RFID 3D Location Sensing Algorithms

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This invention is related to a RFID tag, particularly, to a positioning method using an algorithm.

Introduction

Nowadays, communication over wireless technique is widely applied on our daily lives. It brings us extreme convenience and usefulness on many aspects. Positioning is an example of applying the wireless technique. The known techniques about positioning include global positioning system (GPS), Cell identification, infrared, IEEE 802.11, supersonic, Ultra-wideband, Zig-bee, radio frequency identification (RFID), etc. GPS provides precisely positioning with low cost, however, it is appropriate for outdoor use only. Cell ID and super-wide band are apt in large district positioning. Infrared position is known for environmental interference-prone and high cost for apparatus installation. The performances of IEEE 802.11 and Zig- Bee techniques in positioning have been found not as good as expectation. Cost for constructing a supersonic positioning system is usually expensive.

RFID positioning system is an automatic identification system without direct contact. The RFID tag broadcasts radio frequency out so as to transmit identification message. An identification system is composed of RFID tags and readers. Each RFID tag contains a circuit thereon so that a reader can access the information written on the RFID tags in distant using radio frequency. RFID tag essentially is a silicon chip with a simple antenna formed thereon and then capsulated by glass or plastic film.

A RFID system for indoor positioning was first proposed by HighTower and Borriello in 2001. The research developed a SpotON positioning system to verify the feasibility of using RFID in indoor positioning. In the method of SpotON, unknown positions are not processed by the central control console but are approached by many local detectors. The respond signals, i.e. RSSI (radio signal strength indicator), transmitted from many local detectors distributed in the environment are collected. The RSSI is then analyzed by a positioning algorithm to determine the positions of the article.

RFID positioning is especially apt to indoor use by taking advantage of low cost for system setup. In 3-D (three dimensional) space, for positioning a target RFID tag, one RFID antenna can constitute a sphere surface only and two RFID antennas can constitute a joint area of two spheres. The third additional antenna can further position the target to two possible answers. To obtain a merely reasonable solution, four antennas are generally demanded.

Referring to FIG. 1, it shows three signal transmitter (or stations) with known positions provided to locate a target tag. Each base transmitting a radio signal outward constitutes a sphere as is shown in figure. The coordinate of the transmitters are respectively, located at (X=0,Y=0), (X=1,Y=0), and (X=3,Y=0). The coverage radiuses of them are r1, r2, and r3, respectively. The unknown position can be determined by the intersection of them. With the same concept, utilizing four transmitters to transmit signals are generally called Multilateration.

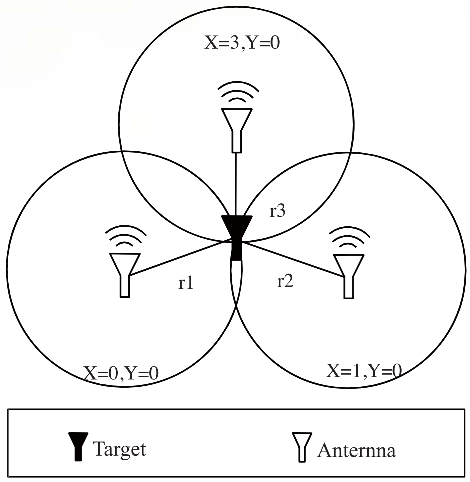

Fig. 1 Trilateration schema

Detailed Description

RFID reader including an antenna can be used to read radio frequency strength indicators (RSSI) emitted from the RFID tags. By means of RSSI, the distance can be determined but the precise position is still unknown. Thus as forgoing description in the background of the invention, at least three antennas are needed (but two positions may still occur).

The present invention utilizes RSSI of the target tag and reference tag to calculate the distance between the reader and the target tag. The present invention provides an algorithm called SPA thereby spatially positioning the RFI D tag. Please refer to FIG.2. It shows a flow chart according to the algorithm of the present invention.

Verification

To verify the feasibility of the aforementioned algorithm (SPA) for spatially positioning, a simulation flow is run. In the experiment, a space with a size of 926cm ×535cm ×211cm is assumed and the target tag is placed at the coordinate (694 cm, 400 cm, 75 cm).

At first, the initially coordinate is set at (1,1,1). The search tendency of the SPA 1.0 algorithm is shown in FIG. 3. In FIG. 3, the curves of x, y, and z represent the distribution values in each iteration. The parameters of α_x,α_y,α_z are setas $\alpha_x = \alpha_y = \alpha_z = 5\times10^{-5}$. Viewing from FIG.3, the initial x and y coordinates are far from the x and y coordinates of the target tag so that the convergent processes shows them approaching the true x, and y coordinates initially. After the tendency of x and y coordinate approaching stable, the convergence of z coordinate starts. The tendency of the error versus iterations is shown in FIG.4. In FIG.4 it shows the method using steepest gradient correction can be successfully used in the spatial positioning. The 3-D variations are shown in FIG. 5. In Fig.5, the trace shows that the estimated coordinates are gradually converged to the target position.

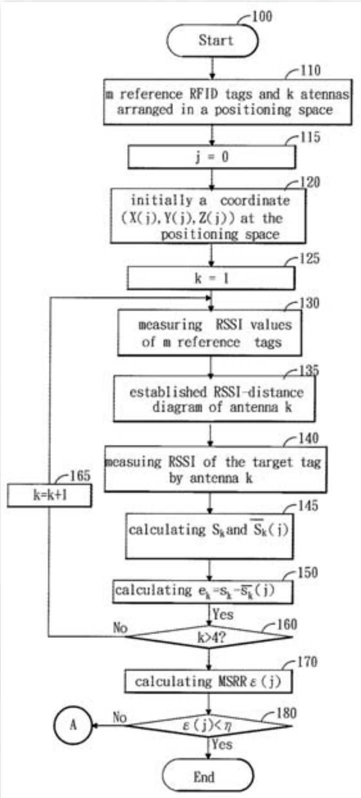

Fig. 2 Algorithm procedure

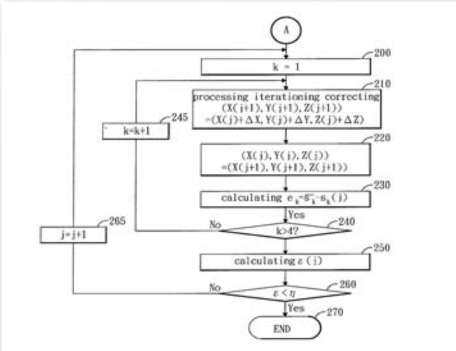

Fig. 2 Algorithm procedure (continued)

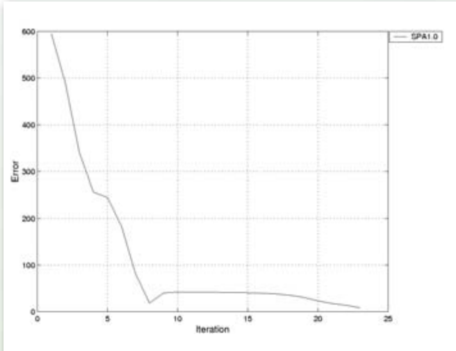

Fig. 4 Error convergence

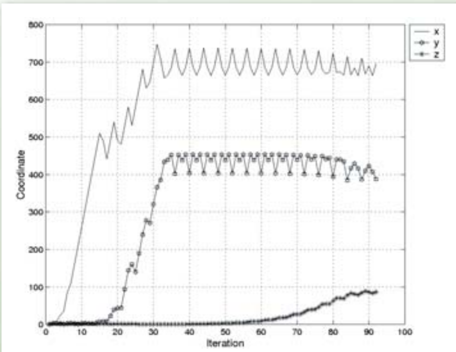

Fig. 3 Searching trends

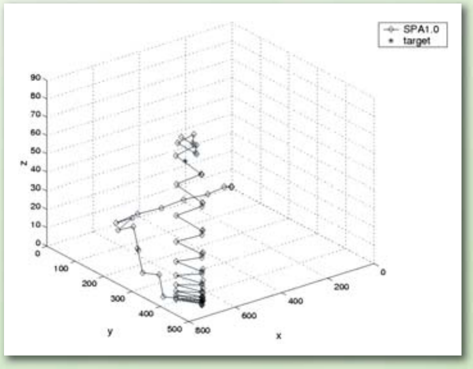

Fig. 5 Convergence tracks

Acknowledgments

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