Design of Elevation Data Transmission Method for Mobile Vector GIS

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Abstract—In mobile GIS environments, a client needs to receive the isogram data with a topographical map from a server, if the mobile client wants to display map with elevation information. Because the elevation data size is normally quite large, the client will suffer some problems to receive the elevation data from server. The main reason is a resource limitation of the mobile devices.

To overcome these problems, this paper proposes new data structures and algorithms. They are designed for efficient transmission of contour data to a client. Because of the contour data are generated as a vector style from elevation information stored at a server, the proposed algorithms are focused to minimize the transmission data volume and time.

Index Terms— Elevation Model, Contour Line, Mobile GIS, Mobile Bandwidth

I. INTRODUCTION

Recently, users who search and make use the information about life and outdoor activities by potable mobile devices on real-time, are increasing. Among this information, the contour style information based on the photographical map is especially related to the applications of the metrology information, the mountain terrain information, and the marine information.

In case of the metrology information, the importance of the information is increased at outdoor activities, and the service to deliver the metrology information into the mobile terminals is becoming more common.

However, till now most these services are based on text data for the weather forecasting. In the future, according to the generalization of the weather map and the advance of the information technique, it is expected that the needs for more detail and special information such as a digital weather map and a satellite pictures will be increasing. Furthermore, for elevation data are important information at the fields of mountaineering and tracking. The elevation information is used to generate and display contour lines, and help users understand the topography of their interesting area.

There are two methods to display elevation information on mobile environments. First, the elevation data can be generated by its stored database directly. The database is TIN(Triangulated Irregular Networks) or DEM(Digital Elevation Models) based data. This approach has several obstacles. TIN or DEM has very large data volume, and so the mobile device has to have enough space to store it. The contour line generation time also will be long at the mobile device. This overhead makes it hard to process the information on real-time.

The second approach is to generate the elevation data of the requested area at server and then transmit them to mobile client. If the generated elevation data are raster image, the transmission efficiency will be high. However, the client cannot extract the elevation information and use them for other applications such as spatial analysis. If the generated data are vector type, the transmission overhead will be very high because of the large data volume.

Fig. 1 Contour Line Display Example on Mobile device

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Figure 1 shows contour line display[1] example on mobile client device. The topological map and the elevation data are transmitted from server to client at the same time. The users can apply these elevation data to reference topological information or to analysis some co-relations.

As the contour line is vector data, the data volume is very large and the transmission time will be too long to service on real-time. To overcome these problem, this paper sets focus on the transmission efficiency of elevation vector data from server to client. The design target of this paper is to propose a new data model to minimize the transmission cost. The data model contains vector array to generate contour line at client.

The organization of the remaining parts of the paper is follows. Section 2 reviews the related works on the topic and Section 3 introduces the proposing data model and Section 4 shows how to make up the data structure for elevation data. Finally, the conclusions of this paper are in Section 5.

II. RELATED WORK

The elevation information generally are expressed as the vector style TIN model or raster style DEM model[2]. Because the TIN model stores an elevation value with (x, y) coordinator, it has an advantage of flexible aspect related to DEM model. The DEM model stores the elevation value with a grid. As the grid size is small, the elevation precision is high. The data volume of TIN model is generally larger than the DEM model's. Especially, for a complex area, the elevation data are stored redundantly. However, the DEM model has the advantage of simpler processing steps than the TIN model. And the DEM model supports easier understanding the whole land shapes than the TIN. But, the DEM also has the problem of data redundancy on the plain area.

This elevation information usually is used to generate contour lines to help users understand the topography. To analysis some correlations between a subject layer and the elevation information, the contour lines are often referenced.

Up to recently, the related researches to deal with the elevation data are classified into 3 areas. First area is a research related to generate the DEM or the TIN model efficiently from other sources. It includes developing the various transformation methods from one model to another model[3]. Another area is related to correlation analysis between a subject layer and the elevation information[4]. Lastly the new interpolation algorithms are still observed in many fields[5].

This paper will consider some issues occurred when elevation data are transmitted to a mobile device. This issue is hardly discussed until now. To transmit elevation data or contour line from a server to a mobile device, takes very large mobile bandwidth, and as a result, in mobile client, long transmission delay will occurred. And yet the mobile client cannot hold the whole elevation data locally because of the memory resource limitation. In this case, the client processing ability is also considered. Therefore, a new efficient method to transmit the elevation data from server is required.

III. DATA STRUCTURES FOR ELEVATION DATA

The approach to transmit elevation data generated from the raw data of TIN or DEM from a server directly to a client, cannot be accepted. This method requires the client to receive large data volume causing long transmission delay. The approach to transmit the converted contour lines from the TIN or DEM data at the server, also has a problem. The vector data volume of contour lines is still too large to receive on time at the client. Another method to generate contour map, transform it to raster image at the server, and transmit it to client, also has a limitation. The client cannot take an advantage of further use of the elevation information.

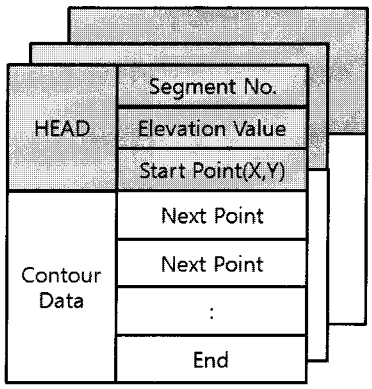

Fig 2. Formatted Contour Data Structure

To overcome these problems, this paper proposes a new method to generate transformed contour vector data. By the transformation, the size of contour data can be decreased dramatically. The method is based on relative coordinator transformation. For this purpose, a new data structure is proposed as shown at figure 2. This data structure is called **FCDS**(Formatted Contour Data Structure), and a set of FCDS which makes up a contour map is called **FCM**(Formatted Contour Map). **Contour Segment** is defined as a geometric feature in the contour lines at a viewport of query area. Lastly an instance of FCDS is called a **FCDS Frame**.

In figure 2, a FCDS contains data of a contour segment in the contour map. The contour map means a set of contour lines for a map which is displayed currently in a client. The segment means a contour line among them. A FCDS is consisted of 2 parts. They are structure head and contour data part. The structure head contains the information about the segment. It includes a segment number as identifier, an elevation value of the contour segment, and a start point coordinator.

The contour data part contains list of points which make up the contour segment, and end mark. The value of 'Next Point' is stored as relative coordinator to start point. It needs only 4 bits. Its value represents one of the 8 directions relative to start point for the first 'Next Point' field. The next field also represents the direction value relative to previous point. The last 4 bit is used to represent end mark. If the 4 bits representing values of 8 directions use from 0000 to 0111, the end mark may be 1111 value.

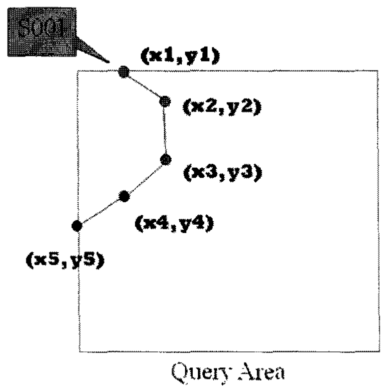

Fig 3. Example of Contour Segment

Figure 3 shows an example of a contour segment. The segment consists of 5 points. Almost in GIS coordinator system, a point needs 8 bytes. Thus, the data size of the segment will be 40 bytes (5 X 8 bytes).

Figure 4 shows a FCDS frame of the contour segment shown in figure 3 and the corresponding display result at a client screen. Here, the data size of FCDS frame can be compared to the original contour segment. In FCDS frame, 10 bytes will be enough for the head size : 4 bytes for segment number, 4 bytes for elevation value, 2 bytes for start point. The frame body takes 3 bytes (exactly 2.5 bytes). Thus, the frame size is less then 13 bytes. Compared to 40 bytes of original segment size, the frame size is less than 1/3 of the original size, that is, over 70% data compression effect is expected.

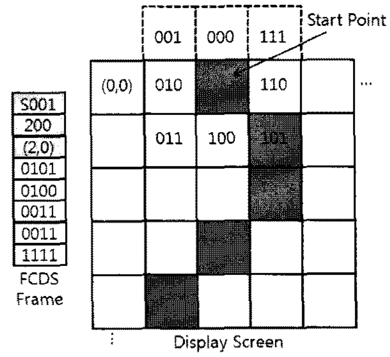

Fig 4. Example of FCDS Frame and Client Display for Contour Segment in Fig. 3

IV. DESIGN of ELEVATION DATA CONSTRUCTION METHODS

The process to construct the FCM is shown in figure 5. In this figure, a server processor extracts elevation data of client query area from entire elevation data. After that, the processor generates FCDS frames with the extracted elevation data. The result of entire processing steps is a FCM for client query area.

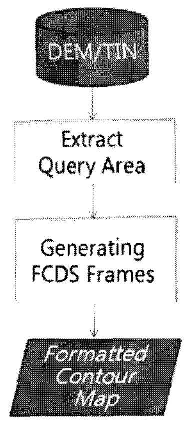

Fig 5. FCM Construction Process

The process to construct the FCDS frame is shown in figure 6. First, the server processor generates contour line list from the extracted elevation data on the previous step. The generated contour lines are translated to FCDS fames as unit of a contour segment. The detail processes include coordinator transformation and pixel trace steps. In the coordinator transformation step, the client screen resolution is provided to transform the server coordinators to requesting client coordinators. Therefore, FCDS has client coordinator values. This fact gives another advantage except the data shrinking. The client can draw contour line directly from FCM without time consuming coordinator transformation process.

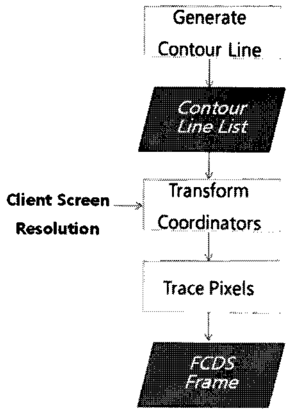

Fig 6. FCDS Frame Construction Process

With the transformed contour line list, the server processor generates FCDS frame in pixel tracing step. In the 'Trace Pixels' step, the processor draws each contour segment on virtual canvas which has same resolution with the request client. And after that, it traces the line to extract start point and following pixels. The algorithm of this step shows in figure 7.

```
FCM TracePixel(TransformedSegment[] s,
                    ClientScreenResolution r) {
   //make virtual canvas
   makeCanvas(r);

   for(s.length) {
      //draw a segment
      startPoint = drawSegment(s[i]);
      //make FCDS Frame
      FFrame = makeFCDSFrame(startPoint);
      FCM.addFCDSFrame(FFrame);
   }
   return FCM;
}
```

Fig 7. TracePixel Algorithm

V. CONCLUSIONS

To support a client to reference contour lines, this thesis proposes an efficient transmission method of elevation data from server to client. The contour line is for the environment of mobile vector map services. The environment requires reducing the transmitting data size from server to clients. Especially the vector contour lines have large data volume. That is, the environment requires a server to generate compressed contour line to make it possible to transmit the data to the client and display the data at the mobile client devices.

To satisfy these requirements, new data structures and algorithms are proposed. They are designed for efficient transmission of contour data to a client. Because of the contour data are generated as a vector style from elevation information stored at a server, the proposed algorithms are focused to minimize the transmission data volume and time. The proposed FCDS data structure helps server minimize the contour line data volume.

The main idea of the proposed method in thins paper, is to make contour lines at server which will be display at a client before transmission. A contour segment stored at a FCDS, consists of one absolute coordinator point, start point, and following points as relative coordinators according to the start point. That is, a FCDS has vector data and the coordinator values are transformed to a client coordinator system. The proposed method can reduce the transmitted data volume dramatically and have a advantage to minimize the display overhead of contour lines at client.

Further researches are needed to implement the proposed data structures and algorithms. The implemented results will be estimated by experiments. The major estimation factors are the benefit of data volume reduce and the overhead of the algorithms. The compression efficiency and processing time will be measured to analysis. Furthermore, some applications can be found to utilize the FCDS at a client.

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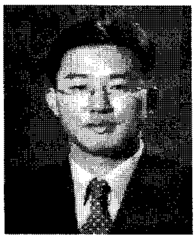

Jin-Oh Choi received his B.S., M.S., and Ph.D. degree in Dept. of Computer Engineering from Pusan National University in 1991, 1995, and 2000 respectively. From 1991 to 1992, he worked at the Hyundai Electronics as a computer system development staff. From 1998 to 2000, he worked as a professor of Kyungdong University. In 2000, he joined the Department of Computer Engineering of Pusan University of Foreign Studies. From 2009, he joined the Department of Embedded IT, where he is presently an associate professor. His research interest is in the area of mobile GIS, vector map display, and LBS.