

Developing a Smart Hard Hat for Employees Who Work On Construction Sites

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ABSTRACT

The Internet of Things has become a big world that contains many features and specialists that facilitated life and facilitated other things. As it is a system consisting of several computing devices, digital and mechanical machines, and things linked to each other through unique identifiers that transfer data over the network. The Internet of Things ecosystem contains smart devices that use embedded systems such as sensors, processors, and communication devices. All data is sent to another place where the data is analyzed. This project will be focusing on the proposal of an IoT base solution, which is a wireless sensor network (WSN) to develop a smart hard hat to monitor the workers' health conditions, safety, and location on construction sites. This will happen while investigating the challenges and the risks of the hard hat, and in the field of construction sites. Moreover, analyzing the current solution of developing the smart hardhat, and Proposing IoT based solution to enhance the smart hard hat functionality which improves the general safety of employees and workers. Lastly, it will be evaluated to find the appropriate functionality sensors of the developed Hard Hat. Kanban is a project management and process visualization tool developed to visualize work and reduce the amount of work. Kanban is an important central component of "lean" manufacturing. There are five main steps to implementing the Kanban system. The first step is visualizing the workflow. Secondly, apply Work-in-Process (WIP) limits. Thirdly, policy clarity. Fourthly, flow measurement and management. Moreover, the last step is iterative optimization with data. The smart hard hat that will develop will ensure to reduce in the accident rate by enhancing the smart hard hat and by improving the features of the Helmet. The smart hard hat contains the Raspberry Pi that sends alerts and notifications to the supervisor of the workers in the administration platform to tell the supervisor that the worker has fallen from a height or is missing. In addition, the hat contains GPS to keep track of workers at work sites, and this will make it easier for managers and supervisors.

Introduction

The construction industry sector is considered an important sector due to the diversity and multiplicity of projects. As there are many construction sites and industrial areas in the Sultanate of Oman. With the abundance of these sites, there are many threats affecting workers in these areas because they are considered one of the most unsafe places to work. This sector is one of the most accident-prone sectors due to the large number of accidents that occur in it, which are considered undesirable. The health and safety of employees are essential conditions for the success of any business or construction project. So, neglecting the health and safety of the employee leads to the failure of the project. The protocol for the use of personal protective equipment (PPE) is extremely strict. This protocol stipulates the necessity of wearing personal protective equipment such as a safety helmet (hardhat), gloves, safety shoes, radios for communication, and many others. Despite the availability of personal protective equipment, some do not work properly, which puts employees and workers at risk. Many studies indicate an increase in the number of deaths of workers and an increase in the number of injuries, although workers on construction sites were using personal protective equipment. If this indicates anything, it indicates that the devices are not working properly. In addition to PPE, the hierarchy of risk management is one of the most popular methods used in the construction industry that is recognized and supported

by most different organizations to protect workers on construction sites. Both the hierarchy of risk management and personal protection equipment minimize and limit the risks faced by workers on construction sites and are essential for an accident-free project. The wireless sensor network can be applied in construction sites, which in turn will monitor the safety and health of workers and employees. This network contains sensor nodes in the Helmet/Hard hat, these sensor nodes obtain workers' data such as temperature and heart rate, and they can locate the worker and send a relief alert in the event of an accident.

Literature Review

IoT and Smart Hard Hat

IoT allows objects to be sensed and to be managed remotely. The development of the Internet of Things, Wi-Fi technologies, Microservice, and micro-electromechanical systems helped develop the Internet of Things and reached construction sites. A smart helmet that is connected to the Internet of Things reduces accidents that usually occur on construction sites. This article mentioned that these accidents occur due to a lack of awareness and neglect of wearing personal protective equipment. This article mentioned the multiple benefits of a smart helmet, such as protecting employees from dangers through the sensors in the helmet. The helmet also contained GPS sensors and emergency buttons to help and rescue workers in the event of accidents that occur on construction sites. The worker will be notified of the problem he faces, and then the supervisor will take the necessary measures that will help the worker. In addition to protecting workers, it supervises the activity of each employee individually. It also mentioned that the main factor of the smart helmet is safety. It is the reason for the development of the smart helmet and the Internet of Things, and because it contains sensors and connects to the Internet. (Jayasree & Kumari, 2020). The definition of the Internet of Things has been mentioned as a network consisting of computing systems, physical objects, and mechanical devices intricately linked to each other, which gives it the possibility to transfer information and data between the networks without the need for human intervention. The article suggested the formation of a monitoring system based mainly on the Internet of Things. The smart hard hat will be designed using devices and sensors that are generally based on the Internet of Things. Everyone on the job site is expected to wear this hat for his or her safety. One of these devices and sensors is the RFID, as the control center will be notified of the absence of the worker in his place or if he exceeds the authorized access limit. In addition to all the features in these devices and sensors, they will all be connected to the Internet. (Wójcik et al., 2022)

Smart Hardhat and the Constructions Sites

An interesting article explains that the association of the smart hat with construction sites may contribute to improving worker safety on construction sites and monitoring each worker's working hours individually. In addition to several features and advantages of this hat, it is designed flexibly and compatible with the requirements of many different workplaces such as construction sites and mines. The smart hat contains multiple sensors to meet the requirements of the previously mentioned job sites, in addition to the sensors, it contains Bluetooth connectivity and visual and sensory devices. (Aliyev et al., 2020) This article mentioned that workers on construction sites face many accidents daily. To reduce these accidents, or at least reduce their incidence, the HeadgearX smart helmet was invented. This hat is connected to the internet and equipped with sensors and multiple actuators to keep an eye on the workers and keep an eye on the business. This smart hat is connected via Bluetooth to each worker's smartphone. When the worker is at the construction site, the smart hat linked to the phone will send the worker's data such as the working hour, his location, and the temperature to the control center (administration platform). Moreover, through which all the data is recorded in it to know all the details of the worker at the construction site. (Aliyev et al., 2020). Shrestha et al mentioned many workers and people working on construction sites work under unsafe conditions, as the United States in 2012-recorded

4,383 fatal work injuries at the construction site, which almost claimed the death of workers at a rate of 89 deaths per week, and 12 per day. It was necessary to find a solution to reduce the number of deaths, as a software tool connected to the hat worn by workers on the construction site was developed by the efforts of both construction engineers and computer science specialists. This hard hat was evaluated at the University of Nevada Las Vegas in the Construction Management Laboratory. This hat contained sensors that detect whether the worker is wearing the smart hat, and if he is in danger, the rest of the workers call for an ambulance to save the worker. This hat will save time, cost, and workers' lives on construction sites because it will reduce injuries and death levels. It will also monitor the workers on the construction site without the head of labor needing to go to the construction site to find out which workers are on the site, and which are absent. It will also assist the worker directly if it senses any accident, run-over, or other situation by sending rescue teams to the worker's location whose location has been determined by the GPS sensors in the smart hat. (Shrestha et al., 2015).

Problems with the Previous Hard Hat that was Invented

The smart hat is a pre-existing idea, but it had several problems, errors, or wrong choices regarding the selection of the appropriate devices that are associated with it. The article mentioned that the sensor used to locate the operator failed to set the location correctly. Because there is an obstacle between the hat and the internet, or because of a malfunction in the sensor used to locate workers. In addition, this problem may fail to detect people who may give incorrect classifications of things and send wrong information to the control center in the event of an emergency that calls for calling rescue teams. (Fyffe et al., 2016). Another problem is the use of Arduino UNO sensors, which are very heavy due to their weight of 25 g. The weight of the hard hat is estimated at 396,893 grams or 0.396 kilograms. So that if the weight of the smart hat is heavy due to all the sensors used, this will hinder the workers from doing their work because of its weight. They will also face the problem of not being able to move and work smoothly due to the weight of the smart hat. (Fyffe et al., 2016)

Methodology

Kanban: A project management and process visualization tool developed to visualize work and reduce the amount of work. Kanban is an important central component of "lean" manufacturing. Kanban relies on properties that help in managing the work properly, that the course of action must be clear, as it is not possible to understand something if you do not see it. It also limits the work-in-progress (WIP) limiting multitasking that can cause wasted time between tasks and forces the mind to become unfocused. Kanban is also the best way to know the work that everyone in the team should do, and to do it systematically and in an orderly manner until it is completed. Kanban is a popular framework that is commonly used in software implementation and development. Moreover, it displays and represents all work items clearly and visually on a Kanban board, allowing all team members to see the work status at any time. A Kanban board is a tool used to visualize work and to improve workflow between team members. Virtual boards are an important feature for software development because they can be tracked and accessed from multiple locations. One of the most important functions of Kanban boards is to standardize workflows, identifying and resolving dependencies and barriers.

Design and Discussion

This chapter will be focusing on the Illustration and the diagrams of the project and its components. Each diagram will contain a detailed description of each part of the Smart Hard Hat, including the IoT layers, the hard hat components (sensors), and how the smart hard hat is connected to gather. In this chapter, there are 4 diagrams that will be added and described, which are: Physical design, which will show how the smart hard hat looks, and how the sensors

are stable and safe in the hard hat and show each sensor's position. Structure Design, which explains the data flow and how the data is being transformed from the sensors to the internet. In addition, it will show what components and devices will help the data to be transmitted through the internet. Lastly, Logical Design, it will show the IoT layers and where each component and sensor's position in the IoT Layers.

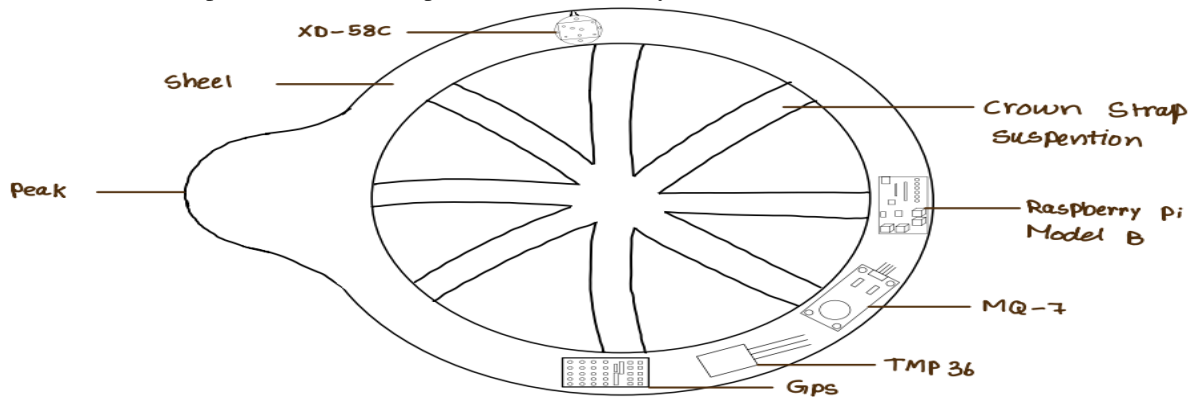


Figure 1. Physical Design-2

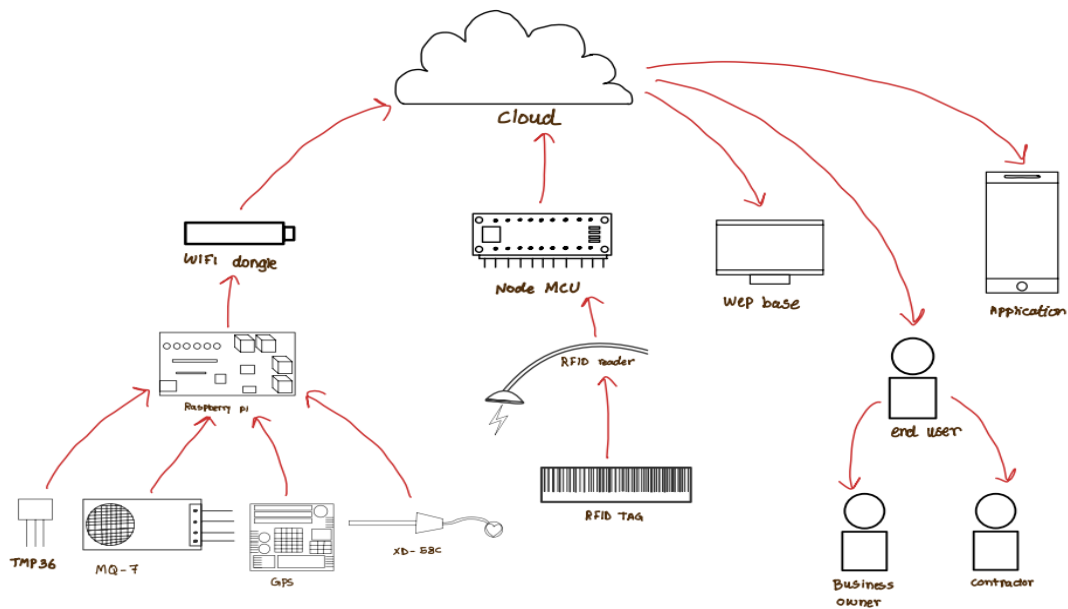


Figure 2. Structure Design

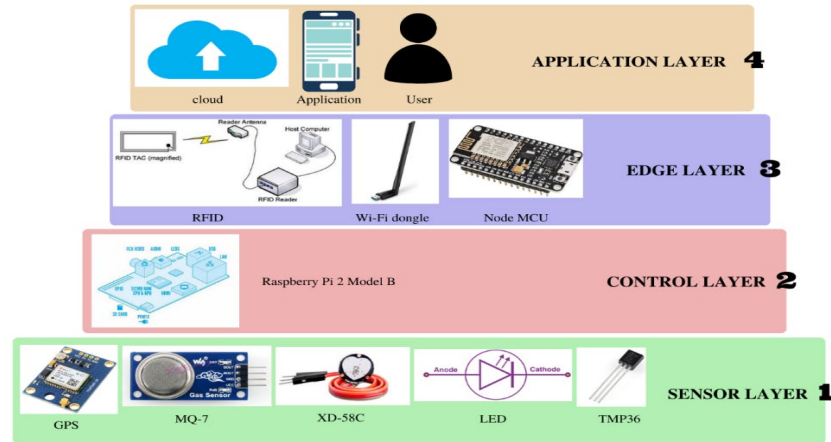


Figure 3. Logical Design

Conclusion

In the end, this project idea will help the workers and the employees in the construction sites to keep them safe and to check their health constantly. Not only the workers who get benefits from the Smart Hard Hat, even the supervisors can monitor the workers and check their health conditions. In addition, each worker will be traced and know if there were in the workplace. All the sensors that were used will make sure that the workers and employees are in good health condition. The raspberry pi will connect the sensors and then collect the data from it. After that it will send all the information collected to the cloud to be stored and displayed to be monitored.

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