Natural Disasters Management Using Internet of Things (IoT)

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Abstract: **The system proposed in this paper is an advanced solution for monitoring the natural disasters at a particular place and make the information visible anywhere in the world. The technology behind this is Internet of Things (IoT), which is an advanced and efficient solution for connecting the things to the internet and to connect the entire world of things in a network. Here things might be whatever like electronic gadgets, sensors and automotive electronic equipment. The tsunami waves cause considerable destruction and kills people. The detection section of the proposed system consists of a microcontroller and a capacitive sensor to detect the Tsunami occurrence. The system deals with monitoring and controlling the conditions like floods, Earthquakes with sensors and sends the information to the web page as well as alerts through SMS and then plot the sensor data as graphical statistics. The data updated from the implemented system can be accessible in the internet from anywhere in the world.**

Keywords: Internet of Things (IoT), Embedded Computing System; ArduinoDUE; ArduinoSoftware, ESP8266, GSM Module.

I. INTRODUCTION

Many Disastrous events are cordially involved with the momentum of nature. As such incidents have been showing off own mastery, situations have gone beyond the control of human resistive mechanisms far ago. Fortunately, many technologies are in place to gain affirmative knowledge and analysis of a disaster's occurrence. Recently, Internet of Things (IoT) paradigm has opened a assured door towards catering of multitude problems related to agriculture, industry, security, and medicine due to its distinct features, such as heterogeneity, interoperability, light-weight, and flexibility. Furthermore, IoT-supported protocols and deployable products are mainly used to address these issues.

Many countries are facing of several social issues in aged population, healthcare, disaster reduction/prevention, safety, security, etc. The smart city concept that utilizes the Internet-of-Things (IoT) technologies to strengthen social infrastructures opens a new door for innovative solutions to the above mentioned issues and also creates a big commercial market. This project proposes a mechanism to disseminate data in community-based IoT networks. If unexpected things happened to the elderly people they need emergency help which may not be provided. Children are usually play outside they need to monitored always which is not possible. Any disaster reduction works may not be monitored by the government. All these are problems of the existing system.

When the a particular region is equipped with sensor devices, microcontroller and various software applications becomes a self-protecting and self-monitoring environment and it is also called as smart environment. In such environment when some event occurs the siren or SMS alerts automatically. The effects due to the natural disasters on human beings can be monitored and controlled by smart monitoring systems. By using embedded intelligence into the environment makes the environment interactive with other objectives, this is one of the application that smart systems.

Human needs demands different types of monitoring systems these are depends on the type of data gathered by the sensor devices. Initially the sensor devices are deployed in coastal region to detect the parameters (e.g., Axes of the earth, water levels etc.) while the data acquisition, computation and controlling action (e.g., the variations in the axes and water levels with respect to the specified levels). Sensor devices are placed at different locations to collect the data to predict the behavior of a particular area of interest. The main aim of the this paper is to design and implement an efficient monitoring system through which the required parameters are monitored remotely using internet and the data gathered from the sensors are stored in the cloud and to project the estimated trend on the web browser.

A solution for monitoring the coordinates of the earth and water levels i.e., any parameter value crossing its threshold value ranges, for example water levels in river in a particular area exceeding the normal levels etc., in the environment using wireless embedded computing system is proposed in this paper. The solution also provides an intelligent remote monitoring for a particular area of

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interest. In this paper we also present a trending results of collected or sensed data with respect to the normal or specified ranges of particular parameters. The embedded system is an integration of sensor devices, wireless communication which enables the user to remotely access the various parameters and store the data in cloud.

II. PROPOSED MODEL

The proposed Embedded device is for monitoring coordinates of the earth, and water levels in a particular region to make the environment intelligent or interactive with the objects through wireless communication. The proposed model is shown in figure 1 which is more adaptable and distributive in nature to monitor the coastal areas parameters.

The proposed architecture is discussed in a 4- tier model with the functions of each individual modules developed for earthquakes and floods monitoring. The proposed model consists of 4-tiers. The tier 1 is the parameters to be considered, sensor devices in tier 2, sensor data acquisition and decision making in tier 3 and intelligent environment in tier 4.The proposed architecture is shown in figure 2.here, the tier 1 provides information about the parameters under the region which is to be monitored for floods and earthquakes control. Tier 2 deals with the sensor devices with suitable characteristics, features and each of these sensor devices are operated and controlled based on their sensitivity as well as the range of sensing.

In between tier 2 and tier 3 necessary sensing and controlling actions will be taken depending upon the conditions, like fixing the threshold value, periodicity of sensing, messages (siren or buzzer or LCD) etc. Based on the data analysis performed in between tier 2 and tier 3 and also from previous experiences the parameter threshold values during critical situations or normal working conditions are determined.

Tier 3 describes about the data acquisition from sensor devices and also includes the decision making. Which specify the condition the data is representing which parameter.

In the proposed model tier 4 deals with the intelligent environment. Which means it will identify the variations in the sensor data and fix the threshold value depending on the identified level of coordinates or water levels. In this tier sensed data will be processed, stored in the cloud i.e.in to the Google spread sheets and also it will show a trend of the sensed parameters with respect to the specified values. The end users can also get the alerts through SMS when exceeds a particular range.

The Arduino Due is a microcontroller board based on the Atmel SAM3X8E ARM Cortex-M3 CPU. It is the first Arduino board based on a 32-bit ARM core microcontroller. The basic features of the Arduino Due are:54 digital input/output pins (of which 12 can be used as PWM outputs),12 analog inputs,4 UARTs(hardware serial ports) ,84 MHz clock,USB OTG(On the Go) capable connection,2 DACs(digital to analog),2 TWI(Two wire interface),Power jackSPI(Serial Peripheral Interface) header. The board contains everything needed to support the microcontroller; simply connect it to a computer with a micro-USB cable or power it with a AC-to-DC adapter or battery to get started.

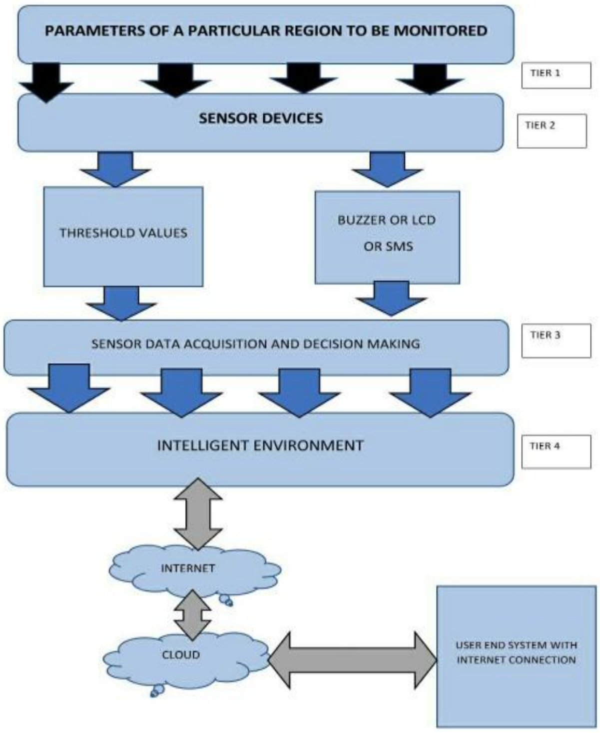

Fig.1: Proposed model

The Due is compatible with all Arduino shields that work at 3.3V and are compliant with the 1.0 Arduino pinout. Unlike other Arduino boards, the Arduino Due board runs at 3.3V. The maximum voltage that the I/O pins can tolerate is 3.3V.The Due has a 32-bit ARM core that can outperform typical 8-bit microcontroller boards. The most significant differences are:A 32-bit core, that allows operations on 4 bytes wide data within a single CPU clock.CPU Clock at 84Mhz.96 KBytes of SRAM.512 KBytes of Flash memory for code. DMA controller, that can relieve the CPU from doing memory intensive tasks.

III.SYSTEM ARCHITECTURE

The implemented system consists of a microcontroller (Atmel SAM3X8E ARM Cortex-M3 CPU)as a main processing unit for the entire system and all the sensor and devices can be connected with the microcontroller. The sensors can be operated by the microcontroller to retrieve the data from them and it processes the analysis with the sensor data and updates it to the internet through Wi-Fi module connected to it.

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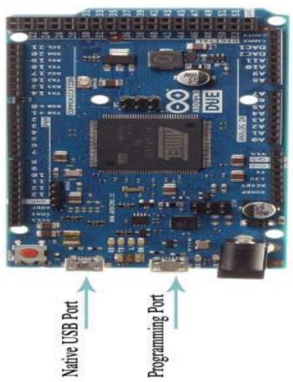
Arduino DUE :



Arduino is an open source tool for making computers that can sense and control more of the physical world than your desktop computer. It's an open-source physical computing platform based on a simple micro-controller board, and a development environment for writing software for the board. Arduino can be used to develop interactive objects, taking inputs from a variety of switches or sensors, and controlling a variety of lights, motors, and other physical outputs. Arduino projects can be stand-alone, or they can communicate with software running on your computer (e.g. Flash, Processing, MaxMSP). The boards can be assembled by hand or purchased pre-assembled; the open-source IDE can be downloaded for free.The Arduino programming language is an implementation of Wiring, a similar physical computing platform, which is based on the Processing multimedia programming environment. It has 54 digital input/output pins (of which 12 can be used as PWM outputs), 12 analog inputs, a 84MHz ceramic resonator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the micro-controller; connect it to a computer with a USB cable or power it with an AC-to-DC adapter or battery to get started. All the modules in the circuit are connected to Arduino module. Sensors are connected to Arduino DUE board for monitoring, ADC will convert the corresponding sensor reading to its digital value and from that value the corresponding environmental parameter will be evaluated.

Thing Speak :

According to its developers, "**Thing Speak"** is an open source Internet of Things (IOT) application and API to store and retrieve data from things using the HTTP protocol over the Internet or via a Local Area Network. Thing Speak enables the creation of sensor logging applications, location tracking applications, and a social network of things with status updates"

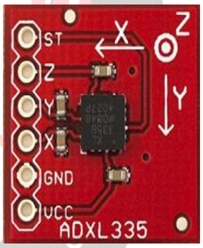
Thing Speak has integrated support from the numerical computing software MATLAB from MathWorks Allowing Thing Speak users to analyze and visualize uploaded data using Matlab without requiring the purchase of a Matlab license from Mathworks.

Wi-Fi Module

Here we used ESP8266 Wi-Fi module which is having TCP/IP protocol stack integrated on chip. So that it can provide any microcontroller to get connected with Wi-Fi network. ESP8266 is a preprogrammed SOC and any microcontroller have to communicate with it through UART interface. It works with a supply voltage of 3.3v. The module is configured with AT commands and the microcontroller should be programmed to send the AT commands in a required sequence to configure the module in client mode. The module can be used in both client and server modes.

Sensors: The system consists of temperature sensor, Accelerometer and water sensor. This 2 sensors will measure the primary factors like coordinates of the earth and water levels respectively. All this sensors will gives the analog voltage representing one particula factor. The microcontroller will converts this analog voltages into digital data.

Acclerometer



The ADXL335 is an integrated circuit sensor that can be used to measure coordinates of the earth with an electrical output . If the coordinates exceeds threshold then an alert will send and vice versa.., The accelerometer is shown in Fig3. The measuring range is +/-3g. The ADXL335 produces values over a range of +325 to -274(x,y,z) .

Water Sensor

Water sensor is designed for water detection, which can be widely used in sensing the rainfall, water level, even the liquid leakage. The sensor mainly comprised of three parts: An Electronic connector, a 1 MΩ resistor, and several lines of bare conducting wires. working voltage is 5v and working current is <20mA

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GSM Module

GSM/GPRS Modem RS232 Operates over frequencies 900/ 1800 MHz and it is built with Dual Band GSM/GPRS engine- SIM900A. The Modem is provided with RS232 interface, so that one can connect PC as well as microcontroller with RS232 Chip (MAX232). Coming to the baud rate it is reconfigurable from 9600-115200 with AT command. The GSM/GPRS Modem is provided with internal TCP/IP stack to enable one to connect with internet via GPRS.

This is used for SMS, Voice along with DATA transfer application in M2M interface. The onboard Regulated Power supply allows one to connect wide range unregulated power supply. With the help of this modem, one can make audio calls, SMS, Read SMS, answer to the incoming calls and internet through simple AT commands.

IV. COMPUTATIONAL ANALYSIS ON PARAMETERS

Here we include some basic analytics methods to calculate the coordinates of the earth and water levels in the coastal region.

We can calculate angle of inclination or tilt by using X, Y, Z's value. Also, we can calculate Roll, Pitch and Yaw angles with respect to X, Y and Z axis. So first we need to convert 10-bit ADC values into g unit. As per ADXL335 datasheet maximum voltage level at 0g is 1.65V and sensitivity scale factor of 330mV/g.
Before the generation of axes ADC values are computed for the corresponding analog values using the formulae.
ADC reading=analogRead(A1)
ADC reading=analogRead(A2)
ADC reading=analogRead(A3)
Below reading is used for the water sensor values calculation.
ADC reading=analogRead(A4)
For water sensor the value is obtained from the formulae
Value=(ADC reading *5/ (1024)).
Below formula gives us acceleration values in g unit for X, Y and Z axis as,
Axout = (((X axis ADC value * Vref) / 1024) – 1.65) / 0.330

Ayout = (((Y axis ADC value * Vref) / 1024) – 1.65) / 0.330

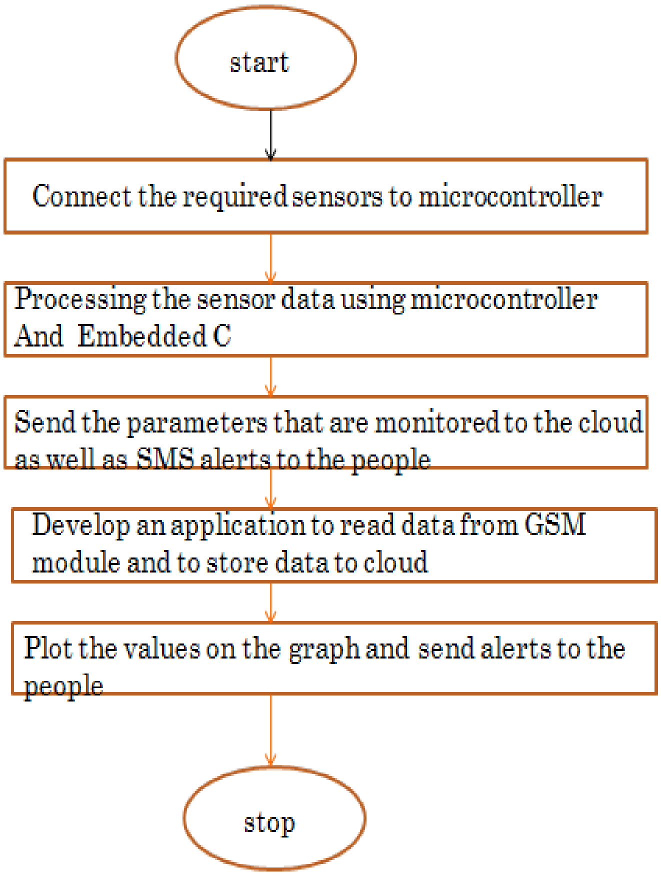
Azout = (((Z axis ADC value * Vref) / 1024) – 1.65) / 0.330

The corresponding axes values are obtained by placing the values in them.Based on the standard values of a particular region (threshold values) an alert is being sent. In our implementation we have considered the standard values for co ordinates of the earth as 500.when ever the standard values are exceeded an alert is send via SMS and LCD display which is located on the premises of the forecast center.

V. IMPLEMENTATION

Based on the framework shown in figure 2, we have identified a suitable implementation model that consists of different sensor devices and other modules, their functionalities are shown in figure 3.In this implementation model we used Arduino DUE board with modules as embedded device for sensing and storing the data in cloud as well as sending SMS. Arduino DUE board consist of analog input pins (A0-A11), digital output pins (D0-D53), inbuilt ADC and modules connects the embedded device to internet. Sensors are connected to Arduino DUE board for monitoring, ADC will convert the corresponding sensor reading to its digital value and from that value the corresponding parameters will be evaluated.

Flowchart :



GSM as well as Wi-Fi connection has to be established to transfer sensors data to end user and also send it to the cloud storage for future usage.

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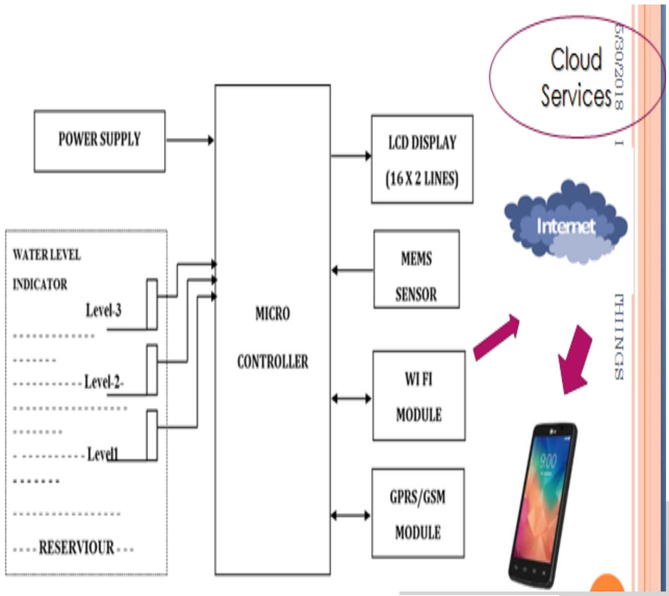


Fig. 2: Schematic diagram of implementation model

An embedded system designed for natural disasters monitoring and its components are shown in figure 5.The embedded device is placed in particular area for testing purpose. The accerlometer detects changes in that area and water sensor will record the different levels in that region, if the threshold limit is crossed the corresponding controlling action will be taken (like issuing message alarm or buzzer or LCD Display).All the sensor devices are connected to internet through Wi-Fi module as well as to GSM module through the corresponding network.

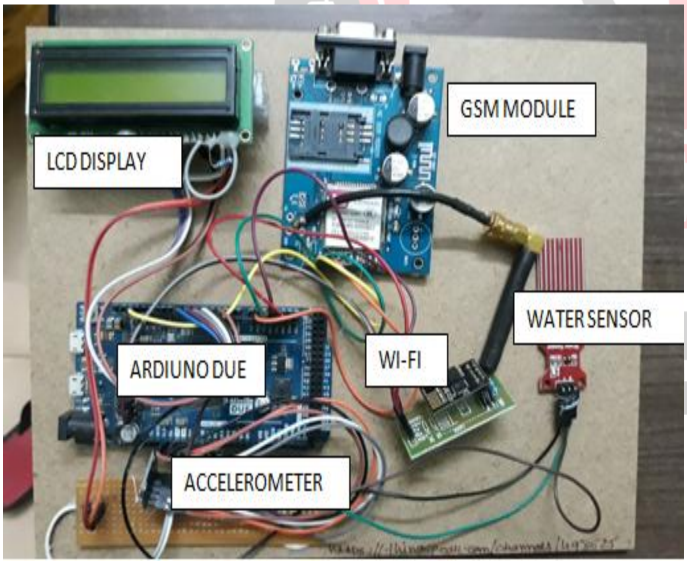


Fig. 3: monitoring embedded system with its components

Figure 3 shows the embedded system with its components for reading and to store the parameters in cloud. After successful completion of sensing, the data will be processed and stored in database for future reference and SMS alerts will be sent to the nearby residents. After completing the analysis on data the threshold values will be set for controlling purpose.

VI. SIMULATION RESULTS

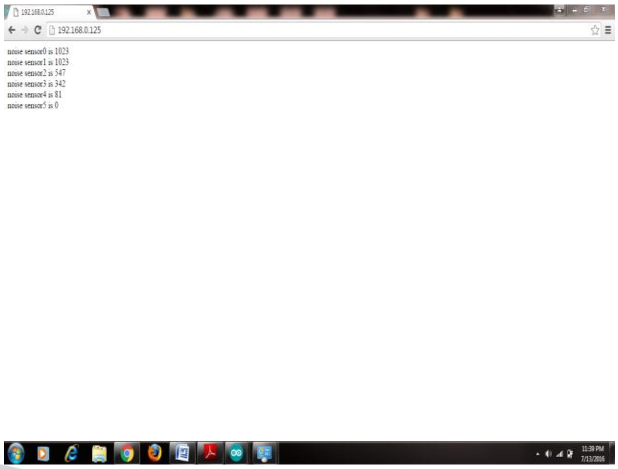
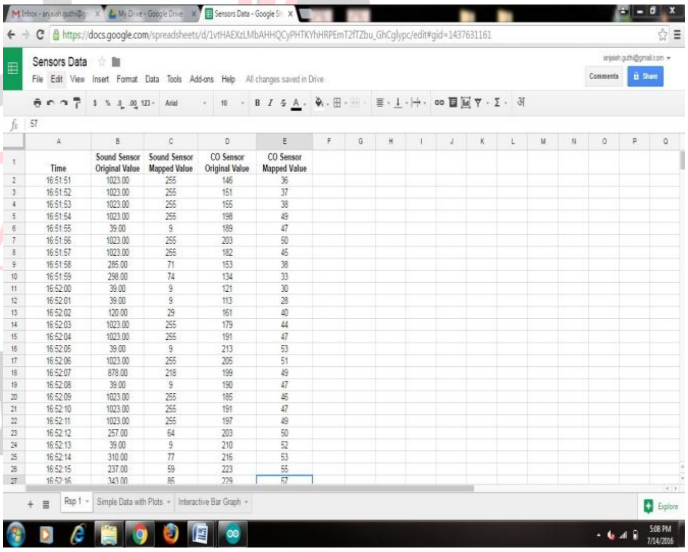


Fig. 4: web server page

After sensing the data from different sensor devices, which are placed in particular area of interest. The sensed data will be automatically sent to the web server, when a proper connection is established with sever device. The figure 4 shows the web server page which will allow us to monitor and control the system. By entering IP address of server which is placed for monitoring we will get the corresponding web page. The web page gives the information about the changes in the coordinates of the earth and the water level variations in that particular region, where the embedded monitoring system is placed.



Time	Sound Sensor Original Value	Sound Sensor Mapped Value	CO Sensor Original Value	CO Sensor Mapped Value
16:51:51	1023.00	255	146	36
16:51:52	1023.00	255	151	37
16:51:53	1023.00	255	155	38
16:51:54	1023.00	255	198	49
16:51:55	39.00	9	189	47
16:51:56	1023.00	255	203	50
16:51:57	1023.00	255	182	45
16:51:58	285.00	71	153	38
16:51:59	298.00	74	134	33
16:52:00	39.00	9	121	30
16:52:01	39.00	9	113	28
16:52:02	120.00	29	161	40
16:52:03	1023.00	255	179	44
16:52:04	1023.00	255	191	47
16:52:05	39.00	9	213	53
16:52:06	1023.00	255	205	51
16:52:07	878.00	218	199	49
16:52:08	39.00	9	190	47
16:52:09	1023.00	255	185	46
16:52:10	1023.00	255	191	47
16:52:11	1023.00	255	197	49
16:52:12	257.00	64	203	50
16:52:13	39.00	9	210	52
16:52:14	310.00	77	216	53
16:52:15	237.00	59	223	55
16:52:16	343.00	85	229	57

Fig. 5: Cloud storage (Google Spread Sheets) for sensors data.

The sensed data will be stored in cloud (Google Spread Sheets). The data stored in cloud can be used for the analysis of the parameter and continuous monitoring purpose. The figure 5 shows the coordinates of the earth and water levels in air at regular time intervals. All the above information will be stored in the cloud, so that we can provide trending of earthquakes and Floods in a particular area at any point of time.

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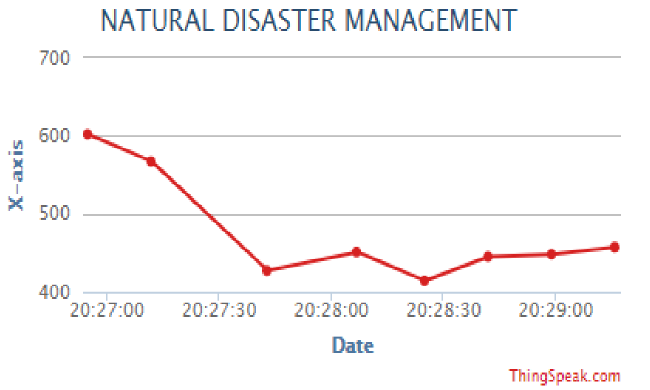

Fig. 6(a)

The graph in figure 6 (a) shows the variation in x-axis at regular time intervals. For each coordinate of the earth a threshold value is set based on the past history of the region. The above shows the x axis variation at different instants of time. Here the reference is taken as 500

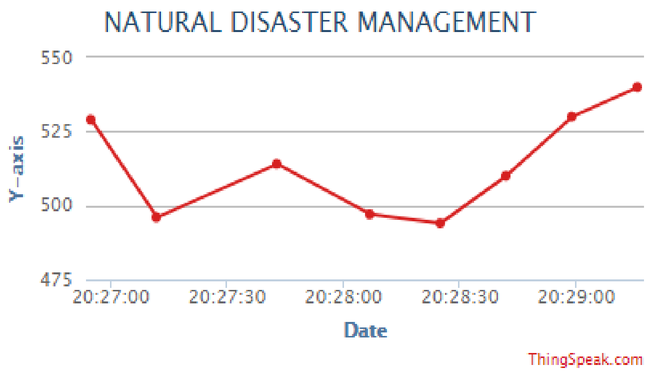

Fig. 6(b)

The graph in figure 6 (b) shows the variation in y-axis at regular time intervals. For each coordinate of the earth a threshold value is set based on the past record of the region. The above shows the y axis variation at different instants of time. Here the reference is taken as 500.

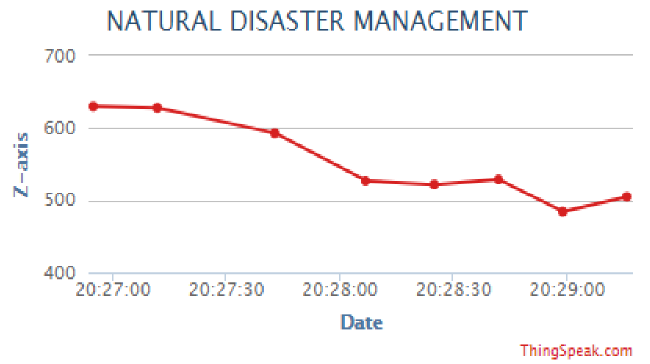

Fig. 6(c)

The graph in figure 6 (c) shows the variation in y-axis at regular time intervals. For each coordinate of the earth a threshold value is set based on the past record of the region. The above shows the z axis variation at different instants of time. Here the reference is taken as 500

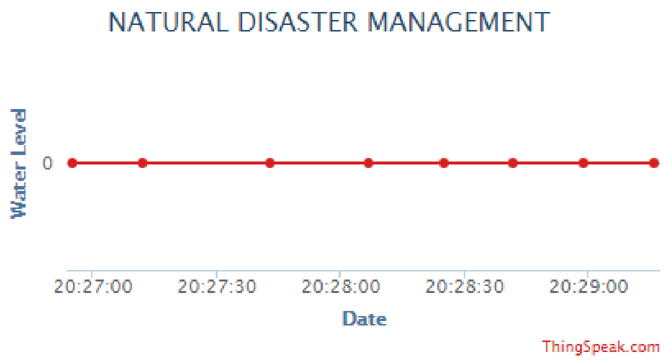

Fig. 6(d)

The graph in figure 6 (d) shows the variation in water levels at regular time intervals. Depending on the variations, threshold value will be decided. Here the water levels range selected is 200.If it crosses the value an SMS is sent to the mobile number which we have given in the program.

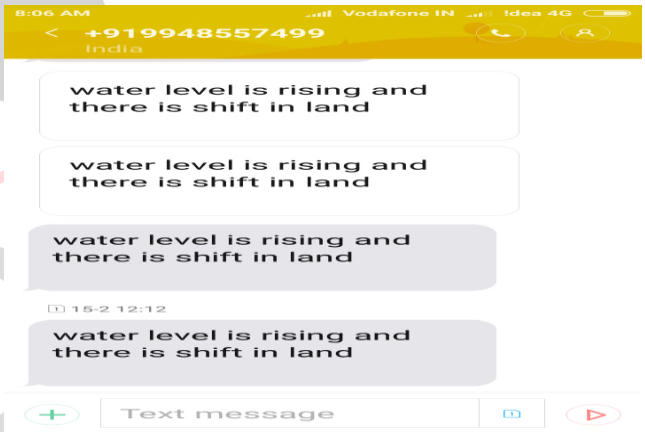

Fig. 7(a)

The graph in figure 7(a) shows the SMS alert received to a mobile number when a threshold value is reached. The mobile number is decided in the program part of the project.

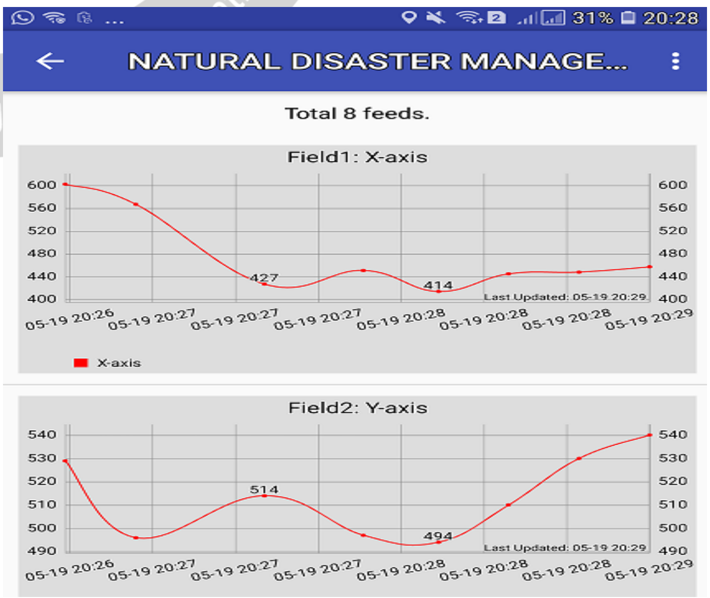

Fig. 7(b)

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The graph 7(b) shows the mobile app display of axes at different instants of time. The app Thingchart make the presentation of the situation at different instants. After completing the analysis on sensed data, the threshold value will be set for necessary controlling actions.

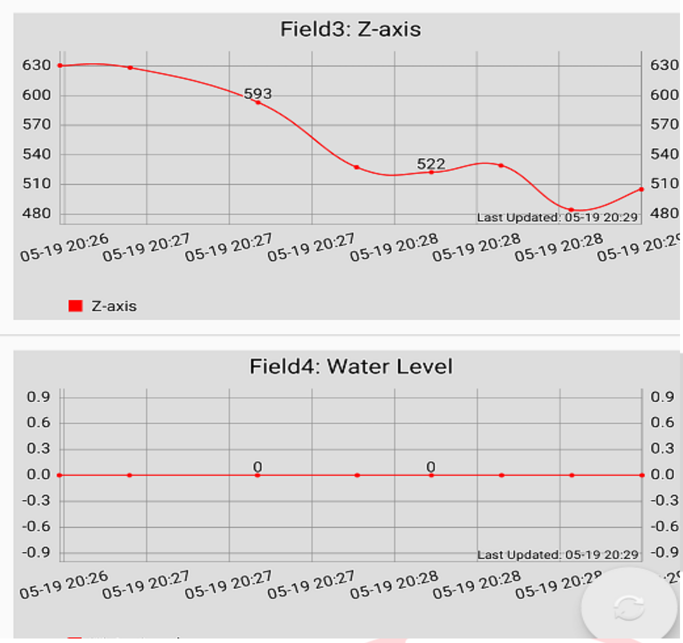

Fig.7(c)

The graph 7(c) shows the mobile app display of axes at different instants of time. The app Thingchart make the presentation of the situation at different instants. After completing the analysis on sensed data, the threshold value will be set for necessary controlling actions and an SMS to the Mobile numbers of the people residing along the coastal line.

VII. CONCLUSION

According to this project we can implement inexpensive wireless sensor network components to detect floods and send alert to the people residing across the coastal line of a country. Adoption of new techniques could reduce the chances of losing human lives as well as damage to large-scale infrastructures due to both natural and human-made disasters. IoT, which allows seamless interconnection among heterogeneous devices with diverse functionality, is a viable solution for disaster management. By applying data analytics and artificial intelligence tools, IoT-enabled disaster management systems are used for early warning about the mishap. Since the impact of any disaster is enormous, the IoT-enabled disaster management system can be applied to find the victim and possible rescue operations.

In summary, the aim of this is to provide fundamentals about IoT-based disaster management systems that help us to understand past research contributions and future research direction to solve different challenges of disaster management systems.

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