A Method for Improving Accuracy of Image Matching Algorithm for Car Navigation System

Jin-Deog Kim, Hye-Young Moon, *Member, KIMICS*

***Abstract*—Recently, various in-vehicle networks have been developed respectively in order to accomplish their own purposes such as CAN and MOST. Especially, the MOST network is usually adapted to provide entertainment service. The car navigation system is also widely used for guiding driving paths to driver. The position for the navigation system is usually acquired by GPS technology. However, the GPS technique has two serious problems. The first is unavailability in urban canyons. The second is inherent positional error rate. The problems have been studied in many literatures. However, the second still leads to incorrect locational information in some area, especially parallel roads.**

This paper proposes a performance tuning method of image matching algorithm for the car navigation system. The method utilizes images obtained from in-vehicle MOST network and a real-time image matching algorithm which determines the direction of moving vehicle in parallel section of road. In order to accuracy improvement of image matching algorithm, three conditions are applied. The experimental tests show that the proposed system increases the accuracy.

***Index Terms*—Car Navigation System, Image Matching, Performance Tuning, GPS Alternatives**

I. INTRODUCTION

AS vehicle industries increase rapidly, in-vehicle networks are inclined to employ various electrical devices for vehicles recently. Recently, in-vehicle network technology has been introduced to provide convenience, safety and so on in the vehicle. MOST and IDB-1394 are also adapted to provide entertainment services for high speed data communication.

Furthermore, the car navigation system has a tendency to combine with the car entertainment service with the MOST network. However, the position of moving vehicle is usually calculated by GPS signal in the existing car navigation system. The GPS technique has two serious problems. The first is that the GPS technique is not able to determine the correct position of moving vehicle in urban canyon such as tunnel, buildings and woods[1]. The second is that the technique has inherent positional error rate. Many literatures have studied for the sake of improving the accuracy of GPS and positioning location with alternative method of GPS[2,3,4,5,6].

However, the error rate still brings about incorrect direction of moving vehicle in junction point of parallel roads. That is to say, incorrect information would be notified when driving lane is different from the lane calculated by navigation system with GPS. In order to solve the above problem of the positional error rate, image matching algorithm could be used[10,12]. However, the existing image matching algorithm has a problem in terms of matching accuracy at road image database.

This paper proposes a method of improving performance real-time image matching algorithm for the car navigation system. The method stores images of each lane of parallel roads and constructs 2 dimensional index for filter step in advance. Then, it utilizes SURF algorithm[8] for matching between the stored images and an image captured by MOST network. Three conditions for post-processing would be proposed for the sake of decreasing matching error in this paper. The results obtained from experimental test on real-time navigation show that the proposed systems work well and the accuracy is increased.

The rest of this paper is organized as follows. Section 2 investigates the related works on GPS and image matching algorithm. Section 3 describes a new positioning method based on image matching algorithm and performance improvement method. Finally, section 4 gives concluding remarks.

II. RELATED WORKS

Many researches on the accuracy improvement of location of moving vehicle have been studied so far. Related work [2, 3] designed the architecture of high sensitivity receiver to use GPS and GNNS. 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 proposed the high-precision architecture to solve code synchronization problems. The architecture was designed with asymmetric structure by maximizing amplification rate of reception and minimizing noise.

Manuscript received July 22, 2011; revised July 29, 2011; accepted August 10, 2011.

Jindeog Kim(Corresponding Author) is a professor of dept. of computer engineering, Dongeui University, Busan, 614-174, Korea (Tel: +82-51-1745, Fax: +82-51-2629, Email: jdk@deu.ac.kr)

Hyeyoung Moon is a graduate student of dept. of computer application engineering, Dongeui University, Busan, 614-174, Korea.

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.

Related work [4] proposed a system which consists 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 of moving objects. 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 partially possible to compensate location information. The GPS signal is required periodically because estimation error increases as time goes by. Thus, if the GPS signal is invalid for long time, the location information will be incorrect.

Now, we will describe studies on measuring location without GPS receiver. Related works[5] 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 a real-time location tracking system is able to cover a narrow area such as hospital and school.

Related work [6] 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. Then, on actual driving, an 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 an 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.

The proposed method in this paper uses the images obtained from the MOST in-vehicle network[7]. The MOST consists of audio, tuner, amp, monitor, navigation and so on for multimedia communication of vehicle. MOST is able to transmit synchronous audio data and asynchronous packet data as well.

There are three algorithm for image recognition which are template matching, SIFT and SURF[8] for image recognition. The template matching algorithm is a simplest algorithm. It recognizes a similar object by using coefficient map and maximum similar value. The algorithm, however, is valid in case when images to be compared have same sizes and orientations.

SIFT algorithm extracts characteristic points of comparable images and uses the points for recognition[9]. It is able to cope with the change of size and orientation of the images. SURF is also highly adaptable to the changes. Moreover, SURF algorithm shows more improved performance than that of SIFT.

Therefore, in order to solve the above error rate problem in parallel roads, this paper acquires images from MOST network in real time and the SURF algorithm for image recognition. Additionally, we also propose a post processing method for increasing the efficiency of SURF algorithm and show the results of experimental tests.

III. PERFORMANCE IMPROVEMENT OF POSITIONING METOD BASED ON IMAGES

Even though the above many literatures is useful for solving error rate problem of GPS[10,11], it still results in the above problem in the parallel roads as shown in figure 1. The position of moving vehicle could be different from that of navigation in the area.

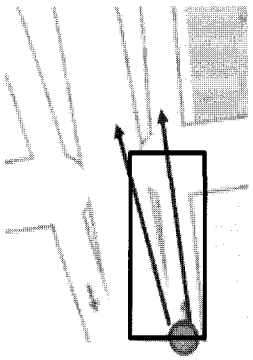


Fig. 1. Example of Parallel Road.

This paper proposes a method for improving accuracy of image matching algorithm for car navigation system. The S/W system for the positioning method consists of image matching module, image database, image acquisition module and modified OpenCV library[8] based on Window OS as shown in figure 2.

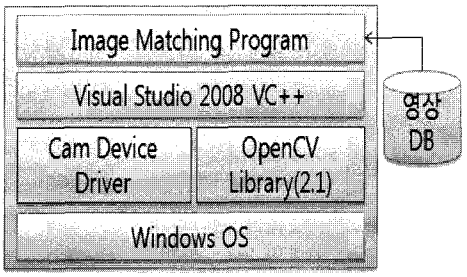


Fig. 2. S/W Module of Positioning System.

Image DB of this paper maintains images of each lane of parallel roads and MBR(Minimum Bounding Rectangle) of the images. The MBR is used for filtering step because the comparison module based on it excludes images to not be compared in advance.

The above SURF algorithm is used for matching between stored images of DB and a captured image by MOST network in this paper. At that time, GPS coordinates are also acquired[12].

If the corresponding coordinates are not contained in each MBR region, the matching algorithm doesn't have to be activated. The algorithm is activated in the MBR region continuously. If a captured image is decided to be matched, matching count increases. When the moving car escapes from the MBR region and the matching algorithm is terminated, the image with maximum matching count is decided to be a matched image.

In this paper, we carried out experimental tests of SURF algorithm 1000 times with 10 stored images and 10 captured images. In the following sections, we will present typical mismatch and match images.

3.1 Mismatched Images

Figure 3 shows a case of mismatch of matching algorithm. In this figure, upper image is a stored image in DB and lower image is an image captured by the cam of moving vehicle. The objectDescriptors means the number of characteristic points of the stored image. The imageDescriptors means the number of characteristic points of the captured image. The ptpair means the number of same points among above characteristic points. The r0~r3 means each inner angle of quadrangle drawn by recognized object.

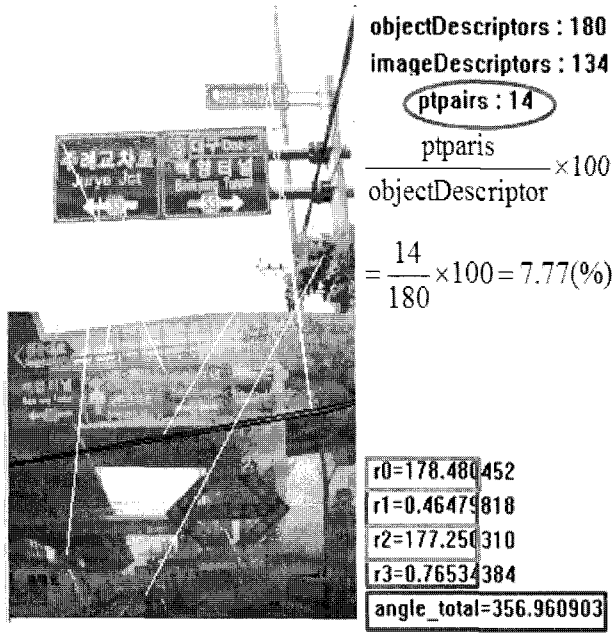


Fig. 3. Mismatch Case 1.

In the figure 3, the ratio of ptpairs is about 7.7% and the sum of interior angles of quadrangle is about 357. The maximum angle among inner angles is about 178.

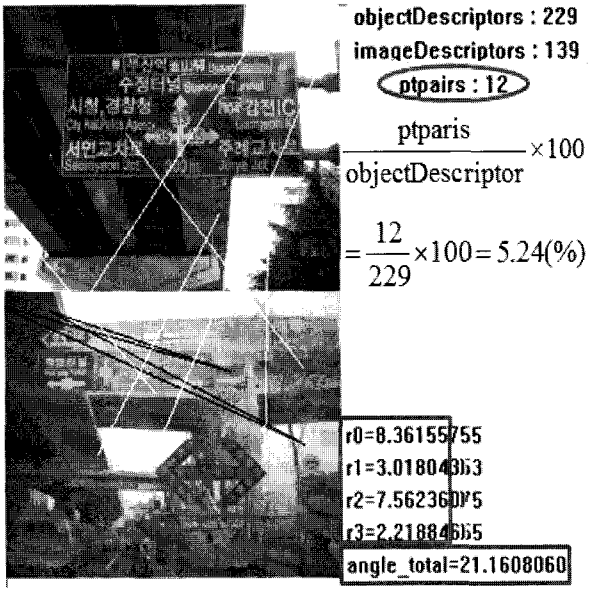


Fig. 4. Mismatch Case 2.

In the figure 4, the ratio of ptpairs is about 5.2% and the sum of interior angles of quadrangle is about 21. The maximum angle among inner angles is about 8.

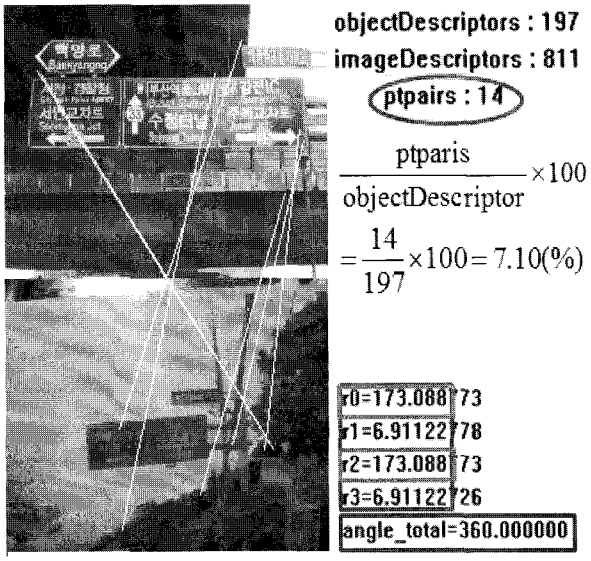


Fig. 5. Mismatch Case 3.

In the figure 5, the ratio of ptpairs is about 7.1% and the sum of interior angles of quadrangle is about 360. The maximum angle among inner angles is about 173.

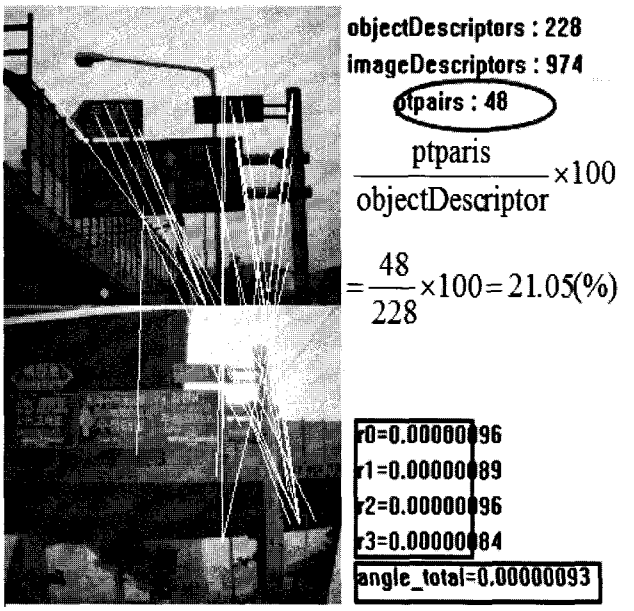


Fig. 6. Mismatch Case 4.

In the figure 6, the ratio of ptpairs is about 21.0% and the sum of interior angles of quadrangle is about 0. The maximum angle among inner angles is about 0.

3.2 Matched Images

Figure 7 and 8 show cases of match of matching algorithm.

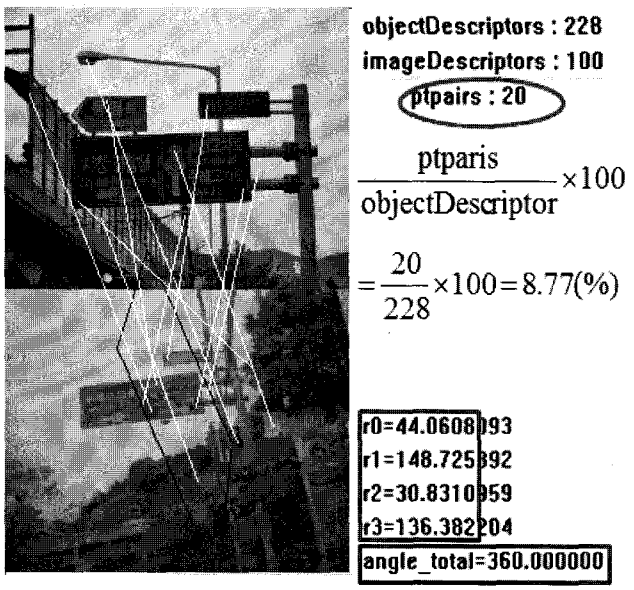


Fig. 7. Match Case 1.

In the figure 7, the ratio of ptpairs is about 8.8% and the sum of interior angles of quadrangle is about 360. The maximum angle among inner angles is about 149.

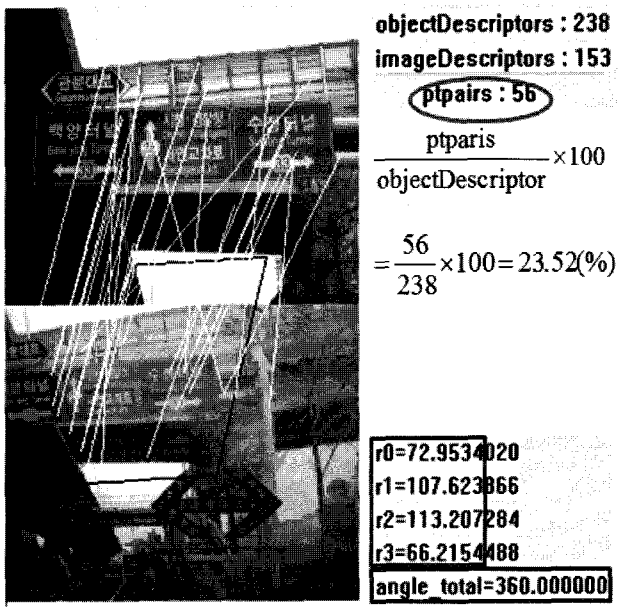


Fig. 8. Match Case 2.

In the figure 8, the ratio of ptpairs is about 23.5% and the sum of interior angles of quadrangle is about 360. The maximum angle among inner angles is about 113.

3.3 Improving Accuracy of Matching Algorithm

The results obtained from original SURF algorithm of OpenCV library show that the accuracy is very low. Thus, taking the above match and mismatch cases into consideration, we will propose three conditions for post-processing for the sake of decreasing matching error in this paper.

Condition 1) the sum of interior angles of quadrangle which binds recognized objects is 360
Condition 2) the ratio of common characteristic points between two compared images is larger than 7
Condition 3) each interior angle of quadrangle which binds recognized objects is 160

The matching accuracy may be increased by adapting post processing with above three conditions.

3.4 Implementation of Positioning System

Figure 9 shows the positioning system implemented with Visual Studio and Access Database. While matching error rate of original SURF algorithm is about 77%, the error rate of our method is below 5%. Thus, our three conditions derived by experimental test are very efficient at real road data.

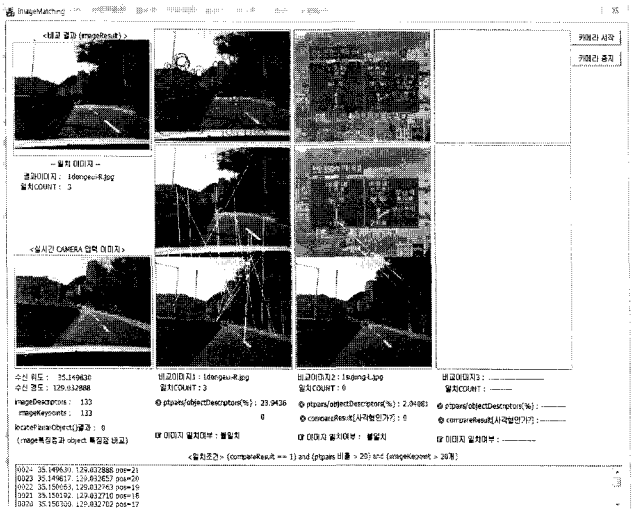


Fig. 9. Positioning System.

IV. CONCLUSIONS

So far, there are many studies on positioning method of moving vehicle. The GPS is widely used in car navigation system. However, the GPS technique has two serious problems: unavailability in urban canyons and inherent positional error rate. The problems have been studied in many literatures. However, the second still leads to incorrect locational information in some area, especially parallel roads.

This paper proposed a method for improving accuracy of image matching algorithm for car navigation system. Taking the results obtained from experimental test, we also proposed three conditions for post-processing for improving accuracy of SURF algorithm.

The implemented positioning system shows that the matching accuracy of our method is drastically improved by adapting post processing with above three conditions.

The proposed method would be expected to be a basic technology for LBS(Location Based Service) and telematics.

REFERENCES

[1] 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.

[2] 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.

[3] 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.

[4] 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.

[5] 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.

[6] 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.

[7] MOST Homepage, http://www.mostcooperation.com

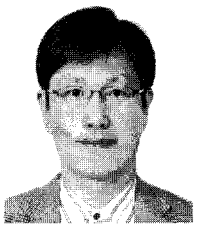
[8] OpenCV KOREA, http://opencv.co.kr

[9] David G. Lowe, "Object Recognition from Local Scale-Invariant Features", Proc. of IEEE Intl. Conf. on Computer Vision (ICCV), pp. 1150-1157, 1999.

[10] Hyeyoung Moon, Jindeog Kim, "A Measuring Model of the Position of Moving Vehicle based on Integrated Vehicle Networks for Spatial Database Applications", International Journal of Maritime Information and Communication Sciences, v.8, no.1, pp.83-88, 2010.

[11] Hyeyoung Moon, Jindeog Kim, Yunsik Yu, "Positioning by using Speed and GeoMagnetic Sensor Data base on Vehicle Network", Journal of Maritime Information and Communication Sciences, v. 14, no. 12, pp.2730-2736, 2010

[12] Jindeog Kim, Hyeyoung Moon, Yunsik Yu, "A Positioning Method based on Images of In-Vehicle Networks", Proc. Of International Conference of KIMICS, v. 4, no. 1, pp.153-155, 2011



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.

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.