Key Technologies Research Based on SWDC Aerial Photogrammetric Camera Flight Management System

Lu Xiaoping[a], Li Tianzi[a], Ji Wenjie[b]

[a] Henna Polytechnic University
[b] Automation Research and Design Institute of metallurgical Industry

KEY WORDS: aerial photogrammetric camera, SWDC, flight management system, flight line, coordinate transformation, exposure document

ABSTRACT:

As the development of digital aerial photogrammetry, research about digital has great advancement, in the foundation of empoldering our country only digital aerial photogrammetric camera - SWDC aerial photogrammetric camera, developing the corresponding aerial photogrammetry flight management system is imperative. Key technologies based on SWDC aerial photogrammetric camera flight management system is depicted in this paper, including data interface, theory of empoldering software and programme. Having provided necessary assisting For SWDC aerial photogrammetric camera apply to aerial photogrammetry.

1. GENERAL INSTRUCTIONS

Along with geo-information science development, need of each domain to space information unceasing grow .The aerial photogrammetry as a fast, highly effective data acquisition and renewal method, becomes one of information acquisition main ways. The photogrammetry including many operation link, the aerial photography is important link, it affects directly the data quality, finally and affects mapping the precision, cost and the cycle of the project. At present the overseas some specialized aerial photogrammetric camera manufacturer already produced the integration flight management system the aerial photogrammetric camera, could solve the automated aerial photography problem, but the usual entire system set quoted price was expensive, moreover also had some overseas companies to develop the similar flight management system, but these system certain of the designs was suitable incompletely for the domestic aerial photogrammetric camera and the airborne control and the aerial photography technical standard. The home mainly selects the manual work method, this way satisfies the increasingly high precision request with difficulty, and if falls across the line deviation, avoids the appearance of leaking phenomenon with difficulty, then can create makes up flies or flies again. Based on the above actual problem, in the foundation of empoldering our country only digital aerial photogrammetric camera - SWDC aerial photogrammetric camera, developing the corresponding aerial photogrammetry flight management system is imperative.

This system take the arm9 embedded system as a platform, integrates the high accuracy the localization function provided by global positioning system (GPS), spatial data management and the analysis function of the geographic information system (GIS). Simultaneously completes with the software of automatically producing aerial photography exposure points based on the PC， coordination using with this system， exposure points document which produces automatically may be transmitted to the arm9 system, to realize automation of the entire aerial photography process.Arm9 embedded system， GPS，GIS，key technologies and the integrated technology in the aerial photogrammetric camera is the primary content to discuss in this paper.

2. KEY TECHNOLOGIES AND RESEARCH PRIMARY CONTENT

2.1. Automatic judgment of flight line

Based on the GIS buffer analysis method, the computation load to enters the route to be possible to simplify greatly in the aerial photography system the distinction, then automatically judges the line which the airplane enters, extracts coordinates of exposure points in exposure point document, realizes automatic exposure of the aerial photogrammetric camera.

When taking picture is automatically completing in scheduled surveying area with the system, it needs to estimate real-time the relative position between aircraft and route. But complexity because of reality(The pilot is able to adjust an aircraft according to different air current situation till the right angle enters an air line) , it needs judging condition comparatively much to rightly judge shooting relative location of aircraft and the air line ,real time calculation needs to commensurately big calculation amounts. The buffer area analysis to the air line, is that building buffer area polygon automatically within certain width of air line vicinity, The aerial photogrammetry system base on GIS is able to generate the appointed form's judging buffer area according to specially needing.Be to ensure that system operates stably, system generates buffer area which judge the relative location easily, therefore system needs judging only if aircraft is in some buffer area, can judge the relative location of aircraft and air lines, arithmetic amounts have decreased greatly.The aircraft is entering some strip buffer areas, at the same time is regarded as effective strip entering accord with some restrict (speed to the earth, restricting to flight height).

2.2 Real-time coordinate transformation

Interior design of photogrammetry exposure point is completed at the national or local flat rectangular coordinate system, the exposure point document automatically generated software based PC, generates coordinates in the flat rectangular coordinates system. Geodetic coordinates of WGS-84 coordinate system is accepted from GPS device based on C \ A code pseudo distance observation, Therefore, the need to achieve the real-time transformation by the WGS-84 coordinate system geodetic coordinates, longitude, latitude (B, L) to the coordinates (x, y) of local flat rectangular coordinate system.

The transformation of state coordinate system to the more commonly used the BJ54 coordinate system as an example, the reference ellipsoid of the coordinate system is Krassovsky ellipsoid (its parameters: the ellipsoid long half axle: a = 6 378 245 m, ellipsoid Flat rate:

A = 1/298.3), projection using Gaussian projection, the transformation formula with the latitude and longitude coordinates is as follows:

$$x = X \times \frac{l^2}{2} N \sin B \cos B + \frac{l^4}{24} N \sin B \cos^3 B (5 - t^2 + 9\eta^2 + 4\eta^4)$$
$$+ \frac{l^6}{720} N \sin B \cos^5 B (61 - 58t^2 + t^4)$$
$$y = lN \cos B + \frac{l^3}{6} N \cos^3 B (1 - t^2 + \eta^2)$$
$$+ \frac{l^5}{120} N \cos^5 B (5 - 18t^2 + t^4 + 14\eta^2 - 58\eta^2 t^2)$$

where $X = C_0 B + \cos B (C_1 \sin B + C_2 \sin^2 B + C_3 \sin^5 B)$； $l = L - L_0$；

$t = \tan B$； $N = \frac{\alpha}{\sqrt{1 - e^2 \sin^2 B}}$； $\eta^2 = \frac{e^2}{1 - e^2} \cos^2 B$

L, B: the latitude and longitude coordinates before transformation; x, y: the Gaussian flat coordinates after transformation; L0: the central meridian coordinate of this projection, as surveying area is relatively smaller, so the meridian through the center of surveying area can choose to test as the central meridian; C0, C1, C2, C3: the constants only with ellipsoid parameters.

For some surveying areas of using urban independent coordinate system, in order to make WGS-84 coordinate system can be converted to urban independent coordinate system, need to two known points coordinates in order to obtain translation parameters, scale factor and rotation angle, to use in urban independent coordinate system. Urban independent coordinate system adopts Krassovsky ellipsoid generally, the central meridian set at the central of city, projection flat as the average height of the city. The surveying areas to large-scale aerial photogrammetry are often small, flat transformation model is used here. First, transforming geodetic coordinates (B_{84} L_{84} h_{84}) received by GPS receiver to space rectangular coordinates (XYZ) T with the ellipsoid parameters of the WGS-84 and the formula (1), then transforming (XYZ) T to geodetic coordinates (B_{54} L_{54} h_{54}) with the ellipsoid parameters of the BJ54 and the formula (2), again in accordance with the central meridian of urban independent coordinate system, elevation of projection flat and offset to the east and the north projects (B_{54} L_{54}) to the Gauss coordinates $\left(x'_g, y'_g\right)^T$ .Finally, according to the translation parameters, scale factor and rotation angle obtained by known points transform $\left(x'_g, y'_g\right)^T$ to urban independent coordinate $\left(x_g, y_g\right)^T$.

$$\begin{bmatrix} X \\ Y \\ Z \end{bmatrix} = \begin{bmatrix} (N+h)\cos B \cos L \\ (N+h)\cos B \sin L \\ [N(1-e^2)+h]\sin B \end{bmatrix} \quad (1)$$

Among them: $N = \frac{\alpha}{\sqrt{1 - e^2 \sin^2 B}}$

$$\begin{bmatrix} L \\ B \\ H \end{bmatrix} = \begin{bmatrix} ar\tan(Y/X) \\ ar\tan[Z + Ne^2 \sin B]/\sqrt{X^2 + Y^2} \\ \sqrt{X^2 + Y^2}\sec B - N \end{bmatrix} \quad (2)$$

Elevation direction , photography scale confirms absolute flight height, absolute flight height adds height of points on the ground that confirms relative flight height of aircraft flying. Flight height of aircraft can be read by GPS receiver directly.

2.3 Real-time receives and withdraw the GPS navigation data

The system transmits localization data whit the RS-232 serial port, reads the geodetic coordinates and the real-time speed which the GPS gain with the serial port communication function of Windows API.

Deploy Serial port:

```
#define IOPMOD (*(volatile unsigned *)0x3ff5000)
#define IOPDATA (*(volatile unsigned *)0x3ff5008)
```

Read data:

```
char *strCafterC(char *strp, char c1, char c2)
{
            char *substr;
            int m = -1, n = -1, i = 0;
            int len;
            substr = a;
            len = strlen(strp);
            for(i = 0; i<=len; i++){
              if(((*(strp+i)) == c1)||((*(strp+i)) == (c1+32))){
                m = i;
                break;
              }
            }
            for(i = 0; i<=len; i++){
              if(((*(strp+i)) == c2)||((*(strp+i)) == (c2+32))){
                n = i;
                     break;
              }
        }
            if((m == -1)||(n == -1))
              return NULL;
            for(i = 0; i<(n-m); i++)
              a[i] = *(strp+m+i+1);
            a[n-m-1] = '\0';
        return substr;
}
```

With this function , information such as time and longitude and latitude can be extracted , moment location coordinate is provided for automatic exposal.

2.4 Software compilations

In Red Hat under the Linux system, with the c++ language, accepts the GPS navigation data ,simultaneously calculates and judges whether outputs the exposure signal, actuates the aerial photogrammetric camera automatic exposure with the double thread. Simultaneously functions and so on perfect error processing is increased in the system, processes in the actual use possibly can appear because the chance factors causes GPS cannot provide the localization data temporarily the situation, enhanced the system use reliability.

When the function `*strCafterC(char *strp, char c1, char c2)` receives GPS data, exposal point data is read by the software from epc.dat, read function as follows:

```
infile2 = fopen("epc.dat","r+");  // the document of exposal point data
getline(&eline1, &elen, infile2);
```

Then according to the theory of automatic judgment of flight line, exposal conditions is given, meet requirements, then high level is exported by the ARM7 SCM, program as follows:

```
IOPDATA = 0x00;
```

Then drive digital aerial photogrammetric camera SWDC to automatically expose.

Simultaneously functions and so on perfect error processing is increased in the system, processes in the actual use possibly can appear because the chance factors, as the signal is kept out, the aircraft dynamic range is too big , the electromagnetic wave is disturbed and just so on, cause GPS cannot provide the localization data temporarily the situation, enhanced the system use reliability.Have mounted the relevance function now, if flight management system works normally, but GPS data be interrupted, aircraft flying speed and direction may be made with the first 5 data , till the GPS data is regular, so fault-tolerant ability and reliability of system can be raised.

2.5 Compiles the software which can produce exposure document automatically based on PC

If the aerial photography region and the mapping scale, principal distance of aerial photogrammetric camera and digital back size is given, according to aerial photogrammetry request of degree of overlap (60% or 80%). This software has the automatic production horizontal line, the vertical line and the inclined line function, the level and the vertical line production quite is simple, paper main introduction algorithm of incline line automatic production. Exposure coordinates can be established according to the route. Mainly aims at the SWDC series digital aerial photogrammetric camera, designs the route automatically with Visual C++ and produces an exposure point document.Content about this part will be introduced particularly in paper《air line design base on digital aerial photogrammetric camera》.

This system has realized to control the SWDC aerial photogrammetric camera automatically exposure, changed the domestic traditional manual work way, has realized the main function of overseas aerial photography management system, the cost actually only 1%of the overseas similar product . Production experiments in places such as Jiaozuo, Henan,Luzhou, Sichuan,satisfies requests completely .The SWDC aerial photogrammetric camera take the ultralight aircraft (for example honeybee - 3) as a platform, only one pilot can completely the aerial photography work.. Having provided necessary assisting for SWDC aerial photogrammetric camera apply to aerial photogrammetry , at the same time having created advantageous condition for SWDC aerial photogrammetric camera generalize.

REFERENCES

Li Fei, 2005(12),Key Technologies Research of Aerial Photogrammetry Flight Management System Based on GPS and GIS. Science of Surveying and Mapping.30(6),pp.38-39

Wang Conghua,2005(8),Research and Design about Survey and Control Management System Unmanned Air Vehicle. Science of Surveying and Mapping. 30(4),pp.54-56

Cui Hongxia,2004(2) Automatic Control System of Unmanned Air Vehicle Remote Sensing Equipment. Science of Surveying and Mapping. 29(1),pp.47-49

Wang Jiexian，2003(4),Transformation from GPS determined coordinate to local system, GNSS World of China. pp.7-10