Security System Integrated on Street Lights using IoT

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Abstract*—Since the Internet of Things and the desire for smart cities have increased, integrating security systems with smart streetlights has become a common solution. The suggested technology enables real-time surveillance and notifies authorities of questionable behaviour in an effort to increase security in public areas. The IoT protocols used by the smart street lights, which are outfitted with cameras, motion sensors, and other sensors, enable wireless communication with a central server. This enables quick alerts to authorised people in the event of anomalies and effective data processing. Algorithms for advanced analytics and machine learning are used to identify patterns and trends, enabling proactive analysis. A key component of the smart street lamp system is energy efficiency. It accomplishes this using two methods: optimising lighting usage by activating lamps based on a defined minimum brightness threshold and shutting them off during the day; and changing bulb intensity when no human presence is detected after nightfall. The bulbs are powered by solar energy, which results in significant energy savings. The suggested system is made to be affordable, simple to implement, and scalable to accommodate various city sizes and security requirements. It provides a comprehensive solution for boosting public safety and security while fostering environmental friendliness by integrating security systems into intelligent street lights. This ground-breaking approach uses IoT to make cities safer and more secure places to live.

I. INTRODUCTION

The advent of IoT and the rising demand for smart cities have greatly increased the appeal of the integration of security systems into smart lamps. By enabling real-time surveillance and sending prompt alerts to authorities in the event of suspicious activity, this ground-breaking system aims to increase security in public areas. These intelligent street lights connect wirelessly and seamlessly to a central server using cutting-edge IoT protocols. They are outfitted with modern cameras, motion sensors, and other sensors. This constant communication makes it possible to process data effectively, enabling prompt notifications to be sent to authorised individuals whenever anomalies are found. The system can recognise complex patterns and trends thanks to the strength of modern analytics and machine learning algorithms, enabling predictive analysis and preventative measures.

The smart street lamp system places a lot of attention on energy efficiency, addressing environmental issues in addition to its security-enhancing capabilities. It does this by employing two main strategies. First of all, it efficiently uses lighting by judiciously shutting off the lights during daylight hours to ensure energy conservation. Additionally, the system turns on the bulbs in accordance with a predetermined minimum brightness level, ensuring that they are only illuminated when necessary. In addition, the technology cleverly reduces the lamp intensity when it detects no human activity after dark. This subtle control enables energy savings without sacrificing a secure and well-lit area. The system's impressive use of solar energy to effectively power the bulbs reduces the system's environmental impact and results in significant energy savings.

The proposed system has been painstakingly created in order to be economical, simple to implement, and easily adaptable to meet the various size and security needs of communities. It offers a comprehensive solution that greatly improves public safety and security by integrating security systems into smart street lights. Intelligently combining cutting-edge technologies not only enables quick reactions to potential dangers but also promotes a more eco-friendly and sustainable environment. This creative approach raises the bar for safety, security, and environmental awareness in cities, making them more desirable as locations to live and prosper by utilising the revolutionary potential of IoT.

II. LITERATURE SURVEY

Systems for security surveillance are essential for improving public safety and safeguarding assets. The field of security surveillance has undergone a revolution thanks to the fusion of machine learning (ML) and Internet of Things (IoT) technologies, which have made it possible to conduct enhanced monitoring, real-time analysis, and preemptive threat identification. By highlighting their approaches, difficulties, and potential future directions, the literature survey seeks to give an overview of the current research and advancements in security surveillance systems that use machine learning and IoT.

Energy efficiency is one of the key benefit of security surveillance systems utilising ML and IoT. These systems lessen their environmental impact while maintaining continuous operation without relying on conventional power grids by using solar power as a renewable energy source[1]. By reducing unused illumination, the incorporation of smart lighting controls, which only turn on lights when a person is identified, further improves energy efficiency.

Traditional security camera systems could be impacted by inclement weather, like heavy rain or fog[2], but ML and IoT-based surveillance solutions get around these restrictions. These systems can make up for decreased camera visibility in bad weather by adding sensors. In spite of environmental difficulties, this guarantees that surveillance capabilities continue to operate, offering trustworthy security monitoring.

Security surveillance systems may now detect irregularities in real-time thanks to ML algorithms. These systems can distinguish between typical behaviour and potentially suspicious behaviour by examining trends and identifying aberrant activity. The severity of detected anomalies is divided into three categories: low (unusual crowding), moderate (vehicular accidents), and high (gun violence or women's safety-related issues) which was missing in earlier prototypes of this system[3]. The technology can then transmit notifications immediately to the closest police station, enabling quick response and action. The inclusion of collected photographs in the warnings enables authorities to assess the gravity of the problem and take the necessary measures.

Different sensor technologies can be used by ML and IoT-based surveillance systems to improve their functionality [4]. For instance, human movement can be identified by ultrasonic sensors, allowing for proactive lighting that lights the path of people. Additionally, battery level indicators can offer useful data on the surveillance system's remaining power, enabling prompt maintenance and uninterrupted operation.

Due to poor visibility in low-light conditions, the system's prior iteration had a significant problem that prevented the camera module from operating as intended [5]. The camera modules were strategically mounted onto smart street lights as a workable solution to this problem. This clever strategy guarantees better visibility, which is essential for getting high-quality film. The system successfully overcomes the visibility restriction by combining the camera modules with the smart street lighting, enabling effective surveillance even in low-light situations.

III. PROPOSED SYSTEM

The "Security System Integrated on Street Lights using IOT" is made up of three unique modules, the first of which is the "Sensor detection module." It is in charge of gathering real-time data with the help of advanced sensors and the micro controller "esp32," which is Bluetooth and WiFi enabled. The second module is called the "Charging Module" and it keeps our batteries charged and ready to go by producing electricity from solar radiation. The third module is referred to as the "Security module," and it is responsible for detecting suspicious activity as well as violent crimes involving firearms or knives.

4.1. Charging Module

Connect as illustrated in the following diagram, and then carry out the following steps:

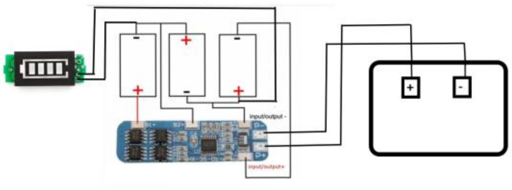

Figure 1. Charging Module Circuit diagram

Orient the solar panel towards the sun. The PV cells in a solar panel take the energy from the sun's rays and transform it into electricity. An electrical charge within the cell that permits electricity to flow is what triggers this process. The lithium ion batteries are charged with this electricity.

Direct current (DC) electricity is the form that solar panels generate their power in. 20 watt and 12 volt solar panel. It has a DC current of 1.67A. They have a 2600mAh capacity, which translates to 2.6A of current per hour. However, as the batteries can be harmed by deep drain or overcharging, we cannot connect the two directly. Batteries could potentially explode or catch fire.

The two are connected by a BMS. A BMS is a mechanism that guards against dangers and prolongs battery life by preventing overcharging. BMS automatically disconnects the batteries from the solar panels and stops charging when the batteries are fully charged. The voltage of every battery is 3.7 volts. Series-connected batteries can provide 11.1 volts of electricity when used all at once.

We have a battery level indicator module to display the battery's current level. It is linked via the battery. Only a red light will be illuminated when the battery is less than 25% full.

4.2. Sensor Detection Module

The LDR sensor begins the full smart street light by allowing light to fall on its register after all the connections for this module have been made. The LDR's resistance reduces in the presence of light, increasing the amount of current that can pass through it. The LDR's resistance rises when light levels drop, decreasing the current that passes through it. This current is measured by the sensor module, which then uses the information to calculate the quantity of light present. The lights will remain off if there is adequate light.

If the LDR is unable to detect sufficient light due to the environment or because it is midnight, the ultrasonic sensor engages. The echo principle underlies the operation of ultrasonic sensors. An ultrasonic sensor emits a sound wave at a frequency that is above the range of human hearing, and after colliding with an object, the time it takes for the wave to bounce back is recorded. The sensor uses this information to calculate how far away the object is.
Object distance = 0.017 * sound wave duration;

The radar sensor is granted control for further detection if the distance is less than 200 cm.

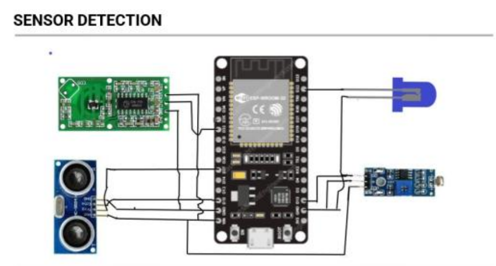

Figure 2. Sensor Detection Module Circuit Diagram

4.3. Security Module

The street light has a camera mounted on top that performs several security-related tasks. First, it records live footage of the surroundings to monitor them. The camera examines the live footage to look for people by utilising machine learning algorithms. The street light doesn't turn on until both a human and a moving item are picked up by the radar sensor. If not, it stays off.

Second, the camera serves as a security component by continuously monitoring the area. The camera instantly sends notifications and real-time footage of any suspicious criminal activity to the closest police station in the event that it is discovered. Based on the intensity of the activity detected, the warnings are divided into three levels.

When an unexpected crowd gathering is noticed, for example, the first level of alert is set off. A vehicle accident within the camera's field of view triggers the second level. Third-level alerts are generated when the camera detects the presence of weapons, knives, or anything related to women's safety.

In order to improve security, this system combines the strengths of radar sensors, machine learning algorithms, and cameras. The safety and wellbeing of the neighbourhood are ensured by its proactive detection and reaction to any threats.

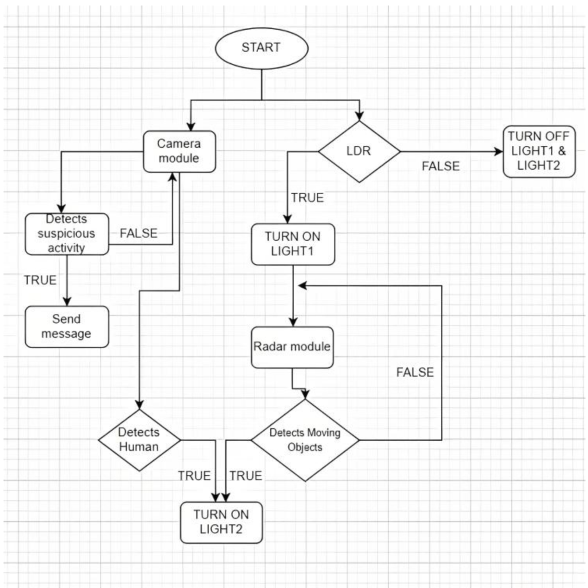

Figure 3. Proposed system flow chart

IV. RESULTS

The research project on "Security surveillance using machine learning and IoT" produced encouraging results and met the project's goals. The following significant discoveries and results were attained:

- The "Haar Cascade" object identification algorithm applied successfully identified knives and firearms with an outstanding accuracy of 82%. The ability of the security surveillance system to quickly identify potential threats and ensure public safety is improved by this vital component.
- With an accuracy of 85%, the algorithm effectively identified violent events including brawls on the street and car accidents. This ability enables authorities to respond and intervene quickly, helping to uphold law and order in public areas.
- When abnormalities were discovered, the system quickly produced warnings with the precise location and pertinent video of the incident. These alerts were classified according to their severity (low, medium, or high) and sent right away to the closest police station, enabling law enforcement officials to act immediately and effectively.
- Intelligent lighting control was made possible by the incorporation of machine learning techniques. When a person was found, the street lights would only come on at night or in low light situations. This increased efficiency and sustainability by optimising energy use while ensuring sufficient visibility for surveillance needs.
- Solar energy was used to power the system's lighting and camera components. The system's carbon footprint was decreased by using this renewable energy source, which also made sure the system ran without interruption in places with limited access to traditional power sources.

CONCLUSION

IoT technology offers considerable improvements in boosting public safety and surveillance capabilities when a security system is integrated on street lighting. This technology efficiently scans the area and recognises people's presence using cameras, machine learning algorithms, and radar sensors.

The cameras' live feeds enable in-the-moment analysis, allowing the system to ascertain whether a person is nearby. It is possible to intelligently manage the street lights using this information along with the radar sensor's ability to identify moving things. In order to optimise energy consumption and guarantee the right lighting levels for safety, the lights are only turned on when both a person and a moving item are detected.

The system's security module also offers helpful surveillance features. The cameras can identify potentially illicit activity by continuously monitoring the live video. The device instantly notifies the closest police station, giving them access to live footage that contains important evidence. Law enforcement can prioritise their response based on the seriousness of the discovered behaviour thanks to the categorisation of these alerts into several levels.

Incorporating IoT technology increases the security system's effectiveness while also enabling seamless communication between police stations, cameras, and streetlights. This interconnection improves the system's overall performance by allowing for quick responses and assisting in the reduction and prevention of criminal events.

FUTURE SCOPE

The use of IoT technology to integrate a security system on street lights has demonstrated to have enormous promise for improving public safety and monitoring. Future research and development can be conducted in a number of areas to further enhance and expand upon this system, including:

- Algorithm Improvement: The system can increase its accuracy in identifying particular activities or behaviours by improving the algorithms used to analyse the live data from the cameras. This entails accurately identifying other criminal activity as well as differentiating between fighting and peaceful gatherings. It is possible to seek improvements in computer vision and machine learning approaches to create models for activity recognition and behaviour analysis that are more reliable.
- Customization for Prison Environments: The security system has shown to be successful in identifying hostile disputes that frequently go unnoticed in prisons. Future studies can concentrate on modifying and perfecting the system specifically for jail settings. This entails modifying the system's algorithms, camera positioning, and alert mechanisms to better suit the particular security needs of prisons.
- Criminals' and Missing Persons' Location Tracking: The system can be improved to track down the whereabouts of wanted criminals and missing people. Identification and capture of people with criminal histories can be aided by integration with current databases and sophisticated tracking methods. By finding missing people, technology can also enhance search and rescue efforts.
- Identification of Suspicious Persons: Security measures can be improved by enhancing the system's ability to recognise unknown people who are frequently present in high-security zones. The system can identify thresholds and patterns of behaviour to identify questionable activities and generate notifications for prompt action.
- Hybrid Energy Model: A hybrid energy model can be used to get around problems with solar energy availability during bad weather. When solar energy is sparse, this device effortlessly converts to AC power to maintain the security system's functionality. The integration of energy storage technologies, such as batteries or supercapacitors, can be studied in order to maximise energy efficiency and boost system reliability.
- Addressing Privacy Concerns: To address privacy concerns related to monitoring and surveillance capabilities, transparent and responsible deployment is essential. Research should concentrate on creating strong privacy frameworks, assuring adherence to moral and legal obligations, and giving people control over their personal information.
- Regular maintenance and system updates are necessary to guarantee the integrated security system's optimum performance and dependability. To reduce downtime and increase system efficiency, research can concentrate on creating automated maintenance protocols, remote diagnostics, and predictive maintenance strategies. To reduce new risks, security fixes and upgrades should also be periodically applied.

REFERENCES

[1] "SnehilGangaprasadJaiswal, Sharad W Mohod" "SmartViolenceDetectionand ClassificationSysteminVideo"; January 2023

[2] "DebanjanKonkar, RishavRakshit, SudiptaDey, DebabrataSamanta, Chinmoy Kar, Himangshu Pal, KalpanaSharma, SiddharthaBhattachar" "Automatic Detection Of Violence Activity-A Tool For Women'sSafety"; April 2020

[3] "Dr.Sandeep Saxena, Dr.S.Balamurugan, Dr.Sandeep Singh Sengar, Dr.Shashank Srivastava" "Artificial Intelligence Based Detection Of Violence Through Surveillance Camera"; September 2019

[4] "Abhay Dhasmana, Akshay Kumar, Rajesh Singh, Anita Gehlot, Dharam Buddhi, Abhishek Joshi, Shaik Vaseem Akram, Mudimela Prasantha Reddy, Neeraj Priyadarshini, Purnendu Shekhar Pandey""Intelligent Ai & Ml Based System For Surveillance, Incident Reporting, Visual Patrolling With Lora Module"; May 2023

[5] "Jammi Venkata Manoj, Maddipati Naveen, Dr. Om Prakash Yadav""A Smart Surveillance System"; May 2023

[6] "Chhaya Gupta, Prof. (Dr.) Nasib Singh Gill, Dr Preeti Gulia""Method To Improve Human Activity Recognition For Enhanced Video Surveillance And Security"; February 2023

[7] "Prof. Preethi P, Dr. Mamatha H.r.""Smarter Home Personalized Security Using Image Recognition Through Surveillance Camera"; January 2023

[8] "Dr. P. Neelaveni, Mr. V. Kumaresan, Ms. Selciya Selvan, Mrs. Dolly Irene. J, Dr. A. C. Shagar, Mrs. Subha T D, Mrs. M. Benisha""A Cognitive IoT Smart Surveillance Framework for Crowd Behaviour Analysis"; January 2023

[9] "Arastu Sharma, Sudhanshu Sharma""Camera Fed And Ai Enabled System For Crime Mapping"; December 2022

[10] "Mr. Ashish Awate, Mr. Jayesh Chaudhari, Dr. Makarand Shahde, Ms. Mayuri Kulkarni, Mr. Bhushan Nandwalkar, Mr. Tejas Chaudhari, Mr. Rushikesh Girase, Mr. Abhijit Patil""Real Time Surveillance System Using Artificial Intelligence To Get Precise Insights And Results For Security And Surveillance Purpose"; January 2023

[11] "Katkar Nihanshu Yuvraj, Garg Dr. Vijay Kumar, Parashar Dr. Deepak, Mohan Dr. Chandra, Dutt Dr. Amit, Agarwal Dr. Prateek, Vs. Sajisha, Khanna Vibhu""Cctv Camera Network Based System For Detection And Tracking Of Criminal Activity"; December 2022

[12] "Debajyoti Chatterjee, Parimal Ashvinkumar Patel, Mrs. Jeipratha. P. N., Dr. Sheshang Degadwala, Dr. Chethana Sridhar, Ravi Choubey""Intelligent System & Method For Home Surveillance With Warning Of Robber Activities Using Iot & Artificial Intelligence Approach"; December 2022

[13] "Dr. Emil Selvan G S R, Dr. Ramkumar M P""Iot-driven System Of Machine Vision-based Person Detection Using Machine Learning For Visual Surveillance System"; December 2022

[14] "Mr. Melwin D Souza, Mr. Varuna Kumara, Mr. Balanageshwara S, Mr. Thimmappa D S, Dr. Basavaraj Kambale, Akshatha Naik, Sookshma Adiga, Shrinidhi N, Raghunatha, Mr. Vishwanath Dinakar""Artificial Intelligence And Iot Based AutomaticAccident Detection System Using Ai Camera, Image Processing And Machine Learning Algorithms"; December 2022

[15] *"Dr. G. Brindha, Dr. Ihtiram Raza Khan, Mrunalini Harish Kulkarni, Dr. Prajakta Ajay Khadkikar, Dr. Tariq Hussain, Ahmed Mohamed Nashaat Ali Rady""System Of Machine Vision-based Person Detection Under Low-illuminance*