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Disaster Pre-Warning System [DPS] for Hill Trains Using WSN

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Abstract— A wide variety of processes that result in the perceptible downward and outward movement of soil, rock, and vegetation under gravitational influence cause a considerable damage to the natural habitat, environment, economy and other resources. The three major issues regarding Real-Time applications are detection [8], monitoring [2] and control [9]. For large scale detection [8] and monitoring [2] the faults is one of the important applications that lead to advancement of many kind of technologies. In this paper A Disaster pre-warning system is being developed for the hill train in The Nilgiris, India. It is a region which has high rainfall and versatile climatic behavior most of the year. Integrating MEMS, Flex, PIR and Moisture sensors forming a heterogeneous wireless network [1] helps in identifying the abnormalities and this paper also includes development, deployment and data retrieval of the sensors information using WSN.
Keywords— Landslide monitoring, Landslide pre-warning, Heterogeneous wireless sensor network, Hill train, GPS.

I. INTRODUCTION

Landslides are viewed as a persistent problem along transportation corridors in mountainous regions. Landslides not only cause damage to properties and life, but also affect the society by disrupting the utility services and economy activities. In order to reduce the impact of landslides on society it is necessary to quantitatively estimate the risk from potential landslides, and carry out a cost-benefit analysis of various risk reduction measures. The research was conducted along a transportation corridor with a road and a railway alignment in the Nilgiris hills in southern India. Historical records belonging to the railway and geotechnical units were used to obtain a multi-temporal landslide inventory for a 23-year period from 1987 to 2009. A substantially complete inventory was obtained for landslides initiating from cut slopes along the transportation lines. In contrast, only little information was available for landslides affecting natural slopes above the transportation lines. Most landslides were shallow translational debris slides and debris flow slides triggered by rainfall. On natural slopes most landslides occurred as first-time failures. Disaster management of various environmental activities and detecting these conditions is one of the crucial parts that any technology should perform. Various technologies have been developed till now and wireless sensor networks (WSN) are one of the technologies that can fulfil the requirement. Data extraction and transmission using WSN is easy with low cost and low power consumption. This paper describes a simple design and basic implementation of disaster pre-warning system with various sensors forming a heterogeneous network and transmitting the data to a master control station. In China, only Wang Yanying and Yang Bin (Southwest Jiao Tong University Computer College) developed a real-time monitoring [2] system based on wireless sensor network. The system focuses on two parts: μC / OS-II operating system porting and sensor network topology. Routing algorithm of network topology has weaker control for routing. So accurate routing is hard to be carried out. Furthermore invalid transmission and energy loss of node are likely to occur. Since residual energy of the node is ignored at the process of routing, it is likely to cause node early death. The life cycle of the network is affected. Remote data transmission by GSM SMS can cause some obvious defects such as transmission delay and poor real-time. So the low-cost, real-time requirements cannot be satisfied. Overall performance of the system is reduced. Currently, Landslide monitoring [2] pre-warning system based on wireless sensor network can avoid the disadvantages of the traditional monitoring [2] method, enhance advantages of traditional monitoring [2] method and improve monitoring [2] performance. But some key parameters such as accuracy, real-time and low power consumption, need to be further improved. In order to meet the landslide monitoring [2] performance needs, wireless sensor with low-power consumption must be adopted. Flexible and effective routing protocol of wireless sensor network can guarantee reliability of data transmission while GPRS technology can implement remote real-time transmission. The combination of the two can achieve the real-time accurate monitoring [2] and pre-warning for landslide.

II. REVIEW WORK

The advancements in electronics industry paved way for improvement of WSN in various real-time applications. The Disaster Pre-Warning System (DPS) has been developed which uses ZIGBEE [13] (SMAC Protocol) and GPS to alert the master control

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station. Besides this system research has shown that sensor deployment is a basic requirement for any kind of fault detection [8] system, monitoring [2] can be achieved by using other techniques like remote sensing; GPS technology and so on can also be used as an individual unit or in a combination to achieve the requirement. In this paper, with the basic information gathered the deployment of heterogeneous WSN [1] network is being discussed. The ease of implementation, low power consumption, minimal maintenance cost paved for turning views to Wireless Sensor Network. This paper includes about the electronic node designing using controller and its interface with various sensors, software development with Keil uVision4.

A. Disasters

Landslides are very common events in the Nilgiris are, which occur mostly as debris flow slides triggered by high intensity or prolonged heavy rainfall. Historically landslides have resulted in numerous losses of lives and properties.

The earliest record pertains to the “avalanche” landslide, which occurred in 1824 due to heavy rainfall lasting for eight days. In 1891, about 740 mm rainfall within few days triggered many landslides along the Kotagiri-Mettupalayam road, which resulted in the closure of the road for 21 days. The unprecedented rains triggered about a hundred landslides in 1978 and nearly 200 landslides in 1979.

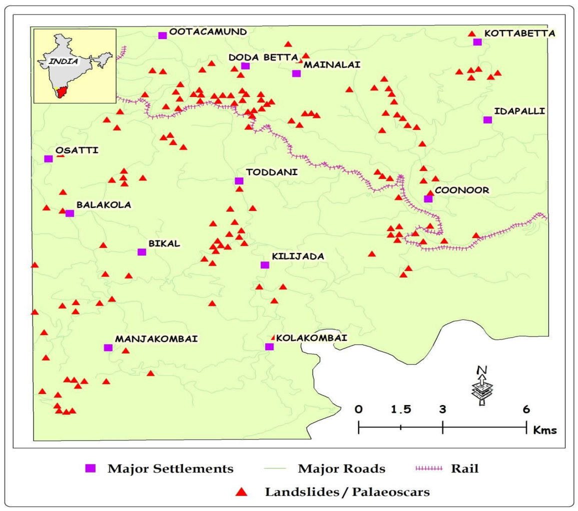

Fig. 1 Key map and the locations of landslides

At present the railway department incur an annual loss of about US$217,000, which includes loss resulting from the physical damage of the infrastructures by landslides, loss from the blockage of the railroad and the railway operational loss. Figure 1 shows the spatial distribution of landslides triggered in 1979 within the study area. In 1978, most landslides triggered around Ootacamund and in 1979, around Coonoor, that is along the road and the railroad between Kallar and Coonoor.

Fig. 2 Blockage of the rail road

B. Heterogeneous WSN [1]

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The heterogeneous WSN [1] consists of sensor nodes with different abilities, such as various sensor types and communication/ sensing range, thus provides more flexibility in deployment. Hence we can construct a WSN in which nodes are equipped with different kinds of sensors to provide various sensing services. A mixed deployment of these nodes can achieve a balance of performance and cost of WSN. This paper concentrates on four sensors.

1) MEMS Sensor

Micro-electromechanical systems (MEMS) incorporate miniature electro-mechanical components fabricated with processing techniques and equipment originally developed in the semiconductor industry. MEMS accelerometer's ability can be used to sense acceleration to measure a variety of things such as acceleration, tilt and tilt angle, incline, rotation, vibration, collision and gravity that are very useful to electronic projects and designs.

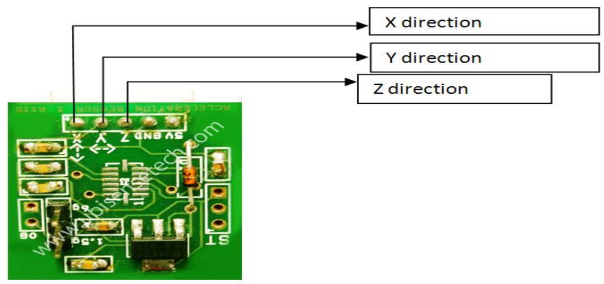

Fig. 3 MEMS Pin Details

2) PIR Sensors

PIR is a pyroelectric sensor module which developed for human body detection [8]. A PIR detector combined with a Fresnel lens are mounted on a compact size PCB together with an analog IC, SB0061, and limited components to form the module. The Ernitec PIR’s are truly passive devices which detect objects entering or crossing its field of view. The detectors have a nominal range of 75 or 100 m with a curtain shaped field of view. The curtain shape is ideal for the protection of perimeters and long buildings as it has a fairly narrow and long range. In this application, a Fresnel lens array is used in conjunction with a pyroelectric detector to create a useful detection [8] pattern. While the primary application for PIR lenses and lens arrays are the security industry.

Fig. 4 PIR Sensor

3) Moisture Sensors

Moisture sensor is a simple water sensor that can be used to detect soil moisture level. Module output is high when the soil moisture is deficit or the module output is low. Sensitivity is adjustable by adjusting the digital potentiometer (shown in blue).

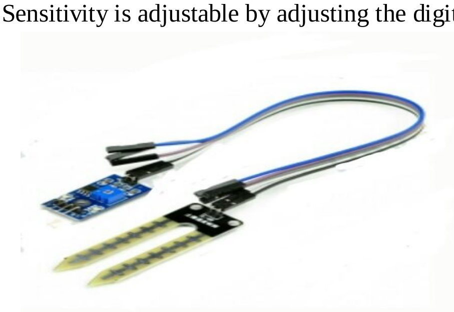

Fig. 5 Moisture Sensor

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4) Flex Sensors

Flex sensors are sensors that change in resistance depending on the amount of bend on the sensor. They are usually in the form of a thin strip from 1”-5” long that vary in resistance. They can be made uni-directional or bi-directional. Flex sensors are analog resistors. They work as variable analog voltage dividers. Inside the flex sensor are carbon resistive elements within a thin flexible substrate. More carbon means less resistance. When the substrate is bent the sensor produces a resistance output relative to the bend radius.

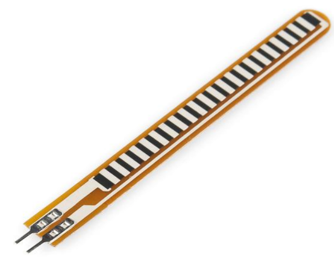

Fig. 6 Flex Sensor

C. Hardware Description

To design the Disaster Pre-Warning System [DPS], the modules are basically fabricated with controllers, UART, GPS and analog to digital convertors.

1) Controller

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. In addition, 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. The Power-down mode saves the RAM con-tents but freezes the oscillator, disabling all other chip functions until the next interrupt or hardware reset

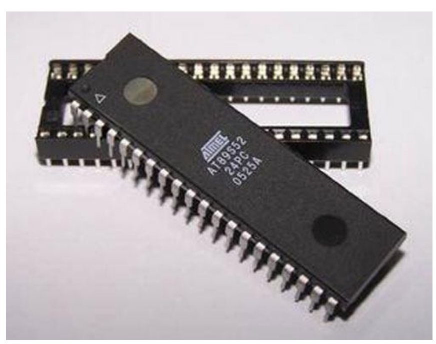

Fig. 7 AT89S52 controller

2) UART

A universal asynchronous receiver/transmitter is a type of "asynchronous receiver/transmitter", a piece of computer hardware that translates data between parallel and serial forms. UARTs are commonly used in conjunction with other communication standards such as EIA RS-232. UARTs are now commonly included in microcontrollers. A dual UART or DUART combines two UARTs into a single chip. Many modern ICs now come with a UART that can also communicate synchronously; these

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devices are called USARTs.

Fig. 8 UART

The MAX232 is an integrated circuit that converts signals from an RS-232 serial port to signals suitable for use in TTL compatible digital logic circuits. The MAX232 is a dual driver/receiver and typically converts the RX, TX, CTS and RTS signals. These receivers have a typical threshold of 1.3 V, and a typical hysteresis of 0.5 V. The later MAX232A is backwards compatible with the original MAX232 but may operate at higher baud rates and can use smaller external capacitors – 0.1 μF in place of the 1.0 μF capacitors used with the original device.

Fig. 9 RS-232

3) 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.GPS is made up of three parts: between 24 and 32 satellites orbiting the Earth, four control and monitoring [2] stations on Earth, and the GPS receivers owned by users. GPS satellites broadcast signals from space that are used by GPS receivers to provide three-dimensional location (latitude, longitude, and altitude) plus the time. Since it became fully operational on April 27, 1995, GPS has become a widely used aid to navigation worldwide, and a useful tool for map-making, land surveying, commerce, scientific uses, tracking and surveillance, and hobbies such as geocaching and way marking. Also, the precise time reference is used in many applications including the scientific study of earthquakes and as a time synchronization source for cellular network protocols.

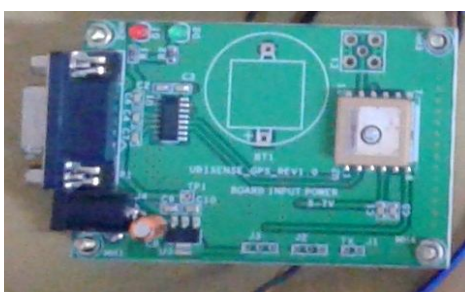

Fig. 10 GPS

4) ADC 0808/0809

The ADC0808, 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 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

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8-bit A/D converter uses successive approximation as the conversion technique. 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.

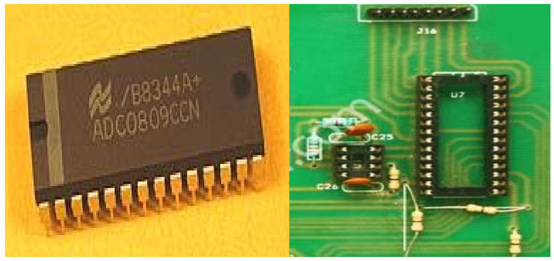

Fig. 11 ADC0809

5) ZIGBEE

ZIGBEE [13] 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 [13] specification is intended to be simpler and less expensive than other WPANs, such as Bluetooth. ZIGBEE [13] is targeted at radio-frequency (RF) applications that require a low data rate, long battery life, and secure networking. One ZIGBEE [13] network can contain more than 65,000 nodes. The networking cooperation with each other may take the shape of a star, a branching tree or a net.

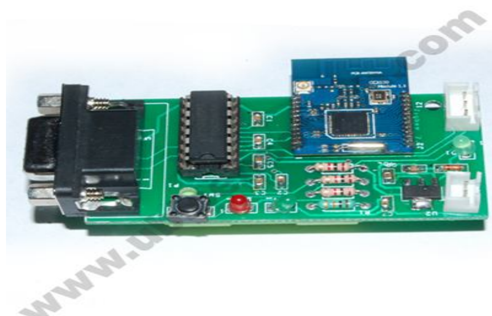

Fig. 12 ZIGBEE

III. MODULE DESIGN

In the Disaster Pre-Warning System [DPS] two hardware modules are to be fabricated – the sensor module and the sub-station module.

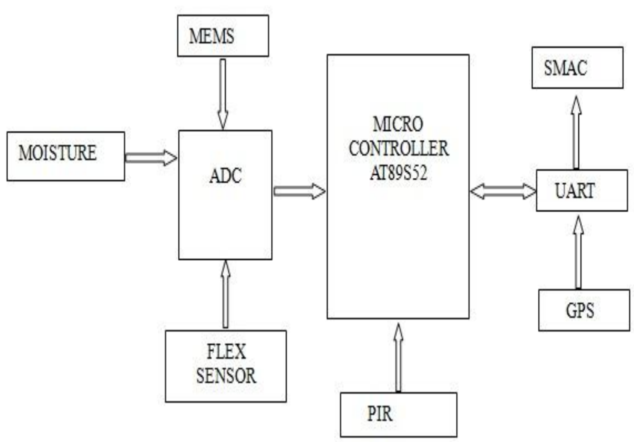

Fig. 13 Sensor module

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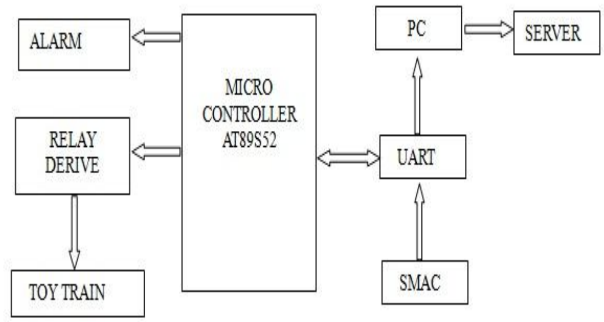

Fig. 14 Sub-station module

A. Sensor module

The sensor module is fabricated with the heterogeneous WSN [1]. The controller in this module gathers the information from various sensors and transmits to the sub-station module through intermediate node without missing any information.

Heterogeneous WSN [1] consists of three analog sensors (MEMS, Flex and moisture) and one digital sensor (PIR) interfaced with the controller (AT89S52). ZIGBEE [13] with SMAC protocol is used as the transmission medium.

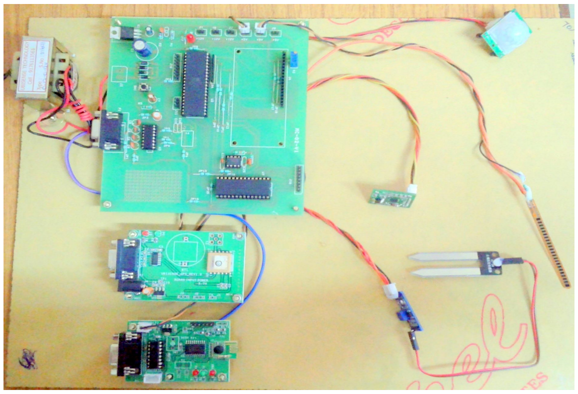

Fig. 15 Sensor module

B. Sub-Station module

The sub-station modules are placed in all the railway stations. The major function of a sub-station module is to alert the train and to pass on the information to the master control module. When an abnormality occurs within the limit of a particular sub-station, then it sets the alarm in that station and pre-warns the train to terminate its journey in the same station.

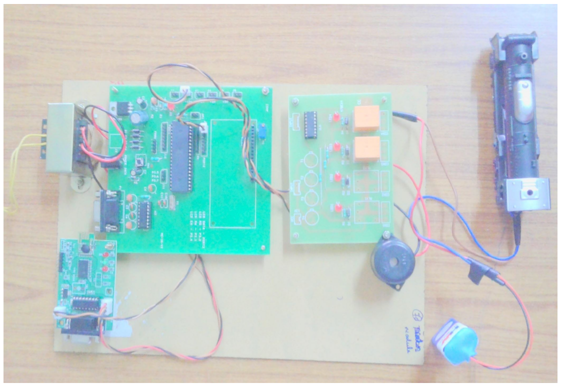

Fig. 16 Sub-station module

C. Master control module

The master control modules which are personal computers are placed only in the end-stations of a train. It uses tracker GPS software to monitor the signal of abnormalities arriving from the sub-station module. The GPS in the sensor module also indicates the exact location of the abnormality occurred in the tracker GPS software with the help of Google map.

IV. SYSTEM ANALYSIS

In Disaster Pre-warning System, we have programmed to detect the mass down-slide of soil, rocks and tree fall, which may occur due to various parameters like change in pressure, increase in dampness of soil and change in gravity.

A. Detection of Landslide due to change in pressure

The deployed Flex sensor detects the sudden change in the pressure and intimates the probability in occurrence of landslide. When such abnormality occurs, the master module will get an alert as shown in figure 17.

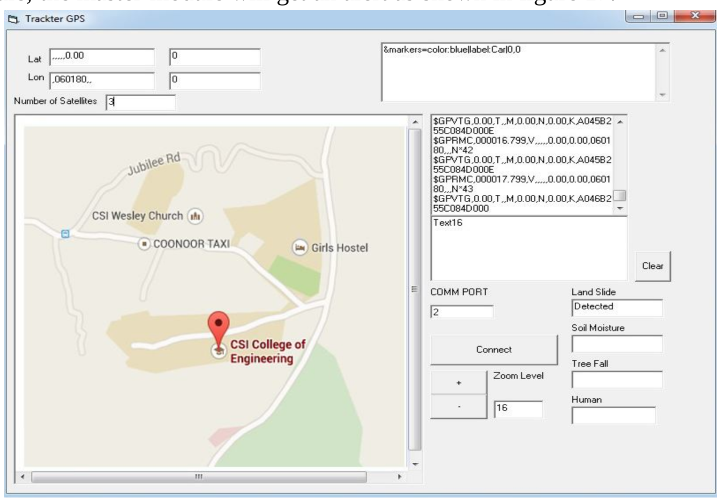

Fig. 17 Detection of Landslide in Tracker GPS

B. Detection of Tree fall

The MEMS sensor is deployed to detect the tree fall and down fall of the rocks on the railway track due to acceleration, vibration, collision and gravity. While programming the MEMS, threshold values of various objects falling is preset. When an abnormality occurs, the MEMS compare with the predefined threshold values and intimate the event occurring as shown in figure 18.

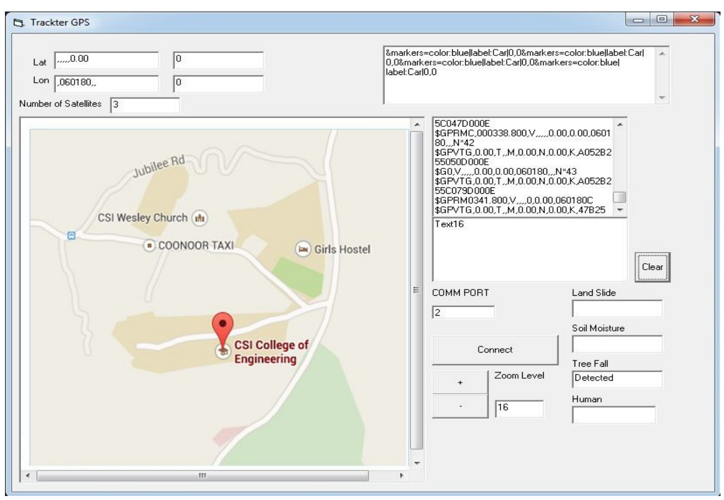

Fig. 18 Detection of tree fall in tracker GPS

C. Detection of increase in soil moisture

The sensitivity of the moisture sensor is preset according to the soil characteristics of the sensor deployed region. When the dampness of the soil increases above the predefined value, the sensor module output becomes low and intimates the master control module as shown in figure 19.

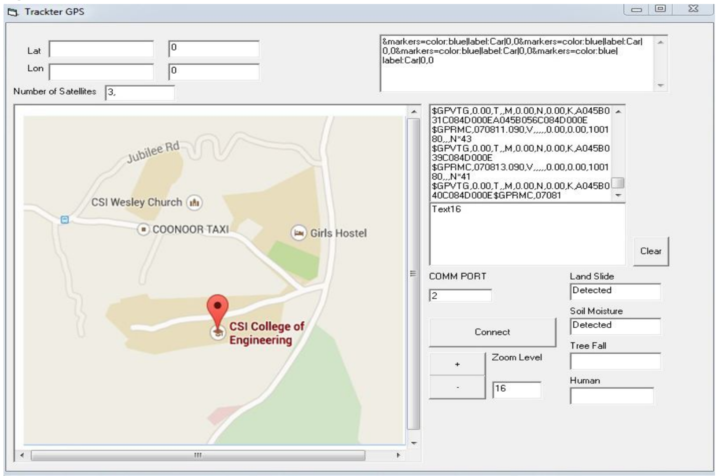

Fig. 19 Detection of increase in soil moisture

D. Detection of Human trapped in Landslides

When a disaster occurs in a region, the PIR sensor deployed in that locality detects the trapped human. If any, then it indicates in the tracker GPS as shown in figure 20.

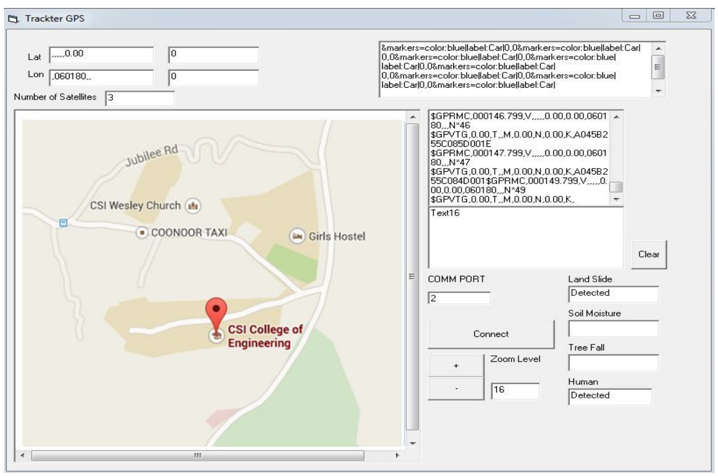

Fig. 20 Detection of trapped human in tracker GPS

V. CONCLUSION AND FUTURE SCOPE

The Disaster Pre-warning System [DPS] has a privilege of being more compatible in expanding with other communication devices for comparatively fast responses. The node is deployed to obtain optimum results with minimum cost. This paper discusses a proto-model of sensor module and sub-station module design for ‘Disaster pre-warning System’ which has a great importance especially in heavy rainfall regions and hilly areas. It has a problem in database storage, where tracker GPS indicates the abnormalities but does not store the data. Hence master control module can be further enhanced with database management. The heterogeneous wsn [1] 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 stations and to the Rescue service.

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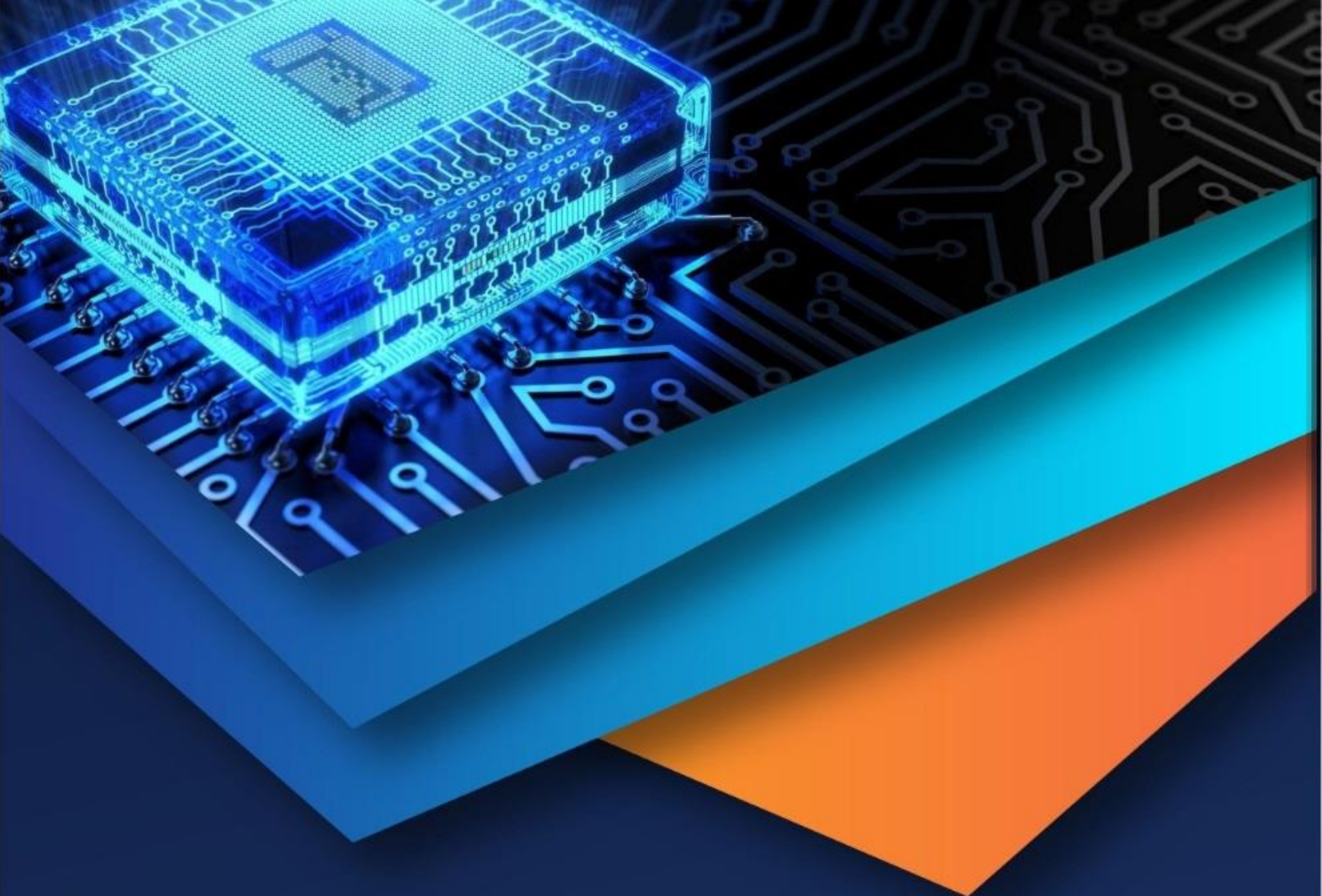

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