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An Automated Sensor System for Livestock Detection, Identification and Warning System based on the Ground Vibration in Cultivation Fields

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ABSTRACT

In the last years, the monitoring of the vast cultivation land is done by the manual process and it is the serious issue for the farmers to monitor the cultivation field, to overcome this problem an automated monitoring system is needed to monitor the intruder in the cultivation field. The movement of intruder, livestock or person over the ground will produce vibrations induced to soil in the form of seismic waves which are measured by geophones. Seismic detection and tracking of personnel and animals is of major importance in intruder detection applications. Considering the importance, under the present research we are proposing a sensor node that uses a LabView based livestock detection and identification system based on ground vibration.

KEY WORDS: LIVESTOCK DETECTION, GEOPHONE, AMPLIFIER, ANALOG CIRCUIT, DATA ACQUISITION

INTRODUCTION

In the world, the economy of many countries is dependent upon agriculture. In spite of economic development agriculture is the backbone of the economy. But because of animal interference in agricultural lands, there will be huge loss of crops. Crop will be totally getting destroyed. There will be large amount of loss of farmer. To avoid these financial losses, it is very important to protect agricultural field or farms from Livestock animals and other intruders. (Abhinav Deshpande et al., 2016). In the last years, the entry of a unauthorized personnel or any livestock animals in a restricted area or in the cultivation fields is a serious threat to the security of crops in cultivation land and restricted areas. (Hui Hong et al., 2011). In these regard, during last few decades various technologies have

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been developed and implemented to detect the unauthorized personnel e.g.; Camera/Image based approach, Thermal imagers approach, Tomographic sensors approach, Sensor-Fusion approach Uninstrumented/Single-Modality approach, Doppler-shift sensor approach, Contact sensors approach, Pressure sensors approach, (Mosad Alkhathami et.al., 2015), Electric-Field sensors, Radio / Ultrasound/Laser approach, PIR and Ultrasonic Sensor approach. (Srinivasa Reddy Gudibandi et.al.,Amarnath M et al., 2015). But none of them is fully accurate and reliable not only that many of them suffers from complexity at hardware implementation level, high cost and poor field performance and those drawbacks have kept the hunt on for better and advanced system. (Gökhan Koç et al. and Korkut Yegin et al., 2013)

Keeping all these scenarios in mind, the proposed research has been framed to engage in developing the algorithm and hardware of a ground vibration sensor system for livestock and human detection (GVSSLD) system for various applications e.g.; Intruder warning system, Livestock warning system, Elephant warning system etc.

Considering the importance, under the present research a livestock detection system based on ground vibration has been designed. Present system uses geophones as inputsensor which is followed by a pre-amplifier and filter section and a Data Acquisition and a data storage Laptop. Acquisition unit for interfacing the system with laptop. The incoming data from the sensor is saved and displayed with LabView software for further data analysis. Present Ground Vibration Sensor System for Livestock Detection (GVSSLD) has successfully detected livestock walking with a detection circle of radius 3 meters.(Ramkumar et al., Sanjoydeb et al., 2016)

MATERIAL & METHODS

A. Seismic Sensor to Detect Livestock and Human

The movement of livestock or person over the ground will produce vibrations induced to soil in the form of seismic waves, which are measured by geophones. Seismic detection and tracking of personnel and animals is of major importance in intruder detection.The GVSSLD is composed of mainly three hardware units and one data storage and display unit as shown in the following figure

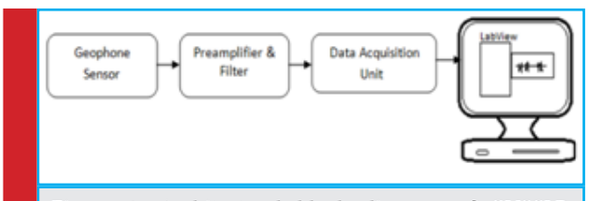

Figure 1. Architectural block diagram of GVSSLD system.

B. Sensor Unit:

A range of sensors available in marketfor detecting ground vibration at various frequency ranges with different level of accuracy. Since, purpose of the present system is to detect low frequency and low amplitude ground vibration, the geophone is the ideal choice. A geophone comprises a magneticmass surrounded with wire coil and mounted on the spring to detect the ground vibrations and convert it into an electrical signal. For presentapplication we have selected is HG-24HS (High sensitivity) from IoNInternational Company, UK which is a vertical geophone with natural frequency of 10Hz.

C. Amplifier and Filter Circuit:

The captured seismic signal with geophone is in the range of micro volts, so that it must be pre-amplified and filtered in order to get desired output to be processed. But designing an efficient pre-amplifier circuit for such low frequency and low amplitude signal is a crucial part of present hardware design.

D. Data Acquisition Unit:

The preamplifier output is connected to computer system by a multifunction Data-acquisition (DAQ: NI USB-6000 OEM). This NI my DAQ consists of 2 Analog inputs, 10 kS/s; 12-bit resolution, current limiter and DC to Dc converter, system timing controller, Digital to Analog converter and Analog to Digital converter, 4 Digital I/O lines; 1 32-bit counter etc. which are highly desirable for present research.

RESULTS AND DISCUSSION

When a person is walking on the ground, the number of impulses will be produced, when the foot hits the ground, which propagates through soil as “seismic” waves.A human’s walk may be modeled as a series of vertical impacts induced to soil by the foot of the walker. These impacts are of short duration and occur on intervals greater than the time needed for them to attenuate. They result on the excitation of the ground at its natural frequencies and travel away from the source on the elastic half-space of the ground.

Most of the energy of such signal is distributed in the band of 30 to 100 Hz and 200 to 250Hz.

After the detailed research it has been found that 1.The human and cow both are creating vibration of frequency within the range of 30Hz to 100Hz and 150Hz to 250Hz.

2. Most of the time, the frequency lies within the range, high frequency vibrations picks are more for cow compared to human. Using these two points an algorithm has been developed for the identification of cow through ground vibration.

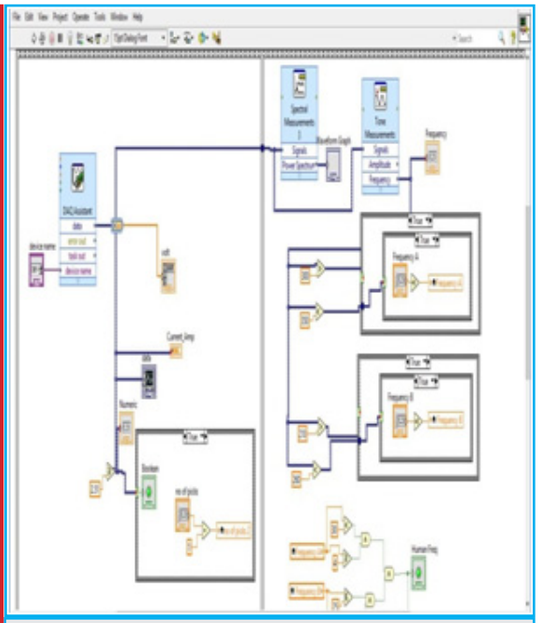

Figure 2. LabView program of Livestock and Human Detection, Identification based on the Ground Vibration

Here, the vertical geophone sensor sm-24 is used, thus the sensor is placed at proper position to get acceptable output voltage level and with present case it has been placed 30 cm under the ground to enhance its range. It has been found that the system is successfully detecting human walking activity in circular range of 3 meters radius. When GVSSLHD has been placed at the Centre of circle (radius of 1.5 meters) and a person is walking along the edge of a circle, the system has been detected individual footstep vibrations for almost 80% cases. Remaining 20% of unsuccessful detection is caused due to ground conditions, background noise, observation & testing fault.

The graph represents the frequency response of human walk around the radius of 3m circle and most of the time, frequency of the seismic vibration lies within the range of 30Hz to 100Hz and 150Hz to 250Hz.The Frequency A represents the frequency band of 30Hz to 100Hz and the Frequency B represents the frequency band of 150Hz to 250Hz. The following figure represents the frequency band 30Hz to 100Hz range response for the human walk around the sensor of 3m radius circle.

The following Figure represents the frequency band 30Hz to 100Hz range response for the human walk around the sensor of 3m radius circle. the band A represents the frequency range from 30Hz to 100Hz

The Graphical representation of the frequency band 150Hz to 250Hz range response for the human walk around the sensor of 3m radius circle is shown in the above figure.

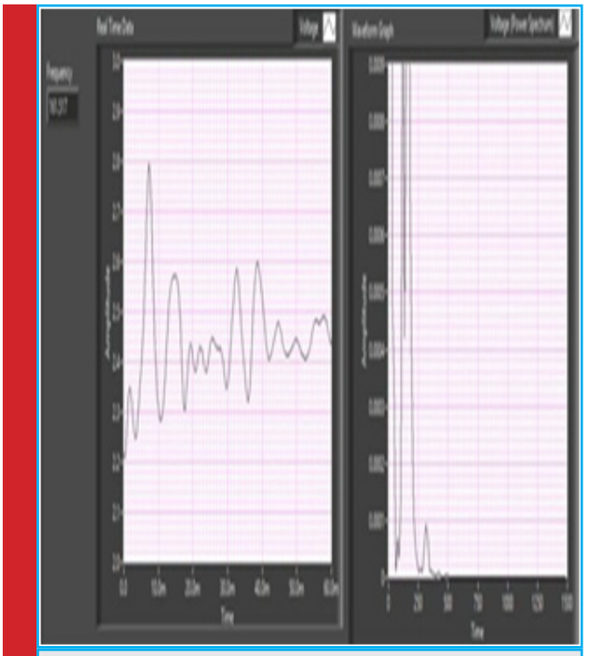

Figure 3. Graphical Representation of the Frequency and Amplitude response of the Livestock walking around the radius of 3meter

The Algorithm describes that the human detection is based on the two parameters, first parameter is the number of picks and the second parameter is frequency. Figure 6, describes that when the frequency count satisfies the condition the human frequency Led will glow

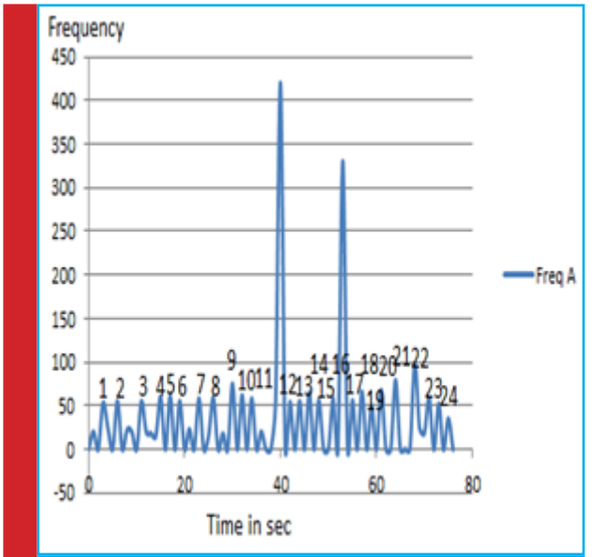

Figure 4. Graphical Representation of Human Frequency Band 'A'Detection based on Ground Vibration

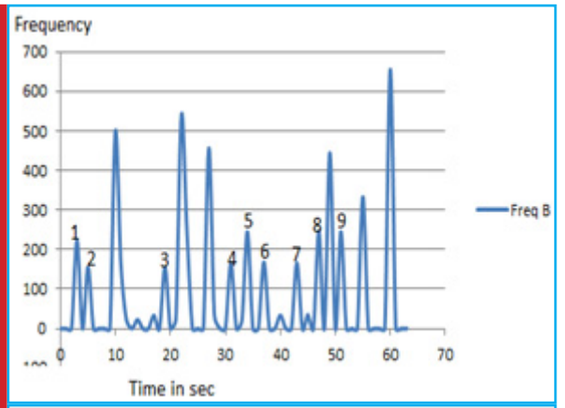

Figure 5. Graphical Representation of Human Frequency Band 'B'Detection based on Ground Vibration

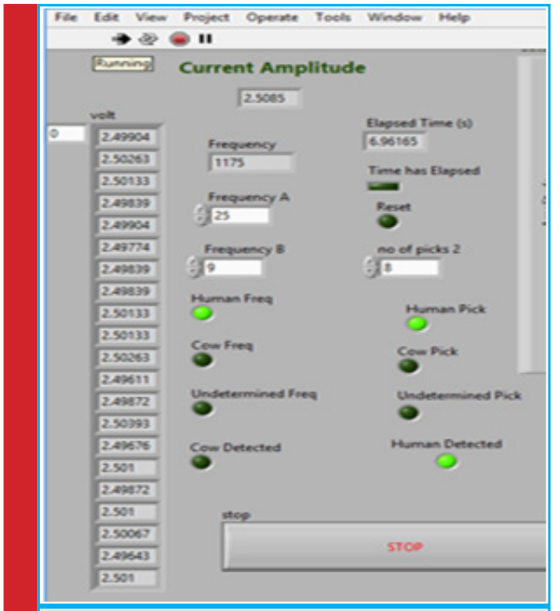

Figure 6. Representation of HumanDetection based on Ground Vibration

and when the number of the picks satisfies the condition the human pick Led will glow. If both the Human pick condition and Human frequency is satisfied, the Human detected Led will be glowing, which represents the Human Detection.

The Ground Vibration Sensor System for Livestock and Human Detection system is tested in the field with cow and after the various testing and research the algorithm has been implemented.

The livestock will keep more number of steps than the human.Every animal or human will have a signature seismic vibration pattern and for the livestock is recorded here and represented as a graph.

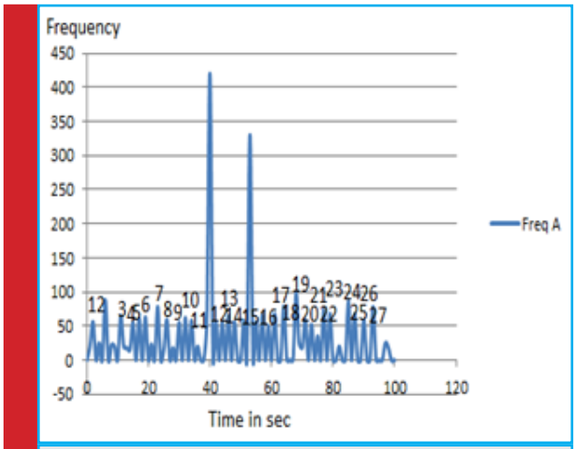

Figure 7. Graphical Representation of Cow Frequency-ADetection based on Ground Vibration

The following figure represents the frequency band from 30Hz to 100Hz range response for the cow walk around the sensor of 3m radius circle.

The Ground Vibration Sensor System for Livestock and Human Detection system is tested in the field with cow and after thevarious testing and research the algorithm has been implemented.

The Graphical representation of the Frequency Band 150Hz to 250Hz, response for the Cow walk around the sensor of 3m radius circle is shown in the above figure.

After the numerous testing we have observed the frequency count for cow and human. In the observation of the test taken the number of footsteps covered by a human in the period of time and at the region is comparatively lower than the cow footsteps. When the frequency count satisfies the condition the Cow frequency Led will be glowing and when the number of

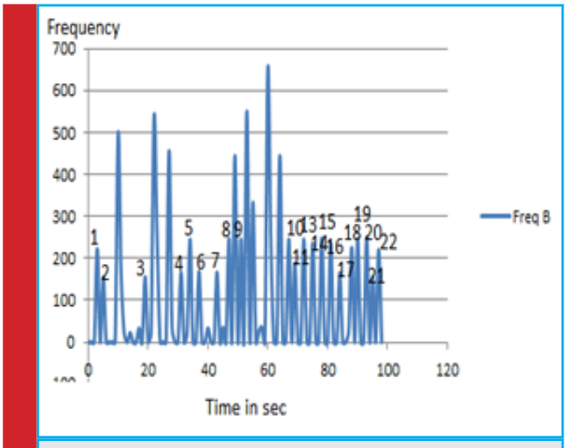

Figure 8. Graphical Representation of Cow Frequency Band-B Detection based on Ground Vibration

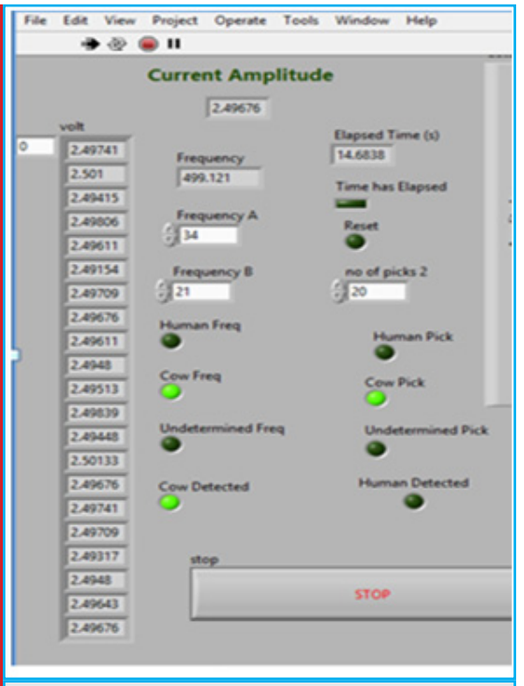

Figure 9. Representation of Cow Frequency Detection based on Ground Vibration

the picks satisfies the condition the Cow pick Led will glow. If both the no of pick of cow condition and cow frequency level is satisfied, the Cow detected Led will be glowing, which represents the Cow Detection.Since, with present system it is very much possible to identify each footstep separately by using parameters amplitude, Frequency and time axis which can be utilized to design a human and livestock identification algorithm. The system has shown 80% accuracy in detecting human footsteps throughout the testing phase. Accurate human and livestock identification algorithm are tricky job, it has been developed with our appropriate analysis of GVSSLHD outcomes.

Since, with present system it is very much possible to identify each footstep separately by using parameters amplitude, Frequency and time axis which can be utilized to design a human and livestock identification algorithm. Considering present day safety and security scenario, design implementation and further advancement of present GVSSLHD system will meet ever growing demand of accurate Human and Livestock detection system.

CONCLUSION

Present research has successfully designed a Lab View based ground vibration sensor system for livestock and human detection with geophone sensor. The design approach of our research has been elaborately discussed with architectural block diagram and technical details about individual blocks. Present system has successfully detected human and cow walking with in a detection circle of radius two to three meters. The maximum output recorded with the system is representing the two frequency band for human and cow in the detection region.

The system has shown 80% accuracy in detecting human footsteps throughout the testing phase. Although finding an accurate human and livestock identification algorithm is tricky job, it has been developed with our appropriate analysis of GVSSLHD outcomes. Since, with present system it is very much possible to identify each footstepseparately by using parameters amplitude, Frequency and time axis which can be utilized to design a human and livestock identification algorithm.

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