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Research Paper

Enhancing Employees Security Using Smart Technologies

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ABSTRACT
The unexpected increase in crimes, accidents, and other hazards related to workplaces and society in recent years has made the topic of employee safety and security a top priority for business organizations. Kidnapping and acts of terrorism have been more common in sub-Saharan Africa in recent years. The novel method for real-time employee activity and movement monitoring is proposed in this study. The suggested system uses Internet of Things (IoT) wearable devices, which include an Arduino Uno microcontroller, wireless Radio Frequency Sensors (RFS), RFID tags/readers, and Global Positioning System (GPS) modules. The system's goal is to track, locate, and record employees' actions and movements at all time, giving information needed by employers (Human Resource Managers) and security organizations to ensure prompt response in case of emergency and urgent evacuation.

Keywords: *GPS, IoT, Radio Frequency Identification, Sensors, Wearable Technology*

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I. INTRODUCTION

The importance of safety and security at work necessitates regular observation of the workplace and employee behaviours in order to guard against theft, kidnapping, and other social vices. It is expected that every corporation would have safety assurance specialists who are tasked with determining whether the workplace is secure and safe for the personnel to carry out their everyday tasks. Recent proposals and enactment of legislation, rules, and policies geared toward environmental protection and public safety demonstrate how various nations prioritize the need to guarantee a safe and secure workplace. Despite all of these efforts, there have been more industrial accidents in recent years, and the industry's existing conditions have not improved. Even with the wide spectrum of current technologies, the environment has a tendency to be more harmful than safe. Safety professionals and labor organizations have recently called for the use of sophisticated instruments to monitor the workplace environment and regulate environmental risk factors in danger-prone areas. The security and well-being of an organization's workforce and physical infrastructure are crucial factors in its overall success[1,16].

International Labor Organization (ILO) reported that about one hundred and fifty-onelabourers face workplace accidents every fifteen seconds. According to ILO reports, globally, a striking three hundred and seventeen million non-fatal workplace-related accidents and occupational hazards occur every year and about three hundred and twenty-one thousand workers die annually from workplace-related mishaps.Workplace accidents are a major problem affecting businesses all over the world and over one hundred and seventy United States of America Dollars are lost annually to workplace hazards[2,3].

The most important aspect of today's working environment for employees in manufacturing and process sectors is security. For Micro, Small, and Medium Enterprises-level businesses, an appropriate safety system still needs to be implemented in order to have a secure workplace.

Despite safety laws and regulations, occupational accidents nevertheless happen often. The recent increase in terrorism, kidnapping, and insurgency has had a significant impact on worker safety. For instance, some employees have been abducted in Nigeria, and several of them have been murdered while performing their duties. The loss of highly talented workers results in significant financial losses for governments and organizations every day, as well as challenges brought on by the inability to find qualified replacements. The list of risks that can occur at work every day is endless and includes things like chemical exposure, equipment malfunctions, exhaustion, stroke, and fatal illnesses [4]. Despite the adoption of stringent regulations, thorough training, and required personal safety equipment, safety procedures and laws do not warn personnel when the outside environment suddenly becomes hazardous [1]. Real Time Location System (RTLS) usage has increased

as a result of recent breakthroughs and evolution in the area. Because of the diversity of platforms and technologies employed by different system players, the identification, tracability, and real-time tracking of persons and products have always been challenging. The emergence of the Internet of Things (IoT) and cloud computing introduce a new strategy, enabling the collecting, archiving, and transmission of data on logistics flow for greater cooperation and interoperability[1].

The world is experiencing a significant and quick shift from isolated systems to pervasive Internet-enabled 'things,' which are now able to communicate with one another and produce data that can be analyzed to derive useful information. Everybody's life will be improved by the highly connected global network structure known as the "Internet of Things," which will also boost company productivity, increase government effectiveness, and much more. The Internet of Things (IoT) is a network of physical objects, including machines, cars, buildings, and other things, that can gather and share data because they are equipped with electronics, software, sensors, and network connectivity. It can also be described as a network of physical items that are connected via sensors, computers, actuators, and connections. This network lets the objects to gather data, turn it into knowledge, make wise decisions, and produce physical actions to change their surroundings. The development of a smart workplace, which is intended to guarantee the safety and security of the HR while also safeguarding and ensuring the profitability of the capital investment, is currently being fueled by the introduction of IoT and smart gadgets[8].

The Internet of Things, or IoT, is the web of interconnected devices that spans almost the entirety of the globe. Through integrated IoT solutions, complex data can be transferred wholly and accurately from device to device to whoever needs to access it, no matter where they or the devices are located, or when they are trying to access it. Through this easy transfer of data, new heights of connection and synchronization between tech and tech users can be reached, changing our lives at home in countless ways. IoT solutions and integrations are transforming the way we do our jobs, and benefiting workers in every industry - in particular by advancing performance in occupational health and safety management.

IoThas sensors at the core of their functionality. Using Internet of Things (IoT) to connect things, servicesand people for intelligent operations has been discussed and deployed in many industry domains such as smart city, smart energy, healthcare, food and water tracking, logistics and retail transportation. However, scarce information is available for IoT usage in industrial automation domain for reliable and collaborative automation with respect to monitoring the movement of employees in the workplace and provision of data to management for employees safety and security [16].In most cases, workplace accidents are preventable if the status of employees is continuously monitored. By adopting technologywith the help of IoT devices and hybrid solutions, one can monitor and send across safety information which includes employee's biometrics[7,8]. This will help organizations reduce their insurance cost through enhancing workplace safety in a smart and effective manner. Since workplace safety is a primary concern, development and collaboration of IoT technologies will be critical for organizations to invest in.This research developed a system for the real-time monitoring and tracking of the activities ofemployees in the workplace by using a hybrid of various positioning technologies and methods in order to cover the different workplace environments and scenarios. The research takes into cognizance the peculiarity of the various workplace scenarios and proposed the most suitable technologies and methodsafter comparing them with existing systems.

II. RELATED WORKS

Ref. [9] presents a hybrid positioning systemcomprising GPS and RFID technologies. The merits of GPS and RFID positioning systems were reviewed and harnessed to complement each other in the development of a hybrid system.Existing literatures revealed high performance and acceptability of GPS in outdoor navigation while RFID was found to perform very well in indoor environment. If the device goes out of the coverage of GPS it switches over to RFID system which is made up of RFID tags and readers. The RFID tags stores data which accessed by the reader through wireless communication. The hardware part of the project is RFID tags, RFID reader, graphic LCD, GPS system and microcontroller.Passive RFID tags are installed on the road sides while the readers are installed in the vehicles. Once the reader gets close to any fixed tag, the reader will read the tag data and communicate this to the controller using the UART module. The controller displays the current location of the vehicle on the graphic LCD based on the latest information received from the reader. In places where there is access to the GPS, current location data are received from the GPS module and displayed on the graphic LCD. However, the research was only limited to passive RFID tags which are incapable of functioning in the absence of a reader and the output uses a graphic display which is not Internet-enabled; hence the location cannot be viewed online.

Refs. [10,11]present the development of a system that caters for the tracking, safety and security of military men on the battlefield.The authors were motivated by concerns regarding the safety of soldiers in the battlefield and their inability to communicate with the control room when they are in danger. There exist inadequate coordination and planning of war strategies due to lack of information about personnel on the field

and absence of soldier-to-soldier communications. The position of the soldier in the field is calculated from the geometric relationships based on the data received wirelessly from the RF transceiver. Two units were designed namely: the base station unit and the soldier unit. A 32bits ARM7 TDMI CPU, Microcontroller with 512kb high speed flash memory, Biosensors, GPS receivers, PC running Visual Basic for the front end. A major limitation of the work was that there was no provision made for monitoring the soldiers when they are in places where there is no line of sight to the satellite.

The authors in [12]present a GPS system for object tracking. The research was motivated by the need for location awareness, object tracking and navigation. The advent and development of GPS by the US Department of Defense made the technology primarily for military purposes but the liberalization of GPS technology has opened it up for use in other areas of human endeavours. The authors explored the concept of GPS technology with the aim of understanding its peculiar features and applications. A detailed comparison of different navigation algorithmssuch as localization algorithms, Particle Filter (PF) and Kalman Filter (KF) algorithms were carried out. Object tracking technologies such as RFID, GPRS, WSN, GPS and GIS were reviewed. From the review of various literatures, the authors were able to reveal basic methods for object tracking using GPS, GSM and RFID. That work contributed to knowledge by presenting an interesting review of GPS, localization improvement algorithm and Kalman Filter algorithm and their application in object tracking. The authorsdiscussions were only theoretical and no implementation was carried out.

Ref. [13]presents an RFID and RTLS-based HR monitoring system. The authors were motivated by the need to adopt the use of RFID technology for human activities monitoring considering its successful utilization in other areas such as fleet management, vehicle tracking, assettracking and so on. There is the need to properly and objectively assess and evaluate the performance of employees and to get rid of the subjective nature of the traditional method of assessment. The methodadopted distance measurement, location estimation and development of the location optimization model. The research used a hybrid of two popular distance measurement of Time of Arrival (TOA) and Received Signal Strength Indicator (RSSI) techniques. The research contributed to knowledge by providing an online RFID personnel hourly duty and availability monitoring system. However, no provision was made for some jobs that do not require that people should be within a building and the proposed system lacks mobile application.

The Ref. [14]presents the design of a framework for combating human trafficking and kidnapping using smart objects and Internet-of-Things. The research was motivated by the incessant and alarming incidence of kidnapping, abduction, human trafficking and societal violence. The research provided a framework for real-time ubiquitous monitoring of human location and recognition. It proposed a model for the heterogeneous positioning system using smart technology. A rich literature on positioning and IoT systems is presented in the research. The proposed framework was not implemented, so it could not be evaluated for its effectiveness and efficiency in combating the menace of human kidnappers and traffickers.

Ref. [15]presents the use of IoT for safety and efficient monitoring of underground miners. The research used different sensors network based on MEMS to monitor the surrounding parameters of underground mines and values are transferred to ARM7 Microcontroller Unit. When a critical condition is detected, alert is given by the system and the statistics is communicated to webserver by initiating ESP8266 module based on Wi-Fi communication. The detected variations in the values are displayed on webserver page that makes it easier for the underground control center to monitor and to take essential instantaneous action to prevent severe damage.

III. ARCHITECTURE OF THE PROPOSED SYSTEM

The architecture of the proposed system as shown in Figure 1 comprises ofthree sub-systems namely: employee and workplace database, localization and positioning data generation and hybrid location filtering and estimation engine. Theemployee and workplace database comprises of the personal information of every employee in the organization, the physical structures, important landmarks and all the IoT devices specifications. The localization and positioning data generation subsystem is made up of the wearable IoT devices, the transmission media which is made up of the hybrid tracking module, GPS, GSM, microcontroller, indoor, outdoor, signal-denied areas and visual camera estimation subsystems. The GSM network can either be Universal Mobile Telecommunication Service (UMTS) or Long-Term Evolution (LTE) depending on the type of GSM service available at the time of transmission. The hybrid location engine comprises of database server, Kalman filtering system which carries out the location information and measurement reading, error detection, correction and position estimation. The web server is used for online display and monitoring of employee activities.

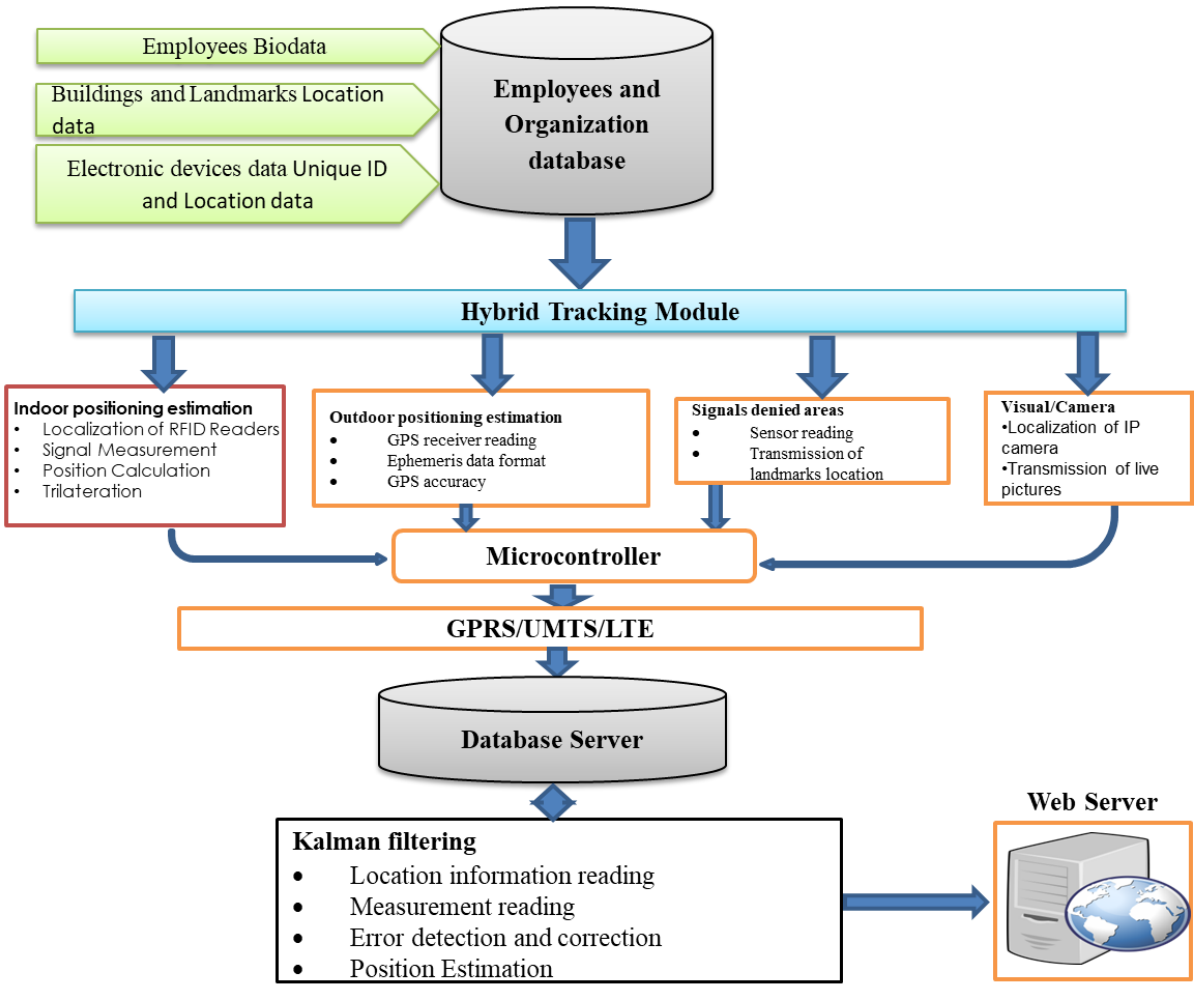


Figure 1: Proposed System Architecture

IV. SYSTEM DEPLOYMENT

The type and specification of the IoT devices used for the research depend on the workplace environment in which the employees were located.In the indoor environment, passive RFID was used and for the outdoor environment, camera, RF sensors and GPS modules were used for monitoring and tracking ofemployees. The positioning algorithms used for the research were Time of Arrival (ToA), Received Signal Strength Indicator (RSSI), Trilateration and Kalman Filtering. A hybrid of ToA and RSSI was used for signal measurement, position calculation and sensors localization while Trilateration and Kalman Filtering were used in position estimation, error detection and correction.Due to the heterogeneous nature of the working environments, that is, outdoor and indoor, the details of thehardware and softwarefunctional requirements and technical specifications used for the research are stated.

4.1 Hardware Specifications

a. Outdoor Environment: The location of employeeis monitored by using the SIM908 GPS module. Outdoor environment provides direct access to the satellites hence the use of GPS which has been found to perform very well in satellite navigation. SIM908 GPS has an industry standard interface that allows seamless tracking of variable assets at any time within signal coverage. It has a super long standby time made possible by the use of Li-Ion batteries. Other notable features of the module are the possession of a Quad-Band GSM/GPRS functionality which enables it tocombine GPS and GSM for satellite navigation. The module signal reception sensitivity is very high due to the possession of sixty six acquisition receiver and twenty two tracking receiver channels. Figure 2 shows the pictures of the devices.

b. Indoor Environment: Long range RFID reader with supports for multiple detection and high baud rate antennas and passive tags are used for the monitoring of the location of employee in the indoor environment. The reader supports multiple detection, offers a high baud rate from 9600 bps to 115,200 bps and can detect a

tag up to a distance of 150m. Figure 3 shows the pictures of RFID devices while Table 1 and Table 2 presents the technical specifications for the indoor tracking devices.


(a) SIM 908 Module (b) GPS Antenna (c) GSM Antenna

Figure 2: Outdoor Monitoring Devices



(a) Long Range RFID Reader (b) RFID Reader Antenna (c) RFID Tags

Figure 3: Indoor Monitoring Devices

Table 1:Specifications of Long Range UHF Integrated RFID Reader

ITEM	**SPECIFICATION**
Operating temperature	-40℃ to 85℃
External interface	2 RJ45 socket, I Mini USB type socket
Network Protocols supported	TCP/IP, SNTP, SNMP, DHCP, DNS
Communication Frequency	865.6 Mhz – 867.6 Mhz
Transmission power	4W ERP
Receive Frequency	433.92MHz
RF Input	60 Ohm BNC
Antennas	4 ports for 4 read points, multistatic topology, circular or linear polarization, reverse polarity TNC connectors

Table 2:Specifications of Passive tag

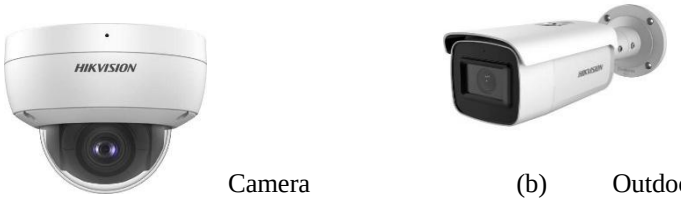
ITEM	**SPECIFICATION**
Communication Frequency	860 – 960 MHZand 902MHZ – 928MHZ
Sensitivity	-17dBm
Supported Standards	GS1 EPC Class 1 Gen 2 Version 2 ISO 18000-63
Antenna power	1 dBi linear (along long axis of the tag)
Supported Temperature	-30°C to + 90°C
Recommended Bending Radius	60mm
Dimensions	92mm x 24mm x 1.5mm
Weight	< 2g

c. Signal-denied environments: These are areas such as forest, riverside and difficult terrains. Due to topographic structures of these places and aerial blockages caused by trees and other tall objects, GPS signals are non-existent. The environment does not allow installation of RFID readers hence the use of battery-powered and weather-resistant Radio Frequency (RF) proximity sensor reader. RF proximity sensor reader uses Ultra High Frequency (UHF) RFID technology and has a low power consumption rating. The presence of high sensitive customized double-antenna sensor tag makes it suitable for the detection and reading of the presence of passive RFID tags once it comes within its coverage area. Figure 4 shows the proximity sensor and its internal circuit.


(a) RF ProximityReader (b) Internal Board of RF Sensor Reader

Figure 4: Proximity Sensor

d. Employee Identity Authentication: In order to prevent identity theft or situations whereby tracking devices get to wrong hands and impostors, camera is used to authenticate the real identity of the person wearing the tracking device. Hikvision IP cameras are installed in strategic locations for capturing visual images of persons in transit within the coverage area of the testbed. The indoor cameras are used inside buildings while outdoor cameras are hung on masts and other tall objects for good aerial view. The captured images are compared with the images of employeestored in the database in order to know the exact person in transit. Figure 5 shows the picture of the Hikvision IP indoor and outdoor cameras. The technical specifications for the indoor and outdoor cameras used in the research are stated in Table 3 and Table 4 respectively.



(a) Indoor Camera (b) Outdoor Camera

Figure 5: Hikvision Cameras

Table 3:Specifications of Hikvision DS-2 Fixed Network Indoor Camera

ITEM	**SPECIFICATION**
Image Sensor	1/3" Progressive Scan CMOS
Max. Resolution	2688 × 1520
Storage	Built-in micro SD/SDHC/SDXC card slot, up to 128 GB
Infrared Lens	11
General features	Line crossing detection, intrusion detection and face detection, Motion detection, video tampering alarm, exception (network disconnected, IP address conflict, illegal login, HDD full, HDD error)
External Interface	1 RJ45 100M self-adaptive Ethernet port
Network protocols supported	TCP/IP, ICMP, HTTP, HTTPS, FTP, DHCP, DNS, DDNS, RTP, RTSP, RTCP, PPPoE, NTP, UPnP™, SMTP, SNMP, IGMP, 802.1X, QoS, IPv6, UDP, Bonjour, SSL/TLS
Frame rate	2688 × 1520@30fps

Table 4:Specifications of Hikvision Varifocal WDR IP Camera

ITEM	**SPECIFICATION**
Image Sensor	1/3" Progressive Scan CMOS
Power Supply	12 VDC, 5.5 mm coaxial power plug; PoE (802.3af, class 3)
Shutter Speed	1/3 s to 1/100,000 s
Angle Adjustment	Pan: 0° to 355°, tilt: 0° to 90°, rotate: 0° to 355°
General features	Anti-flicker, three streams, heartbeat, mirror, privacy masks, password reset via e-mail, pixel counter, HTTP listening
External Interface	Ethernet 10Base-T/100Base-TX, IEEE 802.11g, IEEE 802.11n
Video quality/frame rate	50Hz: 25fps (2688 × 1520, 2560 × 1440, 2304 × 1296, 1920 × 1080, 1280 × 720) 60Hz: 30fps (2688 × 1520, 2560 × 1440, 2304 × 1296, 1920 × 1080, 1280 × 720)

e. Microcontroller and Hybrid Tracking Device: ArduinoUnoRev3 is a member of ATmega328P family of microcontrollers. Rev3isthemost robust, documented and widely used member of the Arduino Uno series.It has an operating voltage of 5V with clock speed of 16MHz, a typical one is shown in Figure 6.The twentyinput and outputpin is made up of fourteen digital and six analog input/output pins respectively. With a length of 68.6mm, width of 53.4mmand weight of 25g, it is very useful for the development of wearable device.

Figure 6: Arduino Uno Rev3

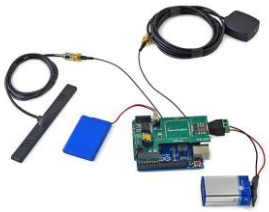


Figure 6: Arduino Uno Rev3 Figure 7: Hybrid Tracking Module

f. Web Server: HP ProLiant ML10 Server hosts the Windows 10 operating system, the web applications and the proposed system. It is a dual core processor server with 4GB RAM and 1TB SATA hard disk drive.

4.2 Software Requirements

Python programming language, MySQL, XAMPP and Google Map API are used for the development of the system. Python is used for development of the back-end web application and this includes the use of python libraries for facial recognition, position estimation and IoT devices communication. MySQL is used for the creation of databases for EMPLOYEE biodata, physical infrastructure and IoT devices. The ability of MySQL to perform very well in real-time applications makes it suitable for use as the database for location information readings and position estimation data generated by the system.Google MAP is connected to the MySQL database using Maps JavaScript APIfor the display of real time position ofemployees on the map. XAMPP is the all-in-one local web server packagewhich contains Apache web server, PHP which is used for the development of the front-end web application and MySQL which is the database.

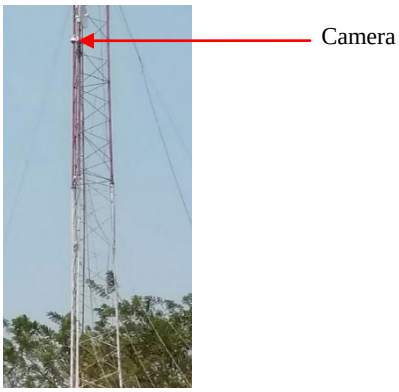
4.3 Testbed

The testbed used was a microcosm of the real-world working environment. It is the western campus of Adekunle Ajasin University, Akungba-Akoko, Nigeria. It is situated within the following satellite coordinates (7.482926N, 5.737127E), (7.485909N, 5.766927E), (7.477880N, 5.737084E) and (7.475679N, 5.766220E). Figure 8 shows the aerial view of the testbed as given by Google map.

Figure 8: Map of Adekunle Ajasin University, Akungba-Akoko.

Indoor location and position monitoring is carried out by RFID readers and indoor IP cameras which are installed at the entrances of selected buildings for the measurement of the entry and exit of employees (Figure 9a). Outdoor location and position monitoring is carried out by using GPS satellites and outdoor IP cameras which are mounted on communication masts within the university premises to capture images of employeeson motion (Figure 9b).Proximity sensors are installed in areas where RFID readers could not be installed due to environmental factors and which are at the same time barred from GPS signals.

(a) RFID Reader and Indoor camera



(b) Outdoor camera on mast

Figure 9: Location of RFID Reader, Indoor and Outdoor Cameras

V. RESULTS AND DISCUSSION

The results and discussions on the following are presented:

a. Employee Instant Location Tracking
b. Instant Location of all employees
c. Movement Route of employees
d. Employee Facial Recognition

5.1 Employee Instant Location Tracking

Human Resource (Employees)Managers need to know the instant location and whereabouts of any employee at any point in time in case of any emergency or hazard. This is achieved by activating the real time page of the system and by clicking on the employee name in the profile tab, instant location of the employee is shown on the map. The snapshot is shown in Figure 10

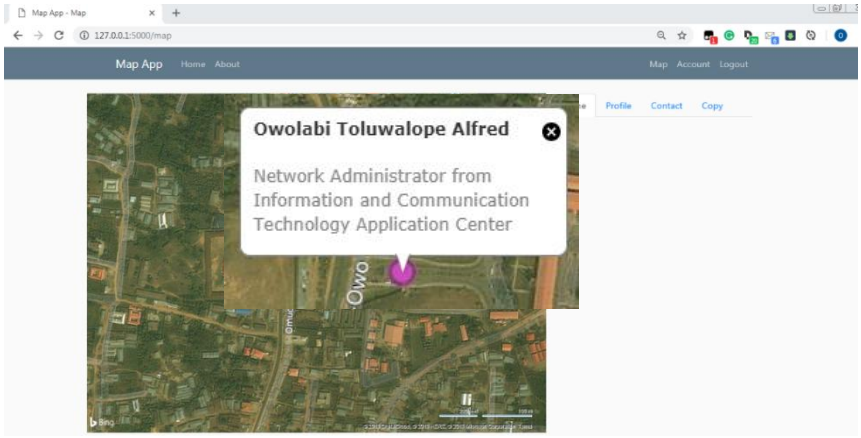
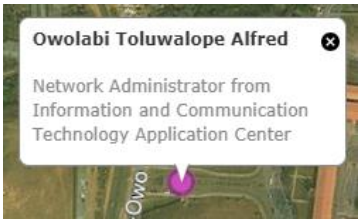


Figure 10: Instant Location of Active Employee

Figure 11: Identity of Tracked Employee

The 'GPS marker' shows the presence of employee at the location. The identity and details of the employee



whose location is represented by that marker is obtained by hovering the mouse pointer over the GPS marker, thereby displaying the details of the employee as shown in Figure 11.

5.2 Instant Location of all Employees

In order to know the number of employees that are present in the workplace at an instant and their respective locations, employeeManagers obtain this by clicking on Profile tab and pick the 'ALL ACTIVE Employees button. The output shown on the map in Figure 12 is the physical location of all employees that are within the experimental testbed at an instant time. By placing the mouse pointer on the GPS markers, the identity of the employees depicted by the GPS markers are revealed as demonstrated in Figure 11. The instant locations and identities of in Figure 12 are shown in Table 5.

Figure 12: Locations of Active Employees

Table 5: HRs Location and Corresponding Satellite Coordinates

Employee-ID	Department	Location	Satellite Coordinates
aauaict017	Software	Faculty of Agriculture	7.480986N, 5.739356E
aauaict009	Network	AAUA CBT Centre	7.480986N, 5.739356E
aauaict010	Network	AAUA CBT Centre	7.480986N, 5.739356E
aauaict002	Administration	ICTAC	7.482184N, 5.741238E
aauaict003	Administration	ICTAC	7.482184N, 5.741238E
aauaict013	Network	ICTAC	7.482184N, 5.741238E
aauaict015	Network	Access Bank	7.479479N, 5.742752E
aauaict012	Network	Library	7.483575N, 5.752748E
aauaict008	Gen. Services	Faculty of Agriculture	7.483773N, 5.750815E
aauaict001	Administration	Senate	7.480462N, 5.756469E
aauaict025	Software	Senate	7.480462N, 5.756469E

5.3 Movement Route

Tracing the route taken by any employee is obtained by clicking on the button 'Profile'. This opens a new page where the list of all employees is displayed, by clicking on the employee whose route is to be monitored, the route for the day for that employee is depicted on the Google Map as shown in Figure 13. The information obtained is helpful in cases of abduction and missing employees.

5.4 Employee Facial Recognition

The system obtains the facial images of employees through the use of IP camera. The cameras were installed at the entrance of each building in such a way that it will be easy to capture the faces of employees entering the building as shown in Figure 14.The camera detects the facial images of employees entering the building and the captured images are compared with the stored images in the database as shown in Figure 15. This is necessary for the verification of the identity of the employee bearing the IoT wearable device. This feature addresses the problem of identity theft and impersonation.

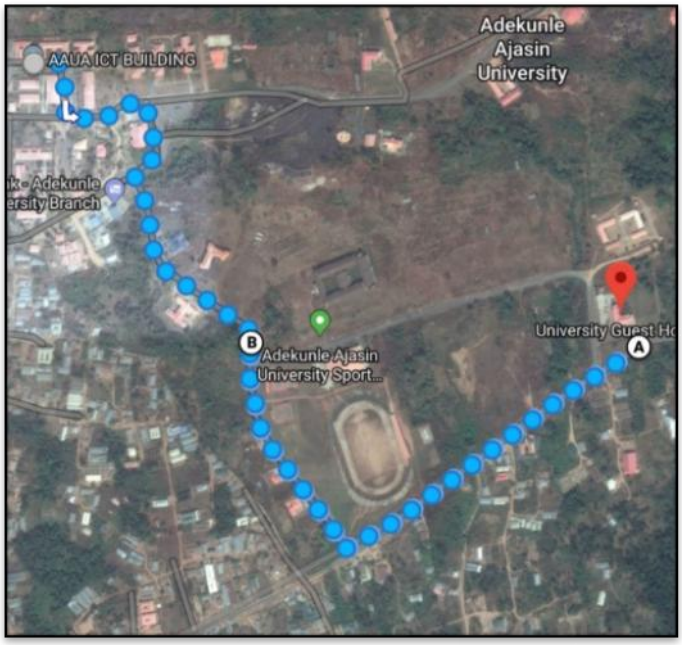


Figure 13: Movement route for Employee

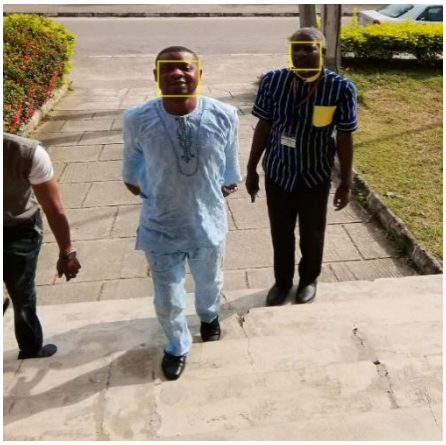
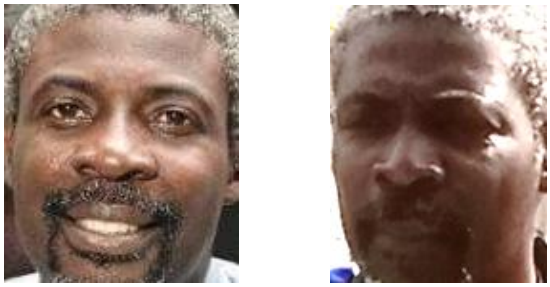


Figure 14: Camera Images for Person Entering a Building



Database Image Captured Image

Figure 15: Comparison of Database Image and Camera Image

VI. COMPARATIVE ANALYSIS WITH EXISTING SYSTEMS

The functionality and versatility of the system was tested based on the major requirements of localization system. The results obtainedwere compared with other existing systems. The comparisons were based on the environment where they were deployed, that is, either indoor or outdoor and the metrics considered

were technologies used, algorithm, accuracy, complexity, scalability, robustness and cost. Table 6 and Table 7 show the comparison of the system with other existing systems by taking into cognizance the environment used.The results obtained show that the developed system has significant improvement in accuracy, cost coverage, robustness and scalability when compared with existing systems.

Table 6: Comparative Analysis of Systems in Indoor Environment

System	Technologies	Positioning Algorithm	Accuracy	Complexity	Scalability	Robustness	Cost
Ref [19]	WLAN RSS	Probabilistic method	2m	Moderate	Good 2D	Good	Low
Ref [20]	Active RFID	kNN	2m	Medium	Nodes placed densely	Poor	Medium
Ref [21]	WLAN	TDOA	2.4m	Moderate	2D	Good	Low
Ref [22]	Passive RFID	ToA, RSS, ANN	1m - 2m	Moderate	2D	Good	Low
ProposedResearch	Passive RFID	TOA, RSSI, Trilateration, Kalman Filter	<1m	Moderate	Good, 3D	Good	Low

Table 7: Comparative Analysis of Systems inOutdoor Environment

System	Technologies	Positioning Algorithm	Accuracy	Complexity	Scalability	Robustness	Cost
Ref [25]	GPS, GSM	Kalman Filter	13.7m – 21m	Moderate	Global	Good	Medium
Ref [18]	GPS, WSN	Cell of Origin (CoO)	12.5m - 18m	High	Global	Good	High
Ref [23]	GPS, GPRS	TOA	10m - 12.5m	Moderate	Global	Good	Medium
Ref [24]	RFID	RSSI Fingerprinting, LSM	6m - 10m	High	Limited by the RFID coverage	Poor	High
Proposed research	GPS, Camera, Sensors	TOA, RSSI, Trilateration, Kalman Filter	<5m	Moderate	Global	Good	Low

VII. CONCLUSION

The paper presents the development and deployment of a multiple sensors positioning system for the tracking, monitoring and localization of the activities of human resources in a workplace using Internet of Things. Real-time information about the location of any employee at any instant is very essential considering the rising spate of kidnapping, terrorism and insurgency in the world. Having established the importance of employee in the actualization of organizational goals and objectives, adequate measures should be taken to ensure their preservation and security at all times. Further works that will include monitoring of health status, environmental condition and other workplace parameters is recommended.

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