Crop Protection against Animal Attacks using Closed Loop Perimeter Guarding & Alerting

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Abstract- *Intrusion of wild animals in the agricultural fields is increasing in day-to-day life. This leads to the reduction of agricultural yield, causes property damage and also loss of human life. This is a major and common issue for farmers having agricultural lands nearby the forest area. The traditional way of manually monitoring the animal intrusion is a complex, burdensome process and this requires more human effort, time and cost which is cumbersome. This clearly underlines the need for the implementation of efficient guarding system to identify, monitor and prevent animal intrusion into the agricultural field. It can be done with the help of Wireless Sensor Network and IoT. This paper is to develop a closed loop animal intrusion detection system with LASER assisted perimeter guarding method where the wireless sensor nodes are placed at the early warning region that is between the forest and the field.*

Keywords- WSN, animal intrusion, Perimeter guarding, Alerting

I. INTRODUCTION

The rising of global population results in higher food production demand. Agricultural lands are always under danger of attacks from various animals. Expansion of cultivated land into earlier wildlife area is the major factor of crop raiding which is becoming one of the most common inconsistency annoying human-wildlife relationships [30]. On the other hand, one of the main challenges facing wildlife conservation in the twenty first century is the increasing interaction between people and wildlife and the resulting conflicts that emerge. Crop fields specifically in the proximity of forest area, the issue of wildlife animals entering and destroying crop field has taken a major crisis situation. The total outcome of crop yield is dependent on how the crop is protected from the animal attacks. Insects, birds, and other intruders may cause damage to the crop from outside. The extensive damage to agricultural crops is caused by crop-raiding animals, and this is always a major issue of controversy all over the world [8].

Some of the socio-economic activities in certain areas lead to the reduced forest coverage which provides animals with lesser habitats and food. Due to these activities, the wild animals are started to raid on crops in crop fields, which results into a clash. Human beings want to survive likewise the wild animals need the same. This is a big challenge to bring conservation and production for both sides. The need for intrusions or crop raiding will be that reduced after the settlement of this issue. Raiding of crops by animals enhances ecological, economical and social sustainability so we need to promote co-existence without disturbing the wildlife habitat. The frequency of crop-raiding by animals is dependent upon several of conditions such as the variability, availability and variety of food resources in the region, event of human activity on a crop field and maturation time of plants.

TABLE I shows the crop damage caused by various wild animals in Kerala (India) and the survey is made by the researchers from different villages which shows that the crop damaged by the wild animals causes major and large economic loss [11].

TABLE I
Percentage of Crop Damage by Animals in Kerala (India)

Wild Animal	Crops	Percentage of crop damage
Elephant	Coconut, Plantain, Paddy	72%
Gaur	Mulberry, Sandal	62%
Sambar	White sapota	17%
Wild boar	Tapioca, tubers, paddy	16%

Fig. 1 shows the survey of elephant attacks in Mankanthpur Village (29023’30.47’’N & 7907’31.28’’E), which is located in the Ramnagar block of Nainital District in Uttarakhand in 2010.

Over 3 months of study, elephants damaged nearly 3.53 acre of crop land, mainly wheat, about 36 mature trees

are damaged across the village: 16 Banana plants, 11 Mango trees, and nine Litchi trees. Jackfruit trees are also smashed by the elephants. The elephants crushed the entire wheat plant without eating the whole plant. Onion seedlings were planted over most of the landholdings which were crushed by the elephants when they were travelled through the Onion plantations. Wheat is the main subsistence and cash crop which is broadly cultivated food crop in that area, it subjected to heavy spoil. Elephants are the reason for all these reported damage. The villagers also complained about minor damage by pigs and monkeys, however these animals were not supposed as the major crop raiders.

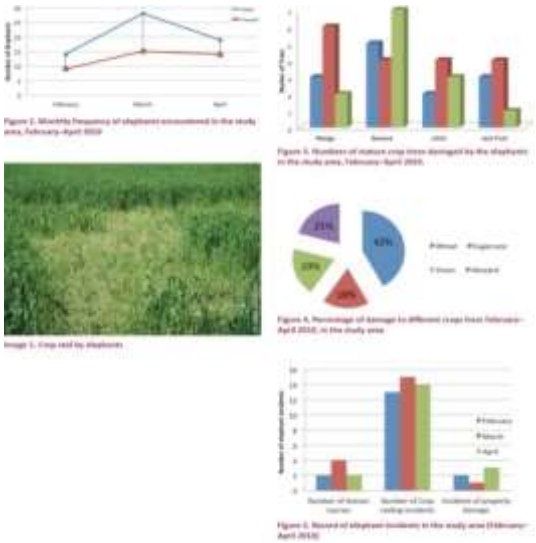

Fig. 1 Study on Elephant Raids in 2010 at Uttarakhand

II. RELATED WORK

Krishnamurthy B et al [16] describes the Agriculture meets food requirements of the people and produces several raw supplies for industries. But because of animal intrusion in agricultural lands, there will be huge loss of crops. Crops are susceptible to wild animals. Therefore, it is very important to monitor the presence of animals nearby crop field. Then repel the hazardous animals done by the actuation of various devices. They proposed a method to protect farms from wild animals using operational amplifier circuits which are utilized mainly for the detection of animal intrusion from the outside of farms. Early warning about probable intrusion and damage by wild animals is provided using this monitoring scheme. The Solar Electric Fence system is used as an alternative to traditional methods of fencing to protect your crops and possessions. Electric Fence is a useful way to reduce damages caused by animals but animals may get hurt due to the electric current.

Long et al proposed a method for controlling of passages which consists of placing cameras at the targeted areas which are activated by an infrared motion detector [17]. This method simply focused on the detection of animals which are getting close to the detector. It will result in covering a very small area, thus many animals are not detected. This structure of employing cameras having only one control point at the entrance which makes unfeasible to conclude whether the animal avoided the structure or not.

Spreading a layer of sand or marble dust on the ground and searching for trails on its surface is another common method [21]. But this method need of a huge effort to study the areas which should be inspected and smoothed on a daily basis, as a consequence it is limited to very small areas.

Burdett et al proposed a tracking method which is used to track consequences for valuable scenarios other than wildlife passages which can also be employed. In this system GPS receivers are attached to animals [5]. This method can be used for tracking animals over large areas, but it is not well suited for small areas due to the problem of passage surveillance. A few GPS-equipped individuals are also intrusive and restrict the studies of these systems.

Chourey S.R., Amale P. A. et al [6] described a review paper which provides the complete technical solution using wireless sensor network (WSN) and Internet of Things (IOT). The farmers are using this method to prevent their crops from animal attacks. It consists of all the types of like controller, sensors, and actuators where actuator is necessary for WSN whereas raspberry pi is the heart of the system.

Viani et al [31] proposed a Wireless Sensor Network (WSN) based designs which are mostly exploited to solve several real world problems. Starting from environment monitoring to advanced wireless localization services WSN based deigns is used in last decades. The wireless distributed system is used to detect wildlife road-crossing events which are used to prevent the problem of accidents with the approaching vehicles. The system is based on a WSN architecture which is deployed along the road sides in order to provide alert to the drivers about the presence of deers within a security area. The wireless network system nodes are integrated with Doppler radar modules. The system aims at providing the information for the smart management of road signs through their adaptive activation only in presence of real dangers.

Researchers at the University of Virginia and Carnegie-Mellon University have developed an energy-efficient WSN system in a stealthy manner for detecting moving vehicles through a passage line [10]. 70 MICA2 sensor nodes running on Tiny OS along a 280 feet long perimeter were

deployed by the authors. The sensor nodes consist of magnetometer, acoustic and photo sensors. By minimizing RF transmission and exposure to minimal, stealth capabilities were achieved. In this work, by assuming that the nodes' locations are known priori localization is done by trouble-free static configuration. The base station node time and all other node time are synchronized. Degree Of Aggregation (DOA) is the performance measurement which represent the system sensitivity.

III. PROPOSED METHOD

The proposed method is a closed loop perimeter guarding system is designed to notify detection of entry of animal in the crop field which is the first issue to be addressed. A technology assisted crop protection system is required which will be reliable, robust, cost effective, and easily adaptable by the farmers. The experiments conducted on the deployment of WSN nodes and animal intrusion detection outperforms other methods included in our performance comparison. Fig.2 shows the System Architecture of Proposed Work.

In the proposed work WSN nodes are equipped with RF module, vibration sensor, buzzer and light flashers. Between the forest and crop field two warning regions are implemented respectively with distance D1 and D2. The WSN nodes are placed between the early warning region 1 and warning region 2. At the warning regions LASER diodes and detectors are mounted at different heights in order to differentiate the height of animal. The central node is located at the center of the crop field which will monitor the animal intrusion and consequently activate the nearby nodes.

WSN nodes will be deployed at the corner of the field with respect to the area of the crop field, strategically chosen locations. The range covered by the individual node and the total area of the crop field will decide the number of nodes to be deployed in the field.

The sensors placed on the WSN nodes will locate the animal presence and divert it by activating flashers and sound devices based on the location. Central node sends alert to the forest office with respect to the vibration. Even when the animal bypasses the early warning region 1 and somehow reaches the warning region 2 central node will activate the flashers and sound devices connected on the region 2. Again, central node alert forest office and corresponding field owner. The sensor nodes in the nearby intrusion region will be activated by the central node while all other nodes are set in sleep mode in order to save power.

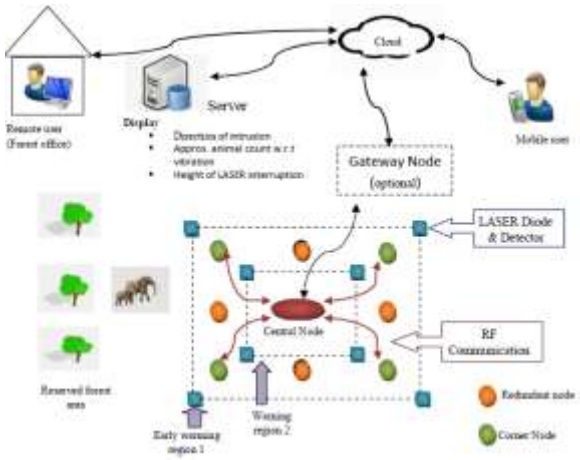

Fig.2 System Architecture of Proposed Work

The contribution of this system is to create a closed loop animal intrusion detection system, which is able to do sense, communicate and take prevention actions in an automated mode. If any intrusion occurs, the detector system will start alarms. Fig. 3 shows the main components of a Crop Protection system of a single node.

The central node of the system will localize all the nodes during the initialization with separate identifier. The information about a particular node which resides nearby fixed or anchor node is adequate to detect intrusion. Then the system shifts to a wait state. Any intrusion at the warning regions is detected by an array of LASER assisted system and is reported to central node. The central node then selects several of these nodes with specific identifier. After the node selection, the central controller sends them an action command.

At the same time, remote user will be informed with the intrusion present outside of the farm field. During this the buzzer and flash light are enabled to divert the animals. The foremost focus of all the commands of central controller is on power saving. Thus, sleep strategy is tailored to our needs by the central node.

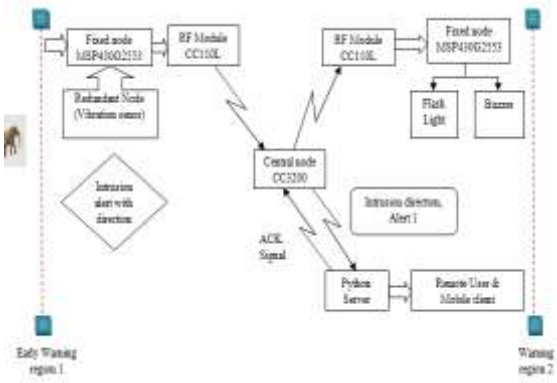

Fig. 3 Functional Diagram of Single Sensor Node

Fig. 3 shows the Functional Diagram of Single Sensor Node. Corner nodes equipped with sounding devices and flashers which are activated based on the intrusion direction. Besides this, a node is also responsible for forwarding any other nodes data to and from the source. The corner node is also responsible to monitor its battery level. The node should inform to the central controller, if the battery level falls below a prescribed value, inorder to activate the redundant node. This process is continued until a stop command is received from central controller.

IV. RESULTS AND DISCUSSION

In the proposed layout, LASER diodes and detectors are placed in opposite stands in both of the regions. The first pair of LASER beam is set at the height of 5cm and the second pair is set at the height of 20cm. This is to vary the size of animal. Fig. 4 shows the complete hardware setup of closed loop perimeter guarding method. In the layout, corner node, central node and redundant nodes are numbered in order 1, 2 and 3 respectively.

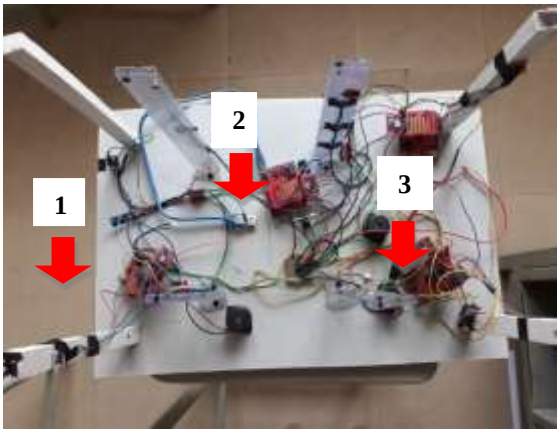

Fig. 4 Complete Hardware Setup

A single corner sensor node has the input from LASER module and provides output at buzzer and light. The redundant node is equipped with vibration sensor, buzzer and light. If the corner node failed of battery became down the nearby redundant nodes are activated to cover the field. The test results are shown in the following Table 2

Input and output voltages of LASER and vibration sensor are tabulated below.

TABLE 2 Test result of LASER Module

LASER Diode & Detector position	Layer 1		Layer 2	
	Input (V)	Output (V)	Input (V)	Output (V)
North- Pair 1	4.05	2.09	4.06	2.00
North- Pair 2	3.50	2.16	3.49	2.15
East- Pair 1	4.26	1.09	4.20	1.16
East- Pair 2	4.39	2.05	3.55	2.16
West- Pair 1	3.29	1.99	4.10	2.00
West- Pair 2	3.50	2.15	3.99	2.16
South- Pair 1	4.05	2.09	4.06	2.00

Redundant node test result is shown in following Fig. 5. The rising time gives the knowledge about the occurrence of vibration.

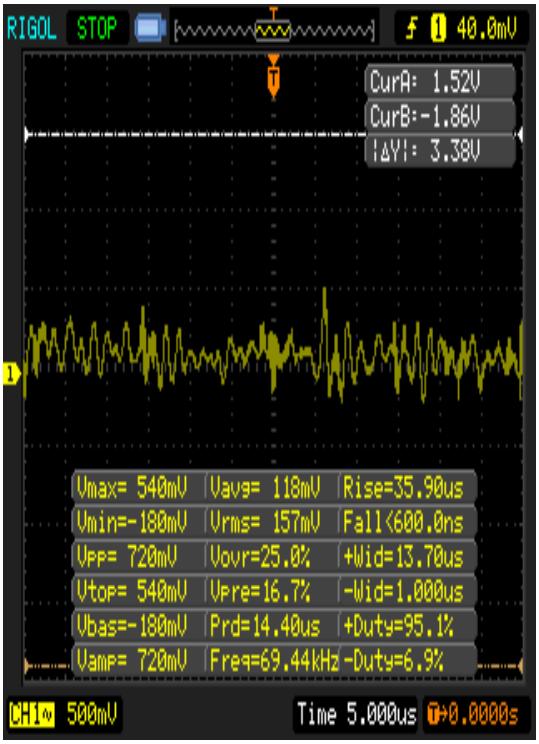

Fig.5 Test Result of Redundant Node

Once the intrusion is detected the nearby node will activate sounding device and light. Alert message about the animal intrusion will be sent to the user through mail. For example, if East side node is intruded by animal following mail will be sent to user and monitor will display the alert message. Fig. 6 and Fig. 7 shows the serial monitor and mail display respectively.

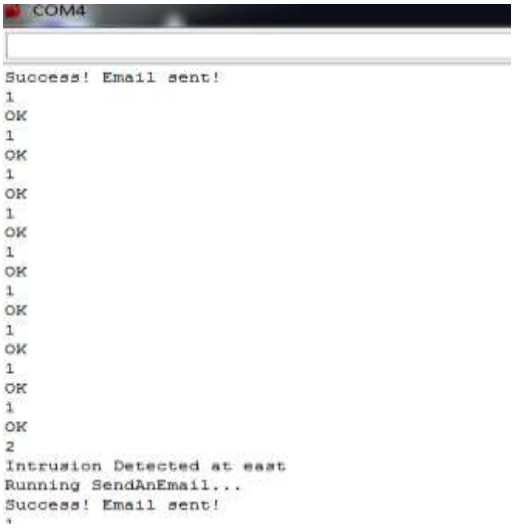

Fig. 6 Serial Monitor Output

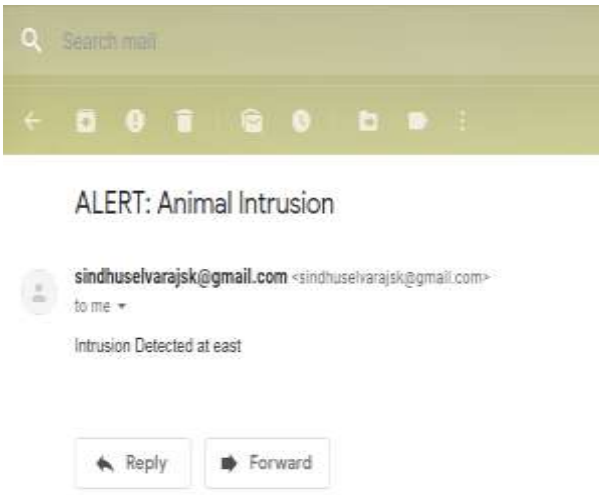

Fig. 7 Mail Alert

The coverage area and speed of detection is improved to 11.88m and 100-200ms respectively. The power achieved for the detection at early warning region is 2.517V (+12dBm). Less than 40% of crops may be damaged because of the redundant node installation.

V. CONCLUSION

The crop fields require protection from the animal attacks in order to meet rising food production demand. To protect and bring about a sustainable environment between human and animal requires the collective effort of the public and the government. The detection and diversion of animals will protect crops from animal attacks which will maintain ecological balance with the help of WSN and IoT technologies. The Sleep modes will minimize the power requirement of the system wherever necessary. Currently, focus is given to the design of intrusion detection system outside the field area to enhance the system robustness and reliability.

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