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A Real-Time Electronic System with Zigbee for the Prevention of Rodent in Agricultural Fields

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ABSTRACT: Rodents, in particular rats contribute to a major loss to crops and stored foods. Due to the damage of crops and storage foods, millions of people do not have an access to sufficient food which in turn effects to the growth of the country. To overcome these problems, we have designed a model that incorporates four main techniques to drive away the rats from fields or from food storage unit. The first technique is using an ultrasonic transmitter which continuously produces variable frequencies such as 30 kHz, 35 kHz and 40 kHz to distress the rats. The second technique uses a pumping unit which pumps the peppermint oil to spread the odour of the oil in air. The third technique has a voice record and playback system which generates sounds of cats, snakes etc., at regular intervals of time to frighten the rats. The last technique is to use a PIR sensor placed inside the cage to detect the movement of the rats. If a movement is detected the stepper motor closes the door and the rat is trapped inside the cage and simultaneously this information is sent to the monitoring unit via zigbeewhich displays the message "RAT TRAPPED" in LCD and a buzzer is triggered.

KEYWORDS: Ultrasonic transmitter, voice record and playback system, Microcontroller, Zigbee, PIR sensor, pumping unit

I. INTRODUCTION

Dated back around 10,000 years ago, since human beings started cultivating cereals and rice etc., the rodent control has been a major area of focus, as the rodents eat up the crops and the stored foods.

In India, around 25% of total food grain is lost in pre-harvest and around 30% in post-harvest due to rodents, bringing a loss of at least $5 billion annually [1]. If the above harvest losses were prevented, it leads to lowering of the food prices and provides sufficient food to feed the millions of people dying due to hunger. According to World Food Programme (WFP), around 805 million people do not have enough to eat. Poor nutrition causes nearly half (45%) of deaths in children under five years i.e., 3.1 million children each year [2].

Rodents even leave their droppings and hairs in an area which if ingested by human beings causes many bacterial, viral and protozoan diseases. They eat almost everything and reproduce very fast (the population becomes four times larger in 75 days). Even a country as "developed" as Britain recently discovered that it had as many rats as people. In many parts of the world, they are an everyday menace, eating crops and stores of food, biting people as they sleep and spreading diseases [3].

There is still no existing advanced technology that can flee rats from agricultural fields. However, there are traditional methods to drive them away but they prove to be ineffective many times, such as by using rodenticides, the body of rodents gets resistant to it.

II. RELATED WORK

The author of this paper designed and developed a model to meet the demands of monitoring, and controlling of pest rodents in rural areas in China. The system includes three sub-systems: data collection software on the basis of PDA+GPS, information management system and information query system for rodent spatial distributing

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characteristics based on WebGIS (Web Geographic Information System). The data collecting software, consists of 2 modules (night trapping method module and valid holes method module), can be used to record pest rodents field-monitoring data binding with position data and transfer the data to the database as main data source of the system. The information management system can manage the data recorded by PDA and provide data for WebGIS system.The information query system can provide various spatial distribution characteristics of pest rodents to users and assist users to primarily determine pest rodent's trends by a multi-criteria query function. The system is integrated with the data recording, transferring, managing, and providing information query services [4].

In this the author has developed the ultrasonic repelling device to solve the problem in controlling the population of rats and scare them away from entering paddy field. This system uses Passive Infrared Sensor (PIR) to detect the motion of rat up to 20 feet away by using a Fresnel lens and infrared sensitive element to detect changing patterns of passive infrared emitted by objects in its vicinity. The detection of the ultrasonic repelling device is controlled by PIC16F876A microcontroller. The microcontroller gets its input from detector circuit and the output emits high frequency ultrasonic wave to expel intruding rats away [5].

III. PROPOSED DESIGN

The Node unit shown in figure 1 is divided into the following parts:

- PIR sensor
- Microcontroller
- Ultrasonic transmitter
- Voice recorder and playback unit
- Pumping unit and External Fan
- Zigbee
- LCD

Study says that high range ultrasonic frequencies around 32 kHz to 62 kHz tend to disturb or distress the rats[6]. Hence this proposed system consists of two ultrasonic transmitters: one above the ground and one underground. The ultrasonic transmitters produce variable frequenciessuch as 30 kHz, 35 kHz, 40 kHz so that the rats don't get habituated to it. Simultaneously voice record and playback system generates sounds of cats, snakes and other animals to frighten the rats. The switching of sounds and ultrasonic frequencies from one to another has time duration of approximately 45seconds.

The system has a pumping unit immersed in peppermint oil to spread the odour of the oil with the help of external fan connected to the microcontroller.

Passive infrared sensor placed inside the cage is connected to the microcontroller via NOT gate. PIR sensor is triggered when the motion is detected and sends the signal to the microcontroller causing the stepper motor to close the door and hence the rat is trapped in the cageand simultaneously this information is sent to the monitoring unit via Zigbee.

The monitoring unit as shown in figure 1 is divided into the following parts:

- Zigbee
- LCD
- Buzzer

The information sent from the node unit saying that rat is trapped in the cage is received via zigbee and given to the microcontroller which displays the message in the LCD as "RAT TRAPPED" and simultaneously buzzer is activated.

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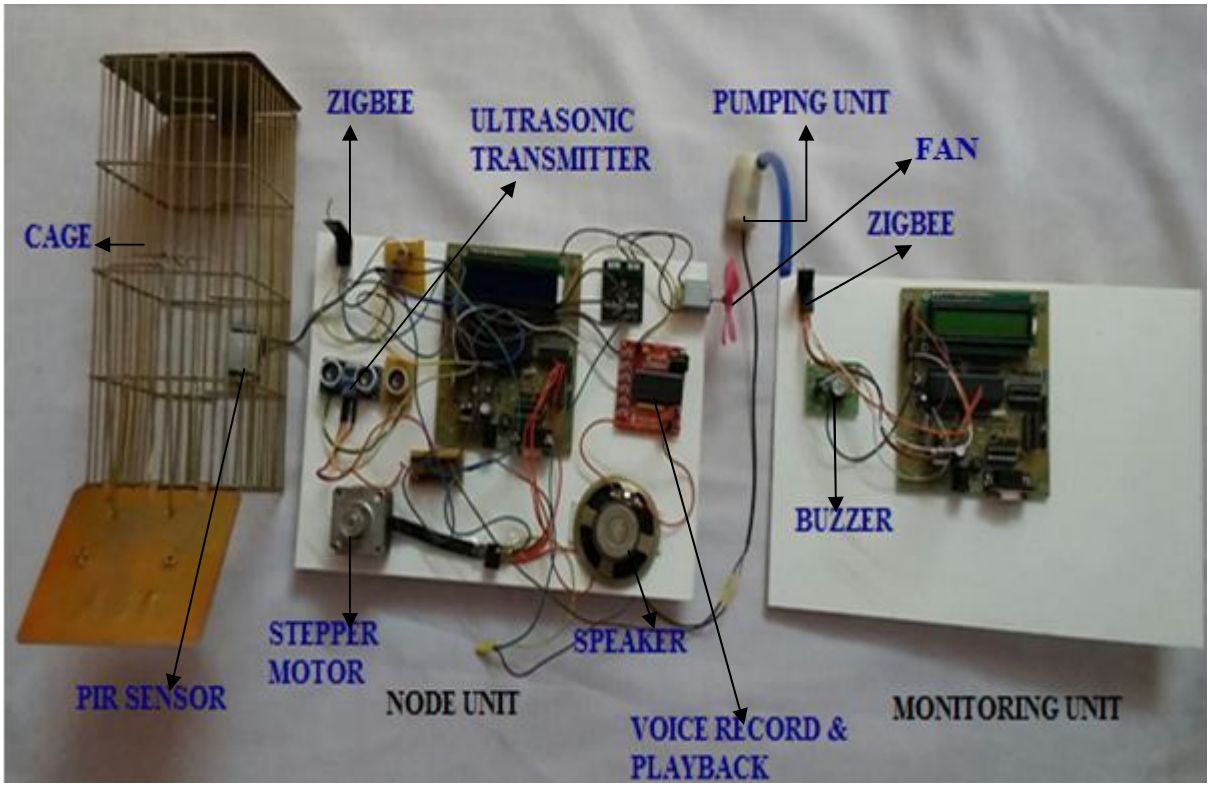

Figure 1: Prototype

IV. HARDWARE DESCRIPTION

PIR sensor (Passive Infrared Sensor): An individual PIR sensor detects changes in the amount of infrared radiation impinging upon it, which varies depending on the temperature and surface characteristics of the objects in front of the sensor. When an object, such as a human, passes in front of the PIR sensor temperature at that point in the sensor's field will rise from room temperature to body temperature, and then back again. The sensor converts the resulting change in the incoming infrared radiation into a change in the output voltage, and this triggers the detection. Moving objects of similar temperature to the background but different surface characteristics may also have a different infrared emission pattern, and thus sometimes trigger the detector. Figure 2 shows a PIR sensor module: DYP-ME003 SEN005.

Figure 2: DYP-ME003 SEN005

Ultrasonic transmitter: Figure 3 shows aHC-SR04 ultrasonic sensor that uses sonar to determine distance to an object like bats or dolphins do. It offers excellent non-contact range detection with high accuracy and stable readings in an easy-to-use package from 2cm to 400 cm or 1 to 13 feet. Its operation is not affected by sunlight or black material like Sharp rangefinders are (although acoustically soft materials like cloth can be difficult to detect). It comes complete with ultrasonic transmitter and receiver module.

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Figure 3: HC-SR04 Ultrasonic Sensor

Voice Record and Playback: The ISD1700 is designed for operation in either standalone or microcontroller (SPI) mode. The device incorporates a proprietary message management system that allows the chip to self-manage address locations for multiple messages. This unique feature provides sophisticated messaging flexibility in a simple push-button environment. The devices include an on-chip oscillator (with external resistor control), microphone preamplifier with Automatic Gain Control (AGC), an auxiliary analogue input, antialiasing filter, Multi-Level Storage (MLS) array, smoothing filter, volume control, Pulse Width Modulation (PWM) Class D speaker driver, and current/voltage output. Figure 4 shows the image of ISD1760PY voice record and playback module.

Figure 4: ISD1760PY Chip

Pumping unit: A pumping unit is shown in figure 5**.** Pumping unit is placed inside the peppermint oil which pumps the oil. The pumping unit consists of DC Motor to rotate the fan connected to the shaft inside the pumping unit. The fan directs the incoming oil towards the outlet. It requires 5V DC power supply for its operation.

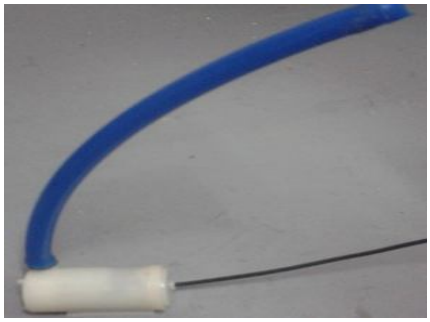

Figure 5: Pumping Unit

Zigbee: ZigBee is a wireless networking standard that is aimed at remote control and sensor applications which is suitable for operation in harsh radio environments and in isolated locations.ZigBee technology builds on IEEE standard 802.15.4 which defines the physical and MAC layers. Above this, ZigBee defines the application and security layer specifications enabling interoperability between products from different manufacturers. In this way ZigBee is a superset of the 802.15.4 specification. Figure 6 shows USB UART Serial port Wireless 2.4G Module replace Zigbee APC220 NRF24101 + CC1101 which is used in the model.

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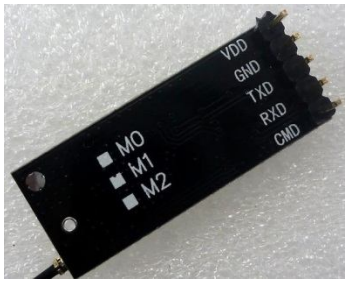

Figure 6: USB UART Serial port Wireless 2.4G Module replace Zigbee APC220 NRF24101 + CC1101

AT89S52 Microcontroller: The AT89S52 is a low-power, high-performance CMOS 8-bit microcontroller with 8K bytes of in-system programmable Flash memory. Figure 7 shows an at89s52 microcontroller. The device is manufactured using Atmel's high-density non-volatile memory technology and is compatible with the industry-standard 80C51 instruction set and pin out. The on-chip Flash allows the program memory to be reprogrammed in-system or by a conventional non-volatile memory programmer. By combining a versatile 8-bit CPU with in-system programmable Flash on a monolithic chip, the Atmel AT89S52 is a powerful microcontroller which provides a highly-flexible and cost-effective solution to many embedded control applications.

Figure 7: at89s52 Microcontroller

LCD (Liquid Crystal Display): Figure 8 shows a Hitachi hd44780 LCD controller with 16×2 compatible LCD screen. The principle behind the LCD's is that when an electrical current is applied to the liquid crystal molecule, the molecule tends to untwist. This causes the angle of light which is passing through the molecule of the polarized glass and also cause a change in the angle of the top polarizing filter. As a result, a little light is allowed to pass the polarized glass through a particular area of the LCD. Thus that particular area will become dark compared to other. The LCD works on the principle of blocking light. While constructing the LCD's, a reflected mirror is arranged at the back. An electrode plane is made of indium-tin oxide which is kept on top and a polarized glass with a polarizing film is also added on the bottom of the device. The complete region of the LCD has to be enclosed by a common electrode and above it should be the liquid crystal matter.

Figure 8: Hitachi hd44780 LCD controller with 16×2 compatible LCD screen

Buzzer: Piezo buzzer is an electronic device commonly used to produce sound. Figure 9 shows the image of ps1240 buzzer. Light weight, simple construction and low price make it usable in various applications like car/truck reversing indicator, computers, call bells etc. Piezo buzzer is based on the inverse principle of piezo electricity discovered in 1880 by Jacques and Pierre Curie. It is the phenomena of generating electricity when mechanical pressure is applied to

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certain materials and the vice versa is also true. Such materials are called piezo electric materials. Piezo electric materials are either naturally available or manmade. Piezo ceramic is class of manmade material, which poses piezo electric effect and is widely used to make disc, the heart of piezo buzzer. When subjected to an alternating electric field they stretch or compress, in accordance with the frequency of the signal thereby producing sound.

Figure 9:ps1240 Buzzer

V. ALGORITHM

Algorithm for Node unit:

Step1: Stepper motor OFF.
Step2: Initialize UART for 9600 baud rate.
Step3: Initialize LCD.
Step4: Display “Project Name”.
Step5: Enable Timer2 (for ultrasonic transmitter).
Step6: Enable Timer0 (for voice record &playback).
Step7: Choose Timer2 values for 40 KHz frequency.
Step8: Enable Timer2 interrupt.
Step9: Give priority for Timer 0 and Timer 1(used for serial communication).
Step10: Start Timer2.
Step11: Enable Global interrupt.
Step12: Enable Timer0 interrupt.
Step13: Start Timer1 for baud rate.
Step 14: Go for Infinite while loop.
Step 15: Increment counter.
Step 16: Display counter value in second line.
Step 17: If counter greater than 5, trigger play button and increment counter2.
Step 18: If counter 2 greater than 5, trigger button to change channel.
Step 19: Also change Ultrasonic frequency to 30 kHz, 35 kHz and 40 kHz one after the other.
Step 20: Check for PIR sensor.
Step 21: If motion detects, disable interrupts, rotate stepper motor clockwise and anti-clockwise and transmit char ‘A’ using Zigbee.
Step 22: Enable interrupts.
Step 23: Repeat from Step 15.

Algorithm for monitoring unit:

Step1: Initialize LCD.
Step2: Initialize UART.
Step3: Go for infinite loop.
Step4: Wait until it receives char ‘A’.
Step5: Compare the received data with template when it receives char ‘A’.
Step6: Turn on buzzer if data matches.
Step7: Display the message in LCD.
Step8: Continue from Step 4.

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VI. RESULTS

Figure 10 shows the LCD at the node unit displaying the delay between sounds played by the voice record and playback system.

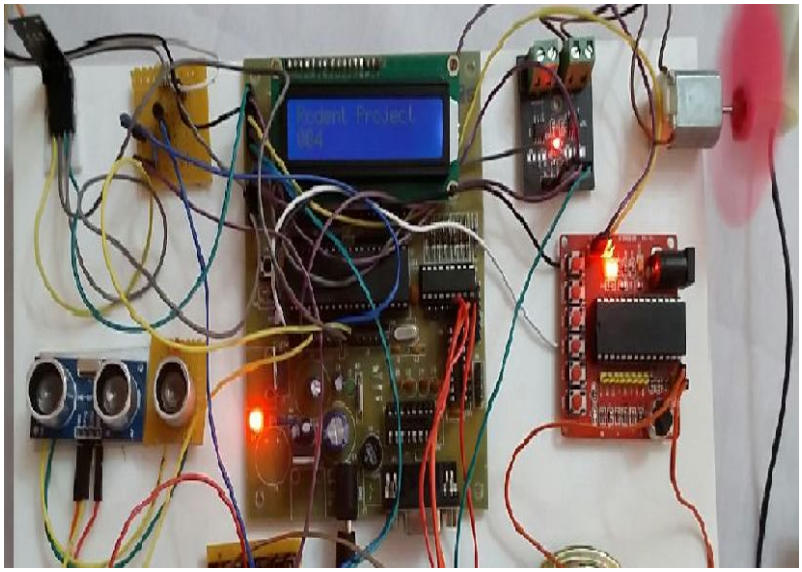

Figure 10:LCD displays the time interval between sounds

Figure 11 shows the LCD at the monitoring unit displaying “Rat Trapped” when PIR sensor senses the presence of rat in the cage and subsequently the cage gets closed trapping the rat at the node unit and buzzer is triggered in the monitoring unit to alert the farmer.

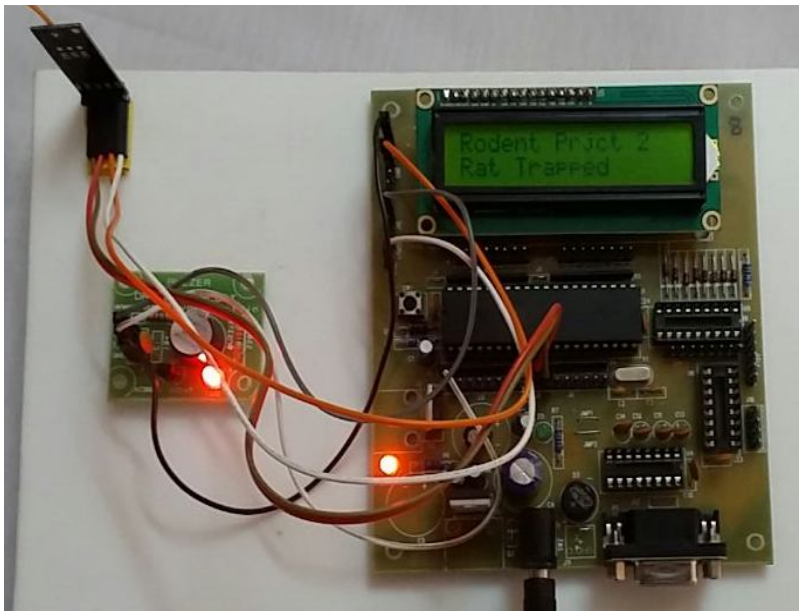

Figure 11:LCD displays “Rat Trapped” and buzzer is triggered

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VII. CONCLUSION AND FUTURE ENHANCEMENT

The model that we have designed uses multiple techniques to prevent the damage caused due to rats. This makes the system highly reliable. The node and monitoring unit is portable. The system is very cost effective as no costly components are being employed in the system. Maintenance of the system is also very easy.

However, this project of rodent control can be made better by making the node units mobile so that the field can be covered with less number of such units, thus reducing the cost of implementation. A webGIS technology can be integrated with this system so that the distribution of rats in an area can be identified and necessary actions can be taken to block their entry through their most probable path of entry.

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