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Li-Fi Enabled Inter-Vehicle Communication for Real-time Landslide Detection

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Abstract: The risk of accidents is very high due to highways, cross-roads, hill station, bunds of the lake and human negligence. Committing small mistakes when driving in these areas may lead to fatality. Despite using signboards, accidents continue to occur because of people's negligence. Researchers found that 57% of accidents are caused solely by driver related factors. The chances of occurrence of landslide in ghat section are high, especially during the rainy season and during the road construction. The objective of the paper is to build a communication between vehicle using Light Fidelity system and indicating the hazardous signals when the landslide occurs. In this work, we have developed a tool using an embedded system design approach, that incorporates hardware components like Arduino Uno, LCD, Buzzer, Moisture Sensor, DHT11, ServoMotor, Li-Fi transmitter and Li-Fi Receiver, Solar Panel, Potentiometer, ADXL345 and software system like Arduino IDE. The tool is tested in an experimental setup for a scenario that warn potential vehicles of different contexts, such as "LAND SLIDE OCCURRED STAY ALERT" along with the temperature, moisture and humidity of the location.

Keywords: Landslide detection, Li-Fi, Road-accidents, Driving

I. INTRODUCTION

The majority of countries globally have a worrisome track record of fatalities and disabilities caused by a massive number of accidents. Most of the traffic accidents are due to driver's ignorance. Researchers found that 57 % [1] of accidents are caused solely by driver related factors. Some studies reported that accidents may be prevented if drivers are warned a few seconds before selecting another route or taking precautions to avoid possible collisions.

The tool is tested in an experimental setup for a scenario that warn potential vehicles of different contexts, such as "LANDSLIDE OCCURRED STAY ALERT" along with temperature, humidity, and moisture. This maybe rectified, if the vehicles are equipped with means of communication system along with the possible collision spot. The number of accidents caused by different road feature and weather conditions are 76,752 [2].

Light Fidelity (Li-Fi) could be one of the possible means of communication. According to Harald Hass, the intensity and potential of a light-emitting diode are the forefront of this technology. This uses visible information transmission light spectrum 10,000 times more than the Wireless Land Area Network (WLAN) technology. Although high intensity LED lights are already used in vehicles, these can act as receiver. Li-Fi technologies on Vehicles can reduce potential collisions by using inexpensive components. This tool consists of an Arduino Uno, LCD, Buzzer, Moisture Sensor, DHT11, Servo Motor, Li-Fi transmitter and Li-Fi Receiver, Solar Panel, Potentiometer, ADXL and software system like Arduino IDE.

II.THEORETICAL BACKGROUND

2.1 INTRODUCTION TO LIGHT FIDELITY(LI-FI)

Light Fidelity (Li-Fi) is a wireless communication technology that uses visible light, ultraviolet, and infrared spectrums to transmit data. Unlike traditional radio frequency (RF) communication methods like Wi-Fi, Li-Fi uses light-emitting diodes(LEDs) to modulate light intensity and transmit information.

Visible Light Communication (VLC): Li-Fi is a subset of VLC, which uses visible light for data transmission.

LED Modulation: Data is transmitted by modulating the intensity of LEDs, which flicker at high speeds imperceptible to the human eye.

Photodetectors: Devices that receive the light signal and convert it back into electrical form for data processing.

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2.2 INTER-VEHICLE COMMUNICATIONS(IVC)

Inter-vehicle communications (IVC) encompass various types of communication between vehicles and between vehicles and infrastructure to enhance road safety and traffic efficiency.

Vehicle-to-Vehicle (V2V) Communication: Direct communication between vehicles to share information about speed, location, and direction.

Vehicle-to-Infrastructure (V2I) Communication: Communication between vehicles and road infrastructure like traffic lights and signs.

Vehicle-to-Everything (V2X) Communication: A broader concept that includes V2V, V2I, and communication with other entities like pedestrians and networks.

2.3 HAZARDOUS MANAGEMENT IN VEHICULAR ENVIRONMENTS

Effective hazardous management in vehicular environments involves detecting and mitigating risks to ensure the safety of drivers, passengers, and pedestrians.

Hazard Detection: Use of sensors and communication systems to detect potential hazards like collisions, adverse weather conditions, and road obstructions.

2.4 INTEGRATION OF LI-FI IN INTER-VEHICLE COMMUNICATION

Li-Fi can be integrated into vehicular communication systems to provide high-speed, secure and interference-free data transmission.

Data Transmission: Li-Fi can transmit data at high speeds, making it suitable for real-time communication in vehicles.
Security: Li-Fi offers enhanced security as light signals do not penetrate walls, reducing the risk of avesdropping.

Interference: Unlike RF communication, Li-Fi is immune to electromagnetic interference, making it ideal for environments with high RF noise.

II. DESIGN AND IMPLEMENTATION

3.1.1 ARDUINO UNO

Arduino Uno is a microcontroller board based on the ATmega328P. It has 14 digital input/output pins. It has 6 analog inputs, a 16MHz ceramic resonator, a USB connection, a powerjack, 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. It is a Replaceable chip.

Fig. 1: ARDUINO UNO

3.1.2 SOIL MOISTURE SENSOR

Moisture sensor has 4 pins. If the soil is dry, then the conduction in the soil is poor, this leads to increase in level of resistance, moisture of soil is measured. It could be joined in two different ways. They are Analog and Digital mode. Working voltage is 5V, working current is < 20 mA and working Temperature is 10°C~30°C.

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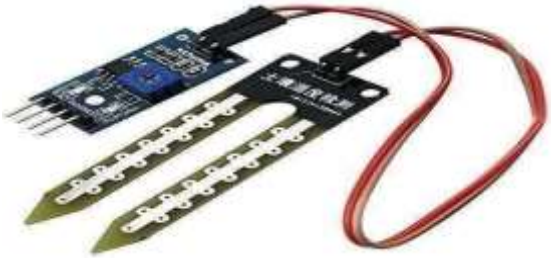

Fig. 2: SOIL MOISTURE SENSOR

3.1.3 LCD

The term LCD full form is **Liquid Crystal Display**.The display is named 16×2 LCD because it has 16 Columns and 2 Rows. It can display (16×2=32) 32 characters in total. Each character will be made of 5×8 Pixel Dots. These displays are mainly based on multi-segment light-emitting diodes.

Fig. 3: LCD

3.1.4. DHT11 TEMPERATURE AND HUMIDITY SENSOR

This sensor is a cost-efficient digital humidity & temperature sensor. It has 4 pins. They are VCC, GND, DATA and NC. The humidity sensing component consists of the electrode and the substrate, which is responsible for retaining moisture. Temperature range: 0 to 50^{o}C error of +2^{o}C and Humidity: 20 – 90 % RH + 5% RH.

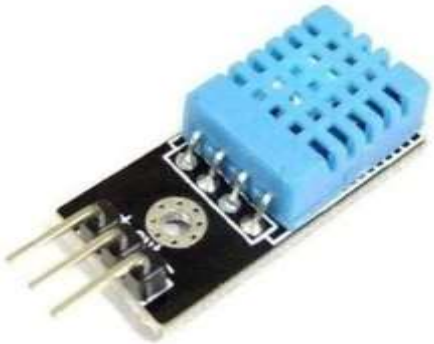

Fig. 4: TEMPERATURE AND HUMIDITY SENSOR

3.1.5 SERVOMOTOR

A servomotor is a closed-loop servomechanism that uses position feedback(either linear or rotational position) to control its motion and final position. The input to its control is a signal (either analog or digital) representing the desired position of the output shaft.

The SG90 Servo Motors comes with three pairs of blades that can rotate from 0 degrees to 180 degrees. The connector wire measures 150 mm in length which is sufficient to install it on a breadboard.

General specifications:
Model No: SG-90 BLUSERVO
Voltage: 12v

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Fig. 5: SERVOMOTOR

3.1.6 BUZZER

Buzzer is an electrical device that is used to get a buzzing or beeping sound when a potential difference is created or voltage is applied. This is a high reliability electromagnetic buzzer with pin type terminal construction for direct mounting on printed circuit board. It operates at a voltage between 3 V - 6 V, 80 mA and produces sound of about 90 decibels.

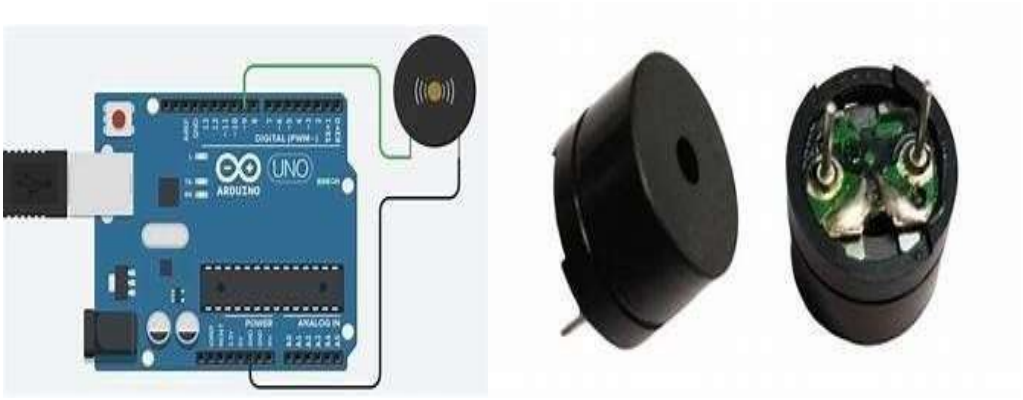

Fig. 6: BUZZER

3.1.7 POTENTIOMETER

A potentiometer is used as a voltage divider or variable resistor in a circuit. Some applications include dimmer switches for lights, brightness controls in LCD Display, televisions and in audio equipment.

Fig. 7: POTENTIOMETER

3.1.8 Li-Fi RECEIVER

Li-Fi Receiver is a custom-design front-end for visible light communications (VLC). It has a wide bandwidth (20 MHz) to support even the most demanding video streaming applications. The receiver features a photo detector with a field-of-view of 170°enabling a robust performance in line-of-sight conditions.

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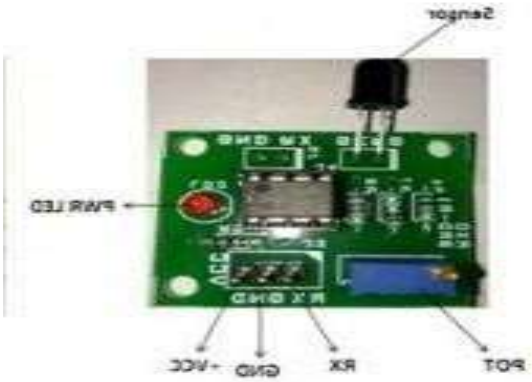

Fig. 8: Li-Fi RECEIVER

3.1.9 LI-FI TRANSMITTER

The Li-Fi Transmitter is a custom-design front-end for visible light communications (VLC). It has a wide bandwidth (25 MHz) to support even the most demanding video streaming applications.

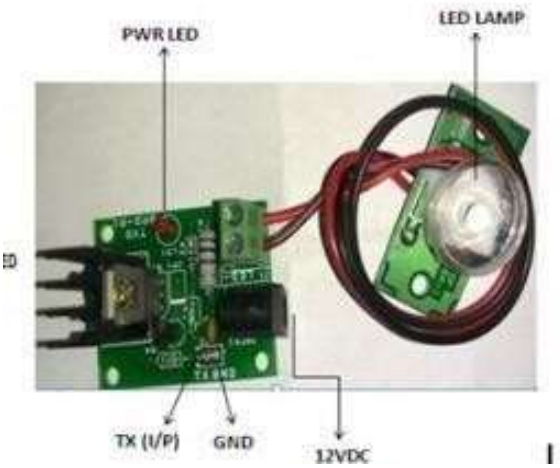

Fig. 9: LI-FI TRANSMITTER

3.1.10 ADXL345

The ADXL345 is a small, thin, low power, 3-axis accelerometer with high Resolution Digital output data is formatted as 16-bit twos complement and is accessible through SPI I^2C digital interface. It measures the static acceleration of gravity in tilt-sensing applications, as well as dynamic acceleration resulting from motion or shock. Its high resolution (4 m*g*/LSB) enables measurement of inclination changes less than 1.0°.

Fig. 10: ADXL 345

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3.1.11 SOLAR PANEL

A solar cell, or photovoltaic cell, is an electrical device that converts the energy of light directly into electricity by the photovoltaic effect. It can output 100 mA of current at 4 Volts under ideal light conditions. It is 6.5 cm x 6 cm in size. It can be used in low-cost solar projects and can connect 3 such solar panel in series and get 12 Volt output.

Fig. 11: SOLAR PANEL

3.1.12 ESP32-CAM WIFI

The ESP32-CAM is a compact and powerful microcontroller board that integrates an ESP32-S chip with a built-in camera module, making it ideal for projects involving image capture, video streaming and IoT applications.

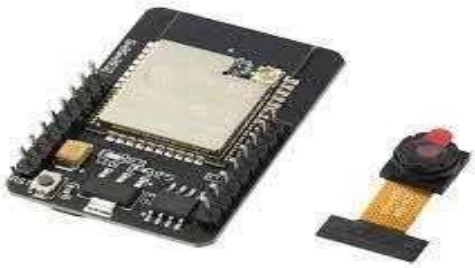

Fig. 12: ESP32-CAM WIFI

In this project, the software used is Arduino IDE and hardware components are ArduinoUno, LCD, Buzzer, Moisture Sensor, DXT11, AC Servo Motor, Li-Fi transmitter and Li-Fi Receiver, Solar Panel, Potentiometer, ADXL. In this prototype, the moisture sensor, DHT 11 sensor, ADXL is connected as input to the Arduino uno. The AC Servomotor is connected to create a tilt movement in this prototype to create a illusion of landslide. The ADXL detects the small tilt movement occurring by the Servomotor. Similarly, the moisture sensor detects the moisture of the soil and DXT11 sensor detects the temperature and humidity. When the soil gets wet and the servo motor gets tilted, the Li-Fi transmitter transmits the data through visible light. The solar panel receives the information which is connected to the Li-Fi Receiver. The DXT sensor also sends the temperature and humidity to the Arduino Uno. The LCD Displays “LANDSLIDE OCCURRED STAY ALERT” along with the temperature, moisture and humidity. In prototype, around 15cm to 20 cm distance can be detected and in real-time, around 1 km to 2 km range, the LED gets ON.

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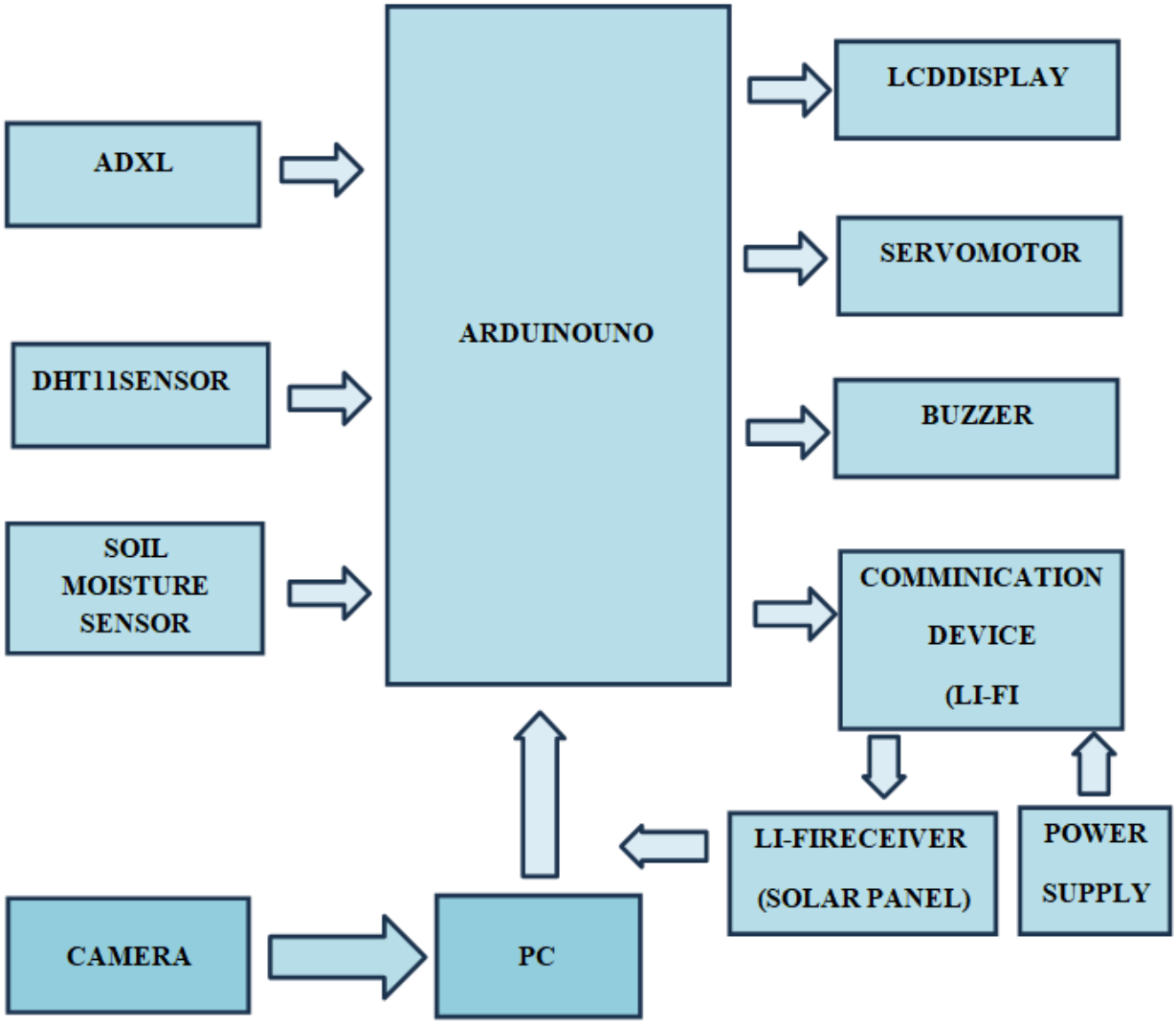

Fig. 13: Block diagram of the system

V. RESULTS AND DISCUSSION

Figure 14 shows the image of hardware setup of the system. Inter vehicle communication between the vehicles was achieved. Hazardous indications to the vehicles through visible light are sent. The message was sent within 10 cm to 15 cm distance in this prototype. Temperature, moisture and humidity are displayed, Cost-effective communication is achieved.

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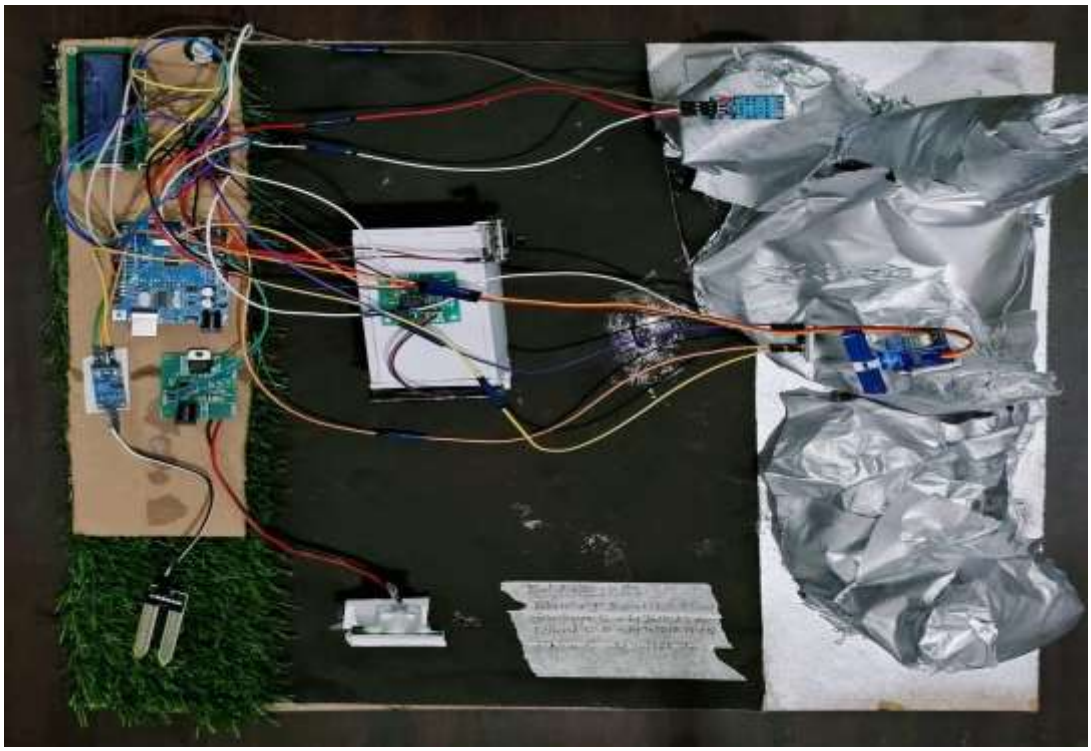

Fig. 14: Hardware setup

VI. CONCLUSION

In this work, inter-vehicle communication using Li-Fi for hazardous management offers a revolutionary approach to road safety has been achieved. The high-speed, interference-free data transmission provided by Li-Fi enhances real-time information sharing between vehicles, improving situational awareness. This leads to faster response times and reduced accident risks in hazardous conditions. The integration of Li-Fi with vehicle sensors and navigation systems ensures continuous updates and alerts, significantly boosting safety. As smart transportation systems evolve, Li-Fi' s high bandwidth and low latency will play a crucial role in advancing vehicular communication and hazard management, paving the way for safer roads and smarter driving.

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