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Three Dimensional Location Tracking in Container Shipment Area Using WSN

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Abstract

Wireless Sensor Network based location tracking is always a concerned area in shipping industry, construction and material location in stacks. The WSN based 3D location tracking algorithm can be used to track and analyze the possible location and it can identify the target object both in indoor and outdoor environmental area. The Received Signal Strength indication is useful for calculating the distance between transmitter and receiver. The location of the Transmitter is calculated with help of gradient descent method. This paper propose a real time WSN based 3D location tracking algorithm that can be used to gradually locate towards the exact location of the target object and enhancing management, safety for the shipping industries.

Keywords: *3D Location Tracking, Trilateration, Friendly ARM, RSSI, ZigBee, Wireless Sensor Network*

1. Introduction

The Shipment industry must manage large numbers of Shipment workers, costly materials, and a variety of container equipment. To successfully manage projects, the shipment manager requires effective monitoring of container movements, container locations, and container equipment. WSN is one of the major technologies of the twentieth century, owing to its durability, rich data capacity, repetitive read/write, and non-contact features, which has become a new technology for enhancing container management in shipment areas. In recent years, researchers have actively used WSN technology in location tracking. The developed results are applicable in assisting shipment managers in locating the positions of relevant container, equipment, apparatus and materials, enhancing management efficiency.

1.1 Wireless Sensor Network Technology

Wireless sensor network (WSN) refers to a group of spatially dispersed and dedicated sensors for monitoring and recording the physical conditions of the environment and organizing the collected data at a central location. WSNs measure environmental conditions like temperature, sound, pollution levels, humidity, wind speed and direction, pressure, etc. WSNs were initially designed to facilitate military operations but its application has since been extended to health, traffic, and many other consumers and industrial areas. WSN consists of anywhere from a few hundreds to thousands of sensor nodes. The

sensor node equipment includes a radio transceiver along with an antenna, a microcontroller, an interfacing electronic circuit, and an energy source, usually a battery.

1.2 ZigBee Technology

ZigBee protocol provides an open standard for low-power wireless networking of monitoring and control devices. ZigBee was created for applications that require low cost and low power, but with the need for a large degree of flexibility. ZigBee uses the IEEE 802.15.4 physical and MAC layers to provide standards-based, reliable wireless data transfer. ZigBee was created to satisfy the market's need for a cost-effective, standards-based wireless network that supports low data rates, low power consumption, security, and reliability. ZigBee adds network structure, routing, and security (e.g., key management and authentication) to complete the communications suite. ZigBee uses the license-free ISM bands, which provide unrestricted geographic use.

The new standard targets home and building control, automation, security, consumer electronics, PC peripherals, medical monitoring, and toys. These applications require a technology that offers long battery life, reliability, automatic or semiautomatic installation, the ability to easily add or remove network nodes, signals that can pass through walls and ceilings, and low system cost. ZigBee and the underlying 802.15.4 standard offer the system designer several classes of devices: the reduced-functionality device (RFD), the full-functional device (FFD), and the network coordinator. All ZigBee networks have at least one RFD or FFD and a network coordinator. Most sensor applications fall natively into the RFD class, with extended networks making use of both FFDs and network coordinators to form bridges and links required by the network topology. ZigBee networks can form autonomously, based on connectivity and function.

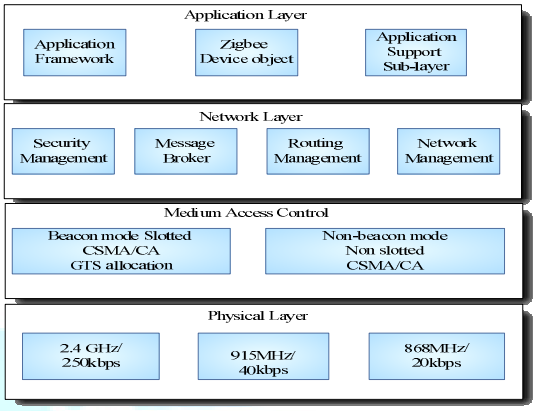

Figure 1. ZigBee Architecture

2. Location Tracking Methods

Automatic location tracking system that automatically detects and tracks the location of the target. Accurate location information is important for location-based service. Increasing commercial use of the wireless sensor network technology will soon make it possible to locate anything, anywhere, anytime. The Wireless sensor technology can provide extremely accurate location information for target objects tracking techniques. Location based technology is an emerging application field that uses the physical, geometric, and logical location information about people or objects.

The Proposed location tracking method by implementing it for a real-time Container tracking system in a noisy and complex shipment area. It reduces the Computation time and enhances the operational efficiency. This WSN 3D Location tracking algorithm can be used for tracking packages in storage environment and personal tracking in pervasive environment. Location tracking refers to the attaining of the current position of an object, stationary or moving. Wireless sensor network concepts frequently used in location tracking are trilateration and triangulation. There are two types of wireless sensor network concepts frequently used in location tracking are trilateration and triangulation.

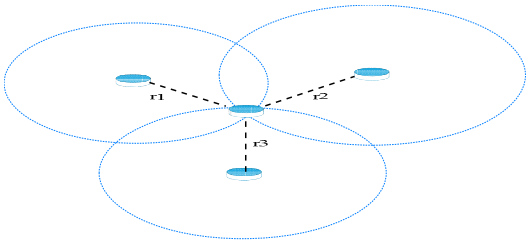

Figure 2. Trilateration Location Tracking Method

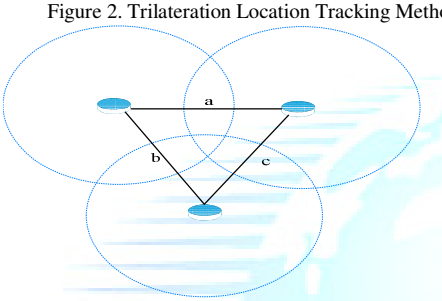

Figure 3.Triangulation Location Tracking Method

3. Proposed Work

This work develops WSN based three dimensional location tracking algorithm in real time. The distance between the sender and receiver is measured using RSSI which is given from XBee motes. Eight XBee motes are being located at the eight corners of the sensing location, Since the containers are cuboidal in nature the location sensing area is also taken as cuboidal in type. Each container in the sensing algorithm is allocated different frequencies for communication purposes.

The target container is communicated with the allocated frequencies with the eight sensor nodes and the RSSI value of the eight sensor nodes is being calculated and used in the following algorithm. When the RSSI value of the XBee motes are low or zero, the target is not located in that specified area. The RSSI Value of Three antennas are taken for computing the location of the target. The RSSI output is always analog and is given to GPIO port of ARM 9, it acts as an ADC. Finally we get Result in Digital Form. Based on the RSSI value we find the distance between Transmitter and Receiver. If RSSI Value is high, distance between Transmitter and Receiver is low. Same as RSSI value is low, distance between Transmitter and Receiver is high.

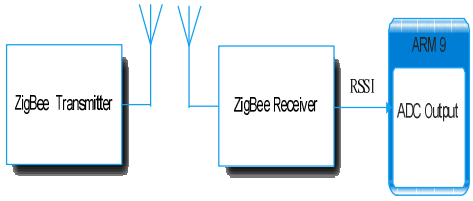

Figure 4. Block Diagram for RSSI Measurement

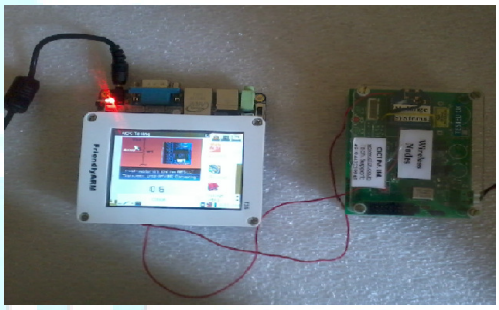

Figure 5. Real time RSSI Measurement

3.1 Three-Dimensional (3D) Location Tracking Algorithms

Trilateration location concept coupled with WSN technology is used to design a 3D location tracking methodology. Compare with existing algorithm it satisfies following thing, it includes no need for no of reference object, and also manage the power management.

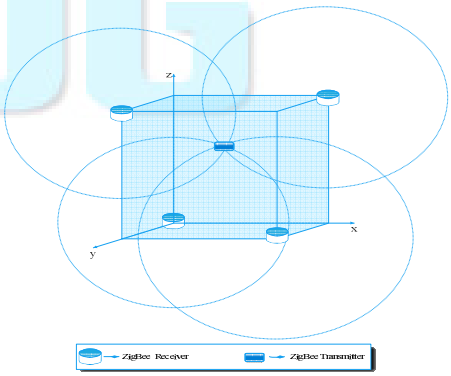

Figure 6. Three Dimensional Wireless Sensor Network

Figure 7. Real time WSN Based Three Dimensional Location Tracking

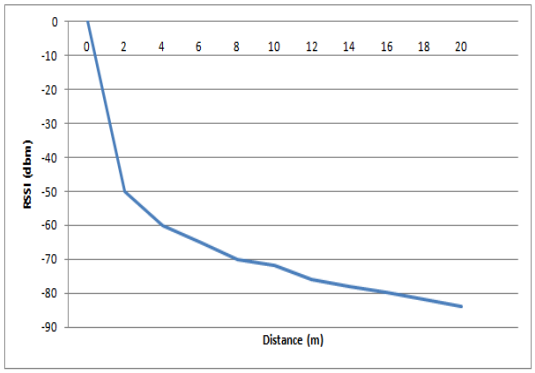

Figure 8. RSSI versus Distances

3.2 Location Tracking Algorithm Procedure

Received Signal Strength Indication (RSSI) is a measurement of the power present in a received radio signal. The received signal strength is a function of the transmitted power and the distance between the sender and the receiver. The received signal strength will decrease with increased distance as the equation below shows.

$RSSI = -(10\, n \log_{10}(d) + A)$ ---------- (1)

- n: signal propagation constant, also named propagation exponent.
- d: distance from sender.
- A: received signal strength at a distance of one meter.

Wireless Signal Attenuation Curve is used to calculate the distance between the ZigBee Transmitter and ZigBee Receiver. The distance between Transmitter and Receiver is measured by employing the wireless signal attenuation with distance principle. RSSI is a signal or circuit that indicates the strength of the incoming (received) signal in a receiver.

3.3. Algorithm for distance Calculation

Input: Initialize Location

(x_k, y_k, z_k) ←Co-ordinate of ZigBee Receiver.

(x_i, y_i, z_i) ←Initial Co-ordinate of ZigBee Transmitter.

Output: Target Location

(x_t, y_t, z_t) ←Actual location of ZigBee transmitter

Begin Process

Calculate Distance of ZigBee Transmitter.

$$\tilde{s}_{ik} = \sqrt{(x_i - x_k)^2 + (y_i - y_k)^2 + (z_i - z_k)^2}$$

S_{ik} = RSSI = $-(10n\log_{10}(d)+A)$

Calculate the Error In Between ZigBee Receiver and ZigBee Transmitter.

$e_{ik} = (S_{ik} - \tilde{s}_{ik})$

If (eik< 0.1)

Plot the ZigBee Transmitter Location Co-ordinate in 3D.

Else

Loop Repeated Until finding the Location of ZigBee Transmitter.

$x_{(i+1)}=x_i+\Delta x_i$, $y_{(i+1)}=y_i+\Delta y_i$, $z_{(i+1)}=z_i+\Delta z_i$

$\Delta x_i = \alpha_x\ x_i\delta_{ik}$, $\Delta y_{i,}= \alpha_y\ y_i\delta_{ik}$, $\Delta z_{i,}= \alpha_z\ z_i\delta_{ik}$

$\delta_{ik}=\xi_{ik} \times e_{ik}$

End process

e_{ik} ← Distance Error Between ZigBee Transmitter and ZigBee Receiver.

S_{ik} ← Distance Between the ZigBee Transmitter i and ZigBee Receiver k.

ξ_{ik} ← Straight Line Distance Between ZigBee Receiver and ZigBee Transmitter.

δ_{ik} ← Gradient.

$\alpha_x = \alpha_y = \alpha_z = 5\times10^{-5}$ ←Adjustment Rates.

4. Algorithm Verification

To verify the performance of the proposed WSN based efficient 3D location tracking for Container Shipment, an actual case was carried out in a location space (10m in length, 4m in width, and 8m in height). The actual target object coordinate is (6m, 3m, 5m). In the central initial point case, the convergence courses along the x, y, z-axis are simultaneously adjusted and approach the actual coordinate. Fig. 9 displays the convergence trend, and Fig. 10 displays the spatial location tracking for target Object.

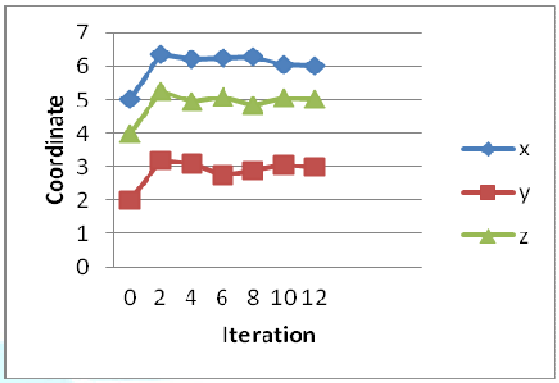

Figure 9. Convergence trend (center initialization)

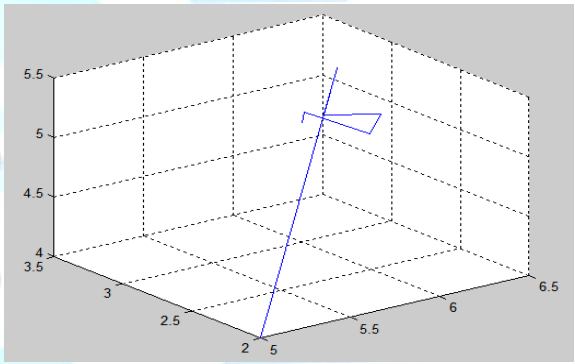

Figure 10. Location tracking (center initialization)

5. Conclusions

This paper employed the trilateration concept to develop a WSN based location tracking algorithm Using gradient descent method for shipping areas and other outdoor target locating applications. The performance of the proposed algorithm was verified using a real Case. The proposed algorithm proves itself to be robust and accurate in location tracking of the target node with a less number of convergences. The target node is located within less computation and within less duration.

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