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Multiple Hazard Detection In Mine Using Embedded System

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Abstract— **A comparative human performance evaluation of a miner's walking speed and head pitch was conducted on miners wearing cap lamps. Walking speed and head pitch are indirect indicators of improved lighting. The better that miners can see the floor, the faster they can walk and the less they pitch their heads downward to illuminate the floor with their cap lamps. Lighting is critical to miners to detect mine hazards. The intent is to provide more illumination in order for miners to better detect STF hazards located on the mine floor and to better detect moving machinery associated with struck-by or pinning accidents. The increase in peripheral vision improves the miner's ability to detect and mitigate hazards, since vision is the primary system used to identify and avoid obstacles and in particular peripheral vision is of key importance in obstacle avoidance. The reduction in head tilt may also be beneficial, as downward head positions have been linked to reduced postural stability in standing through changes body position and vestibular function.. Data were collected in the field from miners in an underground mine and the performance were updated in the nearby monitoring station.**

I. Introduction

An underground mine presents many unique work challenges given that it is dynamic environment that include dust, low reflective surfaces, low visual contrasts ,and moving machinery. One significant challenge is providing adequate lighting for miner sto work safely.Lighting is critical to miners; they depend heavily on visual cues to detect mine hazards [1]. Mine illumination typically consists of a low background light level with a relatively high-intensity light spot from a miner's cap lamp, which is often a miner's most important light source[2].

Two major systems of units are currently used for the quantification of light: illumination Engineering society (IES) and international systems of units (SI). The primary difference between IES and SI systems is that the IES system uses US standard measures for linear dimensions .In the unit definitions while the SI system uses metric measures.US coal mine lighting regulations customarily use IES units.

All standard systems of light units employ certain fundamental concepts that are based on the convenient and meaningful approaches to light energy measurement and quantification. These basic concepts are luminous flux, illumination(illuminance), luminous intensity, and luminance.

Mine hazards of primary concern, given the risk they pose to miners are slip, trip, and fall (STF) hazard and struck-by or pinning hazards from moving mining machinery. Mine Safety and Health Administration (MSHA) accident data for 2006–2010indicatesthatSTFs are the second leading accident class (18.6%, n=2341) of nonfatal, lost-time injuries at un- derground mines, and resulted in 148007total days lost from work[3].

Researchers at the National Institute for Occupational Safety and Health (NIOSH) are investigating light-emitting diode (LED)technology with the objective of improving cap lamps so That miners can better detect multiple hazards, including those Which result in a STF accident. NIOSH has developed an LED cap lamp that provides more illumination of these hazards by using multiple LEDs and secondary optics. When compared to other commercially-available LED cap lamps, the NIOSH LEDcaplampimprovedfloorhazarddetectionupto82%,and improved peripheral motion detection—crucial for detecting Moving machinery hazards—upto79%[4].These visual per- formance improvements were accomplished without increasing discomfort glare[5]. These results were obtained from testing subjects in the NIOSH Mine Illumination Laboratory(MIL)at Bruceton,PA.The MIL is a simulated underground coalmine environment. The interior Is 488cm(192in) wide by 213cm (84 in) high and is coated with a rough-textured material that hasadarkcolorandauniformspectralreflectivityofabout 5% for the visible spectrum, which is typical for coal. The MIL contains instrumentation, networked computers, and electro- mechanical apparatuses, developed by NIOSH researchers for testing trip hazard detection, peripheral motion detection, and glare. Thus, the MIL enabled researchers to control the vari- ables of interest, and

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this environment better enabled the identi- fication and control of extraneous variables that could result in data confounding(miner of height would be on such factor).

Then next step for NIOSH researchers was to move out of the laboratory environment and into the field. There are merits to testing in the field given the real-world conditions; however, it would not be practical transport and use the instrumentation and test apparatuses of the MIL in a coal mine. Therefore, NIOSH researchers devised an alternative methodology for studying cap lamps in the field.

Of prime importance was to address STF accidents given that these have these second highest frequency of occurrence. Our analysis of MSHA STF accident data for 2006–2010 indicated that the miner activity ―walking/ running‖ without carrying any objects was the leading activity when these STF accidents occurred. These findings were consistent with an analysis of British coalmining accidents indicating that the leading mineractivity was walking and not carrying any objects when STF accidents occurred [6]. Thus, walking is an important activity to study.

We inferred that as floor illumination increased, walking Speed would increase and head pitch would decrease—i.e., the Better that miners can see the floor, the faster they can walk and the less they need to pitch their heads down to illuminate the floor with their caplamps. Thus, walking speed and head pitch serve as indirect indicators of improved human performance due to an increase in floor illumination.

The primary objective of this study was to determine if the Light beam distribution from the NIOSH LED caplamp affected how miners walk. Specifically, we were to determine if there are statistically significant differences in average walkingspeed and headpitch when using the conventional LED caplamp and the NIOSH LED caplamp. A pilot experiment was conducted in the field and was followed by a more in-depth testing in a laboratory environment.

II. Methods

A. Proposed System

In this project i inferred that the if the floor illumination increased means the walking speed would increase and head pitch would decrease i.e., the better that miners can see the floor, the faster they can walk and the less they need to pitch their heads down to illuminate the floor with their cap lamps. Thus, walking speed and head pitch serve as indirect indicators of improved human performance due to an increase in floor illumination. A metal sensor was used to detect metal piece in the mine region and it gives a signal to alert the miners to avoid hazards and when miners pass the next sensor, it also sends signal.
With the help of two signals position we can calculate the miners walk. Then head pitch of the person is finding by the MEMS sensor. Also the reflectance from the light illumination is reduced by using LDR.

Advantages

- It has adequate lighting for miners to work safely
- It has head pitch serve to indicate the human performance

2) Laboratory Subjects: These subjects were Federal em- ployees and they were not specifically involved with this cap lamp research. Most of the subjects were not familiar with miner caplamp so they had used them infrequently. A total of 23 subjects participated: 20 male and 3 female. While gender was not a variable in this study, the percentage distribution for gender was representative of the U.S. miner population. The subjects signed an informed consent form and were instructed about their right to withdraw freely from the research at any time without penalty.

B. Experimental Design

The design for the field test is a 2 (Cap Lamp: Standard versus Development) × 2 (Walking Day: Initial Day versus

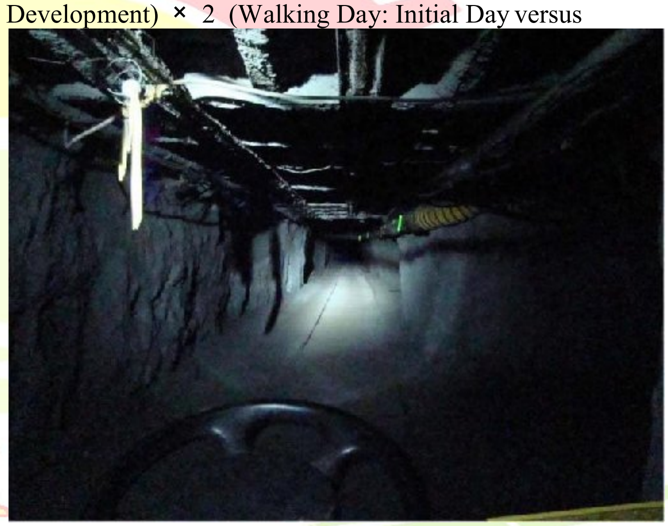

Fig.1. Circular beam spot of the Standard cap lamp used at the field test site. The photograph was taken at the NIOSH Safety Research CoalMine.

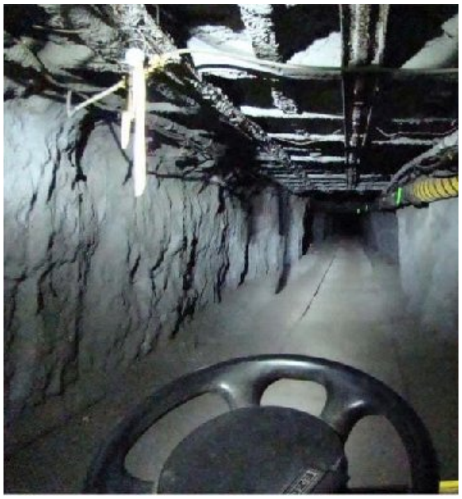

Fig.2. Light distribution of the NIOSH LED cap lamp.The photograph was Taken at the NIOSH Safety Research Coal Mine.

Final Day) mixed design. CapLamp type and Walking Day are Both within-subject variables.

The design for the laboratory test is a one-independent variable, within-subjects design. Only the cap lamp (Standard versus Development) was manipulated during the test.

C. Cap Lamps

Two types of LED cap lamps were used: a standard cap Lamp (Standard) and a NIOSH LED caplamp (Development). The Standard cap lamp was the one commonly used at the mine. Both caplamps were ―corded models ,meaning that the headpiece was connected via an electrical cable to a belt-worn battery pack. The Standard cap lamp used a single phosphor- white LED as the primary light source, along with an optical reflector to direct the light as a spot of about 6 as ° depicted byFig.1.TheDevelopmentcaplampusesmultiple,phosphor- white LEDs as the primary light source along with secondary optics to direct the light to specific hazardous areas in the mine asdepictedbyFig.2.Theintentistoprovidemoreillumination in order for miners to better detect STF hazards located on the

TABLE I CAPLAMPELECTRICALANDPHOTOMETRICDATA

	Electrical characteristics			Photometric characteristics	
Cap lamp	Supply voltage (Vdc)	Supply current (amps)	Supply power (watts)	Peak wavelength (nm)	Correlated color temp. (K)
Stand.	3.95	0.53	2.09	456	6603
Dev.	4.10	0.35	1.44	448	6356

TABLE II
MINEWALLANDFLOORILLUMINANCEDATAMEASURED3.05m(10ft.) FROMTHEBEGINNINGOFTHEWALKINGPATH

Cap lamp	Left wall illuminance (lux)		Right wall illuminance (lux)		Floor illuminance (lux)	
	Min.max	Ave	Min.max	Ave	Min.max	Ave
Stand.	0.16, 0.35	0.24	0.15, 0.32	0.26	0.17, 3.62	0.96
Dev.	0.14, 1.19	0.59	0.13, 1.25	0.56	0.11, 16.26	4.49

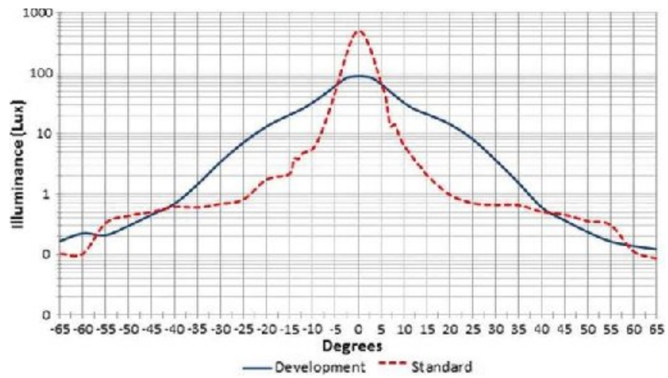

Fig.3. Cap lamp illuminance distributions in the horizontal plane.

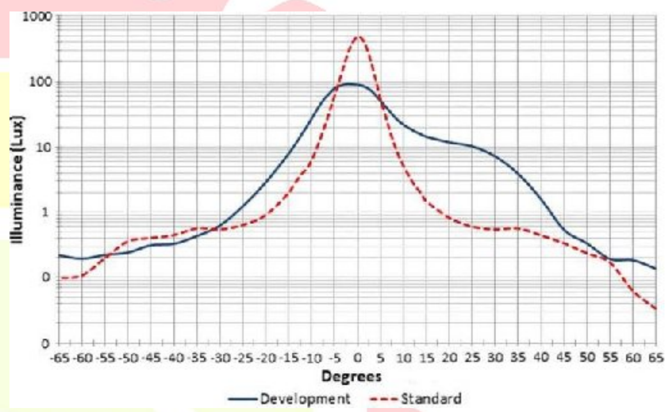

Fig.4. Caplamp illuminance distributions in the vertical plane.

mine floor and to better detect moving machinery associated with struck-by or pinning accidents. For each cap lamp, the electrical and photometric data are listed inTable I. Each cap lamp was energized from fully charged caplamp batteries. Both cap lamps were MSHA-approved. Illuminance data (Table II) were collected at 0.61m(2.0ft.) intervals along the mine walls and floor at a distance of 3.05m(10ft.) from the beginning of the walking path.

More detailed illuminance data for each caplamp is provided (Figs.3and4).

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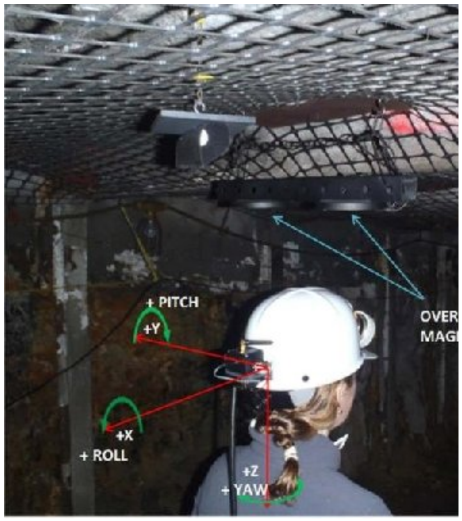


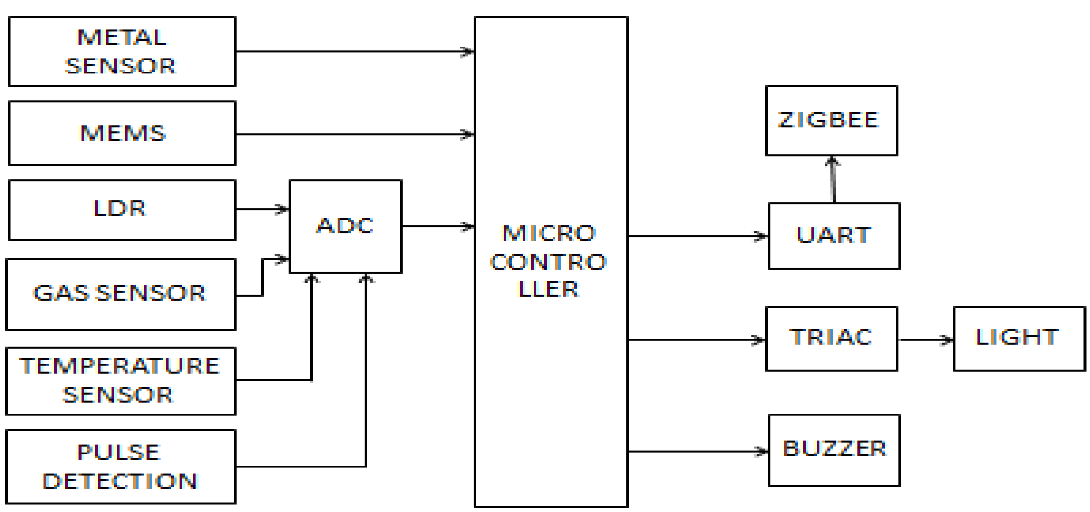
Fig.5. Tracking hardhat worn by aresearcher. The coordinate system diagram And overhead flagging magnets used to indicate the start and stop locations are shown.

III. EXPERIMENTALLAYOUTANDAPPARATUS

A. Hardhat Instrumentation

Each subject was fitted with two major components of instru- Mentation which were used to collect walking speed and head Pitch (rotation about the Y axis) data. The hardhat (Fig.5) was fitted with a 6-axis, wireless inertial measurement unit (IMU; Microstrain3DM-GX2).Inadditiontothe3-axisaccelerometer and 3-axisgyro,the IMU also contains a 3-axis magnetometer.

Transmitter Section



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Receiving Section

The AT89S52 microcontroller 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 programmer.

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 8-bit A/D converter uses successive approximation as the conversion technique. The converter features a high impedance chopper stabilized comparator, a 256R voltage divider with analog switch tree and a successive approximation register. The 8-channel multiplexer can directly access any of 8-single-ended analog signals. The device eliminates the need for external zero and full- scale adjustments.

A 230v, 50Hz Single phase AC power supply is given to a step down transformer to get 12v supply. This voltage is converted to DC voltage using a Bridge Rectifier. The converted pulsating DC voltage is filtered by a 2200uf capacitor and then given to 7805 voltage regulator to obtain constant 5v supply. This 5v supply is given to all the components in the circuit

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. It receives the data from the microcontroller and sends to the Zigbee. UARTs are commonly used in conjunction with other communication standards such as EIA RS-232.

The data is transmitted through Zigbee. ZIGBEE 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 Low-Rate Wireless Personal Area Networks (LR-WPANs), such as wireless light switches with lamps, electrical meters with in-home-displays, consumer electronics equipment via short-range radio needing low rates of data transfer. The technology defined by the ZIGBEE specification is intended to be simpler and less expensive than other WPANs, such as Bluetooth. ZIGBEE is targeted at radio-frequency (RF) applications that require a low data rate, long battery life, and secure networking.

In less than 20 years, MEMS (micro electro-mechanical systems) technology has gone from an interesting academic exercise to an integral part of many common products. But as with most new technologies, the practical implementation of MEMS technology has taken a while to happen. The design challenges involved in designing a successful MEMS product (the ADXL2O2E) are described in this article by Harvey Weinberg from Analog Devices. In early MEMS systems a multi-chip approach with the sensing element (MEMS structure) on one chip, and the signal conditioning electronics on another chip was used.

The light dependent resistor (LDR) is a sensor whose resistance decreases when light impinges on it. This kind of sensor is commonly used in light sensor circuits in open areas, to control street lamps for example. Another possible use is in spectroscopic apparatus. In this kind of apparatus, continuous light or pulsed light can be used. Continuous light is used in common spectroscopic apparatus. The use of lock-in amplifiers made the use of pulsed light in spectroscopy easier, as is commonly used in photo acoustic spectroscopy

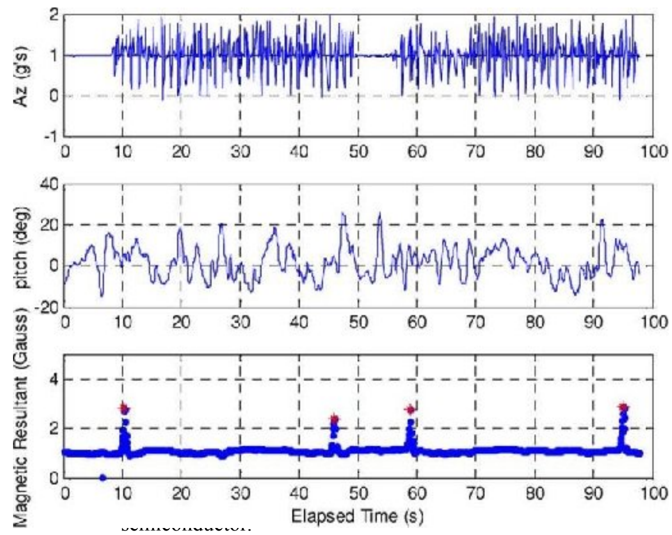

Fig.7. Typical data from both legband (topgraph) and hardhat IMU(middle graph). Note the spikes in the magneticfield (bottom graph) which enables the

distance flaggingof the start/stop points

The TRIAC is a three-terminal device similar in construction and operation to the SCR. The TRIAC controls and conducts current flow during both alternations of an ac cycle, instead of only one. Both the SCR and the TRIAC have a gate lead. However, in the TRIAC the lead on the same side as the gate is "main terminal 1," and the lead opposite the gate is "main terminal 2." This method of lead labeling is necessary because the TRIAC is essentially two SCRs back to back, with a common gate and common terminals. Each terminal is, in effect, the anode of one SCR and the cathode of another and either terminal can receive an input. In fact, the functions of a TRIAC can be duplicated by connecting two actual SCRs. The result is a three-terminal device identical to the TRIAC. The common anode-cathode connections form main terminals 1 and 2, and the common gate forms terminal3.

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Metal sensor is also called as proximity sensor. A Proximity sensor can detect objects without physical contact. A proximity sensor often emits an electromagnetic field or beam and look for changes in the field. The object being sensed is often referred to as the proximity sensor's target. Different proximity sensor targets demand different sensors. For example, a capacitive or photoelectric sensor might be suitable for a plastic target; an inductive proximity sensor requires a metal target.

In capacitive proximity sensors, the sensed object changes the dielectric constant between two plates. A proximity sensor has a range , which is usually quoted relative to water. Because changes in capacitance take a relatively long time to detect, the upper switching range of a proximity sensor is about 50 Hz. The proximity sensor is often found in bulk-handling machines, level detectors, and package detection.

A gas sensor can be used to detect combustible, flammable, toxic gases and oxygen depletion. Also used to detect gas leakage in industries, rigsetc.

Here MQ3gas sensor is used to detect the gas leakage in the mine. Gas leak detection is the process of identifying potentially hazardous gas leak. These sensors usually employ an audible alarm to alert people when a dangerous gas has been detected.

Temperature sensor is measures temperature in the given region or area. The temperature sensor sense the physical change occurs with temperature and it convert the physical change into a numerical value. Here temperature sensor is used to monitor the mine temperature.

A heart rate monitor is a personal monitoring device that allows one to measure ones heart rate in real time or record the heart beat rate for later study. Modern heart rate monitors usually comprise two elements; a chest strap transmitter and a wrist receiver or mobile phone. In this paper pulse monitoring system is used to monitor the pulse rate of the miners to check whether the miners are working safe or not inside the mine region.*Signal Capture and Analysis*

Data from both the hard hat and leg band IMU were wirelessly transmitted to an RF receiver located approximately 5.49 m(18 ft.) from the start of the walking path. This RF receiver was connected to a laptop running Lab View which served as the Data acquisition system, enabling the researcher to view the data in real time. The Lab View program displayed the head pitch angle (deg.), the leg acceleration in the Z direction (g's), and the resultant magnetic field strength vector(Gauss) as measured by the magnetometer located on the hardhat. LabView was used to sample the acquired data at 100 Hz, which was then post-processed in Matlab with a custom, semi-automated script(typical results in Fig. 7, below). The Matlab script identified any data dropouts that occurred due to packet collisions over the wireless link—theseweretypicallyontheorderof5%.Spikes in sensor behaviour were also smoothed by using an average of the force and aft neighboring points. Inorder to consis-tently and automatically find the start/stop points of the walking path, the script looked for localized peaks in the magnetometer data and identified the start/stop of the outgoing and return trip.

IV. RESULT

Conclusion

The provision of adequate illumination and the need to ensure a safe visual working environment is a challenge faced by almost all mining industries. Lighting in mines presents special problems because of the dark surroundings and low reflectance. Lighting provision is mainly important in the underground coal mining industry as there is no natural light, and large machines operate in a confined, dusty and a potentially explosive environment.This project shows that the increased field of view gained by the development cap lamp coupled with the increased illumination of the floor provided by the cap lamp's light distribution enables one to collect more information about the visual environment. The intent of the project is to provide sufficient floor illumination for miners to detect STF hazards located on the mine floor and also to detect moving machinery associated with struck-by or pinning accidents. The increase in peripheral vision improves the miner's ability to detect and mitigate hazards, since vision is the primary system used to identify and avoid obstacles. In particular peripheral vision is a key importance in obstacle avoidance. The reduction in head tilt may also be beneficial, as downward head positions have been linked to reduced postural stability in standing through changes in body position and vestibular function. Hence by determining the contribution of the visual environment to postural walking stability is afforded by the cap lamp lighting distribution.

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