A Method for Land Consolidation Progress Assessment Based on GPS and PDA

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Abstract: - Field survey is a traditional method in the process of land consolidation. But it has such as low efficiency, long time, and some other shortcomings in measuring length, area and calculating the amount of small object, especially for the project area with more complex terrain. The paper puts forward using GPS/PDA to calculate progress for project of land consolidation, which propels the application of GPS/PDA in the fields of land consolidation. The paper introduces the principle of GPS, interface of GPS and PDA, realize real time interaction between the field of project area and the electronic maps by using GPS's location function, on the basis of which accomplishes real time judgment for project land features' progress, quantities and some other accuracy of information.

Key-Words: GPS, PDA, land consolidation, progress

1 Introduction

Land consolidation is important for increasing cultivated land areas and improving its quality, also production conditions and the ecological environment. Ensuring national food security and promoting the general development of rural areas is also of great significance and, nowadays this work is vigorously promoted in China. Land consolidation is a complicated engineering task which involves integration of farmland, water, roads, forests and village structures [1]. To achieve this objective it requires the support of advanced technologies.

Field survey is a very significant element of land consolidation, it is fundamental to project selection, feasibility studies, planning and design, and medium-term inspection [2], appraisal and ongoing conservation and later evaluation studies. Traditional method of field survey is using topographic maps, land use maps, planning maps, completion maps and some other paper-based information sources to complete field survey, location, measurement and recording according to different goal of survey. But the traditional method of field survey has lots of difficulties during the real time operation, especially when judging the project quantities and progress. Because the traditional method has lots of shortcomings such when measuring length, measuring area, and calculating the amount of small objects, especially for the project area with more complex terrain.

In order to improve the efficiency and judge the project progress more quickly and accurately, applying new technology to replace the traditional method of field survey for the project of land consolidation is certain and the direction of the future development. Using GPS technology to field survey will help to improve the level of information. Especially when integrated GPS and PDA perfectly [3], which will save lots of technicians' manual work during the real operation in the field survey, and raise working efficiency greatly. More importantly, as to GPS and PDA technology, calculating project quantities and judging progress is not as difficult as it was [4]. Practice has proved that investigators only need to hand GPS/PDA device to do the survey by using these technologies. They can locate the small object's coordinates in the operation of the project, measure road and trench's length and width, and when walking around the newly built area features, they can quickly and accurately gather its border's inflexion coordinates so that they can attain the area of the feature easily, and they record its attribute into the map in the PDA on-site [5]. By doing so we can compare the data/information we get from the device with planning-designing map to judge the situation of the project quantities and progress. So it improves the efficiency greatly and save a mount of labours.

2 The problem of positioning in on-site investigation

In the actual work of land consolidation's on-site investigation, two categories of issues are often encountered.

Issue 1:

In the design and planning phase of the project, if there is no obvious mark of the topographic features, the designers can't find the position where they are standing in the map exactly when they are doing field investigation and drawing the planning draft, so the layout of the project they draw in the map is not the exact one in their hearts, which leads to a lot of phenomenon of project displacements during the process of project. So it shows that the main reason why the design of project changes especially the change of the project's layout is that the designers can't locate exactly.

Issue 2:

In the stage of acceptance check of the project, positioning inaccurately is the same problem that the inspectors have to face. They can't find the exact position where the stand on the map. So it made field inspection work become very complex and often a formality. It is difficult to gain a clear idea of the situation of the project's implementation. Therefore, it is generally needed to find the local person that is very familiar to the situation of the project, such as the supervisor. They accompanied the inspectors to work together and mainly play a role of guide. But this also makes the inspection work become very passive, led by the nose of others. It is difficult to avoid the phenomenon of cheating.

The above-mentioned two types of problems are derived from the site location are not accurate. It makes on-site investigation and assessment very difficult because of they can't position accurately. To solve such problems, we can learn from the principle of car GPS navigation system. Car GPS navigation system, its built-in GPS antenna will receive data from at least four of 24 GPS satellites around the Earth, combined with the electronic map stored in car navigation instrument, matched with location coordinates determined through the GPS satellite signal, and the determine the accurate position of car in the electronic map, which is usually referred to the function of location. On the basics of location, it can provide the best route and play a role of navigation through the multi-function monitor.

3 Methodology

The proposed method is that using GPS and PDA technologies for calculating and examining the progress of land consolidation project. The GPS receiver provides a serial port so that it can associate with the serial port of PDA. And use the GPS/PDA device, we can locate anywhere in the area of project expediently and obtain its position information through the signals received by GPS. Then we can get its longitude, latitude, time according to the standard format of a complete GPS statement. And we also need to convert the longitude and latitude to the suited coordinate, then we can use the information we got to calculate the quantities of project and assess the progress of the project of land consolidation.

3.1 interrelated conception of GPS

At the end of the 1980s, the global positioning systems (GPS), NAVSTAR-GPS and GLONASS, introduced a new era. For the military, positioning and time became available at any time and place. Both kinds of information could also be used for civilian purposes, even if the accuracy obtained was somewhat diminished. Today, civilian users of GPS may well be in the majority, when viewed worldwide. In North America and Europe, reference services provide positional accuracy of 1–5 m on-the-go. More advanced devices even reach decimetre accuracy, allowing for exact navigation or even automated navigation of vehicles. After switching SA off on May 2, 2000, NAVSTAR-GPS will fulfil positioning without differential services. Another improvement will be available with the transition of GPS to the next satellite generation and the European satellite navigation system Galileo which is likely to be implemented [6]. Therefore, GPS is, and in the future will also be, a technology available to everyone. In land consolidation, the possibilities for application will be seen in positioning and navigation.

GPS consists of three segments: the space segment, the control segment, and the user segment (Fig.1). The user segment includes all military and civilian users. With a GPS receiver connected to a GPS antenna, a user can receive the GPS signals, which can be used to determine his or her position anywhere in the world. And GPS is currently available to all users worldwide at no direct charge.

GPS provides longitude, latitude, height, time, course, and velocity [7]. The horizontal accuracy of the GPS is nearly 100 m, 156 m for heights and 340 ns for time, anywhere in the world and in all weather conditions.

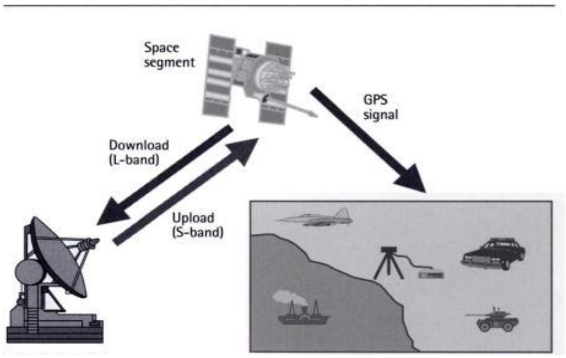

Fig.1 GPS segments

3.2 Data communication

In the design of the method, the GPS receiver provides a serial port. And when the serial port is associated with the serial port of PDA, it can realize the function of real-time signal reception and map location. Serial port's function in nature is as the Intel PXA250 chip and coding converter between serial devices. When data is sent from Intel PXA250 chip through the serial port, the bytes data are converted to serial bit. And when receiving data, the serial bit will be converted to bytes data. Windows CE uses the communication driver Comm.drv in order to use the standard Windows API function to send and receive data [8]. Driver is usually provided by serial device manufacturers to connect hardware and Windows CE. In the design of procedure, it simulates a COM6 serial port. Open the serial port first, then set up Comm. control's attribute, and use the timer to trigger Comm. event to receive GPS data, and achieve real-time reception of GPS data.

3.3 Data preparation

Topographic maps, land-use actuality maps, plan maps, completion maps and other related data are loaded into this system before field survey. Nowadays most maps are produced using AutoCAD. These maps usually do not have attribute information but only have graphic information. To allow interactive inquiries between graphic information and attribute information in real time, AutoCAD data should be converted into GIS data format. In this system shape format of the company ESRI is used as standard data format. Conversions must abide by the following rules:

(1) The original layered data is retained as much as possible. If point, line, and polygon types of geometric features are contained in a uniform layer at the same time, then the layer does the further subdivision according to the geometric types;

(2) The ground objects of the graphics data are converted into shape layer. Graphic decoration information does not need to be changed but setting similar effect is allowed in the layers to show settings;

(3) The attribute data is introduced into the shape attribute data table from other data sources. The PDA will be connected to the PC after the data conversion. According Microsoft ActiveSync, data can be transmitted to PDA.

The data preparation process is as illustrated in Fig. 2.

3.4 Judgment of truthfulness and accuracy of the field data

Veracity and accuracy of judgment is the core demand of the system. Location information for positioning comparative analysis between the map and the field can be released by the GPS system at the investigation process in the GPS-based field survey system. The differences between the actual features and the map can also be judged for real-time management of project monitoring. In addition, the system can calculate two important indicators which are the area and length of the site. For example, we can monitor by positioning a grade of the road to see whether the design standard is suitable and whether the design of the all tasks is completed.

3.5 Field Position

Taking into account the characteristics of field survey, the device must be positioned in real-time. To support a wide range of the GPS receiver, it provides a NMEA 0183 message format support. NMEA 0183 is a standard format developed by the United States National Oceanic Electronic Association for the sea using electronic equipment. Based on the standard forms 0180 and 0182, it increases the output of the GPS receiver content. This format is used as a standard information output format by many GPS manufacturers. [9] The GPGGA format which contains the current GPS position information is as follows:
$GPGGA,<1>,<2>,<3>,<4>,<5>,<6>,<7>,<8>,<9>,m,<10>,m,<11>,<12>*hh

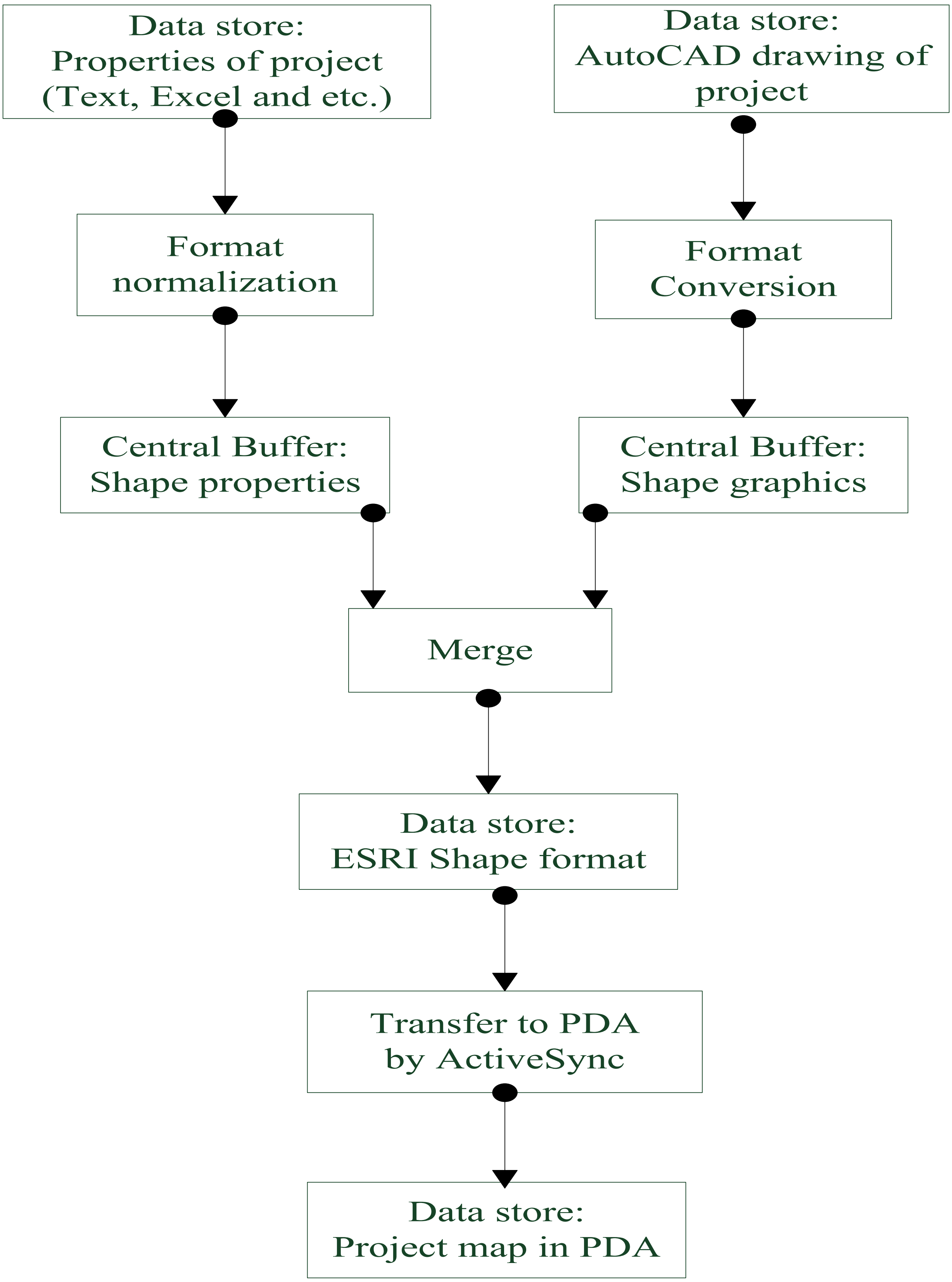

Fig. 2 Activity of project data preparation

The meanings of these symbols are shown in Table 1.

Table 1 Description of GPGGA string

Parameter	Description	Range
$GPGGA	The beginning of position response message	
<1>	Current UTC time of position fix in hours, minutes, and seconds (h., min., s.)	00－235959.59
<2>	Latitude component of position in degrees and decimal minutes (deg., decimal min.)	0－90
<3>	Direction of latitude N = North, S = South	N or S
<4>	Longitudinal component of position in degrees and decimal minutes (deg., decimal min.)	0－180
<5>	Direction of longitude (E = East, W = West)	E or W
<6>	Position type: 0. Invalid or not available 1. Autonomous position 2. RTCM or SBAS differentially corrected	0, 1, 2
<7>	Number of satellites used in position computation	0－12
<8>	Horizontal dilution of precision (HDOP)	0－99.9
<9>	Altitude in metres above mean sea level (orthometric height). For 2D position computation, this item contains the user-entered altitude used to compute the position computation.	－9999.9 to 9999.9
m	Altitude units (m = metres)	m
<10>	Geoidal separation in metres above WGS-84 reference ellipsoid	－999.9 to 9999.9
m	Geoidal separation units m = metres	m
<11>	Age of differential corrections (seconds)	
<12>	Base station ID	0－1023
*	Checksum	
hh	The checksum of all ASCII code after '$'	

There are two setting modes to obtain the GPS position information in the system—automatic mode and manual mode. In automatic mode, the system obtains location information on an automatic operation from the GPS receiver every few seconds; in manual mode, the user must press a button, then the GPS position information is obtained.

A completed NMEA 0183 Ver2.0 statement is a section of strings which is start with the symbol "$ G-PGGA" and end with "<CR><LF>". What information we need is the latitude and longitude, azimuth, the state of GPS positioning and the time when signal is received. So when we receive a complete statement of NMEA0183, the way we extract the useful information is: determine the position of starting symbol '$GPGGA' first, then read the data from the starting symbol and search the character ',' through checked statement, and then get the characters (string) between two ',' to access the data we concerned, at last， a 'Enter' character as the end symbol so that we get a complete GPS data [10].

In the extracted GPS statement, read and get the latitude and longitude according to their comma's position. The way of latitude and longitude's display is used as 'dd mm mmmm. (degrees. minutes. seconds) As unit of the coordinate in map is based on degree, they must be converted.

The receiving and dealing process of a complete NMEA 0183 statement is shown in Fig.3.

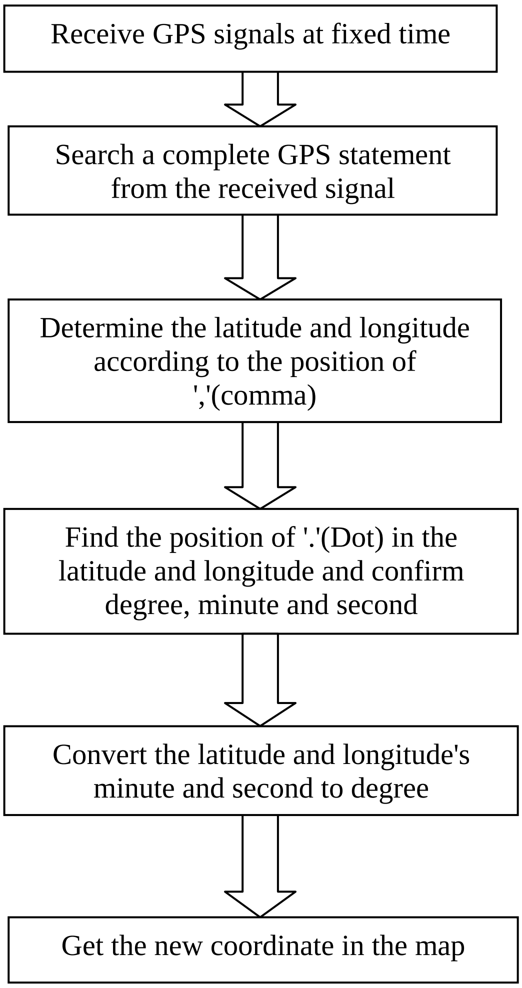

Fig.3 Analyzing the NMEA 0183 process

Using system's positioning function, we can locate the field of the project quickly, locate the specific project accurately, display the walking route in real-time, so that the difficulties of location in on-site investigation can be solved. So field survey is targeted and is changed in from passivity to initiative.

3.6 Coordinate Transformation

The coordinate system of the foundation map is usually the Beijing 54 coordinate system or the Xi' an 80 coordinate system. The ellipsoid of the Beijing 54 coordinate system is Krassovsky which parameters are axis a = 6378245 m, f = 1/298.30. The ellipsoid of the Xi' an 80 coordinate system is IAG 75 which parameters are a = 6378140 m, f = 1/298.257. The WGS84 coordinate system that is adopted by GPS, is a geocentric coordinate system, of which the ellipsoid parameters are a = 6378137 m, f = 1/298.257.

The coordinates should be transformed for registration from GPS location to land consolidation and rehabilitation projects map. Commonly transformed methods are a seven-parameter model, a three-parameter model, and a four-parameter model. The seven-parameter model needs more than three public points to solve the translation and angular rotation of the three space coordinate components x, y, z and a scale parameter. The three-parameter model needs only one public point to solve the volume translation of the three x, y, z components. The four-parameter model is actually a plane transformation model. It needs more than two public points for solving the angular rotation, translation of x, y components and a scale factor.

The scope area of land consolidation and rehabilitation projects in general is around 10 km. At this scale, the results in the three models are not significantly different. In this system the four parameter models are adopted to solve the transformation [11]. The four steps for solving parameters are:

(1) Two or more public points are selected; their WGS84 coordinates and Beijing 54 coordinates or Xi' an 80 coordinates are known;

(2) By WGS84 ellipsoid parameters, the WGS84 coordinates (B, L, H) of the points are converted to space rectangular coordinates (X_1, Y_1, Z_1);

(3) By Beijing 54 coordinate or Xi' an 80 coordinate ellipsoid parameters (X_1 , Y_1 , Z_1) are transformed into geodetic coordinates (B_2, L_2, H_2);

(4) By Gauss-Kruger projection, the geodetic coordinates (B_2 , L_2 , H_2) are transformed to Beijing54 coordinates or Xi an 80 coordinates (X_a, Y_a, Z_a);

(5) Without considering elevation factors, the transformation parameters between the two plane coordinate systems are calculated as:

$$\begin{pmatrix} X_b \\ Y_b \end{pmatrix} = \begin{pmatrix} \delta X \\ \delta Y \end{pmatrix} + (1+k) \begin{pmatrix} \cos\beta & \sin\beta \\ -\sin\beta & \cos\beta \end{pmatrix} \begin{pmatrix} X_a \\ Y_a \end{pmatrix}$$

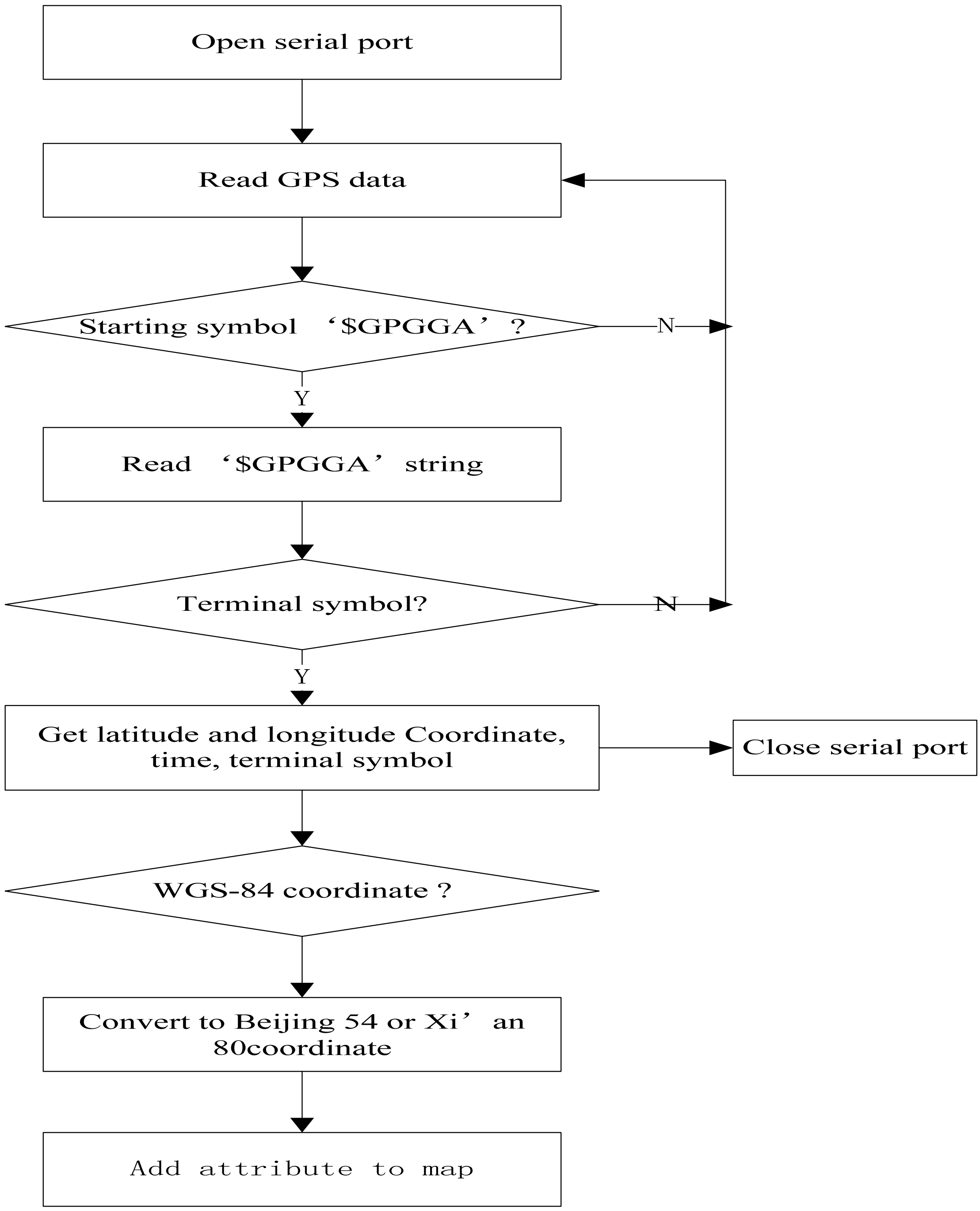

Fig. 4 GPS data receiving and processing flow

(X_b, Y_b) is the Beijing 54 coordinate or the Xi an 80 coordinate; (X_a, Y_a) is the coordinate after the conversion of (2), (3), (4) from the WGS 84 coordinate. The solving four parameters (δX , δY , k, β) represent translation amounts of x and y, scale variation, and plane rotation angle respectively. By the four parameters, all WGS84 geodetic coordinates can be converted to the Beijing 54 coordinate or the Xi an 80 coordinate through the steps above.

The process of dealing GPS signal is shown in Fig.4.

3.7 Assessment of land consolidation progress

Using GPS / PDA technology, import the base map which is made before land consolidation into PDA, make use of the location function of GPS to obtain the information of newly built objects and the sorted objects in the area of land consolidation, calculate the information of project progress[12], and compared with design and planning map, so that obtain the complete situation of project and the job schedule during the process of land consolidation, provide a effective way for the management of land consolidation project.

1. Small objects: Investigators use the GPS/PDA device, and measure the coordinate of small object like wells, bridges in the area of project, generate its graphics features in the base map according to the coordinate, input its coordinate and attribute, and compared with design and planning map, so that examine whether the amount of the wells and bridges are in accordance with the design and planning.

2. Linear features: Investigators use the GPS/PDA device, and get the information of linear features like roads, ditches: move along the border line of road (ditch), acquire the geographical coordinates according to GPS, and generate its graphics features and border in the base map, input its coordinates and attribute. In office work, use ArcGIS to calculate its length, width and so on. And compared with design and planning map, so that analyze the complete situation of road projects, water projects (irrigation and drainage channel) and the rationality of layout in the project area[13].

3. Area features: Investigators use the GPS/PDA device, and get the information of area features like sorted cultivated lands, flood protection forests, wind protection forests, settlements: only need to measure the coordinate of every inflection point, and generate its graphics features and border in the base map, input its coordinates and attribute. In office work, use ArcGIS to calculate its area. And compared with design and planning map, so that analyze the complete situation of the recovery cultivated lands, protection projects and forest distribution.

4 GPS/PDA Field Survey System's function Design

According to the analysis of on-site investigation and assessment of land consolidation mentioned above, in order to complete the on-site investigation tasks, we can establish a GPS/PDA field survey system including the following functions.

4.1 Positioning and navigation function

Positioning and navigation is the most important and basic function in the system. Using the principles of car GPS navigation, import the present land-use map, planning map into the system, realize the linkage between the map and the field, display on-site investigators' position and routes, and change the investigation from passive to active.

4.2 Data transmission function

The system can import and export project map (such as topographic maps, present land-use maps, planning maps, built drawings, etc.) and text information. For example, the system can export on-site inspection report automatically. The information collected on-site by other information collection equipments can also be easily imported into the system to carry out a variety of computing or store into the system's database directly.

4.3 Map operating function

That is, the general function of GIS: on-site investigators can magnify, minify, move, locate the map as long as other operations at any time in accordance with the need.

4.4 Layer management function

Land consolidation project's map is very rich in contents, such as project planning map, including project elements, land-use elements and topography elements. The project is also divided into irrigation and drainage project, field road project and so on. So if they are displayed at the same time, it will be a great confusion and not facilitate to on-site investigation. We can open or close any layer at any time in accordance with the need by using the layer management function of GIS. For example, the system can only display the road layer and close other linear project layers such as ditch when examining the road project. And this function will make it more intuitive and easier.

4.5 Search function

It often need to access to a lot of information during the process of on-site investigation. For example, we must know the design standard of the road when examining the quality of road project. And the general practice is to read the text of Planning and design. We can use the system by clicking on a particular road and search this road's interrelated information by using the system to avoid the trouble of reading the text material. Similarly, we can also know the area of a field, design standard and some other related information by clicking a field.

4.6 Data statistics function

Data statistics function is to improve the statistical work efficiency of project construction task. For example, it will be a very demanding work to count all the field roads' length directly from the drawings, and it is prone to make mistakes. So the results of measuring are inaccurate. Use the data statistics function of the system by setting a statistical condition, such as a 4-meters wide road. We can calculate all 4-meter wide roads' total length quickly. And it will be greatly enhanced the efficiency of the work of data statistics.

4.7 On-site measurement function

In the course of on-site investigation, it often needs to do some measurements. For example, it must measure the scale of project construction, various types of land area and the length of linear project such as road and ditch on-site. While the traditional method has a very low efficiency and sometimes it is difficult to do. The system can measure area and length on-site by using the general function of GPS gathering spot measurement. The precision of measurement is related with the density of the gathering spots. For example, to measure the length of a ring road, it needs to gather more spots to simulate the real situation. And the routine measurement method is very difficult to complete the task in this situation.

4.8 On-site record function

In the course of on-site investigation, it often needs to record some information and collate when back to indoor work. The amount of the work is very heavy, and also very inconvenient. Using the system can complete on-site record work and match the related information with the field feature directly. For example, when examining a road project, we can click the road, and then a dialog box will pop up, we can write the evaluation results of this road into it directly, and stored as its attribute information. The system can also generate on-site investigation report automatically according to outside work's record.

4.9 Graphics editing function

When examining project, if the scope of the project area has been adjusted, it needs to draw the adjusted scope of the project area on-site. In the early planning and design stage, the technical staff also needs to draw the planning draft on-site. The system can greatly enhance the accuracy and efficiency of mapping and form the draft on-site through the location function of GPS and the map editing function of GIS.

4.10 On-site taking photos function

During the investigation, we not only need to do a large amount of text recording works, but also to take photos for some key features on-site to obtain the image information. The system has the function of taking photos, and can match the photo to the feature on the map. And the photo is stored and managed as one of the attribute of the feature.

5 Conclusions

Using the GPS-PDA technology can greatly enhances the quality and efficiency of field survey, can help us solve many problems, and make complicated field survey more simple. In the inspection stage it can help investigators confirm the location easily, obtain the coordinate, identify the exact border, judge whether the location and scope of the project has changed, examine whether the project' s layout is in accordance with planning and design, and whether the building tasks have been completed.

Practice has proved that investigators only need to hand GPS/PDA device to do the survey by using these technologies. They can locate the small object's coordinates in the operation of the project, measure road and trench's length and width, and when walking around the newly built area features, they can quickly and accurately gather its border's inflexion coordinates so that they can attain the area of the feature easily, and they record its attribute into the map in the PDA on-site. By doing so we can compare the data/information we get from the device with planning-designing map to judge the situation of the project quantities and progress. So it improves the efficiency greatly and save amount of labours.

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