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Indoor Positioning of Workers and Monitoring Climatology in Mines Using FM with RSSI

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ABSTRACT: Location based services are becoming a most useful technology in our day-to-day life. Wide utilization of Global Positioning System (GPS) in devices like mobile phones combined with Wi-Fi and cellular networks have solved the problem of outdoor positioning or localization and emerged as a market trend. This, however, is the case only for outdoors. There are many areas, which require the knowledge of user position in indoors. Awareness of user's location is important in such areas as smart environments, assisted daily living, behaviour analysis studies. The main objective of this thesis was A Dedicated RF Frequency Carrier with Modulated Signal is used for mapping the Movement of Object or Human being. The performance of indoor localization using FM transmitter and receivers are compared with Wi-Fi based indoor positioning which has significantly lower Frequency range when compared to FM.

KEYWORDS *- Indoor positioning, indoor localization, embedded system, RSSI.*

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I. INTRODUCTION

Positioning systems is one of the most used techniques since the ancient guiding-star navigation. Since technologies like GPS (Global Positioning System) has been arrived for outdoor positioning. Mobile devices with GPS receivers made the technology available to wide applications based on positioning. However, there are many pervasive computer applications, which can benefit from indoor, where GPS signal is too weak. Indoor location awareness is important for such fields as ambient intelligence, assisted daily living, behaviour analysis, social interaction studies, and myriads of other context-aware applications. Despite the substantial research and development efforts, the existing indoor positioning systems remain too limited for wide adoption. The current de-facto standard, Wi-Fi based localization, has a limited coverage. In previous work, RSSI values of Wi-Fi signals have been primarily used for this purpose, as Wi-Fi access points are widely deployed indoors, and every mobile device is equipped with a Wi-Fi receiver.

Although this approach has been successful in localizing people at a coarse grain (e.g., at the building level [5]), it exhibits several limitations when considering indoor environments where a person needs to be localized at the room level. First, the operating frequency range of Wi-Fi signals makes them susceptible to human presence and orientation as well as to the presence of small objects in room. This introduces variability in the recorded fingerprints that can lead to localization errors. Secondly, several of the deployed Wi-Fi access points are commercial in nature and employ optimizations, such as frequency hopping, to improve network's throughput. These optimizations can result in variations in the observed received signal strength (i.e., RSSI values change across Wi-Fi channels), and therefore in the localization process. Thirdly, Wi-Fi RSSI values exhibit high variation over time that, as we show in this paper, can adversely impact localization accuracy. Fourthly, the area of coverage of a Wi-Fi access point is significantly reduced in indoor environments due to the presence of walls and metallic objects, easily creating blind spots (i.e., basement, parking lots, corner rooms in a building, etc.).

Table 1
Basic Properties of Wi-Fi and FM Broadcast Signals

Signal	Frequency	Range	RX Power
Wi-Fi	2.4 GHz, 5 GHz	30m indoor 300km outdoor	800 mW
FM	88-108 MHz		40 mW

To address these limitations, FM radio is a popular and well-established technology. Broadcasting FM stations provide almost ubiquitous worldwide coverage, while short-range license-free FM transmitters are available at low cost from conventional supermarkets. FM receivers also have low power consumption and do not interfere with sensitive equipment or other wireless technologies. The described features make FM radio a powerful option for a positioning system. No works have been published about indoor positioning using FM radio. The outdoor results cannot be directly projected onto indoor scenario, as indoor and outdoor environments are different with each other. Since technologies like GPS, signals cannot be used in such areas, which are below the surface level like mines and underground. Therefore, FM signals have features of penetrating through walls and can be used in any area even below the surface level.

Some examples of embedded systems are automobile control systems industrial processes control systems, mobile phones, or small sensor controllers. Embedded systems cover a large range of computer systems from ultra small computer-based devices to large systems monitoring and controlling complex processes. The extraordinary number of computer systems belongs to embedded systems: 99% of all computing units belong to embedded systems today.

II. INDOOR POSITIONING TECHNIQUES

1. Trilateration.

In geometry, trilateration is the process of determining absolute or relative locations of points by measurement of distances, using the geometry of circles, spheres or triangles. In addition to its interest as a geometric problem, trilateration does have practical applications in surveying and navigation, including global positioning systems (GPS). In contrast to triangulation, it does not involve the measurement of angles.

In two-dimensional geometry, it is known that if a point lies on two circles, then the circle centres and the two radii provide sufficient information to narrow the possible locations down to two points.

In three-dimensional geometry, when it is known that a point lies on the surfaces of three spheres, then the centres of the three spheres along with their radii provide sufficient information to narrow the possible locations down to no more than two.

Thus, the detailed explanation of the process of trilateration is given in the diagram as follows:

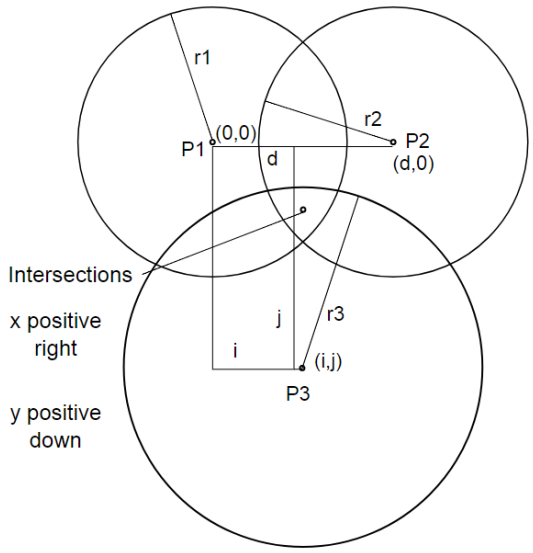

Fig.1 Trilateration

2. Time based multi-Lateration:

Time-based methods leverage the fact that the distance travelled by a signal is proportional to the propagation time. There are two main approaches based on timing information: Time of arrival (TOA) approach requires that the client device and the beacons are accurately synchronized. For localization, the client device transmits a time stamped signal; when the beacons receive this signal, they calculate its travel time and thus the distance to the mobile unit. Three beacons are required to perform 2D positioning. The major drawback of the TOA approach is the need for precise synchronization of all the devices. Time difference of arrival (TDOA) method uses the difference of time it takes the signal from the client to reach each of the synchronized beacons. Each time-difference measurement defines a hyperbolic line with constant distance difference between a pair of beacons; this curve specifies the possible locations of the client. Thus, two TDOA measurements (three beacons) are sufficient to acquire 2D position of the mobile unit. Clearly, the reverse approach is also possible, where the client receives time stamped signals from the beacons with known positions. The most prominent example of this class of methods is the Global Positioning System (GPS) [13], where the mobile receivers estimate their location using time stamped signals from synchronized satellites and information about satellites movement (ephemeris)). Using the signals from a set of GPS satellites, a basic GPS receiver is able to compute its position with the accuracy of about 8 m [13, p. 22]. Unfortunately, GPS signal is too weak in buildings, which make the system inoperative indoors.

3. Received signal strength indication (RSSI).

RSSI is a measurement of the power level received by sensor. Radio waves propagate according to the inverse-square law, distance can be approximated based on the relationship between transmitted and received signal strength (the transmission strength is a constant based on the equipment being used), as long as no other errors contribute to faulty results. Inside of buildings is not free space, so accuracy is significantly decreased by reflection and absorption from walls. Non-stationary objects such as doors, furniture, and people can pose an even greater problem, as they can affect the signal strength in dynamic, unpredictable ways.

III. PROBLEM DEFINITION

In our existing system of indoor positioning system a Wi-Fi, based system with ZigBee is used for positioning along with the trilateration algorithm. In this the distance is obtained only when access points are localized in existing systems since lots of access points are required to get the accurate position. Many authors have proposed that there are few distance and loss errors in Wi-Fi based indoor positioning system. Wi-Fi signals do nothave the potential to penetrate through walls and it will not be supported in multi-floor architecture. The range of Wi-Fi signals can be extended up to 25km but shorter when compared to FM signals

Limitations of Existing System:

- The existing systems with ZigBee for positioning which has a shorter Range.
- Trilateration with or without WBI algorithm.
- Gives the distance only when access points are localized in existing systems.
- Many authors have proposed that there are few distance and loss errors.

IV. PROPOSED SYSTEM

In our proposed paper, it explains that Localization using RSSI overcomes the previous errors. RSSI is a specialized mapping algorithm that converts signal strength to the corresponding distance.

Signal Strength$1/\propto$Distance

Localization of client's distance, path-using RSSI gives an accurate measurement. Along with this Climatological, information like humidity, temperature, light (LUX value) poisonous gas and voice over communication along, guide waveforms are provided. In our method RSSI is used for positioning since, FM signals could not be disturbed by physical obstacles and has a high penetration power, FM waves has a range longer up to many kilometres, it also supports for multi floor environment.

In our project, it was implemented for the people working on the mines. Mining activities is one of the dangerous jobs in which people will work deep under the earth surface level many technologies has been implemented for the purpose of mining, this is also one of them which is implemented by considering the labour safety who are working inside the mines. In the existing system of Wi-Fi based indoor positioning System it will not be suitable for using in mines as per the limitations it doesn't support multi-floor, has shorter range and does not have potential to penetrate through walls Therefore, FM signals is incorporated to do this since it has all the above abilities. In mining activity, several risks may occur like lack of oxygen, low lighting, poisonous gas attack and internal collisions due to vibrations. In such case of any accidents, indoor positioning will be very useful to track the labour inside the mine and help them or even alert them using voice over communication.

VI. HARDWARE USED

1. PIC16F877A (Microcontroller).

Here we are using a 40 pin DIP (Dual inline Package) 8-bit Microcontroller. It has 5 ports A,B,C,D,E in which B,C&D are Digital ports where A & E act ad both Analog and Digital ports. Since limited interfaces are required hence microcontroller will be efficient for limited interfaces. it performs the operation of collection of data from various sensors for climatology monitoring and distance calculation is done with the help of this microcontroller using FM Rssi. It doesn't need an additional memory since it has an inbuilt 8kb flash memory and it is active high.

Fig 2. PIC16F877A Microcontroller

Features:

- High-performance RISC CPU
- Only 35 single word instructions to learn
- All single cycle instructions except for program
- branches which are two cycle
- Operating speed: DC - 20 MHz clock input DC -
- 200 ns instruction cycle
- Inbuilt Watch Dog Timer
- 4K x 14 words of Program Memory,256 x 8 bytes
- of Data Memory (RAM)

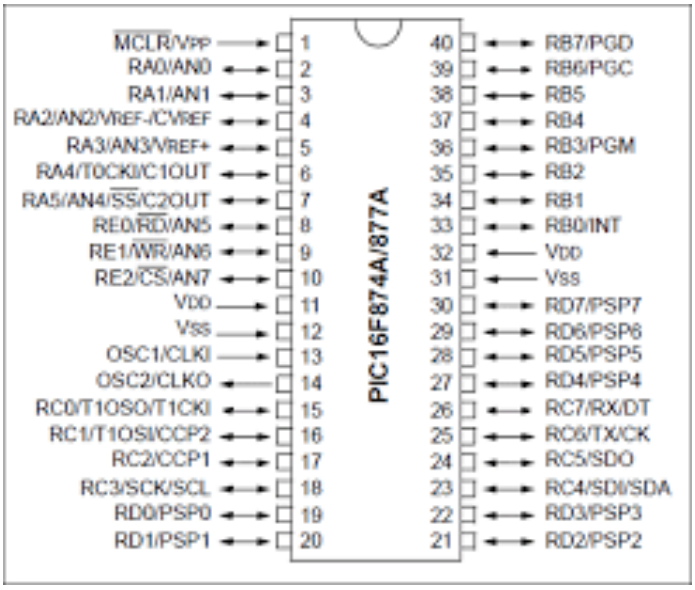

Fig 3. PIC16F877A Microcontroller Pin-Diagram

2. RS 232:

- The most common communication interface for short distance is
  RS-232. RS-232 defines a serial communication for one device to one
  Computer communication port, with speeds up to 19,200 baud.

- Typically 7 or 8 bit (on/off) signal is transmitted to represent a
  character or digit. The 9-pin connector is used. The pin detail is given
  below.

Electrical characteristics of MAX232:
Vcc= 6v V+ = 12v V- = 12
Input voltage :
T1in,T2in : -0.3 to (Vcc + 0.3v)
R1in,R2in : +30v or –30v
Output voltage:
T1out, T2out : ((V+)+0.3v) to ((V-)+0.3v)
R1out, R2out : -0.3V to (Vcc+0.3V)
Power dissipation : 375mW
Output resistance :300Ω

3. SENSORS

Temperature sensor:
A temperature sensor is a device, typically, a thermocouple or RTD, that provides for temperature measurement through an electrical signal. A thermocouple (T/C) is made from two dissimilar metals that generate electrical voltage in direct proportion to changes in temperature.**23 °C** is the normal room temperature. If the temperature changes, then the people in the area will be informed.

Humidity sensor:
A humidity sensor (or hygrometer) senses, measures and reports the relativehumidity in the air. It therefore measures both moisture and air temperature.The ideal relative humidity for health and comfort is about 40-50%.

Light sensor:
A light sensor is an electronic device used to detect light.It is formed with the help of a Thermistor and an LDR.
It measures the light of a room with respect to its dimensions.

Smoke sensor:
A smoke sensor senses the smoke and other poisonous gases such as carbon monoxide, carbon dioxide, etc.,. If the smoke value increases, the people in the particular area will be alerted.

V. WORKFLOW

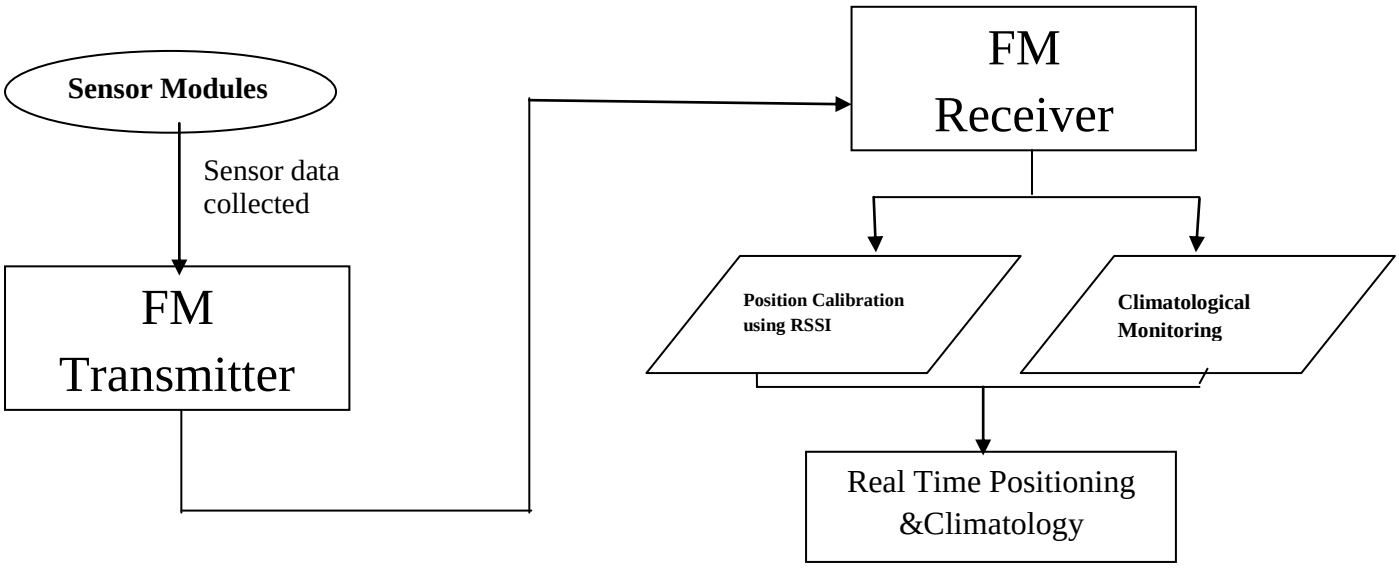

Fig. 2 Flow graph for Indoor positioning.

VI. WORKFLOW DESCRIPTION

Initially the sensors data will be collected from different sensor, the collected data will be transmitted to the admin receiver side Fm receiver it collects the data and performs two operations Position Calibration and Climatology Monitoring. In Position Calibration Module it will detect the signal strength which is Received Signal Strength by using the rssi value it will calibrate the position of workers or objects inside the mines since the carried frequency will be the same for the entire mine and modulated frequency changes for every person according to that it will identify the person information and also real time positioning is shown in admin desktop.In the other hand climatology module will gather the sensor information and check for it value with the given limitation value if it exceeds the limit an alert will be send to the admin desktop (ex. If the temperature increases than the given limit which is human can bear it will send a message to admin desktop as “the temperature is high near the person location). And also it updates the climatology data continuously in admin desktop.

VII. COMPUTER APPLICATION

The Monitoring and Real Time positioning of workers are done using the computer application, which has been created. The computer application has been designed in the Windows platform. The Computer Application uses the database for Calibration and external embedded device for

acquiring the data from the labour. The Technique of RSSI calibration is used for positioning the objects or people inside the Mines. The application will shows the information of temperature, humidity, vision (LUX) value, oxygen and vibration level near the worker and it has a 3D structured map of the mine that is used for real time positioning.

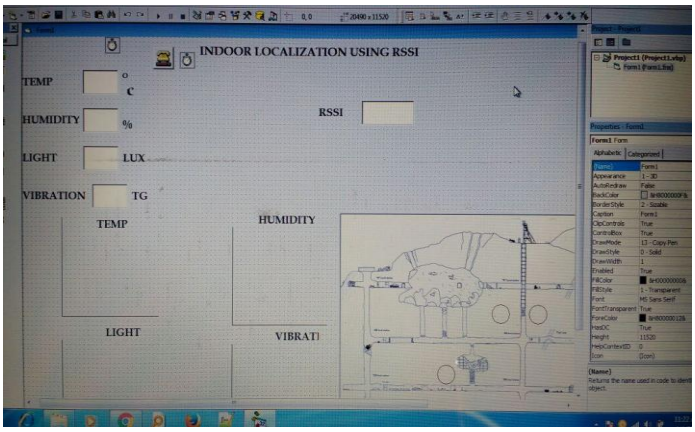

Fig. 3 Computer Application

Conclusions

The concept of the Indoor Positioning System using FM RSSI is presented. The various Technologies, which is used in Indoor Positioning, have been discussed. The Positioning System using FM RSSI will be the life saving technology for the labour of mines. It is very cost efficient when compared to other Technologies.Digital proof will be recorded of entire path for everyone. It will be useful at a time of disastrous happening.

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