Internet of Things-Based Novel Prediction, Management, and Monitoring Industrial Safety Measures

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Abstract

Most Indian companies have a high accident rate, which worries everyone. As important as providing high-quality goods are industries that take into account natural assurance, global safety, and security at the function. They often need a supervising chief, administrator, director, and officers to handle these matters. As with EHS or HSE offices, they are referred to as Environmental, Health, and Safety (EHS) divisions. The majority of senior management in Indian firms does not implement sufficient safety procedures in their workplace. This research project uses Arduino to create an integrated hardware and software solution for EHS safety. The Accident Reduction Model (ARM) and Augmented Data Recognition (ADR) technology are used in the Processing Packages' Internet of Things (IoT) communication architecture. By incorporating wireless sensor network-based criteria, these techniques reduce the number of people who die in accidents while also enhancing workplace safety. With the use of these techniques, accuracy and safety may be measured.

Keywords: *Environmental, Health, Safety, IoT, Monitoring and Reduction Model*

Number: 10.14704/nq.2022.20.9.NQ44324 **Neuro Quantology 2022; 20(9):2781-2791**

1. Introduction

The majority of accidents that occur in Indian businesses cause worry for everyone. Manufacturing facilities need to think critically about environmental assurance and health and safety-related issues in order to produce high-quality goods. The application of safety procedures in health and safety-related concerns must be handled without delay, just as directors, engineers, and supervisors in charge would not allow any production delay. The greatest management of Indian businesses would likely neglect to establish procedures in addition to clients, contract employees, and other interested parties who could have a stake in safeguarding delegates and management at their workplace, at least to the extent required. Enough safety precautions will benefit associations and a large number of employees. This component is included to cover medical expenses, material and hardware damage, production delays, and disruptions. The main goal of this study project is to explain the causes of this foundation.

The purpose of this study project is to identify any zones in which both the qualities and the

regions may be relocated by displaying the evidence of EHS (Environment, Health & Safety) practises in the formation of various Indian firms. The circumstances found in the regions required for the development of such attributes have led to the more positive outcomes. Health, Safety, and Environmental considerations have been made, and regions are not intended, as shown by discernment and evidence. Environmental protection and workplace safety are studied and put into practise via the study and specialisation of environment, health, and safety (EHS). Simply put, it is what businesses must do to ensure that their operations don't damage anybody. Figure 1 displays a schematic of the EHS overview. Regulations are crucial to the EHS discipline, and EHS managers and engineers need to be aware of and comprehend the relevant EHS regulations. They also need to communicate any implications or gaps to top management so that the business can implement the minimal mandatory and pertinent legal and other requirements. From the perspective of health and safety, this entails developing systematic initiatives and practises for recognising workplace risks and minimising risk, accidents, and exposure to hazardous circumstances and chemicals. Additionally, it involves educating staff members on accident and risk reduction, emergency planning and response, and efficient PPE usage (PPE). From the perspective of health and safety, this entails developing a systematic approach to comply with health, safety, and environmental regulations, including managing waste generation, reducing, recycling, and controlling air emissions, preventing water pollution, reducing carbon emissions, etc. to assist industries in lowering their carbon footprints.

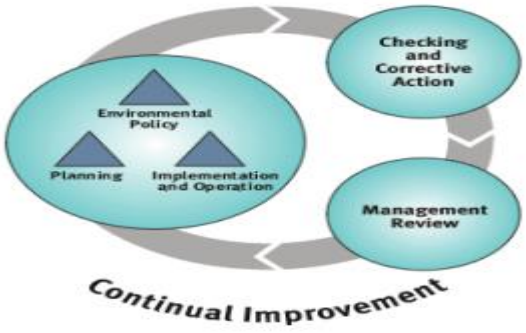

Figure.1. EHS overview diagram

The chemical industry implemented the first comprehensive EHS management strategy in 1985 in response to many disastrous mishaps (like the Seveso disaster and the Bhopal disaster). The International Council of Chemical Associations (ICCA) is in charge of centrally coordinating this global voluntary project known as "Responsible Care," which is implemented in around 50 nations (ICCA). It has eight core components that guarantee workplace safety, environmental protection, and plant and product safety. It also aims to show via image-building efforts that the chemical sector behaves responsibly. However, this programme is only applicable to the chemical sector. Since 1990, the firm has used generic EHS management system techniques like ISO 14001: 2015 for environmental management and ISO 45001: 2018 for occupational health and safety management (EMAS). EHS regulations were also developed by the International Finance Corporation in 1998.

Depending on the appropriate job, organisation, nation, and other recent circumstances, different situations and Health and Safety protocols apply. The provision of a safe and healthy work environment for everyone, however, ensures the particular alteration and the complete eradication of the criteria. Some hallmark characteristics, on the other hand, meet all required conditions in health, safety, and the environment. Continued practise in the areas of safety, health care, and the state will greatly improve the career. As they are obligated by law and have management's backing, make sure the representatives are working in a safe and healthy environment. The highest priority has been given to assuring the safety procedures for the workers, subcontractors, third parties, and visitors in every sector. However, a comparison of the performance with businesses that adhere to World Class Best Practices in comparable sectors including heavy engineering, automotive, manufacturing, textile, and foundry reveals that businesses did not follow the minimal necessary EHS practise criteria. The major objectives of safety procedures are to prevent even a single accident from ending in death or permanent disability, to significantly reduce lost time due to injuries, and to provide a safe working environment free of pollutants.

EHS mitigates the risk of harm or destruction brought on by potential disasters. The potential of injuries, incidents, near-misses, real diseases, disabilities, or even fatalities does not exist. A specific hazardous event's frequency, likelihood of occurrence, and consequences are all combined to form risk. By their very nature, industrial accidents are unplanned and uncontrolled occurrences. Accidents may interrupt or disturb an activity but are not always negative or injurious occurrences.

Direct and indirect costs from accidents are possible. Production loss, medical expenditures, fees for benefits under the compensation system, liabilities, and property damage are the direct costs of accidents. Direct expenses make up a large amount of overall expenditures, are easily quantifiable, and are often cited in assessments of the quality of workmanship. A few examples of indirect expenses include lost productivity and schedules, legal fees and claims, and ineffective operations. Accident-related indirect costs include lost productivity of the injured worker, lost productivity of other workers due to curiosity, low morale among coworkers, and offering assistance, as well as lost supervisory time due to helping the injured worker and rearranging work crews as a result of the lost worker. An industry's effective safety system should be designed to avoid and/or reduce workplace accidents and other dangers to employees. Management should distribute resources and make choices based on a more logical framework in order to increase safety. Management should concentrate on finding the most effective ways to use the important elements to lower injury rates in their respective sectors. Occupational health and safety management is considered essential to prevent accidents and diseases in the organisastion.

2. Literature Survey

It is important to highlight the following research on occupational accidents: [1] reported 319 significant industrial accidents worldwide in their paper. [2] created a database with details on 167 incidents that happened in biogas facilities. The authors came to the conclusion that it is necessary to upgrade and implement safety standards, safety culture, and to raise public awareness of risk reduction. [3] created a database regarding incidents that occurred in the gasoline ethanol industry from 1998 to 2014. According to the authors, ethanol sector fire mishaps are often caused by machine failure. For the alignment of 238 industrial incidents, [4] created the Multi Attribute Technological Accidents Dataset (MATAD). According to the authors, these mishaps caused 182,794 fatalities and $265.1 billion in property damage. Several studies have been conducted in numerous industrial areas to examine workplace accidents. A few examples of study on the examination of industrial accidents include [5], who found that the examining machines posed hazards for different types of injuries and harmful consequences after analysing 106 Accident Reports connected to moving equipment. [6] examined 567 incidents that happened between 2009 and 2012 in a variety of sectors, including construction, manufacturing, agriculture, and services, and found that these accidents happened because small problems weren't fixed and standards weren't being followed. [7] examined explosive incidents with fertilisers made from ammonium nitrate. In his research on industrial accidents, [8] identified the high-risk categories that result in accidents. The efforts of the different scholars in the aforementioned literature should be praised, but on the other hand, their conclusions seem nebulous and unreliable. According to [9], there will likely be a rise in dangers in hazardous sectors in the future years. There are no suitable rules or a mechanism for assessing these hazards. To fill up the gaps in the analytical methodologies, a new method known as risk assessment is needed. To recognise and manage every kind of risk at work, a thorough risk assessment is required. Work permits and Safe Job Analysis are two methods used in risk assessment to keep hazards at a level that is acceptable in the workplace (SJA). The qualitative analysis of risk based on the susceptibility of the immediate environment is known as risk assessment. There are generally 70 risk assessment techniques in use. Risk estimate, safety review, checklist analysis, what-if analysis, preliminary hazard analysis (PHA), human error analysis, Hazard Operability Work (HAZOP), and job safety analysis (JSA), among other approaches, are a few of the methods used. As mentioned above, there are several risk analysis approaches in use for various

situations. These research [10] made work on the past, present, and future approaches and models in process safety and risk management are only a few examples of studies that employed risk assessment techniques. These risk management techniques and models may be classified as qualitative, semi-quantitative, quantitative, or hybrid. [11] examined the dangers of exposure to dust and dirt in coal-rich areas. The author came to the conclusion that the primary method by which filth and dust enter the human body is by eating. [12] created a method for rating risks in coal, oil, and gas accident chains via the use of comparative risk assessment. The dangers in the industrial effluent from the personal care products sectors were evaluated by [13].

According to the evaluation, the level of biological complexity determines the risk (toxicity) in wastewater. In order to determine the low-risk design, [14] employed risk assessment for evaluating hazards in industrial chemicals in [15] and developed a novel method known as Life Cost Base FMEA. The authors also used Monte Carlo simulation to this method to pinpoint the risk's uncertainty. Using the event tree and fault tree techniques, [16] identified the hazards that contributed to 100 fire incidents, their pertinent regulations, and the associated problems in cotton logistics. [17] employed Event Tree Analysis (ETA) to identify lightning hazards associated with large-scale oil tank fire incidents. The authors' approach included a model for estimating the probability of lightning. [18] conducted a survey of the literature on HAZOP used for different safety problems. [19] created a model outlining the series of events leading up to the explosion at the Texas City refinery. In addition, the author used HAZOP to identify the accident's hazards. To identify the high-risk elements in the boiler's ash, [20] conducted an environmental risk assessment on the Bubbling Fluidized Bed (BFB) boiler area. Current risk assessment methodologies seem to be facing a significant challenge in lowering the likelihood and severity of recent industrial accidents. [21] evaluated the guidelines and regulations pertaining to India's risk assessment system. According to the author, there are no suitable norms or framework for in-depth analysis of industrial hazards. The author also mentioned that there are legal and technological shortcomings in the use of the risk assessment methodology. Failure to use effective risk assessment methodologies may cause accidents that result in the loss of lives, property, money, and productivity. The fact that risk assessment methods cannot account for the data's ambiguity is one of their key drawbacks. Risk is a vague and ambiguous notion. [22] examined and categorise the risks associated with industry-related uncertainty. [23] highlighted the need for extensive data analysis via the assessment of key criteria and sub-criteria.

Numerous strategies, including TOPSIS (Technique for Order of Preference by Similarity to Ideal Solution), COPRAS, AHP, SAW, and others, are used in fuzzy logic. Fuzzy AHP is already being utilised in a variety of industries to handle multi-criteria, ambiguous situations that may be either qualitative or quantitative. For an actual manufacturing organisation, [24] suggested a fuzzy AHP to assess the work system's Faulty Behavior Risk (FBR). He used pairwise comparisons to quantify improper conduct using fuzzy triangular numbers and fuzzy linguistic variables to assess the causes. In his opinion, this is the most effective strategy to stop bad conduct and raise the level of safety in the workplace.

Both qualitative and quantitative approaches are used in the study. Nowadays, it is usually advocated in the field of safety to gather both qualitative and quantitative data in order to assess programmes [25]. This advice has more recently been applied, specifically to safety studies [26]. The safety study programme is assessed using the quantitative capabilities of Microsoft Excel, including absolute numbers, tables, percentages, and statistical tools like minimum, maximum, mean, standard deviation, and variance. Contrarily, gathering qualitative data may be done via observation, interviews, and the utilisation of both primary and secondary sources of information. The statistics of the overall safety attribute scores provide the lowest, maximum, mean, standard deviation, and variance for the most important safety characteristic for people, machines, and the workplace. In terms of human, machine, and workplace safety, it was noted that the prevention of combustible dust, safe work speed, and lightning protection stand out. The safety qualities that were implemented and

documented in work had the lowest values when it came to explosion safety, material processing procedures, and firefighting exercises.

Raising capital seems to be one of small company owners' biggest difficulties. One of the weaknesses for small companies is having to deal with the high cost of manufacturing, which falls on the small company owner. When compared to big scale companies, the small scale industries participating in the current activity (the textile and foundry sectors) employ fewer people (between 55 and 80) and generate less revenue (between 40 and 80 lakhs) each year. They thus object to investing additional money in safety measures. In the case of small scale sectors, there is a lack of knowledge about cost-saving options related to techniques for accident prevention and mitigation, waste reduction, optimal energy and resource use, and pollution prevention. Small machines, tools, and human resources handle the majority of the job. As a result, the workers are vulnerable to stress, weariness, and illnesses/disorders connected to their jobs. Additionally, fatigue lowers awareness levels, which raises the danger of being involved in an accident. Creating a safety committee and selecting a safety officer is a crucial component of any safety procedure. An entrepreneur who oversees all aspects of health, safety, and security concerns will be held accountable if it turns out during the inquiry that small-scale companies lack a security guard and a security team that includes a security officer.

Enterprises need the proper information architecture to satisfy the changing demands of the supply chain since quality standards are essential to Supply Chain Management (SCM). The academic community and the industry have recently paid close attention to information architecture for supply chain quality management. Recent studies examine how real-time quality monitoring and control in the supply chain may be enabled by the use of Service-Oriented Architecture (SOA), Radio Frequency Identification (RFID), agents, workflow management, and the Internet of Things (IoT). By reviewing current research and development in information architecture for supply chain quality management and highlighting some of the key technologies that have the potential to significantly improve supply chain quality management performance, the author attempts to analyse the state-of-the-art information management for supply chain quality management. In order to achieve automated supply chain quality management, it is our aim that this effort will inspire the supply chain quality management community to adopt the technologies and their innovations. A hybrid wireless network integration strategy for Enterprise Information Systems based on cloud services was outlined in [27]. (EIS). With the development of cloud computing and hybrid wireless networks. It is essential to create a plan that can easily include these new technologies into the EISs that already exist. A novel framework that covers the frontend layer, middle layer, and backend layers linked to Internet Protocol (IP) EISs is suggested by fusing hybrid wireless networks and computers in EIS. The cloud services management framework and process diagram are described and are based on a collaborative architecture. This approach's important component is the integration of access control features into the hybrid framework, which gives users filtered views of the available cloud services depending on user security credentials and cloud service access needs. Future work is intended to deploy this framework over the Swan Mesh platform by incorporating the UPnP standard into an enterprise information system. The emergence of cloud computing and the Internet of Things (IoT) is altering how information and communication networks are thought about [28]. IoT Cloud is a term used to describe a new kind of distributed system that consists of a collection of smart devices linked over the Internet to a distant cloud infrastructure, platform, or software that may provide IoT as a Service (IoTaaS). Authors tackle this difficult paradigm by concentrating on IoT Cloud Federation security. They describe a number of authentication methods that are suitable for various contexts. The Industrial Internet of Things helps provide a feasible and practical service for the growth of intelligent industry thanks to the increasingly widespread deployment of Internet of Things technology in the industrial sector. Meanwhile, the Industrial Internet of Things is attracting the attention of more and more nations. Massive polymorphism, dynamic heterogeneity, relevance, real-time, and

other characteristics may be found in the Industrial Internet of Things' data.

Attitude control of a spacecraft susceptible to faults or failures has drawn significant attention in a broader spectrum of aerospace technical and academic sectors as a result of a number of mishaps [29]. It addresses practical applications as well as theoretical methods for fault-tolerant control, problem detection, and diagnostics in spaceship attitude control systems. The design of the spacecraft attitude FTC system is described with a summary of recent developments. The foundation of an FTC system is shown. The merits and drawbacks of the theoretical approaches and technical procedures now in use are examined [30]. Additionally, reliability-relevant challenges and current developments in attitude FTC design methodologies are examined. The conclusion is followed by a short assessment of a few unresolved issues with the design of spacecraft attitude control that are susceptible to component defects or failures.

3. Accident Reduction Model

In order to address particular EHS measures with the IoT architecture, a full demonstration of hardware-software application with structural frameworks and the fundamental structure of volume set in the proposed system is presented, and the block diagram of a suggested system can be shown in Figure 2. It illustrates how any populated sensor center-made points follow the IoT framework. Each sensor has a centre point of view and is made up of other sensors. These sensors make a call to the server unit, which then gathers the security parameters and sends them to a coordinator. Using a wireless communication system, information is switched between server sensor centres and the central server. Multiple centres (Variety, N1, N2, and N3) make up the IoT centre, which also monitors the Smart City Environment Cooperation with a Data Server and Cloud Sensor. The Internet of Things gathers data from sensors and other data collecting terminals.

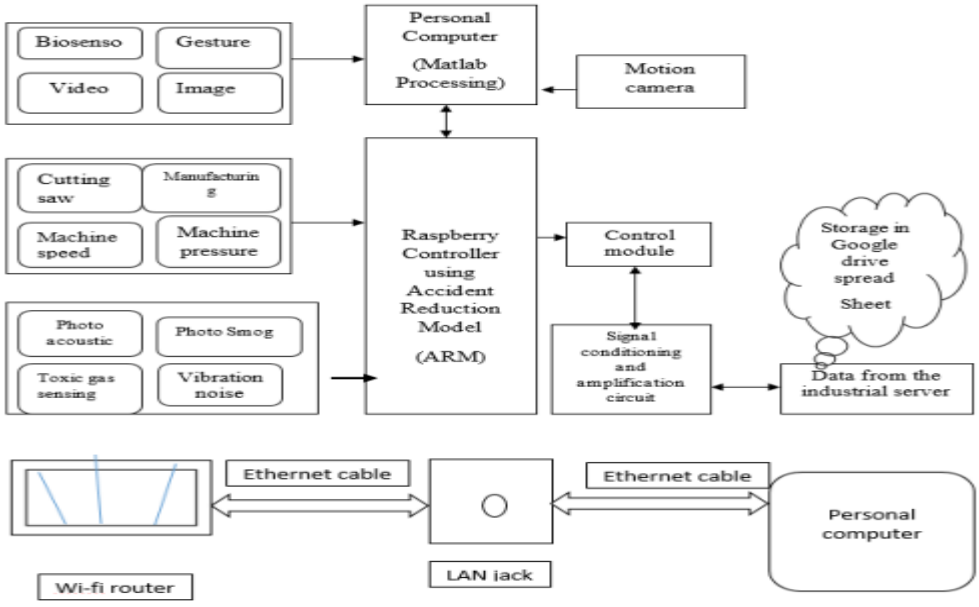

Figure.2. Block diagram of Proposed System

The suggested project consists of an Arduino Uno controller, a collection of sensors, and a WiFi handset module, and it uses IoT to reduce human intervention. The microcontroller in Arduino has been linked to increased data use on USB interfaces. The WiFi handset module of Arduino's microcontroller sends data about industrial safety parameters, which are then analysed by cloud sensors from server sensors.

4. IoT System Requirements

Here, the industry's monitoring and control procedures are shown as the basis for the sensor

data. The temperature, gas, and pressure values are continually sensed in each location of the proposed IoT framework.

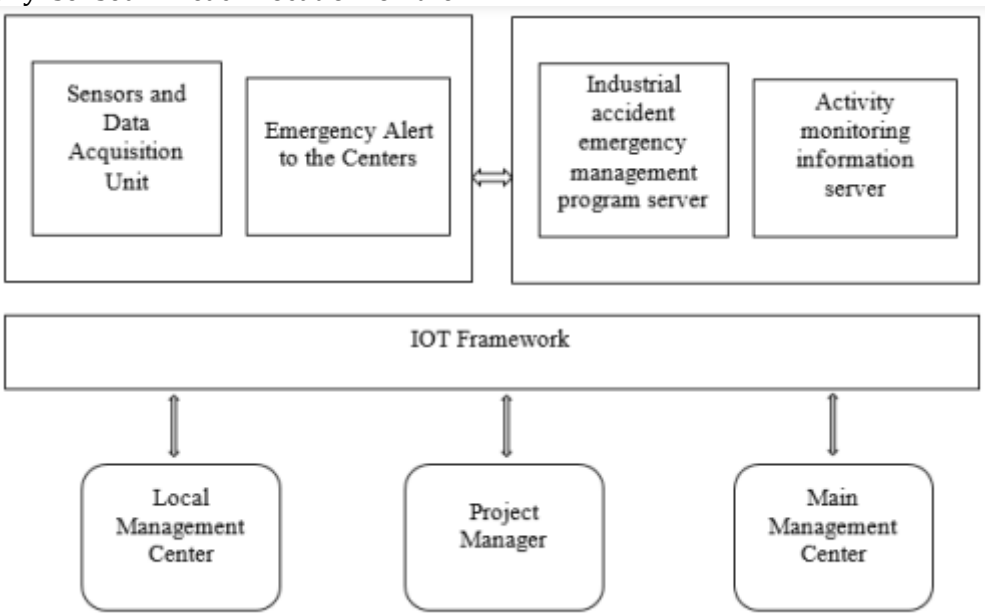

Figure.3. Safety Environments – IoT Architecture

Figure 3 depicts the IoT services architecture for safety and the environment. Some industrial systems may depend on the camera system and be split into two fundamental categories in accordance with their roles. Security and safety are the duties. Some programmes fall into more than one of the aforementioned categories due to their functionality, making it difficult to categorise them precisely. The distinction between safety and security is how the term is defined. The Internet of Things (IoT) approach presented includes cutting-edge IoT hardware and the creation of computer applications. The overview provides security knowledge that, by increasing efficacy and reducing hardware discomfort, will decrease worker injuries and prevent fatalities from "man-down" situations. Remotely connected devices are used to check professional safety estimates online. Instead, it only increases battery control movement while also transmitting data to a distant focus that performs an action. The internet of things is about valuable insights made possible by locating and examining data from linked devices all across the world. Businesses are starting to link devices and objects, gather their data, and identify them in order to make effective business decisions. The information that has been created or conveyed from these physical items is the most significant. These linked items' insights provide knowledge for their future interactions with other things, systems, and people. These interconnected devices are gathering a tonne of data. Business enterprises may streamline their internal operations by using this data and integrating the information they have gathered to cloud-based technologies. The gathering or exploitation of data transfer between these linked items is essential to the IoT's operation. In the IoT, data is crucial for corporate operations. Data will come in a variety of formats, ranges of values, and traffic patterns. Data and information are sourced globally and from a wide variety of sources. Its sources include business platforms, devices, systems, items, and services, and it has a variety of storage types. The data are predictable and come in at any moment. One must automate the flow of data for its receiving, processing, and information storage by offering a framework for data processing and analysis. Since the Internet of Things (IoT) must take care of every item, a significant amount of data must be utilised, including processing and status information. The efficient transmission of data is essential to the IoT's effectiveness. For a smart, connected IoT, businesses must develop a new stack of IT infrastructure. For the network and the cloud database to function, communications are also necessary. In order to construct software applications that may serve as gateways to access the device data or information, a platform

is required for a successful deployment. In turn, this enables the data to be shared with other internet-connected devices and links these items to other application systems.

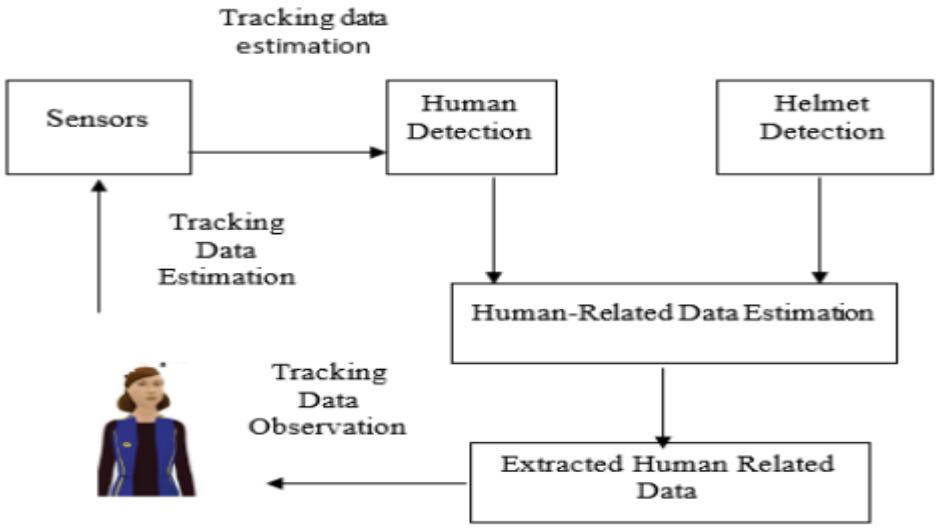

Figure.4. Accident reduction model using Image processing controller

On the basis of worker photographs, image processing techniques are often employed to study human variables. Image processing, which is divided into lower and higher levels, is what is necessary for PC vision. A little amount of research into the picture/video material is used at the lower level. It employs techniques for image compression, handling in advance, and separating images via a division. The larger amount depends on the knowledge and strategies used to accomplish the objectives. It employs low-level calendars for upcoming tasks and movement analysis.

The highest stage, shown in Figure 4, represents low-level image processing universally. The evolution of the picture without a significant state is how image processing is characterised. With this review procedure and high state processing, the overlay starts with low-level picture processing. Even if we demonstrate a fantastic occurrence, our study focuses mostly on the less important portion of the task. The data collecting phase makes use of a total of five sensors. A neoprene sleeve keeps each sensor in place. The placement points for the sensors used in this study are as follows: - two sensors are positioned on the distal third of each shank (left and right), above the lateral malleolus; - two sensors are centred on both left and right feet, parallel to the head of the fifth metatarsal; - one sensor is positioned on the lumbar region, at the fourth lumbar vertebrae. To examine the three primary sensor designs, we categorise the activity signal originating from each sensor using a single device setup. Four combinations of two sensors are examined in the double device setup: the right and left shin sensors, the right and left foot sensors, the right sensors, and the left sensors (foot and shin). The lumbar sensor is included into each of the double sensor arrangements while testing the triple device setups.

5. Results and Discussion

The suggested ARM proposal is motivated by the need to enhance performance and address a few security concerns with wireless-based systems, apart from the want to guarantee sensitive computation overhead with shorter execution times. The effectiveness of the proposed ARM - Industrial Safety Monitoring Framework was compared to the current Industrial Safety Systems in this study paper.

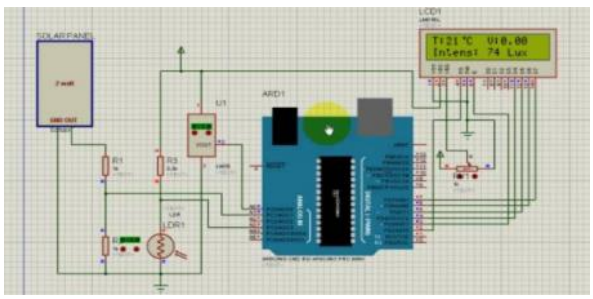

Figure.5. IOT Based Industrial Safety Measures Monitoring

Figure.6. shows the Industrial Safety Monitoring System paradigm with IoT applications. A smaller percentage of CPU cycles are changed during the insert volume operation due to the minimal calculation value, quick execution, and special characteristics. Utilizing the comprehensive rigging of previous industrial safety with a differentiated and verified framework is more flexible and lucrative. In terms of efforts on EHS security monitoring, the suggested research is really realistic. To lessen regard for cost, the suggested system comprises of a range of workout data. In any event, the verification of the full industrial condition of security is ensured by how much can be normal from numerous centre locations.

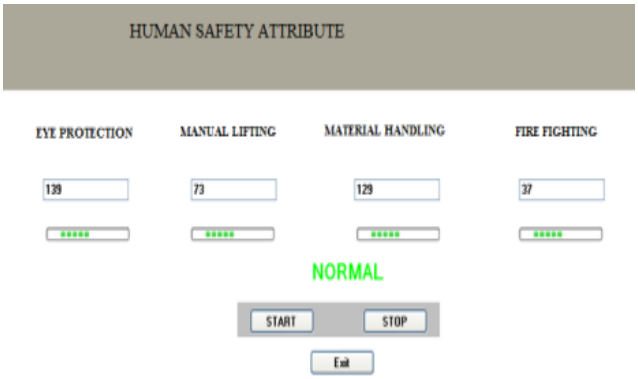

Figure.6. Human safety measurement

This makes perfect sense for monitoring industrial security. To lower the cost of self-worth, the suggested structure comprises of a range of workout data. In any event, the amount that may be considered normal from different places offers a check of the overall EHS state.

6. Conclusion

Utilizing the ARM controller, effective security assessment encompasses unique, subjective, and measurable tests. The ARM controller serves as an example of a beneficial security framework for mechanical computerization systems. This approach is, however, restricted to discrete-time models. This artwork shows an industrial safety centre sensor's IoT interface for displaying IoT status. The structure has creative sensor data collection capabilities. By combining the provided IP address with the implanted model and the use of IoT correspondence, the accurate, reliable, and beneficial information of the beneficial information acquisition structure in IoT condition is specified. The company properly handles the usage of permits and gets sensor data. Important sensor boundary values are efficiently monitored by the required setup process. In an IoT-compatible application, low-cost prediction and quick execution will result in effective performance.

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