

Map Generation System with Lightweight GPS Trace Data

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Abstract— Map data generation in geographic information system is based on large amount of realistic data and therefore requires a lot of time and money to create and change the data. In this study, to overcome such problems, we suggested a real-time map creation system with high accuracy using a few user GPS(Global Position System) trace data. The system enables efficient and economical road map creation in geographical information system, which is one of the essential element of the intelligent transportation system(ITS)

Keywords— Digital map, real-time map generation, road link, GPS trace, GPS, Global Position System, ITS, Intelligent Transportation System, GIS, Geographic Information System

I. INTRODUCTION

Nowadays ITS technology has expanded its filed and utilization and became one of the most important element in our daily life. Geographic information system(GIS), one of the essential ITS technology, computerizes the real-world geographical data and provides it. The main GIS technologies for ITS are digital map data creation and data service. Creating digital map data requires much expanses and time because it is necessary to collect and process large amount of real-time data. Related to this, many researches and technology developments are made for digital map data creation.

Typically, the creation of digital map creation is made by real-world visual analysis and in last few years, the satellite pictures are also used. However, such methods require large initial deployment cost and time and also require longer time to reflect the changes in real-world to the data. For efficient data update, a vehicle equipped with a GPS receiver is used to compare the location data of existing roads to measured location data to predict any changes in road data.

Recently, the prevalence of mobile devices equipped with GPS receiver enables the acquisition of real-time GPS trace data without any built-in GPS receiver in vehicles.

In this paper, to solve the aforementioned problem that digital map creation technologies have, we suggest automatic digital map creation methodology using GPS trace data. Research results shows that even only with small amount of GPS trace data, real-time highly accurate road map creation

was possible and proves the validity of the suggested methodology.

The actual procedure of digital map update is not automated and therefore is inefficient.

II. RELATED RESEARCH

At present, most of the digital maps are obtained after some operations to remote sensing imagery or to paper maps [1]. On one hand, errors could be produced during the operations. On the other hand, for some areas, remote sensing images and paper maps are both absent. Therefore, some paper proposed to generate roads maps using GPS (Global Position System) data.

In [2], an algorithm which exploits clustering techniques is presented to analyze GPS data and to infer roads geometry. In [3], serial operations including eccentric correction, roads curves fitting and multilane data fusion are employed to process GPS data and to generate roads maps. In [4], a novel technical concept -“Data Recycling”, which means derive roads information by collecting massive GPS data of different vehicles on the roads, is proposed and the LSA (Least Squares Approximations) methods are used to extract roads.

Older researches on road map creation using GPS trace data, mostly focused on the process of creating and changing data and mentioned the result always have GPS error range in terms of accuracy.

However, considering the average width of a road is 3m, the error range of GPS data is 15m and can be seen as insufficient to ensure the accuracy of created road data.

To improve the location accuracy, large amount of GPS trace data is used and can process the actual-like road map creation, however, it requires large amounts of data and data processing and therefore difficult to apply it in reality.

III. PROPOSED SYSTEM

This study proposes an automated real-time map creation system which collects and analyzes user's GPS trace data

The suggested system consists of Trace Data Creation Application which creates user's GPS trace data and Trace Data Processing Server which collects and processes GPS trace data. (Figure 1)

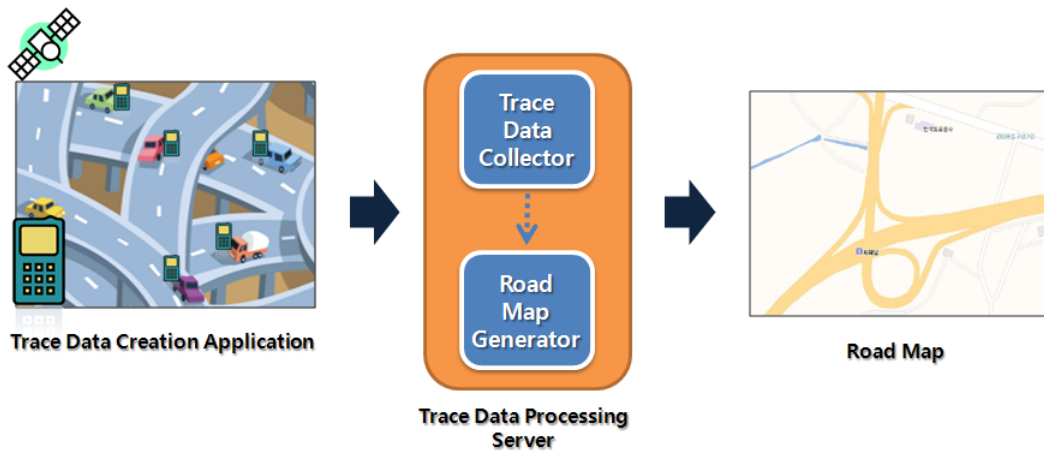


Figure 1. Architecture of proposed system

A. Trace Data Creation Application

Trace Data Creation Application is an application in hand devices equipped with GPS and it creates driver's GPS trace data and regularly transfer it to Trace Data Processing Server.

Trace Data Creation Application consists of six modules, as shown Figure 2.

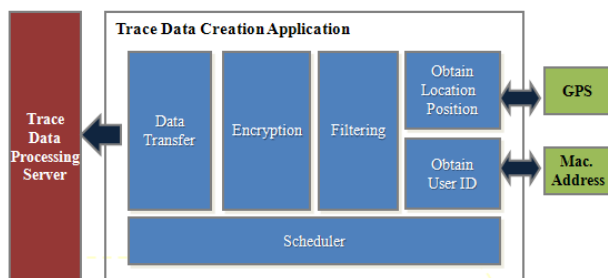


Figure 2. Modules of Trace Data Creation Application

1) **Obtain Location Position:** This module obtains the location information from GPS receiver.

2) **Obtain User ID:** This module obtains the Mac address from network card on device. We use Mac address for creation user id.

3) **Filtering:** This module filters data by verifying location range, data type and data size.

4) **Encryption:** This module encrypts data. We use RSA method for encryption position data and use MD5 method for encryption user id. The user id needs for creation each user's trace data.

5) **Data Transfer:** This module creates packet for transmission and transfer it to Trace Data Collector. Generated trace data is converted into packets to be fitted in transmission format and consists of following three factors.

- Latitude and longitude(WGS84)
- Velocity
- Time

6) **Scheduler:** This module controls schedule of obtaining and transmission trace data. The scheduling configuration can be set on user interface.

B. Trace Data Collector

Trace Data Collector is the server which receives Trace Data packets sent from Trace Data Creation Application. Received trace data packets are parsed and stored in the database. Trace Data Collector consists of three modules, as shown Figure 3.

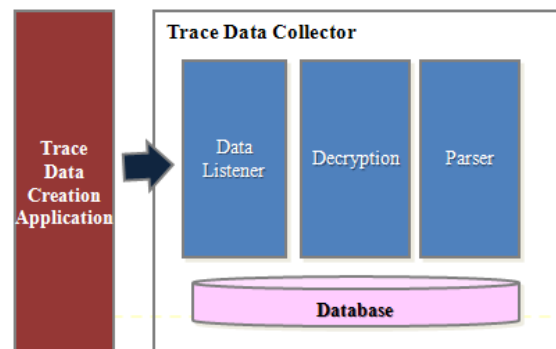


Figure 3. Modules of Trace Data Collector

1) **Data Listener:** This module receives packet data from Trace Data Creation Application.

2) **Parser:** This module parses the received packet.

3) **Decryption:** This module decrypts parsed position data using RSA method.

C. Road Map Generator

Road Map Generator analyzes collected Trace Data and creates road data. Map creation process of Road Map Generator consists of 6 steps, as shown in Figure 4.

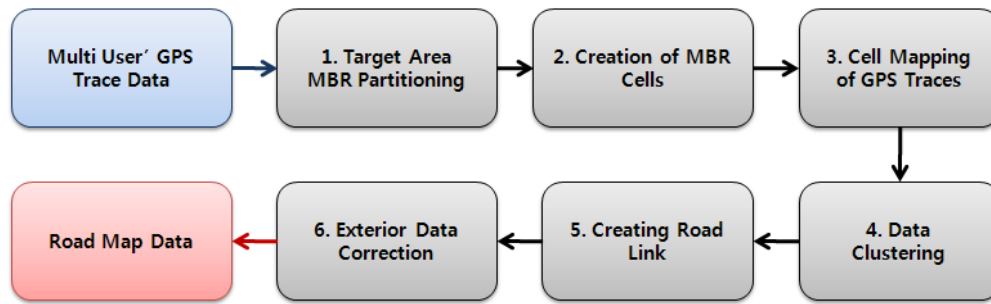


Figure 4. Road map generation process

1) Target area MBR partition: This step divides target location area into MBR(Minimum bounding rectangle) segments. MBR is the minimum divided area for data processing and normally set in a range of a road. Red colored cells in Figure 5 (a) illustrate segmented MBR.

2) Creation of MBR Cells: This step creates MBR partitioned corresponding cells in size of 1m. Corresponding cell is a base unit for processing data in MBR.

3) Cell Mapping of GPS Traces: In this step, GPS trace data is mapped in MBR corresponding cells. Dots in Figure 5 (b) are the result of mapping relative location in MBR's GPS trace data. To map relative location data of MBR's GPS trace data, we translate the WGS84 coordinates into KATEC coordinates. KATEC coordinates system is useful for processing location information because of it has low distortion. KATEC coordinates system is an orthogonal system with 1 unit corresponding to 1m in size.

4) Data clustering: GPS trace data in relative cell of MBR is clustered in this stage. Clusters are formed according to the adjacent distance (distance between cells) of GPS trace data. If the number of data is lower than a certain level, then that cluster is ignored. Figure 5 (c) illustrates created clusters according to adjacent distances of trace data.

5) Creating road link: Road link data creation consists of the following two stages. In the first stage, the road link data of MBR is generated. In this stage, the clusters in MBR are connected and generate road link data. The direction and shape of link data are decided by analyzing the patterns of clusters in MBR. MBR can have one of the vertical, horizontal, curved or mixed patterns. In the second stage, the road link data of MBR is merged.

6) Exterior data correction: This stage corrects the irregularity of generated road link data. The road link data generated in step 5, a shape of linear of curve and therefore further correction is required. The exterior part is corrected by analyzing shapes and angles of generated road link data. Such corrected road link data

becomes the final road map data. Red colored line in Figure 5 (d) illustrates the final road link data.

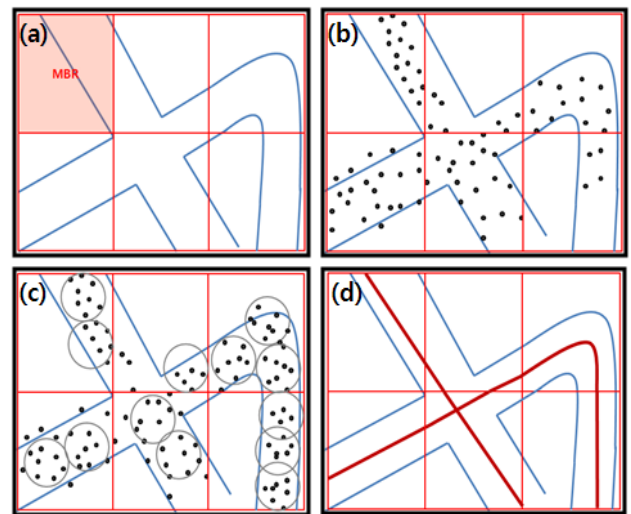


Figure 5. Concepts of Road Map Generator

IV. IMPLEMENTATION AND EVALUATION

A. Trace Data Creation Application

This application implemented such as development environments.

- .Net Compact Framework 3.5
- Windows Mobile 6.0 SDK
- Implemental language : C#
- Application device : SCH-M490

This application obtains following data. Figure 6 illustrates obtained data by Trace Data Creation Application.

- Mac Address
- Location Position : latitude and longitude
- Velocity
- Direction & velocity degree
- Timestamp



Figure 6. Trace Data Creation Application Screen

B. Trace Data Processing Server

This server consists of Trace Data Collector and Road Map Generator. It implemented such as development environments.

- Java JDK 6
- MySQL Server 5.4

To evaluate the accuracy of created road map data, the Open API provided by NAVER is used. Generated road link data is shown in Naver maps and the accuracy of road link location is evaluated[7].

Figure 7 illustrates processing result of curve patterned MBR. (a) illustrates GPS trace data mapped in relative cells of MBR and (c) is the result of corresponding cell data displayed on the map. (b) illustrates link data of the clustered relative cell and (d) is the result of corresponding link data displayed on the map. The size of one cell is 1m in real-world.

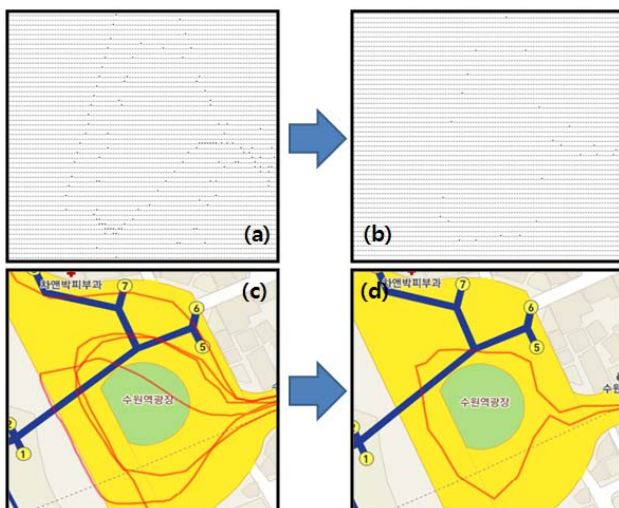


Figure 7. Relative cells of MBR which mapped GPS trace data and curve-shaped road link data produced after clustering: (a) relative cells of MBR which mapped GPS trace data: (b) result of clustering (a): (c) result of displaying a on the map: (d) result of displaying (b) on the map

Figure 8 illustrates the processing result of MBR with linear patterns. (a) is the GPS trace data mapped in corresponding cells in MBR displayed on the map and (b) is the result of generated road link data displayed on the map after clustering.

Figure 9 is the adjusted irregularity of generated road link data. (a) is the irregular link data and (b) is the final road map data generated by adjustment of (a)'s link data.

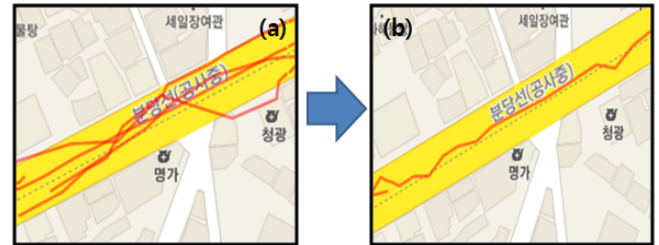


Figure 8. Relative cells of MBR which mapped GPS trace data and linear road link data created after clustering



Figure 9. Final road map data created by exterior adjustment of formed road link data: (a) before adjustment: (b) after adjustment

We make experiment on certain roads in Suwon(Korea) to confirm our system. The road digital map is generated by the system proposed in this paper.

Figure 10 illustrates the generated final road map at target area.



Figure 10. Trace Data Creation Application Screen

The evaluation result of proposed system confirmed the possibility of the map creation with high accuracy with the number of traces less than ten traces.

And the road link was created in less than 0.5 seconds in average for one MBR(200m*200m).

This result shows the possibility of efficient road map creation in short time using real-time data.

V. CONCLUSION

ITS field is evolving rapidly and therefore economical and efficient technology which can coordinate and map the real-world geographical information is required.

The prevalence of GPS equipped mobile devices, facilitated GPS trace data collection and such collected data is used in various fields.

This paper we propose a real-time road map generation system with high accuracy with a few GPS trace data and proved efficiency through estimated accuracy and performance.

Future researches on elevating accuracy of road map shaped by predicting the types of land and road with analyzing GPS trace data are required.

ACKNOWLEDGMENT

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REFERENCES

- [1] Z. Zhu, Q. Wang and D. Wan, "A study on automatic generation road center-lines algorithm based on road contour", *Journal of Image and Graphics*, vol. 8(A), no. 7, 2003, pp. 792-797. (in Chinese)
- [2] R. Bruntrup, S. Edelkamp, and S. Jabbar, "Incremental map generation with GPS traces", *Proc. of the 8th IEEE Intelligent Transportation Systems Conf*, Vienna, Austria, 2005, pp. 413-418.
- [3] S. Shi, Z. Lü, H. Chen and D. Zhao, "Data processing technology in road surveying by vehicle-borne GPS", *Journal of Zhengzhou Institute of Surveying and Mapping*, vol. 23, no. 4, August 2006, pp. 275-277, 283. (in Chinese)
- [4] T.Guo, K. Iwamura, and M. Koga, "Towards high accuracy road maps generation from massive GPS traces data", *Proc. of IGARSS*, 2007, pp. 667-670.
- [5] Jonathan J. Davies, Alastair R. Beresford, Andy Hopper, "Scalable, Distributed, Real-Time Map Generation," *IEEE Pervasive Computing*, vol. 5, no. 4, pp. 47-54, Oct.-Dec. 2006
- [6] Rogers, S., Langley, P., & Wilson, C., "Mining GPS data to augment road models," *Proceedings of the Fifth International Conference on Knowledge Discovery and Data Mining*(pp. 104-113). San Diego, CA: ACM Press. 1999
- [7] <http://dev.naver.com/openapi/apis/map/>