Internet of Things (IoT) based Smart Helmet for Construction

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Abstract. In India, the use of helmets is mandatory at construction sites as per the government rules. The use of a helmet protects the labor head against the impact of the falling object from any height. There was a modification in the ordinary helmet into a smart helmet by adding the Work Mode (ON/OFF) system, GPS System, Smoke Sensor, Task Completion Button. In this, the helmets will automatically be updating the work mode ON, if someone wears it because a clamp turns the system ON and information goes to the supervisor. Same as this, there are two more buttons which indicate the task completion and about the emergency. Using all these buttons and GPS Systems helps the labor in many ways and manage the tasks and time also. For this, GPS and an IOT System are being used for the functioning of a helmet. Real-time signals will be sending constantly with the help of installed various sensors to monitor. The main objective of this study is to activate the installed components so that the various emergencies can be detected at the supervisor’s room or to find the location of the worker, to keep an eye on the various field tasks. It will give the actual location of the worker and in case of emergency; the labor can send his/her exact location to the command office of the construction site. For this, HC12 technology is chosen to give the information by sending pinpoint location, HC12 module which has a GPS module. These components are installed in the ordinary helmet and connect all these with a single computer so that all the activities are to be supervised in a single computer. By installing all the components in one construction helmet, the internet of things based smart helmet is assembled.

Keywords: HC12, Smart, Helmet, Construction, Arduino Uno, GPS System, Safety

1. Introduction
IoT based smart construction helmet reduce construction sites accidence which can be minor or major causes effect [1] on the whole site as well as work of construction. Also, as per a report based on “survey of India”, there is a list of the number of an accident on construction sites which includes majorly a large portion of accidents happened to the labors, due to various factors such as machineries, equipments or some other related factors. There are many advantages of helmets [2, 3]. For the safety of workers at the site, for the work to be completed on time, there is a need for such technological innovations. For the communication between the supervisor and the labor in case of any emergency, GPS sensors and Emergency Buttons were to be needed to install in the helmet [4, 5]. Construction business is growing day by day as all need infrastructures to live and to work. For this, more and more projects need to be completed on time with the safety of all the laborers working on site. Time
management is as much as needed to complete the project on time [6]. Firstly, there are several tasks given to various workers on site. There is a need to make sure that all the workers are working properly without wasting the time, it will be supervised by the ON/OFF Mode button which indicates the worker is working or not. The various sensors installed in the helmet indicate the various activities of the labor [7]. Real-time signals will be sending constantly with the help of installed various sensors to monitor. The main objective of this study is to activate the installed components so that the various emergencies can be detected at the supervisor’s room or to find the location of the worker, to keep an eye on the various field tasks [8]. “To visualize the layer of helmet interaction, Finite Element Analysis (FEA) tool was utilized to predict energy in an impact scenario. In designing the helmet, different cases were exposed to spot the deformation of every layer in a helmet” [9]. “Three-dimensional finite element methods were wont to get the strain energy density of helmet at impact and important strain energy density” [10]. “In comparison with actual tests, the finite element results provided a suitable helmet fracture results during the impact test” [11]. “Several studies like ventilation model [12], with materials like metal foam [13], head injuries [14] and sliding resistance of helmet materials [15] were conducted to reinforce the performance of helmets”. “These seven ML models are commonly used for similar sorts of datasets and tend to supply more accurate predictions compared to other ML models” [16].

2. Methodology:
A smart helmet is a combination of the ordinary helmet with the latest technology as per the requirement of the construction site (Safety, Time Management, and Risk). At the Construction site, Helmet is the basic need for labor. For this investigation, an ordinary helmet is taken into consideration and modified it with the latest advancement to fulfill the various requirements at the construction site like managing the time, the safety of labor, supervising the worker’s activity, how much work is to be completed, about the activities which are going parallel, detection of various gases, etc. To fulfill this entire requirement of the construction industry, the Internet of Things (IoT) is introduced in various projects which play an important role. Various components are installed in the ordinary helmet and connect all these with a single computer so that all the activities are to be supervised in a single computer.

2.1. Background Technical Context
Now a day, everywhere there is a need for advanced technologies. And this smart construction helmet is formed with various technologies that were installed for the proper working and to create a better employment place. The construction industry growing very rapidly and gives the largest contribution to India’s GDP. Construction is not only a contributor to India’s growth development potential but it also gives employment to many people. It’s the responsibility of the employer to provide safety to their employers and about the management of the various tasks at the site. The various major elements which are used to make the IoT based helmet for this study includes: 1. HC12 Module (or HC-12), is a communication module that is wireless serial and half-duplex with 100 channels in the 434-472.6 MHz that can transmit up to 1.2 km, 2. A GPS Sensor, that helps in locating or finding the exact position, velocity, and timing with the satellite-based navigation system, Receivers with antennas are used to provide the information of time; the exact position, and the velocity are GPS sensors, 3. Arduino Uno of 14 digital input/output pins. Tone of the supporting elements may include smoke detector, which is used for the detection of gas leakage at home and industry. In this setup, Gas Sensor (MQ2) module is used. By smoke detector, various gases like H2, LPG, CH4, CO, Alcohol, Smoke, or Propane can be easily detected. Measurement could be taken instantly due to its response time which is at high fast and sensitivity. The potentiometer is used for the adjustment of the sensitivity of the sensor. Light-emitting diode (or LEDs) are used for the indication purpose where the signals have to be received. In the circuit of the helmet, a breadboard is used to test the whole circuit. It helps in testing the circuit in very little time. Before finalizing any circuit, the breadboard helps in checking and testing the circuit.
A breadboard is having several holes in which various IC’s and Resisters can be inserted to test the circuit. After testing the circuit, it can be installed in the helmet. The connections in the helmet are done with the help of the jumper wires, which doesn’t even allowed process of soldering. PCB Board (Printed Circuit Board) is used to connect the different electronics components. PCB Board is a thin board that is also used in various electrical components. This type of board is having both electrical and mechanical connections in which electronics is for connections and mechanical is to fasten the components.

![Figure 1. Smart Helmet Set up](image)

A soldering machine is used for soldering the various components. It is a tool with a metal tip that gets hot. The function of the soldering tool is to transfer the heat to things like wires, transistor leads, and pads. Solder is applied when the area will be heated properly. The last and most important equipment is Wifi antenna. The Wifi signal converts the data to EM waves. To increase the radio strength, more power was required. To send or receive the signal from any area where the antenna is pointed, a Directional antenna’s been required.

2.2. Proposed Flow Model:
The first stage is all about the need for the initialization parameters. The GSM module, a replacement message into the microcontroller coming from the bottom station to counter with the knowledge of the labor, and share his location by using the Global Positioning System module. After sharing the location, a message through the GSM module to the bottom station is going to be sent if the microcontroller detects any hazard by analyzing the information coming from the sensors. The smart helmet is having the technology that installed within the smart helmet that meets the various criterion and the standard rules established by the government body. The guts rate monitor and temperature sensors also are tested by the leading medical agencies to supply a trustworthy product to the end-users.

![Figure 2. Flow Model](image)
The Control Unit of the system is an ARM processor. The main cause for executing the system is based on an ARM processor. It is the concern of the speed and load. Fast responses of the system were required; Fast responses were taken into account. For this, ARM processors are preferred over other microcontrollers; microcontrollers are having more amount of propagation delay as compared to the ARM processor. Micro-controller’s packaging and power consumption are not as good as ARM. Also, there will be no more addition of more characteristics in existing because of the micro-controller. An ARM which is based on a microcontroller (STM32F072) from ST Company which has a lot of characteristics for example crystal-less USB, DAC & Comm. Interfaces, 32-bit MCU, ADC, up to 256 KB Flash, FS 2.0, CAN, 12 timers, 2.0 - 3.6 V Global System for Mobile Communications is a standard.

3. Arrangements of components in Helmet

In a smart helmet, a GPS sensor to locate the exact location of the worker and engineer, and two Arduino Uno boards are used on which codes are uploaded for the functioning of the helmet then two different buttons are used one for security as well as a smoke alert system. The hc12 module is used for the communication of the helmet with the system having another hc12 module. A smoke detector sensor is used for the health safety of the workers and engineers as the smoke detector can detect the harmful gases present in the environment and LED of three different colors is used all of them showing or notifying that the helmet is in an inactive state (blue), the helmet is in alert condition (red), the task is completed by the worker (green).

![HC12 with Arduino Circuit Diagram](image)

The helmet is designed to be with three buttons installed in it and various components also like GPS, Smoke Detection, and Gas Detection, etc. in it. One button is installed on to and the rests two are on both sides. The button on top will reflect the safety and emergency symbol whenever a little force will act on the top of the helmet, it will give the information or emergency alert with the location to the supervisor so that the team will reach the labor easily and take necessary actions. The Second button installed on the right side of the helmet is used to give information to the supervisor for the completion of the specified task.
4. Principles of Smart Helmet

The main aim for developing the concept of the smart helmet was not only focused upon the safety of the workers and labors at the construction site, but also includes many aspects of the ongoing project at the construction site. The basic principles of developing IoT – based helmet is a three – fold dimension, focusing on Safety, Management and Efficiency.
The first principle includes the aspect of safety. Safety was the prime factor which was considered behind the idea of developing the smart helmet. It is designed for all the working – labour class at the construction site. These helmets will be having the same color code which are being employed at the construction site presently, just with the addition of the concept of making it “smart”, attached with different equipments such as sensors. These helmets are designed in such a way that if the worker is facing any kind of emergency, whether it be health related or work related, a different signal (in the form of LED) will be displayed on the screen, making it understand that one or many of the labors are facing problems. Due to which, if some accidents happen at the construction site, the person – in – charge can easily get notified and take the necessary remedial action to the earliest for the safety of the particular victimized labor. The second principle is management. Smart helmet plays an important role in managing different activities such as Time Management, Work Management and Labor Management at the construction site. All these three types of management are inter-related to each other.
easily detect the incoming and outgoing time of the labors. Since it is GPS – enabled, so one can easily track down the location of the labors at the construction site. It makes easy to track down the movement of the labors, if they are moving from their designated “work place” to any other area. Keeping a track on the labor’s movements, not only plays an important role in the Labor Management, but also on the Work Management. If a labor properly works on the assigned “workplace” area and duration, there will be a good management of time in completing that stipulated work, without any time failure, i.e., deadline failure. Also, if all works goes smoothly on time and with proper utilization of man, materials and machineries on stipulated time frame, then overall construction project will complete before the “duration of the project”, thus covering the third principle – efficiency. Therefore, using the concept and idea of smart helmet at the construction site is not only beneficial for the workers or the labors, but also to the officials such as project manager, planning manager, site engineers, contractors and sub – contractors, in completing a particular project, without considering any other unwanted immediate factors.

The proposed helmet is designed in such a way that the labors are designated as “L”, followed by the numerical value. For proper management of the labors, numerical value to the labors is assigned as per some format such as either by alphabetical order or work division. With each worker having an assigned numerical value, tracking of the workers is simple and effective. In this study, the helmet is attached with four different lights (LEDs), each having its own importance and two different types of sensors.

| S. No. | Colour of LED Light | Specification or Role          |
|-------|---------------------|--------------------------------|
| 1     | Red                 | Problematic Situation          |
| 2     | Yellow              | Wearing of Helmet              |
| 3     | Green               | Task Completion                |
| 4     | White               | While using machineries        |

5. Conclusion
The Civil Engineers confirm that there are a number of tasks given to various workers on site. There is a need to make sure that all the workers are working properly without wasting the time. For this, ARDUINO-based smart helmet is designed in such a way which fulfills the various objectives. Real-time signals will be sending constantly with the help of installed various sensors to monitor. The main objective of this study is to activate the installed components so that the various emergencies can be detected at the supervisor’s room or to find the location of the worker, to keep an eye on the various field tasks. LED of four different colors is used, all of them showing or notifying different roles and specifications. The main objective is to focus on overall performance of the workers at construction site including safety and work management. It’s been discussed that how a normal traditional helmet used at the construction site can be modified with the help of emerging application of IoT in the society. The various instruments or electrical components are discussed which are used to make IoT – based helmet. In accompanying with the four lights, smoke sensor or gas sensor is also installed for detection of leakage of gas or smoke in the nearby area. Thus, with the help of this “smart” helmet, one can not only ensure the maximum safety for the labors working at the construction site, but also helps in completing the work in the prescribed deadline. This type of helmet is economical and also doesn’t require much time in its production. The future scope of the smart helmet may include the installation of other sensors or modifying the shape so that it may perform more functions towards the overall effectiveness and efficiency of the construction project.
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