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Wireless Accident Detection System for Improving Safety on Opencast Mines

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ABSTRACT

Over the years the mining industry is evident for fatal accidents involving workforce and machinery and most of the accidents are due to moving machinery, specifically dumpers/trucks. Keeping given the demand for mobile transportation machinery to ascertain more safety, Early detection of elements involved in an accident can probably reduce the rate of accidents. Accidents occur majorly due to the running of dumpers over the vehicles, workforce around it, and colliding with the parked vehicles, previous research made it clear that it is impossible to avoid accidents associated with dumpers but can mitigate the accidents to a possible extent. One of such important safety features is the accident detection system for mobile vehicles such as dumpers. The wireless accident detection system detects the movement of vehicles and workers approaching them. This system acts as an alerting agent when an operator fails to recognize the things around it, upon the alert an operator can immediately apply brakes or can take necessary actions to prevent the vehicle from being collided with the other objects.This system uses an Arduino-based microcontroller, ultrasonic sensor HC-SR04, and other alerting devices. Contrary to what has been happening regularly, this wireless accident detection system improves safety, reduces the chances of a collision, and reduces the rate of accidents in mines, this system is of low cost and occupies less space compared to the state-of-the-art designed systems

Keywords—dumpers, Arduino, sensor, detection.

1. INTRODUCTION

The mining sector is considered the backbone of all industries since it is the only supplier of raw materials/minerals. No other industry can survive without the mining activities, as the demand for the mineral is increasing every year, so to meet the demand and increase the mining sector's contribution to GDP.In recent years the trend of mining operations has been shifting from underground mining to opencast mining rapidly. This is to reduce the accident rate and to increase the production of the mine. The underground mine environment is composed of poisonous gases, making it a hazardous environment and always involved in roof falls, explosions, and inundations, which will lead to loss of life, as well as machinery. Whereas on the other side opencast mines overcame all the difficulties of the underground mines, also these are free from such accidents and ensure safe working conditions and a high degree of supervision in every mining operation.Dumpers are heavy earthmoving machinery, and the main transportation system in opencast mines, since dumper is an off-highway vehicle it suits the opencast mining conditions and they are considered to be the most reliable machinery among the available transportation systems.Despite many advantages, dumpers are frequently involved in many fatal accidents. In opencast mines, the rate of accidents due to wheeled

vehicles such as dumpers/trucks is very high.The shovel dumper is the most common combination used for loading and transportation of broken mineral in an opencast mine respectively, it is due to its flexibility in operation and adaptability in any kind of mining conditions, the shovel loading rating depends on its bucket size and generally offers high loading rates, the loading time of dumper depends on the matching ability of shovel bucket to the dump body of the dumper. Among the wide range of transportation systems available, the shovel dumper combination is the most economical system. Dumpers, despite the most involved machinery in accidents, are still used in most of the open cast mine operations. The shovel dumper combination is ideal for mines with a shorter life.

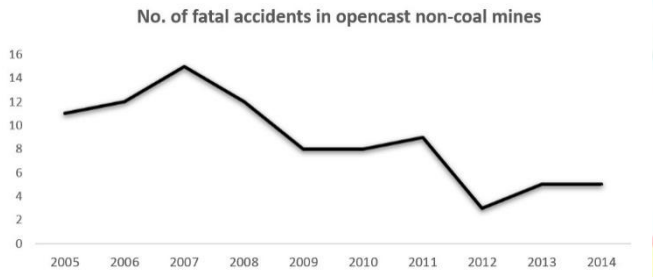


Fig.1 No. of fatal accidents in opencast non-coal mines

Fig.1 shows the number of fatal accidents of dumpers that occurred from the year 2005 to 2014 in non-coal opencast accidents.

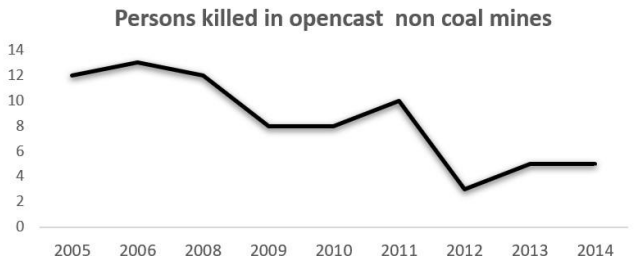


Fig.2 Persons killed in opencast non-coal mines

Fig.2 shows the number of persons killed in the fatal accidents of dumpers during the years 2005-2014, from this analysis it is clear that the trend of dumper accidents in non-coal opencast mines are significantly decreased compared to the earlier years, this is because of the various adaptive measures taken by the management in providing proper training and following the statutory norms, but the trend is flat for few years, this can be reduced with the adoption of the new technologies in transportation systems.

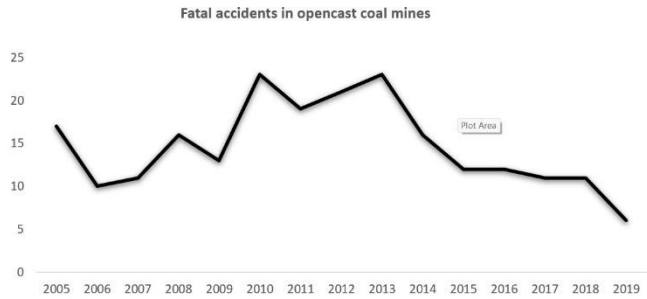


Fig.3 Fatal accidents in opencast coal mines

Fig.3 shows the number of fatal accidents of dumpers that occurred from the year 2005 to 2019 in coal opencast accidents.

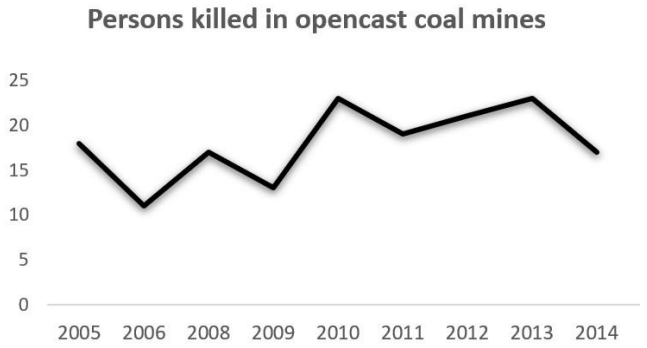


Fig.4 Persons killed in opencast coal mines

Fig.4 shows the number of persons killed in the fatal accidents of dumpers during the years 2005 to 2014, the trend confirms that the number of fatal dumper accidents in opencast coal mines are greatly decreased but was not completely mitigated and the number of persons killed in dumper accidents is very much compared to the non-coal opencast mines.

The general preventive measure that is followed to reduce accidents is: Accident investigations [1] investigating into accidents will reveal the contribution of all the stakeholders in an accident and mitigative measures are taken to control a frequent accident-causing element, Training persons [5] is one of the major steps involving in the reduction of accidents, with proper training and timely refresher training there are chances that workers do not take part into unsafe practices. Enactment of effective policies and programs on safety and framing laws, bye-laws that promote safety [5], and a checklist to investigate the reason for the accident, can help to eliminate a few accident causes, such a checklist mainly focuses on the psychology of the workers [6]. Proper training and education to the truck drivers, with the growing technology the truck operators now can undergo a virtual reality training to execute a pre-working check and is to demonstrate the outcomes when the truck driver misses the checklist, [11], Mine Safety and Health Administration regulations [5].

A OBJECTIVES-

Keeping the mentioned disadvantages in mind, the project is planned with the primary objective of reducing the accidents of dumpers in opencast and it also has the following specific objectives

1. Review of dumper accidents in mines and their analysis.
2. A detailed analysis of proximity.
3. Prediction of advantages based on the analysis of data.
4. To develop a prototype for investigating the possibilities of this system.
5. To analyze the results obtained from the prototype testing.

2. RELATED WORK

Many research works going on this topic. Rahul Sharma, Ankit Jaiswal, Neha Jaiswal,and Ajit Kumar, developed a system that uses laser light to detect the distance and speed of the approaching obstacles a blinder laser detector is used in this system [9],Nikhil Kumar,Debopam Acharya, Divyalohani, using sensor fusion they developed Internet Of Things based vehicle accident detection and classification system [13], Panda, Agarwal,Hossain, arcade nshimiyimana, they identified the effects of the environment on the working of the ultrasonic sensors and suggests an equation for enhancing the accuracy of ultrasonic sensors [14].

3. FLOW CHART OF THE SYSTEM

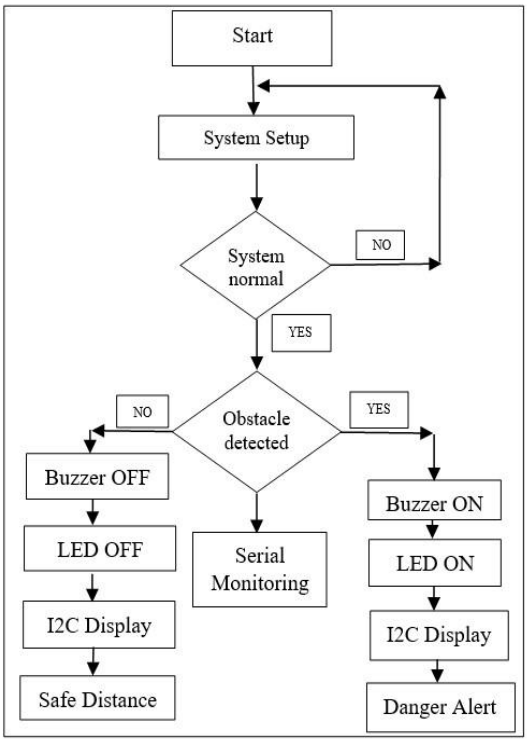


Fig.5 flow chart of the system

The flow chart visualizes the exact functioning of the wireless accident detection system. When the system is supplied with power with a 9v adapter, the system will then be initialized. Then it checks if the system is in normal condition in the case of 'NO'. It further initializes the system with the modifications in the input code.

Now the system is ready for operation, the ultrasonic distance measuring sensor is put into action, and two operations are performed by the sensor. if any obstacle is not detected within the range, the buzzer and led are 'OFF' and on the I2C display be displayed as 'safe distance'. Upon this condition, the operator of the vehicle can head towards the destination to accomplish the assigned duty.

If the sensor detects any obstacle in the vicinity of the given input and sends the signals to the microcontroller, then the buzzer starts buzzing continuously, with LED blinking and warning on the I2C display as 'danger alert'. The same will continue until the obstacle is displaced from the path of the vehicle.

The whole operation can be monitored by a serial monitoring function available with the Arduino IDE software when connected using a USB cable. The safe distance in the code given is 20cm, so any obstacle beyond 20cm will not activate the system. In case the obstacle is near (say less than 20cm) to the vehicle or machine that has been mounted with a wireless accident detection system, the system will be activated.

Soon after this, the driver/operator of the vehicle should abort from moving further forward or reverse, so that no harm will happen to the vehicles involved. This system helps the operator by detecting the vehicles or humans approaching it and ultimately helps in arresting the accident.

A.BLOCK DIAGRAM OF THE SYSTEM

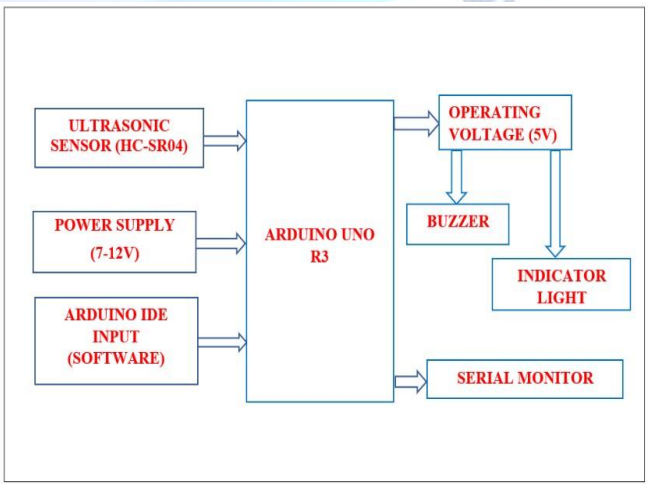


Fig.6 block diagram of the system

The wireless accident detection system canbe explained by dividing it into four units namely:

- The dumper unit: The rear, side, and front parts of the dumpers are equipped with sensors.
- The sensor unit: HC-SR04 Ultrasonic distance measuring sensor is used for this purpose.
- Processing unit: Microcontroller (Arduino UNO R3 board), Arduino IDE software.
- The alerting unit: I2C liquid crystal display, buzzer, and led light.

This system mainly consists of a microcontroller, the Arduino UNO R3 board. The whole operation is carried out by this board. The Arduino Uno R3 board is the heart of the system.

From the block diagram, the operations that are performed by the Arduino UNO R3 board can be broadly divided into two functions. They are

1. INPUT

The input to the Arduino Uno R3 board is given by

- Ultrasonic Sensor (HC-SR04)- This sensor is used for detecting the distance of an object using Sonar and the range is about 0.02m-4.0m. The sensor consists of a transmitter and receiver, this sensor detects the obstacles according to the given range and transmits the same to the microcontroller.
- Power supply- The power supply given to this Arduino UNO R3 board ranges from 7-12v, either by using a battery or directly using an adapter.
- Arduino IDE Software- This software enables the user to compile and upload the code to the microcontroller board, and also has a serial monitor to monitor the working of the project designed through this software.For inputting the code into the Arduino UNO R3 board, the Arduino IDE software is used, to connect the UNO R3 board to the device using a USB cable and select the correct pin and board. Now start compiling the code and check for errors. Buzzer, LED, and I2C liquid crystal display drivers should be installed in the library. Compile the code and upload it to the board. The code typically consists of defining the PINs of the board and components that have been used and defining variables.The most important part of the coding is providing a safe distance in which the whole system is in passive mode. The safety distance is that within which the whole detection system is in inactive mode. The safety distance can be altered according to the requirements based on the conditions the suitable condition like the inclination of the roads, and the average speed of the vehicle.

2. OUTPUT

After giving input to the board, it operates at an operating voltage of 5v.

- I2C Liquid Crystal Display (LCD)- The I2C 16x2 Arduino LCD Screen uses an I2C communication interface. It has only 4 pins for LCD: VCC, GND, SDA, and SCL. I2C stands for inter-integrated-circuit, it consists of a potentiometer for adjusting the brightness levels of the display. I2C module can reduce the difficulty of arrangement of various connections so that users can focus on the core of the work.
- Piezo Buzzer- It is a tiny speaker used to connect to the microcontroller. For buzzing, suitable drivers should be installed in the library of the Arduino I2C software and should be uploaded to the microcontroller.
- LED (Light Emitting Diode)- A LED is used to indicate the microcontroller output. For lighting of LED, suitable drivers should be installed in the library of the Arduino I2C software and should be uploaded to the microcontroller.

B. HARDWARE OF THE SYSTEM

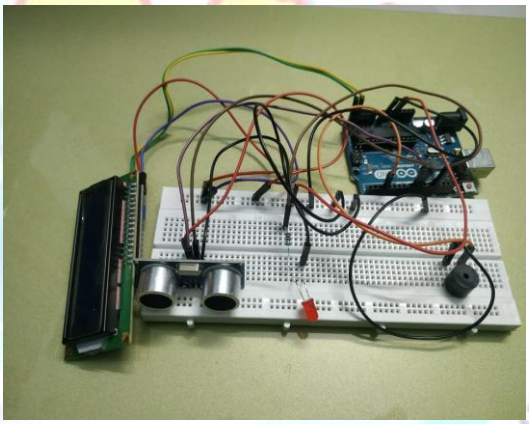


Fig.7 Hardware of the system

The circuit connection to the wireless accident detection system is as follows:

- I2C LIQUID CRYSTAL DISPLAY- The four pins of the display, GND, VCC, SDA, and SGL, are connected to four ports, GND, 5V, VCC, A4, A5, of the Arduino UNO R3 board respectively.
- HC-SR04 SENSOR- The four pins of the sensor VCC, GND, TRIG, and ECHO are connected to the four ports 5V VCC, GND, PIN 9, and PIN 10 of the Arduino UNO board respectively.
- BUZZER- The positive terminal of the buzzer is connected to the PIN3 and the negative terminal to the GND of the Arduino UNO board.
- LED: The positive terminal is connected to the 220-ohm resistor, then to the PIN13 and ohm negative terminal to the GND of the Arduino UNO board.

4. RESULTS

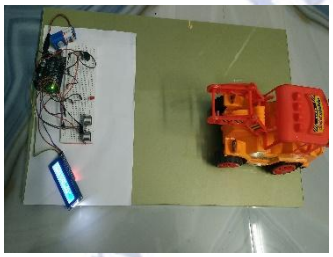
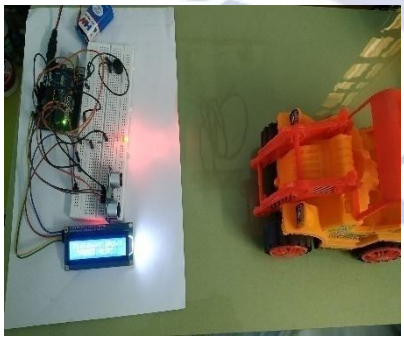
Detection of the obstacle	Output is shown on the LCD
	
	

Fig.8 No obstacle detected

The ultrasonic sensor detects the obstacle distance and transmits the data to the microcontroller, it then analyses the input with the stored data and alerts the operator and in case no obstacle is detected it will not perform any function further it will simply display as "safe distance". From column 1 of Fig.8, the obstacle is beyond the value of data stored in the microcontroller, it will not give any command to the buzzer and LED, in turn, it sends the signal to the display at a safe distance.

Detection of obstacle	Output is shown on the LCD
	

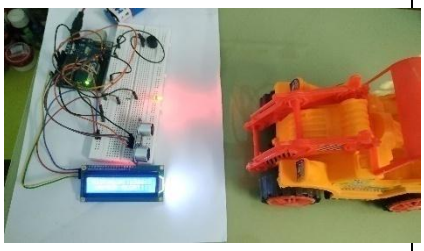
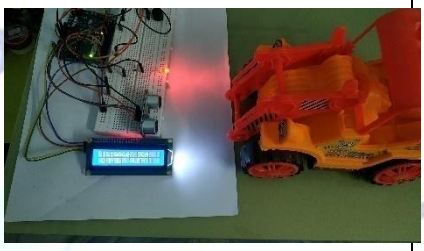
	
	

Fig.9 When an obstacle detected

Fig.9 shows the results of the working of the wireless accident detection system, from the column 1 the obstacle is approaching the sensor, soon after the detection by the ultrasonic sensor, the microcontroller will alert the operator by sending the signals to the buzzer, LED and display as "danger alert" on the LCD. The buzzing will continue until the operator takes necessary action to avoid a collision.

The results from the testing are very accurate and the system is functioning very efficiently, as shown in Table 2 the obstacle is approaching the sensor, the blinking of the LED, and the danger alert are continued till the obstacle is cleared from the vicinity of the sensor.

5. CONCLUSION

The safety of the dumper has come into the limelight with the advent of new technologies. The sophisticated technologies are complex and associated with every part of the dumper. In case of a breakdown, the sophisticated systems will lead to complete exhaustion of time, until an expert is called upon to repair the system. This project is regarding a system that helps in reducing the rate of accidents occurring due to obstacles that are not detected by the dumper operator and it also saves time during maintenance of the dumper. The wireless accident detection system requires less maintenance, a low initial cost, and yields better results. It uses the Arduino platform along with an ultrasonic sensor (HC-SR 04) which detects obstacles very accurately. Consequently, it offers an efficient output for the users. The alerting unit is provided with a maximum delay within which the dumper operator can decide to avoid the accident. This

system has a wide range of applications in the opencast transportation systems as well as the stationary and semi-mobile machinery used for loading and crushing operations.

Conflict of interest statement

Authors declare that they do not have any conflict of interest.

REFERENCES

[1] A.K. Dashet al, "Study and Analysis of Accidents Due to Wheeled Trackless Transportation Machinery in Indian Coal Mines – Identification of Gap in Current Investigation System", Procedia Earth and Planetary Science 11, pp. 539 – 547, 2015.

[2] R. Kumar, A.K. Ghosh, "The accident analysis of mobile mine machinery in an Indian opencast coal mine" Internationa journal of injury control and safety promotion, vol. 21, 2014.

[3] J. Duarte, A. Torres Marques and J. Santos Baptista "Occupational accidents related to heavy machinery: A systematic review", Safety, vol.7, 2021.

[4] V. Kecojevic,D. Komljenovic, W.A. Groves "Risk assessment for haul truck-related fatalities in mining", Society for Mining, Metallurgy and Exploration, vol. 60, pp. 43-49, 2008.

[5] V.Kecojevic,M. Radomsky "The causes and control of loader- and truck-related fatalities in surface mining operations" Injury control and safety promotion, vol.11, 2004.

[6] M.Dźwiarek "An Analysis of Accidents Caused by Improper Functioning of Machine Control Systems" International journal of occupational safety and ergonomics, vol.10, pp. 129-136, 2015.

[7] S. Dubey, A.W. Ansari "Design and Development of Vehicle anti-collision System using Electromagnet and ultrasonic sensors" international journal on theoretical and applied research in mechanical engineering, vol. 2, 2013.

[8] D.Xiao et al "An Anti-collision Early Warning System for Mine Trucks Based on RBF Network and WIFI" Journal of Physics: Conference Series, 1631(1), 012157,2020.

[9] R. Sharma "Vehicles Anti-collision System" International Journal of computer applications, vol. 99, 2014.

[10] M.Choudhary et al "Intelligent driving system at opencast mines during foggy weather" International journal of mining, reclamation and environment, vol. 36, pp. 196-217, 2021.

[11] M.Zhang,V.Kecojevic. "Intervention strategies to eliminate truck-related fatalities in surface coal mining in West Virginia" International journal of injury control and safety promotion, vol. 23(2), pp. 115-219, 2016.

[12] N. Kumar, D. Acharya, D. lohani. "An IoT based vehicle accident detection and classification system using sensor fusion" IEEE Internet of Things Journal, vol. 8(2), pp. 869-880, 2020.

[13] K.G. Panda et al "Effects of the environment on accuracy of ultrasonic operate in millimeter range" Perspectives in science, vol. 8, pp. 574-576, 2016.

[14] Y. Abdullahi, Badamasi. "The Working Principle of An Arduino" 11th international conference on electronics, computer, and computation, pp. 1-4 2014.

[15] M.S. Tiwari,M. Uttarwar. "Sensor-based Management Information System for Dumpers for Indian Mines" Journal of mines, metals and fuels, vol. 68(3), pp. 81-84, 2019.