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Design and Development of Wireless Earthquake Warning Alarm System for People Security

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Abstract: *This present research paper proposes the earthquake warning alarm systems detect the first quivering of a major quake, triggering alarm systems in advance of the most violent shaking. The caution framework that need been recommended for everywhere the universe might use a organize about advanced seismometers deployed around those state with provide for populated ranges up to each moment about development cautioning (depending on the area of the epicenter). The alerts would allow businesses, residents and public agencies time to get ready. The purpose of the study focuses on the detection algorithm using the collected data to decide if an earthquake is occurring. The algorithm is adaptive in nature and is based on a probabilistic approach over a sliding window to maximize the detection of events by adjusting the probability of false alarms under a fixed rate. Finally experimental results are provided showing that the system will support the expected performance with both artificial and real seismic stimuli. A possible extension of the approach could be implementing geological wireless sensor networks using contemporary Smartphone for data acquisition.*

Keywords: *Earthquake warning system, Geological wireless sensor network, MEMS sensor, piezoelectric sensor, real-time seismology.*

INTRODUCTION

An earthquake consists of many individual elastic waves. The functioning of EWS is based on the principle that these waves have travelled from the epicenter to recombine at the recording site as a function of their respective velocities, focal distances, and propagation paths. Body waves propagate within a body of rock and appear in the first arrival.
Seismic tremor happens because of that sudden demise arrival from claiming. Vast add up about vitality starting with those earths outside. Due to this vitality earth generates a few. Ruinous waves known as seismic wave. It need. Been discovered that those seismic waves incorporate shear wave, Longitudinal wave What's more surface wave [1-2]. Those Longitudinal wave and shear wave would otherwise call P-wave Also S-wave separately. Out for the sum waves. Surface wave may be those A large portion ruinous done nature, yet the. Velocity of the surface wave is slower over the opposite. Waves. The P-wave’s vibration bearing and the. Forward movement need aid found with a chance to be same, which will be the. Speediest previously, nature "around those the greater part waves. However, the. Ruinous energy of P-wave may be found will be low. Those S-waves’s vibration may be peroxide blonde of the ahead. Direction, whose velocity is easier over P-wave yet the. Ruinous drive is secondary.
This paper shows the design of low cost earthquake alarm system which can be used by the people in their home to save their lives at the time of earthquake. If the acceleration of the seismic wave is greater than the predefined value, the system blows the alarm[4] [5]. This system can be used in multistoried building as the alarm is connected wirelessly shown the below structure

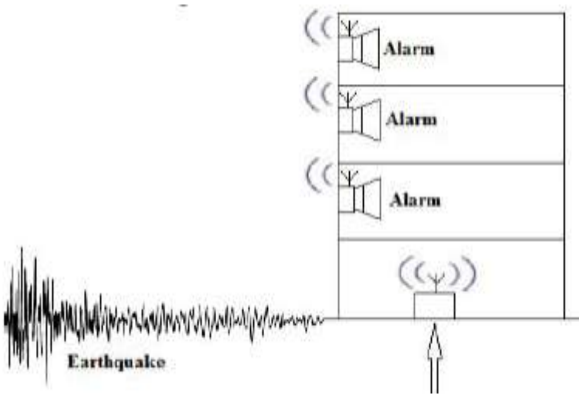

Figure.1. Wireless earthquake alarm

All earthquakes are made of two types of wave. The P-wave compresses the earth as it moves, like a sound wave. It moves fast but does not cause much damage. The S-wave that follows deforms rock up and down like an ocean wave. It delivers most of the tremor’s violent energy .The fastest among these body waves is the primary or P-wave. The P-wave is the first elastic wave to reach the recording site. The secondary arrival contains body and surface waves such as

S, Rayleigh, and Love waves. These later arriving waves often produce both horizontal and vertical ground motion. The combination of their peak velocities, peak accelerations, and duration of time they persist cause significant damage to infrastructures. As P-wave arrive onset of an earthquake, there are systems built for earthquake monitoring using P-wave based technique

Most earthquakes are causally related to compressional or tensional stresses built up at the margins of the huge moving lithosphere plates that make up the earth's surface. The immediate cause of most shallow earthquakes is the sudden release of stress along a fault, or fracture in the earth's crust, resulting in movement of the opposing blocks of rock past one another. These movements cause vibrations to pass through and around the earth in wave form, just as ripples are generated when a pebble is dropped into water. Volcanic eruptions, rock falls, landslides, and explosions can also cause a quake, but most of these are of only local extent. Shock waves from a powerful earthquake can trigger smaller earthquakes in a distant location hundreds of miles away if the geologic conditions are favorable [8-11].

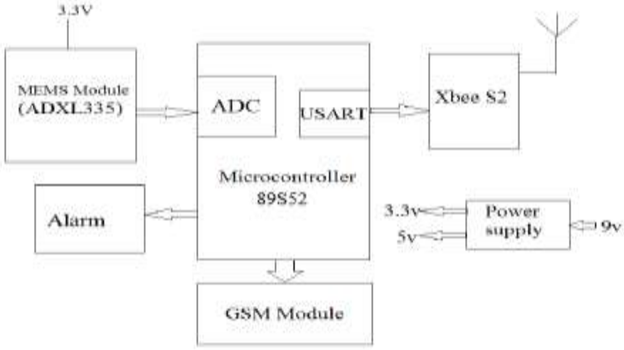

Figure.2. Transmitting part of wireless earthquake alarm system.

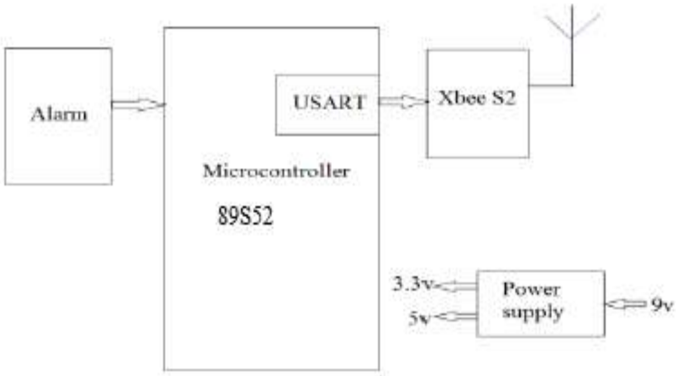

Figure.3. Receiving Part of wireless earthquake alarm system

LITERATURE REVIEW

1) Rui Tan Guoliang Xing Jinzhu Chen Wen-Zhan Song Renjie Huang proposed the work on "*Quality-driven Volcanic Earthquake Detection using Wireless Sensor Networks*" .In this paper, proposed a novel quality-driven approach to achieving real-time, in-situ, and long-lived volcanic earthquake detection. By em-ploying novel in-network collaborative signal processing algorithms, the approach can meet stringent requirements on sensing quality (low false alarm/missing rate and precise earthquake onset time) at low power consumption. It has been implemented the algorithms in TinyOS and conducted ex-tensive evaluation on a test bed of 24 TelosB motes as well as simulations based on real data traces collected during 5.5 months on an active volcano. It shows that the approach yields near-zero false alarm/missing rate and less than one second of detection delay while achieving up to 6-fold en-ergy reduction over the current data collection approach.

2) Narasimha Prasad L V Shankar Murthy P Kishor Kumar Reddy C proposed the work on "Analysis of Magnitude for Earthquake Detection using Primary Waves and Secondary Waves".In this paper, Earthquake is a natural calamity, also known as quake or tremor, occurs due to release of sudden energy which is stored under stress field in the earth's crust. The stored energy is released due to imbalance in stress filed which creates three events called foreshock, main shock and aftershock. Each event is associated with some waves such as primary waves, secondary waves, Rayleigh waves, Stoneley waves and Love waves. As these waves travels from interior of earth to surface they degrades in magnitude and intensity, only a part of the original waves reach the earth surface originated in earth's crust which are recorded as seismograph. Till to date, many of the researchers applied different techniques like prediction based on radon emissions, prediction using extraction of instantaneous frequency from underground water. As the earthquake occurs.

PROPOSED SYSTEM

The Earthquake Warning System comprises of a sensor unit and a base unit. The seismic data is logged and processed in real time in the sensor unit. The base unit controls relays and is connected to the server. A graphical illustration is presented in Fig.1. To ensure system integrity, the fused sensor reading from the dual sensors is analyzed over a sliding time window from the first P phase arrival. It terms this window as the "loop-window." This loop executes only if the sensor fusion algorithm triggers and exceeds the pre-set threshold window size for at least once [5] . Once triggered, the fused sensor readings collected over a 2s loop duration are stored in an electrically erasable programmable read-only memory (EEPROM). Simultaneously, a "threshold-exceed counter" records the number of times the sample values exceed the threshold in real time. It finds that enlarging the time window size may effectively increase system integrity but also reduce crucial warning time [7] [10]

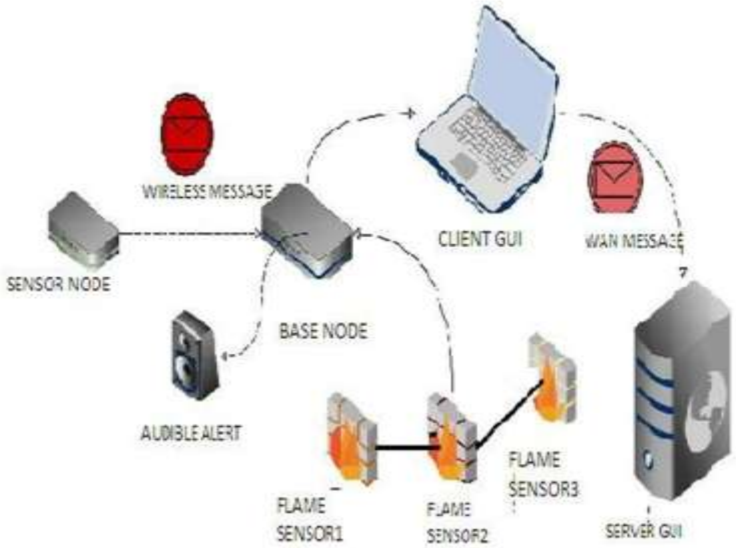

Figure.4. Structural design of the system

The base node controls all the necessary relays and solenoids controlling gas and electricity lines. There are added features which enable the coalition of multiple systems in the same geographic region to a local server. It developed a graphical user interface (GUI) for both the user end and the server end, which can be located under the surveillance of an emergency response team. Any alert issued at the user end will be automatically transmitted to the server end. The packet includes a unique user identification number and location. Integrating multiple flame sensors in the system to detect fire occurrence in as many as 8 different zones of the infrastructure where the sensors are installed. The system has a password protected drill-test-mode which, when activated, will deactivate the server connection temporarily. Meanwhile the system performs all necessary relaying action as it does in case of an actual event.

System Operation

The ADXL335 is a complete 3-axis acceleration measurement system. The ADXL335 has a measurement range of 3g minimum. It contains a polysilicon surface-micro machined sensor and signal conditioning circuitry to implement open-loop acceleration measurement architecture. The output signals are analog voltages that are proportional to acceleration. The accelerometer can measure the static acceleration of gravity in tilt-sensing applications as well as dynamic acceleration resulting from motion, shock, or vibration. The sensor is a polysilicon surface-micro machined structure built on top of a silicon wafer. Polysilicon springs suspend the structure over the surface of the wafer and provide a resistance against acceleration forces. Deflection of the structure is measured using a differential capacitor that consists of independent fixed plates and plates attached to the moving mass. The fixed plates are driven by 180° out-of-phase square waves. Acceleration deflects the moving mass and unbalances the differential capacitor resulting in a sensor output whose amplitude is proportional to acceleration [12]. Phase-sensitive demodulation techniques are then used to determine the magnitude and direction of the acceleration. The demodulator output is amplified and brought off-chip through a 32 kΩ resistor. The user then sets the signal bandwidth of the device by adding a capacitor. This filtering improves measurement resolution and helps prevent aliasing [13-14].

Mechanical Sensor

The ADXL335 uses a single structure for sensing the X, Y, and Z axes. As a result, the three axes' sense directions are highly orthogonal and have little cross-axis sensitivity. Mechanical misalignment of the sensor die to the package is the chief source of cross-axis sensitivity. Mechanical misalignment can, of course, be calibrated out at the system level.

Performance

Rather than using additional temperature compensation circuitry, innovative design techniques ensure that high performance is built in to the ADXL335. As a result, there is no quantization error or no monotonic behavior, and temperature hysteresis is very low (typically less than 3 mg over the −25°C to +70°C temperature range)

Results and Discussion

Wireless Earthquake Alarm system is a low cost system which can be used by people in their home as a consumer product to save their lives. However this system also consumes less power as the microcontroller and Xbee consumes less power and they can be used in sleep mode too. Figures 4, 5 & 6 some snap shots of Wireless Earthquake Alarm System using ATmega 328p, ADXL 335, 8051 controller, GSM Modem, XBee S2, Buzzers and a House Model for Demonstration Purpose.

Earthquake detection at the onset of its occurrence is a challenge because the ground movement is very weak. Such a detection process requires very high precision sensors. Also, the sensors need to be installed in the correct orientation to perfectly detect the ground motion, and hence the alignment of the sensor is a factor that needs critical thinking. To detect the ground motion in the low frequency range, the system uses micro electro mechanical and piezoelectric system sensors. The MEMS sensor is a high precision, digital 3-axis silicon accelerometer with an excellent sensitivity of 0.0039g/LSB, and similar models of these sensors are widely used in contemporary smart phones. The sensitivity of this sensor is superlative for detecting an earthquake of magnitude M 4.0 or higher which corresponds to a peak ground acceleration. The second sensor is a piezoelectric sensor, which is a piezo film element laminated to a sheet of polyester (Mylar). It can produce a useable electrical signal output when forces (in this case ground movement) are applied to the sensing area [10]. To fit this sensor in the design, a charge amplifier is incorporated that can detect ground movement in the frequency band [0.075-3] Hz. The output of this charge amplifier is limited to safe voltage levels. The piezo film sensor's response can be adjusted by adding test mass at the tip of the sensor. As test masses are added, the baseline sensitivity of the piezo film sensor increases .A test mass of 2.7g gives a resonant frequency of about 3Hz, and fits in.

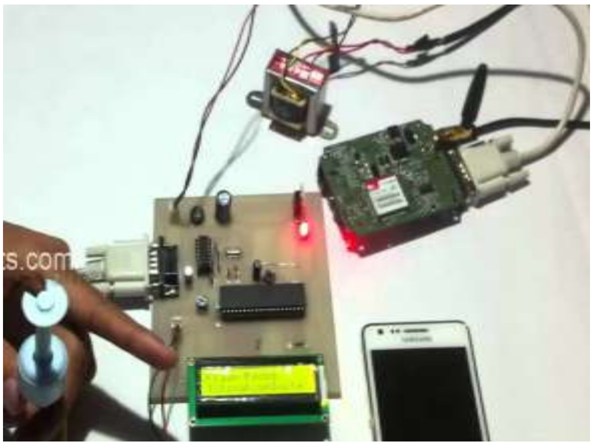

Figure.4. Hardware implementation

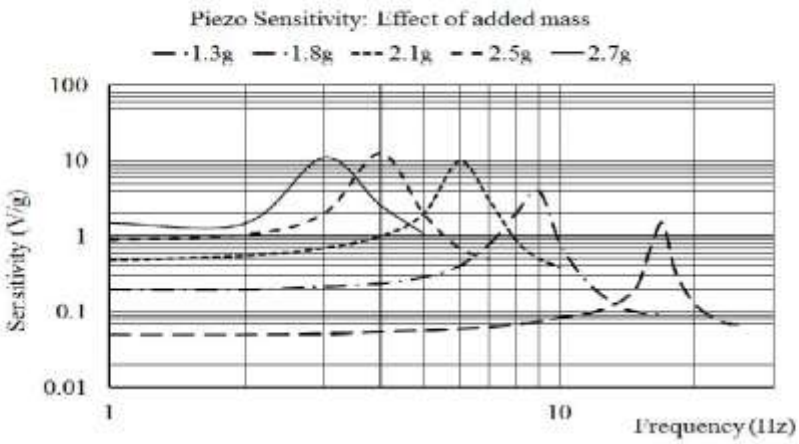

Figure.5. Sensitivity analysis of the piezoelectric sensor

Graphical User Interface

The graphical user interface as in Fig3.(below) allows the user to interact with the system in an interactive manner as well as transmit an alert signal to the central server. With the incorporation of programmable logic controller (PLC) support, the customizable GUI can easily integrate into industrial systems with the added functionality of individual speed control of two DC motors. Upon any fault detection e.g., earthquake or fire, the client software transmits a distress note(with contact information assimilated) to the server.

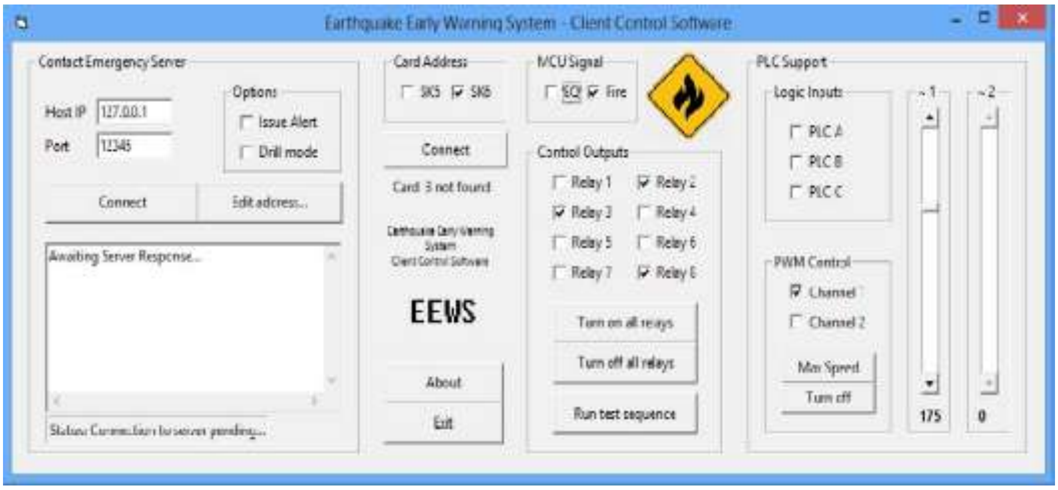

Figure.5.1 .Client End Application

CONCLUSION

The EWS that developed can trigger local security policies (alarms, disconnect hazardous equipment) to lower the impact of a seismic episode. The originality of the approach was to focus on local processing of data, and detection test. In comparison with commercially available seismic networked sensors, the system can allow simpler algorithm and implementation on cheap and low-power hardware, and yet maintain a relatively fair level of accuracy and efficiency. The EWSs developed or effectuated so far provide only warnings regarding the severity of strong motion. They lack the technology to provide information about the characteristics of the ground motion, either spectrum or time series, and trigger alert to minimize casualties. This is a potential drawback for sophisticated applications such as predictive active structural control, where it may appear desirable of EWS to provide comprehensive information, such as the event mechanism, ground motion spectrum, and time series. As more cutting-edge systems are implemented and tested in real time, it will discover novel usage of reliable earthquake early warning information, which will significantly contribute to more effective earthquake damage mitigation system.

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