Forest disease location system based on GIS and PTZ

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Abstract:

The research design explains that forest diseases and pests cause great economic and environmental losses to the society. In order to prevent it, obtain accurate, timely information and save manpower, a participatory survey model for forest diseases and pests is proposed. The system includes a video positioning system and manual identification work with a mobile GIS embedded in a PDA. The video system is effective for scanning the area, especially where there are withered trees. Inorder for workers to be able to inspect the disease control in the disaster area with a PDA, we developed a positioning algorithm and a positioning system. The positioning algorithm is based on DEM and PTZ camera. In addition, the accuracy of the algorithm has been verified. The software is composed of a ٣D GIS subsystem, a ٢D GIS subsystem, a video control Sub System and a disaster positioning subsystem. The ٣D GIS subsystem can provide thematic maps of disasters. The video control subsystem can remotely switch the digital camera to focus on the suspected area. The implementation of the disaster location subsystem and algorithm has proven to be able to detect forest diseases and pests in practical application for the forest sector.

Keywords: Forest disease detection, forest disease with GIS, forest disease with PTZ, pest detection system.

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Introductions:

Forest pests are one of the three major disasters for forest resources and ecology in China, which lead to more serious damage than forest fires and deforestation. In recent years, the situation of forest pests become more severe. On the one hand, the occurrence area of frequent diseases and pests remains highOn the other hand, the invasion of exotic pests is becoming more and more serious. In ۲۰۱۱, the occurrence area of major forest pests in China reaches to ۱۷۵,۲۲۰ thousand mu [۱].

In provinces, counties for diseases and pests and Toreduce disaster losses, multi-level forecasting stations have been established in China. However, they mainly use artificial survey methods to collect forest disease and pest information and report level by level. The survey terrain is characterized by artificial survey and on-site judgment, so it is difficult to collect disaster information comprehensively and timely, especially in areas with complex topography and poor traffic. In order to further improve the monitoring coverage and timely rate, researchers explore the use of remote sensing technology for monitoring and forecasting diseases and pests. Recently, remote sensing technology has been used for forest pest monitoring. Remote sensing has a high detection rate for only a few diseases and pests with text retrieval and analysis [۲],[۳],[٤],[٥].

remote video monitoring technology is mainly used in forest fire monitoring and assist to direct fire- local network, high-definition camera and digital PTZ[۲] are main hardware equip ments of the technology. Through improving existing equipments, the disaster positioning algorithm based on DEM is developed to realize effective monitoring and tracking the diseases. The video positioning system can monitor pests that make tree defoliating, withering and changing of tree crown. The video positioning system will reduce the workload of forest investigators [٦],[٧],[٨],[٩],[۱۰].

Monitoring pattern of forest pests supported by video positioning

In the field of forest pest data collection, the forest pest monitoring data recording system based on GIS/GPS[۳] has been preliminarily popularized which forms a survey mode using PDA[٤] to collect data instead of paper and pen. Although this mode of data collection accuracy and high data processing efficiency still depend on artificial development and has great potential for improvement in coverage and timeliness of survey. Remote visual monitoring is able to complement each other with the mode [۱۱].

Remote video monitoring system can scan the area in a short period of time and achieve positioning of diseases and pests with visual characteristics, to form thematic maps of disasters to provide navigation for ground surveyors to verify on site. And then the verified disaster information is fed back to the system for remote re-examination and tracking spread trends. The collaboration of remote video monitoring system and ground survey improves the agility of the process and significantly saves manpower. Figure ۱ shows the business process

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[۲] **Pan – Tilt – Zoom:** A pan-tilt zoom camera (PTZ camera) is a robotic camera that is capable of panning (left to right), tilting (up and down), and zooming (to zoom in). PTZ cameras are often placed in security posts, their primary function being to provide ۱۸۰- or ۳٦۰-degree views. They can also be set up to automatically monitor motion-triggered activity or to follow a defined schedule.

[۳] **Geographic information science: is a scientific** discipline, also abbreviated as GIS, that studies geographic data and information, including the representation of how phenomena appear in the real world, how and how humans perceive the world, and the organization and spatial analysis of phenomena.

[٤] Personal Digital Assistant: A personal digital assistant, or PDA for short, is a small, portable personal device with an operating system. Its primary use is in situations where the benefits of a regular computer are desired in environments where portability is also required.

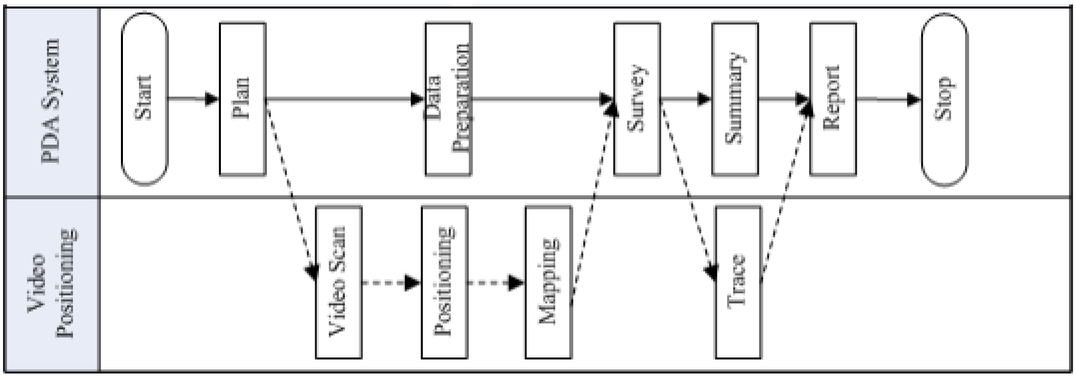


Figure ۱. The investigating mode supported by video positioning.

of the synergy of remote video monitoring system and ground survey. The key to support this process is to build the software system of remote video positioning.

System design:

Driven by business requirements, the design principles of accuracy and visualization are used to build the system. Accuracy: disaster positioning is the core function of the system, whose accuracy is a key issue for the applicability of the system. The positioning algorithm is developed to ensure that the accuracy is within the available range. Visualization: ۲D GIS and ۳D GIS subsystems are developed to assist positioning with spatial visualization, and the usability of the system is improved.

Hardware structure of the system

The hardware architecture of the system is shown in figure ۲, which consists of monitoring points, wireless networks, servers and clients. High-definition camera, high-precision digital pan tilt, pan tilt decoder and wireless video server are core equipment of a monitoring station. Pan tilt decoder is used to receive PTZ control commands. Digital video server is the signal center of a monitoring station, responsible for sending the collected video signal to the client and for transmitting the PTZ control command to the digital pan tilt. It is required that the digital PTZ used in the system can output the angles of azimuth and pitch. Every isolated monitoring station and application servers are connected through wireless network. The network of the monitoring area is built by microware networks, with low cost, ease of deployment, strong anti-interference and scalability, suitable for LAN construction under complex environment in forest area. Remote video monitoring software system is deployed on the application server to provide service for multi-client. Data server can provide basic spatial data service and pest disaster information storage service for the application server. Video server is used for secondary distribution of the front-end video streaming, to provide load balancing service under the condition of increasing users.

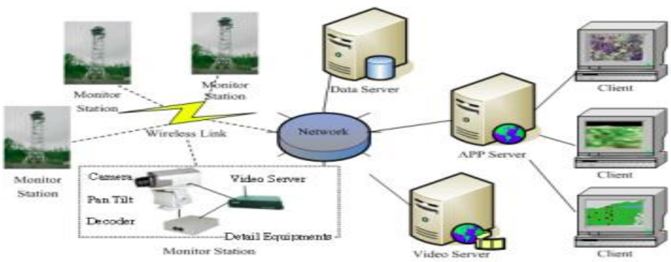


Figure ۲. Hardware architecture of the system.

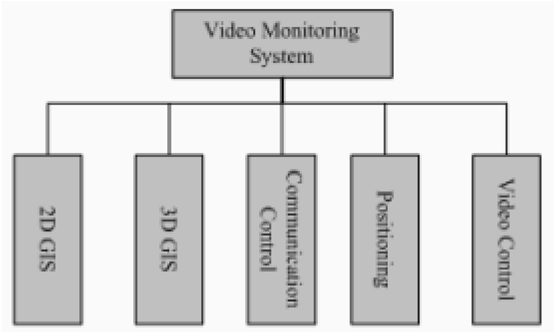


Figure ۳. Software architecture of the system.

۲DGIS subsystem: in addition to the basic functions of layer controlling, roaming, zooming and resetting, it also provides friendly monitoring point navigation and PTZ control, auxiliary disasters positioning, disasters query and thematic mapping output. Moreover, eagle-eye map is provided for ۳DGIS subsystem.

۳DGIS subsystem: in addition to ۳D terrain visualization of forest area, it also provides viewshedanalysis of cameras and auxiliary disasters positioning with virtual cameras. Furthermore, the navigation of monitoring points and PTZ control in ۳D mode are supported.

Video control subsystem: in addition to the control of aperture, focus and magnification of cameras, the rotation, tilt and speed control of digital PTZ are also supported. Moreover, the video window size and video bit-rate can be set, and the operating authorizations of cameras are managed.

Disaster positioning subsystem: using DEM-based disaster positioning algorithm, with the assistance of three subsystems, the positioning of diseases and pests, data save and export can be achieved, and the disaster information reexamined by forest investigators can be imported.

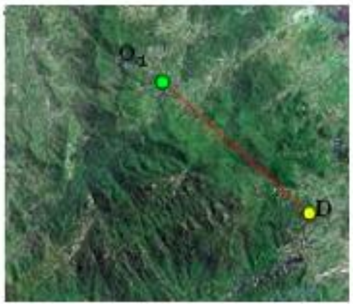
Communication control center: there are frequent calls among various subsystems. For example, video control subsystem requires passing real-time PTZ angles to disaster positioning subsystem in order to calculate the disaster position. Loosely coupled message-based communication mechanism is used. Message routing center adopts unified message scheduling among subsystems, corresponding actions can be executed after receiving the message, and the returned results are also passed through the message routing center.

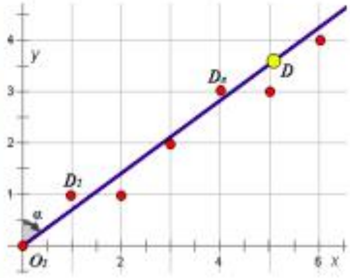
Disaster positioning algorithm

The basic principle of disaster positioning is to construct a ray emitted from the monitoring point according to the angles returned from the PTZ camera. From a geometric point of view, the process of positioning is to get the intersection of the ray and DEM. DEM cannot be expressed by any mathematical function. Thus, in discrete space, the disaster positioning is a process of finding the optimal solution, which is also a constraint satisfaction problem. To improve the efficiency of the algorithm, the viewshed analysis of Arc Objects is called to generate the viewshed raster layer, which can reduce the search space of the optimal solution. Disaster positioning schematic diagram is shown in figure ٤, in which O۱ is the monitoring point, D is the disaster point [۱۲].

Algorithm input: the DEM of the area, the azimuth $\angle\alpha$ and pitch $\angle\beta$ of digital PTZ camera, the height H_y from digital PTZ camera to the ground, the projection coordinates (X_{O1}, Y_{O1}) and elevation Z_{O1} of the monitoring point, and the raster layer of FOV (Field of View).

The steps of the algorithm are as follows.





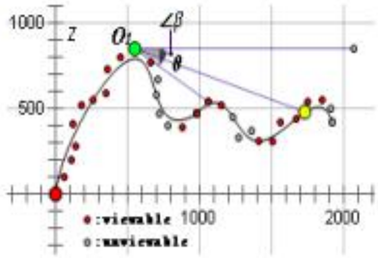


Figure ٤. Disaster positioning **Figure ٥.** Raster ray **Figure ٦.** Disaster point schematic diagram. generation diagram calculation diagram. discrete point set is obtained through Bresenham algorithm, Bresenham algorithm is a classical and effective algorithm to generate lines, the coordinate is expressed by (X_{Dn},Y_{Dn},Z_{Dn}),as is shown in figure ٥.

١.According to the azimuth ∠α and DEM, a ray L{D١, D٢, D٣Dn ,Dn+١...Dm}consisted of
٢. According to the FOV layer, deleting the invisible points in L from O_1 a point set
L {D١, D٢, Dn ,Dn+١...Dm} is obtained, as is shown in figure ٦.
٣. Compute the vertical angles of points in ' L using formula ١.

$$\theta_{D_n} = arctan\left(\frac{Z_{Q1} + H_y - Z_{Dn}}{\sqrt{X^2{}_{Dn} + Y^2{}_{Dn}} - \sqrt{X^2{}_{Q1} + Y^2{}_{Q1}}}\right) \quad (١)$$

٤. If the condition $\theta_{Dn} \le \beta \le \theta_{Dn+1}$is satisfied, and$\theta_{Dn} - \beta| \le |\theta_{Dn+1} - \beta$, then $D_n$is the disaster point, else $D_{n+1}$is the disaster point.
٥. Continue to step ٣, until $D_n = D_m$, that is to say, there is no solution.
To verify the availability of the algorithm, accuracy verification is conducted in a national forest park. First, differential GPS is used to measure the geographic coordinates of simulated disaster points, combined with local three parameters, which is transformed into projective coordinates. Then the simulated disaster points are positioned through remote video positioning system, and the accuracy is assessed by comparing with the actual measurement results [١٢].
Within the range of three kilometers encircling the monitor point, five verification points are deployed in [١km-٢km] and [٢km-٣km] respectively. Results show that: in [١km-٢km], the maximum error is ١٠٧ meters, and the minimum error is ٦٧ meters; in [٢km-٣km], the maximum error is ٢٢٣ meters, and the minimum error is ١٥٥ meters. The measurement error scale is acceptable for forest diseases and pests [١٢].

System implementation and the effect application

To facilitate the deployment and improve the user experience, B/S mode is used in the system. ٢DGIS subsystem which is mainly for query and browse and the disaster positioning subsystem that needs small amount of data transmission are developed in pure web mode. ٣D GIS subsystem and video control subsystem were implemented using the ActiveX control, due to the large amount of graphic rendering required. Thus, the system is ensured to be smooth by taking advantage of local resources. Three servers were set up on the server side with a speed of ١٠GB/S to connect with Ethernet. Data Server stores spatial data and disaster attributes database. Map server uses ArcGIS Server ١٠,٠topublish WMS and WFS services, and the disaster business data is stored in SQL Server ٢٠٠٨.Remoteserver-side video monitoring is deployed on the application server using a middleware of IIS٧,٠. The video server uses D-Link DNS-٧٢٦-٤ to provide load balancing services for the front-end video server.

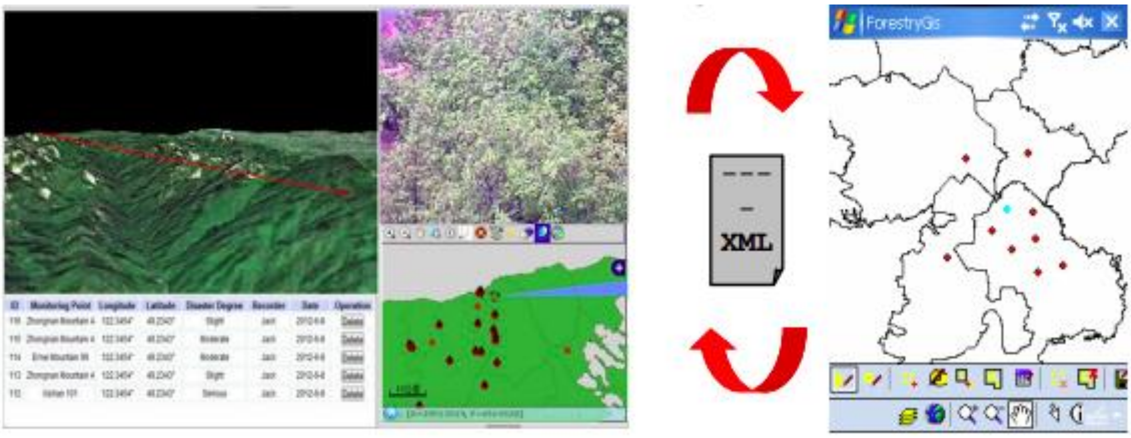


Figure ٧. Application pattern of the disaster positioning system.

This ٢D GIS subsystem is developed based on the preliminary work[١٢] and increases the disaster points.By adding dynamic, auxiliary switch of monitoring points and disasters to assist positioning methods, which is packaged as a Visual Studio ٢٠٠٨ AJAX component. The ٣D GIS subsystem is mainly developed based on OSG (OpenSceneGraph), which is an open source ٣D graphics engine. In the network layer, the libcurl٧,٢١,٣ network is used to transfer WMS terrain pyramid models and image pyramid models. In the data layer, the GDAL ١,٨,٠ class library is used to analyze spatial data. In the function layer, the libMini١٠,٢ terrain rendering library is used to realize ٣D terrain visualization.[١٣]

The application of the remote video monitoring system is shown in figure ٧. Based on the dis aster positioning of PTZ camera, through XML data exchange format, the disaster information is transmitted to PDA with GPS, then the forest workers can conduct on-site verification further. Thus, on the one hand, workload is reduced significantly by using video positioning. On the other hand, the reliability of information is guaranteed [١٣].

Conclusion

The lack of forest disease and pest monitoring methods necessitates the development

A PTZ camera-based remote video positioning system for forest diseases and pests has been implemented considering the business requirements of disease and pest monitoring. Positioning, storage, query and mapping output are implemented with the help of GIS. Through actual verification, the accuracy and usability of the system can meet the needs of disease and pest monitoring. The results show that this design has no contradiction with my research and can be implemented as a research design.

Table١. Plan implementation schedule: Schedule: Specify by hatching the squares.

Steps of implementation	Activity	Implementation time (months)												Activity percentage
		١	٢	٣	٤	٥	٦	٧	٨	٩	١٠	١١	١٢	
First	Research writing	■	■											٢٠
Second	Writing the research according to the regulations		■	■										١٠
Thidm	Review previous topics				■	■								١٠
Fourth	Preparation of research equipment						■	■						١٥
Fifth	Testing of research equipment								■	■				١٠
Sixth	Testing and installation , equipment and software									■	■			٥
SEventh	Software testing and fun											■		١٠
Eighth	System implementation and use											■	■	١٠

Study outputs:

• Final report of the research project in one copy with a CD in PDF-Word format

•Ten-page article report

• Also, the results of this project will lead to the preparation and publication of articles in foreign journals and conferences, scientific-research journals and domestic conferences.

Information about the project results:

• It should be noted that the project results respond to the need for new technology that can inform the audience when diseases and pests occur in the forest.

• Relevant higher education institutions, both governmental and non-governmental, can use the project results

• If approved and willing, the government or private organizations that will cooperate with this project are:

Table٢: Organization Approval

No	Organization name	Type and amount of cooperation	Name of person in charge and signature
١	Organization name is Optional	Yaer and month	Ferst name . Last name
٢	...	...	...
٣	...	...	...

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