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IOT-BASED PERSONNEL SAFETY AND HEALTH MONITORING SYSTEM FOR FIELD OPERATIONS

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Abstract : Workplace safety remains a pressing concern, prompting researchers across various fields to explore effective solutions. However, establishing an efficient system to tackle this issue poses a significant challenge. Additionally, monitoring workers' health vitals is crucial for preventing accidents, especially in field operations. This project outlines a strategy for developing an integrated tracking solution encompassing GPS tracking, health vitals monitoring, and Personal Protective Equipment (PPE) compliance tracking services for workers. By utilizing Internet of Things (IoT) technology, it is possible to perform zone classification, ensure PPE compliance, and monitor vital signs such as heart rate, temperature, blood pressure, and SpO2 in real-time. Leveraging the ESP32 development kit and server infrastructure will facilitate efficient management of workers' data and streamline monitoring processes. Utilizing WI-FI technology for remote data transmission ensures secure storage of information in a web server database, accessible from smart devices.

I. INTRODUCTION

Ensuring workers' well-being, health and work performance requires appropriate working conditions and organizational structures. Specifically, safe and hygienic working conditions significantly impact both work quality and life outside the workplace [4]. Workers are unwilling, forget to wear proper PPE, or wear the wrong kind of PPE due to various reasons such as: 1) negative impacts of PPE on their productivity; 2) uncomfortable PPE wearing, particularly in hot weather; 3) lack of training to wear proper PPE; 4) underestimation of the usefulness of PPE and lack of information regarding the frequency of injuries [2]. In recent years, the availability of wearable Internet of Things (IoT) devices has increased due to the cost reduction in technology production and making them more accessible to the public, provoking a great interest in studying this topic among the scientific community [3].

IoT is making any object internally connected in the recent decade and it has been considered as the next technological revolution. Smart health monitoring mechanism, smart parking, smart home, smart city, smart climate, industrial sites, and agricultural fields are some of the applications of IoT. The most tremendous use of IoT is in healthcare management which provides health and environment condition tracking facilities. IoT is nothing but linking computers to the internet utilizing sensors and networks. These connected components can be used on devices for health monitoring. The used sensors then forward the information to distant locations like M2M, which are machinery for computers, machines for people, handheld devices, or smartphones. It is a simple, energy-efficient, much smarter, scalable, and interoperable way of tracking and optimizing care to any health problem. Nowadays, modern systems are providing a flexible interface, assistant devices, and mental health management to lead a smart life for the human being [1].

This paper aims to represent health vitals monitoring of the workers and PPE compliance using IoT by making use of a suitable microcontroller in which case here is ESP32 Dev Module; suitable sensors modules such as MAX30102, DS18B20, and finally the web server and Twilio, which is a global, cloud-based web service that enables digital communication through several platforms, done via the Internet to perform health vitals monitoring; suitable software and platforms like labelstudio, Pixabay and Google Colab to perform PPE Compliance. Arduino IDE is an open-source electronics platform based on easy-to-use hardware and software and can be expanded through C++ libraries. Twilio is a global cloud-based service enabling digital communication across SMS, voice calls, WhatsApp, email, and video. Its versatile API seamlessly integrates with mobile apps, software, and IoT development boards, enabling easy access to communication functionalities without additional hardware requirements.

The organization flow of this paper is with the literature survey, methodology, results, conclusion, future work and finally references, with descriptions for the block diagrams and results.

Abbreviations and Acronyms

PPE - Personal Protective Equipment , IoT - Internet of Things , M2M - machine-to-machine , IDE - Integrated Development Environment , GPS- Global Positioning System , LCD-Liquid Crystal Display , HR -Heart rate , SBP- Systolic Blood Pressure , DBP- Diastolic Blood Pressure , SpO2- Peripheral capillary oxygen saturation , YOLOv7- You Only Look Once Version 7

II. Literature Survey

Jannatun Ferdous et al implemented an intelligent health care system based on Internet of Things (IoT) for the measurement of the vital signs like pulse rate, temperature, SpO2, using (ESP32 Dev Module) for wireless wearable sensor controller and ESP32 server by June 2023. The Wi-Fi technology is utilized as a communication tool to allow transmission the data remotely. The data of patient are sent to the web server to be stored in the database and view the data on the web page anywhere and anytime using smart devices and alert the doctor to any abnormal state [1].

Xincong Yang et al proposed an automated PPE-Tool pair checking system using the Internet of Things (IoT) with wireless Wi-Fi modules tagged on the PPE by November 2020. The method integrates various sensors and Wi-Fi modules for PPE wearing detection, data transition, and alarm treatment. The experiment results showed that average time lag was 1.229s, which was efficient for on-site safety management.[2]

Sergio Márquez-Sánchez, et al proposed system by July 2021 that guarantees the workers' safety and integrity through the early prediction and notification of anomalies detected in their environment. Models such as convolutional neural networks, long short-term memory, Gaussian Models were joined by interpreting the information with a graph, where different heuristics were used to weight the outputs as a whole, where finally a support vector machine weighted the votes of the models with an area under the curve of 0.81 [3].

Alessia Pisu et al proposed a workplace safety system by March 2024. This paper introduces the Operator Area Network (OAN) system, enhancing portability, privacy, and PPE monitoring through machine learning techniques. Analysing RSSI between PPEs ensures correct usage without compromising worker comfort. The system reduces false positives by about 80% and swiftly detects improper PPE usage, raising alarms in less than seven seconds. Additionally, customizable post-processing algorithms cater to specific needs, balancing detection time interval and overall accuracy [4].

III. METHODOLOGY

The hardware interface comprises of the ESP32 Dev Module microcontroller serves as the central hub, collecting inputs from various sensors and modules, processing the gathered data, establishing Wi-Fi connectivity, and transmitting information to IoT device servers and other output devices for real-time monitoring. Among the components integrated into this system are the MAX30102 Pulse Oximeter Sensor, which measures heartbeat, systolic and diastolic blood pressure, and blood oxygen concentration; the DS18B20 temperature sensor, designed for temperature measurement with convenient digital output compatibility for microcontrollers; and finally, the 16x2 LCD display, offering a clear interface to present up to 32 characters of information across its two rows.

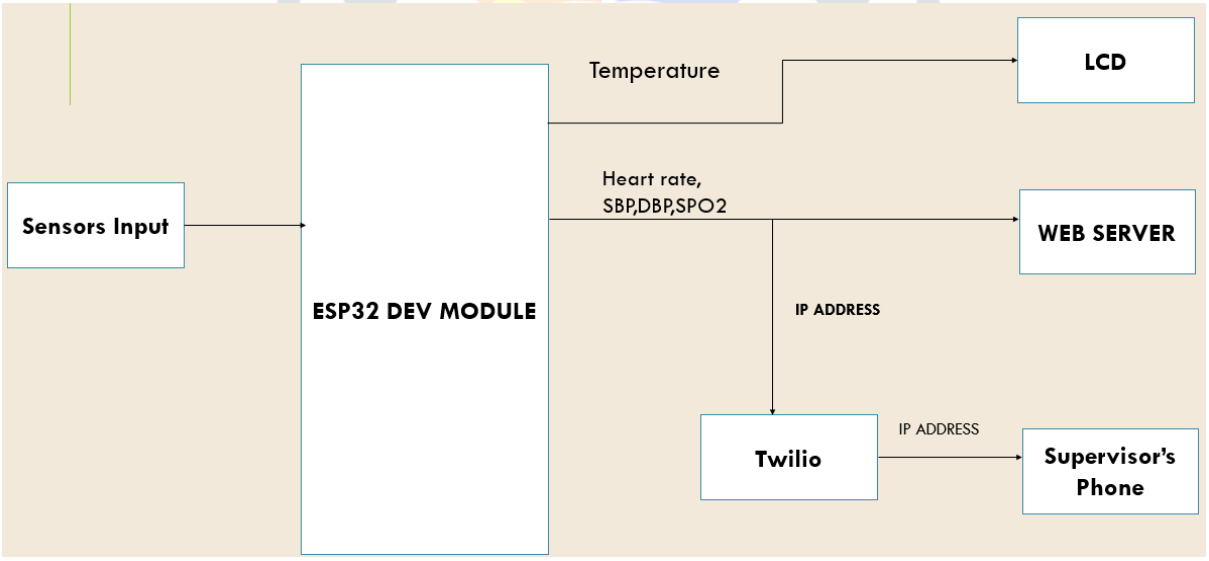

Fig 1: Block Diagram for monitoring health vitals

As seen in Figure 1, the input of the sensors is passed on to the microcontroller, from where necessary operations are done to process the input and the output is also displayed accordingly. The health vitals data of the heart sensor is displayed on the web server, which is accessed via an IP address and that of the temperature sensor is displayed on the LCD. By making use of Twilio, which is a global cloud-based platform which can facilitate digital communication across a variety of platforms, the health vitals data are sent in the form of an IP address to the supervisor, and can thus monitor the health vitals of the workers, thereby achieving monitoring of health vitals. For PPE Compliance, a labelling based solution has been proposed w block diagram is as follows

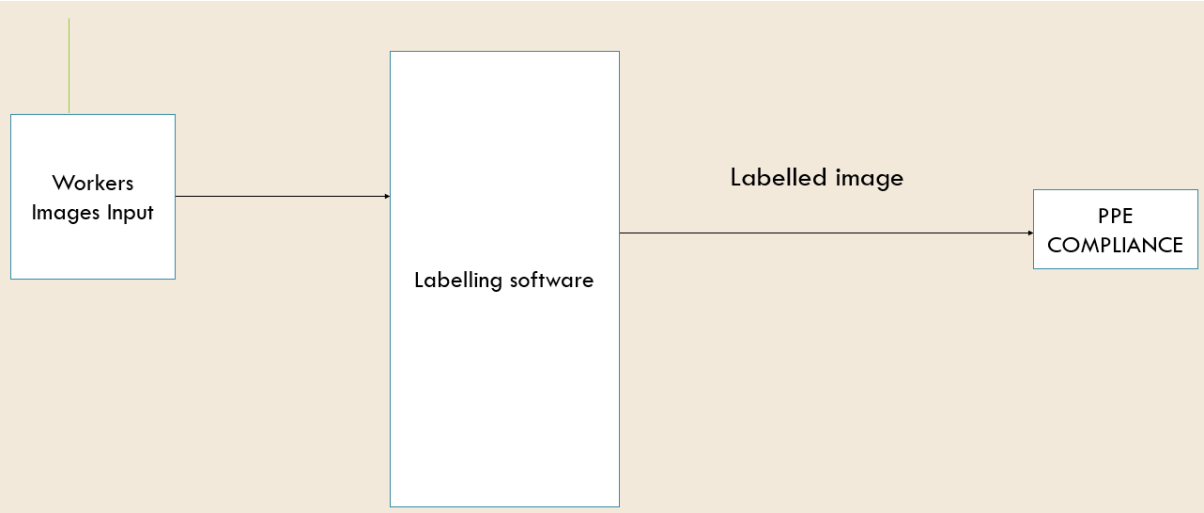

Fig 2: Block diagram for PPE compliance

Figure 2 shows the images of the workers, downloaded from a custom data set will be properly labelled using a labelling software using the YOLOV7 training model. In the image, individual workers will have bounding boxes over them, with appropriate labels to note if they are wearing the PPE or not.

IV. RESULTS AND DISCUSSION

Based on the methodology, the model is developed to perform health vitals monitoring and PPE compliance and the results obtained as follows:

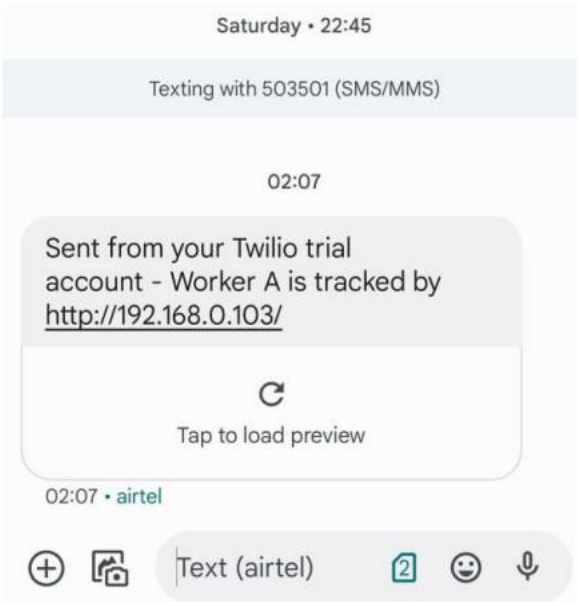

Fig 3: Sending of IP address to supervisor's phone using Twilio

Figure 3 shows once the health vitals from MAX30102 are obtained, an IP address is obtained which is in turn sent via Twilio to the Supervisor's phone and thus health vitals of the workers can be monitored.

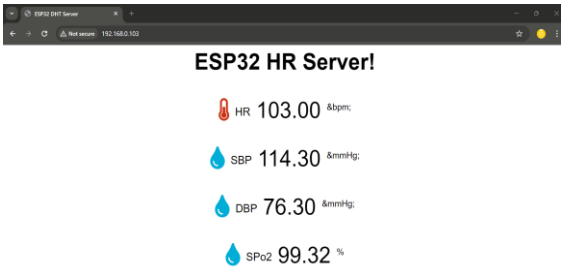

Fig 4: ESP32 Web Server

The health vitals like temperature, SpO2 can be tracked via the IP Address sent using Twilio as shown in Figure 4, and can be monitored by the supervisor.

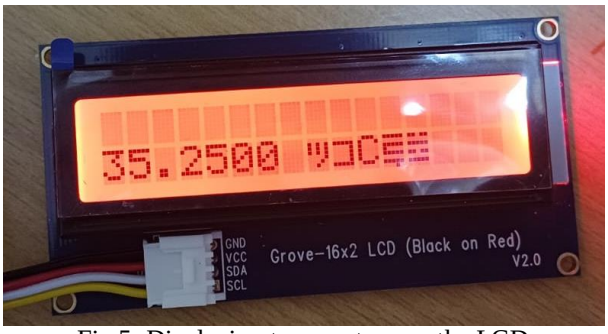

Fig 5: Displaying temperature on the LCD

The body temperature measured as 35 by the DS18B20 is displayed on the LCD as shown in Figure 5.

Fig 6 : PPE Compliance output

Figure 6 shows bounding boxes are drawn on each worker with appropriate labels to detect if they are wearing their PPE or not. The blue box is representing for workers who don't wear the PPE and the orange box is representing for workers who wear the PPE.

V. CONCLUSION

In this paper, an IoT-based personnel safety and health monitoring system has been made such that the objectives of Monitoring health vitals monitoring with a focus on Body Temperature, Blood Pressure, Oxygen level, Heart rate (anxiety level) as the vitals and PPE compliance has been done. Through this paper, a worker's safety and health data can be monitored and appropriate actions and precautions can be taken by the concerned authorities in case of any situations.

VI. FUTURE WORK

This future work of this paper deals with integration of zone tracking using a GPS module to track the coordinates of the worker to prevent accidental trespassing into other zones, which in turn improves worker safety. A possible integration of the body temperature vital to be displayed on the Web server can also be done.

VII. ACKNOWLEDGMENT

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