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Deep Learning Meets Morphological Analysis: A New Framework for Earthquake-Triggered Landslide Detection

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Abstract*:* The paper aims to decrease the number of accidents that occur on curved roadways. To do this, a warning LCD Display that displays as a vehicle approaches from the other side of the bend serves as a message to the driver. The IR transmitter and receiver sensor, which is connected to the Arduino Uno microcontroller, is used to detect the vehicle. And Motor operated gates are fixed upon each sides for free passage of vehicles from one side to other side. On the winding roads in the ghat portion, this might save thousands of lives. By implementing a new technique, they come up with a plan to prevent accidents after determining their causes and effects. Two IR sensors make up the new method, which alerts the vehicle on the opposite road. Landslide is one of the hazardous and critical geographical process, which damages to civil infrastructure and property as well as causes loss of life. This paper is an attempt with regard to the expansion of a landslide susceptible approach by using Accelerometer Sensor. And Rain Sensor is used for detecting heavy rainfall. Upon detecting the landslide condition or Heavy Rains it warns on display as a message and closes gates on either sides of ghat till road condition gets normal.

Keywords: LCD display, Arduino Uno microcontroller, Accelerometer Sensor.

I. INTRODUCTION

The "Deep Learning Meets Morphological Analysis: A new Framework for Earthquake-Triggered Landslide Detection" project leverages a combination of advanced technologies, including Arduino Uno, IR sensors, ADXL sensors, LCD displays, and Zigbee communication, to enhance road safety in areas with deep curves and potential landslide risks. This system offers real-time assistance to drivers by detecting obstacles, monitoring vehicle dynamics, and providing critical updates on road conditions. Deep curves on mountainous roads and the threat of landslides pose significant hazards to drivers and passengers. These challenges include reduced visibility, limited reaction time, and the potential for sudden obstructions due to landslides. This project aims to address these issues by creating a comprehensive solution that assists drivers in navigating challenging road conditions while keeping them informed about potential landslide risks.

On SEPTEMBER 5, 2022, a seismic event of magnitude 6.8 shook Luding County, situated in the Ganzi Tibetan Autonomous Prefecture within Sichuan Province. This seismic activity resulted in a considerable number of landslides, triggered by the ground shaking and surface rupture stemming from the earthquake. These earthquake-triggered landslides (ETLs) have effectively obstructed roads and rivers, engulfed towns, and villages, severely impeding post disaster rescue operations. Consequently, they have exacerbated the direct damage caused by the earthquake and stand as one of the natural disasters responsible for severe human casualties and extensive property damage. Given these implications, the precise identification of ETLs emerges as an urgent and indispensable task in earthquake rescue and relief efforts. ETLs are typically analysed through visual or automated methods. Visual extraction primarily relies on the expertise and experience of specialists in landslides, involving manual analysis of remote-sensing images to determine the location or boundaries of the landslides. Visual extraction takes into account the color tone, texture, development location, geometric shape, and other features of the landslide on the remote-sensing image, results have high accuracy, but it is time-consuming and laborious, and in addition, this method is affected by individual experts, which leads to differences in the results of the judgement. The automatic extraction method is to transform the experience of visual extraction into the methods and rules of remote-sensing software and utilize computers to automatically identify landslides. Compared with visual interpretation, automatic extraction is greatly affected by the quality of remote-sensing images, and the recognition accuracy is relatively low.

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II. LITERATURE REVIEW

[1] Integrating Morphological Analysis with Deep Learning for Improved Earthquake-Induced Landslide Prediction
Publication: 2024 Journal of Environmental Geology
Description: This study introduced a new framework integrating deep learning with detailed morphological analysis. This hybrid approach used both traditional morphological patterns and deep learning for landslide prediction and detection with high accuracy. Morphological analysis combined with deep learning provides robust and accurate detection, reducing computational requirements for real-time applications.

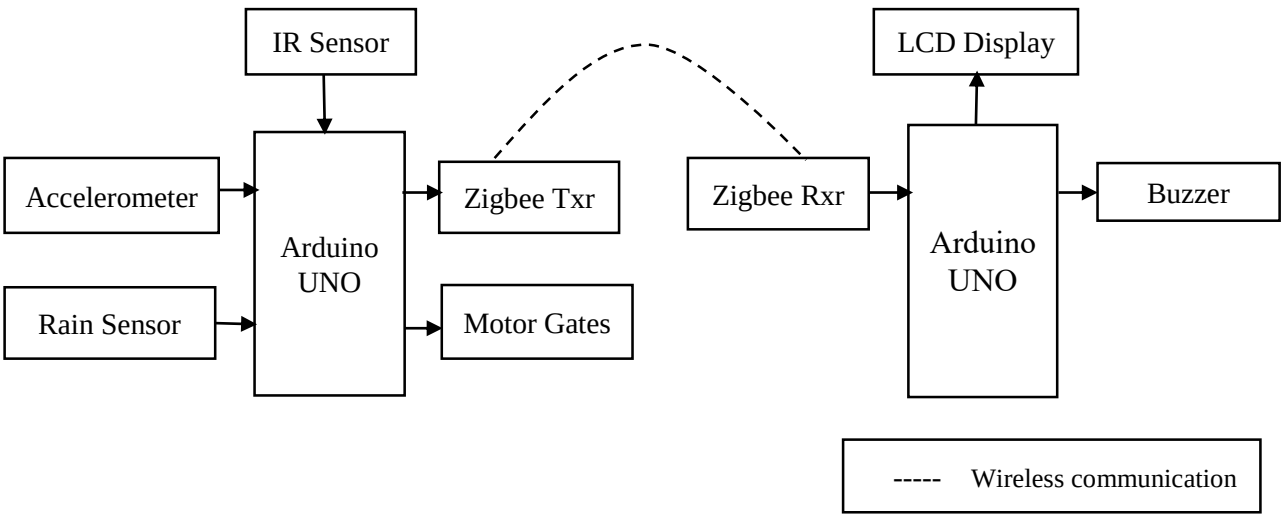
[2] Morphological Analysis and Deep Learning Integration for Rapid Landslide Mapping After Earthquakes
Publication: 2023Geosciences Journal
Description: This paper proposed integrating morphological features with deep learning algorithms to enhance landslide detection. By combining morphological filters with CNNs, the approach increased detection sensitivity. Morphological features play a key role in reducing false positives and improving landslide delineation.

[3] Machine Learning Approaches for Rapid Landslide Susceptibility Mapping Post-Earthquake Events
Publication: 2022 Journal of Geophysical Research
Description: This paper presents machine learning algorithms for quick assessment of landslide susceptibility after earthquakes. The study provides insights into how model-based predictions can aid emergency responses and improve the accuracy of landslide predictions.

[4] Real-Time Earthquake Impact Analysis Using Spatiotemporal Data and AI Models
Publication: 2021Environmental Modelling & Software
Description: This study focuses on using AI to analyse real-time spatiotemporal data for assessing earthquake impacts, including landslides. The approach shows the feasibility of integrating various AI models for swift disaster impact assessment, helping inform decision-makers during critical periods. Deep learning models can automatically extract features from complex datasets, improving the accuracy of landslide detection compared to traditional methods. By utilizing high-resolution imagery from satellites or drones, these models can detect early signs of instability, assess landslide risk, and monitor post-event changes.

III. METHODOLOGY

HUB MODEL **VEHICLE MODEL**



Working principle: IR Sensor Integration: Install IR sensors on the vehicle to detect obstacles and other vehicles in the proximity, especially in deep curves.

ADXL Sensor Implementation: Use ADXL sensors to measure land tilt and ground vibrations and possible land slides, providing real-time data to assess the vehicle's stability.

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Arduino Uno Control Unit: Employ Arduino Uno as the central control unit to process data from IR and ADXL sensors and communicate with other components.

LCD Display Interface: Design a user-friendly interface on an LCD display to show warnings and updates to the driver.
Rain Sensor Integration: Updates about rainfall across the ghat or roads that are passing across mountains and update to driver.

Zigbee Communication Network: Establish a Zigbee network for vehicles to communicate with each other, sharing information about road conditions and obstacles.

IV. HARDWARE AND SOFTWARE DESCRIPTIONS

1.IR SENSOR
The sensor which simply measures IR radiation instead of emitting is called PIR or passive infrared. Generallyin the IR spectrum, the radiation of all the targets radiation and some kind of thermal radiation are not visible to the eyes but can be sensed through IR sensors. In this sensor, an IRLED is used as an emitter whereas the photodiode is used as a detector. Once an infrared light drops on the photodiode, the output voltage & resistance will be changed in proportion to the received IR light magnitude.

Fig.1. IR Sensor

2. ZIGBEE MODULE
ZigBee is a wireless communication standard designed for low-power, short-range communication between devices shown in Fig3.4. It is particularly well-suited for applications involving home automation, industrial control, healthcare etc.

ZigBee operates on the IEEE 802.15.4 standard, defining the physical and MAC (Media Access Control) layers for low-rate wireless personal area networks (LR- WPANs). ZigBee operates in various frequency bands, including 2.4 GHz, 915 MHz, and 868 MHz, The 2.4 GHz frequency band is a common choice, but the specific band may vary depending on regional regulations.

/

Fig.2. ZigBee Module

3. ACCELEROMETER

An accelerometer is a device that measures acceleration forces, such as gravity and motion, by converting them into electrical signals. These devices are used in various technologies, including smartphones for orientation detection and vehicles for stability control. Their ability to detect and measure changes in speed, direction, and tilt makes them essential in numerous applications.

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Accelerometers can be used to measure vehicle acceleration. Accelerometers can be used to measure vibration on cars, machines, buildings, process control systems and safety installations. They can also be used to measure seismic activity, inclination, machine vibration, dynamic distance and speed with or without the influence of gravity. Applications for accelerometers that measure gravity, wherein an accelerometer is specifically configured for use in gravimetry, are called gravimeters.

Fig.3. Accelerometer

4. RAIN SENSOR

A sensor that is used to notice the water drops or rainfall is known as a rain sensor. This kind of sensor works like a switch. This sensor includes two parts like sensing pad and a sensor module. Whenever rain falls on the surface of a sensing pad then the sensor module reads the data from the sensor pad to process and convert it into an analog or digital output. These are essential components for the automatic systems used in the agriculture field because rainfall is detected throughout the months of irrigation. These automatically disable the irrigation system while receiving a preferred amount of rainfall & allow this system to restart its fixed conditions once the sensor module gets dried. The **rain sensor working principle** is pretty simple. The sensing pad includes a set of uncovered copper traces which mutually work like a variable resistor or a potentiometer. Here, the sensing pad resistance will be changed based on the amount of water falling on its surface. So, here the resistance is inversely related to the amount of water.

Fig.4. Rain Sensor

5. ARDUINO UNO

Arduino refers to an open-source electronics platform and a community that designs and manufactures single-board microcontrollers and microcontroller kits for building digital devices and interactive objects shown in Fig 3.4. The platform provides a flexible and user-friendly environment for hobbyists, students, and professionals to create a wide range of electronic projects.

Arduino boards are equipped with microcontrollers (e.g.,AT mega series)that serve as the brain of the projects. These boards come in various sizes and configurations, offering different features and capabilities. The Arduino software, also known as the Integrated Development Environment (IDE),is open source and freely available for Windows, macOS, and Linux. It provides a simple and intuitive interface for writing, compiling, and uploading code to Arduino boards. In our project, Arduino is present in the robot [14] which acts as interface between all the components and system.

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Fig.5. Arduino Uno

6. LCD DISPLAY

A liquid crystal display or LCD draws its definition from its name itself. It is a combination of two states of matter, the solid and the liquid. LCD uses a liquid crystal to produce a visible image. Liquid crystal displays are super-thin technology display screens that are generally used in laptop computer screens, TVs, cell phones, and portable video games. LCD's technologies allow displays to be much thinner when compared to a Cathode Ray Tube (CRT) technology. The principle behind the LCDs is that when an electrical current is applied to the liquid crystal molecule, the molecule tends to untwist. This causes the angle of light which is passing through the molecule of the polarized glass and also causes a change in the angle of the top polarizing filter. As a result, a little light is allowed to pass the polarized glass through a particular area of the LCD.

Fig.6. LCD Display

7. H-BRIDGE

An H-bridge is an electronic circuit shown in Fig 3.9 that allows a voltage to be applied across a load (such as a motor) in either direction. It's a common component in motor control circuits and is widely used in robotics, electric vehicles, and various other applications where the direction of rotation or movement needs to be controlled. The name "H-bridge" comes from the schematic representation of the circuit, which looks like the letter "H". The basic H-bridge configuration consists of four switches (transistors or MOSFETs), arranged in the shape of an "H". The load (usually a motor) is connected between the two arms of the "H" and by controlling the state of the switches, the direction of the current through the load can be changed. H-bridges can implement braking mechanisms to stop the motor quickly. This can be achieved by shorting the motor terminals or applying reverse voltage for a short period. In this project, H-bridges are used due to their ability to control the direction and speed of motors.

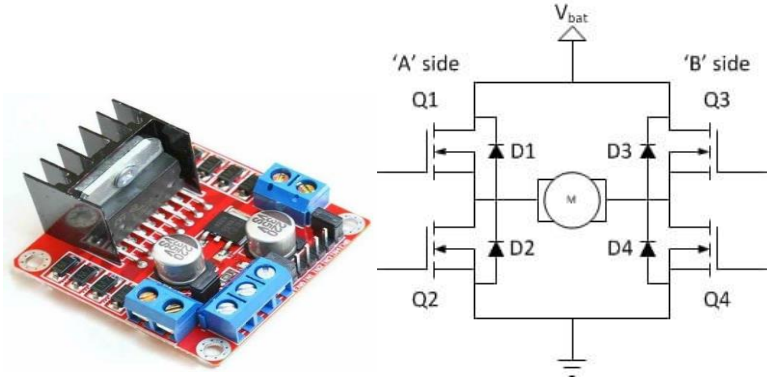

Fig.7 H-Bridge

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8. PIEZO BUZZER

Piezo buzzers, also known as piezo electric buzzers, are simple devices that can produce sound based on an input of electricity. The term “piezo” is derived from the Greek word for “press” or “squeeze”. In the world of electronics, this term is related to the principle of piezoelectricity. Piezoelectricity is the electric charge that builds up in certain materials in response to applied mechanical stress. This phenomenon is the underlying principle that powers piezo buzzers.

Piezo buzzers operate on the concept of piezoelectric effect. A piezoelectric element, usually made of ceramic or crystal material, deforms in response to an electric charge. This deformation generates a sound wave, resulting in a buzzing noise. The sound frequency can be altered by modifying the input current, allowing for a variety of tones to be generated.

Fig.8. Piezo-electric Buzzer

9. DC MOTOR

ADC (direct current) motor is an electrical machine that converts electrical energy into mechanical energy through the interaction of magnetic fields. DC motors are commonly used in various applications where controlled rotation or movement is required. DC motors are fundamental components in electromechanical systems due to their versatility, controllability, and reliability.

DC motors were the first form of motors widely used, as they could be powered from existing direct-current lighting power distribution systems. A DC motor's speed can be controlled over a wide range, using either a variable supply voltage or by changing the strength of current in its field windings. Small DC motors are used in tools, toys, and appliances. The universal motor, a lightweight brushed motor used for portable power tools and appliances can

operate on direct current and alternating current. Larger DC motors are currently used in propulsion of electric vehicles, elevator and hoists, and in drives for steel rolling mills. The advent of power electronics has made replacement of DC motors with AC motors possible in many applications.

Below Fig 3.7 shows DC motor which has a coil of wire with a current running through it generates an electromagnetic field aligned with the center of the coil. The direction and magnitude of the magnetic field produced by the coil can be changed with the direction and magnitude of the current flowing through it.

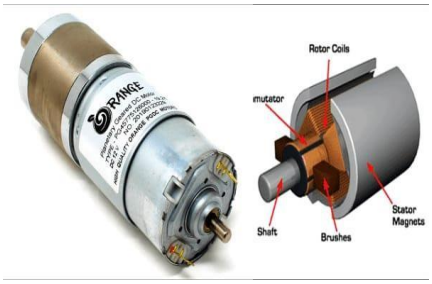

Fig.9. DC MOTOR

10. Python: Python is a high-level, general-purpose programming language. Its design philosophy emphasizes code readability with the use of significant indentation.

Python is dynamically typed and garbage-collected. It supports multiple programming paradigms, including structured (particularly procedural), object-oriented and functional programming. It is often described as a "batteries included" language due to its comprehensive standard library.

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11. Embedded C: Embedded C is one of the most popular and most commonly used Programming Languages in the development of Embedded Systems.

Embedded C is perhaps the most popular languages among Embedded Programmers for programming Embedded Systems. There are many popular programming languages like Assembly, BASIC, C++ etc. that are often used for developing Embedded Systems but Embedded C remains popular due to its efficiency, less development time and portability.

V. RESULT

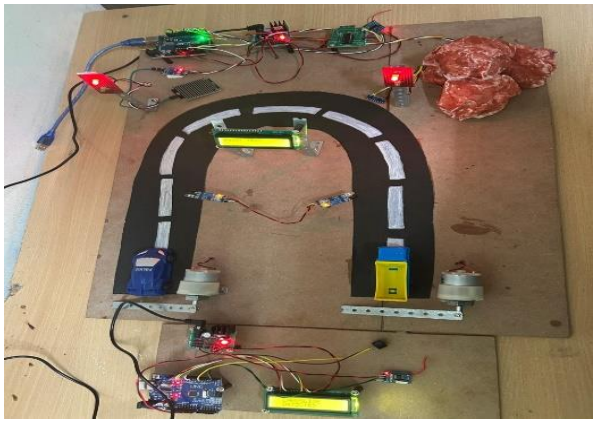

Fig.10. Hub and vehicle model

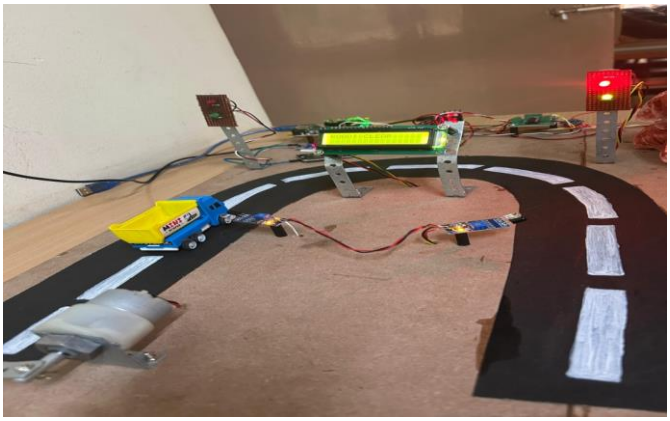

Fig.11. LCD displays road 1 is clear

Fig. 12. Images are detected in laptop camera and then in hub model LCD will display that **PRIORITY FOR BUS GIVEN** and again it will display **BUS CAN MOVE AHEAD**

VI. CONCLUSION

Successful development of an Earthquake-Triggered Landslide Detection. Effective use of Arduino Uno, IR sensors, ADXL sensors, LCD displays, and zigbee communication. The various hazardous impact of landslides on environment where studied. An efficient environment for analysing and displaying results with powerful set of tools.

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