Landslide and Rockslide Detection System with Landslide Early Warning System for Railways

Madhusudhan.Y.V
Department of ECE
Vidyavardhaka college of engineering
Mysuru, Karnataka, India

Renuka.H.C
Department of ECE
Vidyavardhaka college of engineering
Mysuru, Karnataka, India

Bhavya.S.S
Department of ECE
Vidyavardhaka college of engineering
Mysuru, Karnataka, India

Manjunatha.M.N
CAM Engineer
Wuerth Electronik India Pvt Ltd
Mysuru, Karnataka, India

Alfred D'souza
Assistant professor,Department of ECE
Vidyavardhaka college of engineering
Mysuru, Karnataka, India

Kavyashree.B
Assistant professor,Department of ECE
Vidyavardhaka college of engineering
Mysuru, Karnataka, India

***Abstract*— Natural disasters are increasing worldwide due to the global warming and climate change. The Landslides and rockslide disaster is among those disasters which is largely unpredictable and occurs within very short spans of time. Because of landslides or rockslides many accidents occur on highway, hill station and railway track. Therefore technology has to be developed to capture relevant signals with minimum monitoring delay. Wireless Sensors are one of the cutting edge technologies that can quickly respond to rapid changes of data and send the sensed data to a data analysis center in areas where cabling is inappropriate. The status of tunnels and landslides prone area are checked before the landslides occur as well as after the landslides and providing information regarding the status to the railway authorities to protect people and avoid accident. It is now high time to replace the present manual detection systems deployed along the track. Thus the proposed system has sensor network technology which have the capability of developing large scale systems for real-time monitoring of landslide prone areas and give warning signals .Landslide detection system uses camera which monitors track and sends necessary information to railway authorities to take necessary actions if landslide detected.**

Keywords—Landslide,Vibration sensor,Detection system,Early warning system

I. INTRODUCTION

Indian Railway faces major problems during monsoon season due to landslides. Many routes were disrupted in hilly regions. All landslide monitoring systems in India are manual and outdated. People are made to stand in shifts for long hours in landslide prone areas to inform authorities about whether landslide has been occurred or not. Such manual systems increases waiting time for trains at signals, thus increasing their journey duration causing inconvenience to the passengers. Human errors in this case can lead to huge loss of lives and property. A disadvantage of manual inspection systems is that it is highly labor intensive and relies heavily on the actions of people which increases the possibility of human errors. The propose system reduces inconvenience to passengers with efficient functioning of railways and maintaining scheduled train timings. The system which can monitor landslides and send warning signals to the concerned authorities.

Depending on the fast developments in railway systems, high-speed trains are used, and rail transportation is increased day by day. Today's most of the people uses railway for transportation, it is essential for transferring the goods and passengers from one place to another place. But depending on different factors, deformations and derailment may occur on the super structure of railways which can be now avoided using wireless sensor technologies and avoid the risk of accidents in railways.

The proposed system provides a real time system which can monitor occurrence of landslides before landslides happen and detects blockage of railway tracks due to landslides or rockslides and sends precautionary signals to the concerned authorities. So Landslide warning system uses sensor network for providing warning signals to the authorities. Landslide detection system detects the landslide by monitoring the track.This monitoring is done using image processing with a camera and coding is done in MATLAB.

II. PROBLEM DEFINITION

Man has been developing various methods to protect himself from natural calamities since ages. The only scientific solution to natural calamities is development of systems to predict, detect and take preventive measures using recent advancement in technology. Along the highly landslide prone railway line, many people have lost their lives due to landslides. It is now high time to replace the present obsolete manual detection systems deployed along this line. At the very least, these problems result in money losses and delays. Problems, of course, can also cause immeasurable human losses. Some recent examples of derailments and accidents tells the necessity of better assessment of landslides in India.

III. MOTIVATION

Even after all accidents and losses no significant work has been done by railway authorities to improve the detection system by automation. Currently Indian railways doesn't incorporate landslide early warning system which helps them for better landslide assessment so that able to take precautionary measures as soon as they can.

Thus the proposed system is focusing on finding remedies to detect landslides or rockslides which blocks the railway tracks and causes derailment of the rail as well as avoid accidents in railways through automation.

To carefully protect people in landslide prone areas, we need a monitoring and alarm system. In many events such as landslides and water flooding, they can be warned by a raised alarm (warning system) within in a specified period. There are many natural disasters happen like Flood, Earthquake, Tsunami, and Landslide. We are focusing on Landslides. India faces landslides every year with a large threat to human life causing annual loss of US $400 million.

IV. OBJECTIVE

Aim of the project is to provide safety for the passenger and provide information to the railway authority by using

1) Landslide early warning system which uses sensor network and provide precautionary information about landslide.

2) Landslide detection system which uses camera and coding is done through MATLAB to detect the rock slide and land slide on the track.

V. HARDWARE DESCRIPTION

A. vibration sensor

This module features an adjustable potentiometer, a vibration sensor, and a LM393 comparator chip to give an adjustable digital output based on the amount of vibration. The potentiometer can be adjusted to both increase and decrease the sensitivity to the desired amount. The module outputs a logic level high (VCC) when it is triggered and a low (GND) when it is not triggered. There is an onboard LED that turns on when the module is triggered.

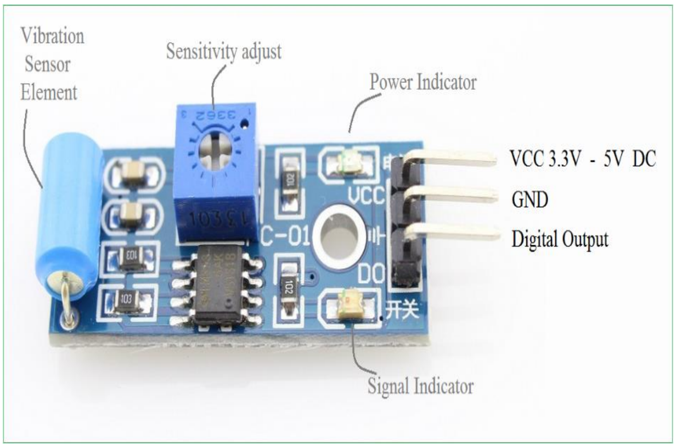

Fig.1 Vibration sensor SW 420 module

Features of vibration sensor SW 420 module are

- The default state of the switch is close
- Digital output Supply voltage:3.3V-5V
- On-board indicator LED to show the results
- On-board LM393 chip
- SW-420 based sensor, normally closed type vibration sensor
- Dimension of the board: 3.2cm x 1.4cm

Many Applications can created by measuring Vibration level, but sensing vibration accurately is a difficult job, due to this, vibration sensor SW-420 and Arduino interfaced then it may helps to design effort less vibration measurement.

The vibration sensor SW-420 Comes with breakout board that includes comparator LM 393 and Adjustable on board potentiometer for sensitivity threshold selection, and signal indication LED.

B. Arduino Uno ATMEGA 328

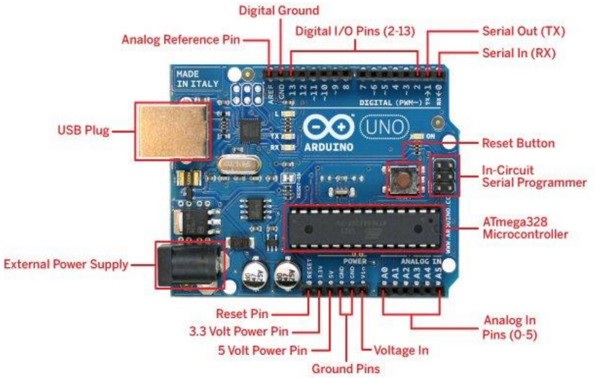

Fig.2 Arduino Uno ATMEGA 328 board

The Arduino Uno is a microcontroller board based on the ATMEGA328 . It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz ceramic resonator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started.

The Uno differs from all preceding boards in that it does not use the FTDI USB-to-serial driver chip. Instead, it features the Atmega16U2 (Atmega8U2 up to version R2) programmed as a USB-to-serial converter.

Revision 2 of the Uno board has a resistor pulling the 8U2 HWB line to ground, making it easier to put into DFU mode.

Revision 3 of the board has the following new features:

- Pinout: Added SDA and SCL pins that are near to the AREF pin and two other new pins placed near to the RESET pin, the IOREF that allow the shields to adapt to the voltage provided from the board. In future, shields will be compatible both with the board that use the AVR, which operate with 5V and with the Arduino Due that operate with 3.3V. The second one is a not connected pin, that is reserved for future purposes.
- Stronger RESET circuit.
- Atmega 16U2 replace the 8U2.

The pin configuration is identical on all three processors:

1) Pinout

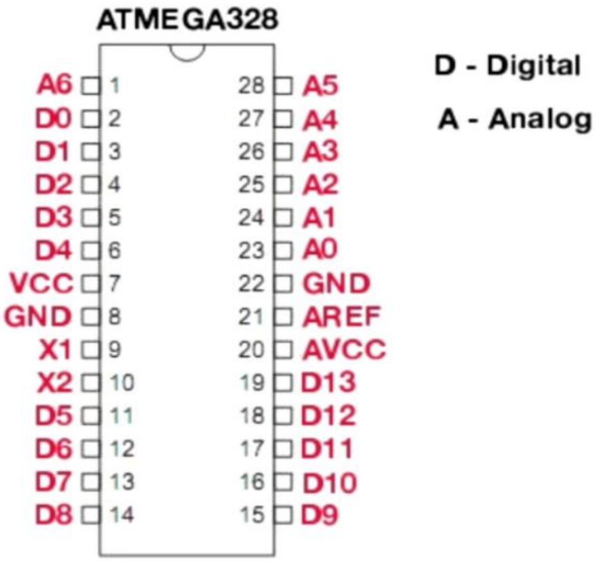

Fig.3 Pinout of ATMEGA328

2) Power

The Arduino Uno can be powered via the USB connection or with an external power supply. The power source is selected automatically.

External (non-USB) power can come either from an AC-to-DC adapter (wall-wart) or battery. The adapter can be connected by plugging a 2.1mm center-positive plug into the board's power jack. Leads from a battery can be inserted in the Gnd and Vin pin headers of the POWER connector. The board can operate on an external supply of 6 to 20 volts. If supplied with less than 7V, however, the 5V pin may supply less than five volts and the board may be unstable. If using more than 12V, the voltage regulator may overheat and damage the board. The recommended range is 7 to 12 volts.

The power pins are as follows:

- *VIN*: The input voltage to the Arduino board when it's using an external power source (as opposed to 5 volts from the USB connection or other regulated power source). You can supply voltage through this pin, or, if supplying voltage via the power jack, access it through this pin.
- *5V*: This pin outputs a regulated 5V from the regulator on the board. The board can be supplied with power either from the DC power jack (7 - 12V), the USB connector (5V), or the VIN pin of the board (7-12V). Supplying voltage via the 5V or 3.3V pins bypasses the regulator, and can damage the board.
- *3V3*: A 3.3 volt supply generated by the on-board regulator. Maximum current draw is 50 mA.
- *GND*: Ground pins.

3) Memory

The ATmega328 has 32 KB (with 0.5 KB used for the bootloader). It also has 2 KB of SRAM and 1 KB of EEPROM.

4) Input and Output

Each of the 14 digital pins on the Uno can be used as an input or output, using pinMode(), digitalWrite(), and digitalRead() functions. They operate at 5 volts. Each pin can provide or receive a maximum of 40 mA and has an internal pull-up resistor (disconnected by default) of 20-50 kOhms. In addition, some pins have specialized functions:

- *Serial*: 0 (RX) and 1 (TX). Used to receive (RX) and transmit (TX) TTL serial data. These pins are connected to the corresponding pins of the ATmega8U2 USB-to-TTL Serial chip.
- *External Interrupts*: 2 and 3. These pins can be configured to trigger an interrupt on a low value, a rising or falling edge, or a change in value. See the attachInterrupt() function for details.
- *PWM*: 3, 5, 6, 9, 10, and 11. Provide 8-bit PWM output with the analogWrite() function.
- *SPI*: 10 (SS), 11 (MOSI), 12 (MISO), 13 (SCK). These pins support SPI communication using the SPI library.
- *LED*: 13. There is a built-in LED connected to digital pin 13. When the pin is HIGH value, the LED is on, when the pin is LOW, it's off.

  The Uno has 6 analog inputs, labeled A0 through A5, each of which provide 10 bits of resolution (i.e. 1024 different values). By default they measure from ground to 5 volts, though it is possible to change the upper end of their range using the AREF pin and the analogReference() function. Additionally, some pins have specialized functionality:
- *TWI*: A4 or SDA pin and A5 or SCL pin. Support TWI communication using the Wire library.

There are a couple of other pins on the board:

- *AREF*:Reference voltage for the analog inputs. Used with analog Reference().
- *Reset*: Bring this line LOW to reset the microcontroller. Typically used to add a reset button to shields which block the one on the board.

The mapping for the Atmega8, 168, and 328 is identical.

C. GSM 800 Module

Fig.4 GSM 800 L module

Mini GSM/GPRS module

SIM800L is a miniature cellular module which allows for GPRS transmission, sending and receiving SMS and making and receiving voice calls. Low cost and small footprint and quad band frequency support make this module perfect solution for any project that require long range connectivity. After connecting power module boots up, searches for cellular network and login automatically. On board LED displays connection state (no network coverage - fast blinking, logged in - slow blinking).

This module have two antennas included. First is made of wire (which solders directly to NET pin on PCB) - very useful in narrow places. Second - PCB antenna - with double sided tape and attached pigtail cable with IPX connector. This one have better performance and allows to put your module inside a metal case - as long the antenna is outside.

Specification

- Supply voltage: 3.8V - 4.2V
- Recommended supply voltage: 4V
- Power consumption:
  - sleep mode < 2.0mA
  - idle mode < 7.0mA
  - GSM transmission (avg): 350 mA
  - GSM transmission (peek): 2000mA
- Module size: 25 x 23cm
- Interface: UART (max. 2.8V) and AT commands
- SIM card socket: microSIM (bottom side)
- Supported frequencies: Quad Band (850 / 950 / 1800 /1900 MHz)
- Antenna connector: IPX
- Status signaling: LED
- Working temperature range: -40 do + 85 ° C

Set includes:

- SIM800L module
- goldpin headers
- wire antenna
- PCB antenna with pigtail and IPX connector

Module pinout

Pinout (bottom side - left):

- RING (not marked on PBC, first from top, square) - LOW state while receiving call
- DTR - sleep mode. Default in HIGH state (module in sleep mode, serial communication disabled). After setting it in LOW the module will wake up.
- MICP, MICN - microphone (P + / N -)
- SPKP, SPKN - speaker (P + / N -)

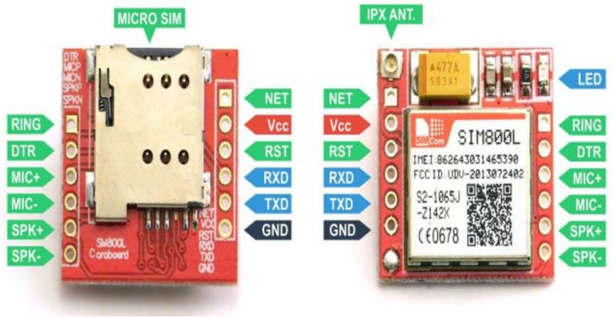

Fig.5 Pinout of GSM 800 L module

Pinout (bottom side - right):

- NET - antenna
- VCC - supply voltage
- RESET - reset
- RXD - serial communication
- TXD - serial communication
- GND – ground

D. Web camera
General descriptions

A webcam is a video camera that feeds or streams its image in real time to or through a computer to a computer network. When "captured" by the computer, the video stream may be saved, viewed or sent on to other networks via systems such as the internet, and emailed as an attachment. When sent to a remote location, the video stream may be saved, viewed or on sent there. Unlike an IP camera (which connects using Ethernet or Wi-Fi), a webcam is generally connected by a USB cable, or similar cable, or built into computer hardware, such as laptops.

Fig.6 Zebronics lucid plus module

Specifications

- Pixel : 24 Megapixels(interpolated)
- Max resolution : 640x480
- Image sensor : CMOS
- Lens : 2P+1R Filter
- Interface : USB

VI. METHODOLOGY

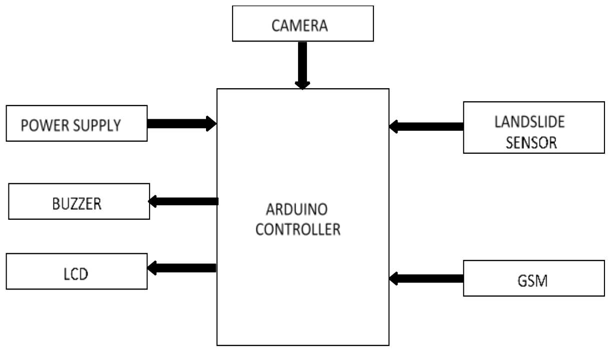

Fig.7 Proposed block diagram

The block diagram of the hardware and software implementation of the entire system as shown in Fig.7

The system basically consists of landslide (vibration) sensor, buzzer, LCD, GSM, camera, Arduino Uno microcontroller. Proposed system is mainly consists of two parts

1) Early warning system
2) Detection system

1) Landslide Early warning system

Early warning system consists of vibration sensor which senses the vibrations in the earth surface and sends signal to Arduino Uno controller.Then arduino controller will sends signal to the buzzer then buzzer will start to generating sound which is warning signal and message will displayed on LCD and send to authority through GSM.

Landslide early warning system sends messages for two different stages of landslide.

When there is minute movements of layers of soil, sensors will senses these movements and gives alert signal to the authorities to take precautionary measures in 'alert' stage.

When landslide occurred sensors will senses these rapid movements and gives alarm message to the authorities in 'alarm' stage.

Early warning system makes railways as more efficient system as it allows to take precautionary measures for the safety of railway and passengers.

2) Landslide and rockslide detection system

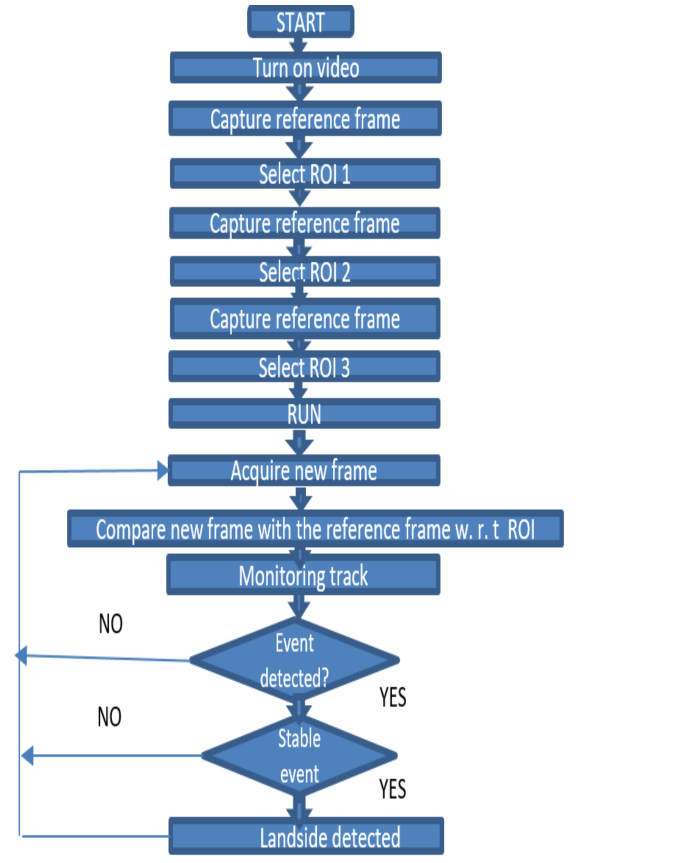

Fig.8 Flow chart of detection system

The proposed Landslide detection system contains hardware setup of camera adjacent to the railway track .So as shown in flowchart Fig.8 initially system should capture reference frame of railway track. For this refererence frame we should initially select region of interest(ROI) by manually.In this way we should select ROI 1,ROI 2 and ROI 3 for the same reference frame captured at 3 different instants.

Once ROI's are selected ,system extracts SURF(Speeded up robust feature) features from the track.These features includes curves,bobs,turns,ups and downs,orientations etc.

Now system start to monitor the track continously.It will capture the live frame and start to compare this with the reference frame stored in the system.While comparing system mainly focuses on SURF features of the selected ROI's of the reference frame with that of the newly captured frame

To differentiate two images it uses two key features of those images.Those are histogram normalization and 2D correlation.System calculates average of these features for some definite samples for reference frame in training period of system .

Now it will calculate these features for caputered frame and start to compare this with the features of stored reference frame.It will perform this comparision for some difined number of samples defined manually.

So when event is detected there will be more difference between these features of two images. When detected event is in motion or stable for very short duration the difference will not be there for all compared samples.From this system displays as landslide is not occurred..

When difference is present for all the compared samples then system understands stable event is occurred.So sends message as 'landslide is detected'.

Monitoring the track continues by capturing new frame and compare this with reference frame unless we turned off the system.

Key features used for differentiating images

1) corr2

2-D correlation coefficient

Syntax

r=corr2(A,B)
r =corr2(gpuarrayA,gpuarrayB)

Description

r = corr2(A,B)

Returns the correlation coefficient r between A and B, where A and B are matrices or vectors of the same size. r is a scalar double.

r = corr2(gpuarrayA,gpuarrayB)

Performs the operation on a GPU. The input images are 2-D gpuArrays of the same size. r is a scalar doublegpuArray. This syntax requires the Parallel Computing Toolbox™.

Class Support

A and B can be numeric or logical. The return value r is a scalar double.

gpuarrayA and gpuarrayB must be real, 2-D gpuArrays. If either A or B is not a gpuArray, it must be numeric or logical and nonsparse. corr2 moves any data not already on the GPU to the GPU. R is a scalar double gpuArray.

Examples

Compute the correlation coefficient

Compute the correlation coefficient between an image and the same image processed with a median filter.

I = imread('pout.tif');

J = medfilt2(I);

R = corr2(I,J)

R = 0.9959

Compute the Correlation Coefficient on a GPU

Compute the correlation coefficient on a GPU between an image and the same image processed using standard deviation filtering.

I = gpuArray(imread('pout.tif'));

J = stdfilt(I);

R = corr2(I,J)

R =0.2762

Corr2 computes the correlation coefficient using

$$r = \frac{\sum_m \sum_n (A_{mn} - A')(B_{mn} - B')}{\sqrt{[(\sum_m \sum_n (A_{mn} - A')^2)(\sum_m \sum_n (B_{mn} - B')^2)]}}$$

Where A' =mean2(A), B' =mean2(B)

2) imhist

Histogram of image data

Syntax

imhist(I)

imhist(I,n)

imhist(X,map)

[counts,binLocations] = imhist(I)

[counts,binLocations] = imhist(gpuarrayI,___)

Description

imhist(I)

Ccalculates the histogram for the intensity image I and displays a plot of the histogram. The number of bins in the histogram is determined by the image type.

imhist(I,n) calculates the histogram, where I specifies the number of bins used in the histogram. n also specifies the length of the colorbar displayed at the bottom of the histogram plot.

imhist(X,map)

Displays a histogram for the indexed image X. This histogram shows the distribution of pixel values above a colorbar of the colormap map. The colormap must be at least as long as the largest index in X. The histogram has one bin for each entry in the colormap.

[counts,binLocations] = imhist(I)

Returns the histogram counts in counts and the bin locations in binLocations so thatstem(binLocations,counts) shows the histogram. For indexed images, imhist returns the histogram counts for each colormap entry. The length of counts is the same as the length of the colormap.

[counts,binLocations] = imhist(gpuarrayI,___)

Performs the histogram calculation on a GPU. The input image and the return values are gpuArrays. This syntax requires the Parallel Computing Toolbox. When the input image is a gpuArray,imhist does not automatically display the histogram. To display the histogram use stem(binLocations,counts).

Examples

Calculate Histogram

Read a grayscale image into the workspace.

I = imread('pout.tif');

Display a histogram of the image. Since I is grayscale, by default the histogram will have 256 bits.

imhist(I)

VII. EXPERIMENTAL RESULTS

These results are obtained for different conditions .As our proposed system consists landslide detection system and landslide warning system we got successful results from both of our systems for different environment and conditions.These results are immediately send to concerned authorities through GSM to take necessary actions with required informations. These different results are shown in below.

Fig.9 shows the status of landslide early warning system in normal condition i.e when no landlide occurred.

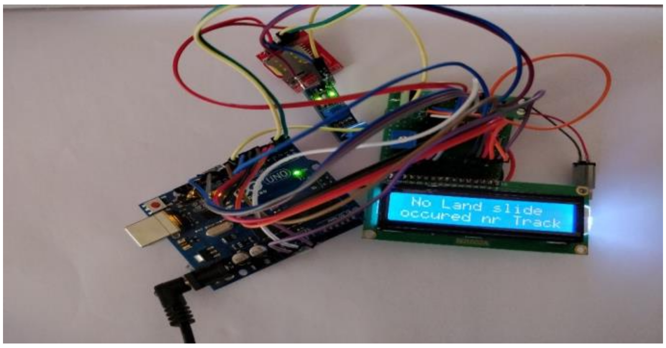

Fig.9 initial stage

Landslide early warning system sends messages for two different stages of landslide. When there is minute movements of layers of soil, sensors will senses these movements and gives alert signal to the authorities to take precautionary measures.It is shown in Fig.10 (a).

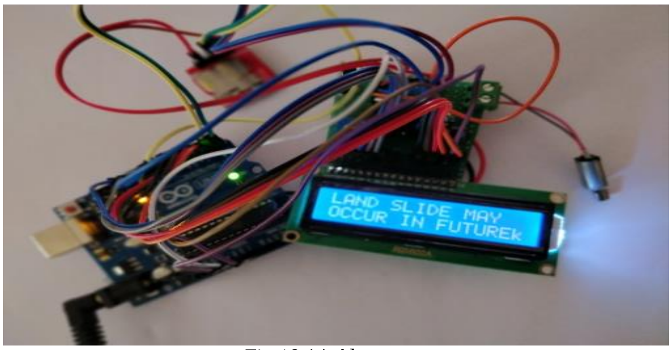

Fig.10 (a) Alert stage

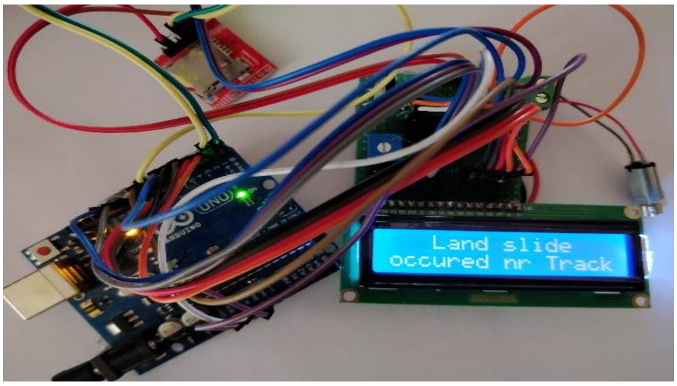

Fig.10 (b) Alarm stage

Fig.10 (b) shows alarm stage of warning system.When landslide occurred sensors will senses these rapid movements and gives alarm message to the authorities.

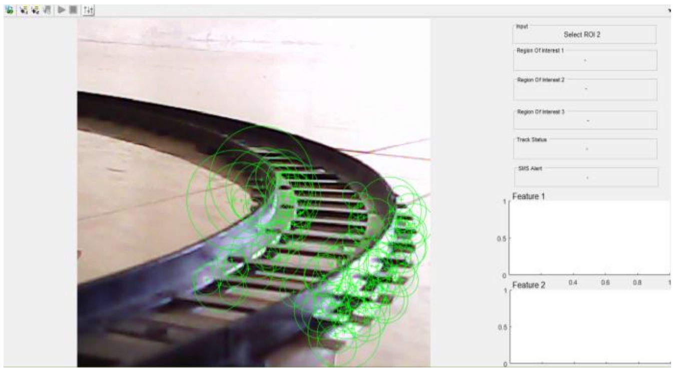

Fig.11 initial stage

In proposed Landslide detection system coding is done using MATLB. It extracts SURF features from selected ROI(Region of interest).This is shown in Fig.11.

In training period, system captures continous samples of track images.In this period it calculates average of histogram and average of correlation feature of all these samples and compares these with the live track with the same features to detect the landslide or rockslide on the track. This is shown in Fig.12.

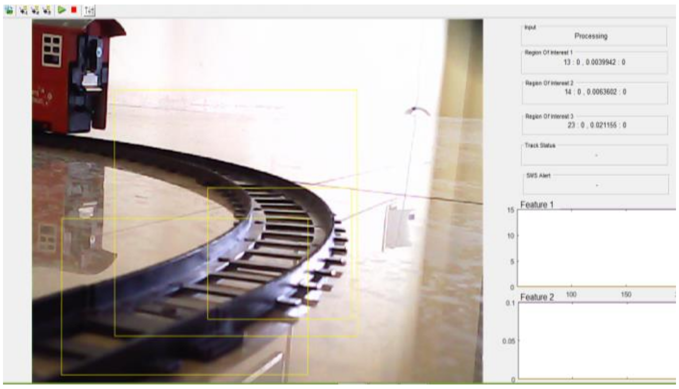

Fig.12 Process stage

Fig.13 Process stage

In the process stage when live track start to monitor it starts to looking any obstacle on the track .if it didn't find any of such after comparing for some definite time it will displays as 'Track is safe'.Even after found any obstacle but if it didn't present for whole duration of comparision it will display the same message as ‘Track is safe’. This is shown in Fig.13.

If some obstacle were present for the whole duration of comparision it came to conlusion that some stable obstacle is presenet .Then it displays as ‘Landslide is detected’.This is shown in below Fig.14.

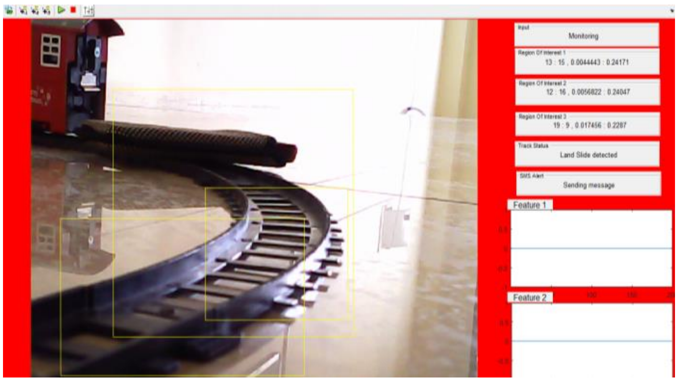

Fig.14 Process stage

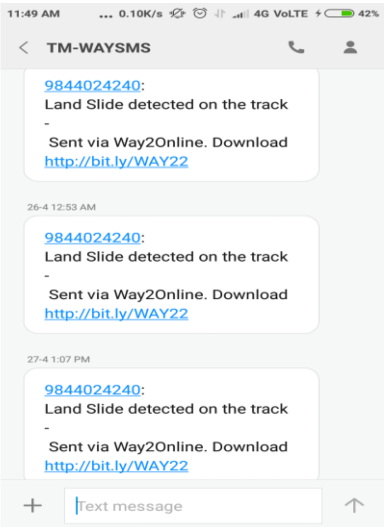

Fig.15 Landslide detected message

In landslide detection system when system detects landslide or rockslide on the railway track it sends this information to the Mobile phones of corresponding authority to take precautionary measures and necessary actions.This makes better assessment of landslide .This is shown in Fig.17.

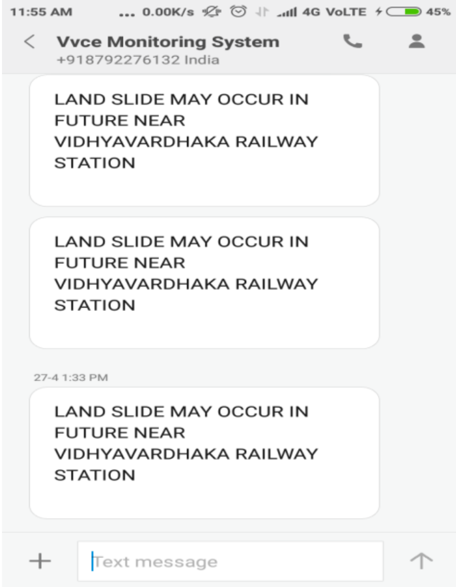

Fig.16 (a)Alert stage

In both the stages of Landslide early warning system message will be send to respective authority through GSM module. When ‘Alert’ message is send then authorities can prepare themselves well for future challenges.When ‘Alarm’ message is send to authorities then will stop further train movements and start to clear the track as early as possible. This will really increases the efficiency of system and reduces the journey time for passengers .It also ensures safety for passengers. This is shown in the Fig.16(a) and Fig.16(b).

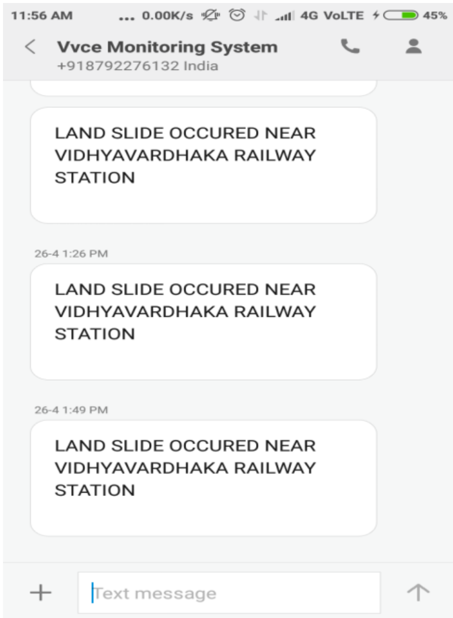

Fig.16(b) Alarm stage

VIII. CONCLUSION

The proposed detection system involves a railway track monitoring technique using image processing provides a robust, efficient and effective solution to detect landslides or rockslides after it occurred along the highly landslide prone regions.With the help of early warning system we can warn the main center about where the landslide may occur using wireless sensor technologies.

IX. FUTURE WORK

A huge landslide prone area can be monitored effectively by setting up more number of wireless sensor network along the railway track. This system can be extend for monitoring railway track condition i.e. detection of cracks along the track. This system can be installed in popular tourist hill stations.

REFERENCES

[1] Mr.Sagar D. Solanki, Mr. Ankit Suthar "Wireless Sensor Network For Landslide Assessment", International Journal Of Engineering And Computer Science, Volume - 3 Issue - 8 August, 2014

[2] Satishkumar Chavan, Shobha Pangotra, Sneha Nair, Vinayak More, Vineeth Nair "Effective and Efficient Landslide Detection System to Monitor Konkan Railway Tracks", International Conference on Technologies for Sustainable Development (ICTSD-2015), Feb. 04 – 06, 2015, Mumbai, India

[3] Mrs. Dhole Minakshi Subhas1, Prof. More P.C. and Prof. Kharade S.N "Landslide Warning System using Wireless Sensor Network", Volume 2, Issue 10, October 2014

[4] Maneesha V. Ramesh, Sangeeth Kumar, and P. Venkat Rangan "Wireless Sensor Network for Landslide Detection", Amrita School of Engineering, Amrita Vishwa Vidyapeetham (Amrita University) Clappan P. O, Kerala, India

[5] T.-W. Sung and C.-S. Yang, "An adaptive joining mechanism for improving the con- nection ratio of zigbee wireless sensor networks," International Journal of Communi- cation Systems, vol. 23, no. 2, pp. 231–251, 2010.

[6] M. P. P. Garje, M. S. B. Bawche, M. V. P. Gund, and M. S. S. Shah, "Landslide detection and warning system using wsn," 2016.

[7] A. Musaev, D. Wang, S. Shridhar, C.-A. Lai, and C. Pu, "Toward a real-time service for landslide detection: Augmented explicit semantic analysis and clustering composition approaches," in Web Services (ICWS), 2015 IEEE International Conference on. IEEE, 2015, pp. 511–518.

[8] V. J. Hodge, S. O'Keefe, M. Weeks, and A. Moulds, "Wireless sensor networks for condition monitoring in the railway industry: A survey," IEEE Transactions on Intel- ligent Transportation Systems, vol. 16, no. 3, pp. 1088–1106, 2015.

[9] Z. Yu, S. Xu, S. Zhang, and X. Yang, "Distributed detection in landslide prediction based on wireless sensor networks," in World Automation Congress (WAC), 2012. IEEE, 2012, pp. 235–238.

[10] A. Al-Radaideh, A. Al-Ali, S. Bheiry, and S. Alawnah, "A wireless sensor network monitoring system for highway bridges," in Electrical and Information Technologies (ICEIT), 2015 International Conference on. IEEE, 2015, pp. 119–124.

[11] G. Qiao, P. Lu, M. Scaioni, S. Xu, X. Tong, T. Feng, H. Wu, W. Chen, Y. Tian, W. Wang et al., "Landslide investigation with remote sensing and sensor network: From susceptibility mapping and scaled-down simulation towards in situ sensor net- work design," Remote Sensing, vol. 5, no. 9, pp. 4319–4346, 2013.

[12] P. Bahirat, A. Chavan, and V. Kulkarni, "Wireless sensor network for landslide detec- tion."