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AN EFFICIENT SENSOR NETWORKING BASED APPROACH TO MONITOR WILDLIFE INTRUSION USING SMART ROAD MANAGEMENT

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Abstract: Wireless sensor networks play a vital role in day to day life. Sensors help humankind in measuring, monitoring and paves way for mitigation of various physical and biological parameters. In this paper, wireless distributed system is utilized for the detection of animals along the road sides of the forest area to prevent animal vehicle collision, ensuring decrease in animal's fatal rate due to accidents. Sensor nodes are deployed along the road sides of the forest area where animal's intrusion is often spotted. Hybrid sensors inhering both active sensor (Doppler radar module) and passive sensor (PIR) are integrated with the sensor nodes to detect animal intrusions which is an obvious remainder for the drivers to slow down their speed of the vehicle to prevent animal vehicle collision. Speed of the vehicle is assessed using three IR sensors and if the drivers violate the threshold speed even after the mark of animal intrusion, image of the vehicle is captured using fixed speed camera and further processed by Automatic License plate Recognition (ALPR) technique. The vehicle number plate in text form is transmitted via GSM module to the nearby forest check post to take necessary actions.

Keywords: Wireless Distributed Architecture, PIR Sensor, Doppler radar Module, IR Sensor, Fixed Speed Camera, Automatic License Plate Recognition.

1. Introduction

Nowadays one of the serious issues perceived in forest areas by all countries is the animal vehicle collision, which leads to take the edge off animal species on the earth. Due to various reasons, many of the wild animals have now come under the category of endangered species. There are more certainties of these species to be extinct. Due to the accommodation insufficiency of people, they are tempted in occupying the habitat of animals. This interferes and alters the normal behaviour of the wild lives [1-3]. Many non technical solutions have been provided regarding these problems. The solutions include fencing and paving underground pathways for the animals. But all of these solutions lead to failures. Overcoming these failures some technical solutions was adopted. Such techniques include fixing thermal cameras, ultrasonic sensors etc. These had certain drawbacks in implementing and providing proper solution. Thermal camera does not suite for curved lanes [9]. Ultrasonic sensors sense all matters including stones and leaves, which again lead to failures [3]. Other earlier system was of an infrared thermal temperature image capturing and processing system. The infrared thermal camera is used to capture the image of deer which is sent to the frame grabber [9]. The images are processed by the image processing unit and the motion is detected using the movement tracking system. Automatic detection of animals is not applicable [16].Further solution includes the IR sensor is integrated within the WSN node which is deployed along the road sides to detect the animals. The indications are given to the drivers through road signals [8-11]. IR sensors cover only short range and hence multilayer of sensors should be placed [9]. Later RF sensors networks are used to localize and track targets easily and do not need to carry any sensors or electronic devices.

Radio Tomography Imaging (RTI) is used to produce images according to the change in the propagation field devices [6]. RTI is restricted only to 4 targets [6,9]. Wireless sensor networks integrated with Doppler radar module are utilized to detect animal movement. This system is of less efficiency and more difficult to adapt [18]. Some serious measures have to be taken to avoid these fatal accidents of animals. One such solution is provided in this paper through wireless sensor networks where the wireless sensor nodes have been deployed along the roadsides of forest areas. Each sensor nodes are fixed with wireless sensors which includes passive infrared sensor (PIR). These sensors are used to detect the animal movement in the targeted areas through the IR radiation emitted by the animals. In addition to this, hybrid sensors is utilized which is the combination of active and passive sensors. The sensors are controlled by Arduino UNO and Raspberry Pi for detection of animals and take necessary precautions. This paper is organised as follows; Section II depicts the complete idea of proposed system for avoiding animal vehicle conflict followed by module description in next section. Section IV exhibits the outcomes of each module with its discussion on reducing the animal fatal followed up with conclusion.

2. Proposed Methodology

The wireless distributed system [19-27] is exploited for the detection of animals along the roadsides in the forest area. The sensor nodes are integrated with hybrid sensor, it consists of both the active sensor (Doppler radar module) and passive sensor (Passive Infrared module).

The active sensor considered is Doppler radar module which comprises of inbuilt internal oscillator. The internal oscillator produces the signal of known frequency. If any animal movement intrusion to road side is within the sensor range, the signal frequency gets deviated. Through which the Doppler radar module identifies the presence of animals. Passive Infrared sensor identifies the animal passage by the detection of IR radiation from the animal body. Being a passive sensor, it only detects and does not produce any IR signal.

The animal detected information via hybrid sensor is communicated to receiver node through Zigbee module controlled by Arduino UNO. This happens only when both the sensor (PIR+ Doppler) display produces the same output of animal's detection. The animal detected information is indicated to the drivers through the boards. Fig. 1 and Fig. 2 sketches the transmitted node and the receiver node respectively. The receiver side Zigbee module accumulates information from transmitted node and feeds to receiver node Arduino where speed of the vehicle is assessed. The speed of the vehicle is measured using three IR sensors. The IR sensors are placed on the road at a particular distance and the threshold is to be fixed. If the threshold speed (30kmph) is exceeded by particular vehicle, the image of the vehicle is captured using fixed speed camera. The fixed speed camera is mounted on the display boards to capture the front view of the vehicle which violates the indication given by the display boards. Once the speed gets exceeded the information is sent to the nearby forest guards through the GSM module. The image captured by the fixed speed camera is processed by the Automatic license plate recognition (ALPR). This technique is mainly used for converting the character in the image to text format using optical character recognition (OCR). At first, the captured image has to be cropped to obtain the region of interest (Number Plate). The gray scale conversion is applied for the cropped image. The cropped image is then segmented and finally the character recognition is done for each of the segmented character by the OCR technique. Each segmented character should be compared with the OCR library character to obtain text in number plate. This text obtained through OCR is conveyed to the authority through the GSM for taking necessary actions against the particular vehicle.

3. Hardware Description

3.1 IR Sensor

IR Sensor is a device used for detection of radiation emitted by the object. An IR sensor consists of two parts, the emitter circuit and the receiver circuit. If there is any variation between these circuits the count gets increased and when no variation is detected between the circuits, count gets decreased. The IR LED represents the emitter and the IR photodiode represents the detector. The IR photodiode is sensitive to the IR light emitted through an IR LED. The change in the photodiode's resistance and the output voltage is proportional to the IR light received. The infrared sensor range is up to 20cm, Size 50x20x10mm (LxBxH), 20mA supply current and 5V DC operating voltage.

3.2 PIR sensor

PIR sensor is a motion detector which detects the movement of animals. Whenever the movement is detected within the range of PIR, the sensor detects the infrared energy and it will be triggered. Power requirement is 3 to 6V DC, communication through single bit which will be high or low. Dimensions (1.41x1.0x 0.8) inner (35.8x25.4x20.3cm) outer .It covers the range of 6 meters. PIR sensor is made up of piezo electric sensor with two parts that it will not only detect the radiations but also the changes in the environment whenever the target trespass the road.

3.3 Fixed speed camera

The fixed speed camera is mounted on the notice boards or above the road so that it captures the vehicle which violates the forest traffic rules. The camera records the speeding vehicle and automatic number plate recognition is done for the speeding vehicle. It can capture pictures up to the range 200metres (660feet). The camera uses infrared photography. This camera capable of capturing frame rates excess of 250 frames per second. The 1000 frames per second are recorded into the DRAM.

3.4 Doppler radar module

Doppler radar module is a type of radar which is actually based on the principle of Doppler Effect. It is used to identify the velocity of the object that is present at certain distance by identifying an altered frequency

deviated from that of the frequency of the emitted signal. The Doppler Effect actually refers to the difference between the frequencies emitted as well as observed. Transmitter frequency 10.525 GHz, Output power 13dbm EIRP, Sensitivity 10db S/N ratio, Antenna gain 8dbi, Dimensions (37x45x8mm) and the detection range is up to 20 metres.

4. Results and Discussions

Wireless distributed architecture is implemented to prevent the animal vehicle collision along the roadside of the forest area. The entire system is segregated into transmitter node and receiver node. The transmitter node with hybrid sensors (Doppler and PIR) administered by Arduino UNO for inspection of animal movements and radiations. Fig.3 represents the Transmitter node. The wireless sensor nodes are deployed all along the road sides to detect animal movement with the help of hybrid sensor which is the combination of active sensor and passive sensor. Doppler radar module detects the animal movement with the help of the known frequency signal produced by the inbuilt internal oscillator. If the signal hits the target or the animal, the signal frequency gets deviated and the signal will be again captured by the radar module. Both the transmitted and the received signal should be coherent. Frequency mismatch between the two signals ensures the detection of animal intrusion. Taking the advantage of infrared radiation from animal's body, passive sensors (PIR) is cast off for absorption of radiation to identify the animal's intrusion. If both the sensors output are correlated, then the detected animal information is passed on to Arduino UNO microcontroller. Fig. 4 represents the receiver node. The receiver node Arduino controller gathers information through Zigbee module. Display boards interfaced with receiver Arduino alerts the drivers when the animal is identified. Fig. 5 unveils the status of display boards when no animal is detected. Fig. 6 shows the status when animal intrusions detected. Once the driver heed the indications they should reduce the speed of the vehicle to prevent animal vehicle collision.

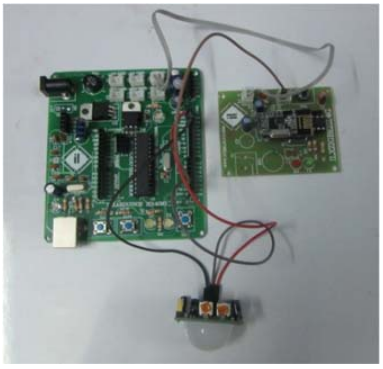

Figure. 3 Prototype of the Transmitter Node

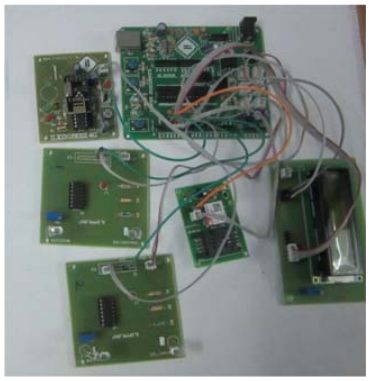

Figure. 4 Prototype of the Receiver Node

The speed of the vehicle is evaluated using the IR sensors deployed under the road. The threshold speed (30kmph) fixed in sensors and the speed of the vehicle crossing the sensor is measured. If the speed of the vehicle exceeds the threshold value it is considered to be high. If it is lower than the threshold value it is considered to be low. These indications are fed to the receiver side Arduino controller. From the Arduino controller the information is conveyed to Raspberry pi model B interfaced with fixed speed camera. The fixed speed camera captures the image of the vehicle when the IR sensor output is high. Usually three IR sensors are used to assess the speed of the vehicle.

Figure. 5 Display output when no animal detected

Figure. 6 Display output when animal is detected

The captured front view of the vehicle image is processed to obtain the number plate of the vehicle. Here, Optical Character Recognition (OCR) technique is employed to retrieve the number plate. Initially captured front view of the vehicle is processed to extract the text of the Number Plate followed by Binarization and segmentation (Single Characters) using ALPR. The Optical Character Recognition technique is resorted to convert the image into text format by comparing with the OCR library database with the help of Computer Vision (CV) modus operandi. The text format of the number plate obtained is communicated to the nearby forest guard through GSM module. Fig. 7 displays the alert message and vehicle number plate via GSM.

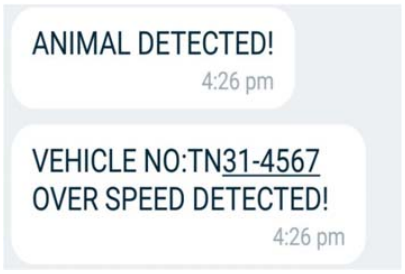

Figure. 7 GSM output

The forest officials get alert in their smart phones via GSM for over speeding vehicle and obligatory measures can be accomplished.

5. Conclusion

Emerging technologies have been employed for the detection of animal movement in order to avoid animal vehicle collision, thereby decrease the fatal rate of animal species. Overcoming the drawbacks in earlier systems, in this system more efficient method to achieve expected solution for saving wild lives is been exploited. Hybrid sensors interfaced with modern controller's viz., Arduino, Raspberry Pi and communication devices viz., GSM, Zigbee are put forth for accurate identification of animal's intrusion along the roadside. In addition to detecting the animal movement, identification of the vehicle violating the indication is also monitored in order to locate the exact position of over speeding vehicles through ALPR with OCR. In future, implementation of solar panels may be used for power supply in order to make it even more efficient.

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