Landslide Pre-Warning System for Railway Track in Hill Station using WSN

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Abstract— **The down sliding of rock, soil and organic material due to various parameters under the influence of the gravitational force causes a considerable hazard to natural habitat, environment, economy and other resources [7]. Real-time monitoring of landslide is a very complex technology[4] and the product of multi-disciplinary combination of detection[4], monitoring[2] and control[1] of the hazard. In this paper A Disaster pre-warning system is being developed for the railway track in hill stations, where the railway transport is affected due to heavy rainfall and frequent landslides. Integrating MEMS, Flex, PIR and Moisture sensors forming a heterogeneous wireless network helps in identifying the abnormalities[1] and this paper also includes development, deployment (analysis) and data retrieval of the sensors information using WSN [2] along with the specification of the location of occurrences of landslide with the help of GPS.**

Keywords---WSN; Heterogeneous sensor network; Landslide.

I. INTRODUCTION

Wireless sensor network (WSN) technology which is utilized in hilly area where geological hazards occurr easily is effective attempt. Because WSN itself has some better characteristics such as redundancy, wireless, the self-adaptive network and strong anti-destruction capability, WSN can still complete the limited communication even though all communications facilities are damaged totally [5].

Combination of Wireless sensor network[2] and Landslide monitoring becomes the focus of research in the world. A number of research institutes and companies have taken a lot of hard work and gained some achievements in scientific research and corresponding products. For example Indian institute of technology designed a distributed monitoring system for landslides monitoring based on wireless sensor.

In this paper Pre-warning[4] and forecasting of landslide are implemented. The system collects landslide data by acceleration sensor [MEMS], Flex sensor, PIR sensor and the soil humidity sensor forming a heterogeneous mote, transmitting data to the nearby station along with the specification of the region of occurrence of landslide[5]. The data collected is transmitted to the receiver end which acknowledges the train about the abnormality occurred for it to be halted.

II. LANDSLIDE

Landslides are simply defined as down slope movement of rock, debris and/or earth under the influence of gravity. This sudden movement of material causes extensive damage to life, economy and environment[7]. Landslide is the most common and universally accepted collective term for most slope movements of the mass movement type. The term has sometimes been considered unsuitable as the active part of the word denotes sliding. Mass Movement[7] is outward or downward gravitational movement of earth material without the aid of running water as a transporting agent. It does not deny the importance of water in either its solid or liquid state as a destabilising factor nor does it excludes subsidence and other movements on flat ground. Controlling[1] (Perpetuating) Factors which dictate the condition of movement as it takes place; i.e. factors which control the form, rate and duration of movement.

III. SENSORS

1. Flex sensor

The Flex Sensor patented technology is based on resistive carbon elements. As a variable printed resistor, the Flex Sensor[1] achieves great form-factor on a thin flexible substrate. When the substrate is bent, the sensor produces a resistance output correlated to the bend radius. Flex Sensors are used in applications like Automotive controls, Medical devices, Industrial controls, Computer peripherals, Fitness products, Musical instruments, Measuring devices, Virtual reality games, Consumer products, Physical therapy. .

Attributes: Custom designed to match customer specs like High level of reliability, consistency, repeatability, harsh temperature resistance, Variety of flexible or stationary surfaces for mounting, infinite number of resistance possibilities and bend ratios.

Fig.1 Flex Sensor

2. PIR sensors:

A Passive InfraRed sensor (PIR sensor)[1] is an electronic device that measures infrared (IR) light radiating from objects in its field of view. PIR sensors are often used in the construction of PIR-based motion detectors. Apparent motion is detected when an infrared source with one temperature, such as a human, passes in front of an infrared source with another temperature, such as a wall.

It is usually infrared radiation that is invisible to the human eye but can be detected by electronic devices designed for such a purpose. The term *passive* in this instance means that the PIR device does not emit an infrared beam but merely passively accepts incoming infrared radiation. “Infra” meaning below our ability to detect it visually, and “Red” because this color represents the lowest energy level that our eyes can sense before it becomes invisible.

Fig.2 PIR Sensor

3. MEMS Sensor:

Mems accelerometer and gyroscope: Acceleration is a measure of how quickly speed changes. An accelerometer is a meter that measures acceleration. An accelerometer's ability can be used to sense acceleration to measure a variety of things that are very useful to electronic and robotic projects and designs like Acceleration, Tilt and tilt angle, Incline, Rotation, Vibration, Collision, Gravity.

A gyroscope is a device for measuring or maintaining orientation, based on the principles of angular momentum. In essence, a mechanical gyroscope is a spinning wheel or disk whose axle is free to take any orientation. Although this orientation does not remain fixed, it changes in response to an external torque much less and in a different direction than it would without the large angular momentum associated with the disk's high rate of spin and moment of inertia. Since external torque is minimized by mounting the device in gimbals, its orientation remains nearly fixed, regardless of any motion of the platform on which it is mounted.

Fig.3 MEMS Sensor

4. Moisture sensor:

The Soil Moisture Sensor[1] uses capacitance to measure dielectric permittivity of the surrounding medium. The sensor creates a voltage proportional to the dielectric permittivity, and therefore the water content of the soil. The sensor averages the water content over the entire length of the sensor. There is a 2 cm zone of influence with respect to the flat surface of the sensor.

Dry soil is made up of solid material and air pockets, called pore spaces. A typical volumetric ratio would be 55% solid material and 45% pore space. As water is added to the soil, the pore spaces begin to fill with water. Soil that seems damp to the touch might now have 55% minerals, 35% pore space and 10% water.

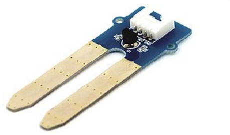

Fig.4 Moisture Sensor

IV. HARDWARE DESCRIPTION:

A controller is taken as the ‘master node’ while designing the system for collecting the sensor data and transmitting it to the receiver node with some intermediate nodes making a whole network into a Wireless Sensor Network.

The details about the controller is given as:

a) Controller: (AT89S52)

The AT89S52 is a low-power, high-performance CMOS 8-bit microcontroller with 8K bytes of in-system programmable Flash memory. The device is manufactured using Atmel’s high-density nonvolatile memory technology and is compatible with the Indus-try-standard 80C51 instruction set and pin out.

The on-chip Flash allows the program memory to be reprogrammed in-system or by a conventional nonvolatile memory pro-grammars. By combining a versatile 8-bit CPU with in-system programmable Flash on a monolithic chip, the Atmel AT89S52 is a powerful microcontroller which provides a highly-flexible and cost-effective solution to many embedded control applications.

The AT89S52 provides the following standard features: 8K bytes of Flash, 256 bytes of RAM, 32 I/O lines, Watchdog timer, two data pointers, three 16-bit timer/counters, a six-vector two-level interrupt architecture, a full duplex serial port, on-chip oscillator, and clock circuitry.

The AT89S52 is designed with static logic for operation down to zero frequency and supports two software selectable power saving modes. The Idle Mode stops the

CPU while allowing the RAM, timer/counters, serial port, and interrupt system to continue functioning.

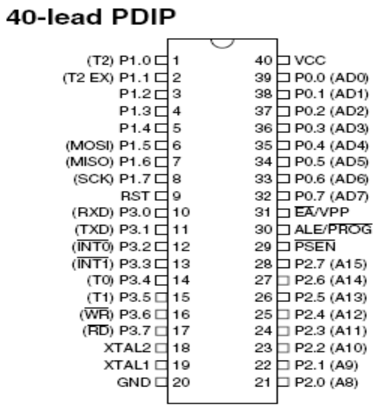

Fig.5 Pin Diagram of Microcontroller AT89S52

b) ADC:(ADC0808, ADC0809)

The ADC0809 data acquisition component is a monolithic CMOS device with an 8-bit analog-to-digital converter, 8-channel multiplexer and microprocessor compatible control logic. The 8-bit A/D converter uses successive approximation as the conversion technique. The converter features a high impedance chopper stabilized comparator, a 256R voltage divider with analog switch tree and a successive approximation register. The 8-channel multiplexer can directly access any of 8-single-ended analog signals. The device eliminates the need for external zero and full-scale adjustments. Easy interfacing to microprocessors is provided by the latched and decoded multiplexer address inputs and latched TTL TRI-STATE outputs.

The design of the ADC0808, ADC0809 has been optimized by incorporating the most desirable aspects of several A/D conversion techniques. The ADC0808, ADC0809 offers high speed, high accuracy, minimal temperature dependence, excellent long-term accuracy and repeatability, and consumes minimal power.

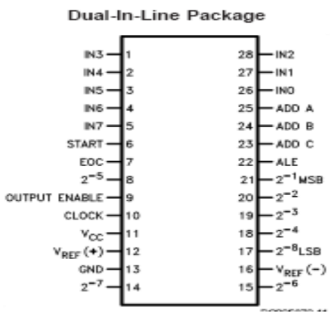

Fig.6 Pin Diagram of ADC0808, ADC0809

c) MAX232:

The Universal Asynchronous Receiver/Transmitter (UART) controller is the key component of the serial communications subsystem of a computer. The UART takes bytes of data and transmits the individual bits in a sequential fashion. At the destination, a second UART re-assembles the bits into complete bytes. Serial transmission of digital information (bits) through a single wire or other medium is much more cost effective than parallel transmission through multiple wires. A UART is used to convert the transmitted information between its sequential and parallel form at each end of the link. Each UART contains a shift register which is the fundamental method of conversion between serial and parallel forms.

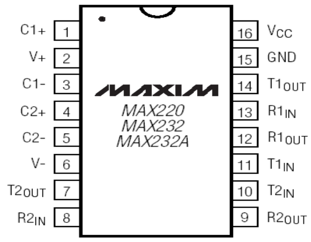

Fig.7 Pin Diagram of UART

d) ZIGBEE:

ZigBee[8] is a specification for a suite of high level communication protocols using small, low-power digital radios based on the IEEE 802.15.4-2003 standard for wireless personal area networks (WPANs), such as wireless headphones connecting with cell phones via short-range radio. The technology defined by the ZigBee[8] specification is intended to be simpler and less expensive than other WPANs, such as Bluetooth. ZigBee[8] is targeted at radio-frequency (RF) applications that require a low data rate, long battery life, and secure networking.

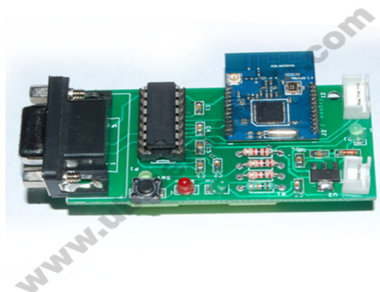

Fig. 8 ZIGBEE

e) GPS:

The Global Positioning System (GPS) is a U.S. space-based global navigation satellite system. It provides reliable positioning, navigation, and timing services to worldwide users on a continuous basis in all weather, day and night, anywhere on or near the Earth. Three satellites might seem enough to solve for position, since space has three dimensions. However, even a very small clock error multiplied by the very large speed of light—the speed at which satellite signals propagate—results in a large positional error. Therefore receivers use four or more satellites to solve for the receiver's location and time. The very accurately computed time is effectively hidden by most GPS applications, which use only the location. A few specialized GPS applications do however use the time; these include time transfer, traffic signal timing, and0 synchronization of cell phone base stations.

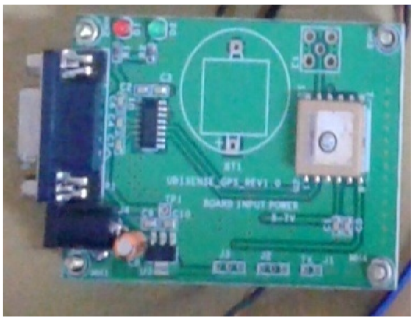

Fig.9 GPS

f) Power Supply:

Power supply is a reference to a source of electrical power. A 230v, 50Hz Single phase AC power supply is given to a step down transformer to get 12v supply. This voltage is converted to DC voltage using a Bridge Rectifier. The converted pulsating DC voltage is filtered by a 2200uf capacitor and then given to 7805 voltage regulator to obtain constant 5v supply which is given to all the components in the circuit. A RC time constant circuit is added to discharge all the capacitors quickly. To ensure the power supply a LED is connected for indication purpose.

V. NODE DESIGN:

There are two modules specified in the proposed system. The Sensor Module and the Receiver Module.

The sensor node[2] will have control[1] over the sensors that are being deployed and gather the information from various sensors. This information is transmitted to the receiver node through the intermediate node without missing any information.

A) SENSOR MODULE:

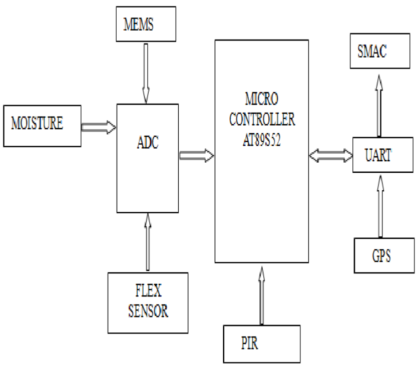

Fig.10 Block diagram of Sensor Module

B) *RECEIVER* MODULE:

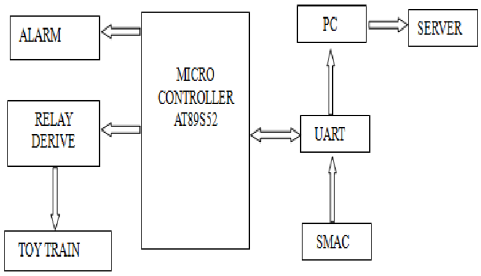

Fig.11 Block Diagram of Receiver module

Fig 12 shows the Sensor module (Transmitter node) consists of 3 analog sensors (MEMS, FLEX, moisture sensor) and 1 digital sensor (PIR sensor)[2] interfaced with the Microcontroller(AT89S52), which collects information from sensors and transmit using the ZIGBEE[8] with SMAC protocol to the receiver module.

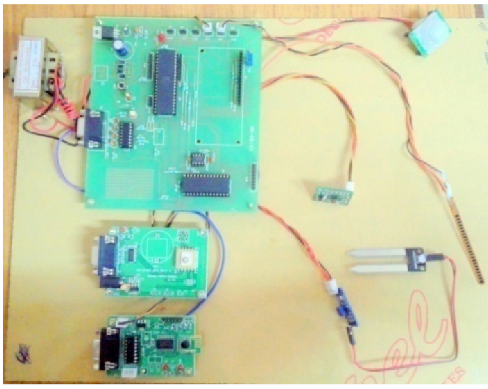

Fig.12 Sensor Module

Fig 13 shows the receiver module gets the transmitted information and sends it to the PC[1], with internet connection that gives the location of the abnormality with the help of Google map. The information is also sent to the train using a relay drive which stops the train with a alarm sound to pre-warn the nearby station.

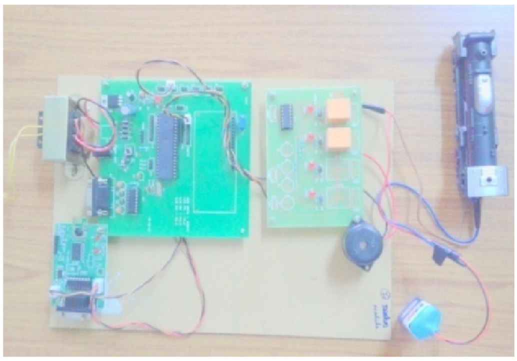

Fig.13 Receiver Module

VI. RESULT:

When the abnormality or disaster is detected by the Sensor module with the GPS, then the information is passed to the train as well as the Master control (PC), connected to the receiver module with the Tracker GPS to give detail about the event and its location. The train is intimated on occurrence of the abnormality even if any one of the sensor detects that the event has occurred.

The different outcome of the consequences faced due to the abnormality that has occurred along the railway track is defined on the Tracker GPS software that is installed in the PC to intimate to the nearby station and to the train.

a) Detection of mass movement in soil:

When the resistance limit of the FLEX sensor[2] exceeds that is when there is a change in the pressure on the track, it is detected[2] and acknowledged[4] by the Tracker GPS software in the PC as 'Landslide Detected'[7] along with the Google map mentioning the latitude and longitude of the location in the Tracker GPS as shown in Fig 14.

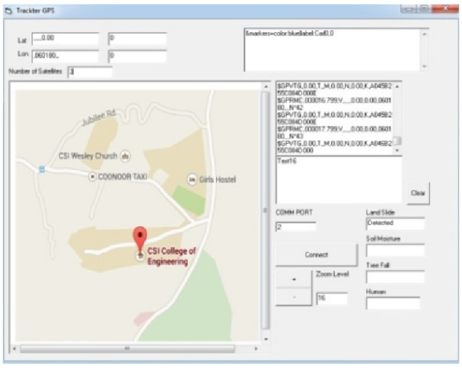

Fig.14 Detection of mass movement in soil

b) Detection of human getting trapped:

In case there is a human trapped in the track when a landslide has occurred, then the PIR sensor acknowledges[2] on the information about the human being trapped and intimates[1] the train to stop and indicated as 'Human detected' along with 'Landslide Detected'[7] in the Tracker GPS as shown in Fig 15.

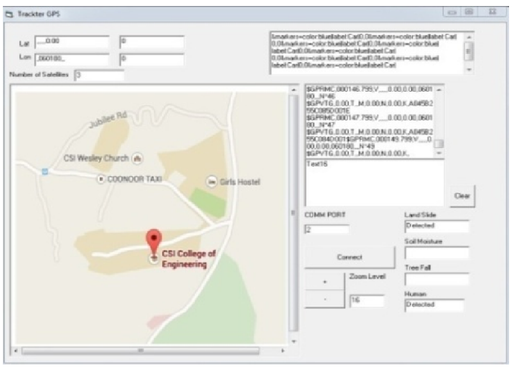

Fig.15 Detection of Human getting trapped

c) Detection of moisture content in soil:

When the soil dampness increases from the stored threshold value then the change of the soil characteristics is noted, this may cause the soil erosion. The moisture sensor when detects this condition it intimate and pre-warn the train about the occurrence of the abnormality for its halt. This is denoted as 'soil moisture detected' in the Tracker GPS as in Fig 16 .

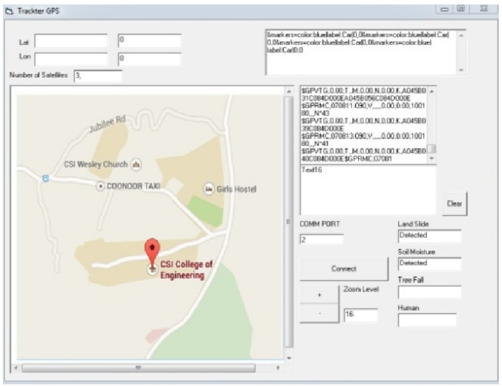

Fig.16 Detection of moisture content in soil

d) Detection of tree fall:

When the MEMS sensor[1] detects the sudden change[4] in the acceleration, tilt, vibration in the deployed region beyond the predefined value given, the Sensor module collects the information and considers it as the occurrence of tree fall. The information is sent[2] to the receiver module and the abnormality is intimated to the Train for it to stop as well as the master control (PC) connected to the module and is denoted as 'Tree Fall' in the Tracker GPS as shown in Fig 17.

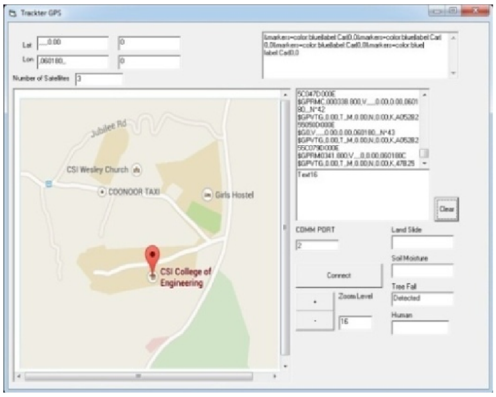

Fig.17 Detection of tree fall

VII. CONCLUSION AND FUTURE ENHANCEMENT:

The advantage of the node deployed is that it can achieve optimum results with minimum cost and even more convenient to expand communication with other devices for fast responses.

In general case Asia is the most affected continent due to land-slides and among Asian countries India one of the countries most affected with. About 25% of India's land mass (0.82 million square kilometers) is prone to land-slides. By use of Wireless Sensor Network any mechanical or geo-physical sensor can be interfaced easily for protection of our on livelihood as well as nation's wealth. This paper discussed a proto-model of NODE design for 'Land-Slide Monitoring' which of great importance especially in heavy rainfall and hilly areas along the railway tracks. The WSN deployment leads to access many of the sensor information and by using Ethernet, Wi-Fi, Satellite or any other wireless protocol the danger intimation can be passed to the nearby station and to the Rescue service.

The Data Acquisition System at the control station is equipped with all the necessary protection equipment for all necessary measures which can be easy for the officials to take necessary steps for disaster protection. The maintenance of the database may become a risk factor of the module.

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