VEHICLE LOCALIZATION METHOD USING THE IMAGES FOR CAR NAVIGATION SYSTEM

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ABSTRACT:Current accuracy of GPS is within the meter level, which is sufficient for route guidance of car navigation system(CNS). But receiving condition of GPS signal varies time to time according to surrounding objects such as building, trees, and terrain. For this reason, the performance of the route guidance is degraded in urban region. In this paper, to improve the performance of the route guidance of CNS, we propose a method for determining location of vehicle using a location of the traffic signal and its pixel size extracted from real-time image.

KEY WORDS: car navigation system, GPS, vehicle localization

1. INTRODUCTION

Recently, CNS is one of the most widely used services in the field of telematics, which informs a driver of the current location of a vehicle and provides the optimal path to a destination. Most essential function of the CNS is to determine the accurate location of a vehicle, mostly by GPS receiver. The current vehicle location determination issue is an important factor for the performance of CNS. But GPS data has the bias error caused by satellite orbit error, atmosphere error, satellite constellation, receiver measurement noise, etc. Especailly, the performance of CNS is decreased in case of urban region with surrounding objects such as high-story buildings, tunnels, underpasses, and overpasses[1].

For this reason, it is necessary to localize vehilcle more exactly in case of weak receiving signal of GPS, for which we make use of road facility (such as traffic signal) and real-time image captured by video camera. In this paper, we propose a method for determining location of vehicle using a location of traffic signal and its pixel size extracted from real-time image.

2. METHOD

The proposed vehicle localization method can correct both along-track error and cross-track error of vehicle[2]. As shown in Fig.1, Let the received low-cost GPS data of vehicle location, reference data of vehicle location by using CDGPS(Carrier Differential GPS)/INS(Inertial Navigation System)/DMI(Distance Measurement Indicator), and actual(corrected) vehicle position be LV, RV, and LC, respectively. Let the position of traffic signal be Ls, where we regard traffic signal as any one of its multiple lamp sets (represented as rectangle in Fig.1).

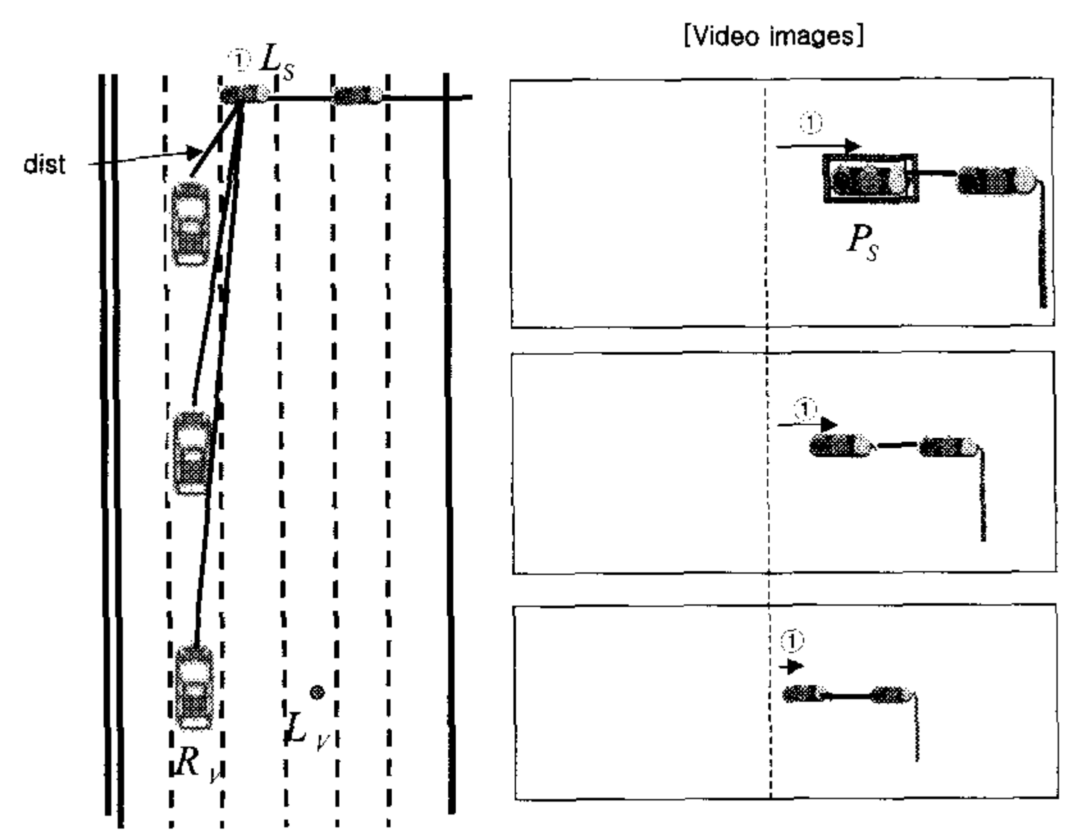


Fig. 1. The proposed vehicle localization method

Let the distance between RV and LS be dist. Let the pixel size of traffic signal in image be PS, which is defined as number of pixel for occupied region of traffic signal in image. Note that, we assume that camera configuration is fixed for the subsequent discussion. a to which the traffic signal(more exactly, a lamp set of the traffic signal) NS (NS)NV

The proposeed vehicle localization is done by two methods: distance localization and lane-level localization. Our proposed methods are described as follows(Fig. 2)

Step 1. Determine LV on the map .

Step 2. Check the quality of GPS signal(See III.1).

Step 3. Search traffic signal database and road data, to find a traffic signal which is ahead of the vehicle and closest to LV.

Step 4. Recognize the traffic signal from image.

Step 5. Execute distance localization through looking up the preconstructed PS vs. dist table with observed PS (See II.1).

Step 6. Execute lane-level localization through dist and x-coordinate of pixel that corresponds to the center of the found traffic signal(See II.2).

Step 7. Determine final LC.

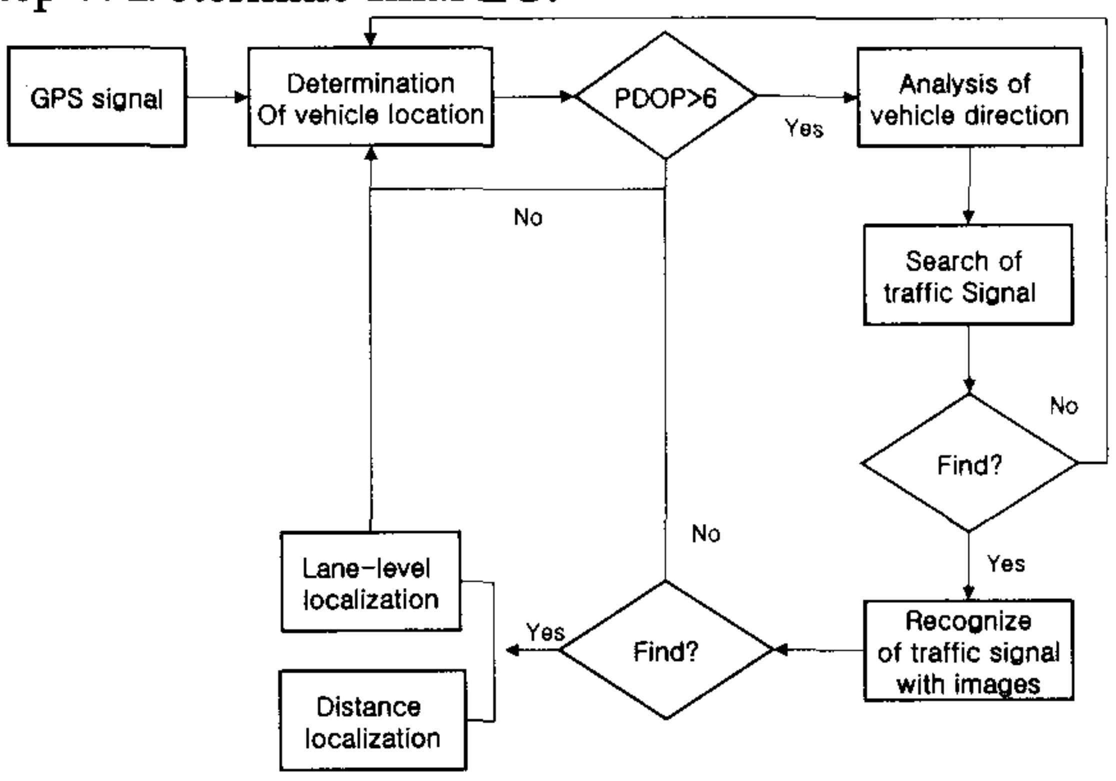


Fig. 2. The proposed approach

2.1 Distance localization

To correct along-track error of vehicle, we analyze relationship between PS and dist. Fig. 3 shows the relationship between PS and dist from 40 traffic signals observed in the test road section, by which we can correct the LV.

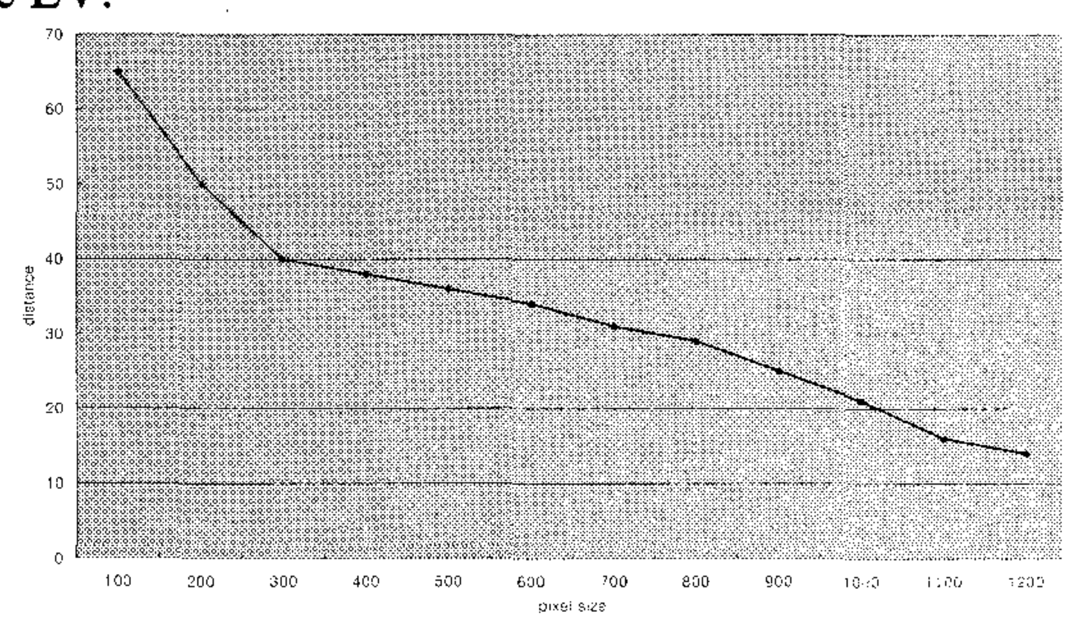


Fig. 3. The relationship between PS and dist

Note that, the traffic signals here have three lamps for each lamp set, which guarantees all traffic signals in this data have same actual size (four-lamp traffic signals yield another relationship; it is omitted). For example, when the traffic signal is recognized with pixel size=100, we can know the distance between the traffic signal and the vehicle is about 65m, and thus can estimate the along-track vehicle location.

2.2 Lane-level Localization

To determine on which lane we are moving, we observe where the traffic signal appears in image. Again, we choose any one of multiple lamp sets of a traffic signal. Using the camera specifications(size of a CCD cell c=0.00465mm, focal length f=4.09mm, and pixel number (x,y)=(1392*1040)), we derive a mapping function from actual width of object to its corresponding pixel width, as

$$pixel = \frac{x * size * f}{c * x * dist} = \frac{size * f}{c * dist} \qquad (1)$$

Also, the width of a lane in test road section is supposed to be 3.25m(referred from official domestic traffic guideline). From (1), we can get the pixel size for a lane is 2858.6/dist, which we denote as w(dist).

Let the x-coordinate of center of detected traffic signal be x, and the x-coordinate of center of image be cx. then we can get NVfromthe relative offset of lane NS, as

$$if(-\frac{w(dist)}{2} < x - cx < \frac{w(dist)}{2}) \quad N_V = N_S$$

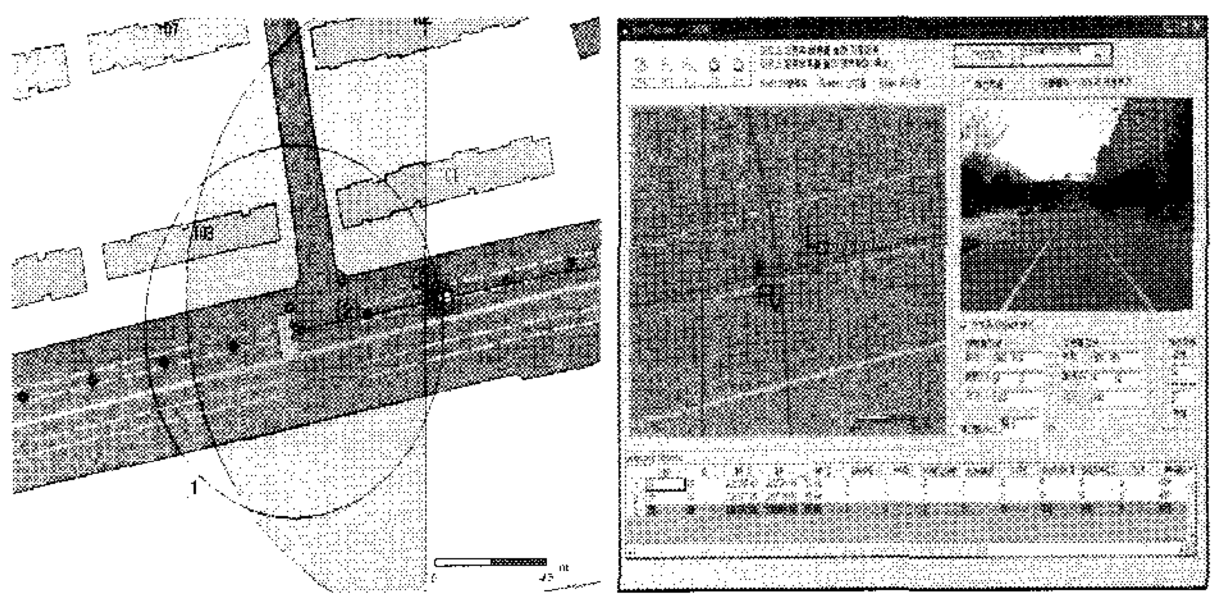
$$if(\pm\frac{3w(dist)}{2} < x - cx < \pm\frac{w(dist)}{2}) \; N_V = N_S \mp 1$$

$$if(\pm\frac{5w(dist)}{2} < x - cx < \pm\frac{3w(dist)}{2}) \; N_V = N_S \mp 2 \quad (2)$$

For example, if the distance is 40m and the center of traffic signal which corresponds to 2 nd lane(NS =2) is found in x=780, then w(dist)=71 and x-cx=780-696=84, we conclude the vehicle is on 1 st lane(NV = NS -1) by(2). Also, when we have multiple lamp sets, each lamp set can be independently processed as above.

3. EXPERIMENTAL RESULT

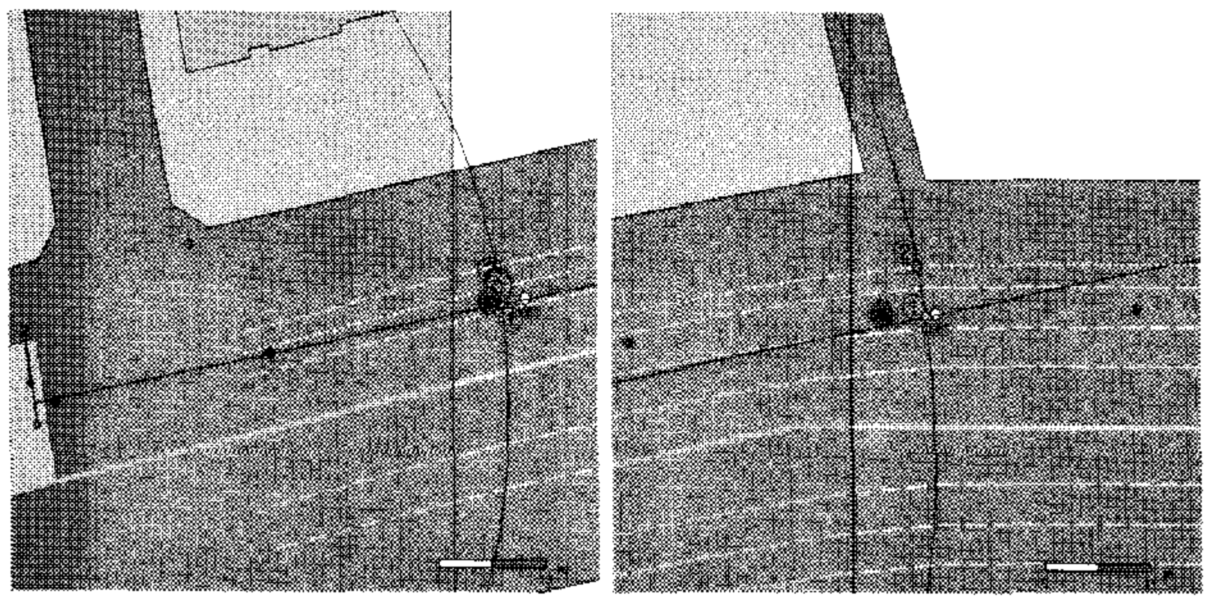
For the experiment, we used 1:5000 digital road map that also contains road lane information. In order to get a reference data of vehicle trajectory, and a databse of traffic signal, we used a mobile mapping system[3]. Fig. 4 shows the result of distance localization process discussed in II.1 at a straight road section, where the relationship between P_S and *dist* is used. In Fig.4, ① is a circle whose center is at L_S and radius is *dist*, and ② is the line segment connecting observed L_V and L_S. The L_C ③ can be estimated as the intersection of ①and ②. Test result shows that L_C is nearer to R_V than L_V is.



a) distance correction b) enlarged view

Fig.4. Localizing a vehicle by distance localization method

Fig. 5 shows the result of lane-level localization presented in II.2, where ① is R_V and ② is L_C. As shown in Fig.6, the proposeed lane-level localization method efficiently works in case of nearly straight road sections. But the method may yield wrong result in case of curved road sections. In order to solve the problem, we use only the traffic signal within 20~40*m* of L_V where a lane is supposed to appear straight.



(a) straight road section (b) curved road section

Fig . 5. Localizing a vehicle by lane-level correction method

Table 1 is a result of correcting vehicle location in test road sections using both lane-level localization and distance localization. As shown in the result, applying two kinds of method does not necessarily yield better accuracy of a location.

Table. 1 The result of vehicle localization in test road sections

Dist	Difference	Accuracy of correction		
		better(m)	similar(m)	worse(m)
80m	R_V-L_V	3.79	**3.03**	**3.67**
	R_V-L_C	**2.70**	5.88	7.85
60m	R_V-L_V	2.94	3.88	**2.81**
	R_V-L_C	**1.42**	**3.35**	3.05
40m	R_V-L_V	2.02	5.03	**2.09**
	R_V-L_C	**1.97**	**1.16**	8.11

It is assumed that such result is mainly due to GPS accuracy(PDOP). We can conclude the quality of the GPS signal should be checked before applying distance localization and lane-level localization. Fig. 6 shows the result of location correction using the two methods together in case of weak GPS signal(PDOP>6). ① is R_V, ② is L_V, ③ is L_C (distance localization applied), ④ is L_C (distance localization and lane-level localization appled). We can see, L_V is corrected to a location near to R_V when the error of L_V is very large (GPS signal is weak).

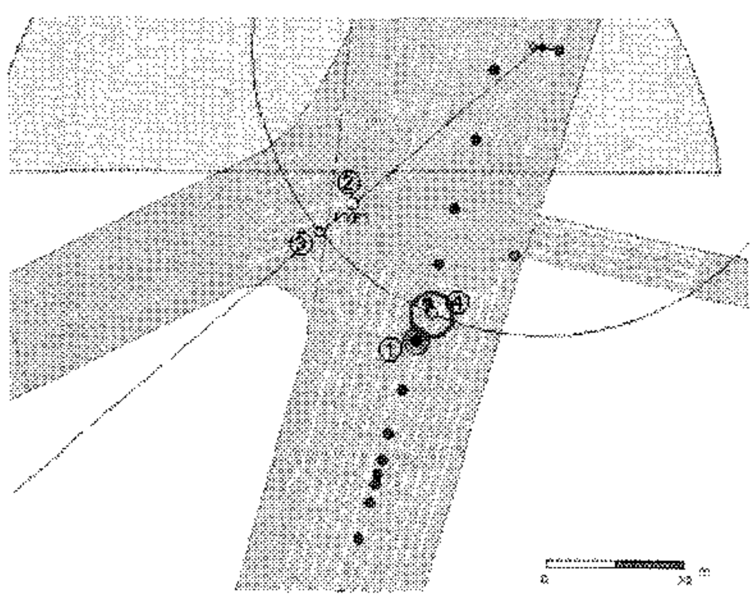


Fig. 6. The vehicle localization in case of weak GPS signal

4.CONCLUSION

In this paper, we propose a new approach of correcting location of vehicle based on recognized object in real-time image. Especially, it is shown that the localization methods are highly effective when the GPS error is large. But the corrected location may be rather worse than the location estimated by stand-only GPS when the accuracy of traffic signal recognition is low or the accuracy of GPS is hight. In this paper, we do not handle about the traffic signal recognition process. However, the performance of the proposeed vehicle localization method depends on reliability of traffic signal recognition, which remains as our further researches.

5. REFERENCE

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6. ACKNOWLEDGEMENTS

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