Vellore Institute of Technology
(Deemed to be University under section 3 of UGC Act, 1956)

SCHOOL OF COMPUTER SCIENCE AND ENGINEERING

J-COMPONENT REPORT

Smart Street Light Monitoring System

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BONAFIDE CERTIFICATE

Certified that this project report entitled “Smart Street Light Monitoring System” is a Bonafide work of Harini S -20BCE1832, Philip A-20BCE1797, Santhosh Kumar G-20BCE1184 who carried out the J-component under my supervision and guidance. The contents of this Project work, in fuller or in parts, have never been submitted to any other Institute or University for award of any degree or diploma and the same is certified.

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ABSTRACT

Nowadays, people are busy with their own work and it is difficult for persons to manually go and switch the light on and off time-to-time. This smart street light monitoring will do the job of supervising the streets and make the light glow whenever the street gets dark. Our work is to make the system detect the darkness and make the light glow whenever it is needed according to the situations. Without light, it will be difficult for drivers to see the vehicles in front of their vehicles and it is dangerous for kids and women to go on streets while it’s dark. Also, in order to save the energy, we only make the light to glow whenever it’s dark. If we execute this idea, then it will be a great help to the people as well as the government because of the cost that it will save.
It follows fully observable environment so it will automatically update its data and work accordingly. And it is based on simple reflex agent so whenever the street is dark, the light will turn on and whenever the weather is bright and clear, it will turn off the light. By this we can save energy and money.

KEYWORDS

power-adjustable LED array, centrally-controlled smart street light systems, Artificial Neural Network (ANN)

1.INTRODUCTION

Population is been gradually increasing yearly and the people accessing resources has also been increasing simultaneously. But the resources are not completely used by everyone. People in urban and metropolitan areas are able to get access to every resource whereas rural people are not. Most of the people are working and everyone uses roads as their basic and primary thing for their transportation. But it is not always easy for them to travel when the roads are not in a perfect condition. At the same time, if there is no proper light and electricity, people will really find it difficult to travel from one place to another. Rural areas basically don’t have this light facility. In metropolitan areas, even though they possess all the resources, they do not use that in an effective way. In order to avoid all these, we came up with the idea called “SMART STREET LIGHT SYSTEM” where it will monitor and detect whether the street is dark or not and functions accordingly. If the weather seems dark and rainy or if it is a night time, then it will switch on the light and whenever it is bright and street seems visible, then it will switch of the lights. By this way, we can save the energy from being wasted as well as the money that is being spent on the electricity.

2.LITERATURE SURVEY

1. Shahzad, G., Yang, H., Ahmad, A. W., & Lee, C. (2016). Energy-efficient intelligent street lighting system using traffic-adaptive control. IEEE Sensors Journal, 16(13), 5397-5405.

The paper "Energy-efficient intelligent street lighting system using traffic-adaptive control" proposes a smart street lighting system that adjusts lighting levels based on real-time traffic conditions to improve energy efficiency while maintaining safety. The proposed model provides energy efficiency by adjusting lighting levels based on real-time traffic conditions thereby, reducing millions for municipalities and utilities. The model also provides improved public safety by reducing light pollution and associated glare. Moreover, the wireless sensor network used in the system is scalable and can be easily integrated with other smart city applications and sensors and the model reduces energy consumption and associated greenhouse gas emissions. Unfortunately, the model has some potential disadvantages such as significant upfront investment in hardware, software, and infrastructure. Variability of accuracy induced due to the placement and working of sensors, prone to incompatibility with the existing architecture, continuous maintenance and monitoring to ensure proper functioning, which may incur additional expenses at the hands of the local corporation. To overcome the limitations in this model, instead of dimming the lights based on luminance, we keep a threshold value for turning the light on/off only with the help on sensors, which do not result in cybersecurity threat or privacy invasion.

2. Kanthi, M., & Dilli, R. (2023). Smart streetlight system using mobile applications: secured fault detection and diagnosis with optimal powers. Wireless Networks, 1-14.

The paper "Smart streetlight system using mobile applications: secured fault detection and diagnosis with optimal powers" by Kanthi and Dilli (2023) proposes a new approach for smart street lighting systems that utilizes mobile applications for secure fault detection and diagnosis, as well as optimal power management. The authors provide a literature survey of existing smart street lighting systems and their limitations, and highlight the potential benefits of using mobile applications for real-time monitoring and control. The proposed system uses secure communication protocols and encryption techniques to ensure the privacy and security of user data. It also employs machine learning algorithms for fault detection and diagnosis, which can optimize energy consumption and improve system reliability. The authors demonstrate that this approach can provide efficient control of street lighting systems, while also improving their fault tolerance and resilience. Overall, the paper presents a comprehensive review of the state-of-the-art in smart street lighting systems using mobile applications, and proposes a promising new approach for further research and development in this field. As this model uses mobile application, it is completely out of the scope of this project but in our project, instead of dimming the lights based on luminance, we keep a threshold value for turning the light on/off only with the help on sensors, trained with ML models with past dataset without accessing the web.

3. Jin, D., Hannon, C., Li, Z., Cortes, P., Ramaraju, S., Burgess, P., ... & Shahidehpour, M. (2016). Smart street lighting system: A platform for innovative smart city applications and a new frontier for cyber-security. The Electricity Journal, 29(10), 28-35.

The paper "Smart-street lighting system: A platform for innovative smart city applications and a new frontier for cyber-security" explores the potential of smart street lighting systems to enable innovative smart city applications and the associated cyber-security challenges. The paper does not present a specific model or implementation of a smart street lighting system, but rather discusses the potential benefits and challenges associated with these systems but based on the information presented in the paper, Smart streetlighting systems can be designed to be more energy efficient than traditional systems, by using sensors to adjust lighting levels based on pedestrian and vehicular traffic patterns, time of day, and other factors. They provide cost savings for municipalities and utilities. They make a flexible and scalable platform for smart city applications as they can be designed to support additional sensors and applications, such as air quality sensors, traffic cameras, and public Wi-Fi access points. They also help in improving public safety by providing better lighting in high-crime areas and enabling real-time monitoring and response to safety incidents. However, some of the limitations include high upfront costs of installing hardware, software, and infrastructure, additional resources and expertise to maintain and monitor them, threat of cybersecurity attack is imminent raising privacy concerns as it is prone to capture sensitive information about individuals via camera and other sensors. Last but not the least, can lead to issues relating to compatibility with existing infrastructure. As this paper does not deal with any model but rather a discussion of potential benefits and challenges, there is no basis of comparing our model.

4. Daely, P. T., Reda, H. T., Satrya, G. B., Kim, J. W., & Shin, S. Y. (2017). Design of smart LED streetlight system for smart city with web-based management system. IEEE Sensors Journal, 17(18), 6100-6110.

The paper "Design of smart LED streetlight system for smart city with web-based management system" by Daely et al. (2017) presents a literature survey on smart LED street lighting systems and proposes a new system design that incorporates a web-based management system. The authors highlight the benefits of using LED lighting systems for energy savings and environmental sustainability, as well as the potential of smart street lighting systems for enhancing public safety and improving urban planning. This paper uses smart LED streetlighting system which results in significant energy savings compared to traditional lighting systems. Due to LED's longer lifespan and energy efficiency, carbon footprint and environmental impact is minimal. This paper enhances public safety by providing high-quality lighting for road users and pedestrians. The system can also incorporate sensors and devices for monitoring traffic and pedestrian activity, which can be used for accident prevention and response. The web-based management system allows users to monitor and control the street lighting system remotely, from any device with internet access. This allows for more efficient maintenance and control of the lighting system, reducing the need for on-site inspections and repairs. This model is prone to raising privacy concerns, cybersecurity risks if not designed with a strong encryption and security protocol in mind and technical issues such as operation whilst power outage, communication failures.To overcome the limitations in this model, instead of using the web, our model uses a dataset to turn the lights on/off based on luminance, humidity and some other factors. We keep a threshold value for turning the light on/off only with the help on sensors, which do not result in cybersecurity threat or privacy invasion and the maintenance is also cost-efficient.

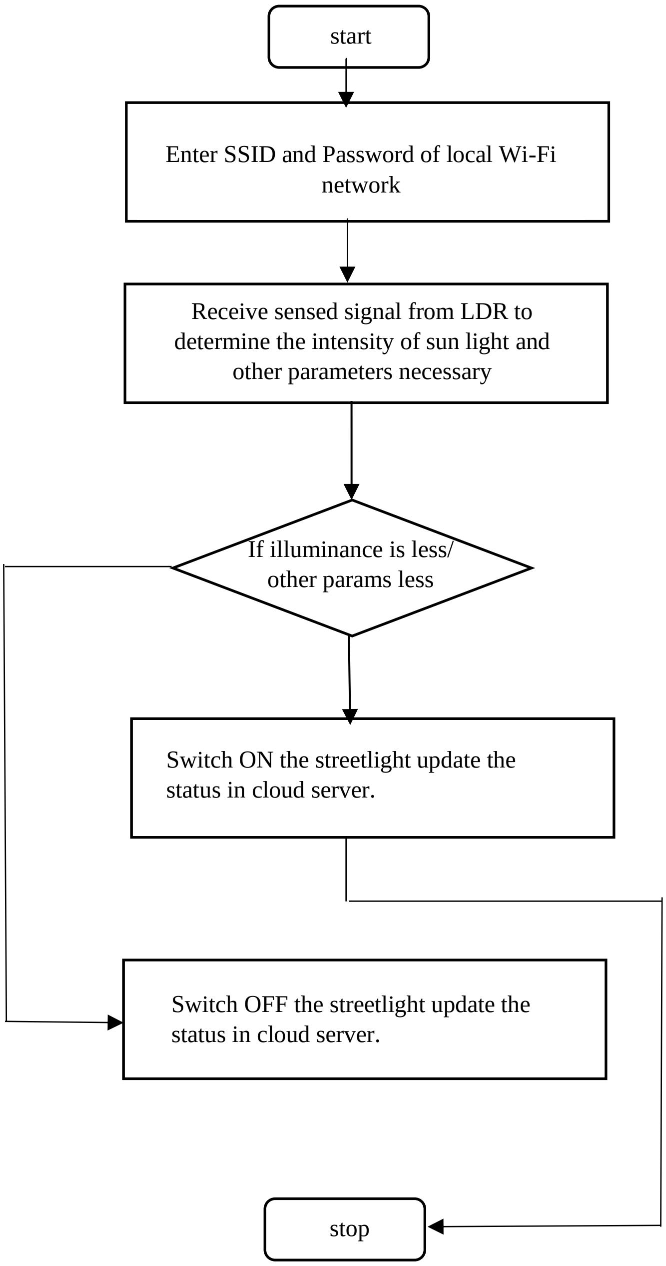
5. Lee, H. C., & Huang, H. B. (2014). A low-cost and non-invasive system for the measurement and detection of faulty streetlights. IEEE Transactions on Instrumentation and Measurement, 64(4), 1019-1031.

The paper "A low-cost and non-invasive system for the measurement and detection of faulty streetlights" presents a new method for detecting faulty streetlights using a low-cost and non-invasive system. The proposed system consists of a camera that captures the light emitted by the streetlights and a computer program that analyses the images to detect faulty streetlights. This paper incorporates a model using only a camera and computer program to detect faulty streetlights making it an attractive option for municipalities or organizations with limited budgets. The model implemented does not require any modifications to the streetlights themselves making it easy to implement without disrupting the existing infrastructure. The paper shows that the system is able to detect faulty streetlights with a high degree of accuracy. This can help municipalities to quickly identify and address issues with their streetlights, reducing energy consumption and maintenance costs. Moreover, the model has the potential to be used for large-scale monitoring of streetlights, which can provide valuable data for city planners and policymakers. This data can be used to optimize the placement of streetlights, reduce energy consumption, and improve overall public safety. Unfortunately, since the model is designed specifically for detecting faulty streetlights based on their light intensity and color distribution and may not be suitable for detecting other types of streetlight faults, such as physical damage or electrical issues. The accuracy of the model may be affected by the positioning of the camera and adverse weather conditions or other environmental factors, such as fog or smog, which can impact the light intensity and color distribution of streetlights. Moreover, the model requires regular maintenance and calibration to ensure accurate results over time. This may be a challenge for municipalities or organizations with limited resources.To overcome the limitations in this model, instead of using the camera, we are utilizing the sensors to ward off privacy concerns and we keep a threshold value for turning the light on/off only with the help on sensors

3.PROPOSED WORK

In this project, the street light system, in which lights on when needed and light-off when not needed. Basically, the sensors present in the system will detect the condition of the weather and the luminescence. The sensor will then send message to the light to turn on or off based on the situation. Here we will be using the components that is cost effective as well as low energy consuming. We propose an autonomous-distributed-controlled light system, in which the lights turn on before pedestrians come or the weather is dark and dull and turn off or reduce power when there is no one by means of a distributed-installed sensor network.

Architectural/flow diagram:



4.PERFORMANCE ANALYSIS

Models used:

Logistic Regression:

Definition: a data analysis technique that predicts the value of unknown data by using another related and known data value.

Drawback: It assumes linearity between the predicted (dependent) variable and the predictor (independent) variables which makes the execution time more. In this case, it assumes the linearity between highly correlated variables which makes the model weak.

SVM Linear:

Definition: Support Vector Machine is a linear model for classification and regression problems. It can solve linear and non-linear problems and work well for many practical problems. The algorithm creates a line or a hyperplane which separates the data into classes.

Drawback: This model is not suitable for large datasets. In cases where the number of features for each data point exceeds the number of training data samples, the SVM will underperform. Our dataset is basically dealing with data that keeps updating every 10-20 minutes. So, this model is inefficient.

SVM RBF:

Definition: real-valued functions that use supervised machine learning (ML) to perform as a non-linear classifier. Its value depends on the distance between the input and a certain fixed point.

Drawback: Long training time for large datasets. Difficult to understand and interpret the final model, variable weights and individual impact. The time was higher when we tried to train the model about the dataset.

SVM Poly:

Definition: uses a polynomial function to map the data into a higher-dimensional space. It does this by taking the dot product of the data points in the original space and the polynomial function in the new space.

Drawback: SVM algorithm is not suitable for large data sets. SVM does not perform very well when the data set has more noise i.e. target classes are overlapping. Ours is a large dataset and this model causes overlapping of attributes.

Gaussian:

Definition: Gaussian Processes are a generalization of the Gaussian probability distribution and can be used as the basis for sophisticated non-parametric machine learning algorithms for classification and regression.

Drawback: This model uses the whole samples/features information to perform the prediction. Hence, it takes larger execution time.

Artificial Neural Network (ANN):

Definition: biologically inspired computer programs designed to simulate the way in which the human brain processes information. ANNs gather their knowledge by detecting the patterns and relationships in data and learn (or are trained) through experience, not from programming.

Drawback: They are not able to generalize from limited training data. On smaller datasets, neural network models tend to overfit.

<u>Why we chose ANN?</u>

Ours is a large dataset hence we don't face this problem. Also, this produces the maximum accuracy with less execution time. Hence, this is the efficient model for our dataset.

<u>Parameters taken into consideration and why:</u>

Wind velocity (m/s):

Wind speed and direction have numerous impacts on surface water. These parameters affect rates of evaporation, mixing of surface waters, and the development of seiches and storm surges.

Wind direction (degree):

In order to predict if there will be rain or not, both wind velocity and direction are important because rain will dim the light therefore the parameters that we should consider might vary.

Temperature (Celsius °C):

The hotter a surface is, the more the light it produces. In this case, we won't need street light and if the situation is opposite, street light is mandatory.

Humidity (kg-1(percentage)):

for high ambient humidity, near 100%, transmission of light through the epidermis is higher. Also, higher the humidity, the more is the chance of raining.

Air pressure (Hectopascal(hPa)):

if air pressure increases, the temperature also increases. If the temperature increase, then the illuminance also increases.

Illuminance (lux):

If the illuminance is high, then the streets look brighter so we won't be needing street lights during that time.

Rain Level (mm):

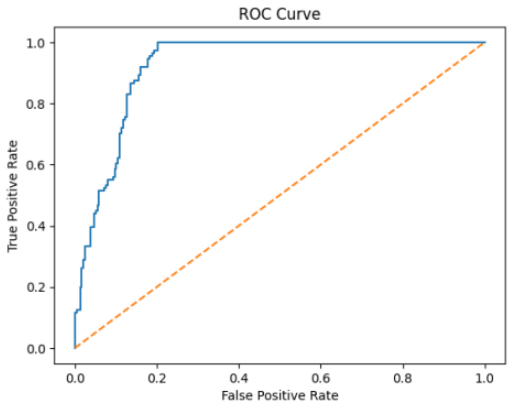
If there is high rainfall level, then the illuminance will be less because of the heavy rain. At that time the street lights must be turned on.

Month	Models	Accuracy	Execution time
	Logistic Regression	0.9166666666666666	1s
January	SVM Linear	0.9367816091954023	1s
	SVM RBF	0.7528735632183908	1s
	SVM Poly	0.6264367816091954	0s
	Gaussian	0.8908045977011494	1s
	Artificial Neural Network (ANN)	0.959770143032074	23s
	Logistic Regression	0.8598726114649682	0s
February	SVM Linear	0.8726114649681529	0s
	SVM RBF	0.7515923566878981	0s
	SVM Poly	0.7515923566878981	0s
	Gaussian	0.7006369426751592	0s
	Artificial Neural Network (ANN)	0.9681528806686401	23s
	Logistic Regression	0.7648809523809523	1s
March	SVM Linear		
	SVM RBF	0.7619047619047619	1s
	SVM Poly	0.7619047619047619	0s
	Gaussian	0.625	1s
	Artificial Neural Network (ANN)	0.9464285969734192	23s
	Logistic Regression	0.7643097643097643	1s
April	SVM Linear		
	SVM RBF	0.7583892617449665	0s
	SVM Poly	0.7583892617449665	0s
	Gaussian	0.5234899328859061	0s
	Artificial Neural Network (ANN)	0.9597315192222595	19s
	Logistic Regression	0.8127659574468085	2s
May	SVM Linear		
	SVM RBF	0.7106382978723405	3s
	SVM Poly	0.7106382978723405	0s
	Gaussian	0.7148936170212766	0s
	Artificial Neural Network (ANN)	0.978723406791687	29s
	Logistic Regression	0.8240740740740741	1s
June	SVM Linear		
	SVM RBF	0.7345679012345679	0s
	SVM Poly	0.7345679012345679	0s
	Gaussian	0.7345679012345679	1s
	Artificial Neural Network (ANN)	0.9753086566925049	15s
July	Logistic Regression	0.7407407407407407	0s
	SVM Linear		
	SVM RBF	0.7315436241610739	0s
	SVM Poly	0.7315436241610739	0s
	Gaussian	0.8120805369127517	0s
	Artificial Neural Network (ANN)	0.9530201554298401	12s
August	Logistic Regression	0.95625	0s
	SVM Linear	0.96875	1s
	SVM RBF	0.71875	0s
	SVM Poly	0.70625	0s
	Gaussian	0.8625	1s
	Artificial Neural Network (ANN)	0.925000011920929	12s
September	Logistic Regression	0.8898809523809523	1s
	SVM Linear	0.9404761904761905	8s
	SVM RBF	0.6785714285714286	0s
	SVM Poly	0.6785714285714286	0s
	Gaussian	0.8988095238095238	0s
	Artificial Neural Network (ANN)	0.9642857313156128	15s
October	Logistic Regression	0.9367816091954023	5s
	SVM Linear	0.9482758620689655	14s
	SVM RBF	0.6781609195402298	0s
	SVM Poly	0.6781609195402298	1s
	Gaussian	0.9252873563218391	0s
	Artificial Neural Network (ANN)	0.9655172228813171	23s
November	Logistic Regression	0.8898809523809523	0s
	SVM Linear	0.9226190476190477	3s
	SVM RBF	0.7202380952380952	0s
	SVM Poly	0.6726190476190477	0s
	Gaussian	0.7976190476190477	1s
	Artificial Neural Network (ANN)	0.9642857313156128	23s
December	Logistic Regression	0.8620689655172413	0s
	SVM Linear	0.8563218390804598	1s
	SVM RBF	0.6896551724137931	0s
	SVM Poly	0.6781609195402298	0s
	Gaussian	0.8793103448275862	0s
	Artificial Neural Network (ANN)	0.982758641242981	23s

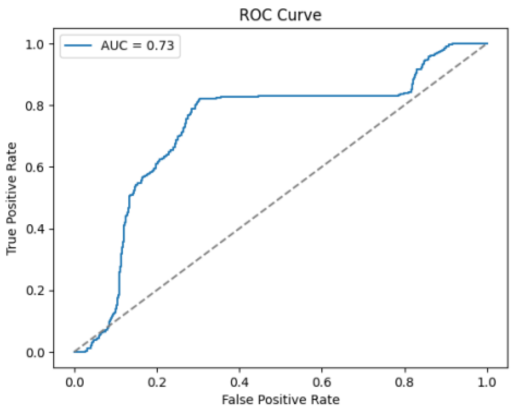
5.COMPARATIVE ANALYSIS

<u>Software done: Artificial Neural Network</u>

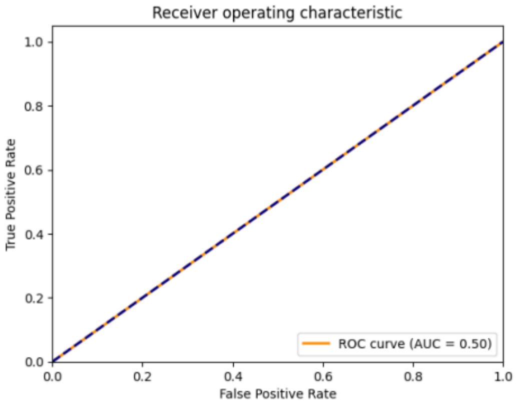
Logistic Regression:



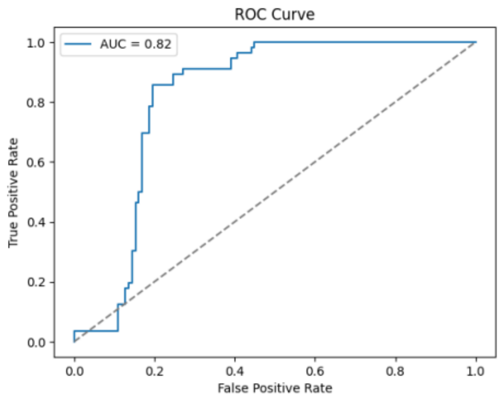
SVM Linear:



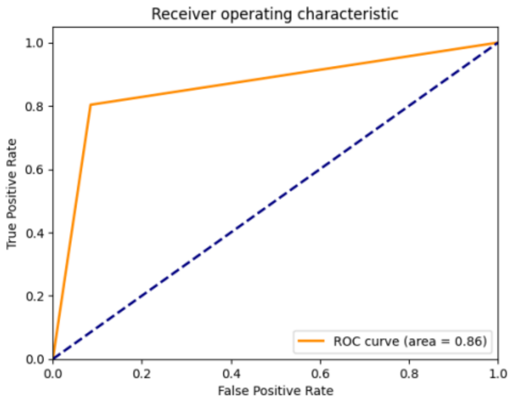
SVM Poly:



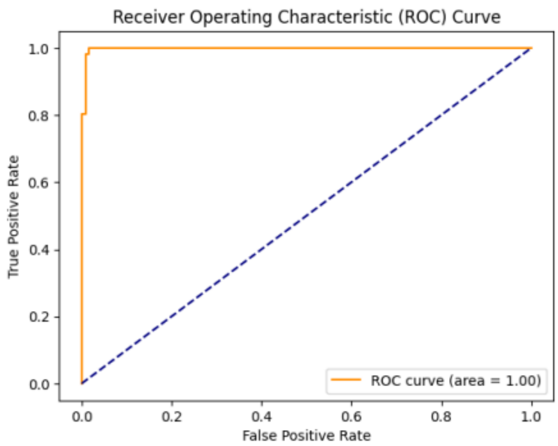
SVM RBF:



GAUSSIAN:



ANN:



Result Tabulation:

Rainy months	*Parameters Considered*	*Non-Rainy months*	*Parameters Considered*
January, February, July, August, September, October	Rain level, illuminance, humidity,	March, April, May, June, November, December	Air-pressure, illuminance, wind velocity

CODE LINK:

[Smart streetlight python file]

6.CONCLUSION

Smart streetlights can be used to enhance public safety and well-being. However, not only it is one of the most draining structures in terms of electricity, but it is also economically straining to local government. Typically, many councils adopt a static or conventional approach to street lighting, this presents many inefficiencies as it does not take into account environmental factors such as light levels and traffic flows. This paper proposed a method, to conserve the electricity that is being utilized to light up the streetlights on Highways, Village roads, streets in urban and rural areas, parks etc. the proposed system monitors the obstacles on the road and controls the street lights. This system is not only to turn ON and OFF the lights and also control the intensity of the streetlights on the basis of the wind velocity, illuminance, air pressure, etc., Thus, this system efficiently conserves the electrical energy for effective street light management. This system uses minimum parameters according to the month. It also uses a smaller number of sensors hence the total cost will be minimum. The system takes less time for execution because of the usage of minimum parameters.

(Difference from other projects):

We used ANN (Artificial Neural Network) Model which provides more accuracy with less execution time compared to other models like SVM, XG Boost, Logistic Regression, etc.

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