IJCSE International Journal of Computer Sciences and Engineering Open Access
Research Paper Vol.-6, Issue-5, May 2018 E-ISSN: 2347-2693

Energy Efficient Smart Street Light System

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Available online at: www.ijcseonline.org

Accepted: 16/May/2018, Published: 31/May/2018

Abstract— Conservation of energy is an important aspect that is to be considered while planning a resource utilizing project. Vitality proficient lighting framework is a stage towards an asset productive and helps to maintain sustainable growth. If pedestrians or automobiles, summarized as active traffic elements, are not situated near street lights, it is not vitality proficient to turn them on when the light intensity is higher in surrounding conditions. The basic plan is to switch on street lights only when they are required to the traffic elements thus fulfilling the need of illumination at dark places. The system also allows monitoring of the lights thus checking their proper functioning at all times. A mechanized lighting or Light on Demand (LoD) framework is required to execute moving light. By automating the street light system, light naturally switches on/off in halfway street areas. A considerable amount of energy is conserved by the system and proper illumination of street lights has been achieved with this designed model.

Keywords— Light on demand, Short Message Service, Light Emitting Diode, Iterative Dichotomiser.

I. INTRODUCTION

Technology used presently has been a work of tremendous amount of research and its effect on real world. The present system comprises of LED lamps that are developing rapidly across the world. LED based street lighting is an important part of the facilities provided in a smart city. Though there is rapid increase in the use of such lights, the system remains independent that makes it difficult to maintain their efficiency and to monitor the working. The system requires manual checkup that is a difficult job and can be made easier by the proposed system.

A network between street lights can help to sync their working according to the requirement of the pedestrian or vehicle (Traffic element).The WIFI technology can provide a suitable network for the LED street light system for controlling and monitoring the working of lights. This technology has multiple features like low powered, quick transfer, high coverage area, reliable communication, sufficient network capacity, secure connection and many more. It has powerful functioning over the network that connects through wirelessly.

We often come across situations where the street light is required but is kind of not present and in other conditions it remains lit even when not required. Suppose in summer, the street lights get switched on yet the sunlight is present while in fog or rainy conditions the light remains switched OFF thus resulting in wastage of energy and improper use of resource.

The main aim behind the proposed framework is to provide energy efficiency by switching on the street light when required. It works by checking the surrounding light, if surrounding gets dark it glows the light and keeps it glowing until required. System also checks the movement of pedestrian near the light to switch the corresponding light ON. In particular, the energy efficient smart street lighting is the combination of LED, sensors and Wi-Fi module that offers adaptable brightening as per ambient conditions and mechanized fault detection.

II. RELATED WORK

Innovation utilized today is a consequence of gigantic measure of research work and understanding the genuine conditions in true. To beat the conditions all of headway in the field of innovation noted by the researcher is useful for future work and investigation of these advancements can be an inspiration for future examinations.

In the year 2010, Yue Wu, Changhong Shi and Xianghong Zhang proposed the framework which can understand the programmed timing control, by pre-introduced time to control street lamps switch and at last to control the street light time. Based on the benefits of the consistent control and the optical control, another advance street smart controller is composed, with double capacities including timing control and programme photoelectric control. [3]

In the year 2013, Fabio Leccese proposed another advance intelligent street lighting framework which coordinates new innovations available on the market to offer higher efficiency and significant reserve funds. The framework manages to inform the remote focal in case of a lamp post fault so that a restore operation would be rapidly possible. [4]

In the year 2011, V. V. S. and V. A. G proposed a framework which controls and monitors the road lights utilizing a GSM module and a microcontroller circuit which is being managed by sending a SMS from mobile. Proposed framework is a power conserving mechanism for street lights using remote communication. It turns out most solid and time effective approach to switch ON/OFF street-lights. The framework may like be utilized for home security and automation. [6]

In the year 2014, E. Nefedov et al discusses an energy efficient street lighting structure that meets required rules for rural streets and is actualized with the IEC 61499 distributed function block architecture. The fundamental goal behind this framework was to propose and coordinate automation architecture for traffic based streetlight control with a simulation of street activity. [7]

In the year 2009, X. Long, R. Liao, and J. Zhou derived the plan of the 9LEDM from the thermal, photometric, power electronics techniques to meet the utilization of street lighting. An adaptive driver with two frequencies to upgrade the life time and simplify the induction treatment has been proposed. [8]

In the year 2008, SungKwan Cho, Vijay Dhingra described a street lighting control framework based on LonWorks power line correspondence on demand market. The basic expectation is that streetlights are an extensive consumer of energy for urban communities, using up to 40 percent of a city's energy budget. If every city introduced, proposed framework, this would go a long way to diminishing energy utilization worldwide and subsequently reducing CO2 levels. [10]

In the year 2008, R. Caponetto, G. Dongola, L. Fortuna, N. Riscica and D. Zufacchi presented remote control equipment for observing and dealing a street lighting framework is. This framework permits the remote monitoring of the status of the lights and their wear, and the control of the lamp utilization. In fact it permits to turn on/off each lamp, to reduce power utilization switching on/off the ALBATROS device by remote control. [11]

In the year 2014, M. Magno, T. Polonelli, L. Benini, E. Popovici, proposed a low cost, remote,

Easy and simple to introduce, adaptable, and smart LED lighting framework to consequently moify the light intensity to conserve energy and keeping up user satisfaction. The paper introduces the plan and usage of the proposed framework in a real world deployment. [14]

III. METHODOLOGY

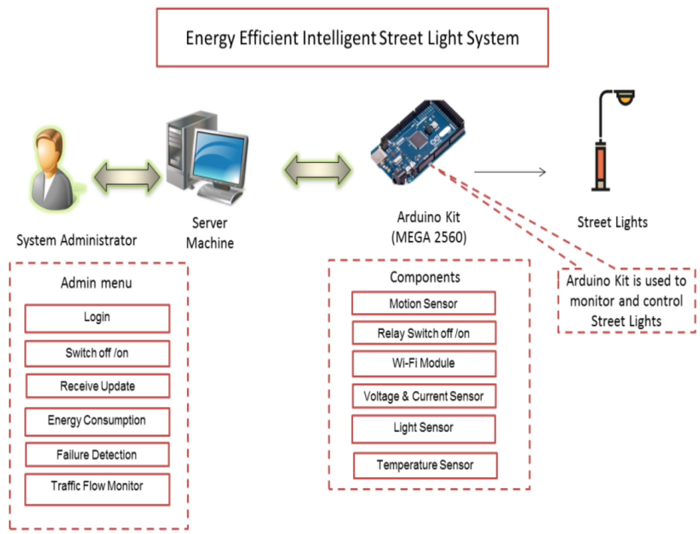

Figure 1: System Architecture

A framework for street lightning system is proposed in our work that is based on light and motion detection considering which the street lights are switched on or off depending upon the situation.

Street lights can be switched on/off using a relay switch. The switch is controlled by Arduino board that has memory to store and send data. The board also has a built-in Wi-Fi connection which is required to make communication with the server machine. Street lights are to be shrewdly switched ON or OFF considering the recognized light and traffic yet admin has a choice to manually start or stop the light.

Each street light is configured with a voltage and current sensor, we measure the amount of current and voltage flowing though the light. Sensors also indicate if there is any failure in the light. Energy consumed is also logged on the server.

Motion sensor is used to count number of vehicles passing by every hour. This value is also synchronized with server to analyze street light operations for next week. If there is no current flowing through the current sensor and light status is ON then we consider the light in failed state and report it to server. In case of failure of light, we can check the log of current sensor. Light sensor is used to detect day and night conditions for ON or OFF operations and it is in synchronization with the motion sensor.

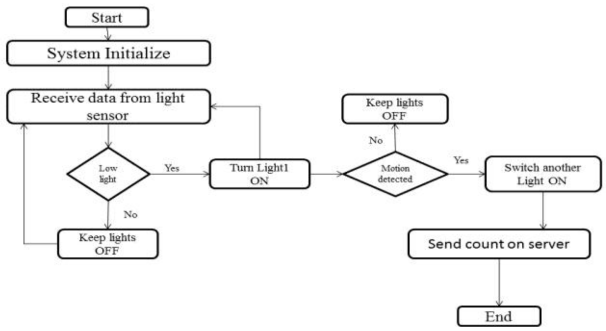

Figure 2: Work flow of the System

Administrator is provided with a login id and password that allows unaltered access to the server data for data analysis and monitoring. Following data parameters are used for analysis purpose- voltage sensor reading, current senor reading, current_status_light1, current_status_light2, vehicle-count, time and date. The user interface also shows a graphical view of the data acquired on the server machine.

ALGORITHM USED:

ID 3 ((Iterative Dichotomiser 3) Algorithm
ID3 builds a decision tree from a fixed set of examples. The final tree is utilized to categorize future model. The time at which a person/vehicle is crossing a particular Streetlight is stored in database to take the decision for switching on/off the light at that particular time for next subsequent days.
The decision node is a feature check through every branch being a probable significance of the feature. ID3 make use of information gain i.e. save the timing information at which light is switch ON/OFF. From the resulting conclusion it chooses which feature goes into a verdict node to make next day decision.

The proposed algorithm constructs a decision tree from a fixed set of illustrations. The subsequent tree is utilized to classify the unseen informational set.

1) Set up the particular categorization time at which street light on/off.
2) Calculate categorization Entropy.
3) For every time feature in R, compute Information Gain with the help of sorting feature.
4) Choose features having maximum gain i.e. at which time light is on/off in maximum time to be the subsequent Node in the tree
5) Remove Node Attribute, which occur very less number of times creating table RS.
6) Replicate steps 3-5 up to all features have been utilized so that decision is to make switching ON/OFF of the light.

ENTROPY:

$$H(S) = \sum_{x \in X} -p(x) \log_2 p(x)$$

Where,

- $S -$ The current (data) set for which entropy is being calculated (changes every iteration of the ID3 algorithm)
- $X -$ Set of classes
- $p(x) -$ The proportion of the number of elements

  in class to the number of elements in set.

When $H(S) = 0$, the set $S -$ is perfectly classified (i.e. all elements in $S -$ are of the same class).

In ID3, entropy is calculated for each remaining attribute. The attribute with the **smallest** entropy is used to split the set **S** on this iteration. The higher the entropy, the higher the potential to improve the classification here.

$$IG(A, S) = H(S) - \sum_{t \in T} p(t) H(t)$$

Where,

- $H(S) -$ Entropy of set S
- $T -$ The subsets created from splitting set S by attribute A such that $S = \bigcup_{t \in T} t$
- $p(t) -$ The proportion of the number of elements in t to the number of elements in set $S -$
- $H(t) -$ Entropy of subset t

IV. Results And Discussion

The table below contains the data send by the kit to the server. This data includes Kit Id, voltage and current measurements, vehicle count at particular time instance.
The light status is also present and is initialized as L1and L2.

Table 1: Data displayed on database

Resultset 1

id	kitmacid	voltage	current	vehiclecount	l1	l2	udate	ip
6	92_207_127_177_51_4_	230	36.48	0	1	0	2018-03-24 19:...	192.168.43.207
7	92_207_127_177_51_4_	230	12.88	0	1	0	2018-03-24 19:...	192.168.43.207
8	92_207_127_177_51_4_	230	12.88	0	1	0	2018-03-24 19:...	192.168.43.207
9	92_207_127_177_51_4_	230	10.73	0	1	0	2018-03-24 19:...	192.168.43.207
10	92_207_127_177_51_4_	230	17.17	0	1	0	2018-03-24 19:...	192.168.43.207
11	92_207_127_177_51_4_	230	12.88	0	1	0	2018-03-24 19:...	192.168.43.207
12	92_207_127_177_51_4_	230	17.17	0	1	0	2018-03-24 19:...	192.168.43.207
13	92_207_127_177_51_4_	230	12.88	0	1	0	2018-03-24 19:...	192.168.43.207
14	92_207_127_177_51_4_	230	17.17	0	1	0	2018-03-24 19:...	192.168.43.207
15	92_207_127_177_51_4_	230	17.17	0	1	0	2018-03-24 19:...	192.168.43.207
16	92_207_127_177_51_4_	230	17.17	0	1	0	2018-03-24 19:...	192.168.43.207
17	92_207_127_177_51_4_	230	17.17	0	1	0	2018-03-24 19:...	192.168.43.207
18	92_207_127_177_51_4_	230	17.17	0	1	0	2018-03-24 19:...	192.168.43.207
19	92_207_127_177_51_4_	230	15.02	0	1	0	2018-03-24 19:...	192.168.43.207
20	92_207_127_177_51_4_	230	12.88	0	1	0	2018-03-24 19:...	192.168.43.207
21	92_207_127_177_51_4_	230	25.75	1	1	0	2018-03-24 19:...	192.168.43.207
22	92_207_127_177_51_4_	230	15.02	1	1	1	2018-03-24 19:...	192.168.43.207
23	92_207_127_177_51_4_	230	15.02	1	1	1	2018-03-24 19:...	192.168.43.207
24	92_207_127_177_51_4_	230	15.02	1	1	1	2018-03-24 19:...	192.168.43.207
25	92_207_127_177_51_4_	230	19.31	1	1	0	2018-03-24 19:...	192.168.43.207
26	92_207_127_177_51_4_	230	15.02	1	1	0	2018-03-24 19:...	192.168.43.207
27	92_207_127_177_51_4_	230	17.17	1	1	0	2018-03-24 19:...	192.168.43.207
28	92_207_127_177_51_4_	230	25.75	2	1	1	2018-03-24 19:...	192.168.43.207
29	92_207_127_177_51_4_	230	15.02	2	1	1	2018-03-24 19:...	192.168.43.207
30	92_207_127_177_51_4_	230	17.17	2	1	1	2018-03-24 19:...	192.168.43.207
31	92_207_127_177_51_4_	230	15.02	2	1	1	2018-03-24 19:...	192.168.43.207
32	92_207_127_177_51_4_	230	17.17	2	1	1	2018-03-24 19:...	192.168.43.207

Figure3 shows the actual setup that includes Arduino kit which has built-in Wi-Fi module and is connected to other components via pins for collective working of the system. Light and motion sensors have green and red LED's lit respectively. 16x2 display shows system status and server update information. Android application helps in system monitoring on a handheld device, user interface is shown in Figure4.

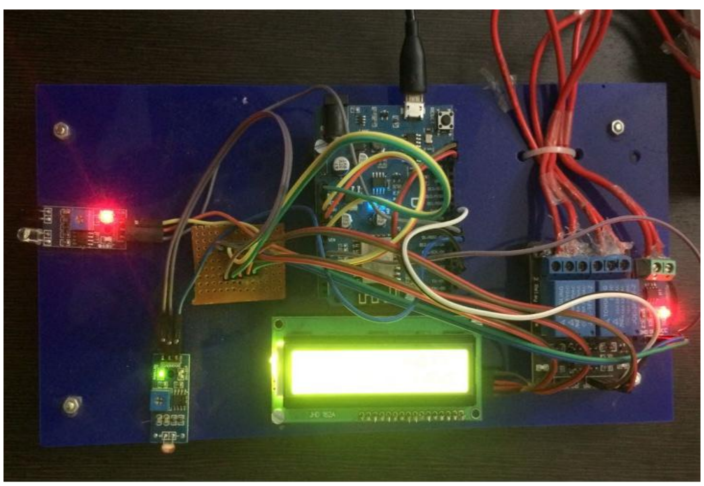

Figure 3: Actual system

The application allows the administrator to login and perform operations like add new member, turn light2 ON and OFF, check vehicle count and the graph displayed shows energy consumption at different time instances.

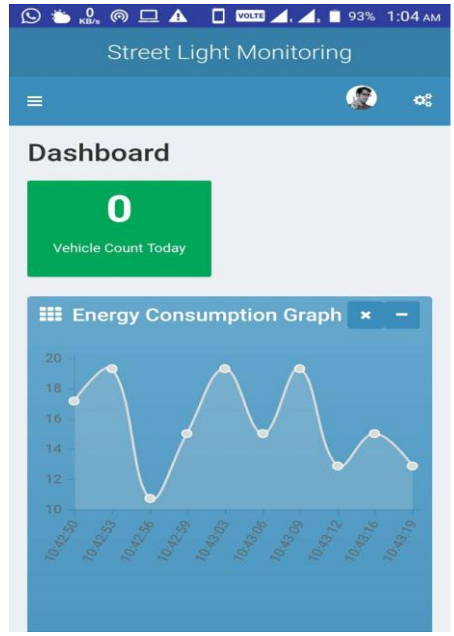

Figure 4: Android Application

In this result analysis, total vehicle count is maintained as per the observations, the data is accordingly sent to the Arduino kit. By using this information accordingly the lights are turned on and off. A light sensor is present which observes the surrounding light intensity and then the lights are turned on and off according to the observations i.e. low surrounding light results in illumination of street lights while street lights remain OFF if there is enough light in surrounding.

V. CONCLUSION AND FUTURE SCOPE

To overcome faults in existing system, and reduce human efforts the framework has been proposed which will detect the surrounding light and motion in the vicinity and switch on the lights automatically. Also the faults can be easily detected in the system without the manual detection due to the power consumption calculation method. In future, the system can be made fully automatic for the administrator. The faults which occur in the system could be easily detected and automatically resolved at the initial level. Also the temperature detection could be included in the existing system to make the system more advanced according to the environment changes.

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