Accurate Bluetooth Positioning Using Large Number of Devices Measurements

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Abstract—**In this paper it considers using the built-in Bluetooth in the cellphone as the positioning device; it is able from the measured RSSI (Received Signal Strength Indication) strength to locate the target or the cellphone position. From experimental measurements using Bluetooth positioning technique in various environments we measure signal fading condition and propose signal fading model; three-point localization method is then developed to determine potential target locations. We propose a specific processes, it is to generate more test points, are then exploited to choose the near points and to determine the target final location. With the processes it is possible by using Bluetooth technique to reduce the distance determination error down to 1 meter range.**

Index Terms—**Bluetooth; Positioning System; Cellphone; Accuracy Positioning;**

I. Introduction

When GPS or Wi-Fi (Wireless Fidelity) is used in location determination it needs to have satellite signals in the GPS application while in Wi-Fi application it works only if there have base stations to transmit/receive signals and then the resulting location determined in using either GPS or Wi-Fi application has high probability in error. In this paper we use Bluetooth in the distance calculation and location determination it not only improves the accuracy in the positioning but also could be used in the disaster environments such as tsunami, earthquake etc. when there are no base stations are available but in this situation the rescuers still can use Bluetooth to carry out their rescue mission.

In our study of using Bluetooth in the positioning we try to reduce the resulting location error down to 1 meter range when using the point-to-point positioning technique under the P2P (peer-to-peer) architecture. We will collect measurement data from field trials, possibly removing the effects of human being and outside environment, between the transmitting and receiving among cell phones, and analyze these data to propose proper signal fading model for Bluetooth signal transmission and then to develop suitable localization algorithm so as to accomplish our task to reduce the resulting location error down to 1 meter range. With our developed system architecture and localization algorithm in using Bluetooth technique for distance measurement it will promote the use of Bluetooth technique in the position determination between cell phones.

The Bluetooth technique is developed by the joint effort of Ericsson and Nokia in the project of inter- connecting their mobile phones and other portable devices; Bluetooth technical protocols have also been established. It is light, thin, short, and small, low price in Bluetooth device to provide people a transmission format, other than the wireline transmission, without using any wire transmission line or network to connect various digital equipment so as to improve people's transmission convenience. In addition to point-to-point transmission, Bluetooth also provides point-to-multipoint transmissions and when the information is transmitted it is broadcasted in all directions; also through omni-directional wireless transmission and the cipher-scripted process enable any person who equips with Bluetooth device can, through Bluetooth, proceeds to secured wireless transmission [1].

Some exemplified Bluetooth applications have been examined and analyzed in the literature as discussed in the following. Subhan et al. [2] from measured indoor data to analyze the relationship between signal strength and distance in connection–based and inquiry-based Bluetooth signal transmission and then to proposed a system model with associated system parameters to enable the estimation of the transmission distance from its measured RSSI values. I era et al.[3] used Bluetooth to establish a short distance wireless communication system to provide emergency, multi-media or games application; it specifically concluded that in short distance transmission by using Bluetooth technique it can effectively reduce the power transmission. In [4] the authors discussed the use of Weibull function to approximate the RSSI distribution obtained in Bluetooth transmission; they also in indoor transmission environment measured the RSSI values with Bluetooth and WLAN transmissions; they then compared the distributions generated from the measured data with the Weibull function. In [5], the authors considered the privacy issue in proximity service, which is an important and burgeoning type of location-based service in social networking. In 3GPP standard, it mentioned in document

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22.803 [6] that it can enable proximity service to enhance the location and presence services.

This paper is organized in the following. In this section we had briefly discussed the reason and its advantages of using Bluetooth as the positioning technique its transmission formats are also described. In Section II we will measure the signal fading phenomena of Bluetooth signal in the field trial in several communication environments. In Section III, it generate large number of test points, are proposed and utilized in the determination of target location. Section IV, it is the simulation using the propose algorithm. A conclusion is drawn in Section V and it is our intention to use the developed location determination algorithm by using Bluetooth technology into other location-based services so as to increase their accuracy in the target positioning.

II. Field Trial Scenario and Data Measurement Functional Flock Diagram

The experimental measurement is indoor no obstructions and the data measurements are taken in the evenings to reduce all possibly incur interferences. The Samsung Galaxy S3 cellphones, are selected as the phones in the experiment in the transmission and receiving of Bluetooth signals. Version 4 Bluetooth is built-in in these phones its transmission distance determination and its stability are far better than its version3's phones. Also in the experimental measurement the cellphone is placed in the same height and transmits in the same direction to reduce possible measurement errors due to the angle and the height variations in the placement of cellphones.

The functional blocks in conducting the experimental measurement is shown in Fig. 1. In the first step it derives the path loss model when it uses Bluetooth signal transmission. We then collect through measurements the target locations and their received RSSI values. From the derived path loss model we convert the measured RSSI values into distances information. Trigonometric function is then introduced to form the basis of distance determination method. The target location is then calculated through our developed distance determination algorithm; the differences between the actual targets locations and their estimated locations are then calculated and compared.

III. Generation of Large Number of Test Points

We use one cellphone as the transmitter and another cellphone as the receiver; these two cellphones are pointed in the same direction and maintained motionless when they are under test so as to remove the possibility of generating interference due to cellphone's angle motion; ten test points, A to J, as shown in Fig. 2 are selected as the test points.

When it happens that it has many test positions are available for the processing of positioning measurements; then all data processed from these test positions are available for use in the localization algorithm; we will base on the measured RSSI strengths among all available test points to select three locations that have the strongest RSSI values and use these

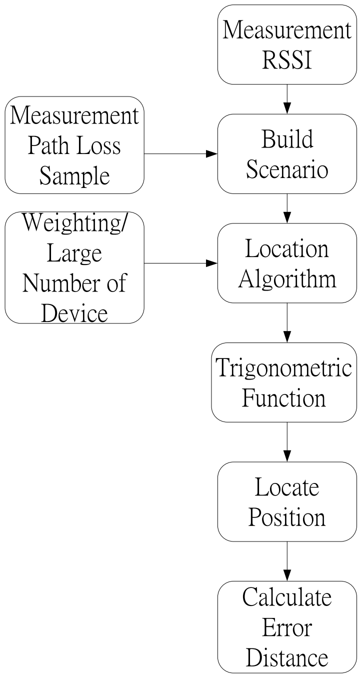

Fig. 1. System Functional Block Diagram in Target Location Determination

three selected locations to perform weighting summation to get the final location determination. In our simulation we use random number generator to generate 10 test locations and then select three positions with strongest RSSI values from these 10 measured data to perform the final location determination.

IV. Simulation Results

Ten test points, as shown in Fig. 2, have been selected and their received RSSI values have been collected and proceeded in the location determination algorithm after through the processes of introducing the weighting factor for each RSSI value and the selection of 3 largest RSSI values from these test 10 points, we have the simulation results as shown in Fig. 3 after averaging 1000 realizations. In Fig.3 the resulting distance determination, it appears that we can reduce the distance determination error down below 1 meter when a large number of test points with weighting factors are included in the localization algorithm.

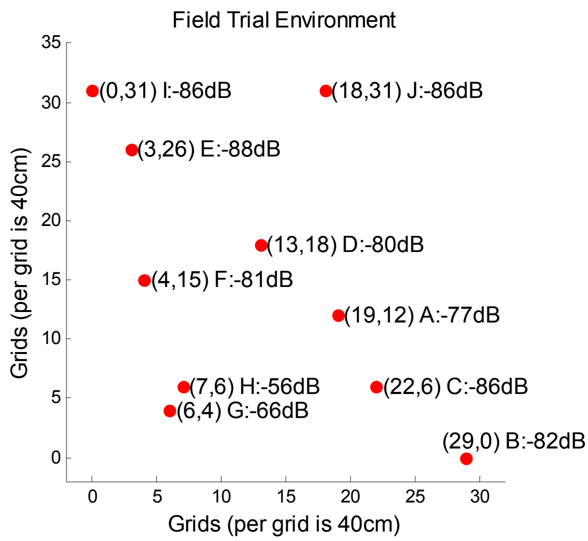

Fig. 2. Field Trial Environment

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In [7] Huang et al. exploited the multi-lateration method in their positioning algorithm it has the simulation results to improve the distance determination error down to 1.5 m ~ 2 m range. In our localization algorithm it can have the distance determination error down below 1 m when three-point localization algorithm is implemented.

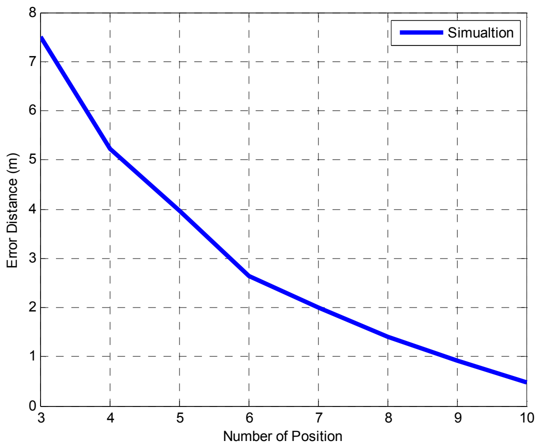

Fig. 3. Distance Determination Errors with RSSI Selection Processes

V. CONCLUSION

In this paper we considered the use of three-point localization method to determine the location of a target node, in this method three RSSI values were collected from three test points. Then in the three-point localization method it generated three pairs of potential target locations and the target location was finally determined from these three pairs of potential target locations.

It generates more test points and then to select some strongest RSSI values for using in the localization algorithm. From simulations we can let the location determination error down below 1 meter. This localization algorithm by using Bluetooth technique as we proposed in this paper can have many applications such as in the searching for the missing children, finding the lost cellphone, locating the restaurant etc.

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