A Measuring Model of the Position of Moving Vehicle based on Integrated Vehicle Networks for Spatial Database Applications

Hyeyoung Moon, Jindeog Kim, *Member, KIMICS*

***Abstract*— Recently car navigation systems which have been widely spread and evolved. The systems use various information and techniques such as real time traffic information and augmented reality technique. In order to provide a shortest path with good flow, real-time traffic information provided by DMB is required. Augmented reality technique is also introduced to give a reality to driver by displaying real images captured by camera during driving. However, these operate well when the system receives GPS data normally. Exact information about the positions of vehicles is a base that supports the above function with realities. This paper proposes a model for acquiring exact position of vehicles. When the GPS does not operate normally, the proposed model uses various data which are generated by integrated vehicle networks.**

***Index Terms*— Measuring Position, Spatial Database, Vehicle Networks, CAN, MOST**

I. INTRODUCTION

Recently, in-vehicle network technology has been introduced to provide convenience, safety and so on in the vehicle. As using ECU(Electronic Control Unit) for high-tech electronic devices increases, various in-vehicle networks such as CAN, LIN, FlexRay and so on are used for IT technology fusion. MOST and IDB-1394 are also adapted to provide entertainment service for high speed data communication [1, 2].

In addition, telematics service which provides a variety of information to drivers' terminal is getting important. The telematics service is classed as a wireless access technology between inter-vehicles, a technology to operate terminal, a GIS/GPS technology and a technology to manage vehicle. Its application service is classed as location-based service, vehicle information management, remote/help service and so on [3].

Especially, vehicle navigation system which is a killer application of telematics has been evolved variously as follows: TPEG service receives and applies real-time traffic information transmitted by the DMB. Augmented reality technique[4] gives also real-time path guidance to drivers by enhancing a reality by displaying real images captured by camera.

The position for these terminals is usually acquired by GPS technology. The technique is applied to many application such as emergency service, accident notification[2, 3], confirming location of vehicle crash[5], early warning system for transport accidents[6] and so on. The GPS technique, however, it has a serious problem that can't provide position data by jammed or blocked signal of satellite when the vehicle is in the tunnel, buildings and woods[4].

Therefore, the telematics system requires a new model to provide exact position of vehicle without cease. The model would serve better reality to telematics system.

This paper proposes a new model to provide exact position in spite of the malfunction of the GPS. The model uses various data generated by integrated in-vehicle networks which will be popular in the immediate future.

The reminder of this paper is organized as follows. Section 2 presents related works about the field of location position system to design the method to measure the position of moving objects. Section 3 introduces a model to reckon exact position of a vehicle based on integrated vehicle networks. Then, give conclusion in section 4.

II. RELATED WORKS

Many researches on the accuracy of location have been studied so far. The improvement of the sensitivity of GPS, Performance improvement based on GPS, Positioning method of alternative GPS are widely used for improving the accuracy.

2.1 Sensitivity improvement of GPS

Related work [7, 8] designed the architecture of high sensitivity receiver to use GPS and GNNS. The GNNS is a new navigation system developed in Europe.

This work proposed a method to enhance receiving rate by solving the problems based on satellite navigation systems of the existing GPS. Its RF receiver model of GNSS can take concurrently both GPS and Galilean satellite's navigation information. It also proposes the high-precision architecture to solve code synchronization problems. The architecture was designed with asymmetric structure by maximizing amplification rate of reception

Manuscript received December 18, 2009; revised January 12, 2010; accepted January 22, 2010

Hyeyoung Moon is with the Dept. of Computer Engineering, Dongeui University, Busan, 614-714, Korea

Jindeog Kim(Corresponding Author) is a Professor of Dept. of Computer Engineering, Dongeui University, Busan, 614-174, Korea (Tel: +82-51-890-1745, Fax: +82-51-890-2629, Email: jdk@deu.ac.kr)

and minimizing noise.

Although the receiver module works well in shaded area such as outdoor forest, It is impossible for the module to receive satellite signal in abnormal area such as tunnel, a lot of high building and underground of building.

2.2 Performance improvement based on GPS

In this section, a study on compensating location with GPS receiver and other device is explained.

Related work [9, 10] proposed a system which consist of GPS receiver and Gyro which is DR(Dead-Reckoning) sensor in order to provide orientation and speed information. The system introduced a method to use Kalman Filter to implement a module which decides optimized location based.

Even though the method with DR sensor works well in above abnormal area, using DR sensor which is suggested for path compensating in this work is possible to compensate location information in portion. But, GPS signal is required periodically because estimation error increases as time goes by. Thus, if GPS signal is invalid for long time, the location information will be incorrect.

2.3 Measuring location with alternatives of GPS

In this section, a study on measuring location without GPS receiver is described. Related study [11, 12] proposed RTLS(Real Time Location System) system. The system applied trigonometry to RSSI(Received Signal strength indication) between Wireless LAN Infra-based Wireless AP and 3G network device for the sake of estimating user location.

RTLS which is real-time location tracking system doesn't cover a wide range because this is applied to limited area such as hospital and school.

Related work [13, 14] proposed a method to estimate the location of an unmanned vehicle as follows: First, images in database should be constructed in advance about driving road networks by an unmanned vehicle. And then, on actual driving, a approximated position can be known by matching an acquired image with a stored image in database. Finally, the vehicle location can be taken from the images by relative position estimation. The proposed method in this study can get a rough position by pattern match between a image captured by camera of vehicle and images in database, even if it can't receive GPS signal.

However, it's difficult to make image database about all the area where it can't receive GPS.

III. MEASURING MODEL BASED ON INTEGRATED VEHICLE NETWORKS

In this paper, we design a model to measure the position of a moving vehicle when GPS information is invalid. This model uses a variety of data sources generated by several vehicle networks.

3.1 Integrated vehicle networks architecture

Vehicle networks are divided in two part: internal network such as CAN, MOST and external wireless network. A variety of data from vehicle's ECU sensor and control data are transferred by CAN network which is one of the internal vehicle network.

High speed data are likely to be transmitted by many kinds of devices such as vehicle terminal, camera, CD/DVD player, amplifiers and so on. So these devices are connected by MOST network which is also one of the internal vehicle network[1, 2].

External wireless network technology consists of CDMA, DMB, DSRC, WLAN and so on. These are used to transfer various information of service center. In addition, wireless LAN environment between wireless AP which is installed personally and Wi-Fi device of vehicle can be used in order to derive the position of moving vehicle without additional cost for constructing infra in downtown. Position information is provided by communication between Road Side Equipment(RSE) and On-Board Equipment(OBE) by using DSRC technology in the outskirts of a city where wireless AP rarely installed. Wireless communication module in this paper integrates and controls these.

Figure 1 shows an integrated vehicle network architecture for measuring position of vehicle. Information of vehicle network is transferred to the terminal which finally measure position via integrated networks.

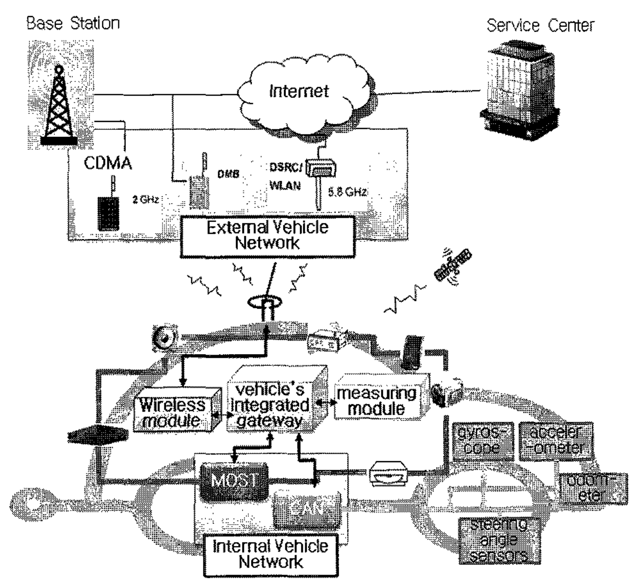


Fig. 1. Integrated vehicle network architecture.

3.2 A flow for measuring position

Figure 2 shows a flow for measuring position based on integrated vehicle networks.

```
if(GPS signal is available) {
    Transmit the GPS position data -
    to the telematics terminal;
} else if(Wireless Communication is available) {
    // External Vehicle Network
    Extract position data by measuring module
    and transfer the measured data –
    to the telematics terminal ;
} else {
    if(data of image DB is exist) {
        Extract position data by matching with
        Image data based on MOST from matching
        module ;
    }
    if(CAN sensor data is available) {
        Extract position data by using dead-
        reckoning from reckoning module;
    }
}
Provide path guidance service by the above data
```

Fig. 2. An algorithm of compensating position.

The measuring module checks whether the GPS signal is available or not when navigation system starts. If the GPS signal is available, it is used for path guidance service. Otherwise, it checks whether external vehicle wireless communication is available or not first of all. If external vehicle wireless communication is available, position data can be received through a wireless network such as WLAN in the center of city and DSRC in the outskirts. Then, the data transferred from server by the external network are applied to in-vehicle network(CAN, MOST). In addition, if both GPS signal and external wireless network are not available, the system receives sensor data by CAN and image information by MOST. And they are also used for extracting position data.

These measuring modules of compensating path are conducted repeatedly to provide exact position data during driving vehicles. Generally, the reception of initial position data by using GPS is started by running path guidance program after terminal turns on.

At that time, GPS takes minutes to search current position usually. Also, in the building where GPS is unavailable, path guidance service isn't directly available because GPS doesn't almost operate. So, vehicle should be away from the building to take exact position data from GPS normally.

In this case, a model of measuring position can make use of position data provided by external wireless communication at first. Secondly, the model can make use of position data provided by internal vehicle network, until the position data of GPS is available.

3.3 Modeling of measuring module

As shown in Figure 3, the input sources of the measuring module are as follows: GPS position data, positioning data and image data of DB(database) which is transmitted from service center via vehicle's external wireless communication, ECU sensor data via CAN and image data via MOST.

These information which uses different communication ways and data types respectively are transferred to the measuring module via vehicle's integrated gateway after they are converted into available data.

Figure 3(①-③) shows processes to handle each received data for measuring position. Position data from external wireless communication(input ①) is used for extracting vehicle's position data. It is also used like GPS signal unless GPS signal is valid.

Image data based on MOST(input ②) is used for extracting vehicle's position data after step of the image matching process with data of image DB by external wireless communication[11].

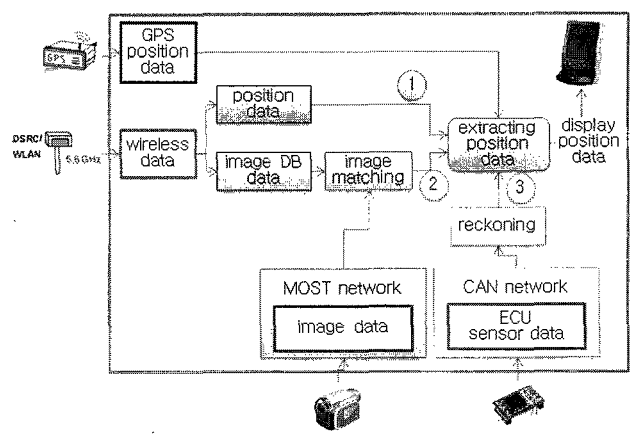


Fig. 3. Modeling of measuring module.

ECU sensor data based on CAN(input ③) is used for extracting position data by adapting dead reckoning on the basis of position data abstracted by input ① and ②. Obtained position data are transmitted to telematics terminal.

3.4 Flow of processing each data

Figure 4 shows the whole flow to process various input data. Each data entered via vehicle's integrated networks is processed by image matching module and reckoning module for sensor data in connection with the measuring module.

(1) Wireless communication data processing of external vehicle network

Figure 5 shows the data processing flow of external wireless communication. Wireless communication usually uses WLAN in downtown and DSRC in the outskirts. In downtown, vehicles are received by communication between wireless AP and vehicle's wireless communication module(charge of Wi-Fi Device).

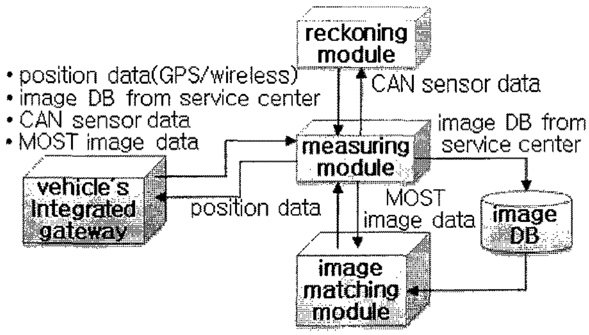


Fig. 4. A flow chart of processing each data.

Wireless AP(Access Point) references a DB which contains the positions of wireless APs and is separately constructed in advance. Based on this, position data can be used for estimating RSSI between vehicle and wireless AP.

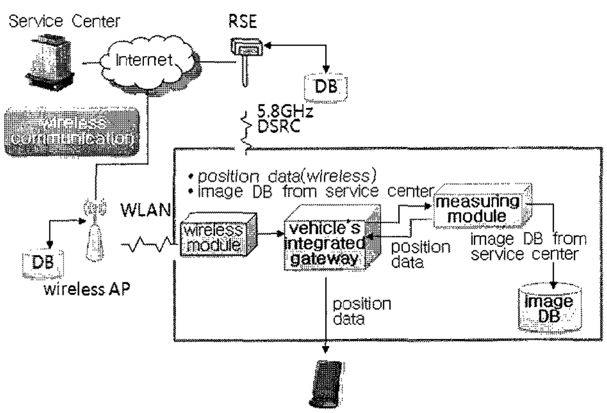


Fig. 5. A flow chart of processing wireless communication data.

In the outskirts, vehicles receives RSE's position data to measuring position by communication between Road Side Equipment(RSE) and vehicle's wireless communication module(charge of On-Board Equipment ;OBE) If a vehicle is a specific area in which GPS doesn't operate and wireless communication devices are built on the driving path, images of the area are transferred from service center DB and stored in vehicle's image DB in advance.

These images which are gathered by moving vehicles with camera on the MOST network in the specific section. They include images of specific points for image matching and their position data.

(2) Image data processing of internal vehicle network based on MOST

Figure 6 shows the processing flow for image data of the MOST network.

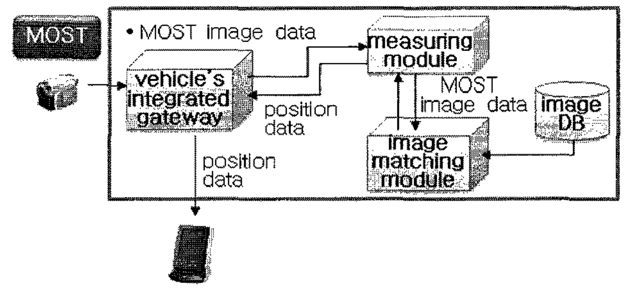


Fig. 6. A flow chart of processing MOST image data.

If a vehicle enters into a specific zone in which GPS and wireless communication don't operate, the measuring module does pattern match operation between an image captured by camera on the MOST network and a image transmitted by the image DB of server via wireless communication network. Then, the module measures the position of the matched image because the image has also its position data.

(3) Sensor data processing of internal vehicle network based on CAN

Figure 7 shows CAN sensor data processing flow of internal vehicle network. If GPS signal and the information of the external vehicle wireless network aren't received, vehicle's driving data generated from ECU sensors in connect with CAN network. Such as direction, speed, etc are useful for measuring the position of the vehicle. Reckoning module with sensors recalculates its position by estimating vehicle's the driving data of various sensors. The module of compensating position based on CAN uses Dead Reckoning sensor.

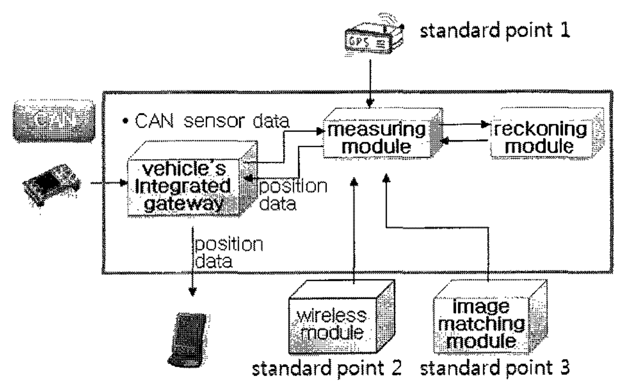


Fig. 7. A flow chart of processing CAN sensor data.

Dead Reckoning sensors consist of gyroscopes, accelerometers, magnetic compasses, odometers, inclinometers, steering angle sensors, etc.

The information of each sensor is transferred to the measuring module by using the integrated vehicle networks from ECU linked on CAN network. The measuring module transfers these data of sensors to the reckoning module again. At that time, if position data is extracted by the module, the data is transmitted to the terminal finally.

If applying dead reckoning in integrated vehicle network, as time goes on, the error rate of the position usually increases. To solve this problem, the module revises the location on the basis of the last position data received.

Figure 8 shows the example of using standard point to revise the position of a vehicle. After GPS position data is received at the standard point 1, if GPS and wireless communication don't operate, the reckoning module extracts position data by calculating position from CAN sensor data on basis of the GPS position data of the point.

Then, until the module receives position data of standard point 2 by wireless communication network, the position data is also extracted from CAN sensor data. On receiving position data of standard point 2 for wireless communication, the module will set the data as a standard point.

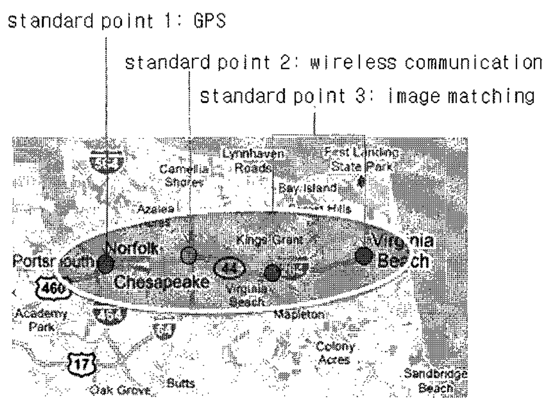


Fig. 8. Example of using standard point.

Then, if a process using CAN sensor data have to calculate a new position immediately, the standard point 2 becomes a reliable point for dead reckoning in order to extract new position data.

Whenever the exact position data is calculated by pattern match of image on the MOST network around standard point 3, the data is set a reliable point for dead reckoning module of using CAN data.

In summary, as time goes by, increasing error rate is revised from following data. At first, GPS position data at standard point 1. Secondly, position data at standard point 2 by wireless communication. At last, position data at standard point 3 by image matching. Therefore, the position data revised becomes a reliable data in any place.

IV. CONCLUSIONS

Telematics terminal usually uses GPS data for guiding path. GPS, however, always doesn't work well anywhere. Thus, this paper proposes the measuring model for showing the exact position of vehicle by using integrated vehicle networks.

The proposed measuring module can receives the position data from wireless communication module, and data of image DB, too.

The image data is used for extracting position data by matching with received images from camera of MOST networks. Also, in case that GPS and wireless communication don't operate, a variety of ECU sensor data which is generated by moving of vehicles can be generated from CAN network and used to extract exact position data.The information received from the integrated vehicle networks is used for extracting exact position of the vehicle continuously.

Lately, vehicle networks are inclined to be integrated and spread widely. In addition, GPS system has still the above severe problem. Therefore, the newly proposed system is expected to be an important model for telematics system to be widely used recently.

ACKNOWLEDGMENT

This Work was supported by Dongeui University Foundation Grant(2008)

REFERENCES

[1] Gu-Min Joung, Hyun-Shik Ahn, “Network Technology Trend of Automobile IT for fusion car”, Embedded World, pp52~59, 2008.

[2] Hyun-Joung Yun, Chang-Min Park, “Vehicle's Gateway Service and Communication Skill”, Electronics and Telecommunications Research Institute(ETRI), 2008.

[3] Jong-Hong Park, Sang-Rak Lee, Eun-Hye Kim,“Application and Service Trend for Telematics Technology of Distribution Industry”, ETRI, Trend Analysis of Electric Communication, Vol. 23, No. 4, pp147~155, 2008.

[4] Tae-Jong Choi, JungKuk Kim, Woong Huh, and Byung-Tae Jang, “Realization of An Outdoor Augmented Reality System using GPS Tracking Method”, The Journal of The institute of Electronics Engineering of Korea, Vol. 39, No. No.CI-5, pp.45 ~ 55, 2002.

[5] Lee Young-Joo, Seung-Jin Moon, "With GPS vehicle location and the service system crash", proc. of Korea Society For Internet Information, 2009.

[6] Se-Chang Oh, Yong-Sung Cho, "Development of Truck Shipment Incident Emergency Response System form Transporting Hazardous Materials Using GPS", Journal of The Korea Institute of Intelligent Transport Systems, Vol.1 2002.

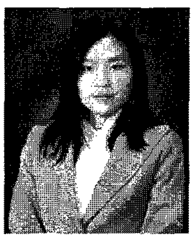
[7] Chi-Ho Park, Young-Hwan Oh, "A Study for Design and Performance Improvement of the High-Sensitivity Receiver Architecture based on Global Navigation Satellite System", The Journal of The Institute of Electronics Engineers of Korea, Vol. 45, No. TC-4, pp.9~21, 2008.

[8] Hernandez-Pajares, M. Zomoza, J.M.J. Subirana, J.S. Colombo, O.L., “Feasibility of wide-area subdecimeter navigation with GALILEO and Modernized GPS”, Geoscience and Remote Sensing, IEEE Transactions on, Vol.41, 2003.

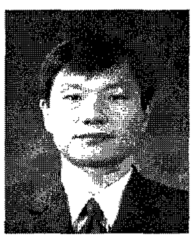
[9] Jae-Seobn Noh, Jun-Ho Oh, "Position Location by Integration of GPS Receiver and Dead Reckoning Sensors", Proc. Korean Society for Precision Engineering, pp.443~447, 1996.

[10] W.Y. Ochieng, J.W. Polak, R.B. Noland, J-Y Park & L. Zhao, P. Elliott, D. Briggs & J. Gulliver, A. Crookell & R. Evans, M. Walker & W. Randolph, “Integration of GPS and dead reckoning for real-time vehicle performance and emissions monitoring”, GPS Solutions, Vol.6, pp.229~241, 2003.

[11] Soo-hee Kim, Inh-wang Jung, "Design of RTLS using triangulation to the AP's RSSI in Wireless Local Network", Proc. The Korean Institute of Information Scientists and Engineers, Vol. 33, No. 2, pp.330~333, 2006.
[12] Nam-gi Kang, Jae-sun Park, Tae-min Hong, Yang-dam Eo, Byoung-kil Lee, Mu-wook Pyeon, Development of RTLS Access Point Allocation Prototype for Location Tracking in Construction Sites, INC, IMS and IDC, NCM '09. Fifth International Joint Conference on, pp. 943~948, 2009.
[13] Yun-su Bok, Young-bae Hwang, In-So Kweon, "UGV Localization based on Scene Matching and Pose Estimation", Proc. The Korea Institute of Military Science and Technology, pp. 1144~ 1150, 2007.
[14] Adachi, T., Kondo, K., Kobashi, S., Hata, Y., Identification of a Scene by Estimating the Position and Pose of a Moving Camera, Intelligent Signal Processing and Communications, 2006. ISPACS '06. International Symposium on, pp. 582~585, 2006.



Hyeyoung Moon was born in Busan, South Korea in 1979. She received a B.S. degree in Dept. of Computer Engineering at Dongeui University in 2001. She is currently M.S. degree in Dept. of Computer Engineering at Dongeui University. Her current interests include spatial database, LBS, In-vehicle Network, Global Positioning System, WiFi Positioning System, CAN Sensor Network and ITS.



Jindeog Kim was born in Busan, Korea, 1968. He received his undergraduate education at the Busan National University, Korea. He earned his M.S. and Ph.D. in Computer Engineering from the Busan National University, Korea. He is currently with the Department of Computer Engineering, Dongeui University as an associated professor. His research interests include a query processing in the spatial database, parallel processing of spatial operation, update strategy of moving object, path search method in the telematics systems and LBS application with RFID, vehicle network applications, etc.