Journal of Electronics and Communication Systems
Volume 1 Issue 1

Designing Intruder Detection System for Intelligent Responsive Safe Environment

Ramkumar. R, Dinesh Kumar. V, Sanjoy Deb
Department of ECE, BIT,
Sathyamangalam, Tamil Nadu, India
E-mail: ramkumarr@bitsathy.ac.in, dineshkumarpev@gmail.com, sanjoydeb@bitsathy.ac.in

Abstract

To meet the ever growing need of creating an intelligent and responsive environment and also to provide safety and security to citizens, designing effective intruder detection system has become inevitable. During last few decades various technologies have been developed for intruder detection system but due to various associated issues like less accuracy, high cost, difficult implementability and others have kept the hunt on for much better and advanced system. So, under present research, technology and hardware for an indigenous intruder detection system based on ground vibration has been developed with geophone sensor. Through various trial and errors, a Ground Vibration Sensor System for Intruder Detection (GVSSID) has been successfully designed, implemented and tested at hardware level. Present GVSSID has shown a detection circle of radius three to four meters with maximum recorded output of more than 2 volts. The result analysis with present system has shown 80% accuracy in human footsteps detection. Result analysis of GVSSID has also shown that it is also possible to develop accurate human identification algorithm which is currently in progress under present research.

Keywords: *Intruder detection, geophone, pre-amplifier, analog circuit, data acquisition*

INTRODUCTION

The need of sensing human has become highly crucial as the technology of creating an intelligent and responsive environment, is high on demand [1]. At the same time, considering the present day security scenario, detection of human intruders at highly vulnerable places is vital to eliminate any security threat [2]. Along with those numerous applications can be envisioned with such detection system which can precisely detect human activity with or without human assistance [3, 4]. Till date different technologies for human detection has been proposed and implemented, e.g., a. Uninstrumented/Single-Modality approach (Passive Infrared, Pressure-Sensitive Tiles, Electric Field Sensors etc.), b. Radio/Ultrasound/Laser approach (Doppler-Shift Sensors, Tomographic Sensors etc.), c. Camera/Image based approach d. Vibration Sensors based approach and e. Sensor Fusion approaches etc. [5–8]. But none of them is fully accurate and reliable not only that many of them suffers from complexity at hardware implementation level, high in cost and poor field performance [9, 10]. So, scientists and technologists are on contentious search for an efficient and accurate human detection system to design highly secure, intelligent and responsive environment for our fellow citizens.

Considering the importance, under the present research an intruder detection system based on ground vibration has been designed. Present system uses geophones as input sensor which is followed by a pre-amplifier and filter section and a data 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 Intruder Detection (GVSSID) has successfully detected human walking with a detection circle of radius 3 miters. Apart from detection an accurate identification algorithm is required for successfully separate human generated signal from the signal generated from other sources but it is a critical task to accomplish [8, 9]. Result analysis of GVSSID has shown, a rather simple identification algorithm can be formulated for accurate human identification. With present success and further research work with GVSSID will provide safety and security form potential threat elements with expected implementation at commercial level.

SYSTEM ARCHITECTURE

The GVSSID is composed of mainly three hardware units and one data storage and display unit as shown in the following Figure 1.

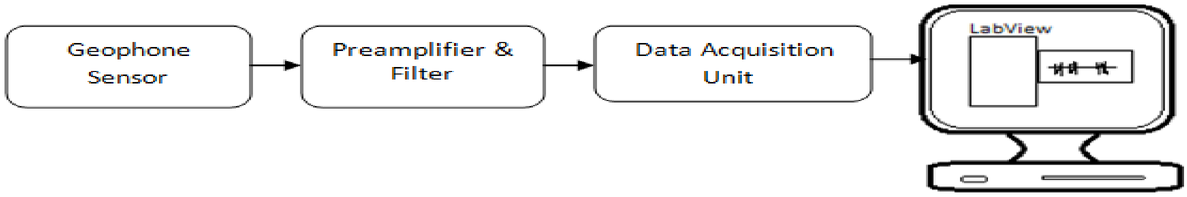

Fig. 1: Architectural Block Diagram of GVSSID System.

Sensor Unit

A range of sensors available in market for 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 magnetic mass surrounded with wire coil and mounted on the spring to detect the ground vibrations and convert it into an electrical signal. For present application we have selected is HG-24 HS (High sensitivity) from IoN International Company, UK which is a vertical geophone with natural frequency of 10 Hz.

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. Under present research through various trial and error methods final design has been made which a two stage amplifier and filter unit designed with IC AD8607 (Figure 2). The AD8607 is low power precision real-to-real input/output amplified and simulation circuit has been design for minimum operational frequency of 5 Hz and maximum voltage gain of 2500 as shown in Figure 2.

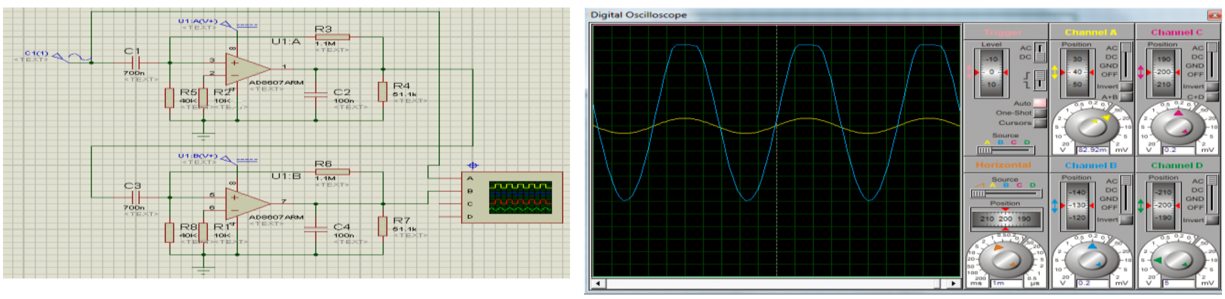

Fig. 2: Pre-Amplifier Circuit (Left) Designed with Proteus Software and Corresponding Simulated Input-Output (Right).

MAT JOURNALS
Journal of Electronics and Communication Systems
Volume 1 Issue 1

Data Accusation Unit

To connect pre-amplifier output to computer system a multifunction Data acquisition (DAQ: NI USB-6000 OEM) has been used. This DAQ is having 8 analog inputs, 10 kS/s; 12-bit resolution, 4 digital I/O lines; 1 32-bit counter etc. which are highly desirable for present research.

Output Display Unit

Sensed data has been saved finally into laptop and at real time the graphs have been displayed in LabView software. Later saved data in LabView has been plotted and analyzed in excel to extract some concluding results.

RESULT AND DISCUSSION

Through consecutive analytical calculations and simulation analysis, the hardware of the present GVSSID has been designed and tested at in-lab and outdoor environment (Figure 3).

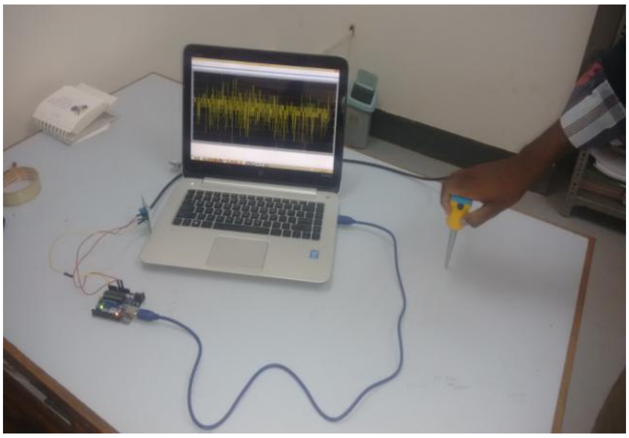

Fig. 3: *Hardware of Pre-Amplifier Circuit (Left) and In-Lab Testing of GVSSID System (Right).*

To get acceptable output voltage level from the vertical geophone sensor, it has to be placed at proper position and with present case it has been placed 30 cm under the ground to enhance its range as shown in Figure 4.

Journal of Electronics and Communication Systems
Volume 1 Issue 1

Fig. 4: *Outdoor Field Testing of GVSSID System; Sensor Placed 30 cm Underground (Left) and System Under Operation (Right).*

Present system has been also tested with horizontal geophone (SM 24 HGS from same company) but it has been found that the horizontal geophone based system is less immune to background noise, as shown in the Figure 5.

Fig. 5: *Field Testing of Horizontal Geophone based GVSSID with Human Footsteps: System on Operation (Left) Footstep Input (Right).*

It has been found that the system is successfully detecting human walking activity in circular range of 3 meters radius. When GVSSID has been placed at the centre of circle (radius of 1.5 meters) and an average weight (60 Kg) person is walking along the edge of a circle, the system has been detected individual footstep vibrations for almost 80% cases as shown in Figure 6. Remaining 20% of unsuccessful detection can be justified with ground conditions, background noise, observation and testing fault or with little higher system relaxation time.

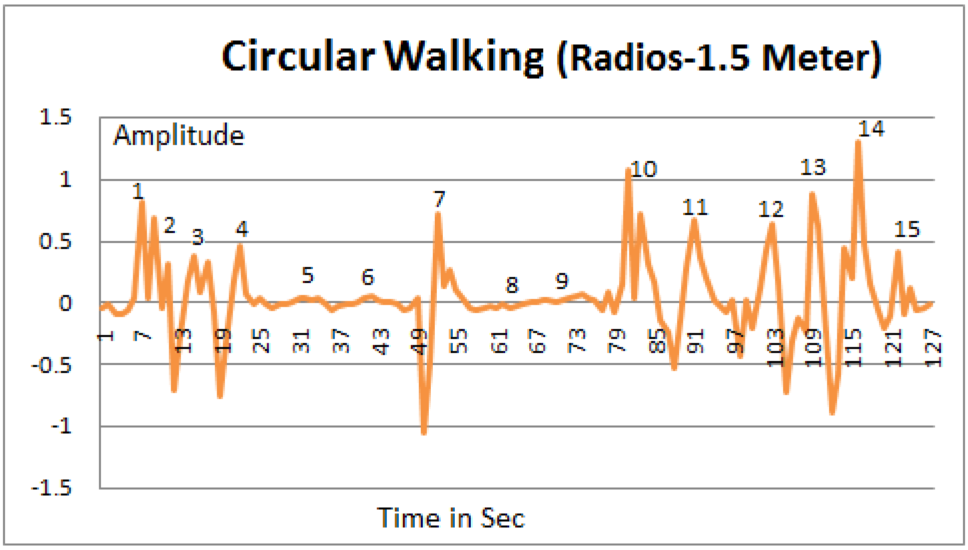

Fig. 6: *Average 60 kg Man walking Along the Circumference of a Circle of Radius 1.5 meters while GVSSID placed at the Centre. Where Y-axis is Signal Amplitude in volt, X-axis is Representing Time in seconds. At the Top of the Graph Footsteps have been Marked with Numbers 1,2,…,15 and Footsteps 5,6,8 and 9 remained Undetected.*

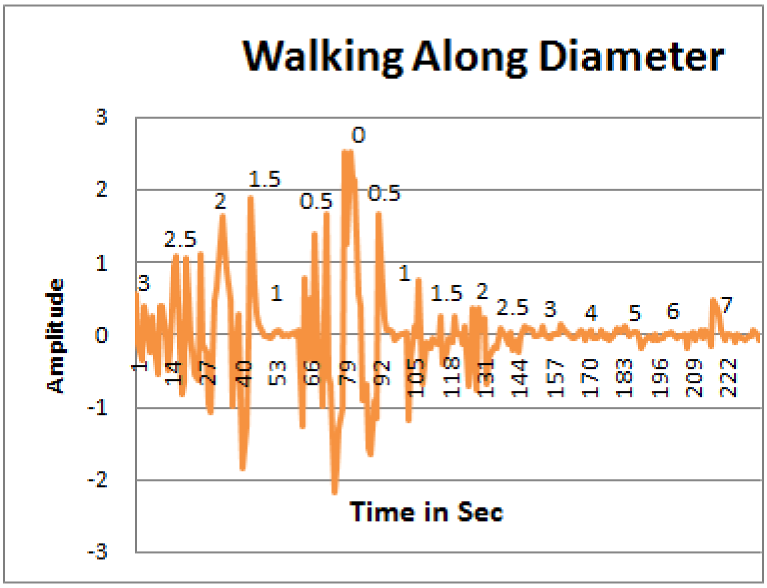

Fig. 7: *Average 60 kg Man walking along the Diameter of Detection Circle of Radius 3 meters. Where, Y-axis Indicating System Output in volts and X-axis Time Seconds. Top of the Graph, Position along the Diameter is Indicated with Distance 3, 2.5, 2,……., 6, 7 meters and Footsteps at 1 meter 3 meters remained Undetected.*

When an average weight person has walked along the diameter of detection circle of radius 3 meters (starting from one edge of the circle to the other edge through the centre) the signal output recorded with GVSSID is presented in Figure 7. When person directly standing over geophone, the maximum output signal recorded with the system is 2.5 volts. Here, also few footsteps have been missed by the system and accuracy of system is calculated as 80%.

The output of the GVSSID has shown it is possible to identify each footsteps separately both at amplitude and time axis. Those data can be utilized to design a signature pattern of human walking and a subsequent identification algorithm. But to avoid any false detection scenario, experiments with all other potential vibration sources (except human) have to be carried out and statistical analysis has to be done with large number of samples. Not only that many human samples have to be investigated and data has to be averaged, to encounter the difference in human physiology and walking pattern. Presently our further research work is concentrating on developing such identification algorithm based on present GVSSID results.

CONCLUSION

Present research has successfully designed a ground vibration sensor system for intruder detection with geophone sensor. The GVSSID design approach has been elaborately discussed with architectural block diagram and technical details about individual blocks. Present system has successfully detected human walking with in a detection circle of radius three to four meters. The maximum output recorded with the system is more than two volts when an average weight person is directly standing over geophone sensor. The system has shown 80% accuracy in detecting human footsteps throughout the testing phase. It has been also found that although finding an accurate human identification algorithm is tricky job, it can be developed with appropriate analysis of GVSSID outcomes. Since, with present system it is very much possible to identify each footsteps separately both at amplitude and time axis which can be utilized to design a human identification algorithm. Considering present day safety and security scenario, design implementation and further advancement of present GVSSID system will meet ever growing demand of accurate intruder detection system.

ACKNOWLEDGEMENT

We sincerely express our gratitude to WWF India for providing the financial support under Small Grant Programme-2014 (SGP) to execute this present research work.

REFERENCES

1. Hui Hong et al. Design and implementation of environmental monitoring system in intelligent home. *Preceding of IET International Conference on Wireless Mobile Communication and Computing (CCWMC 2011)*. 2011; 522–526p.
2. Thiago Teixeira et al. A survey of human-sensing: methods for detecting presence, count, location, track, and identity. *ACM Computing Surveys*. 2011; 5: 1–35p.
3. M. Olagunju, O. A. Alabi. Design of microcontroller based intruder lighting system (MBILS). *Olagunju and Alabi; PSIJ*. 2015; 6(3): 185–195p.
4. H. Lei et al. Analysis of a human detection system based on electrostatic detection. *Proceeding of International Conference on Intelligent System Design and Engineering Application (ISDEA)*. 2010; 273–276p.
5. Korcak M., Lamer J., Jakab F. Intrusion prevention/intrusion detection system (IPS/IDS) for Wifi networks. *IJCNC*. 2014; 6(4): 77–89p.
6. Mosad Alkhathami, Lubna Alazzawi, Ali Elkateeb. Border surveillance and intrusion detection using wireless sensor networks. *IJAET*. 2015; 8(2): 17–29p.
7. Kim, D., Lee, S., Kim, T et al. Quantitative intrusion intensity assessment for intrusion detection systems. *Security Comm. Networks*. 2012; 5(10): 1199–1208p.
8. Mosad Alkhathami et.al. Model and techniques analysis of border intrusion detection systems. *Global Journal of Researches in Engineering: F Electrical and Electronics Engineering*. 2015; 15(7).
9. Gökhan Koç, Korkut Yegin. Footstep and vehicle detection using seismic sensors in wireless sensor network: field tests. *Hindawi Publishing Corporation, International Journal of Distributed Sensor Networks*. 2013; 8 p.
10. R. Vera-Rodriguez, J. S. D. Mason, J. Fierrez et al. Analysis of time domain information for footstep recognition. *In Advances in Visual Computing*. 2010; 6453: 489–498p.