Automatic Lighting Mechanism on Highways during Midnight

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Abstract—*This paper presents the key points in implementing automatic lighting mechanism on highway roads with the help of moving object detection in urban cities during midnight. The objective of the object detection system will be to detect objects confined in a particular area. The detection system will thus require important information like speed of moving objects, size of objects and number of vehicles on the road. The lighting system is responsible for switching off the lights in a particular area where the object detection monitoring system evaluates to a minimum threshold value. The lighting system will be active 350m to direction of the object moving in a particular direction.*

Keywords—Magnetic Detection, Object Detection, Luminaire Installation, Cost Analysis.

I. INTRODUCTION

Importance of Moving Object Detection Monitoring System is on the upward spiral due to the increase of number of vehicles irrespective of the financial and energy crisis around the globe. Traffic monitoring and object detection plays an important role in helping travelers reach their destination in less time and with minimum usage of resources. The key to light up the roads on a specific road depends upon the number of vehicles approaching the particular area of the highway. Before we move to the idea of switching on the lights in required areas of the highway it is important to first detect the objects that are moving with a particular intensity and speed. Appropriate and adequate lighting mechanisms are essential to ensure roadway safety. With the advancements in lighting technologies, many types of new lighting devices have been developed in recent years. The most prominent technologies for roadway lighting are LED (light emitting diode), induction, and plasma and metal halide (MH) lighting systems. The high pressure sodium (HPS) is the type of light sources adopted in India.

II. OBJECT DETECTION METHODS IN USE

The most commonly used techniques for object detection are through video detection, induction loops and acoustic detection [1, 2]. Induction loop technique is one of the most popular. The inductance of a loop varies frequently from steady state condition due to passing cars. The number of moving vehicles with their respective speeds can be determined by the fluctuations in energy levels. The disadvantage involved with induction loops is the complexity involved with their installation [1, 2]. Also, maintenance of these will require complete shutdown of junction and thus increase traffic.

The video detection system consists of multiple cameras that gather images of the junctions. A special processing unit is responsible for examining the captured data. Specialized software efficiently calculates the size and speed of moving vehicles. This technique provides a real time preview of the junction. The disadvantage involved with the video detection technique is it's unreliability during different weather conditions [3, 4].

In the acoustic detection technique, a set of microphone provides traffic information based on the noise generated by moving vehicles. The disadvantage involved with this technique is the inability of the system to calculate the difference of noise generated by adjacent lanes. Also, natural factors like rain and snow can produce noise and cause trouble [5, 6].

III. MAGNETIC DETECTION AND LIGHTING MECHANISM

Given the drawbacks of all mechanisms mentioned before, the reflection of Earth's magnetic field can be used for object detection. This system will be based upon sensors that will be used to measure the various parameters of the magnetic field in a confined area. Sensors are to be mounted on the highways equipped with luminaire illuminations. When vehicles approach the sensors mounted, the electronic sensor will be able to detect the disturbance in the earth's magnetic field [5]. An example of the above phenomenon is shown in fig -1.

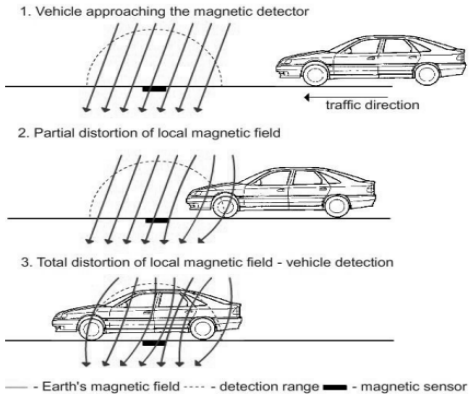

Fig.1: Object detection using magnetic sensors [5]

Multiple sensors need to be installed at equal distances so that they can capture the disturbance on earth's magnetic field. With installation of independent sensors at independent locations we can carry out maintenance without disturbing other areas of the roadway. The sensor will be responsible to define the size and speed of the vehicle based on the noise level detected on the sensor. Data collected from the sensors will be passed to the controller. The controller in turn will be responsible in handling the lighting mechanism on the highways.

Sensors will need to be mounted at 350m distances apart since we need to control the lighting mechanism for vehicles not detected in that confined area. The sensor is constantly active to detect objects and calculate the number of vehicles, speed and size. This information is sent to the controller. The job of the controller is to collect data from the sensor and monitor the number of vehicles in a particular area. The controller will switch off the lights in areas where objects detected are 0. When an object is detected at a particular junction then the controller will switch on the lights at the next junction of the direction of the moving object. It is to be noted that the first junction and the last junction of the highway always have their lights switched on. The purpose of keeping these switched on throughout is that when an object enters the highway, the lighting mechanism should already be powered on rather than the controller trying to switch on the lights. The advantage of using LED lights in this system is that they power on and spread light quickly. Thus, there will always be enough light and road safety will be ensured.

IV. LUMINAIRE INSTALLATION AND POWER MEASUREMENT

A luminaire is a complete set of lighting unit which has a capability of widespread light distribution. Currently, the lighting mechanism adopted in India consists of High Pressure Sodium lights. For the installation of new luminaire it's important to have a site that can be used for testing efficiency of existing system and the ones proposed. As a part of testing, installation of total of 10 types of luminaires mainly involving 4 LEDs, 3 HPS (High Pressure Sodium) and 1 each of plasma, induction and MH (Metal Halide) was installed at a research site in Crawfordsville, Indiana [7].

The installation will require a few technicians and time for installation will reduce when technicians are more familiar with the process. On the basis of experiences it can be summarized that there would be no complications in installation of luminaires.

Electrical power can be defined as the rate of doing work or the rate at which electrical energy will be supplied to a circuit or consumed by a load. It is the amount of energy consumed per unit time. The rate at which energy is converted from electrical energy into light energy which forms as a part of radiant energy is Electrical Power. Electrical power can be expressed in watts. Power (p) in watts is calculated in terms of current (I) in amperes and voltage (V) in volts:

$$p = IV \quad \text{…equation (1)}$$

The rated and measured power values are presented in Table - 1.

Table -1: Measured and Rated Power Values [7]

Luminaire Type	Rated Power (W)	Measured Power (W)	Difference (W)
HPS 250 W	250	302	52
HPS 400 W	400	473	73
LED 258 W	258	244	−14
LED 270 W	270	241	−29
LED 200 W	200	254	54
Plasma 295 W	295	267	−28
Eco-Luminator Induction 200 W	200	227	27
HPS 6 * 1000 W	6000	7430	1430
LED 6 * 392 W	2352	2196	−156

From the table, it can be inferred that differences between rated power values and measured power values are significant. Therefore, measured power values should be

utilized to calculate costs incurred with power consumptions rather than the rated power values [7].

In comparison to existing HPS lighting systems, the new lighting systems show lower measured power values. This states that the new lighting systems would consume less power than the existing ones installed.

V. COST ANALYSIS

Life cycle cost analysis is a method for assessing the total cost of ownership. These costs involve not only the initial costs incurred to build a particular system but also all the future costs. Life cycle cost analysis is basically done when an agency or the government decides to undertake a project and needs to determine the lowest and most cost effective life cycle cost while adhering to the project objectives.

To make sure that life cycle costs are accurately calculated, the analysis needs to be performed for a multiyear period. As the value of money differ at different points of time there needs to be a generic method to analyze life cycle costs.

The most common method is to convert the future costs that might be incurred to the present value using an interest rate. 4% interest rates are applied in highway projects in India. We will consider 4% interest is applied for our lighting systems. It is important to know the service life and the replacement cycle for each lighting mechanism. The HPS lights have a service life of 25 years with a 3 year replacement cycle. LED lights proposed for this system will also have a service life of 25 years though the replacement cycle is difficult to determine. The warranty period issued by the manufacturer can be considered as a replacement cycle metric.

The present and future value of money can be calculated by following equations where

- i will represent interest rate.
- n will represent number of years

The present value of money (P) can be calculated as:

$$\text{Given } P, \text{ to find } A. \quad A = P\left|\frac{i(1+i)^n}{(1+i)^n - 1}\right|$$

…equation (2)

From present year to nth year the value of money can be calculated as:

$$\text{Given } F, \text{ to find } P. \quad P = F\left|\frac{1}{(1+i)^n}\right|$$

…equation (3)

The end of year payment (A) for n years which is equivalent to present year can be calculated as:

$$\text{Given } A, \text{ to find } P. \quad P = A\left|\frac{(1+i)^n - 1}{i(1+i)^n}\right|$$

...equation (4)

The above equations provide a relationship between the present, future and end of year payment respectively to provide the present value of money [7].

The below table -2 shows costs involved for each type of lighting mechanism where annual cost(Rs) can be calculated as:

Annual Cost= Electricity Cost + Maintenance Cost

… equation (5)

Here,

Electricity Cost =0.65×measured power W x 4000h ÷100

Maintenance Cost = 5070 for HPS, 2600 for LED

Table.2: Annual Costs incurred for luminaire

Luminaire Type	Lamp Life(years)	Annual Electricity Cost(Rs)	Annual Cost(Rs)
HPS 250W	3	7865	12935
HPS 400W	3	12285	17355
LED 258W	5	6370	8970
LED 270W	5	6240	8840
LED 200W	3	6630	9230
PLASMA 295W	5	7020	9620
ECO-LUMINATOR INDUCTION 200W	5	5915	8515
HPS 6*1000W	3	193180	200005
LED 6*392W	5	57070	63895

On comparison of the costs incurred between existing HPS lighting mechanism and the proposed LED lighting mechanism we can conclude that the proposed mechanism are cost effective than the ones which exist.

VI. CONCLUSIONS

Through this paper, knowledge has been obtained on the mechanism to detect objects on roadways via magnetic sensors and automate the lighting mechanism throughout the highway. The electronic sensors play an important role in object detection and control of switching on and off of the lights. The proposed luminaire are simple to install and essentially consume less power than the existing HPS lights. Also, cost analysis show that the LED lights proposed are cost effective than the existing HPS lights. LED lights proposed ensure widespread distribution of light and road safety.

This system should be implemented in places only where movement of vehicles during midnight is low. When there is a high amount of vehicle movement on the highway, the lighting mechanism will be turned on throughout and would be ineffective. This mechanism of automating lighting mechanism can be extended from highways to the cities provided movement in the cities is minimum during night.

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