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GPS/RFID Integration Using Feed Forward Time Delayed Neural Networks

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Abstract: ***A vehicle-mounted GPS receiver used for positioning can undergo from signal blockage. To cure this problem, GPS/ RFID integration can be considered as an answer in some cases. Though, in the case of metropolitan areas where there are severe multipath conditions, the performance degrades noticeably. The last decade we have seen several proposals of techniques aiming at improving the precision of GPS positions. The difficulty of these techniques increases with the increase of the accurateness required. These techniques usually combine multiple techniques like fuzzy logic… etc. In this paper, we propose a new technique based just on neural network, which offers a improved performance while showing a lower complexity. The idea is to utilize a neural network, which emulates the behavior of a given estimator in order to change it. Here, we present simulations results, which confirm the performance and the robustness of our proposed scheme in a heterogeneous environment.***

Keywords: Kalman Filter; Localization; GPS; RFID; Neural Network, FFTDN.

1. Introduction

Today‟s scenario based on the use of GPS for estimation of the positions of moving object. A mobile unit equipped with a GPS receiver can locate itself using the signal received from four or more GPS satellites and by processing tri-lateration technique. However, GPS as well as the majority of systems of localization cannot provide a position with a high accuracy in all situations. The performance of GPS is usually satisfactory in flat open areas where line-of-sight (LOS) to multiple satellites is possible, and the average error of an estimated position is 10 meters. But, the performance can be severely deteriorated in indoor and closed areas (e.g. tunnels, indoor parking etc.) with non-line-of-sight (NLOS) or in downtown areas with multipath problem. The error in such cases can up to 50 m.

To improve the accuracy of GPS positions and to overcome the problem of signal blockage in closed area, researchers started their work to integrate the GPS reading with the measurements of other localization means like INS, RFID, DRS, Map Matching etc.

RFID technology is stable and evolving and it cannot be easily replicated. Therefore, RFID is becoming increasingly available in variety of fields including manufacturer, transportation, warehousing, distribution, retail, healthcare and security. In recent years, the RFID (Radio Frequency Identification) is known as a ubiquitous technology used in real-time tracking. Because of its accurate and fast identification, RFID is applied extensively to improve the logistics management, supply chain operation and asset tracking.[1]

The integration of GPS/RFID by means of Kalman Filter (KF), and other tools are also used to enhance the accuracy of positions. The neural networks are generally used to estimate errors and noises in order to omit their effects from the estimation procedure and also simplifying complexity and giving more robustness to system. The RFID tags information and the GPS data can be processed in time. In this paper, a new technique for integrating GPS and RFID using Neural Network is proposed. [6]

2. Standalone Localization Techniques

In this section different localization techniques has been discussed. As all these techniques are insufficient for accurate localization in all conditions therefore an integrated localization techniques has discussed in brief.

A. Global Positioning System (GPS)

GPS is a satellite-based system that uses a constellation of 24 satellites to give a user an accurate position. GPS can be used to achieve all of these accuracies in all of these applications, the difference being the type of GPS receiver used and the technique employed. GPS was originally designed for military use at any time anywhere on the surface of the earth. Soon after the original proposals were made, it became clear that civilians could also use GPS, and not only for personal positioning (as was intended for the military). The first two major civilian applications to emerge were marine navigation and surveying. The GPS system functions according to exactly the same principle in order to calculate one,s exact position all that needs to be measured is the signal transit time between the point of observation and four different satellites whose positions are known.[15]

B. Assisted Global Positioning System (A-GPS)

A long delay can occur when locating a mobile unit using GPS. A-GPS systems are set up to resolve this long delay. Wireless A-GPS operates on GSM, GPRS and UMTS networks. Like GPS, A-GPS uses satellites in space as reference points to determine location. A-GPS can be accurate up to 10 meters.

C. Differential Global Positioning System (DGPS)

Differential GPS (DGPS) consists of two receivers observing the same GPS satellites. One of these receivers is stationary and the other one is roving. The stationary receiver resides at a known location and obtains the pseudo-range from the satellite signals, so it identifies a global error by comparing the measurements with its location. The stationary receiver transmits the global error correction to the roving receiver so that the roving one can correct its measurements. It is possible to avoid most global errors and obtain accurate location measurements by using a differential GPS receiver (DGPS).

D. Map Matching

Current advances in Geographic Information Systems (GIS) have allowed the collection and storage of, as well as access to, very accurate geographic data even for less powerful devices. This technology has been successfully applied to store city map information in recently developed map localization systems for vehicle navigation.

E. Dead Reckoning System

This is another method of localization, called Dead Reckoning System (DRS), in this technique, the new localization is depends up on how far an object has moved from a known place given the directions and distances traveled over small periods of time. Therefore this technique is inexpensive and simple, it can be used for many applications; however, it has a disadvantage in that the errors in the measurements of the direction and/or the distance affect the final location estimation. In other words, the measurement errors accumulate over the total period of time. Since Dead Reckoning accumulates errors rapidly over time and distance, it is considered only as a backup system for periods of GPS outage, in which a vehicle enters in to a tunnel and loses its GPS connection.

F. Inertial Navigation System (INS)

The Navigation is the process used to estimate the position, orientation and velocity of a vehicle and inertial navigation means the inertial sensors are utilized for the navigation, basically an Inertial Navigation System (INS) is to provide accurate worldwide navigation information independent of external aids; the system neither transmits nor receives any signals. After being supplied with latitude and longitude of the ramp position prior to departure, INS is capable of continuously updating extremely accurate displays of position, ground speed etc. The most common INS sensors are accelerometers and Gyroscopes. The INS consists of 3-axis gyroscopes which give the roll, pitch and yaw rates about the body axes. It also has 3-axis accelerometers which give the accelerations along the three body axes. In Accelerometers by attaching a mass to a spring, measuring its deflection, we get a simple accelerometer. By Einstein's principle of equivalence also we can measure Gravitation with accelerometers. The Gyroscopes measure angular velocity relative inertial space.[16]

G. Radio Frequency Identification (RFID)

A typical RFID system consists of a reader, tags, antennas and a connection to database management system. The reader can receive the information (a unique ID) of tags in the available range of the reader. Using the merit of accurate and fast identification and tag reading from a greater distance, all kinds of related messages can be received by the RFID reader. Hence RFID can improve accuracy and efficiency.[11]

Radio Frequency Identification (RFID) technique has attracted a lot of interest in recent years due to its widely adoption by the industry. According to the types of the used tags, the techniques are classified into two categories, active tags based technique and passive tags based technique. Passive tags are more attractive than active tags because of its low cost and convenience for large-scale deployments.

There is problem of location tracking using passive RFID tags. The solution of this problem is desired by a lot of emerging applications, such as vehicle monitoring and tracking in the depot or warehouses, robot navigation and so on. This problem is distinguished by two issues from the previous RFID localization problem which has been extensively studied [5]. First focus on the tracking of mobile objects rather than localization of stationary objects. It is more challenging because the algorithm to estimate the objects current location must be executed before a deadline in order to meet the accuracy requirement. Second assumption is that the RFID readings gathered from real world are noisy. It means that each passive tag in the reading range of the RFID reader is not certainly but possibly to be detected.

There are many RFID/RTLS technologies currently on the market (Axcess, Wavetrend, Ekahau, RF-Code, Passport Technology, etc.), it has been very difficult to get the right technological combination allowing real time tracking both inside and outside of buildings. This is because the existing technologies are not effective in reliable indoor and outdoor tracking of mobile resources. To remedy to this problem, GPS/ RFID integration can be considered as a solution.

3. Integrated Localization Techniques

The Integration of two or more techniques of localization can improve accurateness and provide better performance in comparison with stand-alone system. Hence it is possible to use map matching with GPS, RFID with INS, DRS and INS etc. But typically the GPS is integrated with local positioning e.g. RFID, INS, DRS etc.[12] The most used solution is GPS/INS, GPS/DRS, GPS/RFID with the INS integration. As a factual each system compensates the inadequacy of the other one when utilized individually.[13]

4. GPS/RFID Integration Using FFTDN

To improve the precision of GPS positions, here we develop an uncomplicated and robust scheme based on neural network that will offer same accuracy like any other technique and can be used in open or metropolitan environment. The implementation of the new integration scheme can be achieved in three stages:

A. Review and evaluation stage

In this stage we select a scheme used to correct the GPS positions in order to use its data in the training stage. We must choose a complex scheme that gives a high accuracy positions in metropolitan and open environment. Many schemes responding to such criterion can be found. In this paper, we simply choose the one where KF is used to integrate GPS and RFID (We call it adopted scheme "AS").

This scheme is used to increase the localization robustness and accuracy for every vehicle in the network.

B. Training stage

In this stage, the neural network FFTDN (i.e. Feed Forward Time Delay Neural Network) will be feed with sets of GPS and RFID data from review and evaluation stage. This stage is divided into two cases. In GPS signal availability, As input, the difference between GPS and RFID position, and as output, the difference between GPS and output of AS will be taken. It is assured that the positions provided by AS are very accurate and can improve the localization system.

In case of signal blockage, the set of training data inputs represent large values of errors and as output the value „0‟ will be added. This scheme is general and used to improve the accuracy of positions in GPS signal blockage or in open area with availability of GPS reading.

C. Correction stage

After the training stage, the trained neural network takes the place of the AS. Accordingly to AS in the training stage, the correction scheme in case of GPS signal availability or signal blockage shown in figure 3 below.

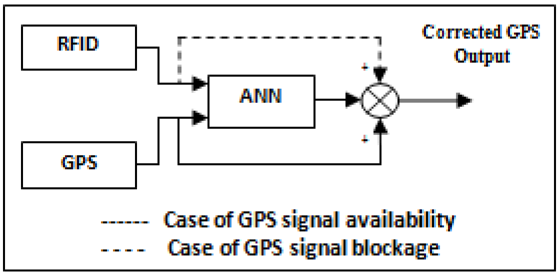

Figure 1: Block schematic of GPS/ RFID using FFTDN

5. Simulation Results

To generate data that will be used in the training phase, we implement the AS in Matlab. Then, we generate sets of data in order to verify the robustness and the functioning of the new corrector.

As mentioned the localization simulation for GPS/RFID integration has been implemented in MATLAB 7.14. The simulation scenario consists of a straight 5000 Meters road on which vehicle is moving. Vehicle travelling along a straight road consist different regions (environments) such as an open environments, GPS outage and GPS/RFID outage environment.

The GPS outage area is in between the 2100 to 2400 and 2700 to 2900 meters where error is introduced because of GPS outage.

The GPS and RFID outage area is in between the 3800 to 4200 meters where large error is introduced because of GPS outage and absent of RFID poles. The simulation period is equal to total time required for a vehicle to cover a distance of 5 km i.e. 360 seconds (vehicles velocity is 50 km/hr). In simulation three regions are considered with an open as well as outage environment. The first region consists of open environment which is of 2100 meter (from 0 to 2100 meters). Second region consists of GPS outage environment which is of 500 meters. Third region consists of GPS/RFID outage environment of 400 meters and again open environment of 800 meters. The eight RFID poles are placed exactly with 500 meters interval on 500m, 1000m, 1500m, 2000m, 2500m, 3000m, 3500m, and 4500 meters excluding the RFID pole is absent on 4000m location.

Figure 2 shows the unscented Kalman Filter estimated localization i.e. AS using tightly coupled approach travelling over 5 km with constant velocity of 50 km/hr. It shows the effect of GPS, RFID outage environment is minimized in the UKF output.

We note that the error of our AS is in between +25 and -1.5 for GPS errors that are between +250 and -125. Therefore we can say the rate of success is about 92.93%.

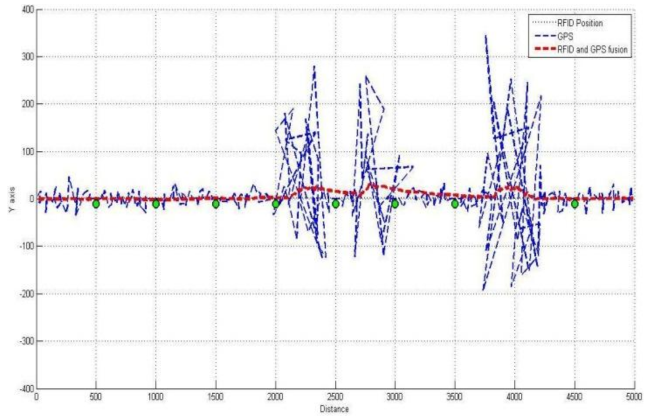

Figure 2: Performance of AS i.e. UKF using tightly coupled approach

The FFTDN is implemented with creating total 360 sample points, shifting neural network time series by tap delay of 50, total 10 neurons and 50 iterations.

The NN inputs are real positions; and GPS, RFID positions as random variables. The FFTDN is trained with initial inputs, training inputs and targets for over first 50 samples.

After successful training of FFTDN the Neural Network is solely done integration up to last 360 samples and predicts the positions. The following figure 3 describes the NN predicted positions and optimized GPS/RFID fused positions.

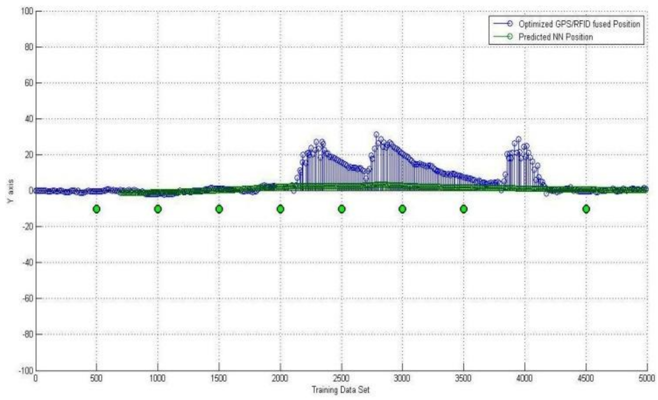

Figure 3: Neural Network predicted positions and optimized GPS/RFID fused positions.

Here we note that the error of FFTDN is between +3.5 and -0.65 for GPS errors that are between +250 and -125. Therefore we can say that the rate of success is about 98.89%.

Figure 4 illustrates the good performance of NN, which gives a high accuracy as compared to AS.

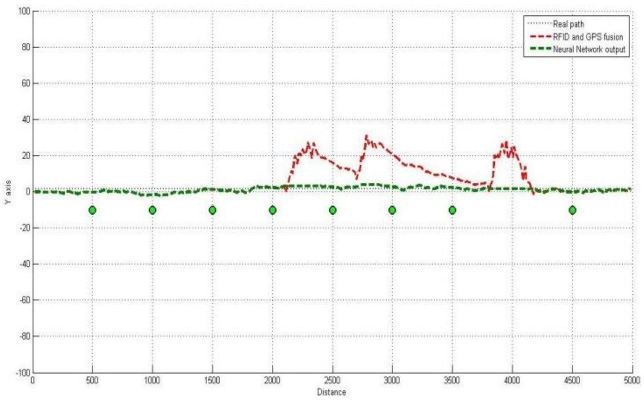

Figure 4: Comparison of performances of NN scheme and UKF in a heterogeneous environment.

According to results obtained, we observed that the error of FFTDN is between +3.5 and -0.65m. So we can say that FFTDN has a success rate of 98.89%. The results obtained in all heterogeneous environments are summarized below,

Table 1: Summary of Mean Errors (Meters)

Sr. No.	Type of Environment	Mean Error (meters)		
	First Open Environment	*GPS*	*GPS/RFID Using UKF Tightly Coupled Approach*	*GPS/RFID using FFTDNN*
1	First GPS Outage	-10.43	-4.42	-5.11
2	Second GPS Outage	84.50	17.58	2.67
3	Second Open Environment	130.10	18.72	3.18
4	GPS/RFID Outage	10.10	9.84	2.31
5	Third Open Environment	52.26	9.43	1.34
6	First Open Environment	-2.10	-0.51	-0.59

6. Conclusion

In this paper, we presented a GPS/RFID integration technique using FFTDN which aims to decrease complexity of the AS i.e UKF, and which to correct the positions obtained by the GPS system. The objective from the use of this technique is to achieve at least same performance of the existing scheme and show that a FFTDN can provide a best accurateness with lesser computing complexity. According to the simulation results for heterogeneous environments, an efficiency achieved is 98.89% using FFTDN while in AS it is 92.93%, so we conclude that the efficiency of our technique is 9.96% more and it reduces complexity simultaneously.

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