

Chapter 2

Monitoring Techniques of Forest Diseases and Insects with Airborne Digital Videography

1. Introduction

US forest service has been working with airborne videography as a tool for the detection of forest pest infestations since 1986. During the past fifteen years US forest service has standardized an off the shelf videography system. And now they have been developing more advanced systems. Based on the last videography system they replace the S-VHS video camera with high resolution digital camera and develop the electronic sketch-mapping system. Therefore the technique has been more perfect. Because of technical problems, it is difficult to use digital camera and electronic sketch-mapping in developing countries. Whereas the airborne digital videography can play important roles in forest healthy protection.

Airborne digital videography has proved to be an effective remote sensing tool for resource managers. Some of its major benefits can be described as following:

- 1) video data provides a permanent record conditions at the time of the detection, and hence eliminate the subjectivity of the observers,
- 2) cost of video imagery is far less than conventional frame photography,
- 3) video operator can view live imagery in the aircraft as the imagery is being collected, thereby vastly improving the quality of the data according to different terrain,
- 4) video operator can record real-time GPS position data input as the video data is being collected, and
- 5) the convenience for computer processing

The practical application has found digital video to be useful but there are some technical barriers to overcome. The primary barrier is the high cost to mosaic and geometrically correct the digital video data due to the long time needed. Therefore we can only process the single frame with ERDAS image processing system now to extract the position information of damage areas or points.

Aerial sketch-mapping is the main method to detect forest diseases and insects all along in those countries with vast forests, such as USA and Canada. Limited by national power and other factors, the developing countries have been adopting the ground investigation method. Facing the invasion of fatal disaster, such as pine wood nematode disease (*Bursaphelenchus xylophilus* Nickle), pine needle hemiber lesion soale (*Hemiberlesia pitysophila* Takagui), Loblolly pine mealy bug (*Oracella acuta* Lobdell) and American white moth (*Hyphantria cunea* Drury), our current method is so helpless. With the diffusion of disaster region and the lack of precise detection, the loss is so heavy in China that it has endangered the ecological security in many world-level heritage protection regions, such as Huangshan Mountain, Jiuhua Mountain. Therefore, currently the most crucial task is to solve the problem of precise detection and dead tree cleaning. In order to conquer the defect of aerial visual sketch-mapping and aerial photography, USFS has begun the research in the field of aerial videography and aerial infrared digital camera since mid-1980s and has achieved satisfactory progress. China introduced this technology at mid-1990s and gradually solved many technological problems in practice. Aerial video technology has the advantage of mobile flexibility and real-time detection. Therefore, it has been one of the approaches to detection of forest diseases and insects in many countries.

2. Equipment needed by video acquisition system

2.1 The flight acquisition system

- Video Camera

Sony DCR VX-1000E (or another DV enable video camera system) with IEEE 1394 (Firewire, Ilink) interface

- Camera Mount

The mount provides a stabilized, vibration-free, rigid, vertical camera port. It allows the camera to be mounted vertically inside the aircraft within the camera port, providing an unobstructed field of view to the ground below.

The mount provides the ability to rotate;À45 degrees around the vertical axis of the camera lens centerline, thereby allowing for correction due to aircraft drift from cross-winds. Furthermore it allows the ability to rotate;À10 degrees about the lateral axis of the field of view to correct for tip. Finally, it allows the ability to rotate;À5 degrees about the longitudinal axis of the field of view to correct for roll.

- Video Monitor Panasonic BT-S1000N AC/DC color monitor

The on-board color monitor is Panasonic BT-S1000N AC/DC. It is used in place of an electronic viewfinder that would have had to be mounted on the camera and would have been difficult and uncomfortable to use, give the camera's vertical mounting. The aerial videographer used the monitor to verify what imagery was being acquired.

- GPS Equipment

Any GPS receiver capable of output data with one time per second. It should be noted that navigation equipment and positioning receivers must be equipped.

We use GARMIN GPS 195 portable receiver to navigation and positioning in the flight and the field. Trimble GPS 132 receiver is used to precisely position for airborne video data.

- Attitude Sensor

The Watson Industries attitude sensor (ADS-C232-1A/18) is used to measure the tip and roll angle of the aircraft during video acquisition. The data can be used to improve the imagery geometrical characteristics.

- Horitor Time Code Generator

The Horitor Time Code Generator (GPS_3_USFS) ties the GPS and attitude data together and encode the information onto the digital video tape using SMPTE time codes. It generates its own caption that can be display on screen.

2.2 The ground image processing system

- PC computer

PC Pentium III 550, with a minimum of 128MB of RAM for Windows 98 or Windows NT server 4.0, a minimum of 128MB of RAM for Windows 2000, a minimum of 20GB of hard disk, and 24-bit color graphics card.

- IEEE 1394 Interface Card DV 500 IEEE 1394 interface card

The DV 500 processes analog (S-Video, Composite video) and digital (DV, IEEE1394) signals via corresponding inputs and outputs.

- Software ERDAS, ARC/INFO, GPStran and so on.

2.3 Airplane type

All kinds of airplane are suitable. But for lowering cost, we prefer light plane or small plane.(seeFig.2.1)



a) Yun-5 airplane of China



b) Haiyan light plane of China

Fig. 2.1 Small planes in monitoring and protection of forest insects

3. Technical process of aerial digital videography

3.1 Aviation preparation and airline design

It is required to mark precisely the detection region on large-scale topographic map; provide the aviation parameters, including aviation height, coverage area and aviation intervals, and so on; finally, with special software, calculate all waypoints and preliminary points that can be directly uploaded to the GARMIN navigation receiver after compilation.(see Fig.2.2)

In general, to assure the airplane to correctly enter predetermined course, according to the velocity difference

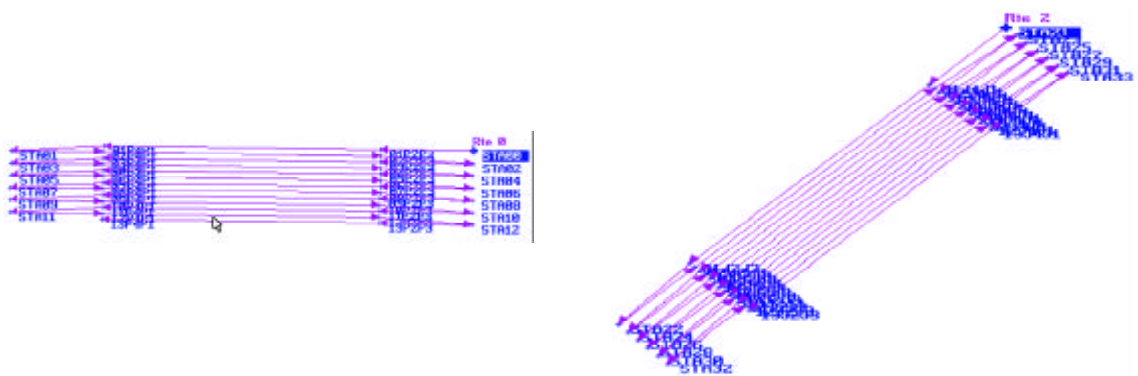


Fig. 2.2 Flight line and waypoint designed by thematic software

of airplane, the adjustment region with some lengths are necessary. The length of adjustment region of Yun-5 airplane is 3 kilometers .

If the data can not be uploaded into computers, all waypoints must be printed and passed to the pilot.

3.2 Installation and test of aerial video data acquisition system

Data collection part of airborne video detection equipment mainly includes digital camera, GPS receiver, attitude sensor, coding/decoding instrument, monitor, power adapter etc. These equipments should be installed stationary position of airplane in terms of work need. Most of the equipments apply the DC provided by airplane. Of course, the storage cell is also of better choice.

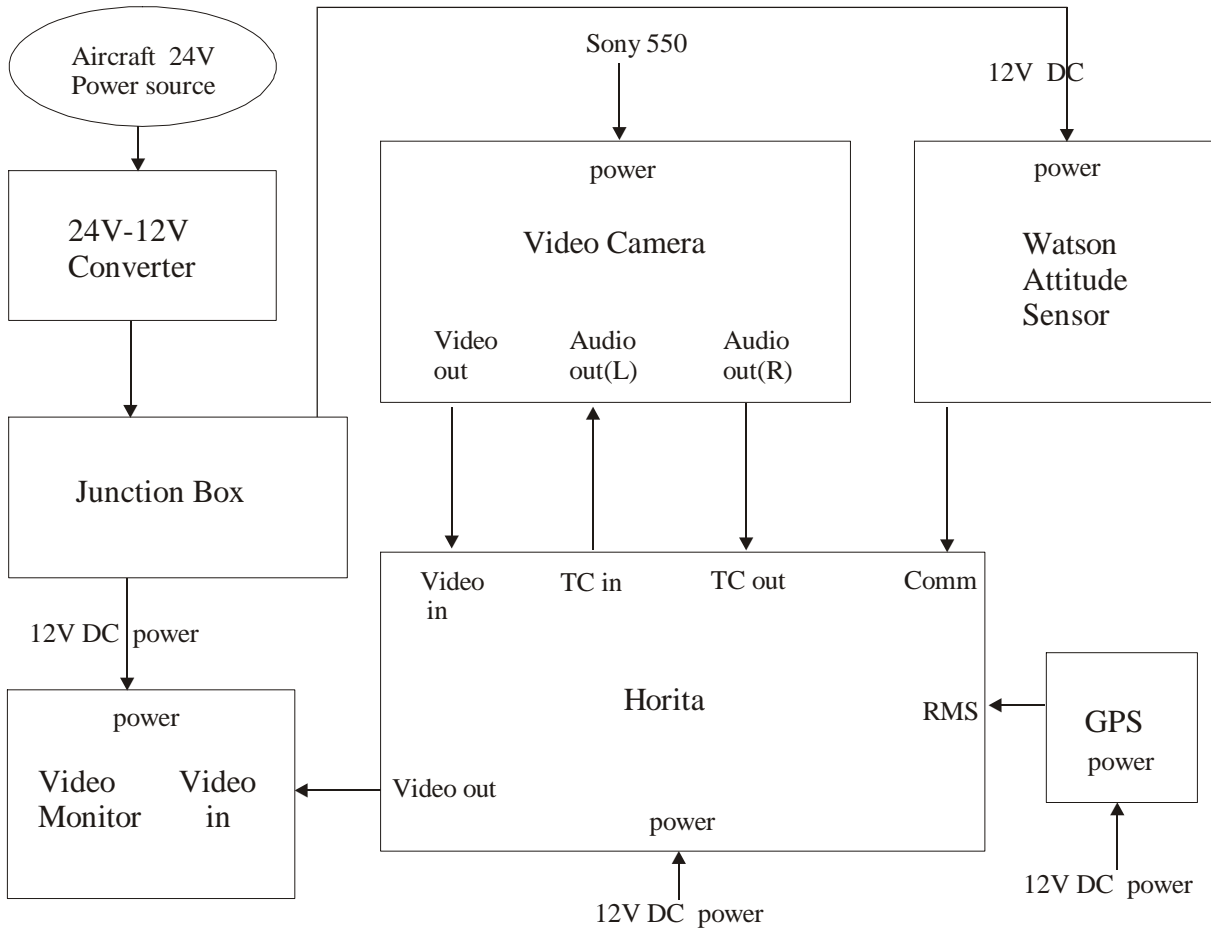


Fig. 2.3 Airborne video camera acquiring system

Most of the aerial video detection equipments apply 12V DC, ASTRON 2412-20 power convertor is used to convert 24V-28V DC to 12V DC. Electrical trunks line box mainly distributes the 12V DC provided by the power convertor to each image collection unit. Fig.2.3 is Technological process of data acquiring.

3.3 Collection of video data

According to the navigation information or the notification information of the pilot entering or exiting work areas, open and close camera in time. When the plane fly stably and before the data of each flight is recorded, the attitude should be reset.

Because of no high resolution DEM, the attitude's low sensibility and lack of stable application software, we can not automatically mosaic the image data at present. Considering obvious terrain in forest region and the difficulty of maintaining the aviation height, the focus should be adjusted momentarily to ensure a stable range of ground coverage.

4. Indoor processing of video data

4.1 Extraction of GPS data of flight line

In the design of this system, the data of flight track and attitude is recorded on audio channel at stable rate. For the precise positioning of image, GPS data must be outputted by special software. Fig.2.4 is technological process of data reading.

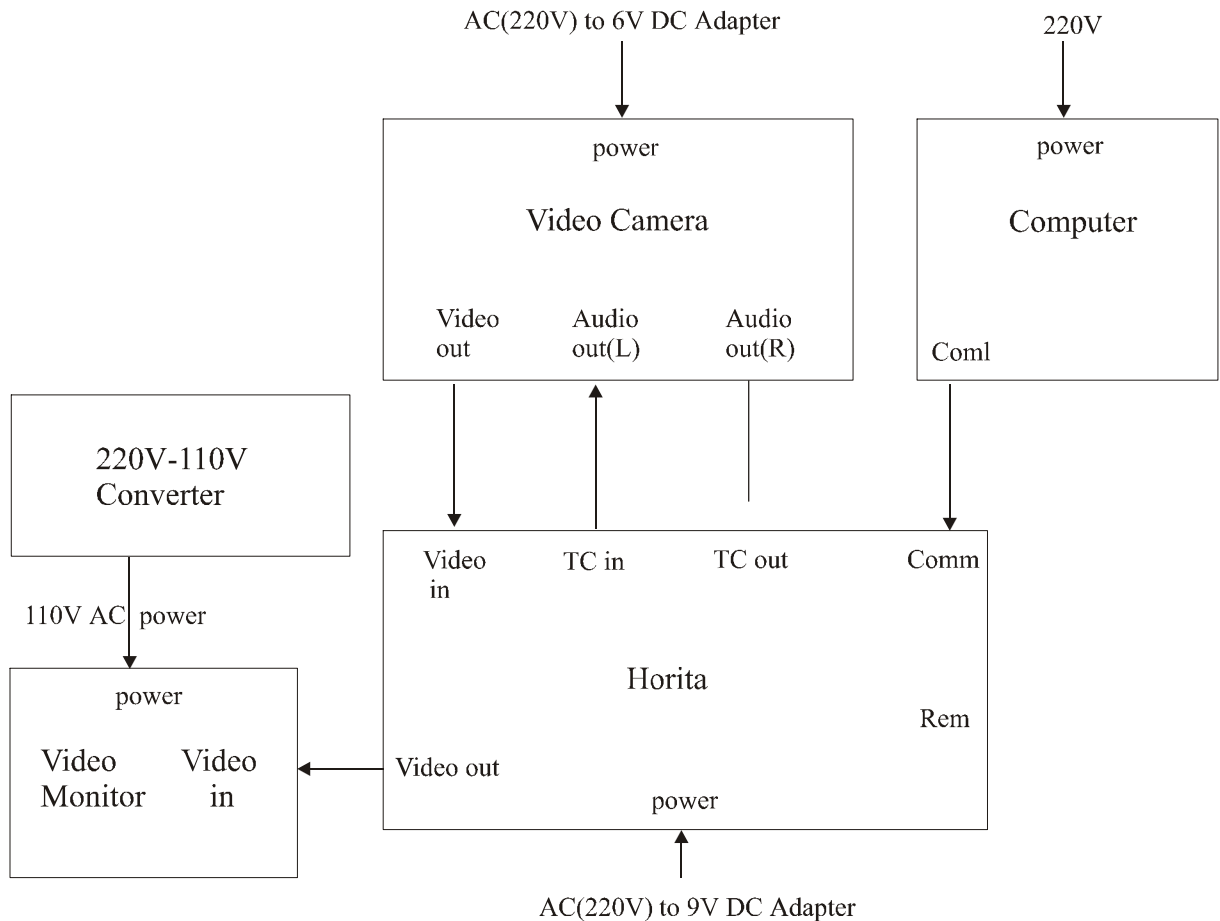


Fig. 2.4 Reading of GPS data

4.2 Projection transformation of flight line data

The transformation was done between WGS-84 coordinate system and 1954 Beijing coordinate system in China with special software so that users can analyze the disaster data by integrating with other GIS data.

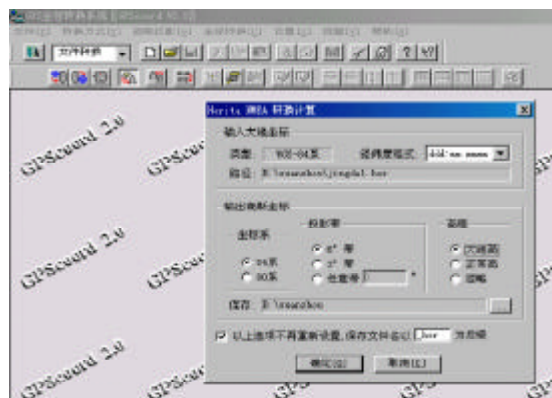


Fig. 2.5 Interface of data transformation

4.3 Extraction and positioning of disaster data

From a theoretical view, images can be mosaicked with highly precise DEM data. But for many reasons, the application prospect is not so evident. The only thing we can do is to provide real-time, precise disaster information to satisfy the need of forest production. Now we extract the forest change region mainly by viewing first, then make special process and analysis to these regions. Then we can calculate image size by home-made software. And ERDAS image process system can be used to extract damage information. Fig.2.6 is the process of data processing.

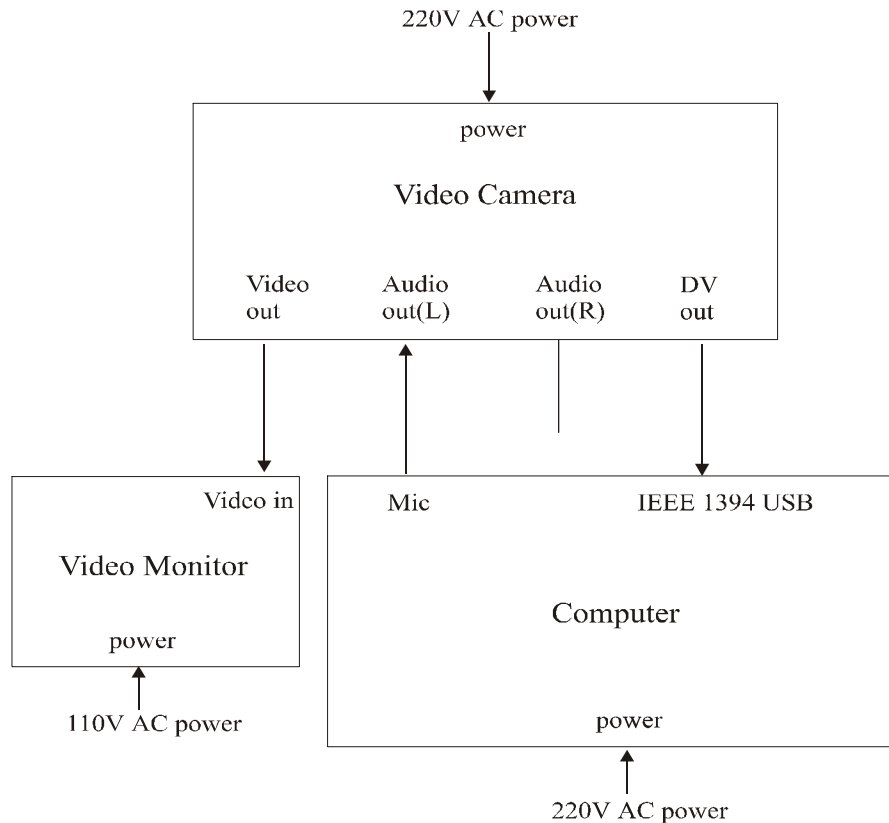


Fig. 2.6 Reading of damage data

4.4 Output of disaster point and disaster areas

Because the information extraction of disaster point and disaster region mainly depends on the vector model in ERDAS, coverage file can be easily converted to the data format file.

5. Key technology of airborne digital videography

In the practical application, we should commendably resolve the following problem to accurately, timely, and effectively detect the forest pest damage.

5.1 Automatic design of flight line

The quick calculating and uploading of flight line is an important factor to improve work efficiency and reduce the cost.

5.2 Conversion of GPS data

Airborne digital videographic system is actually a integrated system of GIS, GPS and remote sensing techniques. The accurate data transformation between GPS and GIS is also very important.

5.3 GPS and video data's synchronous search technology

To ensure the synchronization between GPS data and video frame is the key technique in the image processing.

5.4 Rapid repositioning of disaster areas

Base on GIS, we can output the location information of damage areas and damaged single tree. And we can find them in the field with GPS receiver.

5.5 Damage classification technology

We can quickly extract the damage information with monitoring models.

6. Application of airborne digital videography

In 2000 and 2001, we respectively took four detection tests of pine wood nematode disease (*Bursaphelenchus xylophilus* Nickle) and pine caterpillars in Huizhou City of Guangdong Province, Xuancheng region of Anhui Province, Nanning region of Guangxi Zhuang Autonomous Region and Huangshan City of Anhui Province. During these tests, we got much precious experience and data that are valuable for the improvement of system function.

6.1 Detection test of individual dead trees

Pine wood nematode, known as pine cancer, has cost tremendous loss in the world. Because of its infectivity and truculency, it is difficult for current ground investigation method to find the early affected individual trees and control them timely. As a result, the disaster diffuses and the loss aggravates. So it is significant for the protection of environment to find and clean wilted stumpage as soon as possible. The aerial detection method becomes the best way to implement real-time forest health detection. Though it is impossible for modern remote sensing technique to precisely distinguish the harm of different diseases and pests, the technology has active sense in reducing investigation range and grasping development status. Therefore, all levels of production departments have high ardor and expectation for developing effective and applied aerial remote sensing detection technology.

Several images beneath show the wilted stumpages under different terrain and plant composition condition. They illustrate that airborne digital videography technique can precisely assess the current status and quality of single tree.

Limited by technology, local units can not utilize image processing system and GIS to analyze and visualize vector and raster data. However, in order to facilitate the field detecting, trace and hazard point data can be overlaid with topographic maps and the result can be in TIF format so that more direct information can be achieved.

Fig.2.7, Fig.2.8, Fig.2.9, Fig.2.10 are the frame images of airborne video system. Fig.2.11, Fig.2.12, Fig.2.13 are the monitory results map in Anhui Province.



Fig.2.7 Individual dead trees



Fig.2.8 Dead trees on top of cliff

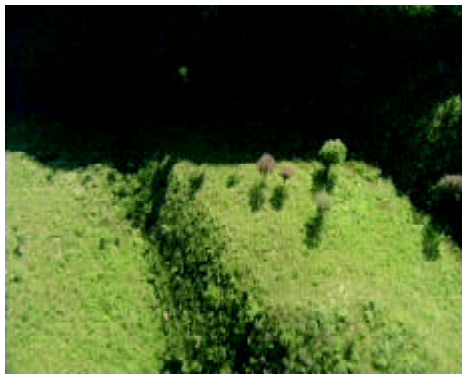


Fig.2.9 Dead trees on barren grass slope

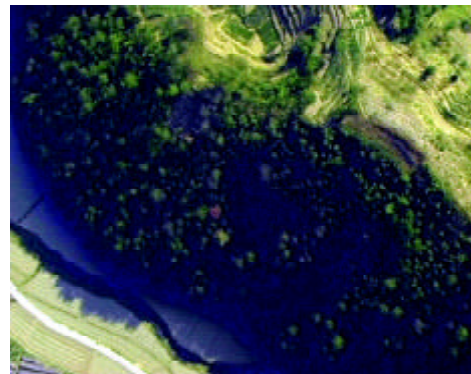


Fig.2.10 Standing tree that is just dead

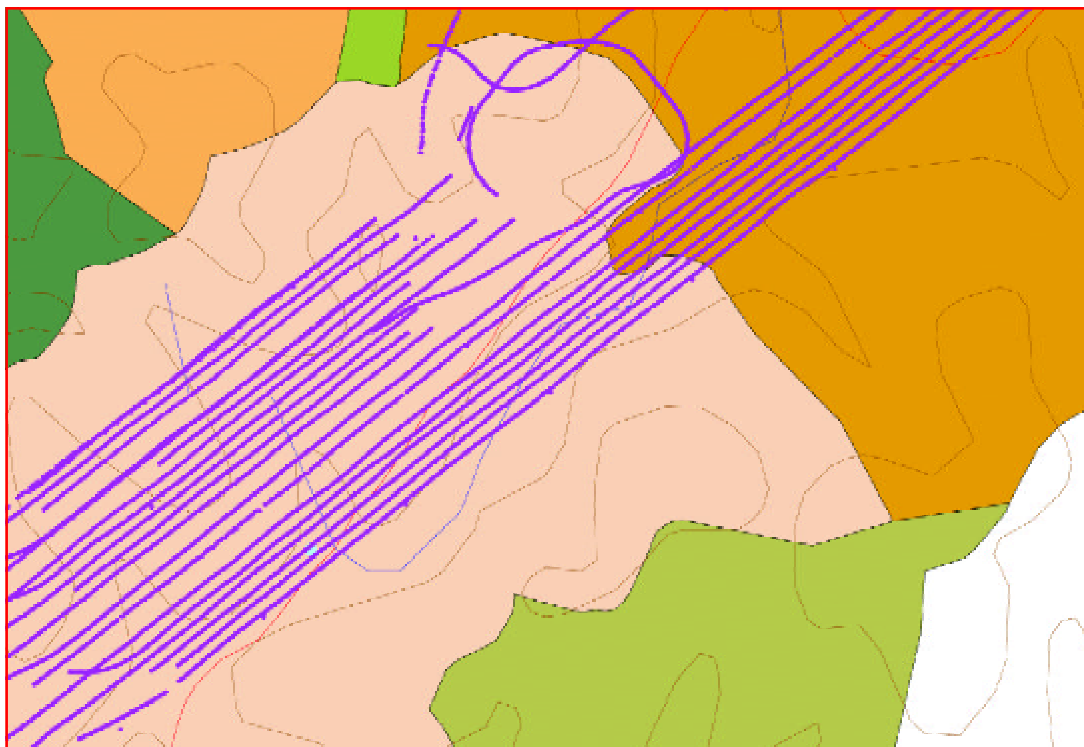


Fig.2.11 Overlay of the track point with thematic map

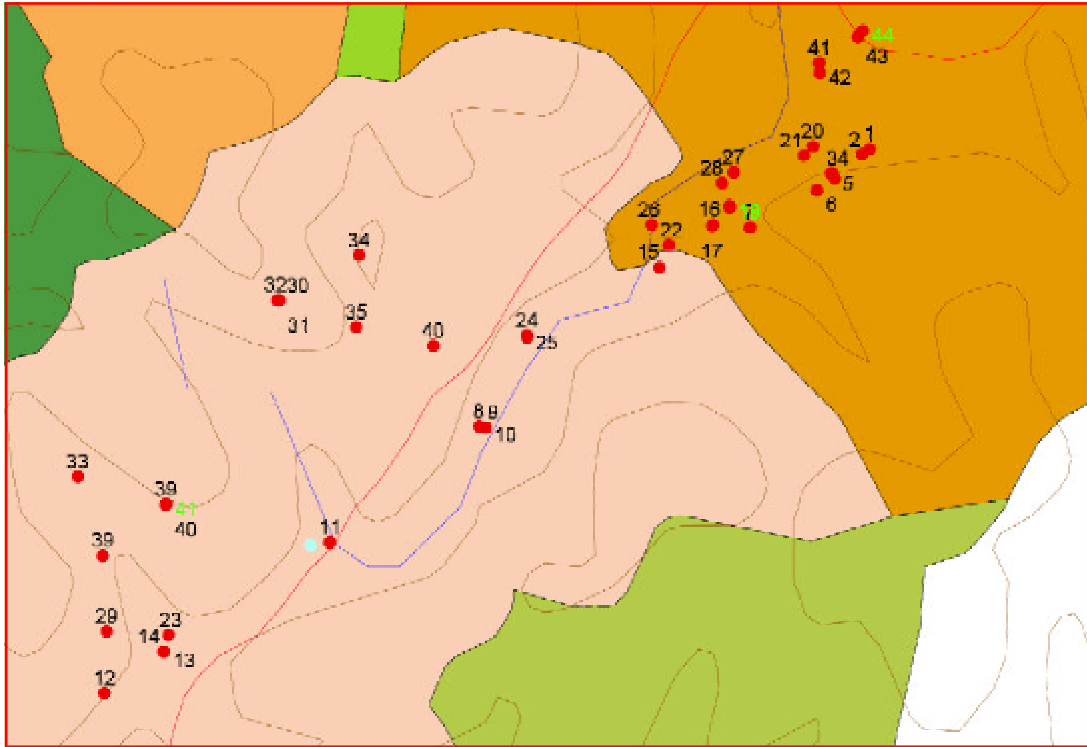


Fig.2.12 Overlay of single dead tree and thematic map

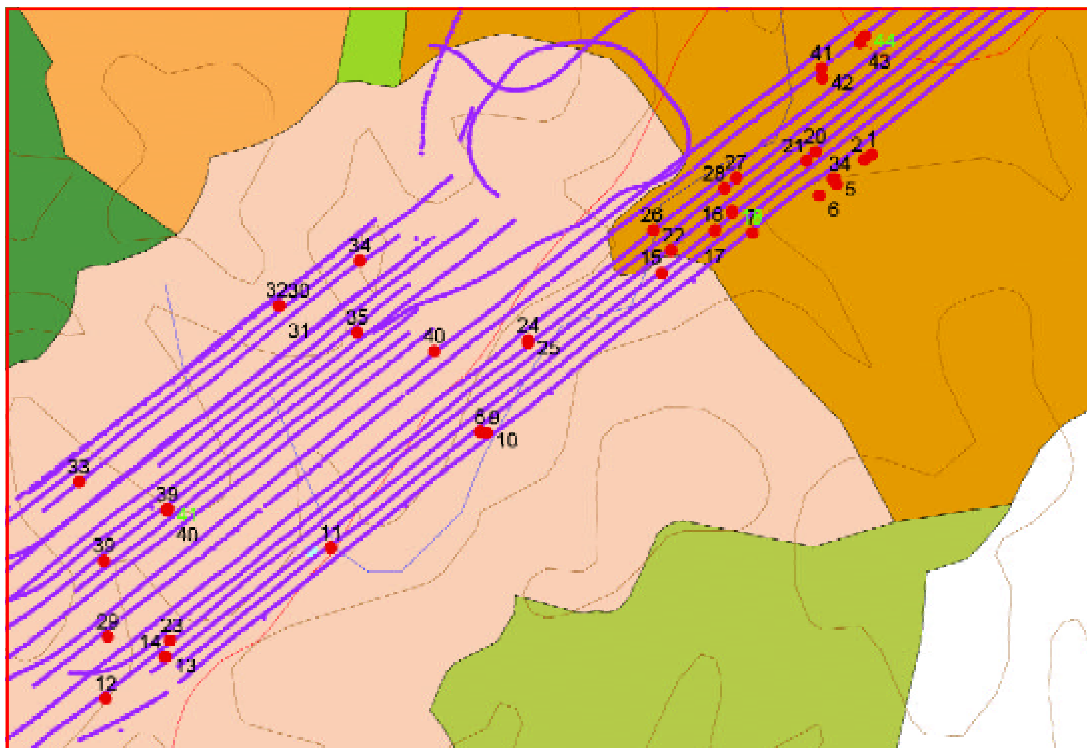


Fig. 2.13 Overlay of frame center, dead tree position and thematic map

After acquiring hazard data, ARC/INFO's `ungenerate command` can be used to output coordinates of hazard points.

1	674893.0625	3365094.25
2	674401.0625	3364422.25
3	673377.0625	3362374.25
4	672509.5	3360564.5
5	672649.5	3360564.5
6	675367.0625	3364858.25
7	675209.0625	3364766.25
8	674809.0625	3364206.25
9	674133.0625	3362862.25
10	673141.0625	3361346.25
11	673616.5	3361557.5
12	673623.5	3361576.5
13	673643.5	3361601.5
14	672296.0	3364192.5
15	672893.0625	3364774.25
16	672709.0625	3364600.25
17	672627.0625	3364624.25
18	668399.0625	3356800.25
19	668095.0625	3356522.25
20	667243.0625	3354530.25
22	672760.0	3364152.5
24	667527.0625	3354510.25
25	673252.0	3363444.5
26	673530.0	3363892.5
27	673532.0	3363904.5
28	674105.0625	3364354.25
29	673703.0625	3363810.25
28	668851.0625	3355164.25
29	670022.0	3356876.5
30	670036.0	3357066.5
31	670092.0	3356966.5

END

And then to transform them into WGS-84 coordinates with `GPStran`, and they can be used in navigation (see following figure).E.

Serial number	Spot name	Latitude with WGS-84	Longitude with WGS-84	Change reason
1	1	3015.9588	11841.2166	
2	2	3015.9451	11841.2762	
3	3	3015.9254	11841.2908	
4	4	3016.2938	11841.7996	
5	5	3016.6704	11842.423	
6	6	3016.0947	11841.758	
7	7	3016.1032	11841.7656	
8	8	3016.0934	11841.6906	
9	9	3016.0628	11841.7101	
10	10	3015.9821	11841.594	
11	11	3015.424	11841.7332	
12	12	3015.072	11841.3332	
13	16	3016.0204	11842.4424	
14	17	3016.1121	11842.7158	
15	15	3014.7089	11841.1301	
.....	

Fig. 2.14 Investigation table for field detection

6.2 Detection disaster in vast region

In the zone of equator or sub-tropic, for plenty of rain, it is difficult for traditional optical remote sensing data to detect forest insects and diseases, that is to say, the data can not be sufficiently ensured. Therefore, in order to periodically monitor the forest quality, aerial remote sensing technology is necessary. So we began our detection research and experiment to masson pine caterpillar in Guangxi Autonomous Region in China and made great progress. Fig.2.15, Fig.2.16, Fig.2.17, Fig.2.18 are the stand images of damage areas. Fig.2.19 is damage map of Guangxi.

7. Acknowledgments

The research described in this chapter was sponsored by National Forestry Administration, Anhui Province, Guangxi Zhuang Autonomous Region and Guangdong Province of the People Republic of China. The work was carried out in the Xuancheng region, Huangshan region of Anhui Province, Nanning region of Guangxi Zhuang Autonomous Region, Huiyang region of Guangdong Province. We wish to acknowledge the contribution of Wu Jian, Shi Jin, Xue Zhennan, Chen Murong, Tang Jian, Jiang Liya, Luo Jitong, Wang Fugui, Yang Xiuhao, Ma Shengan, Zhang Hong, Zhang Zhijian, Gao Shu, Ma Xiaoming, Li Shiming, Zheng Wei, Chen Jiwen, Xie Cheng and others who worked during the course of airborne videography.



Fig. 2.15 Stands with less than 30% needle loss (Yellow green region)



Fig. 2.16 Stands with 50% needle loss (Orange region)



Fig. 2.17 Stands with 70% needle loss (Brown region)



Fig. 2.18 Stands with above 90% defoliation (Dark brown region)



Fig. 2.19 Overlay of damage area and thematic map