ISSN: 0975-833X

Available online at http://www.journalcra.com

International Journal of Current Research
Vol. 13, Issue, 07, pp.18329-18333, July, 2021

DOI: https://doi.org/10.24941/ijcr.41953.07.2021

INTERNATIONAL JOURNAL OF CURRENT RESEARCH

RESEARCH ARTICLE

IMPORTANCE OF TECHNOLOGY IN MANAGING SAFETY

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ARTICLE INFO

Article History:
Received 25th April, 2021
Received in revised form
19th May, 2021
Accepted 24th June, 2021
Published online 30th July, 2021

Key Words:

Bansagar Dam, Minerals, Heavy Metals, Seasonal Variation, Drinking, Phusico Chemical Parameters.

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ABSTRACT

This research investigates the connect between technology and office safety, As the world continues to become more connected, it's becoming increasingly important to adjust security and safety procedures in the workplace and adapting or use of technology will be one of the recommended solution. Intelligent and Smart surveillance is a function available in IoT It takes several forms. Facility managers across different industries can explore using the use IoT to obtain live information about potential emergency situations with a view to responding before the issue gets escalated. **Method:** Use of several methods including case studies , data sources and validation of findings with industry representatives and conference peer-review processes, have been used to validate the research design and findings during the research process Initial exploratory interviews, observations in industry seminars and industry reports. The starting point for this research was the interest on the topic of enhancing and improving efficiency of workplace security system through technology. To investigate what this interest was in particular, the author had been participating in several industry seminars, where the technology, sustainability and health and safety were the subject of discussion. At the same time, several industry reports published on the topic of IOT and technology improving the security systems in the workplace where studied. The observations from industry seminars and reports were used for designing initial exploratory interviews with real estate/work place owners. These seminars and reports addressed the topicality of technology used and integrated with the workplace security system to improve the safety and security of the employees and the premises and improve the occupier satisfaction and save cost, which therefore indicate that the research has potential for practical relevance. The Study reveals that the author, have been core advisory member of various associations and in touch with the fraternity and been following the trend globally, author being a core Facility Management professional and has personally seen the best practices followed and integration of technology with workplace security has resulted in improvement of the then entire security process and led the users satisfaction and overcome avoiding any kind of incidents. The study reveals that the author has been doing research and has read various articles on technology and its positive impact on workplace. The findings from the literature review demonstrate that there is a need to integrate the technology with the workplace security system to the occupier satisfaction, enhance better control and surveillance, save cost & contribute towards sustainability.

Citation: Dr. Abhijit Sarkar. 2021. "Importance of Technology in managing safety", *International Journal of Current Research*, 13, (07), 18329-18333.

INTRODUCTION

The new technological paradigm, usually defined as Internet of Things (IoT), is widespread in several sectors and influences both industrial operations and people daily life. IoT represents the transition from computer networks to a network of objects where each object of everyday social and working life - such as the refrigerator, the machine tool, a garment - becomes endowed with its own digital identity and communicates data automatically with an external system aiming to analyze them and provide feedbacks to users. The main goal of this technologies is to add "features" to objects aiming to provide automatic information to people interacting with these objects. These objects are usually defined as Smart Objects (SOs): SOs are able to exchange itself information and also with the surrounding environment thanks to specific enabling technologies. An evolution could be realized when SOs interact with each other by adopting a digital platform. This system – SOs interacting trough digital platform – could be a value added tool for supporting safety management and control at This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/ licenses/by-nc-nd/4.0/). Peer-review under responsibility of the scientific committee of the International Conference on Industry 4.0 and Smart Manufacturing. 10.1016/j.promfg.2020.02.040 workplace. IoT technologies are now adopted to support a more effective management of safety in complex systems, which is currently a challenge for both researchers and companies (1-5).

Different promising IoT technologies could be applied for managing more dynamically safety levels, these include identification and tracking technologies such as Radio Frequency I Dentification (RFID) and Bluetooth Low Energy (BLE), wearable technologies, sensor networks, etc. RFID technology is widespread in industrial systems and services for the identification and traceability of products and/or people. The RFID identification, unlike traditional barcode, uses radio waves to read the data encoded on electronic labels (or tags); the performance of the reading process - that occurs through an appropriate device - shall vary from a few centimeters to meters. RFID technology allows the identification of objects without contact, by using a radio frequency transmission of information. The basic elements of an RFID system are the so-called tags (composed of an antenna and a chip), applied on or inside of the objects to be identified, and the reader, which communicates with the tags. Tags could be active or passive: the main difference is due to their reading distance which is higher for active ones. Using tag attached or included in an object could transform it in a SO thus identifying SO without physical contact or visual recognition, as required by the barcode technology, and exchange information and data from/to the environment where it is located. This technology has spread very quickly in different contexts, such as goods and people logistics, in order to ensure a faster and more reliable traceability of items and people. An evolution of RFID technology is the BLE: the basic structure is the same but tags are always active and the reader could be also a general-purpose equipment, such as a tablet and/or mobile phones.

Recently, some studies outlined the use of IOT technologies for preventing accidents and injuries caused by the proximity of a worker to a hazardous area or equipment. One field of application is the identification of the worker location during normal working activities or emergency events. The study of Kim & Kim (3) introduced an innovative application for improving the occupational safety in the steel industry by introducing a warning system that signals to the operators the proximity to hazardous machines. In detail, the proposed system aims to enhance the worker's safety under a cargo crane; it is composed of active RFID tags, receivers, and a location-sensing server. Tags are attached inside workers' safety helmets, which is monitored by readers installed on a cargo crane. The distances from tags to the receivers are estimated by using RF signal and transmitted to the location-sensing server. Ruz et al. (6) suggested a similar system, i.e. the worker is equipped with a RFID bracelet (with a passive UHF tag) and every time the worker is too close to the "danger zone", a stop signal is sent to the equipment. The system has been tested in laboratory using a robot simulation experiment. Results showed that the distance of detection of RFID tag depends of its orientation and velocity. Other studies analyzed the contribution of IOT technologies for preventing accidents in hazardous working area. Qiuping et al. (7) and Yinghua et al. (8) proposed some feasibility studies to evaluate the application of IOT technologies in controlling safety levels and increasing the overall effectiveness of emergency management in underground production areas, i.e. the mining industry. Several papers regard the construction industry as some pilot projects have been developed. An interesting application for the managing occupational safety levels is proposed in (9). The focus is on the design and develop of a Cyber-Physical System to check in real time the use of PPEs (Personal Protective Equipment). The architecture consists of a mesh network for transmitting information, gathered from devices worn by the workers, and a Body Area Network, distributing several PPE detectors (i.e. readers) in worker's clothing. It was developed a prototype system by using RFID tags for the PPE detection systems and a different technology for designing the mesh networks. Wu et al. (10) and Wang et al. (11) critically discussed the contribution of IOT technologies to provide a dynamic risk model based on a real time information system of accident precursor events (e.g. near-misses) reported at workplace. Teizer et al. (12) proposed a prototype IOT equipment for tracking workers in proximity to heavy equipment in construction site. Lee et al. (13) described a complex IOT system for the real time tracking of workers in hazardous areas within a construction site aiming to prevent fall injuries. Kelm et al. (14) proposed an IOT based system to support the checking process of PPE by a worker at the entrance of a construction site. Sun et al. (15) proposed the use of IOT technologies for monitoring process conditions of hazardous activities (i.e. logistics of tailings) in the mine industry. Mishra et al. (16) developed a RFID based system for tracing at workplace hazardous (i.e. explosives) materials. In this paper the integration of three different solutions through a digital platform (or called vertical-tool) is exploited in managing industrial and occupational safety. In Section 2 the proposed IoT system is presented; Sections 3-6 illustrates the characteristics of the three solutions solving three different safety issues and the digital platform that share information used by each specific solution; Section 6 describes a use-case; and Section 7 provides conclusions.

The proposed IoT prototype system

The IoT based prototype system integrates different technologies for managing, in a holistic way, industrial and occupational risk at establishments, where the Seveso Directive for the prevention of major hazards is enforced. A special focus is on the issue of equipment aging, which is an emerging risk at Seveso sites, as discussed by (17). The prototype is featuring different "vertical" tools and their functionalities include:

- Identifying uniquely equipment at the workplace area, trough smart labels, enabling a dynamic system for tracking maintenance activities carried out periodically;
- Visualizing and forecasting, in a more reliable way, the actual aging level of equipment (e.g. vessels) by means of a "virtual sensor";
- Managing alerts derived from unsafe conditions occurred to workers during hazardous activities through wearable smart objects and environmental sensors
- The added value of the proposed prototype system is its capability to interact with users – by sharing and/or updating information - both in a traditional way (e.g. from a remote-
- control room) and in a real-time way (e.g. walking through the working area).

The core of the system is a high-level communication protocol, layered on an industrial platform. It enables to access a shared database, which deal different information, including equipment identification, inspections' results, workers' positions and conditions. Further information on safety management are included in the database of the digital platform. A basic schema is proposed in Figure 1. The prototype is targeted to different types of users, including: 1) the workers that have to access the hazardous areas for inspection or maintenance purpose, 2) the HSE managers,

which must supervise workers' safety during mission in hazardous areas, 3) the auditors, which have to visit

Figure 1. The prototype Schema

periodically the plant in order to assure a safe management of such an equipment from monitoring different hazards, i.e. efficient maintenance of equipment as well as their functional aging during time. The prototype provides apps for smartphone, suitable to be used on the field, as well as tools to be used in the desktop to manage the equipment, plant and supervise the missions.

The digital platform: The main function of the digital platform is to provide common data standard protocol for sharing information between all vertical applications developed to manage different processes by each vertical application. The platform manages common data about each equipment (e.g. installation date, periodic maintenance activities, unexpected faults, etc.). Furthermore, it also manages real time data acquired by different sensors used by vertical applications.

The Smart Label application: The application aims to provide reliable and updated data about all mandatory maintenance activities developed by owners for a specific hazardous equipment. This information is provided both to plant owners and workers and to inspectors, who periodically verify the current state of such an equipment based on legislative duties. A smart label based on IOT technologies will be attached to each equipment at its first use and/or during its use life time. The IOT technology adopted is the Near Field Communication (NFC) based on proximity communication. Smart labels communicate at the workplace with users – i.e. equipment owner or inspector- trough mobile devices. A web based application manage data about each inspection date and provide information to users. In the web-software tool, each category of actors – previously introduced- have to manage information in different "cloud space" aiming to provide security of data: one regards information about company strategies adopted to maintain in a safe way equipment to be inspected periodically through an external mandatory audit. A part of these – defined as the inspection audit module- will be shared virtually with inspectors before and during the inspection audit. The same occurs for the inspector side: some information and documents (e.g. the control registry, the audit report) will be virtually shared with employers in the cloud space; other data will be accessed only by technicians of the public or private body.

The Virtual Aging Sensor application: The "virtual sensor" is an application, used by an inspector or a supervisor, during a walk inside a process plant. It makes him/her to "see" the actual state of aging of the unit or piece of equipment which he/she is inspecting. Aging information, related to a single piece of equipment, may be displayed on a small sized viewer, integrated with a smart helmet, which was developed to provide a "free hand" solution. A web application for the smartphone is also available. The virtual sensor uses the aging index defined by the "*Aging Fishbone method*" adopted by the Italian Environment Ministry for inspections under Directive 2012/18/ Seveso III. The method is applicable to the static containment systems, critical for the point of view of the prevention of major accidents. They include all types of vessels and pipes, both atmospheric and pressurized. The method assigns scores to the various factors that accelerate or decelerate the aging process. The first group of factors include service time, deterioration mechanisms (dependent in turn on materials, environment and processes), defects, failures, unexpected stops and recorded incidents/near misses. The second ones include coatings, effective inspections, qualified inspectors, adequate management procedures, certified control systems (18). The aging virtual sensor uses the shared database to retrieve and update relevant information. During the walk inside the establishment, the virtual sensor recognizes the vessels and pipes identified by the smart labels (NFC tag or QrCode), as described in the previous paragraph, and provides the inspector with the relevant aging information, according to the *fishbone method*. The virtual sensor is also able to gather the results of the integrity measurements performed on a single vessel or pipe, in order to update the shared database and eventually to evaluate residual useful lifetime (19).

The Safe Work monitoring application: This application integrates IOT sensors– based on BLE technologies for worker localization - together with a software tool for effectively managing data acquired by sensors. The main purpose is to monitor in real time workers conditions in hazardous locations and activities. Three are the basic components:

- A localization service to estimate the position of the worker that has to be shared in case of emergency,
- An indirect shared warning system devoted to exchange relevant information about human and environmental conditions,
- A state estimation tool responsible for the estimation of the anomalous situations.

In addition, the application system uses a algorithm to discriminate different worker's activities in order to generate an alarm in the case of an anomalous situation. The system is specifically designed taking into account the privacy of the worker, hence all information is locally managed and shared only in the case of emergency. More details about the technological issue of this application could be find in (20).

The Use case development: The prototype has been tested at an industrial site of a thermo- electric power plant: in detail, atmospheric tanks have used to the test activity. First of all, all data plants required have been digitalized in the platform starting from the establishment plant to data regarding installation and maintenance activities developed to specific tanks in the area in analysis (see figure 2). Next, smart labels have been attached to equipment to be used for the testing activity as depicted in Figure 3. The following steps have focused on testing the functionalities of the Virtual Aging Sensor application (see Figure 4): by a mobile device, information about ageing process of the equipment are visualized; next a maintenance activity has been simulated and

information stored at the digital platform have been updated through the mobile device in real time. Finally, a potential injury – i.e. a fall during the simulated maintenance activity- has been tested trough the Safe Work monitoring application: one inspector has been equipped by the BLE based sensor tool which has alerted in real time the other inspector, who has come to the injury location helping the other colleague thanks to the alert sent in real time by the application.

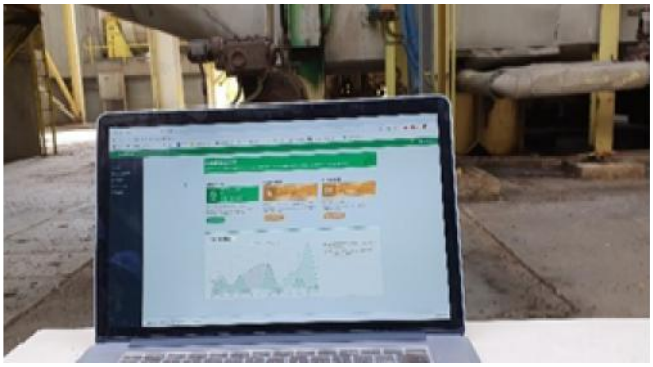

Figure 2. The digital platform

Figure 3. The smart label attached to a tank

Figure 4. The test of the Virtual Aging Sensor application

Figure 5. The test of the Safe Work monitoring application

RESULTS AND DISCUSSION

Employees and Workplace safety is paramount for every organization and every employees feel comfortable and confident when they know that the work place is safe and they are in protected environment. Health and safety is the key factor for all the organizations so that they promote and improve the wellness of both employees and employers. There is abundant evidence that good health and safety practice can improve productivity because healthy employees are productive employees, and productive employees have a positive impact on the company's bottom line. When employees start feeling that their work is unsafe or that their employer's don´t not care about their well-being, productivity slip. In order to ensure the safety is at optimum level, technology can play significant role in improving workplace safety. Technology when integrated with workplace safety will enable the organizations to comply with HSE standards. The rise of more sophisticated tools and gadgets offers a new perspective on how workplace safety can be continuously improved. Employee safety monitoring, training and reporting are just a few ways technology is improving workplace safety for employees. Technology also offers high-speed communication that could help remote employees to be safer while on the job. Some of the technology which can be used to improve safety in the workplace are , Safety apps Hazards are everywhere, and safety apps have been developed to look at safety-related issues, providing valuable information at the touch of a screen.

3D visualization technology: The 3D visualization software technology can help employees to become more aware of their workplace surroundings and its risks. The software generates lifelike images by recording the image using two angles. This tool has great advantages for workers training sessions for any given environment. 3D visualization software can recreate environments and workplace sites allowing workers to know the dangers and hazards in advance. It can additionally notify managers on what safety equipment and materials workers would require to prevent any accident. Virtual reality :Virtual reality is Using virtual reality, allows employees to get more "hands on" training, which is far more effective than just reading a training manual.

Drones: Using drones in the workplace can reduce the risk of accidents and when they do occur, it is easier to see how and why something went wrong in order to prevent similar incidents. Additionally, where some environments can be unsafe, sending a drone in to check the area gives a team crucial information without endangering human health. Drones allow access to dangerous sites reducing the exposure to employees. They can also collect the essential information and deliver, at the right time, to the appropriate person.

Conclusion

The current study proposes a tool to coordinate. maintenance, control and inspection of dangerous equipment and working environments. The aim of is to design of a prototype platform integrating different vertical applications able to manage four main services: a tool to manage information about equipment and machinery maintenance (based on the smart labels), a tool to identify possible structural faults, an algorithm to estimate the level aging (i.e. degradation) of the equipment and a system to monitor in real time worker and environment status.

The idea is to use all this information to provide an accurate and contest drive awareness information to workers.

Use of technology managing workplace security and safety: Will not only improve employees health but has also make them comfortable, satisfied and more productive. Technology provides right tools & mechanism which enables to collect adequate data and leads to faster reaction times. It can also have a significant impact in the reduction of injuries and incidents in workplace.

Technology in workplace for managing safety is an essential aspect which can result in experience better work turnout and more satisfied and healthier employees. Can also keep them safe and expedite communication flow between management and workforce and finally enable employees to be more productive, efficient and innovative.

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