2001년도 대한전기학회 하계학술대회 논문집 2001.7.18-20

Implementation of IDGPS Based Car Tracking System Using Internet and Mobile Phone

°Sun-Jun Ko*, Hee-Seok Ho*, Jong-Hoon Won*, Ja-Sung Lee*
*Electronics Engineering, Ajou University

인터넷과 mobile 폰을 이용한 IDGPS 차량추적시스템 구현

°고선준*, 호희석*, 원종훈*, 이자성*
*아주대학교 전자공학과

Abstract - This paper presents the implementation of an efficient car tracking system based on Inverted DGPS (IDGPS) using mobile phone and internet for data communication link. The IDGPS technique, which may provide the same level of accuracy as DGPS, is subject to degradation in real time applications when transmission time delays occur in the communication links. Therefore, an effective communication system is the key element for successful application of the IDGPS.

The combination of internet and mobile phones provides a high data rate, unlimited communication packet size, flexible data structure, and wide coverage without additional communication devices. An implementation of such a data link system is described. Field test results are included to evaluate the performance of the proposed system.

1. Introduction

The Inverted Differential GPS (IDGPS) is one of the most frequently used relative positioning techniques in GPS based tracking system[1]. This method has a similar structure with DGPS and may provide the same level of position accuracy. However, IDGPS shows growing position errors as the transmission time delay increases. Therefore, an efficient communication link is critical for real time IDGPS based tracking system since timely transfer of the correction information is required to ensure the optimum accuracy for such a system. The communication link must provide reliability of the data transfer. It is also desired that the links are available without much restriction in order to cover wide range of users.

A pair of wireless modems is often used in relative positioning system, such as DGPS, IDGPS and Real-Time Kinematic (RTK) applications. Such a communication link requires relatively expensive devices and is subject to the regulation on limited frequency sources and short range in radio link. Other methods such as the Sending Message Services (SMS) has been suggested in Korea. The SMS is the method using a mobile phone providers service for data communication to send a simple character set. Although this method is cheaper and easily available, it has a serious limitation in communication packet size and is subject to large transmission time delay because of the low priority of the data transmission over the voice communication[2].

The combination of internet and mobile phones can provide a high data rate, unlimited communication packet size, flexible data structure, bi-directional communication, and wide coverage without additional communication devices. An implementation of the IDGPS with such a data link is described in this paper for a car tracking system. Field test results are included to evaluate the performance of the proposed system.

2. Internet Protocol for Implemented System

Internet is the worldwide computer network system which appears to be the most important and common communication method nowadays mainly because of its fast data rate and availability to unlimited users. Generally, Transmission Control Protocol/Internet Protocol (TCP/IP) is used in Internet as the standard protocol. There are two methods to transmit data in TCP/IP, one is via the TCP and the other is via the User Datagram Protocol (UDP)[3]. The UDP can readily be used to transmit small size data packets and can speed up data rates. But, it is relatively less reliable in data transmission because it is not based on the connection-oriented structure but has a stream-oriented data structure. The TCP, which is based on connection-oriented structure, provides better reliability and stability in data communication. Generally, the order of connection and data transfer with TCP/IP is,

1. Server opens ports and wait for clients
2. Client tries connection with the server using IP address
3. Server checks in the IP address and accepts
4. Communication of the data begins

3. IDGPS Structure Based on Internet

The IDGPS car tracking system implemented in this paper uses the wireless Internet connection with mobile phone and TCP/IP protocol to form an efficient data communication link between the reference and mobile. Such a data link is constructed by connecting mobile phones with wireless internet link between reference station and mobile users. This method can provide many advantages. First of all, it is possible to transfer large amount of data including GPS time, satellite information and raw measurements by providing a sufficient communication packet size. It can also provide a fast communication speed and wide coverage to unlimited users. Figure 1 shows the structure of the proposed IDGPS based car tracking system. As shown in the figure, the packet data including raw measurements, satellites and GPS time information is transmitted from the mobile users to reference station through the wireless internet link and mobile phones. The data transmission rate and positioning output rate are all 1 Hz. The implemented system based on such a data link, have several advantages; there is no need to use the additional communication devices such as wireless modem, and it provides the reliability of the data and stability of the system. This system also provides the capability to access the multiple users at the same time.

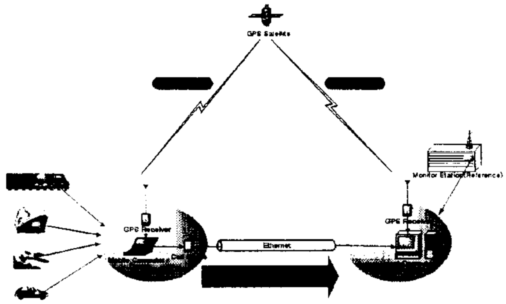

Figure 1. IDGPS Structure Using The Wireless Internet

4. Mobile System

In IDGPS, mobile system transmits its data to reference station. The data structure is shown in figure 2. The mobile system is constructed by three module; the serial port module to control the RS-232c port, the TCP/IP communication module, and the raw measurement processing module. The serial port module is connected to the GPS receiver for receiving raw measurements such as GPS time, satellites ID, pseudoranges and so on. Then, these data is processed to form a communication packet. TCP/IP module is operated when IP address is received. Then, it requests the connection to server, and the packet is transmitted to server when accept signal is received. Figure 3 represents the layout of the communication window of the mobile system.

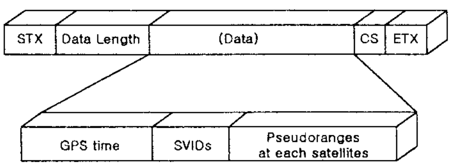

Figure 2. Communication Packet Structure

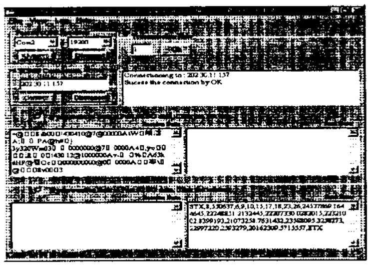

Figure 3. Mobile System Communication Window

5. Reference System

Reference system takes a major part in IDGPS since the main algorithms for positioning reside in the reference system. It is possible to overcome the high computational load by processing the data in the asynchronous data access mode. It requires code optimization and time scheduling for efficient real time processing. In this paper, the real time system is designed in a PC-based windows environment. Each part of the system is constructed by separate modules, and a thread design concept based on Object-Oriented Programming (OOP) is utilized to ensure the stable operation of each module[4]. Boland C++ Builder is used to program the system. Figure 4 and 5 present the definition of the priority of various tasks and the main reference system communication window layout, respectively. The lower priority of task is operated after the higher one is performed when events of two tasks occur at the same time. This structure makes it possible to process various tasks smoothly in real time. The TCP/IP module for reference system starts to operate when the system initialization is performed, and then opens the ports and waits for mobile connection. Once success in the connection between reference and mobile is made, the connection is maintained until the reference forces to disconnect it.

In this paper, the performance of the system is analyzed by static and kinematics field tests.

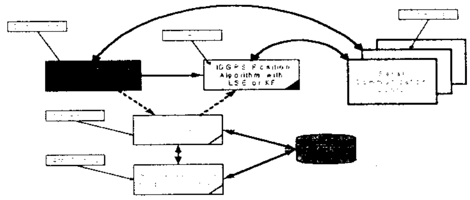

Figure 4. Reference System Structure and Definition of Priority in Each Tasks

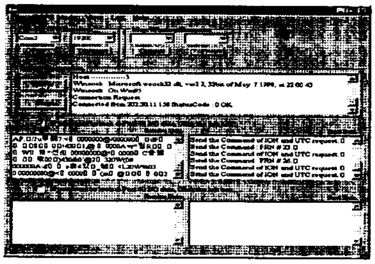

Figure 5. Reference System Layout

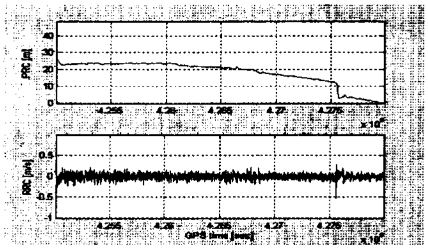

Figure 6. Pseudorange Correction Data and Range Rate Correction Data of 16 Satellites

6. Real-Time Experiments

To evaluate the performance of the implemented system, static and kinematic field tests were performed. The equipments used are listed in table 1.

Table 1. Test Equipments Configuration

	Reference station	Mobile
GPS Receiver	Trimble 4000SSi	Trimble 4000SSi
Connection	Ethernet	CDMA PCS Phone - 14.4Kbps
Computer	Desktop (Pentium II 300Mhz)	Notebook (Pentium 133Mhz)

The reference position is located in the roof of the Engineering building at Ajou University. The position is known accurately in Earth Centered Earth Fixed (ECEF) coordinates as, X=-3060929.808, Y=4055654.110, Z= 3842493.107. The IP address of the reference station is 202.30.11.157.

The static field test is performed for about 30 minutes with 1 Hz data rate. The mobile receiver was located at a known site about 0.5 meters apart from the reference position in the east direction. Figures 6 represents pseudorange correction data of 16 satellites. The correction data includes the common bias errors without S/A such as ionospheric, tropospheric delay terms. Figure 7 shows the static positioning result. As shown as in the results, the position error is less than 0.7 meters in radius, and estimated positions are centralized about the static true position. the RMS of the errors is 0.58 meters.

Kinematic test is performed by driving a car along a triangular path in Ajou University several times. The average speed is 30km/h, and the data transmission rate is 1Hz. Figure 8 is shows the kinematic field test result which shows high agreement of the positions throughout the repeated turns. The transmission time delay in this test was about 0.3 seconds, which is relatively small and does not affect the performance.

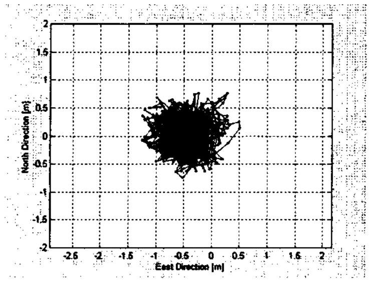

Figure 7. The Static Field Test Result using Kalman Filter

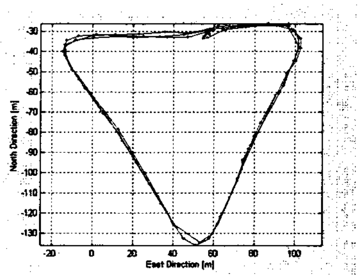

Figure 8. The Kinematic Field Test Result using Kalman Filter

7. Conclusion

In this paper, IDGPS based efficient car tracking system using the internet data link and mobile phones has been implemented and tested in real time both in static and kinematics field tests. It was demonstrated that the system provides a positioning accuracy within sub-meters with a single frequency C/A code receiver. The wide availability of the Internet and mobile phone system will make this system applicable in virtually unlimited relative positioning applications.

Reference

[1] Strang, G. and Borre, K., *Linear Algebra, Geodesy, and GPS,* Wellesley-Cambridge Press, 1997.

[2] Sun-Jun Ko, Jong-Hoon Won and Ja-Sung Lee, "A Practical Real-time Precise CDGPS Positioning Using Mobile Phones and Internet and Low Cost C/A-Code GPS Receivers," Proceeding of ION National Technical Meeting 2001, Long Beach, CA, Jan. 22-24, 2001

[3] W. Richard Stevens, *TCP/IP Illustrated : The Protocol, Vol 1,* 1999.

[4] S. Meyers, *Effective C++*, Addison-Wesley, 1998.