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A New Smart Seismic Approach for Earthquake Detection Using PIC and Raspberry PI

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Abstract:

This paper describes the design of a low cost and highly efficient earthquake detector using a PIC microcontroller and a Raspberry Pi SOC is proposed. The microcontroller with help of a vibration sensor is used to detect the earthquakes, the Raspberry Pi acts as a server, by taking the data from microcontroller, processing it, plotting the frequencies of Earthquake against the time and sending this to clients attached to it. The advantage of this system is that they run on low cost embedded system, using devices like PIC16F73 and Raspberry Pi. The detector is tested with good results. After detection, with a seismic activity detected, the people around are alerted through an LCD display and by sending SMS to each of them using a GSM module. The server is connected the clients through Wi-Fi, as the range of the less, the clients are meant to be located around. For this system, the aim is to build a detection mechanism for earthquakes and a prediction system by analyzing the readings over a period of time.

Index Terms:

PIC16F73, Raspberry Pi, SOC, Frequency Vs Time plot.

[1]INTRODUCTION:

The seismic waves are result of rupture in the faults or the shift and inter or intra-plate contacts in the tectonic plates inside the earth's upper mantle and crust. The seismic waves are classified as body and surface waves. The body waves are the seismic waves inside the earth's body, but the damage due to the quakes is mostly by the surface waves. So, by detecting the body waves, the upcoming earthquake's can be detected. The primary or pressure waves are the fastest among the body waves and of least strength. Detecting these waves can give the people in the area of impact a chance to escape. And by collecting the data from the area of impact over a period of time (say 10 years), a prediction system can be developed.

Many papers are published to find a best suited method to detect the earthquakes, collect the data and use it to predict the quakes. Samvel G. Gevorgyan, Vardan S. Gevorgyan, Hovsep G. Shirinyan, Gagik H. Karapetyan and Albert G. Sarkisyan proposed a new principle of operation for the seismic detector by using a new sensor to detect the nano scale vibrations [1]. It made use of inertial sensors/seismometers, which measures the motion of the ground with an inertial mass suspended. By detecting the difference between the two points using the strain meter, the quake is detected. Based on this a nano scale shift position sensor with 10-100 times more sensitivity and band is proposed. Jiro Chiba and Tsunehiro Obata presented a theory [5] that the large seismic wave can be predicted by the gravitational wave detectors [Antennas]. The gravitational field turbulence propagates with the velocity of light and is much greater than seismic wave velocity (7km/s). And the gravitational field turbulence induces a strain in the antenna bar so the gravitational field turbulence due to seismic waves is detected first than the seismic waves itself, so it can help to predict the following seismic event. But, the problem here is the sensitivity of the detector to noise.

Alham Fikri Aji, I Putu Edy Suardiyana Putra, Petrus Mursanto, Setiadi Yazid proposed an idea of using Smart phone's accelerometer to detect an Earthquake [8]. It is by studying the pattern of earthquakes that are recorded in accelerometer. There are previously proposed methods for detecting earthquakes using mobile devices. The previous method is Quake catcher network, which uses USB MEMS sensors which are plugged into a computer. It contacts the central server to detect any seismic activity. Instead of the equipment here a mobile is used here. The implementation here is named as Community seismic network (CSN). The proposed method uses highly sensitive vibration sensor yet immune to noise and instead of using mobile phone's accelerometer, we use a micro controller to process the sensor. An alerting system is proposed here, an LCD display for visual alerts and a GSM modem for alerts over air.

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To note the data for studying the earthquake prone area, we propose to plot a graph of the seismic activity on a PC. The post detection process is completely done by using an SOC Raspberry Pi.The earthquake can be detected based on the frequencies of the seismic waves.

TABLE:I.FREQUENCIES OF SEISMIC WAVES:

Frequency (Hz)	Type of measurement
0.1-10	P and S waves with magnitude M>2
10-1000	P and S waves with magnitude M<2

The paper is organized as follows: Section II provides the design of the Earthquake detector using microcontroller. Section III provides the design of a circuit using Raspberry Pi to plot the data from previous section. Section IV presents the results. Section V gives the conclusion.

[2]EARTHQUAKE DETECTOR:

In general, the seismic waves cause vibrations with frequencies 0.001Hz to 100Hz. The waves that are effective and devastating come in the range 0.01Hz to 10Hz. We use a vibration sensor which is very sensitive and is capable of detecting those frequencies. As the sensor we take here is a digital device with a TTL output, we consider the frequencies 1Hz to 10Hz. After detecting the vibrations the frequencies are to be processed and checked with the thresholds. With the appropriate thresholds applicable alerts are to be given. So, we use a micro controller with fewer instructions and better speed. We use PIC16F73, which is 28 pin IC with RISC architecture. The block diagram of the Earthquake detector is shown in the Fig 1.

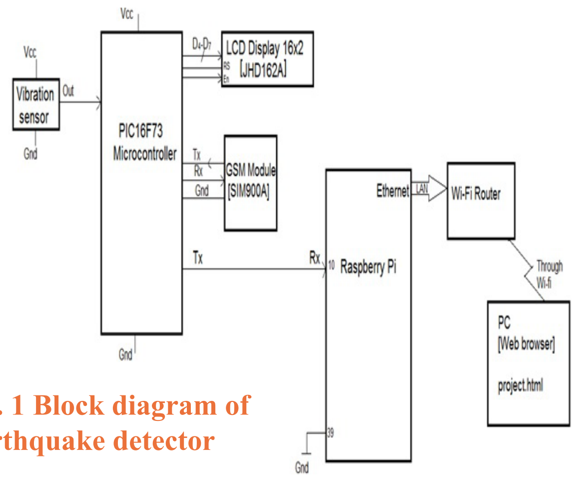

Fig. 1 Block diagram of Earthquake detector

The vibration sensor is a digital sensor that detects the vibrations from seismic activity. The data is then sent to the 28 pin PIC16F73's port C. The condition is checked for the frequencies to be in between 1Hz-10Hz. The frequency data is shown on the LCD display and if the frequencies are within the range then alerts are given. Even in the required range, the frequencies are divided for those with huge effect and mild effect. The alert is shown on the Display and SMS alerts are sent using the GSM Module. The vibration sensor is shown in Fig 2. And the arrangement of the micro controller with vibration sensor, LCD display and GSM Module is shown in Fig 3.

Fig 2. Snapshot of the digital Vibration sensor

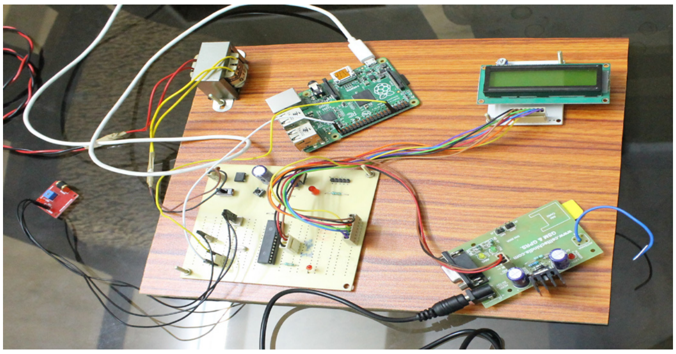

Fig. 3 Snapshot of Earthquake detector arrangement

[3]RASPBERRY PI AS A SERVER:

After the data is processed by the micro controller unit and alerts are sent, the data is sent to a server to transmit it to the clients for further analysis. At the client the data is shown in form of a graph. It is not appropriate to plot the readings at the client end, as there will be many clients and the plots at the clients may differ from each other. So, it has to be done at the server. To process the data and to act as a server by sending the processed data in the form of graph to clients is done by an SOC.The SOC which that we use here have to be very precise in doing the processes and should also be cost-efficient. Among various SOCs available like Beagle bone, Cyclone V etc. the Raspberry pi is both efficient and easily affordable.

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The SOC we use here is Raspberry Pi 1 Model B+. The Pi is ARM 11 based SOC, with ARM1176JZF-S as the core and Video core IV as GPU. This 512Mb RAM SOC is capable of performing huge tasks at ease. The Raspberry Pi B+ is shown in Fig 3.

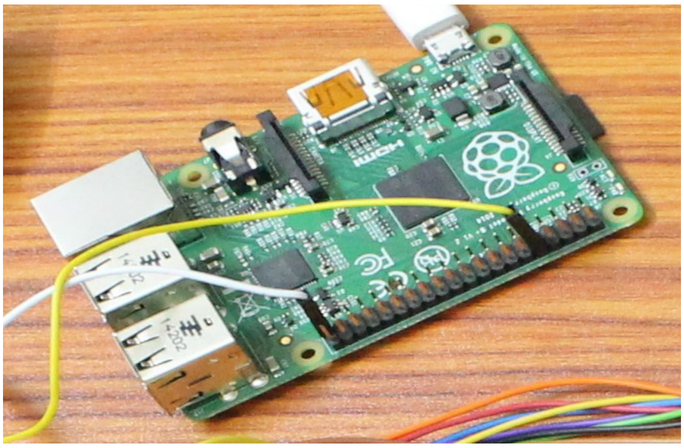

Fig. 4 Snapshot of Raspberry Pi 1 Model B+

The data from controller is sent through the USART pin of PIC16F73 to the RXD pin among the GPIO pins of the Pi. The data taken in is processed by the Pi, plotted in a frequency Vs time graph and is ready to transmit. Through LAN the Pi is connected to a Wi-Fi router i.e. The Pi is configured as the DHCP server through Wi-Fi router. From their PCs, clients are connected to the server through the web address dynamically allotted for the server. They can now see the plot in the webpage allotted by the server.

[4]RESULTS:

The Earthquake detector is turned on. Then it is tested by shaking the vibration sensor. The frequency of the vibrations and the Earthquake alert is shown on the LCD display. The Detector when turned on is shown in Fig 4. Then SMS alerts are sent to the people with the help of the GSM module we used. After the SMS has been sent, the data is transmitted to the Raspberry pi.

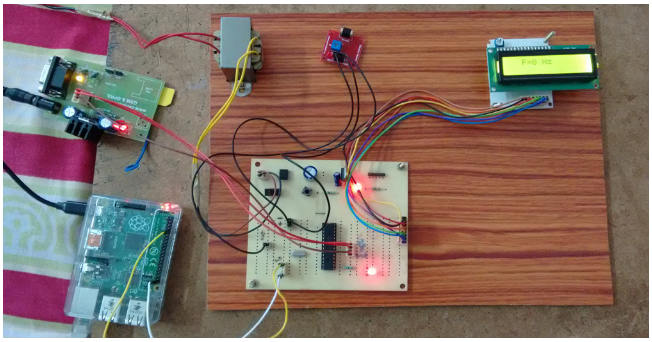

Fig. 5 Detector when turned on The frequency of the vibrations is displayed in the Fig 5.

Fig. 6 Frequency of Vibrations The SMS alerts sent to the people is shown in the Fig 6.

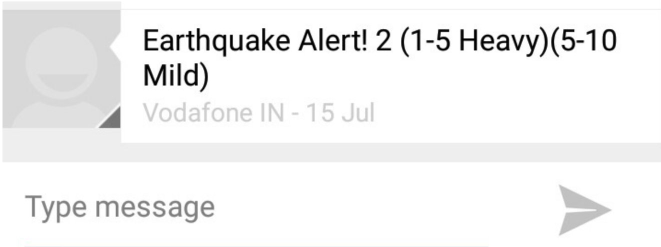

Fig. 7 Screen shot of Earthquake SMS Alert

The server is turned on with the device. The clients are connected to the server after initial boot of the Pi. The clients are verified in the router's homepage under DHCP clients. After the alert has been sent to the people wirelessly through SMS, the Pi generates the frequency [magnitude] Vs time graph. Through Wi-Fi all the clients receive the data and they can see it in the web address allotted for the server.In the graph, the magnitude doesn't exceed the threshold of the micro controller we have set. The horizontal axis in the graph is the clock time and it will sync with the exact time of that zone, when the client is connected to the internet.The frequency Vs time plot for the earthquake detected is shown in the Fig 7. and Fig 8.

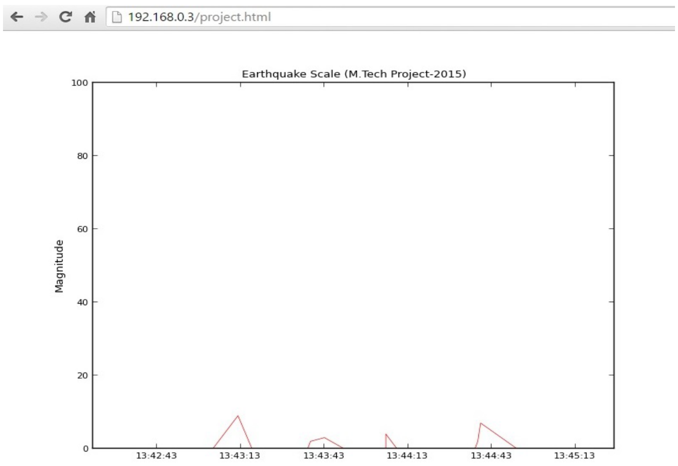

Fig. 8 Earthquake scale

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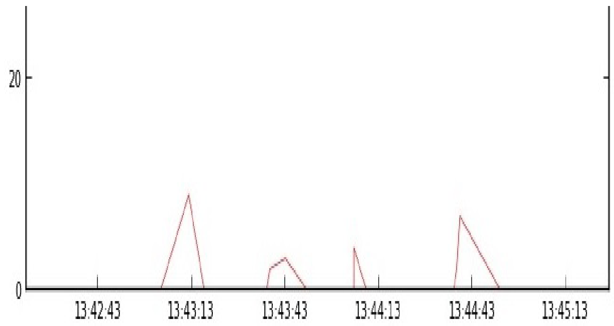

Fig. 9 Magnitude [Frequency] Vs Time graph

[5]CONCLUSION:

The paper presented the design and working of an Earthquake detector based on PIC16F73 and Raspberry pi. The sensor we used here is digital, which may not detect the decimal frequencies, but is very precise and sensitive. The controller even with its ability to process a single task, has done a very good job by sending both visual and SMS alerts as well as sending data to the Raspberry Pi. The Pi was very efficient in doing the job prescribed for it. This detector achieves a better balance in both alerting the people and noting down the readings for future use. This detector meets the targeted requirements mentioned in the abstract and design is successfully implemented. All the results are mentioned in the section IV.

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