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Smart Street Lighting System to Overcome Energy Crises in Pakistan

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Smart Street Lighting System to Overcome Energy Crises in Pakistan

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***Abstract*— Deficiency in the energy sector is the major problem of Pakistan which also obstructs economic growth as well. Pakistan is suffering from major energy crises since 2005. Pakistan is trapped by low energy and high consumption of energy. The versatility of technologies like Arduino, cloud storage and the availability of everywhere wireless internet connection intelligent street lightning system becomes reality. The conventional Street lightening system remains online most of the night without any purpose and in the result large amount of power is wasted. The key idea that we want to achieve is "Energy on demand" i.e. will be available whenever needed. In order to accomplish our goal, smart street lightning system (LS) a feasible solution is purposed that will use an Arduino and its different shields based on motion-based actuation system to automate the street lightening system. The purposed framework ISLS has great potential to revolutionize the street lightening and to accomplish the demand for flexible street lightening system.**

Keywords*— *IoT, Street Lighting System, Automation, Arduino, IoT Development.

I. INTRODUCTION

One of the prime concerns is to improve the traditional street lightening system [10]. One of the major and important concepts of Pakistan is electricity. [1] [7]. In Pakistan, a high amount of electricity is consumed due to the continuous operation of street lighting all over the night. The roads and streets are illuminated constantly for more than 10 hours. Pakistan's Electricity Consumption: In June 2017 Street Light data was reported at 484.000 Giga watt-hours (GWh). Street Light data is updated yearly, from June 1992 to 2017 the average is as 382.500 GWh reported by Ministry of Finance (Figure: 1).

Here we present the idea to reduce the electricity consumption and wastage of energy in Pakistan. This idea gives a concept to make streetlights to detect real-time traffic and change its state (On/Off) automatically. We can attain the following advantages [5] [2].

i. Reducing CO2 pollution and light emission

ii. Improve general well-being

iii. Energy Savings

Our design of a smart street lighting system reduces the wastage of electric energy and will also reduce the investments of Pakistan in energy production.

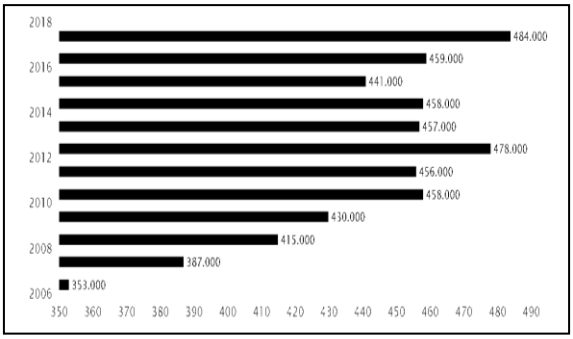


Fig.1. Streetlight: Electricity Consumption (Source: www.ceicdata.com | Ministry of Finance)

The total sections of this paper are represented as the next section presents related work, the 3rd section describes the working of the system, and the 4th section explains limitation, whereas the 5th section concludes the paper and 6th section presents the future work.

II. RELATED WORK

In public sectors, the lightening systems that are designed and implemented are still based on old technology and getting the advantage of latest technology [8]. Several schemes were proposed including wireless and wired medium to control street lightening system, however the wireless network gained popularity [9]. Due to environmental issues like global warming and climate change energy-saving solutions gained popularity in recent years [3]. Hundreds of researchers are working on the automation of the street lightening system. Their prime focus is on the automatic switching of light as nightfall and some focus on motion detection to change the state of light. Both scenarios have some failings. Automating switching uses a transistor as a switch to switch "ON and OFF" the streetlight system automatically. The light will switch ON as it detects there is no sunlight and will automatically switch OFF as Sunlight detected, by using a sensor called LDR (Light

Dependent Resistor) it just acts as human eyes. Motion Sensor Street lighting control system will automatically activate when a car or pedestrian is noticed in the area. If there is no activity in the area, the light is automatically adjusted to an optimized minimum light level. Any kind of moving object can trigger the PIR sensor type. Idea and design represented by this paper to overcome these flaws and will be able to give the true energy-saving system for streetlights [4]. At present the streetlamps of most of the urban areas are handled manually. This mechanism is in-efficient and waste of manpower [6].

III. PROPOSED METHODOLOGY

System design is given by this paper as it will capture the image of the road and trace human, LTV, HTV and then change the state of lights. This system cannot detect day or night because the system must perform for the whole day, and it will consume high energy for the whole day. For the development of this system, we use Arduino [5], internet card, camera, and cloud server.

A. Why Arduino

Arduino (Figure: 2) is an open-source microcontroller that is easy to program, erased and could be reprogrammed when required. Arduino is the best way to build devices for hobbyists, students, and researchers. Arduino's important property is that it interacts with the environment using sensors and actuators and also has an ability to send and receive information over the internet using Arduino shields (Arduino Ethernet Shield (Figure: 3), Arduino Wireless Shield, Arduino Motor Driver Shield) and Adafruit Camera [11].

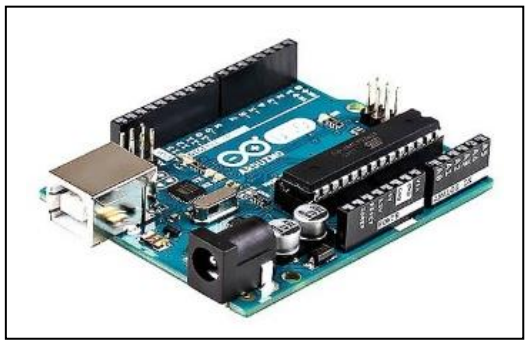


Fig. 2. Arduino [11]

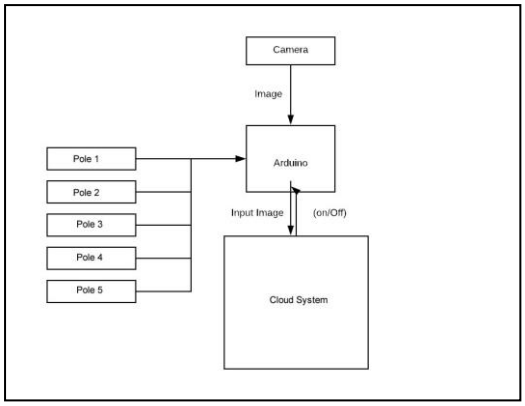
Fig. 3. Arduino Ethernet Shield [11]

B. Working

It is a residential street with two lanes and sidewalks in both directions. The road width is 7 meters (m) (3.5 m for each lane) and the sidewalk width is 1.5 m. The total width of a street is measured as 10 m having length of 2 km. Lamp posts are positioned on one side of the road with a spacing of 25 m. The mounting height of light sources is 8m. The maximum beam pattern's length is 13 m, in both directions, and the width is 10 m. The light source is an LED luminary chosen in accordance with the distance parameters. Attached to each light source there is a node.

Suppose road has a width of r and there are two roads with width r and it will be turn out into 2*r. Roads with r width have lights poles on one side with one-sided face which cover whole road and road with 2*r has poles on center of road with opposite-facing each side cover r of road. We discuss the set of poles of one face. Poles have distance of 50 m between them that limit us to use one system per set of three poles. The system is mounted on middle pole and capture image when motion is detected and send image to server for process. The server will examine the image and figure out objects such as humans and vehicles. As it detects object of interest then the state of light will be (Switched ON) on all of three poles.

C. Block Diagram



D. Algorithm

1) *Take an image from the camera and send to the server.*
2) *If a server detects human, car or bike cycle turn ON the lights.*
3) *Otherwise, turn OFF all the lights.*
4) *Repeat step 1*

E. Flow Charts

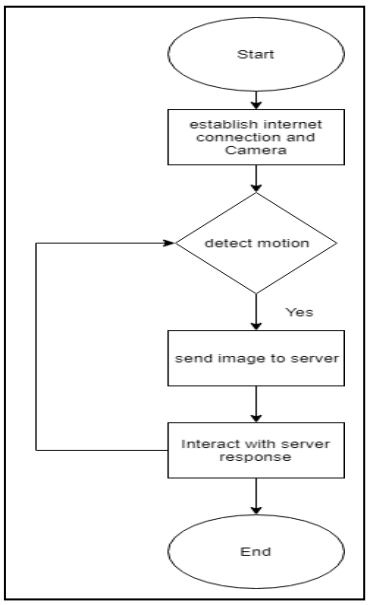
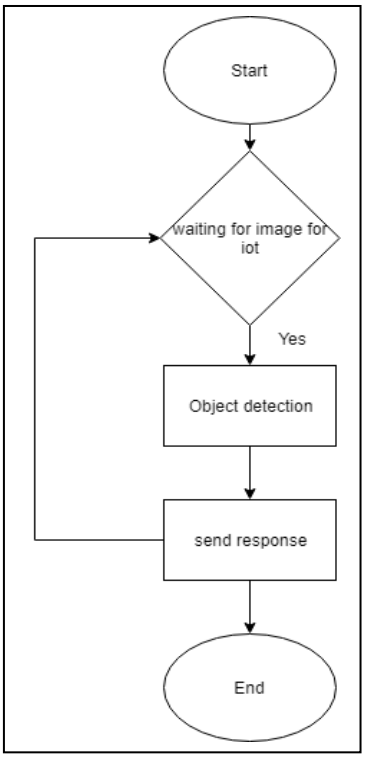


Fig.4. Poled Device



F. Scenario Cases

The model represented in this paper is that each light contains two lights one for left side and the other for right side. One light takes xW (Watt) and one pole consumes 2 * xW (Watt). This system consumes yW, total consumption of one unit of system is given by 10 * (energy consumed by light) + energy consumed by system. Energy consumed by cloud server does not include because one severs control lights of at least one city. These are three cases that could occur throughout the whole night are described below.

*1) **Best Case:** For whole night no car or human pass from road, therefore, no need to turn on the light, in the result total energy consumption by light is 0W and total consumption is 10 * 0 + yW = yW and we saved 10*xW - yW as without system it will be 10 * xW.*

*2) **Average Case:** Car or human pass from road for a half night therefore light will remains on for half night and total energy consumption by light is x/2W and total consumption is 10 * (x/2) +yW = (5*x+y) W and we saved (5*x+y) W - yW as without system it will be (5*x+y) W*

*3) **Worst Case:** Car or human pass from the road for whole night in the resulting light will remain on for whole night and total energy consumption by light is xW and total consumption is 10 * xW + yW and we unable to save energy but we consumed yW more.*

*4) **Code Snippets:** This section has code snippets to build the energy-saving system for street lights. On Arduino Uno pin number 2 and 3 is connected to camera's Tx and Rx respectively and set the image size to 640x480 (bigger image takes longer time) [12].*

- Software Serial camera connection = Software Serial (2, 3);
- Adafruit_VC0706 cam = Adafruit_VC0706 (& camera connection);
- Cam.set Image Size (VC0706_640x480);

The next step is to configure an Ethernet card with Arduino to communicate with the server [13] and begin serial communication.

- byte Ethernet MAC Address[] = ETHERNET_SHIELD_MAC;
- Ethernet Client client;
- Serial. Begin (9600);

Binary data of image very long and it's not possible to send over the internet so, we need to convert binary Image to base64 (image encoding system for web) [16] to prepare it to send to the server: [15].

- uint16_t jpglen = cam. Frame Length();
- while (jpglen> 0) {
  // read 32 bytes at a time;
- uint8_t *buffer;
- uint8_t bytes To Read = min(32, jpglen); // change 32 to 64 for a speedup but may not work with all setups!

- buffer = cam.read Picture (bytes To Read);
- int encoded String Length = base64_enc_len(bytesToRead);
- char encoded StringBuffer[encodedStringLength];
- encodedStringLength = base64_encode(encodedStringBuffer, (char *)buffer, bytesToRead);
- jpglen -= bytesToRead;
- }
- String ImageFileContentsValue = String(encodedStringBuffer);

The scalability of server is very important as we know the purposed system must wake against motion and then object detection such as human so, we only send data to serve when motion has occurred [12].

Setup:
- cam.setMotionDetect(true);

Update:
- if (cam.motionDetected()) {
- cam.setMotionDetect(false);
- cam.resumeVideo();
- cam.setMotionDetect(true);
- }

Finally, we must send Data to webserver to process it using Ethernet system [13]. Servers process the given image and result an output that has status change information such as or off sate of lights. Data is sent by getting rest requests [14] to respond output of on or off state of lights.

- client.print("GET / Get_data.php?");
- client.print("img=");
- client.print(ImageFileContentsValue);
- client.println(" HTTP/1.1");
- client.print("Host: ");
- client.println(server)
- client.println("Connection: close");
- client.println();
- client.println();
- char status = client.read(); // on or off lights
- client.stop();

IV. LIMITATION

The system given by this paper required a high-speed internet connection and a server to process data. On slow speed internet this system cannot work efficiently. At last we assumed that there is no delay between any sensors.

V. CONCLUSION

The system proposed a framework to save energy. But first, we must investigate where we must implement it as there are some roads that have traffic for the whole night. This system is best implemented for the roads with average or no traffic. Results show that life of a lamp will be increased to 53% and energy saved by the mechanism will reach up to 65%.

VI. FUTURE WORK

In future poles can also communicate with each other to add scalability to the server and reduce internet usage. This proposed system could also be implemented in parks, public places and housing societies. By using GSM technology, we can also monitor all the poles on our smart devices and distant places.

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