Smart Building Sites: Using AI and RSSI to Ensure Proper Worker Attire and Safety Compliance

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ABSTRACT

In construction and building sites, workers are often at risk of injury or entrapment due to accidents such as building collapses, where individuals may become buried beneath debris and rendered unreachable. To enhance search and rescue efforts, we integrated Received Signal Strength Indicator (RSSI) technology, which uses signal strength from devices like smartphones or personal locator beacons to accurately triangulate the location of trapped individuals beneath rubble. By incorporating RSSI into our rescue protocol, we can rapidly assess the environment and streamline rescue operations, significantly reducing the time required to locate injured workers. Additionally, our system continuously monitors the RSSI of workers on-site, triggering an alert via a buzzer if a worker moves away from the designated construction area, ensuring real-time safety and preventing unauthorized departures. This innovative approach improves the overall effectiveness of rescue missions and workplace safety by enabling quick and accurate worker location both during emergencies and routine operations. The use of RSSI in high-risk environments highlights the potential of advanced technology to safeguard workers, ensuring timely rescues and proactive safety measures.

KEYWORDS: construction safety, RSSI technology, search and rescue, worker monitoring, emergency response, signal strength, location tracking, building collapse, debris recovery, real- time alerts, workplace safety.

1 INTRODUCTION

GENERAL :

This project focuses on enhancing safety and emergency response in construction and building sites by implementing Received Signal Strength Indicator (RSSI) technology. Given the inherent risks associated with construction work, such as building collapses and the potential for workers to become trapped beneath debris, our system aims to revolutionize search and rescue operations. By leveraging the signal strength from personal devices, such as smartphones or locator beacons, we can accurately pinpoint the location of individuals in distress, significantly reducing the time needed for rescue efforts. Additionally, our monitoring system tracks workers' movements on-site, providing real-time alerts if they stray from designated areas. This dual functionality not only facilitates swift location and recovery during emergencies but also fosters a proactive safety environment, ensuring that workers remain within safe zones. By integrating advanced technology into construction safety protocols, we aim to improve rescue mission effectiveness and safeguard workers in high-risk environments, ultimately contributing to a safer workplace culture. This innovative approach exemplifies how technology can be harnessed to address critical safety challenges in the construction industry.

The scope of this project encompasses the integration of RSSI technology into construction safety protocols to enhance search and rescue operations and monitor worker movements. It includes developing a robust system for accurate location tracking of trapped individuals during emergencies and implementing real-time alerts for workers straying from designated areas. This project aims to improve response times in critical situations, foster safer working environment, and reduce the risks associated with construction sites through advanced technology solutions.

EXISTING SYSTEM :

Reactive Safety Systems: Current safety systems in the construction industry are predominantly reactive, focusing on incident reporting after accidents occur rather than preventing them in real- time.

Limited Scope of Safety Measures: Existing systems often only ensure compliance with safety equipment usage, neglecting broader proactive measures to minimize injury risks during operations.

2 LITERATURE SURVEY

Title: Heart Rate Variability Measurement to Assess Acute Work-Content-Related Stress of Workers in Industrial Manufacturing Environment—A Systematic Scoping Review

Author: Tuan-Anh Tran, Márta Péntek
Year: 2023
Description: This study reviews whether heart rate variability (HRV) is a reliable indicator for assessing acute work-content-related stress (AWCRS) in industrial settings. It systematically reviews the literature from 2000-2022 and finds that HRV may not fully capture AWCRS during work and calls for further trials in real manufacturing environments.

Title: No Evidence of Thyroid Consequences in Seven Nuclear Workers at the Tokyo Electric Power Company Fukushima Daiichi Nuclear Power Plant Accident: 10-Year Follow-Up Results of Thyroid Status
Author: Hideo Tatsuzaki, Riwa Kishimoto, Osamu Kurihara, Takako Tominaga, Shunichi Yamashita **Year:** 2023
Description: This paper discusses a 10-year follow- up study of seven nuclear workers exposed to I-131 after the Fukushima Daiichi accident. Despite receiving high thyroid doses, no abnormalities related to radiation exposure were found, although continuous monitoring is recommended.

Title: Pick the Right Co-Worker: Online Assessment of Cognitive Ergonomics in Human–Robot Collaborative Assembly
Author: Marta Lagomarsino, Marta Lorenzini, Pietro Balatti, Elena De Momi, Arash Ajoudani **Year:** 2023
Description: This article introduces a vision-based framework to assess cognitive workload in human- robot collaborative systems using AI algorithms. It uses stereo cameras and advanced tracking to monitor operator attention and body kinematics, offering a novel method for adapting robotic systems to reduce worker cognitive strain.

Title: A Review of Computer Vision-Based Monitoring Approaches for Construction Workers' Work-Related Behaviors
Author: Jiaqi Li, Qi Miao, Zheng Zou, Huaguo Gao,Lixiao Zhang, Zhaobo Li, Nan Wang
Year: 2024
Description: This review explores the use of computer vision technology to monitor construction workers' behaviors, focusing on detection, localization, and safety. The study highlights the increasing use of object detection algorithms and anticipates further multi-algorithm integration to enhance the robustness of these systems.

Title: Robot-Aided Contactless Monitoring of Workers' Cardiac Activity in Hazardous Environment **Author:** Roberto Cittadini, Luca Rosario Buonocore, Eloise Matheso
Year: 2022
Description: This work presents a robotic system designed for non-invasive cardiac monitoring in hazardous environments. The system adapts its behavior based on distance and zoom to minimize error in heart rate calculations. It highlights the system's effectiveness through experimentation with volunteers and its improved accuracy compared to previous models.

3 PROPOSED SYSTEM

RSSI-Based Location Tracking: Implement RSSI technology using Arduino microcontrollers to triangulate the positions of workers on-site, enabling quick identification of individuals trapped beneath debris. This system continuously monitors signal strength from personal devices to provide real-time location data.
Health Monitoring and Alert System: Integrate heart rate sensors to continuously track workers' vital signs, automatically detecting anomalies. Upon detection, the system transmits location data to management and alerts caregivers via GSM for immediate intervention, ensuring timely medical response.

PROPOSED SYSTEM ADVANTAGES

RSSI-Based Location Tracking: Enables precise worker location in emergencies, reducing rescue time. Continuous monitoring improves overall site safety. Helps quickly identify trapped individuals under debris for faster intervention.

Health Monitoring and Alert System: Tracks vital signs in real-time, ensuring early detection of health issues. Sends instant alerts to management and caregivers for timely intervention. Enhances worker safety by providing immediate medical assistance when needed.

This the proposed system main key advantages in The work

4 PROJECT DESCRIPTION GENERAL :

This project integrates RSSI-based location tracking and health monitoring to enhance safety and emergency response on construction sites. By implementing RSSI technology using Arduino microcontrollers, the system can accurately triangulate the positions of workers, continuously monitoring signal strength from personal devices to provide real-time location data. This ensures quick identification of workers trapped beneath debris in the event of accidents, enabling faster rescue operations and improving overall site safety. Additionally, the project incorporates a health monitoring system that utilizes heart rate sensors to track workers' vital signs in real time. Any detected anomalies, such as irregular heartbeats or signs of distress, are immediately flagged, and the system sends alerts containing the worker's location to management and caregivers via GSM communication for prompt medical intervention. This proactive approach not only reduces the risk of unnoticed health emergencies but also ensures timely response to potential life-threatening situations. Together, the integration of RSSI technology for location tracking and health monitoring significantly enhances worker safety in high-risk environments by combining real-time monitoring, quick alert systems, and efficient rescue protocols. This project demonstrates the potential of technology to safeguard workers, minimize risks, and ensure that emergency responses are both timely and effective, contributing to a safer and more secure construction work environment.

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5 BLOCK DIAGRAM

6 MODULES NAME

1. RSSI-Based Location Tracking Module
2. Health Monitoring and Alert Module
3. AI-Based Safety Gear Detection Module

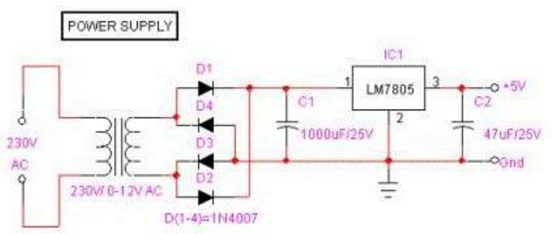
MODULE DESCRIPTION :

RSSI-BASED LOCATION TRACKING MODULE:

This module leverages Received Signal Strength Indicator (RSSI) technology, integrated with Arduino microcontrollers, to pinpoint the location of construction workers on-site. Personal devices suchas smartphones or wearables emit signals whose strength is measured by strategically placed receivers throughout the construction area. The RSSI data is processed by the Arduino to triangulate the worker's position, providing accurate real-time location updates. In the event of a building collapse or accident where workers are trapped under rubble, this module ensures rapid identification of their position, facilitating quicker and more effective rescue operations. Continuous monitoring of worker locations also enhances safety by preventing unauthorized entry into hazardous zones and ensuring worker compliance with site protocols.

HEALTH MONITORING AND ALERT MODULE:

This module integrates heart rate sensors to continuously track the vital signs of workers. These sensors are attached to workers and connected to the Arduino, which processes



the data to detect any abnormalities, such as irregular heartbeats or signs of distress. When anomalies are identified, the system immediately generates an alert containing the worker's location and health status. This data is sent to the construction management team for an on-site response and, simultaneously, transmitted via GSM to medical personnel or caregivers. This rapid response system ensures that workers receive prompt medical attention in case of health emergencies, reducing the risk of severe consequences from unnoticed health issues.

AI-BASED SAFETY GEAR DETECTION MODULE:

This module uses an AI model to assess workers' adherence to safety protocols by monitoring their attire. The AI is trained to recognize whether workers are wearing mandatory safety equipment, such as helmets, reflective vests, or gloves, by analyzing real- time video footage from cameras placed throughout the construction site. The AI model is integrated with the Arduino and alerts the management team if any worker is found to be non-compliant with safety guidelines. This ensures that all workers are properly equipped to minimize risks associated with construction work. The AI-based safety gear detection enhances operational efficiency and proactively reduces the chances of injury caused by non- compliance with safety regulations.

7 BLOCK DIAGRAM WORKING

The system is centered around an Arduino microcontroller, functioning as the core processor to enhance safety in construction and building sites. Workers are often at risk of injury due to accidents such as building collapses, where individuals may become trapped beneath demolished walls. To address this critical issue, RSSI technology is employed to accurately determine the location of construction workers within the site. Concurrently, a heart rate sensor monitors workers' health metrics, promptly

detecting abnormalities. When anomalies are identified, the worker's location data is automatically transmitted to the construction management team for an immediate response. Simultaneously, alerts are sent via GSM to caregivers for timely intervention. Additionally, an AI model assesses workers' attire, ensuring adherence to safety protocols. This integration facilitates real-time monitoring and intervention, optimizing worker safety and operational efficiency on construction sites. In emergency situations where workers are injured and unable to be located beneath debris, the combination of RSSI technology and health monitoring significantly enhances rescue operations, ensuring prompt identification and support for those in need.

8 HARDWARE AND SOFTWARE DISCRIPTION

HARDWARE DESCRIPTION :

Power Supply:

This section describes how to generate +5V DC power supply

The power supply section is the important one. It should deliver constant output regulated power supply for successful working of the project. A 0- 12V/1 mA transformer is used for this purpose. The primary of this transformer is connected in to main supply through on/off switch& fuse for protecting from overload and short circuit protection. The secondary is connected to the diodes to convert 12V AC to 12V DC voltage. And filtered by the capacitors ,Which is further regulated to +5v, by using IC 7805**.**

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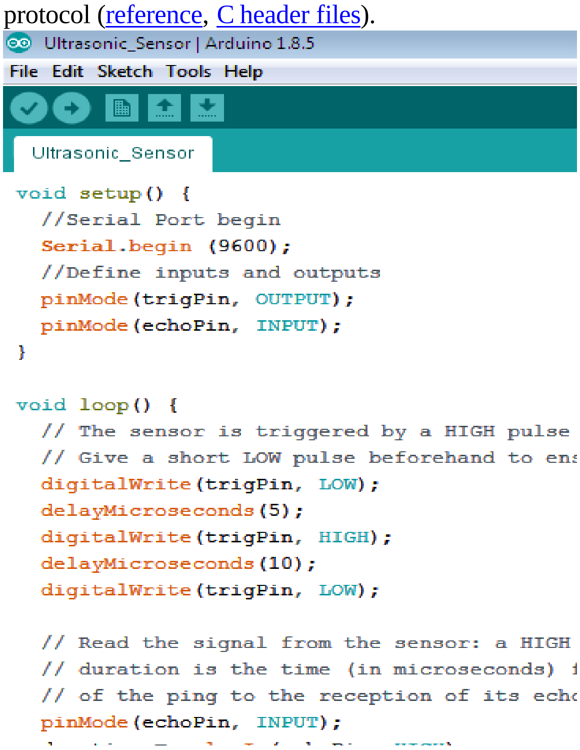
HARDWARE:

Arduino is open-source hardware. The hardware reference designs are distributed under a Creative Commons Attribution Share-Alike 2.5 license and are available on the Arduino website. Layout and production files for some versions of the hardware are also available.
Although the hardware and software designs are freely available under copyleft licenses, the developers have requested the name Arduinoto be exclusive to the official product and not be used for derived works without permission. The official policy document on use of the Arduino name emphasizes that the project is open to incorporating work by others into the official product. Several Arduino-compatible products commercially released have avoided the project name by using various names ending in -duino. An early Arduino board with an RS- 232 serial interface (upper left) and an Atmel ATmega8 microcontroller chip (black, lower right); the 14 digital I/O pins are at the top, the 6 analog input pins at the lower right, and the power connector at the lower left.
Most Arduino boards consist of an Atmel 8-bit AVR microcontroller (ATmega8, ATmega168, ATmega32 8, ATmega1280, ATmega2560) with varying amounts of flash memory, pins, and features. The 32- bit Arduino Due, based on the Atmel SAM3X8E was introduced in 2012. The boards use single or double- row pins or female headers that facilitate connections for programming and incorporation into other circuits. These may connect with add-on modules termed shields.
Multiple and possibly stacked shields may be individually addressable via an I²C serial bus. Most boards include a 5 V linear regulator and a 16 MHz crystal oscillator or ceramic resonator. Some designs, such as the LilyPad, run at 8 MHz and dispense with the onboard voltage regulator due to specific form-factor restrictions.
Arduino microcontrollers are pre-programmed with a boot loader that simplifies uploading of programs to the on-chip flash memory. The default bootloader of the Arduino UNO is the optiboot bootloader. Boards are loaded with program code via a serial connection to another computer. Some serial Arduino boards contain a level shifter circuit to convert between RS- 232 logic levels and transistor–transistor logic (TTL) level signals. Current Arduino boards are programmed via Universal Serial Bus (USB), implemented using USB-to-serial adapter chips such as the FTDI FT232. Some boards, such as later-model Uno boards, substitute the FTDI chip with a separate AVR chip containing USB-to-serial firmware, which is reprogrammable via its own ICSP header. Other variants, such as the Arduino Mini and the unofficial Boarduino, use a detachable USB-to-serial adapter board or cable, Bluetooth or other methods. When used with traditional microcontroller tools, instead of the Arduino IDE, standard AVR in-system programming (ISP) programming is used.An official Arduino Uno R2 with descriptions of the I/O locations The Arduino board exposes most of the microcontroller's I/O pins for use by other circuits.
The Diecimila,[a] Duemilanove,[b] and current Uno[c] provide 14 digital I/O pins, six of which can produce pulse-width modulated signals, and six analog inputs, which can also be used as six digital I/O pins. These pins are on the top of the board, via female 0.1-inch (2.54 mm) headers. Several plug-in application shields are also commercially available. The Arduino Nano, and Arduino-compatible Bare Bones Board and Boarduino boards may provide male header pins on the underside of the board that can plug into solderless breadboards.

Many Arduino-compatible and Arduino-derived boards exist. Some are functionally equivalent to an Arduino and can be used interchangeably. Many enhance the basic Arduino by adding output drivers, often for use in school-level education, to simplify making buggies and small robots. Others are electrically equivalent but change the form factor, sometimes retaining compatibility with shields, sometimes not. Some variants use different processors, of varying compatibility.

PROGRAMMING:

The Arduino Uno can be programmed with the (Arduino Software (IDE)). Select "Arduino/Genuino Uno from the Tools > Board menu (according to the microcontroller on your board). For details, see the reference and tutorials.
The ATmega328 on the Arduino Uno comes preprogrammed with a boot loader that allows you to upload new code to it without the use of an external hardware programmer. It communicates using the original STK500 protocol (reference, C header files).



You can also bypass the boot loader and program the microcontroller through the ICSP (In-Circuit Serial Programming) header using Arduino ISP or similar; see these instructions for details.
The ATmega16U2 (or 8U2 in the rev1 and rev2 boards) firmware source code is available in the Arduino repository. The ATmega16U2/8U2 is loaded with a DFU boot loader, which can be activated by:

- **On Rev1 boards:** connecting the solder jumper on the back of the board (near the map of Italy) and then reseing the 8U2.

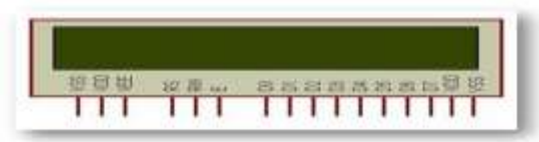
- **On Rev2 or later boards:** there is a resistor that pulling the 8U2/16U2 HWB line to ground, making it easier to put into DFU mode.You can then use Atmel's FLIP software (Windows) or the DFU programmer (Mac OS X and Linux) to load a new firmware. Or you can use the ISP header with an external programmer (overwriting the DFU boot loader). See this user-contributed tutorial for more information.

LIQUID CRYSTAL DISPLAY:

LCD screen is an electronic display module and find a wide range of applications. A 16x2 LCD display is very basic module and is very commonly used in various devices and circuits. These modules are preferred over seven segments and other multi segment LEDs. The reasons being: LCDs are economical; easily programmable; have no limitation of displaying special & even custom characters (unlike in seven segments), animations and so on.

A **16x2 LCD** means it can display 16 characters per line and there are 2 such lines. In this LCD each character is displayed in 5x7 pixel matrix. This LCD has two registers, namely, Command and Data. The command register stores the command instructions given to the LCD. A command is an instruction given to LCD to do a predefined task like initializing it, clearing its screen, setting the cursor position, controlling display etc. The data register stores the data to be displayed on the LCD. The data is the ASCII value of the character to be displayed on the LCD. Click to learn more about internal structure of a LCD.

We come across LCD displays everywhere around us. Computers, calculators, television sets, mobile phones, digital watches use some kind of display to display the time. An LCD is an electronic display module which uses liquid crystal to produce a visible image. The 16×2 LCD display is a very basic module commonly used in projects. The 16×2 translates to a display 16 characters per line in 2 such lines. In this LCD each character is displayed in a 5×7 pixel matrix. **16X2 LCD PINOUT DIAGRAM:**



9 FUTURE ENHANCEMENT

For future enhancements, the system can be upgraded by integrating Raspberry Pi with a cloud-based database to enhance data management, scalability, and real-time analytics. Raspberry Pi can serve as the central processing unit, handling data from various sensors, such as RSSI modules, heart rate sensors, and AI-driven cameras, while efficiently managing larger datasets. By connecting the system to a cloud database, all worker location, health, and safety compliance data

can be stored and analyzed in real-time. This will allow construction management teams to access and monitor site conditions remotely from any device, ensuring constant vigilance. Historical data can be logged and analyzed to identify patterns in worker movements or health metrics, enabling predictive analytics for accident prevention and safety optimizations. Additionally, integrating machine learning algorithms on the Raspberry Pi can further improve decision-making, such as predicting potential health risks based on historical data or adjusting rescue protocols dynamically. This enhancement will not only boost the system's performance but also provide valuable insights for improving safety strategies and compliance in construction sites, ensuring a more data-driven and proactive approach to worker safety management.

10 CONCLUSION

In conclusion, this system provides a comprehensive solution to enhance worker safety and operational efficiency in construction sites by integrating advanced technologies like RSSI, health monitoring, and AI-based safety gear detection. The RSSI-based location tracking module ensures real- time identification of workers, particularly in emergencies such as building collapses, enabling faster rescue operations. By precisely triangulating workers' locations, the system reduces response time in critical situations, significantly improving the chances of survival for those trapped under debris. Simultaneously, the health monitoring module tracks vital signs, automatically detecting anomalies and transmitting real-time alerts to both management and caregivers for immediate intervention. This proactive approach prevents health emergencies from going unnoticed, ensuring prompt medical attention when needed. The AI-based safety gear detection module further ensures that workers adhere to safety protocols, minimizing the risk of injury caused by non-compliance. By monitoring safety equipment in real-time, the system helps enforce a safe working environment, ultimately reducing the likelihood of accidents. This integration of location tracking, health monitoring, and safety compliance creates a robust safety framework that optimizes both worker protection and operational workflows. The solution highlights how leveraging modern technology can address critical safety challenges, ensuring that workers are safeguarded against the inherent risks of construction sites while providing timely interventions in emergencies.

11 REFERENCES

[1] C. B. Tatum, J. A. Vanegas, and J. M. Williams, “Constructability improvement using prefabrication, preassembly, and modularization,” Stanford Univ., Stanford, CA, USA, 1986.

[2] J. Zhou, Y. Li, and D. Ren, “Quantitative study on external benefits of prefabricated buildings: From perspectives of economy, environment, and society,” Sustain. Cities Soc., vol. 86, Nov. 2022, Art. no.

104132, doi: 10.1016/j.scs.2022.104132.

[3] X. Li, C. Wang, A. Alashwal, and S. Bora, “Game analysis on prefabricated building evolution based on dynamic revenue risks in China,” J. Cleaner Prod., vol. 267, 2020, Art. no. 121730, doi: 10.1016/j.jclepro.2020.121730.

[4] M. O. Sanni-Anibire, A. S. Mahmoud, M. A. Hassanain, and B. A. Salami, “A risk assessment approach for enhancing construction safety performance,” Saf. Sci., vol. 121,pp. 15–29, 2020, doi: 10.1016/j.ssci.2019.08.044.

[5] L. Song, H. Li, Y. Deng, and C. Li, “Understanding safety performance of prefabricated construction based on complex network theory,” Appl. Sci., vol. 12, no. 9, 2022, Art. no. 4308, doi: 10.3390/app12094308.

[6] H. Li, H. Guo, M. Skitmore, T. Huang, K. Y. N. Chan, and G. Chan, “Rethinking prefabricated construction management using the VP-based IKEA model in Hong Kong,” Construction Manage. Econ., vol. 29, no. 6, pp. 233–245, 2011.

[7] Y. Shen, M. Xu, Y. Lin, C. Cui, X. Shi, and Y. Liu, “Safety risk management of prefabricated building construction based on ontology technology in the BIM environment,” Buildings, vol. 12, no. 6, 2022, Art. no. 765, doi: 10.3390/buildings12060765.

[8] Y. Jiang, H. Chen, X. Nie, and M. Tao, “Experimental study on bond and anchorage of steel bars in precast concrete structures with new-toold concrete interface,” Eng. Struct., vol. 247, 2021, Art. no. 113086, doi: 10.1016/j.engstruct.2021.113086.

[9] S. Han, A. Bouferguene, M. Al-Hussein, and U. Hermann, “3Dbased crane evaluation system for mobile crane operation selection on modular-based heavy construction sites,” J. Construction Eng. Manage., vol. 143, no. 9, 2017, Art. no. 04017060, doi: 10.1061/(asce)co.1943-7862.0001360.

[10] M. M. Fard, S. A. Terouhid, C. J. Kibert, and H. Hakim, “Safety concerns related to modular/prefabricated building construction,” Int. J. Inj. Control Saf. Promot., vol. 24, no. 1, pp. 10–23, 2017,doi:10.1080/17457300.2015.1047865.