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Research Article

Movement Aware Smart Street-lights for Efficient Energy Utilisation

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Abstract: Now a days, energy is an essential resource as the number of energy resources are sinking day by day. Movement Aware Smart Street light is a simple yet powerful concept, which uses transistor as a switch and replaces the manual system. It instantly switches the lights ON when the sunlight goes below the visible region. As energy is the scarcest source, this requires finding innovative ways to use it efficiently. Big cities consume a large amount of electricity and it is required to save energy by operating the street-lights at the time of need. In this paper, an effective method of street-light operation is presented which detects the sun set and sun rise alongside detection of vehicle movement on roads to utilise the energy only when it is required. Furthermore, a system is proposed which reduces energy consumption by replacing manually operated street-lights as they are not switched OFF even the sunlight appears and also switched ON earlier before sunset. The proposed mehtod has saved the municipal utility budget by 35% - 45% through energy saving. This paper also discussed the elimination of manual operation like ON time and OFF time setting and clearly demonstrates the working of transistor in saturation region and cut-off region.

Keywords: Energy Consumption, Intelligent lighting Control System, Automatic Street-lights, Traffic Density, Sensors.

1. INTRODUCTION

The perception of street-lights from rural to urban areas is mounting rapidly. Street-lights offer safe night time journey for passengers. To grant a safe street-lights to road users is a main responsibility of the city administration. One of the critical apprehensions of developing countries is street-lights because of considered significance of social and economic steadiness. Unnecessary lightening wastes important economic resources every year whereas, on the other hand poor lights create insecure situation. One of the noticeable power losses are road lights (energy consumption is one of the most dangerous streets inciting factors and is also one of the largest energy expenditure) and with the help of advcane technology, 35-45% of the cost of municipal utility budget can be saved. Civilization indexes of any society are development of the transportation facilities. Highways, roads, and streets are the main component of the transportation model which needs to be properly illuminated for proper visibility. Automation systems preference is on manual mode as it reduces unused energy consumption. The energy-saving automated systems play an important role in making daily life opportune for consumers from deck ventilators to washing machines and many other different applications. Above all, road lights play a vital role and have a significant role in lighting which provides security during the night. During the night all the street-lights are ON but at day time if, the lights are ON it is wastage of energy and resources. On normal days street-lights operation requires adequate amount of energy. Energy being a precious resource must be saved and it can be as simple as turning the lights OFF when its not needed. Traditional energy sources like coal, petroleum, hydro-electric power and natural gases are limited energy sources that need to be consumed smartly. In this regard, the intelligent lighting control system reduces the cost of street lighting up to 70% and

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increase the capacity of the equipment. Traditional lighting was restricted to only two options and is also not effective for this type of operation because the loss of energy due to continuous working to the maximum voltage and the wastage of energy resources. Automation in any industry can increase the efficiency and same goes for street-lights. By manual operation of street-lights, if we turn ON a light it will remain in the ON state for a straight 13 hours on average despite the scenario on the road whether there is any traffic or pedestrian movement or not. By transforming the manual operation to automate we can save an adequate amount of energy. In smart street-light system, the natural light intensity is measured and accordingly the street-lights are turned ON/OFF. Movement on the road is detected by the system which will accordingly keep the lights operational [1-3]. Movement aware smart street-light and properly design mechanism can reduce the cost of street-lights. Implementation of movement aware smart street-light helps to reduce utilization of power, and efficiently consumption of renewable resources for the applications related to street-lights and signals for traffic. The primary goal is to reduce energy usage when cars are not moving on the highway. Lights turned on when cars are on the road and turned off otherwise. So, the system provides a solution for energy savings. In this paper, movement aware smart street-light is proposed and observed that 70% of the energy can be saved as compared to other automatic street-lights and manually controlled systems.

1.1 Literature Review

Due to high energy consumption by street-lights several research based systems are proposed to reduce the amount of energy consumed by street-lights and use them efficiently.

S. Suganya *et al.* [1] have suggested street-light operation by sensing of car motion. It is a system that utilizes the LED technology. The proposed method automatically regulates the street-light operation. K.Santha Sheela *et al.* [2] proposed an algorithm in which street-lights operates according to luminosity and is self-adjustable to different seasons. Prathib Kumar *et al.* [3] studied street lighting scheme, the research was based on the movement of vehicles. It automatically controls the street-lights according to pedestrians and vehicle movement on roads. P. Caroline Cynthia1 et al [4] proposed an automated street-lights control system that detects the movement of objects and vehicles in the streets and accordingly operates the street-light system. The proposed scheme ultimately saves the energy to light-up the system for more hours and increase the lifetime too. K M Harshitha *et al.* [5] proposes a system in which the street-lights glow with maximum intensity during traffic movements and dims the light when there is no movement. The proposed system also identifies the fault location if occurred. Mohd Azaz *et al.* [6] proposed a vehicle detection model which uses laser sensors to detect the vehicle and automatically operate the street-lights by reducing the power consumption in low traffic or zero traffic scenario. A study in [7] designed a system that is based on movement detection and sun rays to operate the street-lights. It avoids the manual operation to control the street-lights. The proposed system is based on Aurdino which used light detection resistor and an infrared sensor. The energy is saved by turning the lights to dim in night hours and it turns to glowing state when it detects the vehicle movement.

Researchers in [8] proposed a microcontroller based system that controls the LED based street-lights. The system glows the street-lights with 5 different levels according to traffic intensity and resultantly saving the 77-85% of energy. Study in [9] developed an automatic system to switch ON/OFF the street-lights intelligently. It uses light sensors that detects the sun rise and sun set times according to geographical area and adjust the brightness of street-lights accordingly. The system saves the energy by operating street-lights intelligently and making the life time of lights longer. Baburajan, S *et al.* [10] proposes a model for street-lights that replaces the conventional lamps with LEDs and a method is introduced to control these LEDs automatically via motion detectors at the same time the operation of LEDs can also be controlled with a mobile app. The faulty lamps can be traced via the mobile app. The battery is charged using solar energy during daytime and provide electricity at night. Y. M. Jagadeesh *et al.* [11] uses infrared sensors to sense the traffic intensity on a road and uses a microcontroller to automatically adjust the street-lights intensity according to the traffic density. The proposed model in [12] uses two sensors LDR and vehicle video sensors. The LDR

adjusts the intensity of the light according to solar activity and vehicle video detectors sense the area for any movement of vehicle in the low light area and based on the value of these sensors the street light operation is performed intelligently by saving energy and providing street light wherever needed. An IoT based system was proposed in [13] which smartly detects the sun light and operates the street-lights . The system can monitor any suspicious activity. The proposed system is linked online with the web to control the operation remotely. In [14] authors propose a solution to timely controls the street-lights and utilize them efficiently to save the energy consumption. The proposed models consider certain factors like sun rise and set timing, 24 hours lightening conditions and weather conditions like dusty, raining or cloudy. The system design is based on nanowatt technology and it uses LED and light sensors. The model in [15] uses photoelectric sensors and light sensors to control the street-lights automatically and save the energy by operating the street-lights relative to sun light and movement in streets.

A smart street lightening project [16] proposed the automatic street-lights. The study proves that the proposed model can save up-to 45% of the energy. In [17], a method to save energy used by manual street-light control system was proposed which uses low cost and efficient components. The system was transformed to automated which controls the light intensity during high and low traffic and detects the solar rays to turn ON and OFF the street-lights. [18] proposes a system to control the street-lights using sensors network and Zigbee and GPRS technology. The street-lights are adjusted according to surrounding lightening condition and efficiently operated to save the energy. Zain Mumtaz et al in [19] and Somnath Rakshit et al in [20] also proposed a street-light controlling system which is based on Aurdino to sense the sun movement and detects the traffic intensity to control the street-lights. The study in [19] also proposes a system which count the number of objects passed the road.

S. Ganesh Moorthi [21] discussed about "Automatic street-light control by detecting vehicles movement". The author has used two types of sensors "IR and LDR sensors [21]" to automate the street-lights. Surrounding of passage and pedestrians is sensed by the sensors. The author has discussed about the lights on highway at night are ON for vehicles at the same time much of the energy is wasted when there is no vehicle or pedestrian. The paper discussed about that the lights needed to be ON at utter night fall. This approach wastes energy. Automatic Street-lights work as key solution to save energy. The paper aimed to detect the movement of vehicles on road to turn ON and to turn OFF the lights when desired to accumulate the energy [21]. Khalid Masood [22] discussed about "Automatic street-light intensity control and road safety module using embedded system "which aimed to develop a safer way for roads by using intelligent traffic street-light system. Based on the movement of vehicles automatic street-light

Table 1. Literature Review

Paper title	Cost	Energy consumption	Techniques used	Year
Street-lights that glows on detecting vehicles movement using sensors [1]	50% Reduction	High	Microcontroller based	2014
Automatic street-lights control based on vehicles detection using Arduino for power saving applications [4]	70% Reduction of fund budget	High	Arduino based	2017
Automatic streetlight control and fault detection [5]	50% Reduction	High	Microcontroller	2017
Arduino based solar street lighting [17]	Minimum	Average	Arduino, solar based	2018
Residential areas streetlights intelligent monitoring management [18]	Low cost	High	ZigBee and GPRS	2017
Automatic streetlights that glows on by detecting objects during night [19]	Low cost	50%	Arduino based	2018
Piezoelectric Transducer and Arduino Based Wirelessly Controlled Energy-Saving Scheme for Street-lights [20]	70% Reduction	Low	Arduino	2019

control is enabled to reduce the power consumption [22] during the hour of inadequate road usage by controlling the light intensity. All the literature available has used some techniques for making the street-light system automated and improving the energy efficiency by utilizing it smartly. Furthermore, the table1 gives a brief comparison between different schemes to control the street-lights smartly. The Table 1 presents the techniques used with comparison to reduce the cost.

2. MATERIALS AND METHODS

The street lighting automatic control system operates on a 12-volt DC current source. The automatic street-light control unit has a photoconductor that changes its resistance to the light range, which turns the lamp ON or OFF using the transistor as a switch. Based on light, a photovoltaic device was used as a transformer to convert photovoltaic energy into electrical energy. Figure 1 and 2 shows the circuit diagrams of the hardware circuit. In the proposed model IR sensor, LDR (Light Detection Resistor) and Aurdino UNO are used. The LDR senses the light intensity in the environment and sends its value to Aurdino which will decide to switch ON/OFF the street-lights according to the value detected. The IR sensor is used to detect the movement in the streets by emitting infrared rays. In the case of motion detection, IR sensors will trigger the street-light and it will turn ON otherwise, they will remain in OFF state. Figure 3-5 shows the detection of vehicle movement and ultimately turning the respective area street-light while the other lights remains off.

The central idea of the circuit is that the change in voltage falls through the resistor which depends on the lighting in the dark or the dark changes the transistor between the broken area or the saturated zone and turns off or lights up the LED indicator as we know the LDR during the time the resistance today is low, so the voltage at the inverted input is higher than the voltage at the inverted input and then the output at pin6 is low and thus the transistor goes to the cutting case which means the LED or the lamp will not glow. These outputs are sent from the LDR to an Arduino controller that specifies this reading time whether day or day if it is detected at night time from the control unit that checks the senor output if infrared sensors are detected and then the LEDs running are still out. We use six IR sensors sequentially when the vehicle approaches from the beginning, the first light is on, and when the first light is turned on, it will be automatically stopped and the operation is done by the second IR sensor and all other devices one by one. By this system, we can save a lot of energy without any manpower.

Inputs in the street lighting system are LDR and photoelectric sensors, after dark, the light sensor will activate the system, be ready to detect anything by infrared sensors, on the road to turn on the street lamps. Lamps will be used as street lighting in this paper. In this section, each circle designed will be discussed. First, LDR and RV1 form one arm of the bridge, while R1-R2 is the other arm. These weapons can be considered as potential separators, with the R1-R2 arm applying a fixed half-supply voltage to the inverted inputs of the amp, and with the LDR-RV1 being applied to a variable voltage at the centre of the terminal. In use, the RV1 is adjusted so that the LDR-

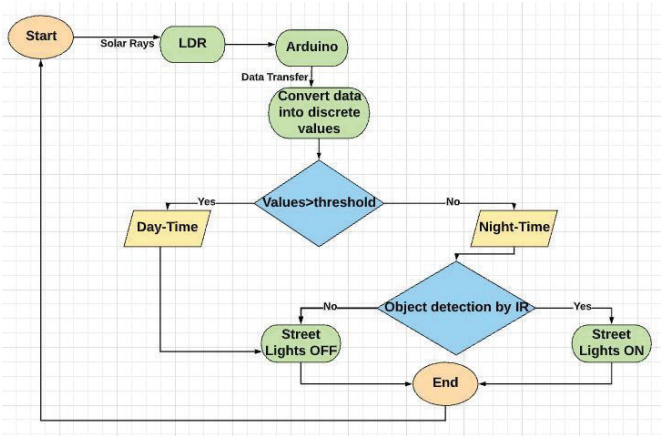

Fig. 1. Model Flow Chart

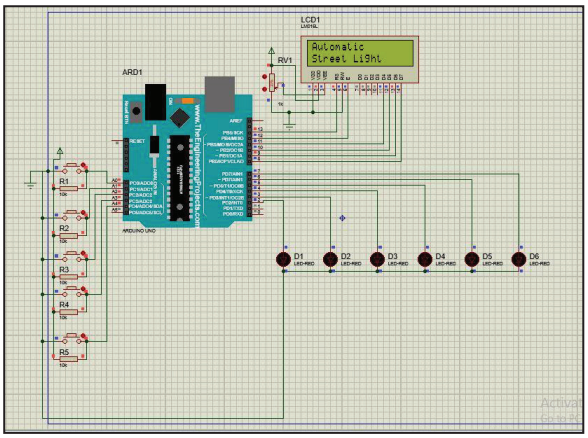

Fig. 2. Proteus simulation design

RV1 is slightly higher than the R1-R2, with the light intensity increasing to the desired trigger arm. In this case, the amp output turns to negative saturation, thus pushing the relay through Q1 and the R3-R4 bias resistors decreasing the intensity of mathematical methods and techniques of improvement in engineering [12]. Below this level, the output of the op amp goes to positive saturation. The circuit is very sensitive, so that it can detect changes in the light level so small that it cannot be seen by the human eye. The circuit can be adjusted to function as a dark active transformer accurately either by inverting the inverted and inverted reference amperes or by transferring RV1 and LDR. Furthermore, the circle reset is used to place Arduino in a known condition. Normally, when you reset Arduino, execution starts from address 0 of program memory. Also, the oscillator circuit was used to supply Arduino with an hour, so Arduino could implement a program using six IR sensors in this paper. Its function is to sense the target that pass across the street, at the same time giving a signal to Arduino to turn on the lamp. The idea of saving energy, where the system is designed to light the lamp at night only and only if anything is passing through the street. Except that the light will be off. The first infrared sensor is used to automatically activate the first Arduino lighting column when any object passes in front of it. Meanwhile, the second option electric sensor turns the second light column on and off after a short delay when the object passes in front of it. The third sensor will activate the third light column when the object passes in front of it, and the second light column will turn off after a little delay.

Fig. 3. Vehicle Detection in Start

Fig. 4. Vehicle Detection in the Middle

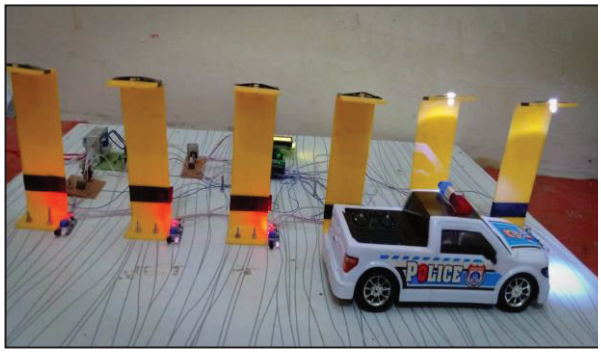

Fig. 5. Vehicle Detection in the End

3. RESULTS AND SIMULATION

The proposed scheme was simulated using MATLAB and targeted results were achieved. The hardware model designed detected the vehicle up-to the mark and lights are illuminated at every stage (start, middle and end). Random traffic is modelled for the proposed scheme to check the efficiency with respect to the traffic intensity in different hours. Figure 6, shows the traffic scheme for the simulation model, busy and low traffic can be seen. Figure 7 shows the energy consumption with respect to modelled traffic intensity scheme. The Figure 8 shows the time and traffic relation of a road. It shows that, in some hours the traffic is more on the road shown in the graphs peak values and in some time traffic is minimum or less traffic on road that is also shown in the graph down values. Graph

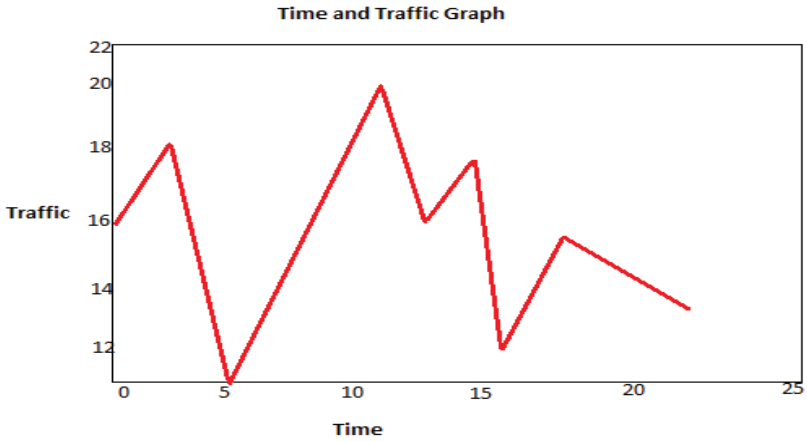

Fig. 6. Traffic Intensity throughout the Day

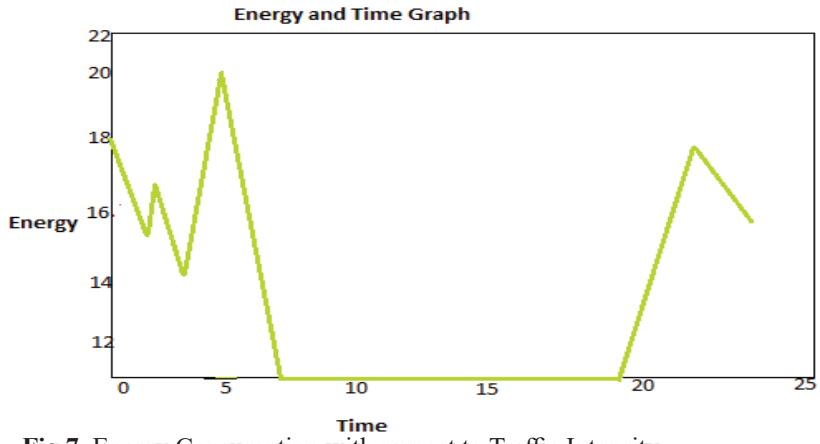

Fig.7. Energy Consumption with respect to Traffic Intensity

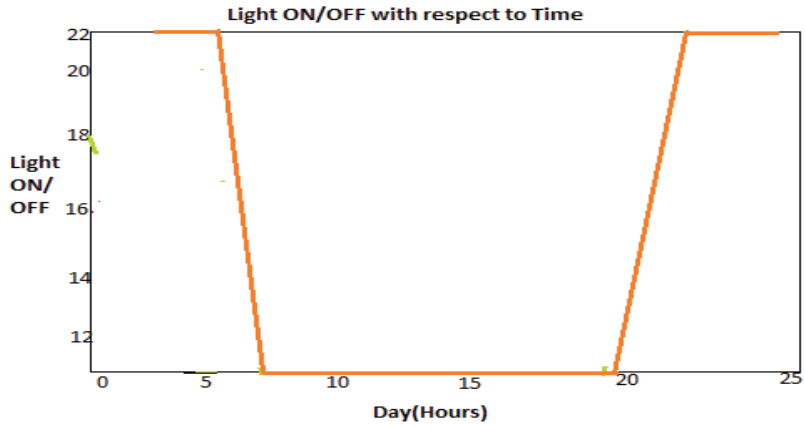

Fig.8. ON/OFF lights

Figure 7 shows the energy consumption at the time due to traffic.If the traffic is more the energy consumption will be greater at night time and if the traffic is minimum the energy consumption will alos be minimum. At the day time there will be no energy consumption because this system is LDR based. The threshold value is selected to control the lights. Smart algorithm designed in MATLAB is considered traffic density in different situations of the day and refers to the system to provide automatic control. Figure 8 shows the duration of lights are ON at day time and OFF at night time. The system is based on LDR, therefore, at day time all the lights are OFF as shown in Figure 9. The traffic intensity on the road at night time is also shown in Figure 10. At night time all the lights will

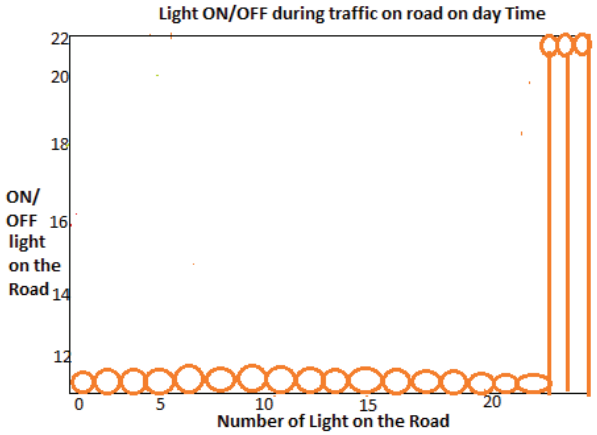

Fig. 9. Day Time Graph

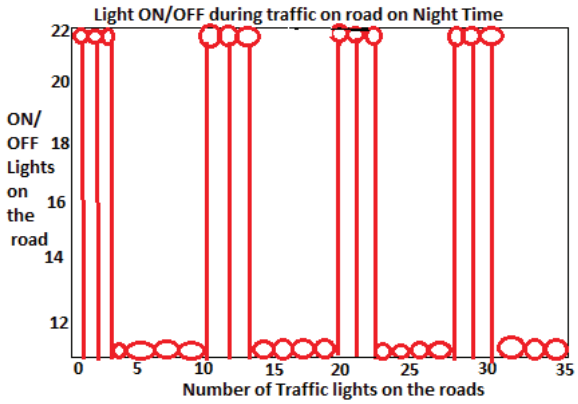

Fig. 10. Night Time Graph

turns ON. The high values shows the ON lights when the sensors detscts vehicles or other objects and the zera values shows that the lights are OFF because of no detection on sensors.

LDR is used in the proposed model due to which it is traffic aware and always turns street-lights ON whenever it senses any movement or traffic in the street. Another thing that should be observed that the energy is consumed only in dark hours when sun light is not present which shows that our model is smart enough to operate only in the scenario when natural light is not available.

4. DISCUSSION & CONCLUSION

The LDR light intensity and traffic density control module in developing countries will be more cost effective and security compared to complex lighting control systems. The intelligent lighting control system applied in this work is easy to use and can increase power. According to natural light intensity and IR sensors, used to detect the movement in the streets, the lights remain turned OFF for no movement and if it detects movement it will turn ON the lights. In this prototype, street-lights were successfully controlled by a microcontroller through commands from the console. In addition, the disadvantages of the street lighting system have been overcome by using the timer, where the system depends on the photoelectric sensor. The proposed model is smart enough to achieve the energy efficiency by controlling the street-lights smartly. LDR is used in the model to detect the solar rays through which the model will turn OFF/ ON the street-lights. The system under experiment can be used for short as well as long roads.

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