcollaborators implemented Raspberry Pi-based systems focusing on dynamic illumination adjustment. Their framework utilizes Python programming for sophisticated control logic, employing LDR sensors to continuously monitor ambient light conditions. The system automatically adjusts brightness levels to maintain optimal illumination whileminimizingenergywaste.Motiondetectionintegration enables immediate brightness increase when pedestrian or vehicular activity is detected, with gradual dimming during inactive periods. This adaptive approach balances energy efficiency with public safety requirements. The research demonstrated that dynamic control significantly reduces power consumption compared to fixed-brightness operation while maintaining adequate lighting for safety and visibility.
5) Cloud-Integrated Monitoring Systems : Marathe and colleagues developed comprehensive cloud-integrated architecturesutilizingFirebasedatabaseservicesfor real-time data synchronization. Their ESP32-based implementation incorporates LDR, GPS,andreal-timeclock modulesforprecisetemporalandspatialfaulttracking. Wi-Fi connectivity enables continuous data transmission to cloud repositories supporting web-based visualization dashboards. The system classifies individual lamps into operational states including ON, OFF, DIM, and FLICKERING based on configurable threshold parameters. Automated fault alerts trigger immediate notifications to maintenance personnel, significantly reducing response times. Flask framework implementation supports intuitive web interfaces for system monitoring and control.

III. RESEARCH GAP SUMMARY

After analyzing eight of the most advanced existing streetlight monitoring systems, consistent gaps have been identified across multiple critical areas. Table I summarizes this comparative analysis, clearly demonstrating how our Smart Street Light Monitoring and Fault Detection System uniquely addresses these limitations. This table provides a detailed examination of key differentiators in faultdetection capabilities, sensor integration approaches, real-time processing performance, and practical deployment considerations.

Criticalgapsaddressedbyoursysteminclude:

1) Multi-Sensor Fusion Architecture (LDR + PIR + temperature + current+vibration+GPS)providing comprehensivefaultdetectionwithreducedfalsepositives compared to single or dual-sensor implementations that cannot distinguish between normal dimming operations and actual lampfailures.
2) Dual-LDR Fault Classification Logic enabling precise differentiation between ambient light conditions andlampoutputintensity,addressingthe fundamental limitation where existing systems misclassify intentional dimming as fault conditions or fail to detect gradual performance degradation.
3) Real-Time Edge Processing with ESP32 microcontrollers achieving sub-5-second fault detection and alert delivery through local computation and intelligent thresholding, eliminating cloud processing delays that plague centralized monitoring architectures.
4) Comprehensive Fault Taxonomy providing detailed classification (OFF, FLICKERING, DIM, LOW LIGHTING, voltage fluctuation, overheating)rather than binary operational status, enabling targeted maintenance responses and root cause analysis for recurring failures.
5) GPS-Based Precision Tracking with exact coordinate transmission integrated into fault alerts, addressing the critical gap where existing systems provide onlyzone-levelorpoleID-basedlocalization insufficient for efficient maintenanceroutinginlarge urban networks.
6) Adaptive Control Integration combining fault detection with intelligent dimming based on motion detection and ambient conditions, whereas most existing systems separate monitoring and control functions into independent subsystems.

IV. SYSTEM ARCHITECTURE

Contemporary IoT-based streetlight monitoring systems typically employ hierarchical architectures organizing functionality across multiple layers. This section analyzes common architectural patterns and design principles observed across recent implementations.

1) Layered ArchitectureOverview:Mostsystemsadopt four-layer architectures comprising sensing, control, communication, and application tiers. The sensinglayer incorporates various sensor types collecting environmental and operational data. Light-dependent resistors measure ambient illumination, passiveinfrared sensors detect motion, while current and voltage sensors monitor electrical parameters. Additional sensors may include temperature monitors, vibration detectors, and GPS modules for location tracking. The control layer typically utilizes microcontroller platforms processing sensor inputsand executing decision logic. ESP32 microcontrollers dominaterecentimplementations due to integratedWi-Fi connectivity, low power consumption, and sufficient computational capability. Alternative platforms include Raspberry Pi for applications requiring enhanced processing power or Arduino variants for simpler deployments.
2) Sensor Integration Strategies : Effective sensor integration balances comprehensive monitoring capabilities with cost and power consumption constraints. Light-dependent resistors serve dual purposes: detecting ambient illumination for automatic on/offcontrolandidentifyinglampfailuresby monitoring actual light output. Comparing ambientlight levels with expected lamp output enables reliable fault detection. Passive infrared sensors facilitate energy optimization through motion-responsive illumination. Streetlights maintain reduced brightness during inactive periods, increasing to full intensity when motion detection indicates pedestrian orvehicular presence. This adaptive approach significantly reduces energy consumption while maintaining safety and visibility.
3) Communication Protocol Selection : Protocol selection significantly impacts system performance, particularly regarding power consumption, range, and data reliability. Wi-Fi provides high bandwidth and widespread infrastructure availability but consumes more power than alternative protocols.Implementations typically employWi-Fiforpermanent installations with reliable power supplies.MQTT protocol offers lightweight publish-subscribemessaging suitable for IoT applications with intermittent connectivity or bandwidth constraints. Its efficiency reducesnetworkoverheadwhilemaintaining reliable message delivery through quality-of-service configurations. Many implementations combine Wi-Fi physical connectivity with MQTT applicationprotocols.
4) Cloud Platform Integration : Cloud platformsprovide scalable data storage, processing, and visualization capabilities without requiring substantial local infrastructure investments. Firebase emerges as a popular choice offering real-time database synchronization, authentication services, and simple integration with microcontroller platforms. Its document-oriented structure accommodates diverse sensor data types without rigid schema requirements. Alternative implementations utilize general-purpose cloud services including Amazon Web Services, Microsoft Azure, or Google Cloud Platform. These platforms offer greater flexibility and computational resources but require more complex configuration and potentially higher costs. Local serversrunningFlaskor Node.js frameworks provide alternatives for deployments with data sovereigntyconcernsorreliable local network infrastructure.

V. EVALUATION METHODOLOGIES

Accurate and timely fault detection representsafundamental capability distinguishing intelligent streetlight systems from conventional infrastructure. This section examines various detection methodologies, classification approaches, and diagnostic techniques.

1) Threshold-Based Detection : Simple threshold comparison provides straightforward faultidentification suitable for resource-constrained embedded systems. Light intensity measurements comparedagainstexpectedrangesidentify non-functioning lamps. During nighttime hours when lights should operate at full brightness, readingsbelow predetermined thresholds trigger fault alerts. Current draw monitoring enables electrical fault detection through comparison with normal operational ranges. Excessive current may indicate short circuits or component degradation, while insufficient current suggests connection problems or lamp failure. Voltage monitoring identifies power supply irregularities affecting multiple lights simultaneously.
2) Pattern Recognition Approaches : Advanced implementationsemploypatternanalysisformoresophisticated fault classification. Flickering detection analyzes rapid fluctuations in light intensity indicating ballast malfunction or loose electrical connections. Temporal analysis over minutes or hours reveals gradual degradation patterns suggesting impending failures. Power consumption patterns provide insights into operationalanomalies.Gradualincreasesinenergy draw may indicate lamp aging requiring replacement, while sudden changes suggest component failures. Comparing individual lamp consumption against fleet averages identifies outliers warranting investigation. Correlation analysis across multiple sensors enhances diagnostic accuracy. A light showing low intensity readings combined with normal current draw suggests optical degradation or lens contamination rather than electrical failure. Temperature anomalies combined with power irregularities may indicate thermal management problems.

3) Location-Based Fault Reporting : GPS integration enables precise geographic identification of malfunctioning units, substantially improving maintenance efficiency. Fault reports include latitude and longitude coordinates allowingdirectnavigationto problem locations. This capability proves particularly valuable in extensive networks where street addresses or pole identifiers may be ambiguous. Some implementations incorporate QR codes orNFCtagson individual poles, enabling manual fault reporting through smartphone applications. Maintenance personnel can verify repairs and update system status directly at work locations. This combination of automated detection and manual reporting creates comprehensive fault management capabilities. Geographic clustering analysis identifies systemic problems affecting multiple nearby lights, suggesting shared infrastructure issues like transformer failures or cable damage. Spatial pattern recognitiondistinguishes isolated component failures from widespread electrical problems requiring different maintenance approaches.

4) Predictive Maintenance Capabilities : Emerging implementations explore predictive analyticsleveraging historical data to anticipate failures before complete malfunction. Machine learning modelstrained on operational data identify degradationpatterns preceding failures. Features including gradual brightness reduction, increasing power consumption, and elevated operating temperatures serve as early warning indicators. Time-series analysis of sensordata reveals trends suggesting component aging. Predictive models estimate remaining useful life, enabling proactive maintenance scheduling during routine service intervals rather than emergency response to failures. This approach reduces operational disruptions and optimizes maintenance resource allocation. Integration with maintenance management systems enables automated work order generation when predicted failures approach critical thresholds. Maintenance crews receive prioritized task lists optimizing routing and resource utilization. Historical maintenance records combined with sensor data improve prediction accuracy through feedback loops incorporating actual failure modes.

FIG:OverallArchitectureOfProposedSystem

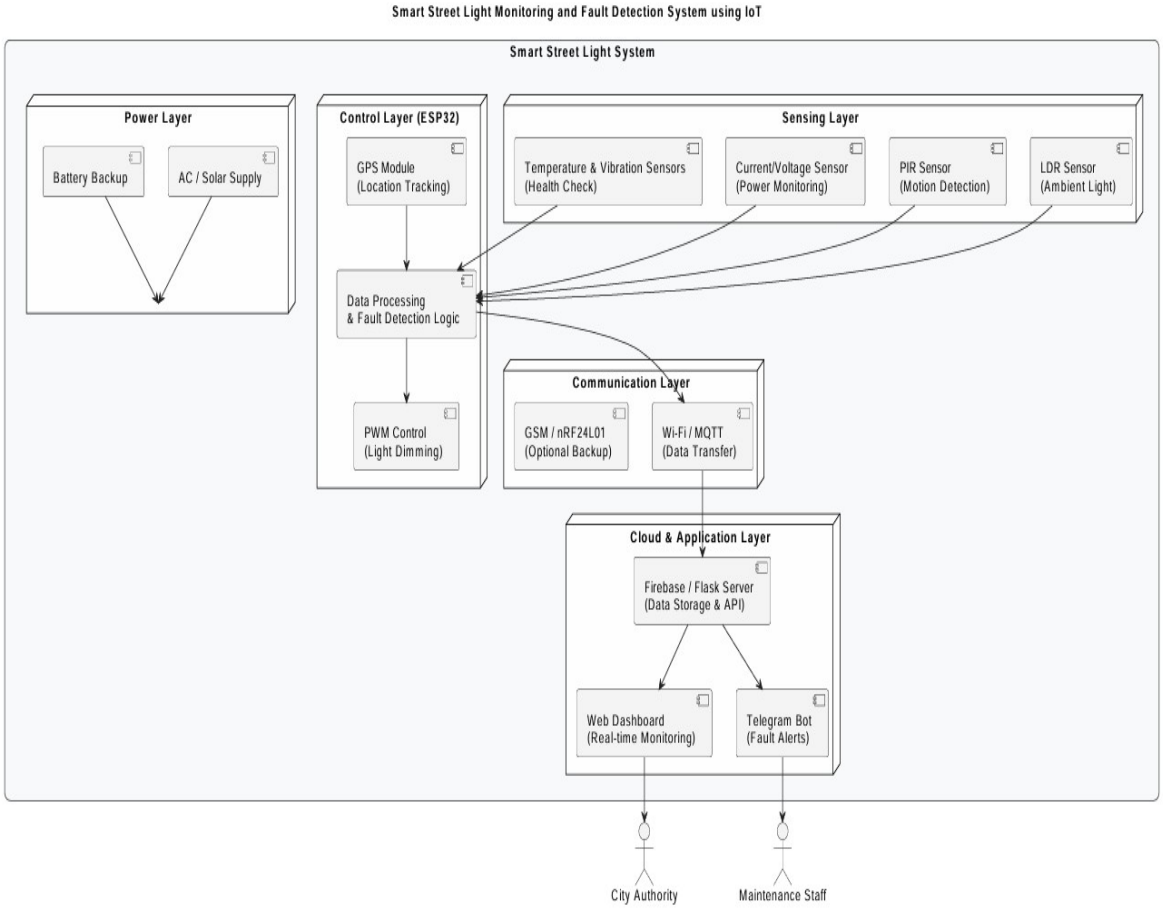
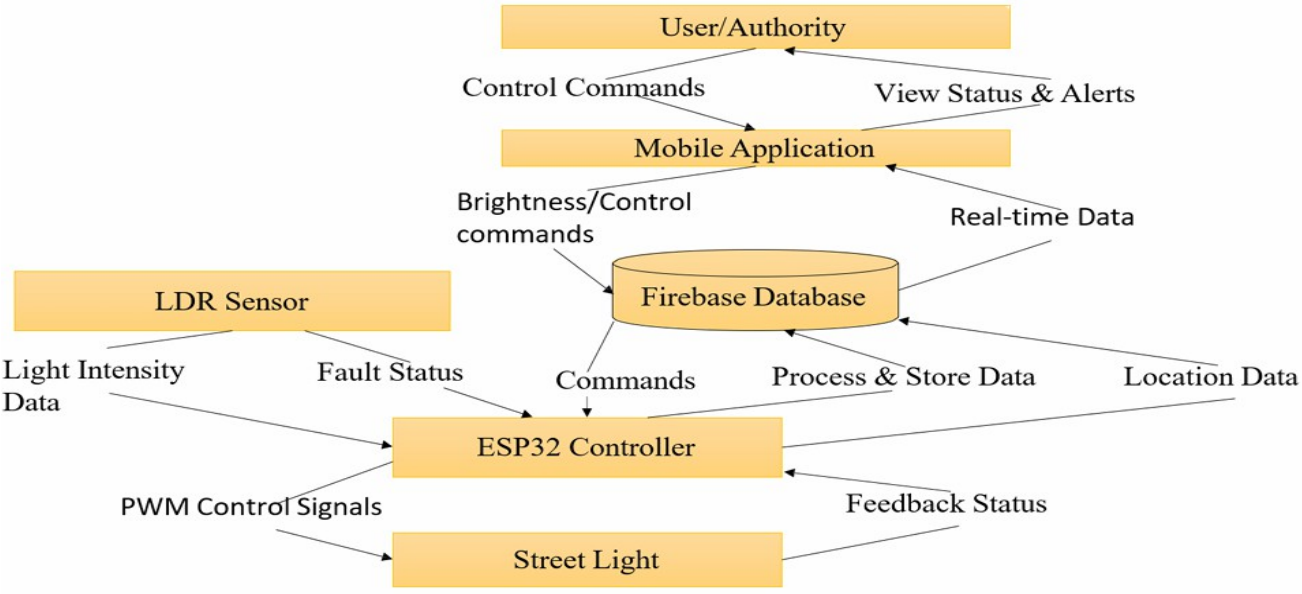


FIG:DataFlowDiagram



VI. PERFORMANCE METRICS FRAMEWORK

Thesystemevaluationemploysacomprehensivemulti-dimensional metrics framework assessing six critical performance aspects:

1) *Fault Detection Accuracy*: Evaluate the system's ability to correctly identify and classify different fault types (lamp burnout, flickering, dimming, electrical anomalies, overheating, structural damage) compared to ground truth observations through manual inspection and controlled fault injection testing.

Metrics:

- Precision = True Positives / (True Positives + False Positives): measures the proportion of fault alertsthat correspond to actual failures, minimizing unnecessary maintenance dispatches.
- Recall = True Positives / (True Positives + False Negatives): quantifies the system's ability to detectall occurring faults without missing critical failures that compromise public safety.
- F1-Score = 2 × (Precision × Recall) / (Precision + Recall): provides balanced assessment of detection performance considering both false alarm minimization and comprehensive fault coverage.
- Classification Accuracy: percentage of correctly classified fault types among detected anomalies, validating the multi-sensor fusion approach for detailed diagnostic categorization.

2) False Alarm Performance: Measure the effectiveness of dual-LDRlogicandtemporalconfirmationwindowsin

- False Positive Rate (FPR)=FalsePositives/(False Positives + True Negatives): quantifies unnecessary maintenance alertsaspercentageofnormaloperation periods.
- Missed Detection Rate (MDR) = False Negatives / (True Positives + False Negatives): measures proportion of actual faults that escape detection, representing potential safety risks.
- Alert Reliability Score = 1 -(FalsePositives/Total Alerts): indicates percentage of generated alerts corresponding to genuine faults requiring maintenance intervention.

3) Energy Efficiency Performance: Quantify energy consumption reduction achieved through adaptive dimming based on motion detection and ambient light conditions compared to conventional fixed-schedule operation maintaining constant full brightness throughout nighttime hours.

Metrics:

- Energy Consumption Reduction = (Baseline Consumption - Smart System Consumption) / Baseline Consumption × 100%: percentage savings over traditional streetlight operation.Dimming Response Time: latency between motion detection and brightness adjustment, affecting user experience and safety perception.

- Adaptive Control Efficiency: correlation between traffic density patterns and actual brightnesslevels, validating intelligent control algorithmeffectiveness. Reducingspuriousalertscaused bytransientconditions5. Communicationand System Performance:Evaluate (passing vehicle headlights, lightning, brief power fluctuations,temporaryobstructions)comparedtosingle-sensor baseline systems.

Metrics:

- Precision = True Positives / (True Positives + False Positives): measures the proportion of fault alertsthat correspond to actual failures, minimizing unnecessary maintenance dispatches.
- Recall = True Positives / (True Positives + False Negatives): quantifies the system's ability to detectall occurring faults without missing critical failures that compromise public safety.
- F1-Score = 2 × (Precision × Recall) / (Precision + Recall): provides balanced assessment of detection performance considering both false alarm minimization and comprehensive fault coverage.
- Classification Accuracy: percentage of correctly classified fault types among detected anomalies, validating the multi-sensor fusion approach for detailed diagnostic categorization.

4) False Alarm Performance: Measure the effectiveness of dual-LDR logic and temporal confirmation windows in reducing spurious alerts caused by transient conditions (passing vehicle headlights, lightning, brief power fluctuations,temporaryobstructions)comparedtosingle-sensor baseline systems.

Metrics:

real-time capabilities, reliability, and scalability of the IoT communication architecture for fault alert delivery and continuous monitoring across distributed streetlightnetworks.

Metrics:

- End-to-End Latency: time from fault detection at sensor node to alert appearance on dashboard and Telegram bot, targeting sub-5-second performance.
- Packet Delivery Ratio (PDR): percentage ofsensor data successfully transmitted to Firebase cloud database without loss.
- System Uptime: percentage of operational time with functional monitoring and control capabilities.
- Network Resilience: system performance degradation during connectivity interruptions, measuring autonomous operation capability.

5) Location Accuracy and Maintenance Efficiency: Assess GPS-based fault localization precisionanditsimpact on maintenance operations through routingoptimizationand response time reduction.

Metrics:

- GPS Coordinate Accuracy: positional error measured in meters between reported and actual streetlight locations.
- Maintenance Response Time: duration from fault detectiontorepaircompletion,comparingGPS-enabledtargeteddispatchversustraditional zone-basedsearching.
- First-Time Fix Rate: percentage of maintenance visits successfully resolving the reported fault without requiring return trips due to incorrect diagnosis or location identification.
- Scalability and Cost-Effectiveness: Evaluate system performance across varying deployment scales and assess total cost of ownership compared to conventionalstreetlight infrastructure and alternative smart lighting solutions.

Metrics:

- Node Scalability: system performance stability when increasing from single-node prototype tocity-wide deployment with hundreds or thousandsof streetlights.
- Cost Per Node: total hardware, installation, and operational costs for each streetlight monitoring unit.

VII.FUTURE WORK

1) Integration of Machine Learning for Predictive Maintenance : In future iterations, historical sensor data (temperature, current, vibration, and brightness) can be used to train predictivemodels.Thiswillallow the system to forecast potential light orcircuitfailures before they occur, minimizing downtime and maintenance costs.

2) Renewable Energy Integration : Future versions can include solar-powered streetlights connected toasmart grid, optimizing energy usage and reducingdependency on conventional electricity sources.

3) Enhanced Communication Protocols : Transitioning from Wi-Fi to more scalable protocols such as LoRaWAN or NB-IoT can extend coverage in large urban or rural areas, improvingreliabilityandreducing operational costs.

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4) Mobile Application for Public Reporting : A dedicatedmobileappcouldbedevelopedforcitizensto report streetlight issues or suggest improvements, creating a community-driven smart maintenance system.

5) Edge AI for Local Decision-Making : Implementing lightweight AI models directly on ESP32 microcontrollers can enable real-time, on-device fault classification and adaptive brightness control without constant cloud dependency.

6) Environmental Monitoring Expansion : Sensors for air quality, temperature, and humidity could be integrated to turn the system into a multifunctional Smart City Node, supporting broader environmental and urban analytics.

7) Integration with Smart City Infrastructure : The system can be linked with traffic management and surveillancesystemstocoordinatelightingwithreal-time road usage, emergency routing, or public safety alerts.

8) Scalability and Cloud Analytics : Future development could focus on building a large-scale cloud platform for multi-city deployment, allowing central monitoring, energy analytics, and AI-based optimization.

VIII. CONCLUSION

This comprehensive survey examined the rapidlyevolvingfield of IoT-based intelligent streetlight monitoring and faultdetection systems. The analysis encompassed diverse architectural approaches, sensor integration strategies, communication protocols, and deployment methodologies developed across recent research initiatives. Contemporary systems demonstrate substantial capabilities for automatedfault detection, energy optimization, and maintenance efficiency improvements compared to conventional streetlight infrastructure. Integration of light intensity sensors, motion detectors, power monitors, and GPS modules enables comprehensive monitoring withprecisefaultlocalization.Cloud platform adoption provides scalable data management and intuitive visualization interfaces supporting centralized operations management. However, several challenges constrain widespread adoption and optimal performance. Network reliability concerns, scalability costs, environmental durability requirements, and security vulnerabilities require continued attention. Standardization efforts remain incomplete, limiting interoperability and competitive technology evolution. Future research directions including artificial intelligence integration, enhanced sensor capabilities, and advanced communication technologies promise substantial performance improvements. The convergence of declining component costs, improving wireless technologies, and increasing smart city initiatives createsfavorableconditionsforacceleratedintelligentstreetlight deployment.Assystemsmatureandstandardsdevelop, IoT-based lighting networks will increasingly constitute fundamental smart city infrastructure supporting sustainable urban development objectives.

REFERENCES

[1] S. Selvam, S. Manivannan, T. Saravanan, and R. G., "Street Light Fault Detection and Control System Urban Glow," in *International JournalofEngineeringResearch in Electronics and Communication Engineering (IJERECE)*, vol. 11, July 2024.

[2] R. Maheswaran, R. Ridhish, V. Vasikaran, R. D. Gomathi, S. Nanthakkumaran, S. Sumesh, S. Poovizhi,and J. Sasikala, "Centralized Monitoring System Street Light Fault Detection and Location Tracking for Smart City," in *IEEE International Conference on Electronics, Computing, Communication and Control Technology (ICECCC)*, 2024.

[3] S.K.Saravanaraaj,P.Kavitha,N.Vishal,Y.Sukhi,G.S. Sriram, and Y. Jeyashree, "PVBasedSensorsforSmart Street Light Fault Detection and Tracking," in*Proceedings of the 20255thInternationalConferenceon Expert Clouds and Applications (ICOECA)*, 2025.

[4] S. C. Suseendran, N. K. B., and M. S. Bennet Praba, "Smart Street Lighting System," in *IEEE International Conference on Communication and Electronics Systems (ICCES)*, pp. 630-634, 2018.

[5] S. M. Kumthekar, T. A. Khot, A. K. Lande, P. B. Pawar, and R. S. Dalvi, "IoT Based Street Light Fault Detection and Location Tracking," in *International Journal for Research in Applied Science and Engineering Technology (IJRASET)*, vol. 12, issue IV, April 2024.

[6] M. Kanthi and D. Ravilla, "Smart Streetlight System Using Mobile Applications: Secured Fault Detection and Diagnosis with Optimal Performance," in *Wireless Networks*, Springer, Feb. 2024.

[7] A. K. Singh and R. Kumar, "Energy Efficient Smart Street Light System Based on IoT," in *International Conference on Innovations in Information,Embeddedand Communication Systems (ICIIECS)*, 2023.

[8] P. Sharma and M. Gupta, "Intelligent Street Lighting System Using IoT for Smart Cities," in *Journal of Ambient Intelligence and Humanized Computing*, Springer, 2023.

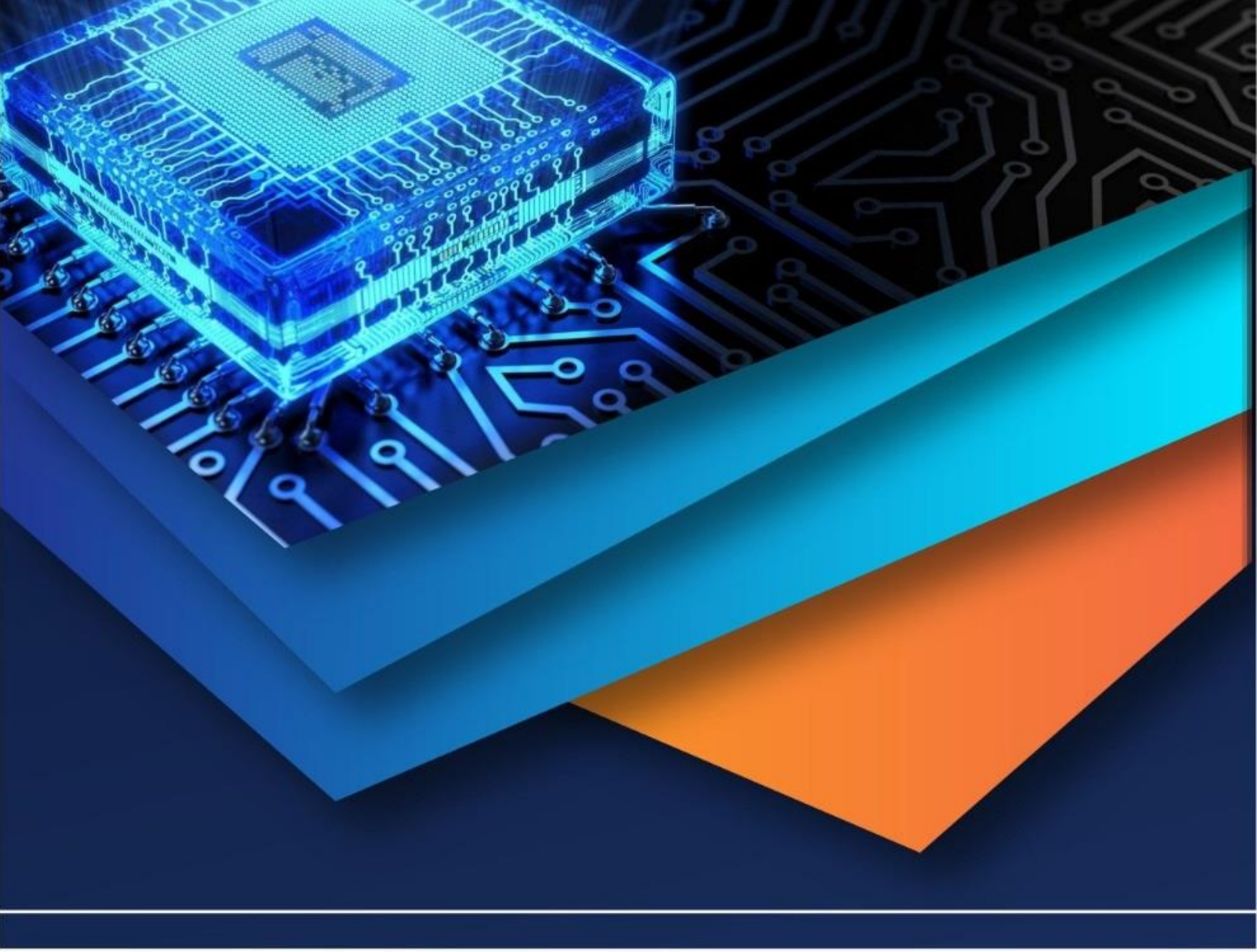
[9] L. Zhang, Y. Wang, and J. Chen, "Machine Learning Based Predictive Maintenance for Smart Street Lighting," in *IEEE TransactionsonIndustrialInformatics*,vol.19, no. 3, pp. 2156-2165, March 2023.

[10] T. Johnson and K. Anderson, "Blockchain-Based Energy Management for IoT Street Lighting Systems," in

[11] *IEEEAccess*,vol.11,pp.45678-45690,2023.

[12] R. Patel andS.Shah,"LoRaWANBasedSmartStreet LightingInfrastructureforRuralDeployments,"in*InternationalJournalof Distributed Sensor Networks*, vol. 18, issue 6, June 2024.

[13] M. Williams and A. Taylor, "Security Challenges in IoT-EnabledSmartStreetLightingSystems,"in*Computers & Security*, Elsevier, vol. 127, pp. 103-119, April 2024.



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