The Design of Embedded GPS Navigation System Based on Internet Structure

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Abstract - Combining wireless devices, GPS, and client-server system in the Internet, we could run a current guidance system and query all the computerized data. The problem in using GPS in Taiwan is the accuracy between actual latitude and longitude position and the data in the coordinate system, therefore when combining real data we have to take into account the coordinate system conversion problem, and also must simplified data size avoiding the limitation of Internet bandwidth problem. To improve the above problems, we proposed an embedded Internet globalize satellite navigation system design, providing end-user with client-server architecture running signed applet, able to cross website or receiving data from server to get the latest information. In real time interconnection, a user GPS also able to send 3D position data automatically updating server's database, changing2D database into 3D database.

1 Introduction

When wireless Internet access is becoming more and more popular, it also brings another possibility for information application. For example, pinpoint position and digital information of the region can be fetched with the help of GPS. The available information may include digitalized relief map, cadastral map, land registration data, administrative information, doorplate, satellite picture, as built drawing, plan, gas pipelines, water pipelines, power lines, traffic information etc. The up-to-date digitalized information can be obtained online in real time. Following disadvantages can be listed for the current systems if the data is not automatically updated via Internet:

i. Information overdue: An automatic updating system is required for a scheduled complete or partial updating, in order to keep the information up to date. However, there will be time differences, and the results of query may be invalid.

ii. The data is huge: the capability of portable equipment like laptop computer is limited. Bringing all required information is just impossible.

iii. Higher risk for data loss: if the portable equipment is lost, the data is lost at the same time. If the lost data is confidential, the risk of purloining rises.

iv. Special application system is required to be installed: if the data is needed by the user urgently, a backup computer may not be helpful since there is no authorized software installed.

GPS (Global Positioning System) calculates the current position by the free satellite data received passively. Simultaneous signals from at least three or four satellites without defilade are required. The returned positioning data is longitude and latitude based on the reference ellipse WGS84. Traditional GPS system is platform specific. Therefore, the data is written into the system during the installation. No new information can be fetched. This is a defect of the system. A data updating mechanism like downloading from Internet or upgrading by CD-ROM is required to make the data up-to-date. We have to put the digitalized data into our consideration for a GPS application, such as image registration. Generally, images can be classified into vector images and bitmaps.

i. Vector : there are many formats for vector images. For example, popular DXF format, commercial GIS exclusive formats such as DGN, as well as many other exclusive formats for specific application systems. Currently, the scales for the available digital relief maps in Taiwan are 1:25,000, 1:5,000 and 1:1,000. The plane reference frames adopted are mainly TWD97 and TWD 67.

ii. Raster: these are common photo files. They can be satellite images, aerial survey images, scanned images etc. We have to mention that a single original picture of aerial survey may be as large as several hundred MB. Therefore, besides compression, we have to separate the image into several small images before transmission. The image file and the coordinates of the four corners are used in the registration of land coordinates.

2 System environment

Following options can be adopted in the system with GPS navigation.

i. Portable equipment (such as PDA and cell phone): they are small in size and long in battery life. The shortcoming is that they are limited by the speed of hardware, LCD resolution and number of pixels. Massive data processing and complete displaying may be a difficult job for them.

ii. Notebook/Tablet PC: Good performance and LCD display. However, they are too large in size and short in battery life.

Currently, an entry-level notebook and a high-class PDA are close in price. At the same time, the Notebook/Tablet PC is becoming smaller and cheaper. Power supply on the car can be utilized to prolong the life of battery. The software for Notebook/Tablet PC can be executed on the Desktop, too. Therefore, a notebook/tablet PC with high c/p ratio may be better than waiting for the performance upgrading of PDA. In the current networking environment, if a user tries to access the Internet by wireless connection for imbedded GPS navigation, the following items despite of high flexibility and up-to-date information may limit the implementation.

i. Bandwidth: an Internet-based application is always limited by the bandwidth. Therefore, the transmitted data cannot be overly huge. A simplification mechanism without losing precision is required.

ii. Execution environment: When accessing the Internet by the browser, the user's OS is not limited to Microsoft Windows. It can also be Linux, Apple Mac etc. Therefore, the platform should not be OS specific. Java is a good choice [1].

Basically, there are two modes of vector maps for a browser:

i. The maps are updated by the server: there is a browser at the user end. If zooming or moving is requested, the image is re-generated at the server end and then transmitted to the user end for displaying. The advantage for this method is that the user end only receives a processed image, so only a browser is required. The shortcoming is that the response may be slow if there are a large number of users and a rapid operation is required by the UI. At the same time, it tests the processing speed of the server. Therefore, high-class servers or grid computing such as Grid Service is required.

ii. The maps are updated by the client: The server supplies the data. The advantage for this method is that the server is only responsible for transmitting data to the client. The load of the server is low. The client may have better UI and speed of response since local resource is used. The disadvantage is that more data has to be sent to the user end and a corresponding program is required to be installed. However, since the performance of the client is becoming more faster, utilizing the processing capability of the client may be a better choice.

Java platform: Compared with the traditional programming languages, Java is a new generation of language and platform. It is object oriented and supported by the standard Internet libraries, which are absent in most of the traditional languages. The .NET platform developed by Microsoft is limited on the Windows system. Free runtime and development (such as eclipse [2]) environment: It is good for study and low-cost constructions and applications.

3 Proposed design and process

3.1 Integration of reference frames

Currently, the basic maps for Taiwan region are based on Transverse Mercator Projection (TM). They are called TWD97 and TWD 67 .The WGS84 data received from GPS is different from TWD97/TWD67. It can be integrated into the same system by appropriate transformation formula and parameters.

3.2 Simplification of digital relief map

Currently, the digitalized relief maps for Taiwan are stored as images, such as the 1:25,000 and 1:5,000 maps of Taiwan. The coordinate system is based on TM. The scale, range and digitalization precision are listed in Tab. 1:

Following items should be considered during the simplification of vector data:

i. The original data is based on floating point numbers. Compared with the integers that can be calculated rapidly, is there a way that can reduce the network transfer and storage and enhance the display performance without losing precision?

ii. It should be capable of deleting continuous or close points

iii. Resources needed for the transformation should be low

Although there are other more complete compact processing patterns [3], a special integer grid map system is designed to meet the above requirements because a lot of server resources are needed, as shown in Fig. 1. The rules are described as the followings.

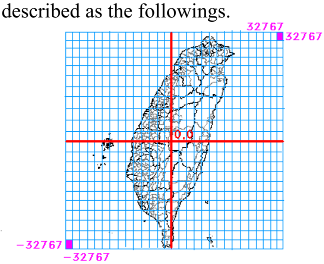

Fig. 1 the integer grid map system

i. Images are stored as short integers. The available range for short integers is +32767 to -32767, totally 65535 grids. Each grid represents a coordinate range of a pixel. It will be good if the value of the pixel is better than the data precision.

Scale	error in the cartography	range(m)	digitalization precision(m)	Pixel precision(m)
1/25000	7'	14000	0.2mm*25000=5.0	14000/65535=0.21
1/5000	1.5'	2800	0.2mm*5000=1.0	2800/65535=0.04
1/1000	0.3'	600	0.2mm*1000=0.2	600/65535=0.01

Tab. 1 The precision comparison between the data of relief map and transferred data

ii. The centre point of the original floating-point data is the centre point of the 65535 grids. That is the origin (0,0) of the integer coordinate system. The stored data is the rounded value after division by Pixel.

iii. The selection of pixel: the maximum vertical or horizontal data differences divided by the distance of integer value domain. After inspecting the relationship between the digitalized data and pixel, it's better than the digitalization precision (as shown in Tab. 1).

Formulas for transforming coordinates into short integers:

shortX = (x – originX)/pixelValue (1)
shortY = (y – originY)/pixelValue (2)
x , y are data coordinates
originX ,originY are the coordinates of data center point.
pixelValue is the coordinate value of each grid

iv. For continuous points, if the integer coordinates values of the connected points are equal, they can be removed.

v. If the compaction of the data is required to be enhanced, we can compare the calculated integer coordinates data with the previous point and determine whether they are close to each other. If they are close, they should be abandoned. In other words, we directly abandon the points that are too close to each other.

vi. Here are the rapid calculation formulas for image output.

offsetX ＝(originX － displayLeftX)/pixelValue (3)
offsetY＝ (originY － displayLeftY)/pixelValue (4)
Let, scale1/scale2 = displayPixel / pixelValue
drawX = ((shortX+offsetX)* scale1)/ scale2 (5)
drawY = ((shortY+offsetY)* scale1)/ scale2 (6)
drawX，drawY： Display, displayed coordinates
displayLeftX，displayLeftY： Setting of the corresponding actual coordinates at the display's left down corner.
displayPixel: the actual coordinates for each pixel of the display.
Note: here we assume that the integers are 4 bytes long. Therefore, there won't be the problem of overflow.

3.3 Data transformation

When processing the published relief map data, we preset the DXF format as the data source, since all of the needed data can be obtained in Autodesk's DXF format, which is in pure text with layers, blocks, entities' points, lines, arcs, text etc. [4]. Two different modules are established for the transformation:

i. DXF object module: Since the original data is in DXF format, we develop a set of image objects to analyze the DXF file by OOP. The inheritance of graphic primitive objects accords with the graphic primitives defined by DXF. Besides, there is also a display module to check whether the display of the image is close to the AUTOCAD as required.

ii. Data transformation module: Define the compatible DXF objects using the integer grid map system described in the previous section. The only difference is that the data is stored in short integers. The content of the DXF object is directly simplified. After the transformation, each image can be compressed and archived directly by Serializable interface or sent out from the memory.

If we process the 1:25,000 relief maps of Taiwan region by this way, the size of original DXF file is about 900MB. It still accounts for 150MB after the compression. After the simplification and compression, the file size drops to about 40MB (4K for minimal image and 548K for maximum image. An image covers 165KB in average). This is only 1/22.5 of the uncompressed data and 1/3.75 of the compressed data. This reduces the total transmission on the Internet and the time needed. At the same time, it accelerates the display at the user end.

4 Proposed system architecture

The server processes the data before sending to the user. At this time, the update properties such as total content should be checked before determining whether to send the data completely or the simplified data by the above modules. If the data is located at other web sites, the server can fetch the required information and send to the applet after simplification or notify the applet to fetch them by itself. Fig.2 shows the architecture.

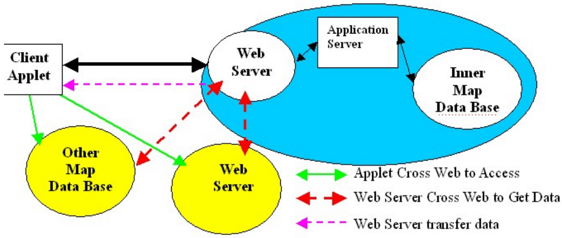

Fig.2 System Architecture

The software functions at the user end are described as the followings.

i. Receive GPS data through a connected GPS.

ii. After the data is fetched from the GPS, it should be transformed into appropriate coordinate system and invoke related image files.

iii. Display the basic satellite image and transmission information such as date, time, longitude and latitude.

iv. Map window is adjustable by the user. The program can fetch the required image in the required region automatically.

v. The trace can be recorded and drew on the map window. Saving the trace is also possible.

Installation: only JRE is required to be installed at the user end before starting the application. At the initialization stage of the program, the system will prompt for whether the user accepts the certificate and wants to execute the signed applet. The program connects to the GPS only if the user says yes.

Since the GPS connection is not included in the standard support of JRE. We need to install the Java Communications API (JCA)[7]. On windows system, the installation of JCA for application is a bit different from the installation for applet, as shown in Tab. 2.

<java_home>/bin/win32com.dll
<java_home>/lib/comm.jar
<java_home>/lib/javax.comm.properties
<java_home>/lib/ext/comm.jar*
<java_home>/lib/ext/javax.comm.properties*

Tab.2 The installation of JCA component.* required for applet installation. (This is not mentioned in the documentation of Java Communications API).

To make it less troublesome for the user, we have an automatic installer for Windows users. The installer prompts for whether to accept the certificate and execute the signed applet at the beginning. After the confirmation by the user, the installer will install and remove the related files according to the list of Tab. 2. After the installation, the user has to close all web browser windows and start them again. The JRE will then be started for the connection to GPS.

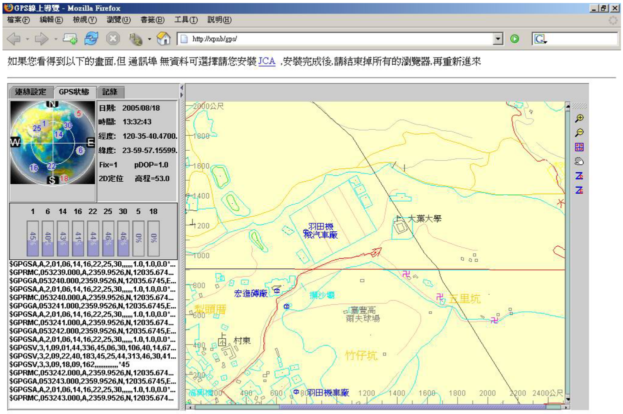

Fig. 3 The screenshot of execution. The satellite signals and data transmission status is on the left side; the map and trace are on the right side.

5 Conclusion

In this paper, we propose a design of an Internet based imbedded GPS navigation system. Besides general GPS application and fetching up-to-date map data, the system also supports many future technical developments, for example:

i. Automatic feedback update of map database: for traffic network, there are only plane coordinates available currently. The height data is absent. If the GPS is in 3D mode, the coordinates and the altitude will be available for the reference point. Then we can upload the 3D data to the server. At the server side, the data can be integrated into the traffic network data. Through this mechanism, the 3D model of the roads can be established by the feedback data of the users.

ii. Application in environment protection: If some wastes that may affect the public security are found by the environmental staffs, the landowner and address can be fetched through GPS and the system in real time. The local government staffs and land administrative staffs are no longer needed. The operation becomes more efficient.

iii. Application in the social security: In case of some emergency event, we may need to find the gas valve or tap water controller as soon as possible to cut the supply. If the layout can be fetched by the system, the location can be found together with the on-site data, waiting and response time may be greatly reduced.

iv. Cross system query: In the client-server architecture, if the server does not contain the required data, the server may try to fetch the data for the user or simply provide a URL. Therefore, if the data access requires authentication, the server may fetch the data and send it to the client side after processing it. If the data is open, the server may simply returns a URL for the client, and the applet can then connect to the target to fetch the data.

v. Commercial application: resources provided by different web sites differ from each other. If the user wants to fetch some data, he has to sign up at every site. Besides difficult integration, sometimes the user just occasionally needs a map. He has to go through the complicated registration or pay a monthly fee to access the needed data. This definitely affects user's will to use the service. And it's impossible for the site to attract enough users. Therefore, we can establish a portal to solve this problem. All map resources can be available through this portal. It also deals with the payment and the procurement. By the mode described in this paper, all required maps can be displayed at the client side. It enhanced the application level greatly.

Currently, search engines like Google [8] provide software to browser satellite photos online. If the authorization can be obtained through co-operation, the links of satellite photos can be included. Other public information can also be obtained by the same way and provides the users with a collection of all kinds of information.

6 References

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