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ADVANCED ANIMAL AND VEHICLE COLLISION PREVENTION USING SOLAR POWERED VISIBLE LIGHT COMMUNICATION AND SENSOR ACTUATOR NETWORK FOR SMART ROADS

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ABSTRACT

The environmental impact of roads and railways is of increasing concern. Roads and railway tracks, all over the world, often encroaches into animal habitats which cause serious danger to animal and human life. In India this problem is often looked over as a result of which thousands of animals and humans die every year. Multiple approaches have been taken to mitigate this problem like overpasses for animals, use of sensors and detectors of various kinds and wireless networks and others. All of the mentioned methods suffer from the lack of robustness, increased cost and installation and the systems require power.

The new proposed solution tackles all of these problems and provides a simple, robust and cost effective solution. It uses VLC or Visible Light Communication to quickly detect and alert people of the potential wandering animals on and near road or rail. VLC combined with a simple controller and actuator network provides an effective control system against animal and vehicle collisions. The VLC is solar powered with batteries for storage of excess charge and is thus a step towards Green Technology as well. The overall advantages make the proposed solution highly feasible.

Keywords: LED, Smart Roads, Solar Powered, VLC

I. INTRODUCTION

One of the major causes of concern all over the world is the increase of animal vehicle collisions and the after effects. Till today, it remains one of the leading causes of loss of animal and human lives related to transportation, and also leads to serious accidents, post-collision damage and extensive repair losses. Many rules and regulations have been implemented across the world [1]. However the accidents cannot be controlled methodically. Roads and railways are both prone to such disasters and increases concern for the effects of human encroachment in wildlife territories. In India, we often hear increasing animal-vehicle collision tragedies. Animals will continue to enter roads and railway lines as animal behavior cannot be controlled. However, we can provide with intelligent solutions to mitigate this problem. Today, it is one of the leading areas of academic research to find the optimum solution which can save lives.

Figure 1 – animal-vehicle collisions have caused numerous deaths, raising questions on animal safety (dead elephant after collision)

There are many existing systems to tackle the crisis of animal-vehicle collisions. Proposed and implemented solutions include finding animal collision patterns, building smart sensors, detectors and wireless communication networks to alert people and officials, raised platforms and crossings for animals and putting special squads to check animal collision accidents. Many of these solutions have had mixed results of success. The Indian Government along with IIT Delhi has found a solution to save elephant collision deaths using wireless sensor devices [2]. An optimum solution must include quick detection and alert systems, total cost effectiveness, ease of installation and fairly damage resistant. Visible Light Communication (VLC) can be the perfect solution for this case.

Recently VLC has attracted a lot of attention in both academia and industry. It has been recently tested and perfected in 2015. A detection and communication network based on light has many advantages. Coupled with a robust system of sensors and actuators to quickly alert people, this can become a feasible solution in the near future. The challenge is to integrate it into a functioning system, something that is attempted through this paper.

II. THEORY

Visible light communication (VLC) [3] is a medium for data communication using visible light between 400 and 800 THz. Fig 2 summarizes the characteristics of visible light. Light is the optical carrier for data transmission and illumination. Using LEDs [5], a low rate data transmission at nearly 2 kilometers (1.2 miles) can be achieved. In the proposed system, powerful LEDs are used which are capable of high speeds. The photo receiver is kept as photodiodes. An array of vertical photodiodes can cover nearly all animal heights. The benefit of using VLC is that it can be simultaneously used for data or signal transmission as well as general illumination. Being solar powered, the system does not need extra batteries for power but contains a storage unit for storing the charge from solar energy. This keeps the system running during the day as well as functional at night. The lights can be dimmed when not required during the day but the system continues to work [4].

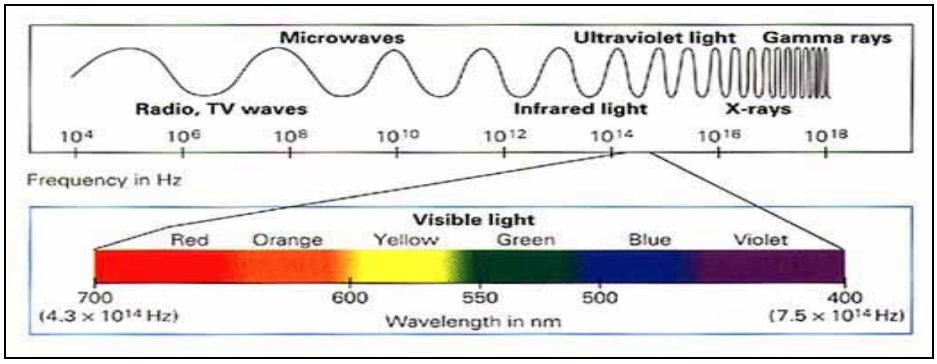

Figure 2 – characteristics of visible light

There are many disadvantages with present anti-collision systems being proposed or used, more so in India. This includes externally powered wireless data communication systems and associated network.

2.1 Disadvantages of Present Animal-Vehicle Collision Prevention Systems

1. Unstable system and not so robust. They contain sensors which are usually prone to damage.
2. Cost of installation is high, majorly in India.
3. The system itself is complicated and needs a large number of installed parts.
4. The cost of maintenance is high. Replacement cost also increases after damage due to collisions or otherwise.
5. Cannot cover all animal heights. Multiple sensors required for the same.
6. Requires external power like batteries. This makes the entire system bulky.
7. Animal detection time on road/rail is high.

The proposed system of animal and vehicle collision prevention using solar powered visible light communication and sensor actuator network for smart roads covers all the required areas.

III. PROPOSED SYSTEM

3.1 Strategy

The system is designed to protect animals from fatal collisions with vehicles. Figure 3 shows the proposed system. It consists of placing an array of LEDs on a single lamp, at a minimum distance of 2 feet from the road. The LED lamps serve a dual purpose of data communication and illumination during dark. Each LED lamp is powered by solar panels, situated at the top, with a battery at the base for storage of excess charge.

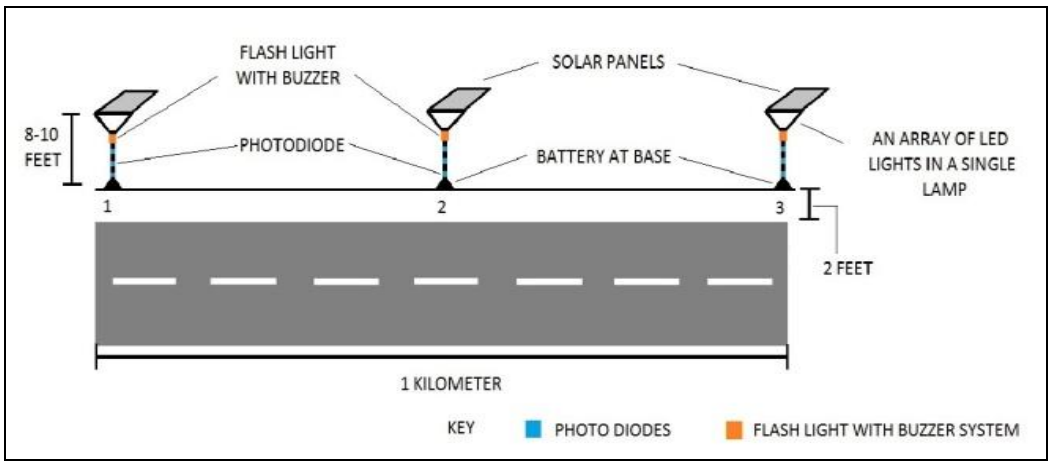

Figure 3 – position and configuration of the overall system along a stretch of road (1 km)

As shown in fig. 3, a number of photodiodes, at various heights are fitted along individual lamps. If an animal suddenly crosses these lamps, the passage of light, emanating from the LEDs and received by the photo diodes, is disrupted. The system instantly alerts the vehicles on road or the train on the tracks by flashing a red light and sounding an alarm. The flash light with buzzer/alarm is situated immediately below the LEDs. This ensures that people far away can see the red flashing as well as the system remains compact. The system constantly pauses and checks for any obstruction along the road sides. If such an obstruction is found to be present after some delay, it sends a message "POTENTIAL ACCIDENT ON ROAD" to the nearest officials. This makes the system capable of acting both as an alert and prevention system as well as an informer. The use of VLC makes the system response time quick as in real life scenarios the driver does not have much time to act in case an animal comes in front of it. This makes the system more efficient hence less time consuming.

In case an animal stays on the road or moves randomly near the road and LED lamps, the system is designed to trigger nearby alarms as well. As in fig 3, if an animal crosses the system at LED lamp no. 2 and moves towards LED lamp no. 1, the alarm system of all three systems (1, 2 and 3) will be at once triggered. This disruption of light transmission is send as a signal to nearby systems, even across the road, to alert traffic or trains on all sides. Due to the large distance gap between two such systems on the road, only those alarm systems with an obstruction to light flow in addition to the data from other alarm systems warning, will go off. It will not disturb the entire stretch of LED lamp systems.

The minimum distance of 2 feet is kept as a measure to prevent parking cars from becoming as a potential barrier to the VLC and triggering the alarm system. It can also be increased or decreased according to road and track requirements.

3.2 Working

The system has a number of components which makes it detect an animal beside the road or track, alert the drivers visually and aural and informs the officials in case of accidents or prolonged interference to VLC transmission and reception. The working block diagram of sensors is shown in Figure 4. The actuator system is shown in fig 5.

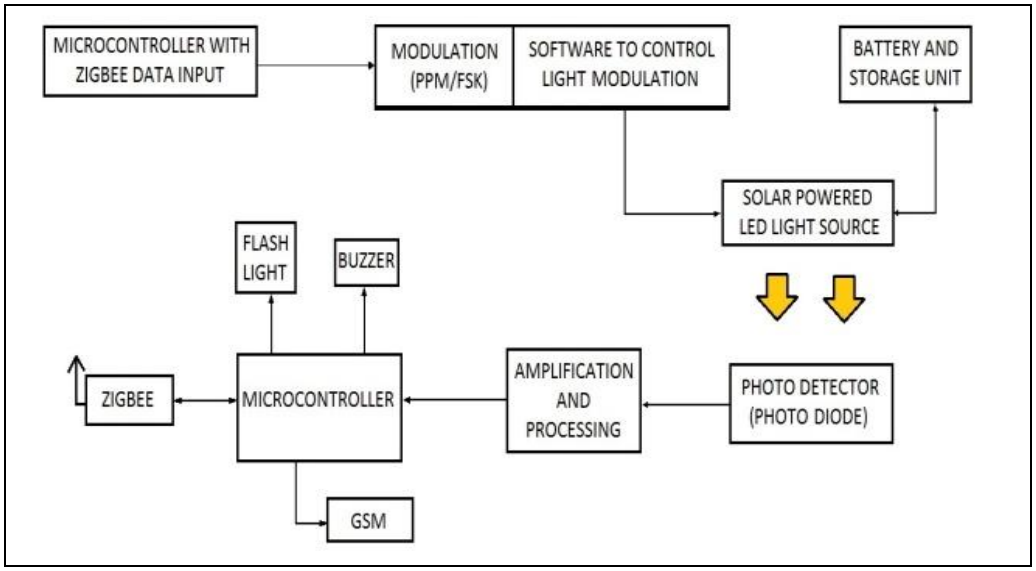

Figure 4 – block diagram of the sensor module of the entire system

Under normal circumstances, the solar powered LED lamps illuminate the road or are dimmed (during day) but the photo diodes at the other continue to receive the light. The LEDs are properly projected so that the light remains focused along the line adjacent the road or track. The Microcontroller does not send a signal after processing the signal from the photodiodes. In case an animal crosses the light stream, the light to the photodiodes is disrupted. The microcontroller will immediately sound the alarm sound and flash the red light. Such a signal is sent as input to all the nearest microcontrollers, through the ZigBee [6]. ZigBee devices are often used to transmit data over long distances. It is a specification based on IEEE 802 standard for personal area networks using small low powered digital radios. This signal is used by microcontrollers as input in adjacent systems. After modulating this input (fig 4.) the signal is sent to the LEDs via software which makes the LED bulbs to flicker at a high rate. This is sensed by the photo diodes and the adjacent systems become alert. In case the animal disrupts the path of light in any of the already alerted system, the alarm system goes off instantly. In this way, when the stream of pulsating light encounters an obstacle or barrier in the form of an animal or car on the roadside, it immediately stops to transmit the data and sends a signal, which in turn triggers the alarm system. An LED is a semiconductor and electronic device. It has the property that its intensity can be modulated at very high speeds. Light 'ON' and 'OFF' serves as a binary code, and it is this flickering that the photo diode senses. It is not majorly affected by the ambient light and does not need a line of sight.

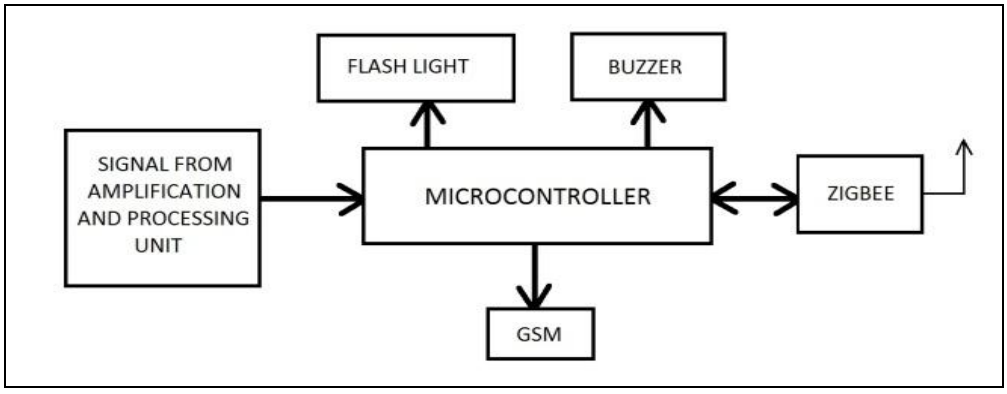

Figure 5 – block diagram of the actuator module of the proposed system

In this system, if after a delay in time, the alarm system (flash light + buzzer) is found to be 'ON' or the light path is found to be disrupted in between any two systems, a message is sent to the officials by the microcontroller controlled GSM (Global system for mobile communications) [7] stating "POTENTIAL ACCIDENT ON ROAD". Such a message can also be forwarded to all nearby drivers to alert them. This function helps in alerting others not involved in the accident and the road/track officials to investigate. This is the primary work of the actuator module. This only occurs in case the animal is not scared off from the flashlight or buzzer and continues to walk in or near the road, which is found to be one of the leading causes of animal and vehicle collisions. From the point of view of the drivers, they will be able to see the flashlight and hear the buzzer helping them to stop immediately or become alerted, depending on their proximity to the actual animal on the road. The system constantly checks for any possible disruptions in VLC or alarm systems triggered and shuts off only when both conditions are fulfilled. Even if the animal strays on the road, alarm system stays 'ON' long enough to alert drivers. This ensures swift action without causing injury to animals and can prevent collisions on road or railway tracks.

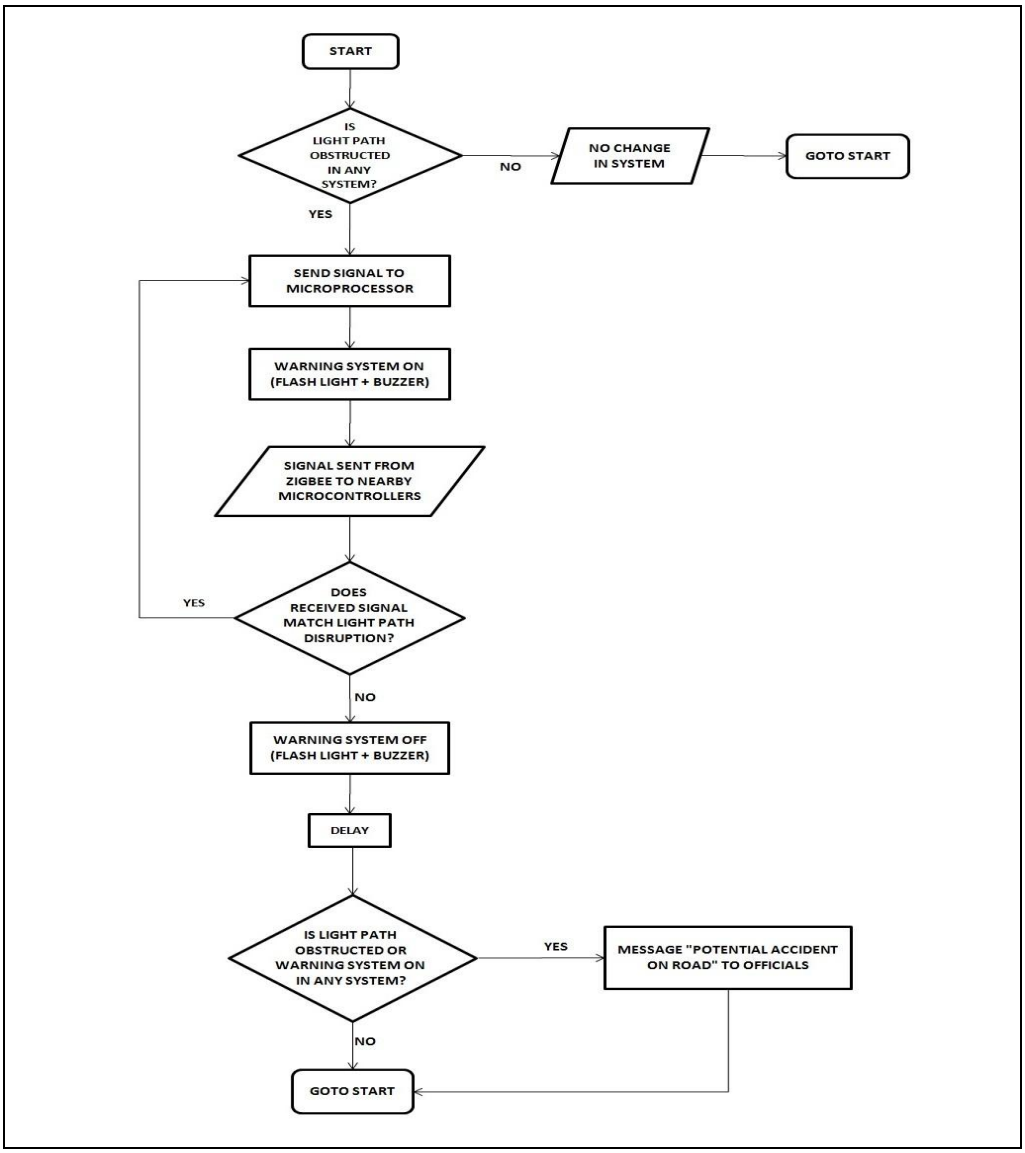

Figure 6 – flowchart of the working and the event sequence of the proposed system

The flowchart showing the working of the system is given in fig 6. It shows the working of the entire system and the possible sequence of events which occur.

IV. SMART ROADS

With the advent of better technologies to aid drivers on road, smart roads are an active area of interest for academic and industrial sectors alike. In the proposed system, the entire system can aid in making smart roads. Built with LEDs, the system also serves the purpose of illuminating the roads and rail tracks at night. During the day, the lights can be dimmed to a point where the human eye cannot detect it. However the system continues to work. The software used can perform the function of dimming the lights when it is required. The entire system can be controlled from a large distance. The driver is informed of a potential animal collision much before and has some time to react. Even if the animal comes directly in front of the vehicle during darkness, the system alerts quickly and the driver might get a precious few seconds to make a live-saving decision. The driver need only concentrate on the road while driving. There is no technological hassle of checking information via cell phones or other time consuming devices because in real-life scenarios the driver has to decide in seconds.

The entire system is solar powered and has a unit for storage of excess energy. It is certainly a step towards Green Technology [8]. The stored charge is used at night for road/track illumination. If the system is connected to the power-grid and provided with better solar panels, it can provide excess charge to the grid. Thus one system serves many facilities including providing benefit to drivers and traffic officials by preventing animal and vehicle collisions. It is also cheap, compact and requires no external charge.

V. CONCLUSION

There are a few ways to make this system more efficient. Powerful LED lamps make the job of VLC easier. In place of a Zigbee, the photodiodes can detect the red flashing light and the system must be designed to act accordingly. There is also a scope of introducing the concept of Light Fidelity (Li-Fi) [9] [10] as the primary means of VLC. Receivers (photodiodes) or other mechanisms [11] in moving cars and trains can detect such signals and provide fast internet access to all passengers. Li-Fi was successfully tested recently in November 2015 with promising results. The rapid evolution of technology seen at present can make this future concept a reality soon. As such, the proposed system of animal and vehicle collision prevention also provides us with many advantages, which are listed thus.

1. The proposed system is a low cost solution. Cost of installation and maintenance is low.
2. The system is extremely compact and not easily damaged.
3. It can cover all animal heights as obstruction of light can be detected by intelligently placed vertical photodiodes. Also, light travels in all directions and can be received by multiple receivers.
4. Quick response time and efficient to detect and alarm drivers and officials.
5. Number of devices required is lesser than any present systems.
6. It requires no external power from batteries.
7. Uses renewable energy as a source of energy which can give energy back to the power grid in case of excess.
8. An added advantage of illuminating the roads and railway tracks can be had.

9. Extremely secure system. Cannot be hacked in or tampered as such.
10. Device need not have a direct line of sight to function.

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