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IoT Concept for Animal Detection Using ANN to Prevent Animal Vehicle Collision on Highways

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Abstract: Being in a world where wildlife animals are becoming extinct and remaining getting run over by vehicles while crossing through the roads, this paper proposes an IoT concept to prevent animal-vehicle collision on highways and roads in reserve areas. Electric fencing being a huge threat to animal's life our paper brings in a great replacement of this electric fencing by giving alerts through smart phones and huge LED displays placed across the major places where animals are found to cross the roads. This paper uses two major algorithms such as the motion detection algorithm with the sensors and object recognition algorithm using artificial neural networks. In this paper we have used the motion detection PIR sensor to detect the animal movement near roads and the ANN for object recognition. Once the motion is detected the object recognition algorithm recognizes whether the motion detected was due to an animal movement or any other factors. If it is because of an animal movement it sends alerts through the LED signage boards and to the android application which uses Google maps to show alerts on the corresponding area through MQTT. This paper achieves object recognition accuracy of up to 91%.

Keywords: ANN (Artificial Neural Networks), IoT, PIR, MQTT, Object recognition

1. INTRODUCTION

As the world is evolving towards 'smart' technologies approaching anything with smart technology is the smartest way. This paper proposes an IoT concept to prevent animal-vehicle collison by using various sensors and image processing algorithms. In certain highways and in roads that go through the reserve areas various wildlife animals are present and they tend to cross the roads. Animals are unaware of the vehicle movement so does the vehicle drivers. Each year thousands of animals get hit by vehicles and die. Hence we developed an approach to prevent this from happenning or atleast the numbers can be reduced to a huge amount.

On various bench marking analysis we have proposed that PIR (Passive Infrared) sensors can be used for motion detection. Which helps us to find any movement in that premises. In order to confirm that movement is due to an animal and not any external factors we use the IP cameras which uses image recognition algorithm to confirm that it is an animal.

Having confirmed the presence of animals a message is sent through huge LED displays and alerts through google maps who are using it on the premises.

2. ANALYSIS OF ANIMAL VEHICLE COLLISION

Our paper proposal was initiated with the depth analysis of animal vehicle collision across the world. Various statistical data was analysed and based on the results the we have included certain additional algorithms to our approach in order to prevent the animal vehicle collision to the maximum. Folllowing are few of the statistics that has been analyzed.

The below table gives the detailed data with the number animals killed each year from 2014 to 2018 month wise. It is found that each year hudreds of animals are being killed due animal vehicle collison. The statistics also provides the rare type of animals which are being killed.

BY MONTH	2014	2015	2016	2017	2018
JAN	9	5	11	22	-
FEB	11	2	9	17	-
MAR	7	8	17	17	-
APR	4	18	9	24	18
MAY	5	21	46	33	35
JUN	35	60	83	52	71
JUL	28	43	61	82	33
AUG	32	73	38	42	31
SEP	34	39	29	23	39
OCT	27	27	49	29	24
NOV	27	26	51	46	44
DEC	20	16	22	28	23
UNKNOWN	0	0	1	0	0
TOTAL	239	338	425	416	318

Table.2.1 *Animals killed record*

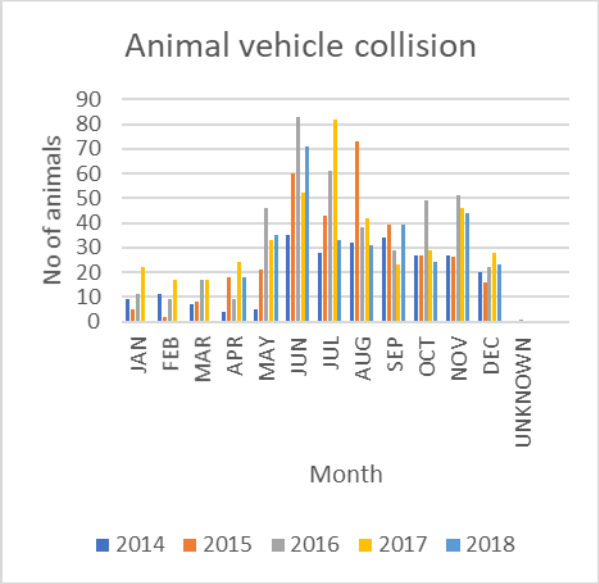

Fig.2.1 *Animal Vehicle collision chart*

TYPE OF ANIMAL	NUMBER OF ANIMALS	YEAR
Bear	4	2018
Bighorn	1	
Cat	2	
Coyote	3	
Deer	220	
Dog	1	
Elk	31	
Fox	2	
Lion	4	
Moose	3	
Pheasant	1	
Rabbit	1	
Raccoon	4	
Skunk	2	
UNK	39	

Table2.2 *Type of animal dead by animal-vehicle collision*

Based on the above statistics we infer huge number of animals become victims of animal-vehicle collision. Hence our paper proposes the method to reduce the number of deaths caused by animal-vehicle collision to the maximum and preserve the nature with a technical and smart approach.

To implement this approach specific locations which are considered as animal crossing zone are chosen.

The Fig.2.2(a) shows the alert signage boards on highways denoting moose crossing for next 5 kms. Zones similar to this are chosen across all states in a country and the project can be implemented.

(a)

(b)

Fig.2.2 (a) *Animal crossing alert displays,* ***(b)*** *Deer in a highway*

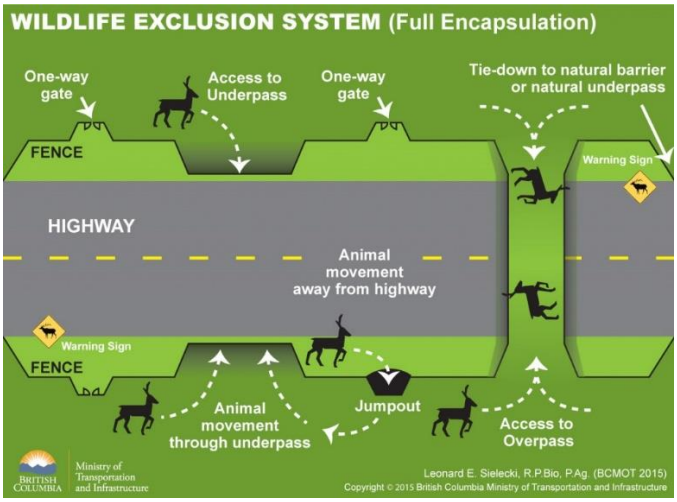

Fig.2.3 *Wildlife exclusion system*

The British Columbia ministry of transportation and infrastructure has released a detailed picture of the animal crossing in highways. This picture also explains the ways in which the animal jumps out of the fence and a method to encapsulate by building an underpass for animals and the warning signs kept on highways.

3. SYSTEM ARCHITECTURE

3.1 SYSTEM ARCHITECTURE

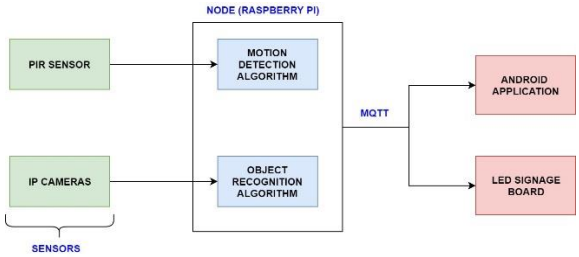

Fig.3.1 *Proposed system architecture*

The above block diagram illustrates the overview of the alerting system. There are two major sensors that is being used in this system they are the PIR sensor and the cameras. Detailed description of the sensors are explained in the below sections.

3.1.1 PIR Sensor

A passive infrared sensor (PIR sensor) is an electronic sensor that measures infrared (IR) light radiating from objects in its field of view. They are most often used in PIR-based motion detectors. PIR sensors are commonly used in security alarms and automatic lighting applications. PIR sensors detect general movement, but do not give information on who or what moved. For that purpose, an active IR sensor is required.

Fig.3.2 *PIR Sensor*

PIR sensors are commonly called simply "PIR", or sometimes "PID", for "passive infrared detector". The term passive refers to the fact that PIR devices do not radiate energy for detection purposes. They work entirely by detecting infrared radiation (radiant heat) emitted by or reflected from objects. This PIR sensor is used in our application to detect the movement of animals.

3.1.2 IP CAMERAS

An Internet Protocol camera, or IP camera, is a type of digital video camera that receives control data and sends image data via the Internet. They are commonly used for surveillance. Unlike analog closed-circuit television (CCTV) cameras, they require no local recording device, but only a local area network. Most IP cameras are webcams, but the term IP camera or netcam usually applies only to those used for surveillance that can be directly accessed over a network connection.

3.1.3 LED SIGNAGE BOARD

The LED signage board is used to show alert message when an animal motion is detected. In this paper we use RS-232 communication port to send message to the board and display the messages published through MQTT.

3.1.4 NODE

The node here refers to the controller that has been used on the premises to process the data received from the sensor and sends alerts to LED signage boards and android applications. In this paper we are using an ARM based contoller. Following are the specifications of the ARM based controller.

SoC: Broadcom BCM2837

CPU: 4× ARM Cortex-A53, 1.2GHz

GPU: Broadcom VideoCore IV

RAM: 1GB LPDDR2 (900 MHz)

Networking: 10/100 Ethernet, 2.4GHz 802.11n wireless

Bluetooth: Bluetooth 4.1 Classic, Bluetooth Low Energy

Storage: microSD

GPIO: 40-pin header, populated

Ports: HDMI, 3.5mm analogue audio-video jack, 4× USB 2.0, Ethernet, Camera Serial Interface (CSI), Display Serial Interface (DSI).

Fig.3.3 *ARM based controller*

There can be multiple nodes across the country. Each node can be named as Node-1, Node-2, Node-3 etc., each node

sends alerts to the LED signage boards and android application through the common communication protocol i.e., MQTT.

3.1.5 MQTT

MQTT is a machine-to-machine (M2M)/"Internet of Things" connectivity protocol. It was designed as an extremely lightweight publish/subscribe messaging transport. It is useful for connections with remote locations where a small code footprint is required and/or network bandwidth is at a premium. For example, it has been used in sensors communicating to a broker via satellite link, over occasional dial-up connections with healthcare providers, and in a range of home automation and small device scenarios. It is also ideal for mobile applications because of its small size, low power usage, minimised data packets, and efficient distribution of information to one or many receivers.[2]

3.1.6 NODE ARCHITECTURE

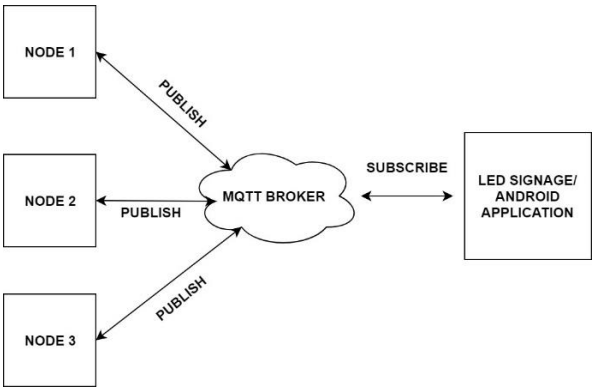

Fig.3.4. *Node architecture*

The fig.3.4 describes the common communication protocol. Unlike HTTP this protocol communicates with the publish subscribe basis. The user end subscribes to the particular URL from where the data has to be received. The node acts the publisher which publishes the message to the broker this broker in turn sends the message to the end user who has subscribed to the node.

4. IMPLEMENTATIONS

4.1 FLOW CHART

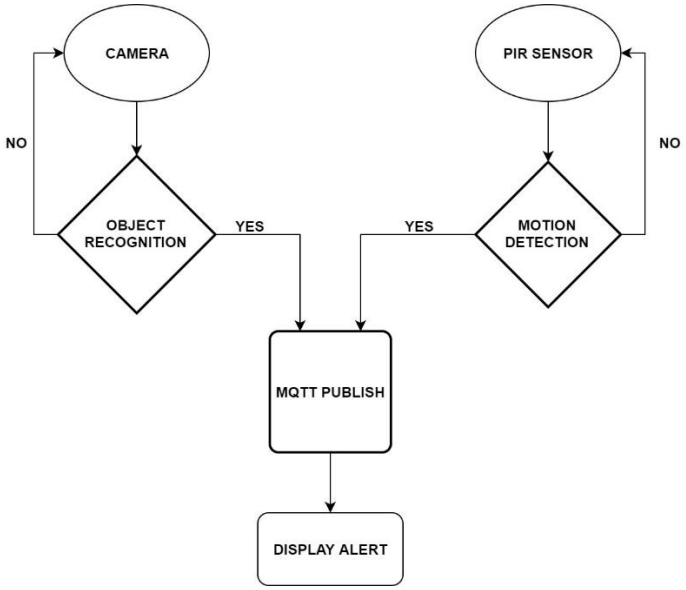

Fig.4.1 Flow Chart

The Fig.4.1 describes the flow chart of the whole system. Firstly the PIR sensor detects any motion on its premises, if yes it sends the alert to MQTT broker. Similarly the camera detects if the movement is because of animal movement or any other external factor. If it recognises animal then it sends alert to the MQTT broker. This broker in turn publishes the alert to the LED signage boards and mobile application.

4.2 OBJECT RECOGNITION TECHNIQUE

In this paper we use the object recognition technique to identify the prescence of animal each and every time when motion is detected in the premises, an alert is sent to LED signage board & android application.

In this paper we use the Artificial Neural networks technique for object rocognition. The neural network is trained with the data sets of animals and produce result with more than 90% accuracy. Neural network uses the backpropagation algorithm to train the datasets.

4.3 MQTT SETUP

In this paper MQTT is used as the common communication protocol between the user and the end devices/sensors. The following images describes how to establish a MQTT connection and publish messages on the subscribed URL.

MQTT FX is the testing tool that is being used to check publish and subscribe operations.

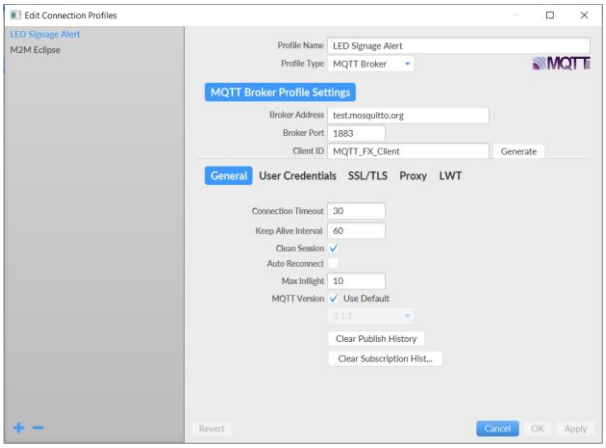

Fig.4.1 *MQTT settings*

After installing MQTT FX open the connection settings page. In the settings page we enter the profile name, profile type, the broker address and the broker port. In this paper we are using the mosquitto broker. MQTT always uses port 1883 to listen.

After applying the changes, we connect to the broker. Once it is connected to the broker the status changes to green color on top right of the window as shown in Fig.4.2. This denotes that the broker is listening and its active. When the connection is lost it turns into red color.

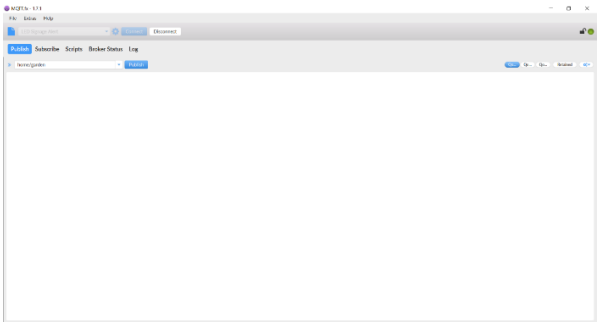

Fig.4.2 *MQTT Connection*

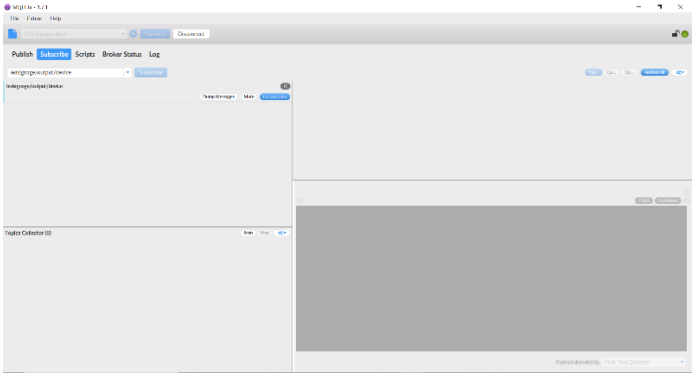

Fig.4.3 *MQTT Subscribe*

In Fig.4.3 you see how to subscribe to a particular url. The url has to be entered and the subscribe button is clicked. Once it is subscribed the publish tab is used to publish the messages to the end device.

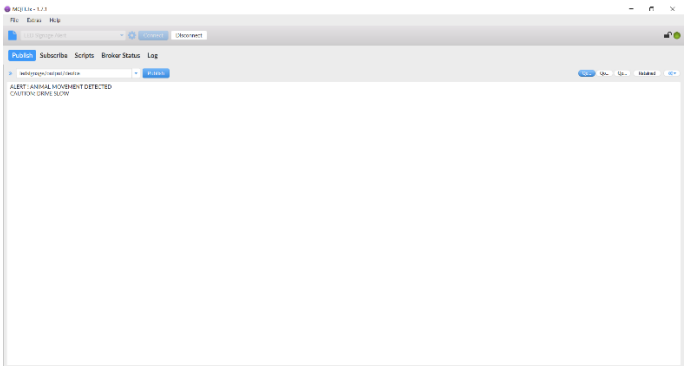

Fig4.4 *MQTT Publish*

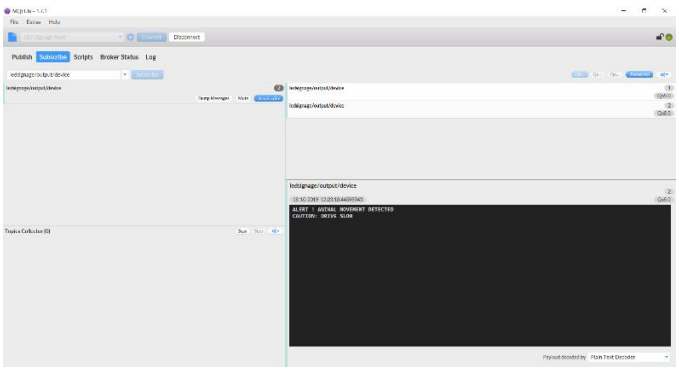

Fig.4.5 *MQTT Message published*

The published message can be seen in the fig.4.5.Which shows

“ALERT ! ANIMAL MOVEMENT DETECTED CAUTION : DRIVE SLOWLY”

5. RESULTS AND DISCUSSIONS

The results obtained from object detection & MQTT message publish to the LED signage boards are as shown below. In Fig.5.3 you can see the accuracy is 0.9158 which is 91.58 %. And the total network error is diplayed in Fig.5.2

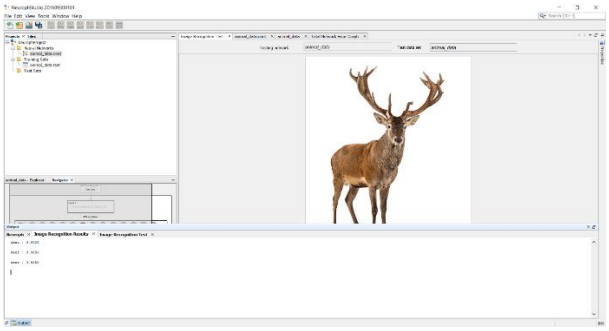

Fig. 5.1 *Objet recognition output*

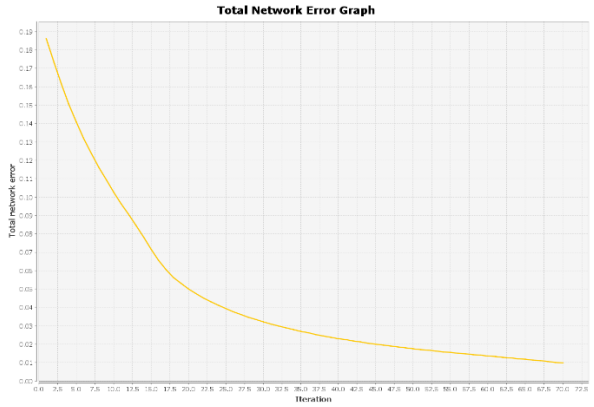

Fig.5.2 *Network error graph*

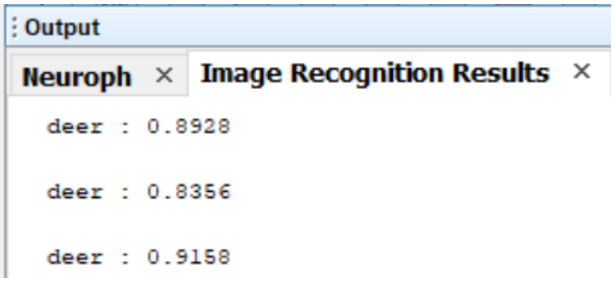

Fig.5.3 *Image recognition result (Accuracy)*

6. CONCLUSION

In this paper we have deeply analyzed the animal vehicle collision happening across the world. We have derived at a solution to prevent animal vehicle collision using IoT. We have used sensors such as the PIR sensor to detect motion and IP cameras to recognize the movement of animal. These sensors having satisfied with the condition sends message to the MQTT broker which in turn publishes the message to the LED signage boards placed across the roads which are animal crossing zone. Our paper uses the MQTT broker in cloud. The entire client server communication happens through the node.

7. FUTURE SCOPE

Our future scopeis to involve with the development of an adroid application which comes with maps and shows alert directly on the maps when the user is moving along the location. Also when the user crosses one zone to the other zone MQTT has to be unsubscribed from the current zone and be subscribed to the next zone, MQTT handoff is one biggest challenge which has to be addressed in future. Once the above two objective are developed the entire system has to be deployed in real time environment.

8. ACKNOWLEDGEMENT

Our thanks to all experts who have contributed to our research work.

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