Smart Streets

Introduction

Technological evolution has become a common scenario over the past decade due to massive investment in research, innovation and education which is making our lives easier [1]. Automation is one of those technological advancements which is making every aspect of our life efficient starting from our home to industry development. Our streets can also be made smart by using these modern tools which can save a decent amount of energy, power and human labour. Automatic street light control and speed measurement of vehicles are some of the techniques which can make our streets intelligent and help in building a smart city.

Application Area

The Smart Street System comprises a few simple functionalities to make roads safer and more efficient. In our proposed model we plan to automate street lamps with the help of LDRs. Based on the light intensity of the incident light ray, the street lamp automatically turns ON when it senses a gloomy ambience and turns OFF when bright.

To further enhance the efficiency of street lamps, the lamps will be equipped with motion sensors to detect any moving objects within the proximity of the street lamp. In case of any pedestrians or vehicles passing by the lamp, it will glow, otherwise, it will remain off. This will reduce down the energy consumption, lowering its maintenance cost and light pollution alongside.

A street won't be deemed smart if it is not safe for the pedestrians and the cars plying on it. While many factors can cause road accidents, speed will be a leading contender. To ensure road safety our system keeps speed in check by penalising vehicles exceeding the speed limit. A couple of IR transmitter-receiver module sensors set 5 meters apart will detect the time interval of any object passing through them. When the vehicle obstructs the first IR transmitter-receiver module sensor, a timer starts. The timer stops when the vehicle obstructs the second sensor. The time measured is the time taken for the vehicle to cover the 5 meter distance. If the speed measured exceeds the speed limit, the Arducam OV5642 Camera Module takes a snap of the number plate and sends it over to the Traffic Control Department.

Technology and Tools

Sensors:

1. LDR
2. IR Sensor
3. Microwave Motion Sensor

I / O devices:

1. ON/OFF Switch
2. Street Lamp (5 watt LED light)
3. Camera

Integrated circuit (IC)

1. Arduino UNO

Software

1. Arduino IDE
2. Proteus Simulator

Others

1. Bread board
2. Lead-acid 12V Battery

Programming Language

We will use Arduino IDE to write, compile, and upload the code which will be written in C++. For designing the circuit, we will use Proteus.

Working Mechanism of Sensors

LDR - When light falls on an LDR, its resistance decreases, increasing its conductivity. The energy of the photons of the incident light must be enough to excite the electrons from the valence band to the conduction band. The reverse happens when the intensity of light is low. Meaning conductivity decreases, increasing its resistance.

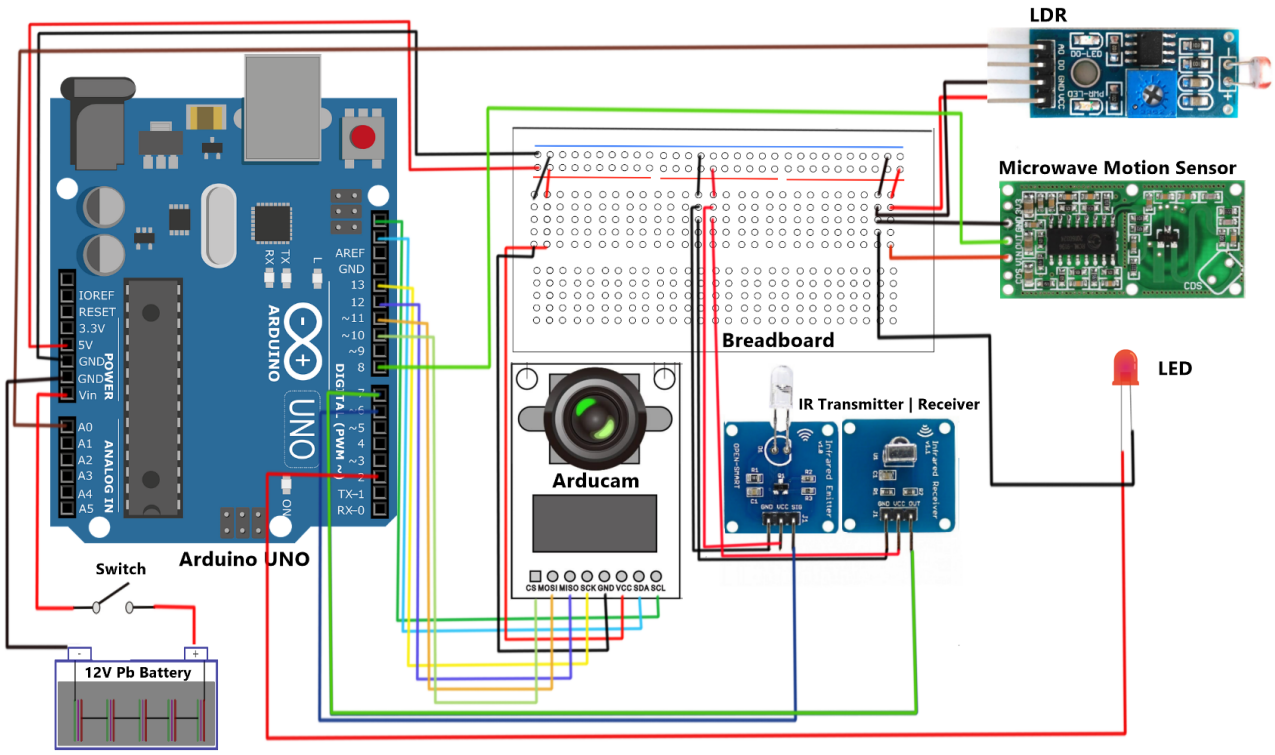
Microwave Motion Sensor - A microwave motion sensor uses electro-magnetic radiation. It emits microwaves which are then reflected back to the receiver. The receiver analyzes the waves

that are bounced back, and if it is the same waves bounced back, the receiver outputs a logical low signal. Now, any moving object can hit the emitted waves, and alter its properties. The microwave sensor's receiver is able to detect any alteration in the reflected waves, and accordingly outputs a logical high signal. Because of the way that microwave motion sensors work, they can be either more sensitive or less sensitive and this can identify very minute changes or be calibrated to require large scale movement to avoid false positives. It is completely safe to use and can be used large areas.[3]

Infrared TX-RX sensor - Infrared sensor is an electronic device that emits infrared rays to detect certain aspects of the environment. It is composed of pyroelectric metal; pyroelectric can be described as the ability of certain materials to generate a temporary voltage when they are heated or cooled. This device consists of two parts i)Transmitter and ii) Receiver. Transmitter is used to transmit or emit the infrared rays and the receiver is used simply to receive those radiations.Transmitter is often known as IR LED and the receiver as IR Sensor. An infrared sensor can sense motion as well as measure the heat of an object. Almost all of the objects emit some kind of thermal radiation in the infrared spectrum.These are invisible to our eyes but detectable by an infrared camera.The emitter is a simple infrared LED (Light Emitting Diode), and the detector is a simple infrared photo diode that detects infrared light of the same wavelength as the IR LED.

Connection with IC

- The Arduino UNO will be powered by a 12V Lead-acid battery whose positive terminal is connected to the UNO Vin pin, and negative with the GND pin. There is a switch to control this enable/disable.
- For the speeding system, the IR transmitter and receiver are both powered by the UNO 5V pin and grounded by the GND pin. The transmitter module SIG receives signal from UNO pin ~6, and the receiver module OUT sends high or low voltage to UNO pin 7.
- The 5MP Arducam has pin connections according to the following :
  Arducam {SCL, SDA, VCC, GND, SCK, MISO, MOSI, CS} to Arduino UNO {SCL, SDA, 5V, GND, 13. 12. ~11. ~10}
- The LDR is powered by the UNO 5V to LDR Vcc, and GND pin to LDR GND. It sends high or low voltage to UNO pin 8.
- Microwave motion sensor is once again powered by the UNO 5V pin to sensor Vin, and GND pin to sensor GND. The sensor outputs voltage to UNO pin A0.
- The LED positive terminal will be supplied by UNO pin 2, and the negative terminal grounded by UNO GND.
  Note: We are using LED instead of street lamps for prototyping and ease of interfacing with the Arduino UNO microcontroller.



Dataflow from Sensors through ICs to I/O Devices

LDR:

When light falls on the LDR, it sends a low (0) signal to the Arduino through pin 8 indicating that it is day and the LED must be turned off. When LDR can't detect any light, it sends a high (1) signal to pin 8 indicating that the LED should be turned on. Arduino reads the data sent by LDR from Pin 8 and sends necessary output voltage to the LED.

Microwave Motion Sensor :

Microwave Motion Sensor emits microwave signals in a certain area. If there is no object nearby, it bounces back at a fixed time interval. Then it will pass a corresponding analog read signal to Arduino through pin A0 which will indicate an OFF(0) signal. The microcontroller will read the digital signal through the IC and will write on the IC to keep the lights OFF. The LED connected with the microcontroller at pin 2 will get the output signal.

When there is a passerby or a vehicle, the signal will bounce back at a different interval by which the sensor will get a conclusion that there is an object nearby. The sensor will again send a signal to Arduino through A0 pin but this time it will send an ON(1) signal. The microcontroller will read the signal in the same process and will write 1 in output letting the Lamp know that it has to emit light. This only applies for an LDR logical high reading.

However, if LDR gives 0 to Arduino, Arduino won't care whether Motion Sensor gives 0 or 1. It will always give 0 output to the Lamp. When LDR gives 1 and Motion Sensor gives 1, only then the lamp will turn ON.

Truth Table:

LDR	Motion Sensor	LAMP
0	X	OFF
0	X	OFF
1	0	OFF
1	1	ON

Street Lamp:

The Street Lamp (LED) is an output device which shows the status of the microcontroller pins. There are two ways in which the LED can work which area- active high logic and active low logic. In our project the LED will work on active high logic which means when the connecting port of Arduino gives logic high (1) signal, the LED will turn on and when it gives logic low (0), the LED will be turned off. The ON and OFF signal will come from the microcontroller after it reads the data from the LDR Sensor.

In case of controlling the light emittance, the LED will be connected with another pin of Arduino which will determine whether it will emit light or not. When the LED gets ON signal from the microcontroller, it will check whether the second port is 1 or 0. If the second port gives 1, then the LED will emit light. When it is 0, it will turn off. The 1 or 0 signal will be sent by the microcontroller through the interfacing IC after reading inputs from the Motion Sensor.

IR Transmitter - Receiver with Arducam:

The IR transmitter receives a voltage signal (at SIG) from the microcontroller pin ~6. The magnitude of this voltage can be set by the microcontroller as it is sent by a PWM pin. This results in infrared transmission by the emitter, Meanwhile, as the IR receiver module keeps receiving this 28kHz IR transmission, the output sent by the receiver (OUT) to the microcontroller pin 7 remains active high. As soon as the module stops receiving this IR transmission, it outputs an active low signal to the microcontroller. The microcontroller translates this signal as an obstacle blocking the receiver module.

If the microcontroller computes the speed of a vehicle to be above the speed limit, it sends a command to the Arducam to take a snapshot of the moving vehicle. This command is sent through the MOSI line between microcontroller pin ~11 and Arducam pin MOSI. After receiving the command, the Arducam takes the instantaneous snapshot and sends the data to the microcontroller from the Arducam MISO pin connected to the microcontroller pin 12.

Estimated Cost Analysis

Our proposed system is moderately cheap as we are using very few inexpensive sensors and devices. Cost of each component is mentioned below:

1. Arduino UNO - 530 BDT
2. LDR sensor module - 65 BDT
3. HB100 Microwave Sensor Doppler Radar Motion Detector - 620 BDT
4. IR Transmitter Receiver Module Pair (38 KHz) - 595 BDT
5. Arducam OV5642 Camera Module - 3500 BDT
6. ON/OFF switch - 15 BDT
7. Breadboard - 65 BDT
8. Lead-acid 12V - 7Ah battery - 1100 BDT
9. Jumper Wire (10 pcs) - 30 BDT
10. 5 mm Red LED (for prototype purpose) - 5 BDT

The total cost of this entire system will be 6525 BDT. When we connect our device to the Street Lights, we might need some additional devices to connect the arduino with the Street LEDs (minimum cost of a Street 20 Watt LED is 4,500 BDT). So within 12,000 BDT this entire system can be developed in the streets of Dhaka City or in some specific areas to make it a Smart City.

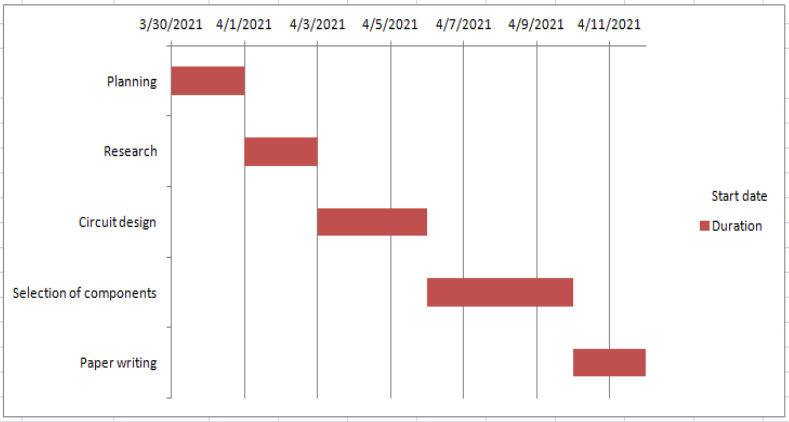
Responsibilities of Each Member

1. Shoummo Ahsan Khandoker(18101218):
    - Overall Planning and Research
    - Connection with IC, Diagram Drawing, Dataflow from Sensors through ICs to I/O Devices (Camera, IR Sensor, Switch).
2. Imam Mohammad Zulkarnain (18101246):
    - Overall Planning and Research
    - Paper Writing: Tools and Technologies (Design and Planning), Application Area, Dataflow from Sensors through ICs to I/O Devices (LDR), Cost Analysis.
3. Jawaril Munshad Abedin (18101058):
    - Overall Planning and Research
    - Paper Writing: Introduction, Programming Language, Dataflow from Sensors through ICs to I/O Devices (Motion Sensor and LED), Responsibilities of Each Member, Conclusion, References (Collecting Articles).
4. Mohd. Rahat Bin Abdullah (17301215):
    - Overall Planning and Research
    - Paper Writing: Working Principle of Sensors(LDR, Motion, IR), Gantt Chart.

[All of the team members worked together and helped each other in each section starting from finalizing the idea to selecting the sensors, analyzing the cost, figuring out the application in real life and building the working principle of the entire system]

Work Plan(Gantt Chart)

Task	Start date	End date	Duration
Planning	3/30/2021	4/1/2021	2
Research	4/1/2021	4/3/2021	2
Circuit design	4/3/2021	4/6/2021	3
Selection of components	4/6/2021	4/10/2021	4
Paper writing	4/10/2021	4/12/2021	2



Conclusion

In order to build a smart city, smart streets can be stated as a crying need. Smart streets are a combination of physical infrastructure, sensors, network and services which can be made at a low to medium cost which can save a massive amount of energy and money in the long run. As a developing country, Bangladesh needs implementation of modern technology and automation in every sector in order to keep up with the developed countries of the world. Our project can help our country in this journey of development by investing low amount of money as we are using cheap products e.g. LDR, IR, Motion Sensors and cheap microprocessors such as Arduino Uno whereas we are saving electricity during midnight [2] which also solves our load shedding problem. By detecting the speed of vehicles, we are able to alert the drivers and passively reduce road accidents which is one of the biggest issues of our country. Moreover, our project can be improvised by adding humidity and temperature sensors with an LCD by which pedestrians can identify the weather condition. This additional feature will make our streets more intelligent to build an intelligent city.

References

[1] Khan, M.K. **(**27 December 2019**).** Technological advancements and 2020. Retrieved from https://link.springer.com/article/10.1007/s11235-019-00647-8

[2] Coxworth, Ben (12 July, 2011). Intelligent street light system uses 80 percent less electricity. Retrieved from https://newatlas.com/motion-sensing-streetlight-system/19199/

[3]Slade, Lauren(September 3, 2020**).**What is a Microwave Motion Detector? Retrieved from https://brinkshome.com/smartcenter/what-is-a-microwave-motion-detector