Weather Adaptive Smart Street lighting with face recognition

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***Abstract*—**This paper demonstrates the energy consumption through Smart street light system and detection of theft through face recognition. In Smart street light system the light is turned ON when there is vehicle movement and OFF when there is no movement of vehicle. The intensity of light is controlled by IR sensor and LDR sensor is used for the detection of weather. The system uses camera for security purpose. The concept is Automatic Theft detection i.e., the detection of criminals is done through the surveillance camera and it automatically sense the message through the GSM. The face recognition method consists of two steps namely, Face detection in which the Viola-Jones algorithm is used for finding the theft face among the training faces and the Eigen-Face method is used for face recognition. The system has been successfully designed for Automatic energy saving and for security purpose.

Keywords-Arduino mega ,IR sensor, LDR sensor, LED, LCD, Viola-Jones algorithm.

1. INTRODUCTION

As the world is moving towards the smart energy management and theft detection, the system will require changes not only in the way energy is supplied, but in the way energy is efficiently consumed and the theft is clearly detected. Streets, roads and highways has to be adequately illuminated so that a sufficient visibility is guaranteed to the safety of the people travelling on the streets. However, these streets are lightened for nearly 13 hours daily even when there is so need for the lights. The need for the security is fulfilled by using surveillance cameras in conjunctions with the face recognition system. They can be taken even without user"s knowledge and further can be used for security based applications like criminal detection and face recognition. When a test image is given to a system it is classified and compared with the stored database and finally the theft is detected. A number of studies in recent research work has focused on automatic ON/OFF of the street lights and automatic theft detection using surveillance cameras. The proposed work for this system is briefly discussed below.

2. PROPOSED METHOD:

The Arduino Mega uses AT Mega microcontroller. The microcontroller converts the sensor"s output to usable parameters. Arduino mega has totally 8 pins, two output pins namely power supply and 6 input pins namely (D4, D5, D6, D7, RS and ENABLE). The first 4 pins are DATA pins and the last 2 pins are CONTROL pins. The six input pins are connected to 2, 3, 4, 5, 6, 7 pins of the Arduino mega controller. The 3 LED lights are connected to 22, 24, 26 pins of the Arduino mega controller. All the 3 pins are commonly grounded. The three IR sensors are connected to 8, 9, 10 pins of the Arduino and the LDR sensors are connected to 11, 12, 13 pins of the Arduino. The 3 IR sensors detects the presence of the vehicle and the three LED"s started to glow for a particular IR sensor while the 3 LDR sensors turns ON/OFF according to the intensity of the light serves as an input to the Arduino.The LCD is used for displaying the ON/OFF of the LED lights and shows whether the theft is detected or not detected. The RS (Register select) pin of the TTL board is connected to the RS pin of the Arduino and this acts as transmitter. Face detection and face recognition are the two steps followed for the detection of theft. Face detection is done by Viola-Jones algorithm which involves four steps 1.Haar-Feature, 2.Integral Image, 3.Adaboost, 4.cascade classifiers. The face recognition is achieved by the Principle Component Analysis (PCA) using Eigen faces. The python software which is used for theft detection transfers the information to the Arduino. The Arduino collects the data and sends the information as message to the Mobile (GSM).

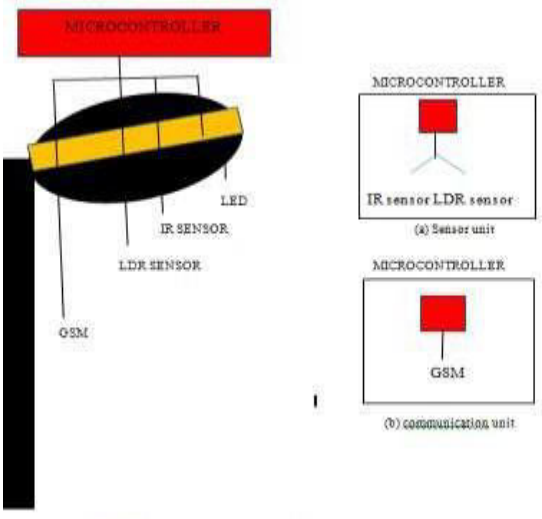


Figure 1. PICTORIAL REPRESENTATION OF SYSTEM

3.A) Abbreviations and Acronyms

Tx- Transmitter, LDR- Light Dependent Resistor, IR- Infrared Sensor, GSM- Global System for Mobile Communication, Open CV- Open source computer vision, LED- Light Emitting Diode.

B) Units

V-volt, mA- milli ampere, MHz- Mega Hertz, KB- Kilobyte.

4. COMPONENTS USED:

4.1 ARDUINO MEGA:

The Mega2560 is a microcontroller board based on the ATmega2560. It has 54 digital input/output pins (of which 15 can be used as PWM outputs), 16 analog inputs, 4 UARTs (hardware serial ports), a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC to DC adapter or battery to get started. The Mega 2560 board is compatible with most shields designed for the Uno and the former boards Duemilanove or Diecimila.

TECHNICAL SPECIFICATION

Microcontroller	AT mega 2560
Operating Voltage	5V
Input Voltage	7-12V
Input Voltage(recommended)	6-20V
Digital I/O Pins	54(of which 15 provide PWM output)
Analog Input Pins	16
DC Current per I/O Pin	20 mA
DC Current for 3.3V Pin	50 mA
Flash Memory	256 KB of which 8KB used by bootloader
SRAM	8 KB
EEPROM	4 KB
Clock Speed	16 MHz
LED_BUILTIN	13
Length	101.52 mm
Width	53.3 mm
Weight	37 g

PROGRAMMING OF ARDUINO

The Mega 2560 board can be programmed with the Arduino Software (IDE).The ATmega2560 on the Mega 2560 comes preprogrammed with a boot loader that allows us to upload new code to it without the use of an external hardware programmer. It communicates using the original STK500 protocol. We can also bypass the boot loader and program the microcontroller through the ICSP (In-Circuit Serial Programming) header using Arduino ISP.

The ATmega16U2 (or 8U2 in the rev1 and rev2 boards) firmware source code is available in the Arduino repository. The ATmega16U2/8U2 is loaded with a DFU boot loader, which can be activated by:

- On Rev1 boards: connecting the solder jumper on the back of the board and then resetting the 8U2.
- On Rev2 or later boards: there is a resistor that pulls the 8U2/16U2 HWB line to ground, making it easier to put into DFU mode.

POWER FOR ARDUINO

The Mega 2560 can be powered via the USB connection or with an external power supply. The power source is selected automatically. External (non-USB) power can come either from an AC-to-DC adapter (wall-wart) or battery. The adapter can be connected by plugging a 2.1mm center-positive plug into the board's power jack. Leads from a battery can be inserted in the GND and V in pin headers of the POWER connector. The board can operate on an external supply of 6 to 20 volts. If supplied with less than 7V, however, the 5V pin may supply less than five volts and the board may become unstable. If using more than 12V, the voltage regulator may overheat and damage the board. The recommended range is 7 to 12 volts

The power pins are as follows:

- V in : The input voltage to the board when it is using an external power source (as opposed to 5 volts from the USB connection or other regulated power source). We can supply voltage through this pin, or, if supplying voltage via the power jack, access it through this pin.

- 5V: This pin outputs a regulated 5V from the regulator on the board. The board can be supplied with power either from the DC power jack (7 - 12V), the USB connector (5V), or the VIN pin of the board (7-12V). Supplying voltage via the 5Vor 3.3V pins bypasses the regulator, and can damage our board.
- 3V3: A 3.3 volt supply is generated by the on-board regulator. Maximum current drawn is 50 mA.
- GND: Ground pins.
- IOREF: This pin on the board provides the voltage reference with which the

microcontroller operates. A properly configured shield can read the IOREF pin voltage and select the appropriate power source or enable voltage translators on the outputs for working with the 5V or 3.3V.

IR SENSOR:

Introduction to IR sensor

An infrared sensor is an electronic device, that emits in order to sense some aspects of the surroundings. An IR sensor can measure the heat of an object as well as detects the motion. The emitter is simply an IR LED (Light Emitting Diode) and the detector is simply an IR photodiode which is sensitive to IR light of the same wavelength as that emitted by the IR LED. When IR light falls on the photodiode, the resistances and these output voltages, change in proportion to the magnitude of the IR light received.

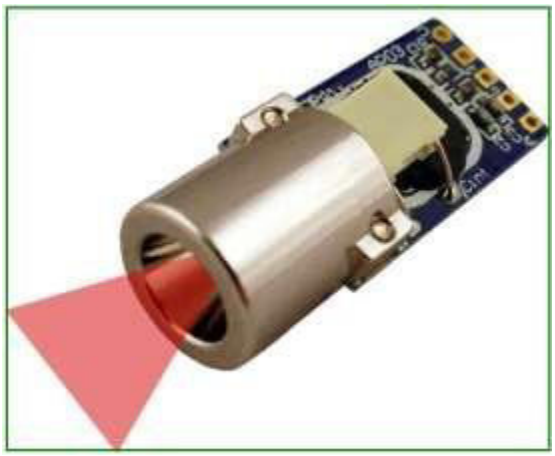


Figure.2.IR Sensor

This circuit comprises of the following components

- LM358 IC 2 IR transmitter and receiver pair
- Resistors of the range of kilo ohms.
- Variable resistors.
- LED (Light Emitting Diode).

In this project the three IR sensors are connected to the pins of the Arduino and the presence of vehicle is detected by the IR sensors.

LDR SENSOR:

An **LDR** is a component that has a (variable) resistance that changes with the light intensity that

falls upon it. This allows them to be used in light sensing circuits.

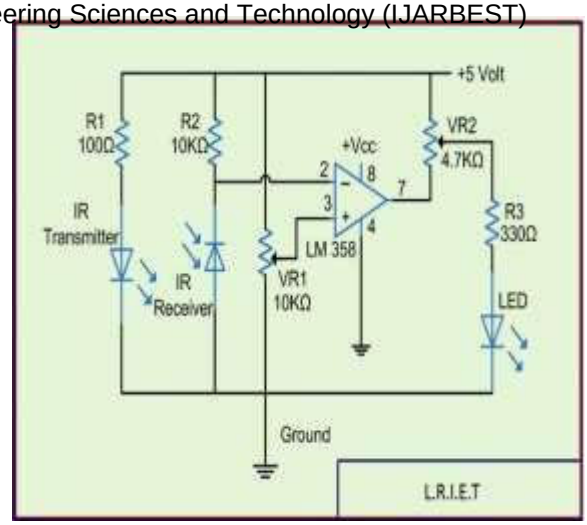


Figure.3.Circuit Diagram of IR Sensor

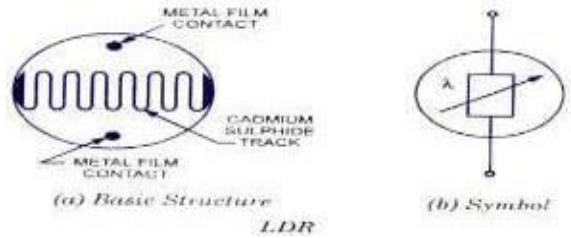


Figure 4. LDR

The snake like track shown below is the Cadmium Sulphide (CdS) film which also passes through the sides. On the top and bottom are metal films which are connected to the terminal leads. It is designed in such a way as to provide maximum possible contact area with the two metal films. The structure is housed in a clear plastic or resin case, to provide free access to external light.

WORKING OF LDR SENSOR

A LDR works on the principle of photoconductivity. Photoconductivity is an optical phenomenon in which the material conductivity reduces when light is absorbed by the material. When light falls *i.e* when the photons fall on the device, the electrons in the valence band of the semiconductor material are excited to the conduction band. These photons in the incident light should have energy greater then the band gap of the semiconductor material to make the electron jump from the valence band to the conduction band. In this study the 3 LDR sensors turns ON/OFF based on the intensity of the light and gives input to the Arduino.

LED:

A LED (Light Emitting Diode) is a p-n junction diode, which emits light when activated. When we apply voltage across its leads, electrons are able to recombine with holes within the LED, releasing energy in the form of photons which gives the light.

Hence, it is a two-lead semiconductor light source. Light emitting diodes represents our lighting system and the amount of light emitted by it is directly related to the amount of light in the environment that is when outside light is less than the light given by LEDS is more and when outside light is more than the light given by LEDS is less.

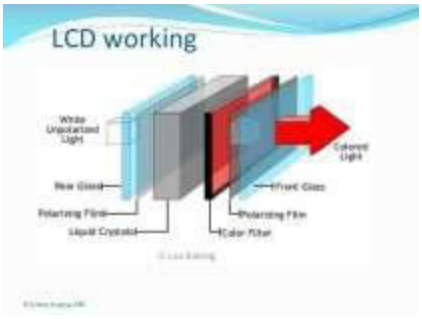
Figure 5. Red, green and blue LEDs

WORKING PRINCIPLE

When a suitable voltage is applied to the leads, electrons are able to recombine with electron holes within the device, releasing energy in the form of photons. This effect is called electroluminescence, and the color of the light (corresponding to the energy of the photon) is determined by the energy band gap of the semiconductor. In this study the LED light turns ON when vehicle is identified and turns OFF when vehicle is not identified.

LCD:

A liquid crystal display uses a liquid crystal to produce a visible image. It has two polarized panel filters and electrodes. Light is projected from a lens on a layer of liquid crystal. This combination of colored light with the gray scale image of the crystal forms the collared image. LCD is used for displaying the ON/OFF of the LED light to find, theft is detected or not detected.



FACE DETECTION

Face detection is a computer technology being used in a variety of applications that identifies human faces in digital images. Face detection also refers to the psychological process by which humans locate and attend to faces in a visual scene. The algorithm that I used here is viola- jones algorithm.

VIOLA-JONES ALGORITHM

- The characteristics of Viola-Jones algorithm which make it a good detection algorithm are:
- Robust – very high detection rate.
- Real time – For practical application.
- Face detection only (not recognition) – The goal is to distinguish faces from non-faces (detection is the first step in the recognition process).

FOUR STAGES OF THE VIOLA-JONES ALGORITHM:

- Haar Feature Selection
- Creating An Integral Image
- Ada Boost Training
- Cascading Classifiers

FEATURES:

Three kinds of simple features are used.

- Two-Rectangles features
- Three-Rectangles features
- Four-Rectangles features

HAAR – FEATURE:

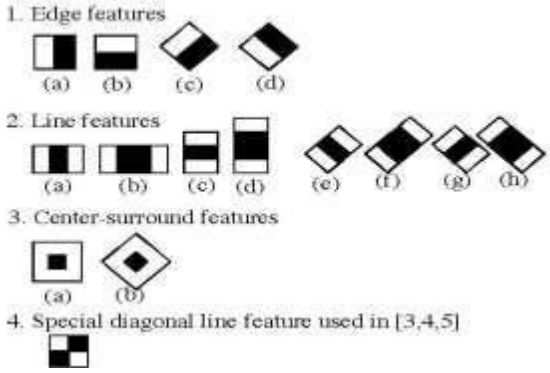


Figure 6. Haar Feature.

HAAR FEATURES

HAAR FEATURES:-

- **Haar-like** features are used in object recognition
- RGB pixel values at each and every pixel of image.
- Viola and Jones adapted -haar wavelets and developed Haar-like features.
- A Haar-like feature considers adjacent rectangular regions,sums up pixel intensities ,calculates the difference between these sums to catagorize subsections of an image.
- Observes the region of the eyes is darker than the region of the cheeks.

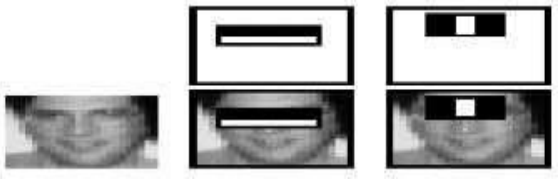


Figure 8. Haar Feature.

CALCULATION OF HAAR-FEATURE:

- The black and white area denotes the pixel intensities.
- 0:white
- 1:black
- Delta=dark-white
- Delta=(SUM OF THE BLACK REGION-SUM OF THE WHITE REGION)
- Delta=(AVERAGE OF THE BLACK REGION-AVERAGE OF THE WHITE REGION)
- Delta for ideal haar feature is 1
- Delta for the image: 0.74-0.18=0.56
- The closer the value of 1,the more likely we have found a Haar-feature.

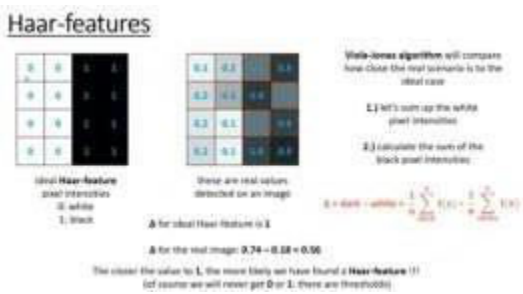


Figure.9 Haar Feature

FINDING THE RANDOM VALUES FOR AN IMAGE:

0	0	1	1
0	0	1	1
0	0	1	1
0	0	1	1

0.1	0.2	0.6	0.8
0.2	0.3	0.8	0.6
0.2	0.1	0.6	0.8
0.2	0.1	0.8	0.9

Figure 10. Random value for an image.

INTEGRAL IMAGE

- In an integral image the value at pixel (x,y) is the sum of pixels above and to the left of

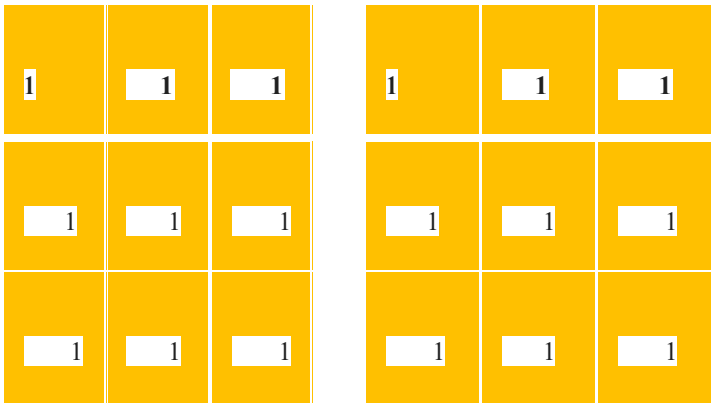


Figure.11 Original Image Internal Image

VIOLA-JONES ALGORITHM

HAAR – FEATURE|INTEGRAL IMAGE|**ADABOOST**|CASCADING CLASSIFIER

- "Adaptive" boost-Machine learning meta-algorithm
- Constructs a "strong" classifier as a linear combination of weighted simple "weak" classifiers
- The system will tell you it is „+" or „-".For example,Face or non-Face.
- Major contribution of the Viola and Jones detector.

- Summation of pixel values of the original image.
- Whole image converted to integral image and a window buffer used to scan the entire image.

4. DISCUSSION

The developments of our proposed work are briefly described,

- Low cost: The basic advantage of LED street lighting system is energy efficient than conventional street lighting technology such as sodium lamps. The LED lights automatically turns ON/OFF due to the intensity of light in the atmosphere. The cost is also less due to the GSM technology.
- Self–detection: The best event is that the LED light turns ON automatically in the presence of the vehicle using IR sensor and Turns OFF when there is no vehicle movement. The LDR sensor automatically adapts to the weather conditions. The theft detection is also automatically done using the surveillance camera. The automatic operation is the advantage of this system.
- Construction: Safer traffic due to increased visibility of hazards. Environmental impacts can be measurable due to reduced energy consumption. There is a great safety of the public due to developed lighting system. Public safety is provided through cameras. There is an advantage of Mobile broadband connectivity.

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