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Research Article

MONITORING OF HUMAN RESOURCES IN THE WORKPLACE

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ABSTRACT

Globalization, evolution of computer technology and the fast pace of technological advancements have affected every facet of human lives and endeavours. The effects are becoming noticeable in the field of Human Resources Management (HRM). Several researches have shown the centrality and importance of Human Resources (HR) to the success and competitive advantage of any organization, hence the need to ensure the monitoring of activities and safety of this all-important factor of production. HR monitoring has evolved over the years from the traditional methods of attendance register and movement books to real time monitoring using several technologies and techniques. The major challenge has been the inability of a single technique to adequately monitor and provide accurate positioning data due to the changing environments of the workplace. This paper proposes a framework for heterogeneous positioning and monitoring of HR using a hybrid of GPS, RFID, Cameras and Sensors. GPS is used for monitoring and localization in the outdoor environment, RFID is for indoor environment monitoring, cameras are to give visual images of tracked objects while sensors are used for GPS and RFID-denied areas. Data transmission from tracking devices to the database server is carried out by using Long Term Evolution (LTE) network. The research presents an integration of different positioning technologies for the purpose of monitoring the activities of HR and ensuring their availability and safety in the workplace.

INTRODUCTION

The major assets of a corporate organization are human, machine (market, method, material), money and time. Man uses machine, money and time to achieve the aims and objectives of the corporate organization. Organization success largely depends on performance of Human Resources (HR) which provides the platform for achieving competitive advantage because of its capability to convert other resources (money, machine, money and time) into output (products and services) as shown in Figure 1.

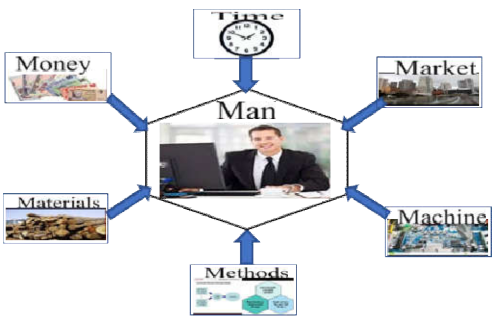

Figure 1 Man, Money, Machine, Material, Market, Methods and Time

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It is clear that at the heart of all the resources needed for productivity is the HR. Recently, HR has shifted its emphasis to knowledge sharing and strategic workforce analysis; it has become a significant contributor in the strategic management of organizations [1]. HR data are used as a resource for achieving cost savings and unique competitive advantage in all core management aspects comprising; planning, leading, organizing, monitoring and control [2]. Improper procurement and management of the HR of a corporate organization has often led to the improper utilization of the other assets and poor performance of organization [1]. HRM is concerned with hiring, developing, motivating and maintaining people in an organization. It focuses on people in organizations and designing management systems to ensure that human talent is used effectively and efficiently to accomplish organization goals [3]. The speed at which workplace technology has evolved recently has been startling; technology has already changed the face of work across industry sectors by enabling relevant information to be shared with employees in real time irrespective of their locations. Since it is clearly shown that employees are vital asset of an establishment, there is the need to ensure they are preserved, cared for, monitored and made to perform the tasks they are employed to perform.

Employers usually track their employees to reduce costs, especially labour costs and costs related to unnecessary product shrinkage. In this context, employers attempt to protect their business interests. The motivation for tracking employees is linked to improving organization productivity and at the same time ensuring the security and well being of employees within the confine of the organization especially in the face of rising global terrorism and insurgencies. Several traditional means have been used to monitor and control the activities of HR. This include the use of attendance register to monitor time of arrival and departure and movement book which employees must sign whenever they are leaving their duty post or coming into their post[3]. The methods are susceptible to human manipulations so they are unreliable as means of assessing and evaluating the performance of personnel. The need for automated system which will adequately address the limitations and vulnerabilities of the traditional methods gave birth to the application of Real Time Locating System (RTLS) in HRM. RTLS is a type of local positioning system that allows the tracking and identification of objects in real time. It uses simple, inexpensive badges or tags attached to the objects, readers receive wireless signals from these tags to determine their locations. Organizations have been using these technologies for many purposes. The use of on-board systems and GPS technology are major break-through in transportation fleet management (vehicle tracking, speed and waiting time). In addition, RFID technology enables parcel tracking, pharmaceutical product returns management and counterfeit identification, shipment tracking and tracing [4]. The identification, traceability and real-time tracking of people and goods have always been difficult, because of the heterogeneity of platforms and technologies used by various actors of the system. The advent of the Internet of Things and Cloud Computing has introduced a new concept for the gathering, transfer, storage and sharing of information. [5].

Related Work

According to [6], HR influences the efficiency and effectiveness of the utilization of other resources of the organization. The performance of the HR component is critical to the growth and development of the organization due to the fact that HR is the driver of all other resources. A survey by [7] reveals that millions of dollars are lost annually due to personnel absenteeism and unavailability at their duty posts while the organizations incur losses by paying for work not done. In [8], about $26.4b are lost annually to employees' truancy, lateness and idleness in the workplace in the United States.

The application of Information Technology (IT) has proved very effective and useful in a number of professions but its application to the management and monitoring of the activities of personnel has over the years been limited. In [6], a personnel recruitment system was developed, other areas of HRM activities such as monitoring and controlling, personnel development, productivity and behavior patterns were not covered in the research work. The authors in [2; 3] developed RFID monitoring system for personnel working within building. Personnel whose job descriptions are unrestricted to a fixed location are not catered for. The authors in [9] developed RFID monitoring system for both indoor and outdoor environments but it was not effective due to the inability of RFID signal to travel long distance. In the works of [10; 14], GPS-based soldier tracking system was developed. The system addressed the problem of soldier-to-soldier communication and soldier unit to control base communication. Also, the location of a soldier on the battlefield can be easily tracked but the system was limited by its inability to function effectively in environments where the soldier is shielded from the sky such as under a building, caves, tunnels and so on.

Existing RTLS technologies such as [2; 3; 4; 9; 10; 11; 18; 19] have allowed organizations to track and monitor in real time the precise location of persons within buildings or outside, but not both at the same time. Several attempts at integrating two or more techniques have been made. In [12], a cost-effective GPS-GPRS tracking system is presented. The work was motivated by high operational cost of existing tracking systems which has prevented widespread use and the alarming rate of car theft, asset theft, kidnapping and other related vices which called for the development and deployment of affordable tracking and monitoring systems. The research focused on the reduction of overall cost of tracking and in order to do so used NAVSTAR-GPS, a satellite based service developed and provided by United States Department of Defense. GPS is a 24-hour worldwide service. Google Map is used for mapping the location.

In [13], a hybrid GPS-GSM localization of automobile tracking System is proposed. The research is motivated by the need to manage fleet and accurately detect vehicle location and its status, advance scheduling of assignments based on current automobile location and the need for large enterprises to meet the varying requirements of customers and to improve their productivity. The proposed system has two main modules, namely the tracking device and the recipient workstation. The tracking module composes of a GPS receiver, microcontroller and a GSM modem. The GPS receiver retrieves the location information from satellites in the form of latitude and longitude real-time readings. The GPS readings are further corrected by Kalman filter. However, the research did not take into account that urban areas that have tunnels and high-rise buildings which may block GPS signals. The effects of signal attenuation and multipath effects which are synonymous with GPS measurements were not considered.

The research in [15] presents a design of accurate vehicle location system using RFID. The research was motivated by the fact that modernization and the evolving smart cities has thrown up a great challenge and discourse for the transportation system. The quest and desire to match up the transport system with the emerging urban realities has become a major concern. Several researches have proposed various technologies for vehicle location and tracking but their inability to present real time information has been a concern. Failure of existing works to provide reliable and accurate information especially in tunnels and urban built-up environments coupled with the inability to provide a platform for the integration and harmonization of the advantages of different positioning technologies motivated the research. The objectives of the research are to design a model that integrates RFID, GPS and GPRS and develop the system with the aim of improving the precise vehicle location and get the mechanical information of vehicle status by the technology of wireless data communication. The system architecture consists of four layers to regulate the vehicle location system namely; physical layer, device layer, data transmission layer and application layer. The research was able to harness the use of RFID for outdoor monitoring and it contributed to knowledge by integrating RFID, GPRS and GPS for vehicle positioning system. However, it was limited by its inability to connect to the cloud terminal for online monitoring which makes it unsuitable for real time system applications.

In [17], a low-cost RFID/GPS location sensing algorithm for urban infrastructure is presented. The research was motivated by the fast growth in urban infrastructural developments and the accompanying societal misdemeanor such as car thefts and other security challenges which call for critical information on urban management and application of location-based services. Several technologies and techniques have been proposed by various researchers but these researches have been hampered by high cost of deployment and large number of equipment required, hence the need to provide a low-cost algorithm based on multilateration to estimate tag location by mobile RFID reader equipped with GPS which will consequently reduce to a great extent the cost of the system motivated the research. The research however failed to take into consideration the presence of high rise buildings in urban areas which may block access to the satellites thereby generating errors. The authors in [16] present the design of a framework for combating human trafficking and kidnapping using smart objects and Internet-of-Things. The research was motivated by the high rate of kidnapping and human tracking which has attained global dimension and has defied several measures adopted by governments and organizations through the use of human personnel for surveillance which have been ineffective and susceptible. The framework has two phases, namely: hardware operational requirements phase and software analytic framework phase. The conceptual diagram of the structure is shown in Figure 2:

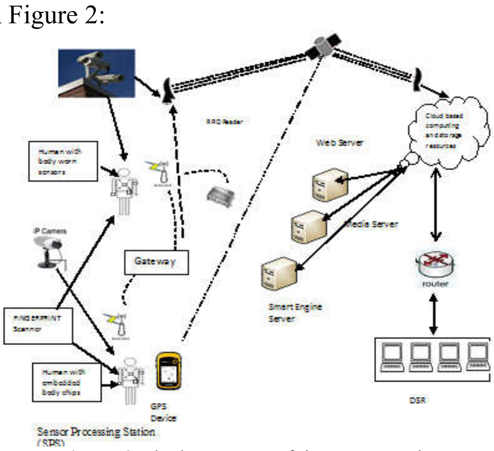

Figure 2 Block structure of the Framework

The hardware devices are categorized into two major divisions, namely: Non-visual module (NVM) and the Visual module (VM). The NVM comprises of IOT objects and RFID sensors and Geographical Positioning Systems that are responsible for signals and location. The visual module is made up of devices related to the capturing of real time images and multimedia. The Software Analytic Framework Phase is responsible for the analysis of data received from the various positioning devices. The research proposed a framework for real-time ubiquitous monitoring of human location and recognition, a model for the heterogeneous positioning system using smart technologies and a rich literature on positioning and IoT systems. However, the framework was neither implemented nor evaluated for its effectiveness in combating the menace of human kidnappers and traffickers.

Proposed Framework

The architecture of the proposed HR monitoring system is presented in Figure 3. The system comprises of the database, localization and positioning data generation as well as and hybrid location engine sub-systems. The database subsystem deals with the creation of the human resources personal record database, enumeration of organization buildings, important landmarks and the mapping of the entire research area. It also comprises of the technical specifications and assigned locations of RFID readers, IP cameras, hybrid globaltags, fixed and movable sensors, reference tags, GPS modules and all electronic devices used for the research. The monitoring and localization subsystem deals with the generation of heterogeneous positioning data depending on the environment. Due to the autonomous nature of globaltags, it has facilities to switch to either GPS or RFID mode depending on the environment it is operating. The activities involved in this subsystem include the generation of location data from the indoor and outdoor positioning estimations, the signal denied areas which are referred to as landmarks and the visual images captured by the camera. These data are aggregated by the microcontroller and the output is sent to the positioning and decision making sub-system using any of the GSM services available, that is, GPRS, UTMS or LTE.

The positioning and decision making subsystem hybridizes readings obtained in the second subsystem by using Kalman filtering algorithm, error detection and correction, optimization of results and updating of the application database for online display. Relational database management system is employed for the creation of the database due to interrelation between the various entities.

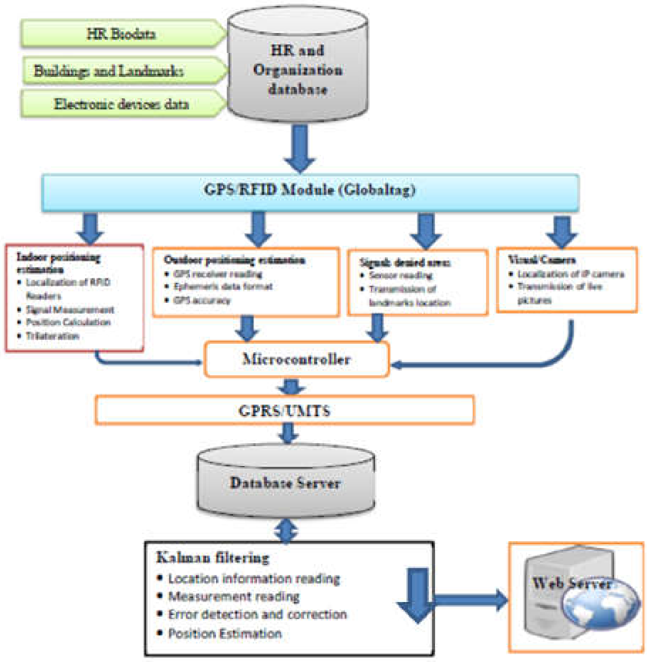

Figure 3 Architecture of Proposed Human Resources Monitoring System

Human Resource and Organization Database

Development of the HR and organization infrastructure database is the first step in the design of the system. The database includes the personnel biodata, organization infrastructures, landmarks, electronics and wearable devices.

Human Resource Personnel Biodata

The HR personnel database contains the personal data of the human resources used for the research. The entities and the schema of the database are presented as follows:

1. Organization data <org_id, org_add, org_type, web_address, zip_code, phone_number>
2. Personal details <per_id, fname, other_name, gender, marital_status, dept, dob, phone_number, email_add, dependants, passport_number>
3. Contact details <home_add, town, lga, state, country>
4. Job details <division, dept, job_title, employment_type, grade_level, hired_date>
5. Salary structure <payment _type, basic_salary, allowances>
6. Leave details <leave_type, taken_leave, deferred_leave, begin_date, end_date>
7. Emergency contact details <next-of-kin_name, address, phone_number, relationship>
8. Health details <height, weight, blood_group, allergy, insurance>
9. Work experience <(organization_name, hired_date, resign_date, position_held>
10. Educational details <institution_name, address, certificate awarded, duration>
11. Assigned Hybrid Globaltag unique identification number <globaltag_id, per_id>

Organization Buildings, Infrastructures and Fixed Locations

The enumeration of all the buildings, infrastructures and physical landmarks involved in the research is required and database of all necessary parameters will be created. All physical landmarks where there would be no RFID readers and at the same time, GPS-denied will be identified and assigned fixed sensors with unique identification codes. The following data are required:

1. Building name
2. Department
3. GPS location coordinates
4. Installed reference readers
5. Landmark name
6. Landmark sensor ID

Electronic devices

The electronic devices is the database of RFID readers, IP cameras, global tags, GPS receivers and Inertia system units. The information needed include:

1. Device name
2. Device type
3. Physical location of electronic devices
4. Media Access Control (MAC) address
5. Serial number
6. Deployment information
7. Assigned identification code.

Localization and Positioning Data Generation

This is responsible for the detection of signals by the readers, position calculation and estimation. Due to the heterogeneous nature of work environments, HRs are expected to work within buildings and outdoors. The nature of some jobs requires the employees to work outside the main building. This sub-system generates positioning data from the following environments:

1. Indoor
2. Outdoor
3. Signal-denial areas, that is, Landmarks
4. Outdoor and Indoor IP Cameras

Indoor positioning estimation

The research makes use of RFID technology in the indoor environment which has been found to have the best performance and accuracy in indoor environments [3]. Coupled with its ability to overcome Non-Line Of Sight (NLOS) problem associated with other wireless solutions and level of accuracy in indoor positioning, RFID is the preferred technology for indoor positioning estimation. A typical indoor positioning system is shown in Figure 4.

Correct placement of readers is very important for the effectiveness of the system. The readers are deployed to areas where there are no direct lines of sight to the satellites, that is, where there is no GPS signal. The readers are deployed within buildings and locations where they have access to power supply. The signal process is shown in Figure 5. The localization process is divided into signal measurement phase and position calculation phase as shown in Figure 6.

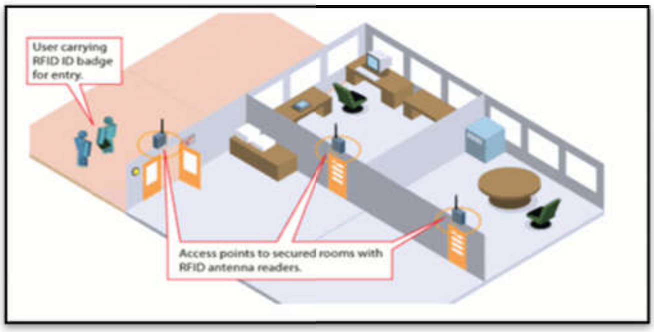

Figure 4 Indoor positioning system

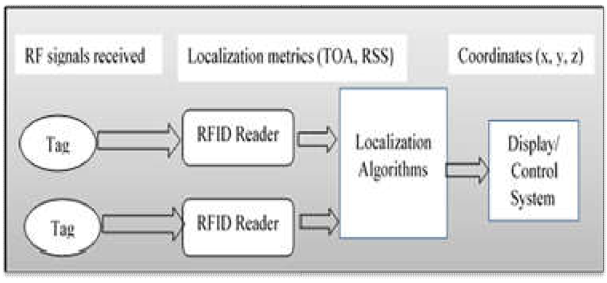

Figure 5 RFID Signal Process

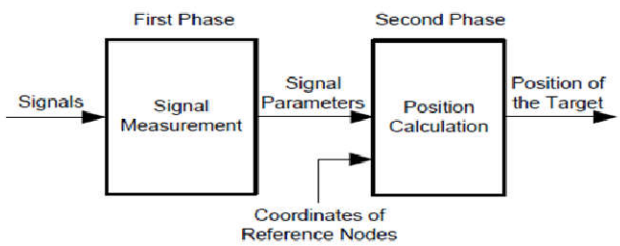

Figure 6 Localization Phases

In the first phase, radio frequency (RF) signals are transmitted between the target node (representing the communication entity attached to the people) and a number of reference (sensor) nodes. During this process, some properties of these signals, such as arrival time, signal strength and direction, are captured by the RFID readers which keep logs of the all signals received in its flash memory and their properties. In the second phase, the physical position of the target node is calculated by the reader based on the signal parameters obtained in the first phase. The most common technique used here is based on ranging, whereby distance or angle approximations are obtained. In this context, geometric approaches are employed to calculate the position of the target node as the intersection of position lines obtained from the position-related parameters at reference nodes.

Outdoor Positioning Estimation

GPS is used for prediction of the location of objects in outdoor environment. The use of GPS for outdoor positioning has been widely accepted due to its high accuracy and wide coverage in outdoor environment [3; 13; 14]. Satellites transmit signals to earth equipment or GPS receivers with sensors, GPS receivers only receive satellite signals and they do not transmit but a clear and unobstructed view of the satellite in the sky is required as shown in Figure 7 which means that there is the need for direct Line Of Sight (LOS) between the transmitting satellites and the GPS receiver.

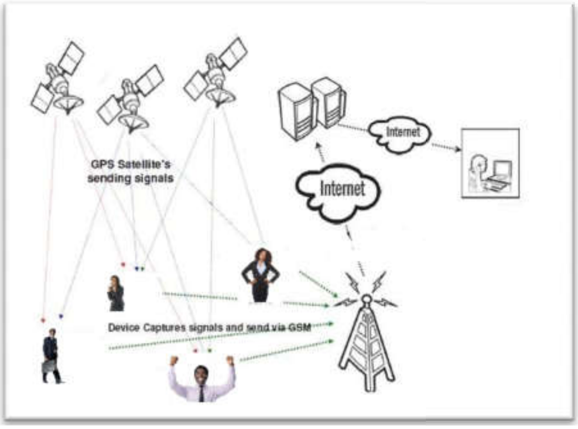

Figure 7 GPS tracking of employees

In a GPS system, the receiving user whose position is to be determined must have access to at least four satellites at the same time in the same earth orbit. The calculation of the position of a receiving user is obtained by solving a set of equations based on Pythagoras theorem in three dimensions and a time offset from the GPS reference time as shown in Equations 1 through 4.

$$d_i = \sqrt{((x_i - X)^2 - (y_i - Y)^2 - (z_i - Z)^2)} \qquad 1$$

$$d_j = \sqrt{\left(\left(x_j - X\right)^2 - \left(y_j - Y\right)^2 - \left(z_j - Z\right)^2\right)} \qquad 2$$

$$d_k = \sqrt{((x_k - X)^2 - (y_k - Y)^2 - (z_k - Z)^2)} \qquad 3$$

$$d_l = \sqrt{((x_l - X)^2 - (y_l - Y)^2 - (z_l - Z)^2)} \qquad 4$$

where

where $x_i, y_i, z_i, x_j, y_j, z_j, x_k, y_k, z_k, x_l, y_l, z_l$ are known positions of the GPS satellites in Earth-Centered Earth-Fixed (ECEF) coordinates, X, Y, Z are the positions of the receiving user in ECEF coordinates.

The general model for calculating the position of a user relatively to the transmitting satellite is expressed as:

$$d = c(t_r - t_t) \qquad 5$$

where c is the speed of light

t_r *is* the user time offset with respect to GPS system time.

t_t is the autocorrelation sequence time which is obtained from GPS equipment.

In most cases, access to four satellites at a time in the same earth orbit may not be possible due to environmental factors; in that case, the GPS navigation messages are broadcasted by multiple satellites synchronized with the same reference time. Messages arrive at a specific GPS user at different times due to the different receiver/satellite distances. However, even if the transmission epoch of a specific navigation messages and position of the satellite radiating it are known to the user's receiver, the receiver itself is unable to compute its distance from the satellite since its local reference time is different from the satellite one, that is, from the GPS reference time. On the basis of the reception epochs on the user time scale and of the relative delays between navigation messages originating from distinct satellites, the so called pseudoranges can be estimated. Assume that the considered GPS user receives the navigation messages from *N* distinct satellites, that is, from another orbit, the pseudorange, ϑ_i, evaluated on the basis of the message coming from the i^{th} satellite is expressed as follows:

$$\vartheta_i = d_i + cb_u + \epsilon_{\rho_i} \qquad 6$$

$$d_i = \sqrt{(x_u - x_i)^2 + (y_u - y_i)^2 + (z_u - z_i)^2} \qquad 7$$

where d_i denotes the geometric range between the GPS receiver having coordinates (x_u, y_u, z_u) and the satellite having coordinates (x_i, y_i, z_i); c is the speed of light; b_u denotes the clock bias between the receiver and satellite; ϵ_ρ is the composite error. The composite error of the ith satellite is expressed as follows:

$$\epsilon_\rho = \epsilon_b + \epsilon_r + \epsilon_n + \epsilon_m + \epsilon_q \qquad 8$$

ϵ_b, ϵ_r, and ϵ_n are the orbital error, the error due to the troposphere delay and the error due to ionosphere delay respectively.

ϵ_m is the pseudorange multipath effect.

ϵ_q is the measurement noise in the pseudorange.

Multi Camera Surveillance System

Internet Protocol (IP) based cameras are used for the visual tracking of HR. The cameras are to provide visual images of HR while in the workplace. IP cameras are installed in both indoor and outdoor environments thereby giving a multi-camera tracking platform. The use of the camera is expected to provide a system for the recognition of HR while in the workplace and thereby revealing the presence of non-HR or unauthorized persons in the work environment. In order to implement the tracking and recognition module, the adaptive background updating is exploited to detect the moving object in an image sequence captured by each camera. At first, all pixels of an image are classified into background and foreground. Then, each threshold of the R, G and B color channels is derived and used to generate the complete foreground regions. In general, the foreground (that is, moving people) segmentation will be mainly affected by the person’s shadow and illumination changes, because they will generate the non-determined pixels, called fuzzy pixels. By analyzing characteristics of shadow pixels, the proposed method classifies those fuzzy pixels into the main background pixel, background-shadow pixel, light background pixels, and main-foreground pixel. The system has three sub-systems and these are:

Feature extraction model

In this system, the features of the moving HR are extracted and labeled with the feature colour vector, in order to identify and track each person. Based on the human visual system, colour is the most perceivable feature of a person, the Hue Saturation

Intensity (HIS) colour space model is very suitable because the hue component is intimately related to the way in which human beings perceive colour. In human visual system, the image intensity or colour can be used to distinguish persons. Thus, the average saturation (AS) is calculated and used to check if the people image is colour-oriented or gray level-oriented. The saturation of the captured image is compared with the saved images in the database to find out the best similarity.

Spatial location

Because moving HR always has a certain direction and trajectory, it is allowable to record the initial appearing location and the trajectory of person for enhancing the tracking ability. If the relationships among all camera surveillance are given, that is, whether they are all distinct or overlapping, it can predict that the person will appear in which camera surveillance.

Human tracking

This system keeps track of the movements of HR and the time stamps for all the images captured in a log.

Microcontroller

Readings from the indoor, outdoor, camera and signal-denied areas are integrated by the microcontroller. A microcontroller is a self-contained system with peripherals, memory and a processor that can be used as an embedded system. The schematic diagram for microcontroller is shown is Figure 8.

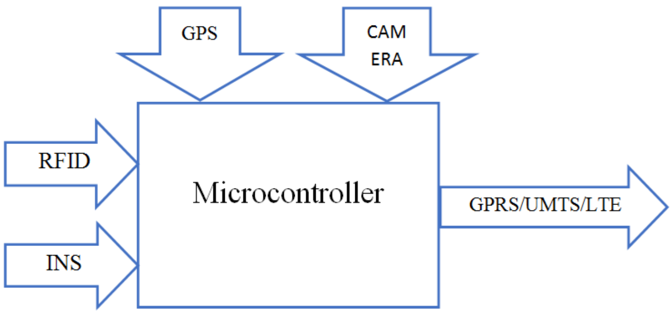

Figure 8 Microcontroller

Hybrid Location Engine

The hybrid location engine is the core of the positioning and tracking system and is the centralized location engine where hybrid positioning algorithm is implemented to periodically estimate the positions of all the unknown mobile nodes. A typical mobile node is equipped with a global-tag which has GPS receiver, RFID tag and sensor badge as shown in Figure 9. Four different observations (RSSI measurements derived from RFID readers, ephemeris coordinates

Figure 9 ST-694 Globaltag

data from GPS receivers, images from the camera and sensors data) are sent to a context database (DB) server as shown in Figure 10.

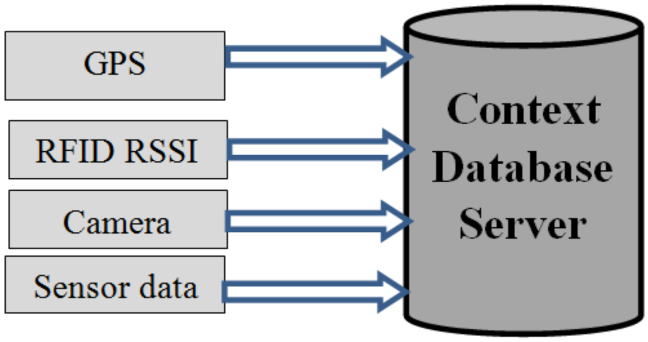

Figure 10 Context Database Server

The main task of the hybrid location engine is to estimate the positions of mobile users. For multiple sensors integration, there are essentially two general models: loosely-coupled and tightly-coupled. The loosely-coupled model, shown in Figure 11, uses a decentralized filter that has several sub-filters to process the sub-systems independently.

In other words, the solutions from the positioning sub-systems are combined in a Kalman filter that provides integrated navigation solution. In contrast, the tightly-coupled model as shown in Figure 12 uses a single main filter to process the output of all sensors. In GPS/RFID/INS integration, tightly-coupled systems have obvious advantages especially in environments where GPS signals are frequently lost, because they can rely on other sensors when GPS positioning becomes impossible. In the tightly-coupled model, the raw observations of all sensors will be input to the main filter.

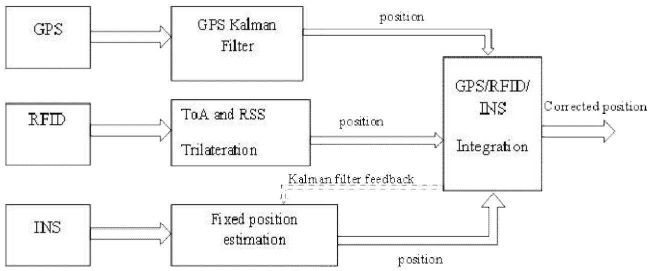

Figure 11 Loosely Coupled Model

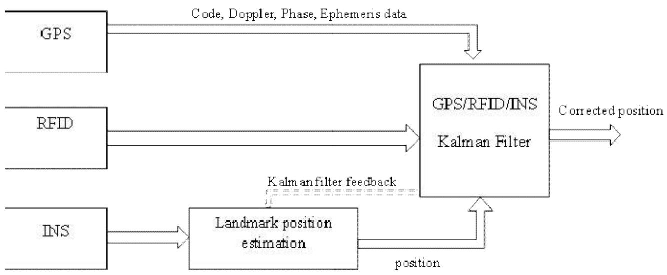

Figure 12 Tightly coupled model

The flow diagram for the hybridization is shown in Figure 13. In every change in time for every node, denoted by ΔT_n, it completes the following processes:

Location information reading. At the beginning of each time step ΔT_n, the hybrid location engine queries the database for the unique device ID and corresponding category (for example, GPS, RFID, Camera or Sensor). For each device there is a flag which indicates if it is fixed or mobile. A fixed device may be either a RFID reader or a Sensor reader whose positions are perfectly known and are stored in the database; while a mobile device is a movable node whose position is not known. In addition, the device association information is read.

Measurements reading. During this step, the hybrid location engine reads available observations such as GPS Ephemeris data, RFID tag, camera images and sensor detection events from the database and the time interval is chosen from previous time ΔT_n to current time t_k, that is, $[t_k - \Delta T_D,\ t_k]$, where ΔT_D is the width of the temporal window. In general, ΔT_D is set equal to position update time step ΔT_n, so that all the observations are used only once.

Position estimation. In this step the hybrid location engine estimates the positions of mobile nodes by using location information and measurements which are provided by the two previous steps. Since the sensor readers are only installed at strategic points which serve as landmarks where there are no GPS and RFID signals, they provide only sporadic detection events. In most of the time, the hybrid location engine relies on GPS measurements from the satellites, RFID events and image data from the multi-camera system for localization. In order to have a good estimate of a mobile position, the location engine adopts a hybrid cooperative tracking algorithm which takes into account all the available observations, that is, GPS measurements, image data and RFID tag detection events. At the end of the estimation process, the estimated position is displayed on the map and are uploaded to the Database server with a time stamp that shows the exact time the reading was taken. The periodic repetitions of these three steps form the whole procedure of the hybrid location engine.

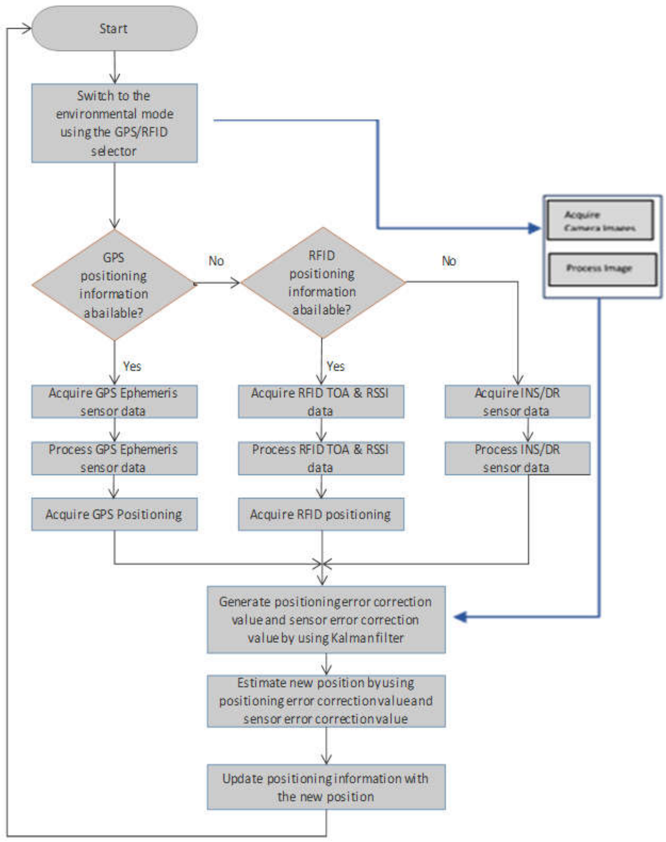

Figure 13 Hybridization Flow Diagram

CONCLUSION

This paper focuses on the design of the framework for heterogeneous positioning and localization of HR in the workplace. It presents the model for integration of different technologies for both indoor and outdoor monitoring. The stated model when implemented will ensure safety of employees in the workplace and will provide real-time information about the whereabout of employees to organizational leadership in time of emergencies while at the same improving productivity. Further research shall include the implementation of the model and evaluation of the system.

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