Fusing RFID with Mobile technology for Enhanced Safety of Construction Project Team Members

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Abstract

The development of the fourth industrial revolution has provided different inventions for assessing real-time locations among them includes RFID (Radio Frequency Identification). Thus, this study proposes fusing RFID with mobile technology for easy identification of construction workers on site towards enhancing construction safety. The study adopted convenience purposive sampling method in obtaining data from selected construction professionals in Gauteng Province South Africa. A total of 34 questionnaires were obtained from the construction professionals out of 40 that was distributed. The data were analyzed with SPSS V 24, using, frequency distribution. The result from the analysis shows that the construction professionals are willing to adopt RFID for construction safety purpose. The study concludes that fusing RFID with mobile technology will decrease occurrence of accident on construction site. The article provides an innovative approach towards improving the safety of construction workers as it changes the perception of safety personnel from a reactive point of view to a proactive approach. Hence, it is envisaged that innovative ideas for ensuring construction workers safety will require an interdisciplinary collaboration between computer scientist and safety personnel.

Keywords
Fourth Industrial Revolution, Health Hazards, Occupational Health and Safety**,** Radio Frequency Identification (RFID)

1. Introduction

The construction industry is a major source of occupational accidents thereby exposing construction workers to higher occupational hazards than those in other industries such as manufacturing and banking (Spee, 2006, Idoro, 2008, Umeokafor *et al.* 2013). Idoro (2007) opined that the occupational accident of construction industry is worse in developing countries when compared to developed nations. Towards reducing the occupational accident experience within the industry different suggestions has been provided. They include; the preparation of a specific health and safety regulation policy, increase the compliance level to health and safety regulations, provision of protective equipment for construction workers and many others. Despite the ways provided for reducing occupational hazards in the construction industry occupational related hazards are still experienced especially on construction sites. This study proposes a paradigm shift in the way occupational hazards is been combated on construction site as it recommends the fusing of RFID (Radio-frequency identification) with safety inspection for enhanced safety of construction project team members.

The use of RFID has been in existence for several decades, and it was made popular after the advent of the fourth industrial revolution that was made popular by the German Federal Government in respect of its manufacturing sector. Daniel and Muller (2016) and Osunsanmi *et al.* (2018) acknowledged that industry 4.0 enables the connection of people and objects or objects and objects which is powered by the internet of things towards enhancing the passage of information. Based on the concept of industry 4.0 the RFID technology adopted is expected to eliminate the manual inspection of a construction project team member through the provision of a precise or detailed information concerning their location. Sardroud (2012) submitted that technology that can provide real-time access to workers location is a major boost in the management of construction activities as it supports the manual process and ensures prompt decision making regarding activities within the construction site.

Tolman et al., (2008) described Radio frequency identification (RFID) as a generic term for technologies that adopt radio waves for automatic identification of people and objects on construction site. Xiao, *et al.* (2008) submitted that the RFID was originally designed for usage in improving warfare technology in Britain. It works through using radio waves to transmit data from a sender called a tag to a receiver or reader to perform a specific task or identify the location of an object depending on the reason the tag was installed (Graafstra, 2006 and O Brien 2006). Similarly, Wu *et al.* (2010) asserted that RFID is a technology that provides automatic identification of an object using radio frequencies to capture and convey data from a tag, or transponder. It can be inferred from the above that easy identification of an object and individual location can be provided through the use of RFID.

Unfortunately, there is little research in developing countries into the use of RFID for providing the real-time location of construction professionals regarding their safety activities on construction sites. In support of this opinion, Wu *et al.* (2010) and Ergen and Akinci (2007) affirmed that the advantages of using RFID technology for safety on construction sites have not been given adequate attention. Therefore, this study proposes the integration of RFID for construction safety management. Although in the construction sector there has been research into the application of

RFID especially in the areas of tracking, inventory management, equipment monitoring, identification of stress in concrete members and many others (Yagi et al., 2005; Wing, 2006; Erabuild, 2006; Domdouzis et al., 2007; Kiziltas et al., 2008; and Tolman et al., 2008). Some studies were also conducted in relation to construction safety by Chae and Yoshida (2010), Yang *et al.* 2012 and Nasr *et al.* 2013 But these studies did not capture the opportunity for using mobile phones as the readers for the RFID with the intention to save cost and respond rapidly. Thus, this study examines the readiness and awareness of construction professionals towards adopting RFID and mobile phones for construction safety on sites. Therefore, the objective of this article is to enhance construction safety through the fusing of RFID with mobile technology for easy identification of construction workers on site.

2. Review of Construction Safety and RFID

2.1 Safety in the South African construction industry

There has been disagreement in literature on the development of occupational health and safety. Venart (2007) submitted that occupational health and safety (OHS) became an integral part of an organization after the Flixborough accident in Europe that wiped out the entire village. Adeogun and Okafor (2013) avowed that occupational safety developed after the meeting of the international labor organization aimed at promoting the physical, mental and social well-being of workers. It can be deduced from both opinions that OHS grew with the intention to prevent hazards to a country labor force and improve its income.

The majority of a country's income is provided by its labor force thus making occupational health and safety crucial to the development of a nation's economy (Annan, 2010). In support of this opinion Bima, and Abdulateef (2015) affirmed that the economy of a country will increase with an adequate attention toward improving the health and safety of the country labor force. CIDB (2010) uphold that occupational health has an impact on the economy because a healthier labor force will result in enhanced productivity of any industry. The aforementioned option shows the importance of an health labor to the development of a country's economy.

The construction industry is often regarded as the largest employer of labor accounting for the employment of one-quarter of the country's labor force (Agumba and Haupt, 2009). Annan (2010) affirmed that the construction industry contributes significantly to the development of a country through the activity of its labor force. Kheni, et al (2008) avowed that out of the four factors of production required to provide infrastructures for the construction industry labor is the most significant. Likewise, Yankah (2012) submitted that labor is so important to the construction industry that shortage or poor management of labor could result to construction project delay.

However, despite the importance of labor to the construction industry it is regarded as a risky industry to work especially in developing countries including South Africa (Idoro, 2008; Smallwood et al, 2009 and Umeokafor *et al.* 2013). Towards reducing the occupational hazard experienced in the construction industry the Government of South Africa has established various act and policies. The act includes; occupational health and safety act(OHSA) act no 85 of 1993 and compensation for occupational accidents, injuries, and diseases of 1993 that substituted the

machinery and occupational safety act. The construction regulation act of 2003 as stipulated by section 43 of the occupational health and safety act of 1993.

Among all this safety act the construction regulation was developed specifically for the construction industry with the intention of reducing the occupational health and hazards experienced in the industry. Despite, the enactment of the construction regulation act the health and safety records in the industry has not improved significantly (Agumba and Haupt, 2009). Likewise, Smallwood et al (2009) and Goldenhar (2002) reported that the South African construction industry contributes to a large proportion of occupational injuries when compared to other industries and is ranked the third highest death rate industry. This, therefore, calls for the need for a modern form of managing health and safety on construction site. Therefore the objective of this article

2.2 Radio frequency identification (RFID) and Safety

RFID has been identified as one of the biggest contributory technologies of the twenty-first country (Sardroud, 2012). Tolman *et al.* (2008) described RFID as an emerging technology that utilizes radio waves to identify a specific object or items. Yagi *et al.* (2005) affirmed that RFID has been in existence in the past decades but was initially used for access control and tracking of objects. Ever since the rise of RFID, it has been a point of attraction for academicians and researchers. Thus, accounting for various form of research from different discipline into RFID such as; tracking (Wing, 2006), development of warfare equipment (Xiao, *et al.*,2008) submitted that the RFID was originally designed for usage in improving warfare technology in Britain and many others.

A common phenomenon among all the research conducted is that RFID has three major components which are the tag, reader and the backend system. The concept behind RFID works by placing the tags also referred to as transponders on the targeted objects. Xia *et al.* (2008) opined that the tag contains an antenna created from a combination of coils and microchips embedded in an encapsulating material used for sending information regarding the attached object. Graafstra (2006) affirmed that the tag can incorporate sensors for tracking the location of an object including reporting the environmental conditions of the object.

Rotter (2008) confirmed that they are four types of RFID tags which are; passive, active, semi-passive and semi-active tags. The authors expatiated further on the difference between the tags and concluded that passive tags operate without a battery, active tags are powered by a battery. Whereas the semi-passive and semi-active are in the middle because they both use a small battery. The semi-passive uses the small battery to power their chips and semi-active use the battery to power their antenna. Sardroud (2012) reported that the most crucial component of the RFID is the tag which is followed by the reader also referred as the scanner or interrogator used for communicating with the tag made possible by the radio waves sent by the tag's antenna. The reader then converts the received radio waves into digital information that is passed to the backend system. The back-end system is referred to as the database for storing the information collected from the reader.

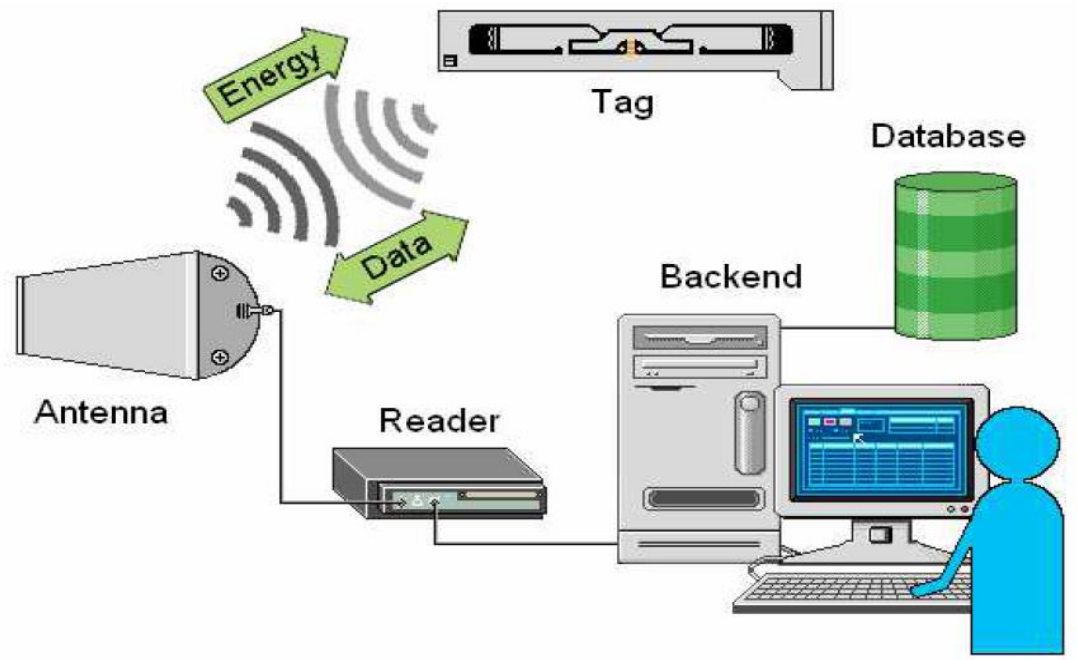

Figure 1; Operation of RFID
Source; Xia *et al.* (2008)

Figure 1 shows the generic operation for RFID. It can be inferred from the operation of RFID as shown from the reviewed literature that it operates as a wireless automatic identification and data capture technology. This unique characteristic forms the basis for adopting RFID for construction safety. As literature (Idoro, 2008, Annan, 2010 and Umeokafor *et al.* 2013) as shown that the cause of occupational hazards on construction sites could be attributed to the poor identification of unsafe practices of construction workers.

Thus, towards curbing the occupational hazards on construction sites this study proposes the use of RFID for monitoring the unsafe practice of construction workers. This will be achieved by fixing the tag on the protective equipment used by the construction workers on site. It is expected that fixing of the tag on the site workers will provide easy identification of the construction workers by the safety personnel or site managers. The identification of the workers will allow the restriction and monitoring of the movement of the construction workers on site.

This study introduces a novelty idea of using the phone as the reader for the RFID tag. The growth of the industry 4.0 has made possible the advancement of mobile phones providing the opportunity to run various software's on the phone (Nasr, *et al.* 2013). Vaha, *et al.* (2008) affirmed that mobile technology has developed to the extent of imputing integrated RFID reader software on telephones. The use of Mobile phones as RFID tags will provide a fast and easy way for monitoring construction workers activity remotely on site. Unfortunately, the construction industry has not tapped into the advantage of using RFID tags and mobile devices. This, therefore, leads to little studies conducted towards examining the awareness and readiness for using mobile phones as RFID reader.

3.Methodology

The study area is focused on Johannesburg within Gauteng province South Africa. Johannesburg was perceived as the most appropriate area for the study for several reasons. The most significant among the reasons are attributed to the nature of Johannesburg city. The city is the center of commercial and industrial activities and has absorbed population drift from a different part of the province over the years (Agumba and Haupt, 2009). This continually prompts the need for construction activities within the city. This, therefore, formed the basis for picking construction professionals located within Johannesburg.

The study adopts convenience purposive sampling for selecting the respondents within the study area. This technique was chosen because of its capability to produce smaller size from a larger population with the intent for making a generalization about the larger group (Kumar, 2011). Creswell (2009) reported that convenience purposive sampling works on the concept of obtaining a comprehensive list of a larger population and purposely select individuals to be adopted for the sample. The concept behind this sampling technique makes it suitable for this study because they are numerous construction professionals within Johannesburg. Therefore, professionals with close proximity to the researcher that are registered with their respective professional bodies are selected. A total of 40 construction professionals were selected with the selection based on their involvement of health and safety on construction site. Out of the selected construction professionals, 34 responded effectively and their response was analyzed.

The study utilized quantitative research method due to is capacity for analyzing data in number format through mathematical methods and generalizing the findings across a large group of specific peoples (Muijs, 2011). The quantitative data were analyzed adopting statistical package for social science (SPSS) version 24 using frequency distributions.

4.0 Discussion of Findings

4.1 Background information

The background information of the respondents is summarized in table 1 below;

Table 1. Summary of Background Information

	Frequency	**Percent (%)**	**Cumulative percent**
Category of Respondents			
Consulting base	17	50.0	50
Contracting organization	17	50.0	100
Total	**34**	**100**	
Highest Academic Qualification			
ND/Diploma	11	32.4	32.4
B.Sc/ B.Tech	15	44.1	76.5
M.sc/ MBA/ MPM	5	14.7	91.2
Ph.D	3	8.8	100

Total	**34**	**100**	
Working Experience			
1-10 years	9	26.5	26.5
11-20 years	15	44.1	70.6
31-40 years	7	20.6	91.2
41-50 years	3	8.8	100
Total	**34**	**100**	

Table 1 shows that an equal proportion of response was received from respondents working with consulting and contracting organization. Regarding the academic qualification of the respondents, Table showed that they are all educated thereby confirming their eligibility to answer the question posed by the research instrument. However, 44.1% of the construction professionals are B.Sc/B. Tech degree holders, 32.4% of the respondents are ND/Diploma holders, while 14.7% have obtained MSc/MBA/MPM degree and few (8.8%) have studied up to Ph.D. level.

4.2 Awareness and readiness to adopt RFID

Table 2 presents the respondent's awareness, readiness to adopt RFID and their level of agreement with RFID as a tool for preventing health hazards.

Table 2. awareness and readiness to adopt RFID

	Frequency	**Percent (%)**	**Cumulative Percent**
Awareness with RFID			
Yes	28	82.4	82.4
No	6	17.6	100
Total	**34**	**100**	
Readiness to adopt RFID with Mobile phones			
Neutral	5	14.7	14.7
Ready	16	47.1	61.8
Very ready	13	38.2	100
Total	**34**	**100**	
Agreement with RFID as a tool for preventing health hazards			
Neutral	3	8.8	8.8
Agree	6	17.6	26.5
Strongly agree	25	73.5	100
Total	**34**	**100**	

Table 2 showed that almost all (82.4) of the respondents are aware of the possibilities for using RFID for monitoring construction safety. These findings coincide with studies done by Vaha, *et al.* (2008) and Yang et al. (2012) as they indicated that construction professionals are aware of the potentials of RFID. Table 2 further shows that a cumulative of 61.8% of the respondents are ready to adopt RIFD with their mobile phones on their construction site for safety purpose while 14.7% are neutral about the adoption of RFID. This confirms that construction professionals are open to the use of mobile phones for the reader when using RFID.

Almost all (73.5%) of the respondents agreed with the opinion that RFID has the potentials for curbing the health hazards experience on construction site while 8.8% are neutral about the use of RFID.

5. Conclusion

Towards the reduction of occupational hazards, this study proposes the combination of RFID with mobile technology for enhanced safety of construction project team members. The use of RFID became popular after the growth of Industry 4.0. It has been applied to the various field of work such as; electronic toll collection, book tracking in the library, animal tracking on farms, E-passport, supply chain and many others. It will work on construction sites through the fixing of wireless sensors (tags) on construction workers safety protective equipment for ease monitoring of their activity. The mobile phones will serve as RFID reader with the intention of saving cost and changing the way in which information is passed. Also, the use of RFID technology will reduce time spent on manual monitoring while taking construction safety from reactive to a more proactive approach.

The study revealed that the construction professionals are willing to adopt RFID for construction safety purposes. Also, they agree with the opinion that fusing RFID with mobile technology will reduce the occupational hazards on construction site. Thus, this study recommends that construction professional bodies should create more awareness regarding the use of RFID for construction safety. Also, more research should be conducted on the hinderance of fusing mobile technology with RFID for construction safety in South Africa construction industry.

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