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Design and Development of Ultrasonic and IR Insect Detector for Oilseeds Crop

[1]Kanishk Sisodiya, [2]Mandeep Singh
[1]Electronic Product Design and Technology, C-DAC, Mohali, Punjab, India
[2]Digital Electronics & Communication Division, C-DAC, Mohali, Punjab, India

Abstract
In India each year, insects cause a massive economic loss. Hidden swarm of insects attacks plants slowly but it cause enormous loss in agriculture field. If, however, these insects can't be detected in their early stage and farmer could use the pesticides and insecticides without knowing whether insects are there or not. Then this could decrease the economical state.
This paper presents the design of an Ultrasonic insect detector that comprises of an ultrasonic sensor, an infrared sensor and a GSM module in which ultrasonic sensor will detect the sound of insects by detecting ultrasonic signals generated by the feeding event of insects in crops. After that the presence of insects will be confirmed by the heat radiated by the insect's body through infrared sensor. Once the presence of insect is confirmed by both the sensors a message will be sent by using GSM module in which it will inform the farmer about the presence of insects after that farmer can use pesticides or insecticides according to their crops. This research not only helps the farmers but also increase the agriculture productivity.

Keywords
Ultrasonic, Passive Infrared, GSM, Pesticides

I. Introduction
Oilseed crop is an important part of commercial crops in India. In the world India has major area in the production of oilseeds. Five major oil seeds like groundnut, sesame, mustard and castor seed, rapeseed and linseed taken 212.24 lakh hectares (2002-03) which is over 15 per cent of the net area sown. Other than area covered by oilseeds like soybean, sunflower etc. also included and area covered by them becomes about 20 percent of the net area sown. Due to insect pests the estimated losses was given as rupees 689400 millions to major crops in India as shown in Table 1 [1].

To increase the oilseeds production in India, we will have to adapt the technologies that will not only protect our crops from insects but also standardize the balanced crop nutrition. There are only few states like Madhya Pradesh, West Bengal, Haryana and Rajasthan that will increase their oilseed production through productivity and through area expansion. Whereas states like Himachal Pradesh, Maharashtra and Tamil Nadu increased their output via productivity.

India ranks 2nd in global population index and ranks 7th in land mass [1]. Agriculture is the backbone of Indian economy. Therefore, with the increase in population the daily needs of resources also increases. For increasing agriculture productivity, the use of chemical fertilizers and pesticides has played an important positive role. In India, about 3% of the total pesticides reflect that cotton crop only devour 44.5% pesticides followed by rice, which consumes only 22.8%. In India, these two crops consume more than two thirds of the total quantity of pesticides. For satisfactory performance of pesticides, the proper application of pesticides is necessary in the field. Therefore to understand when and how much pesticides and insecticides will be used, we are implementing this hardware, so that we can increase its productivity.

Table 1: Estimated Losses Caused by Insect Pests to Major Crops in India [1]

Crop	Actual production (million tonnes)	Approximate estimated loss in due to insect pests (%)	Approximate estimated loss in due to insect pests Total (million tonnes)	Hypothetical Production in the absence of losses due to insect pests (million tonnes)	Monetary value of estimated losses (million rupees)
Rice	93.1	25	31.0	124.1	164300
Wheat	71.8	5	3.8	75.6	23560
Maize	13.3	25	4.4	17.7	21340
Other cereals	20.6	30	8.8	29.4	42680
Chickpea	5.3	10	0.6	5.9	7200
Other pulses	7.9	20	2.0	9.9	26400
Groundnut	6.9	15	1.2	8.1	16080
Rapeseed and Mustered	5.0	30	2.1	7.1	27300
Other Oilseeds	8.6	20	2.2	10.8	26400
Sugarcane	300.1	20	75.0	375.1	46540
Cotton(lint)	10.	50	10.1	20.2	287600
					689400

By visual inspection, discovery of infestations in early stages is time consuming and ineffective as the number of insects are small and tiny and usually hidden from view. The finding of insects using ultrasonic and PIR device is detected by PIC16F877A microcontroller.
Human beings cannot sense ultrasonic frequency, but most of the animals can produce and hear ultrasonic frequency. Even several insects can communicate through these frequencies like bats, rodents, insects, etc. Flies, spiders, etc can detect Ultrasonic frequency through "Tympanic membrane". Cockroaches can sense via "Sensory hairs". The response to Ultrasonic frequencies of animals given below:-

- 22-25 kHz: Dogs, Cats
- 38-44 kHz: House Fly, Spiders, Fleas
- 52-60 kHz: Lizards
- 60-72 kHz: Rats

Ultrasound frequency is biologically safe for human beings but frequency closer than 30 kHz is able to sense by children. The insect detection system detects the insect activity by detecting sound generated by insects in the audio frequency range (20 – 20,000Hz). "Acoustic Emission" technology can be advantageously used in detecting insects. This technology has been primarily used in non-destructive testing of metal parts and assemblies. Researchers found that using Acoustic emission technology we can detect the feeding insects that produce ultrasonic signals. As an insect feeds, it tears the fibrous tissue which creates mechanical disturbances which propagate throughout the material on which the insect is feeding. These mechanical disturbances produce ultrasonic waves which can be detected by the Acoustic Emission technology. Taking a "bite" out of the material will be defined as a "feeding event".

II. Types of Oilseeds Crops and Their Insects [2]

A. Groundnut (Arachis Hypogaea Linn.)

Except from groundnut crops it is also feeds on Rhynchosia minima (Fabaceae), sorghum, Pennisetum typhoideum L., finger-millet, cotton, castor, etc as shown in fig. 1 [3].

Fig. 1: Bihar Hairy Caterpillar and Castor Spiny Caterpillar on Castor Crop [3]

B. Mustard (Brassica Campestris)

1. Mustard Sawfly Athalia Lugens Proxima (Klang) (Tenthredinidae: Hymenoptera)

Fig. 2: Mustard Aphid and Lipaphis Crysimi on Mustard Flowers [4]

Distribution: This is one of the very few hymenopterous insects noticed to infest Cruciferous crops all over India. It is a pest of cold weather, generally active during October to March as shown in fig. 2 [4].

C. Coconut (Cocos nucifera)

1. Rhinocerosbeetle Oryctes rhinoceros L. (Scarabaeidae: Coleoptera)

Distribution: It is widely distributed in India and persistent in all coconut growing areas.

2. Red palm weevil Rhynchophorus ferrugineus (Curculionidae: Coleoptera)

Distribution: This is one of the important pests of coconut in India in Kerala, Karnataka, Goa, Tamil Nadu and Andhra Pradesh and its attack often results in the death of the palm.

III. Previous Work

According to their appearance and their sound production, insects are mainly categorized as species specific. Using trapping and observation methods the location and species recognition of insects usually done manually. But identification and detection of insects is highly complex procedure [5].

Ultrasonic devices emit short wavelength, high frequency sound waves i.e. too high in pitch and not audible by human ear as all these frequencies are greater than 20,000 Hz. Human can't hear ultrasound but animals such as dogs and rodents can hear well and also some insects, such as grasshoppers and locusts can detect frequencies from 50,000 Hz to 100, 00 Hz, and moths and lacewings can detect as high as 240,000 Hz [6].

Todor et al. [7] implemented a bio- acoustic automatic detector of a catastrophic pest attacking palm trees, appeared in Mediterranean countries. In this method, they used piezoelectric sensor which is inserted in the trunk of tree and they record feeding power of the insect. This system is portable and tested on-site in a real field setup with minor human intervention.

A warning system was designed to alert the animals, so that they could leave the road before they struck by the vehicle's sound and light that may be heard and seen by an animal ahead of moving vehicle [8].

Richard E. Shade, et.al. [9] designed an apparatus and method for detecting insects by detecting ultrasonic signals using acoustic emission technology.

Silva et.al [10] presented an intelligent trap that catches the insects using a laser sensor for selectively classification of insects so that we can control the population of harmful insects and enhance the beneficial effects.

Hulya Yalcin et al. [11] designed a low labour cost and gives accurate record of the insects count and their type. This method could discriminate and classified the insects under the trap using computer vision and machine learning algorithms.

Subhodip Maulik [12] designed a low cost wireless device that capture a photo using CCD camera, detects diseases and pest in crops by sending and receiving the signal from the base station and verification done by via a Bluetooth module.

The use of X-ray and NIR (near- infrared) spectroscopy has been used to identified the hidden insects. An image analysis program had been developed to automatically scan X-ray images, so that they detect the infestations insect [13].

In this research paper, Potamitis et al. [14] represented equipment which automatically recognized the acoustic insects. Basically it identified the different characteristics of target insect family with the help of the acoustic patterns e.g. cricket family.

A low cost and effective electronic trap was designed for insect pests, which was distressful for the cultivation of crops for the farmers. In this system the insect pest trapped by the electronic device sends the images of those insects. This system was powered by the solar panel and the battery [15].

In this research, authors discussed the phytochemicals of sunflower plant. Also discussed, how to analyze and identify the leaves and their insect's effect [16].

This research reviews the different sound generating mechanisms like percussion, clicks mechanism, etc. in insects and also described the hearing organs such as hair sensillae etc. [17]

An efficient acoustic device was designed to detect the feeding

larvae in grains. The piezo microphones were used in the wooden box which was more sensitive than larvae generated signal between 2 and 6 kHz [18].
S.J. Kolte reviews the several diseases, insect pests of mustard plant and how to diagnose these diseases and pest insect [19].
Dhaliwal et al. reviews the crop losses due to insect pests and also described the importance of changing crop production and crop protection technology [20].
B.K. Rai reviews the pests of major oilseeds crops in India and how to take protective measure to control the growth of pests, chemical control using pesticides and biology of individual pests in oilseeds crop also discussed [21].

IV. Proposed Design

A. Ultrasonic insect detector comprises of an ultrasonic sensor, an infrared sensor and a GSM module in which ultrasonic sensor will detect the sound of insects by detecting ultrasonic signals generated by the feeding event of insects in crops and heat radiated by them. The various aspects for the need of this method are:

- Its effects on human health for long time.
- Its great effect on environment.
- Increase the productivity.
- Decrease the use of unnecessary pesticides.
- Probability to make a test in field conditions.

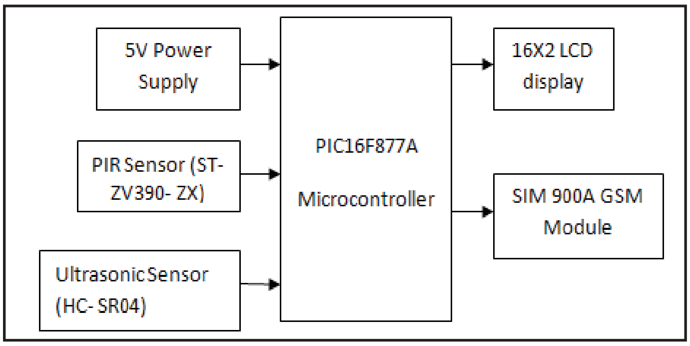

Fig. 3: Basic Block Diagram of System

1. Ultrasonic Sensor

Ultrasonic sensors are used to convert ultrasound waves into electrical signals. There are the transducers that both receive and transmit ultrasound waves and are called as ultrasound transceivers. Above the limits of human audibility, the source of ultrasonic waves is sound waves. Ultrasound is divided into three categories depending upon frequency, namely, as a) power ultrasound (20 KHz-100 KHz) b) high-frequency ultrasound (100 KHz-1MHz) and c) diagnostic ultrasound (1MHz-50 MHz). The insect detection system detects the insect activity by detecting sound generated by insects in the audio frequency range (20 – 20,000Hz). "Acoustic Emission" technology can be advantageously used in detecting insects. This technology has been primarily used in non-destructive testing of metal parts and assemblies. Researchers found that using Acoustic emission technology we can detect the feeding insects that produce ultrasonic signals. As an insect feeds, it tears the fibrous tissue which creates mechanical disturbances which propagate throughout the material on which the insect is feeding. These mechanical disturbances produce ultrasonic waves which can be detected by the Acoustic Emission technology. Taking a "bite" out of the material will be defined as a "feeding event".
At ultrasonic frequencies, most human activities do not generate much acoustic energy. Therefore, the sounds detected by the transducer are those, caused by the tearing off plant tissue, occur during insect feeding. The action of the insect's mouthparts tearing the material is directly related to the ultrasonic mechanical disturbances.

2. Pyroelectric Sensors

All objects in the world radiate heat if they have a temperature greater than absolute temperature. The radiation is in the range of infrared radiation.
Passive Infrared (PIR) sensor is also known as Pyroelectric or IR motion sensor. PIR sensor is used to detect motion whether human or animal has moved in or out of the range of sensor. The PIR sensor is made of a crystalline material; it produces infrared radiation when the surface is exposed to heat which generates an electric charge.

3. Construction

A Fresnel lens based assembly is placed at the front for the collection of radiation that is called as Sensor Face. The Fresnel lens improves the area of operation of the sensor. The core of PIR motion sensor consists a set of Solid State sensors made off pyroelectric materials. A pyroelectric material generates energy when exposed to heat.

4. Working

Generally the PIR sensors detect the change in amount of radiation corresponding to the environment in front of the sensor. For example in this work the sensor will be focused on a baby in cradle. When there is a movement in an insect the temperature starts varying from body temperature to surrounding temperature. This will cause a change in output voltage of sensor and trigger the detection.

B. The presence of insects will be confirmed by the heat radiated by the insect's body through infrared sensor and the sound generated by the insects detected via ultrasonic sensor. Once the presence of insect is confirmed by both the sensors a message will be sent by using GSM module in which it will inform the farmer about the presence of insects after that farmer can use pesticides or insecticides according to their crops.

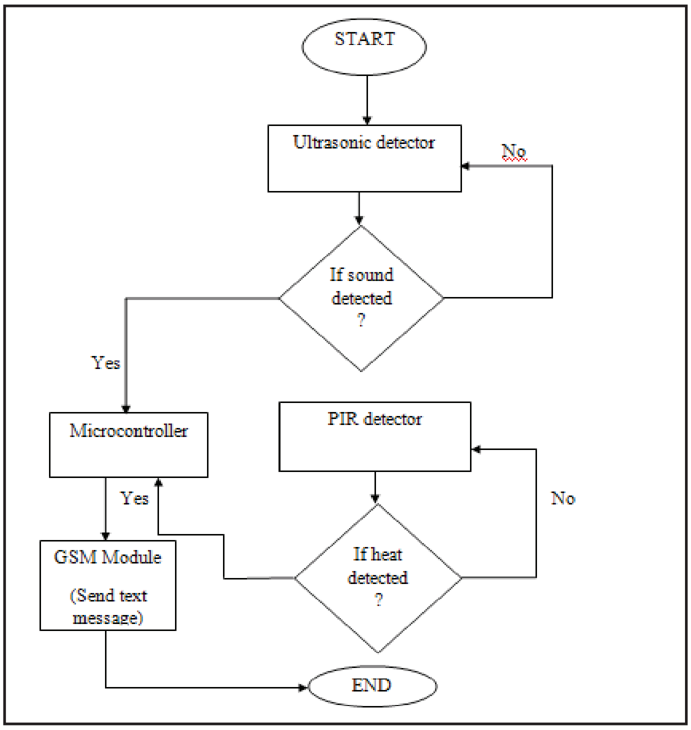

Fig. 4: Methodology of System

V. Experiments and Results

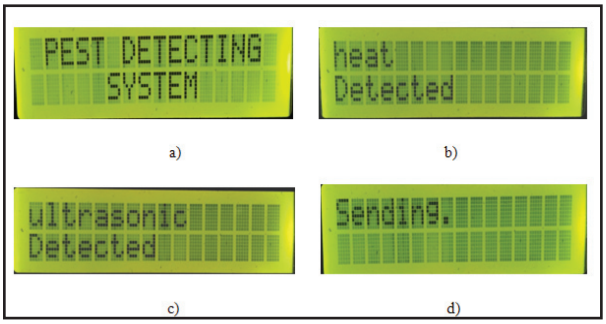

Fig. 5: Testing of Insect Detection System

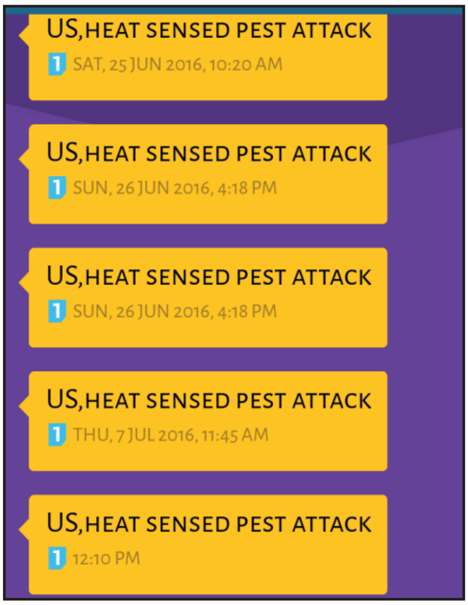

Fig. 6: Results of Insect Detection System

A. In fig. 5, testing of insect detection system has been shown, where (a) shows the welcome message i.e. "Pest Detection System" when system is on, (b) shows the activation of PIR sensor via displaying "heat detected", (c) shows the activation of ultrasonic sensor and displayed "Ultrasonic detected" both the sensor get activated when insect attack the crops and (d) shows the activation of GSM module to alert the farmer by "Sending" message.
The fig. 6 shows the message i.e. "US (Ultrasonic) heat sensed Pest attack", which is sent to the farmer when insect pest attack on to the oilseed crops.

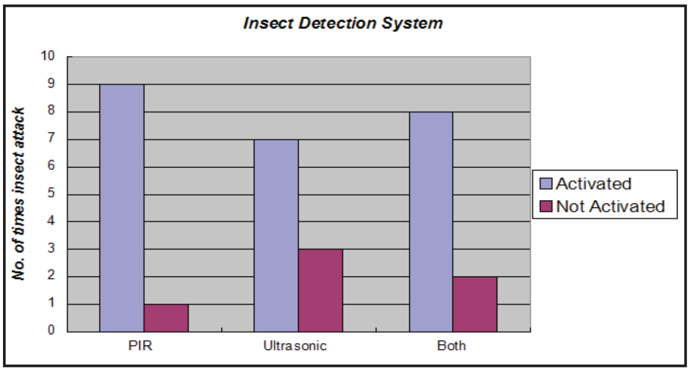

Fig. 7: Status of Sensors Based on Insect Attack on Oilseeds Crop

B. Fig. 7 represents the status of sensors used in this system based on insect attack. It tells whether sensors are activated or not activated when insects attack on the oilseed crop at different time intervals. When 10 times insects attack on to the crops, we checked the status of sensors i.e. PIR sensor and ultrasonic sensor gets activated only 9 and 7 times respectively, where only 8 times both the sensors are activated.

VI. Conclusion

Development of a nation directly depends upon infrastructure availability. As all mechanical systems are likely to protect us from unnecessary use of pesticides and insecticides in the crops and alert the farmers in real time for modern use of application, so that it can increase the productivity of crops. It is not only an Ultrasonic insect detector device but uses a relatively new modality of IR sensor that helps to detect the insect via their body temperature and sends a message to farmer's registered phone number. So that he can use pesticides and insecticides accordingly. Therefore this research helps to alert the farmers to increase the productivity of oilseeds crops.

VII. Future Scope

In this work the main focus is to aware the farmers regarding insects and use of insecticides. The system has microcontroller based charge controller circuitry in it. As per the latest technology development there are some various implementations which can enhance system practicality and productivity:

In future consideration, memory unit can be interfaced to develop database for different insects.
Some other sensors can be interfaced to get more accurate result.
Use of image processing so that we can take snapshots of insects in real time.

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Kanishk Sisodiya has done her bachelor of technology degree in Electronics and Communication engineering with first division from NIMS University, Rajasthan in year 2012 and currently pursuing his Master of Technology degree in Electronics Product Design & Technology from CDAC, Mohali. Her areas of interests are microcontrollers, Analog and digital electronics.

Mandeep Singh is currently associated as an Engineer with Centre for Development of Advanced Computing (A Scientific Society of the Ministry of Communications and Information Technology, Govt. of India), Mohali, Punjab, India where he is leading the research and development activities in embedded systems for biomedical applications and ubiquitous computing. He received his Bachelor of Technology in 2003 and Master of Technology in 2008 in Electronics and Communication Engineering respectively. He has more than 10 years of experience in various geographies He has published about 22 papers in international/national journals and conferences and guided 20 M.Tech thesis. He is the recipient of most innovative product award (Year 2013) at IESA Technovation Awards- 2013 held at Bangalore, awarded by India Electronics and Semiconductor Association.