Video Surveillance GIS: A Novel Application

Xingguo Zhang[1, 2]*, Xuejun Liu[1], Hongquan Song[1]
[1]Key Lab of Virtual Geographic Environment, Ministry of Education, Nanjing Normal University, Nanjing, China
[2]College of Urban and Environmental Science, Xinyang Normal University, Xinyang, China
*Corresponding author, e-mail: zhangxingguo2012@163.com

Abstract—**The integration of GIS and video surveillance systems is very useful for security and city management, which can provide real-time spatial-temporal information and display them on electric map. The key technology mainly includes the mapping between videos and map, the tracking for dynamic objects. Firstly, we propose an integrated framework of GIS and video surveillance system. Secondly, we present a cross-mapping model between videos and 2D GIS. Then, we describe a semi-automatic cross-mapping method based on 2D GIS and some constraints, which needs less interactions and can easily to be used, especially in city management. Finally, we develop a prototype system and discuss the implementation details including cameras' views display in 2D GIS using the cross-mapping model. Test results show that Video surveillance GIS (VSGIS) is very useful for the city safety management.**

Keywords-video surveillance, GIS, video-map mapping, object tracking

I. INTRODUCTION

With the acceleration of urbanization, cities face many complex issues, and security is one of the most important issues. At present, installing video surveillance systems is one of the most common methods of security, instead of the traditional guards. The video surveillance probes are used in many important corners, from indoor to outdoor, from macro to micro, from the police to civilian, and from HD to infrared, which serve various fields of the city security, such as urban transportation, case investigation, large gatherings, neighborhood and school security, bank supervision etc. Typically, video surveillance systems are mainly used to record images, and are poor in intelligence analysis. Therefore, how to automatically monitor the geographic environment partially instead of security guard responsibilities has become the focus in academia and government administration.

At the same time, GIS (Geographic Information System) becomes more and more popular. Through GIS, users can view detailed and latest remote sensing images, topographical map and all kinds of thematic maps. The wider application of video surveillance systems makes GIS face new opportunities and challenges. Live videos are clearer and more suitable for human visual habit, especially real-time. But nowadays, video is corresponding to a smaller area and is independent of each other. Video surveillance probes cannot cooperate. And videos lack spatial reference, which cannot be measured. However, For GIS, spatial data has some spatial reference and can display whole situation. How to integrate GIS and intelligent video surveillance and display their strengths is an urgent problem. The solution not only provides the collaborative framework for video surveillance systems, but also promotes the development of geographic information science.

Our solution to this problem is that based on GIS all videos in specific geographic environment are projected to 2D or 3D GIS. In this approach, the mapping of geospatial data and videos is a key technology, which includes two aspects. On the one hand, the spatial features in geospatial database can be projected to videos, such as point, line, polygon, 3D object, text etc. On the other hand, the moving objects, land features and land form in videos can be mapped to GIS. Therefore, cross-mapping algorithms are the key to the integration of video surveillance system and GIS. For the case of easily getting the exact parameters and detailed geographic data, no problem exists. However, in fact, for current many monitoring probes except for PTZ probes, it is difficult to get all the precise parameters. At the same time, DEM or DSM and 3D object of the micro scene usually do not exist, which causes the mapping of videos to GIS to fail. Therefore, it is necessary to study the mapping algorithm. In this paper, we first design a framework of video surveillance GIS. And then because of the main monitoring area is some plane in cities, a semi-automatic method of 2D GIS data and videos mapping is proposed based on 2D GIS and some constraint parameters.

This article is organized as follows: Section 2 presents an overview of videos and GIS integration. In section 3, the architecture of video surveillance GIS is designed. In section 4, we describe a kind of semi-automatic cross-mapping method, which is based on current poplar geospatial data. Section 5, we develop a test system to test the proposed software framework and algorithm. Finally, Section 6 presents the conclusions.

II. RELATED WORK

In order to display the results of video surveillance in GIS, the cross-mapping method between videos and 2D/3D is the key. At present, the methods are divided into two categories, which are homogenous transformation [1-3] and view line intersection with DEM [4-6]. For the former, the precision, number and spatial distribution of the selective points are very important. At the same time, the method requires more user interaction. The mapping matrix from 2D or 3D GIS to videos is the result. For 2D GIS, the mapping is double direction. But for 3D GIS, the mapping is single direction, through which 3D GIS data can be projected into the videos, but videos cannot be located in the geography space. For the latter, the intersection points of view lines and DEM are the geospatial points of the image pixels. The method requires precise parameters including inner and outer camera parameters and

Supported by Key Projects in the National Science & Technology Pillar Program during the Twelfth Five-Year Plan Period under Grant No.2012BAH35B02, Natural Science Research Project of the Education Department of Henan Province under Grant No. 2011B170010 and School Youth Fund Project of Xinyang Normal University under Grant No.2012059.

DEM.

In fact, except for PTZ probes, it is very difficult to get the parameters and precise geospatial data. At the same time, the existing research ignores the cross-mapping and only emphasizes the project from videos to GIS. Geospatial data need to be projected to videos.

For GIS software, the current platforms are not open or popular. The data models, visual methods and analysis methods are not discussed thoroughly. Magnanimity and real-time data bring the new opportunities and challenges to geographical information science. In recent years, some researchers have proposed the mapping model between surveillance video and 3D GIS [7-8], but ignored the project from videos to GIS.

In short, automatic and precise cross-mapping method is the most basic and key problem. Based on current geospatial data, how to achieve the cross mapping is very important. How to build the cross-mapping model is also urgent. The integrated framework of GIS and video surveillance system should be open and practical.

III. THE INTEGRATED FRAMEWORK OF GIS AND VIDEO SURVEILLANCE SYSTEM

VSGIS (Video surveillance GIS) is based on geospatial data and monitoring videos database, has the functions of data collection, management, analysis and simulation, and achieve real-time alert or temporal-spatial pattern discovery.

The integrated framework contains three tiers which are data tiered; middle tier and presentation tier, as shown in figure 1. For data tier, geospatial data and monitoring videos are the core data. Geospatial data mainly contain precise DLG, DOM, DEM, DSM etc. Monitoring videos, the location and height of the cameras are other important data. For the middle tier, GIS and video surveillance systems are independent of each other. They provide components for developers which are the important base of the framework. In figure 1, the component of Videos and GIS mapping is the core component, which provides a bridge between monitoring videos and GIS data. Videos analysis and cooperation are mainly based on GIS and user can take GIS as the main view which gives spatial reference, macroscopic view to monitoring videos for presentation tier, the framework provides interactive interface and specific functions.

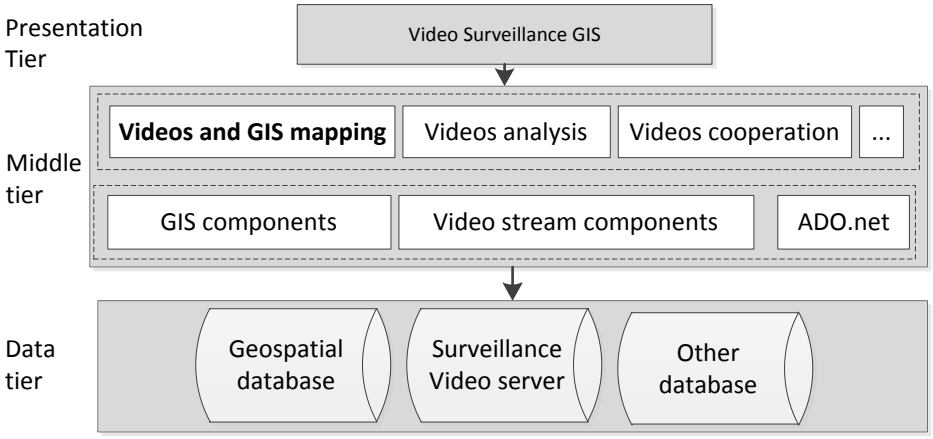

Figure 1. The framework of video surveillance GIS

IV. THE CROSS-MAPPING METHOD BASED ON 2D GIS DATA

A. The cross-mapping model of 2D GIS data and videos

2D GIS data are the world model, which project 3D world to the digital orthophoto map and only contain X and Y. These data are widely applied. However videos are a view of the world, which are 2D images. Each pixel contains the coordinate value of u (column) and v (row). Both 2D GIS data and videos are 2D data. Therefore, the transformation is the cross mapping between Point(X, Y) and Point (u, v). In theory, this transformation is not feasible, only to ensure the accuracy of some planes. In figure 2, for the point P', its mapping point in 3D GIS is P and in 2D GIS is L, not Q in the plane MNL. However, if the core monitoring area is planar, this transformation is accuracy, such as the plane MNL.

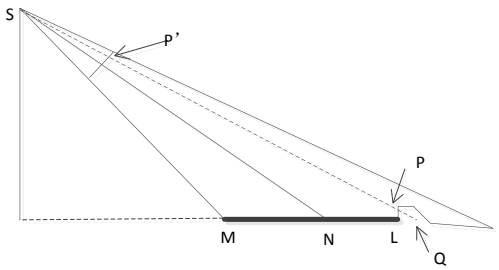

Figure 2. The relation of video and 3D surface

Based on the above analysis, we design the cross-mapping model between 2D GIS and monitoring video under z0 constraint, as follows:

The transformation matrix contains inner and outer camera parameters and z0. z0 is the altitude of a ground plane or approximate altitude. Therefore the computation of the transformation matrix is the key.

B. The proposed method

Many parameters in video surveillance applications are easy to get. Based on these parameters, the transformation matrix can be quickly calculated and many interactive steps are reduced. In figure 3, S is the position of the camera and H is the height. Ais the azimuth, αis tilt and βis the vertical view degree. If the rotation degree of the camera is 0, the monitoring area in 2D GIS is a trapezium.

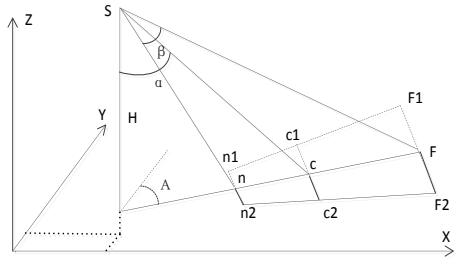

Figure 3. The diagram of camera shooting

The detailed steps are:

1. When the video surveillance system is setup, the manager specifies the position of the photography center S in 2D GIS. At the same time, the height of the camera can be estimated based on our knowledge, such as the height of each floor, lighthouse and step etc.

2. Set the vertical view angle β based common camera parameter, estimate the azimuth A and the tilt angle α. Here the rotation angle is 0.

3. In figure 3, by the spatial geometry calculation, we can get each point of the trapezoid (n1, n, n2, c2, F2, F1, c1).

4. Based on the pixel coordinate and geospatial coordinate of the trapezoid, the transformation matrix can be computed. Of course, in order to guarantee the accuracy of the nearer region, the system can only select the points (n1, n2, c1, c2).

5. Adjust the azimuth and inclination. The step needs the interaction. Of course, we can use feature matching to reduce the interaction. The experiments are underway.

V. APPLICATION

In order to test the software framework and the mapping method, video surveillance GIS (VSGIS) is developed. The system is mainly based on current popular GIS components (ArcEngine 10.0), video surveillance components (HCNetSDK) and OpenCV. The core functions include the cross-mapping between 2D GIS and videos, dynamic tracking and its real-time display in 2D GIS.

A. Cameras display in 2D GIS

The camera position is represented by the point symbol. In 2D GIS, we design a point layer and the property of each camera contains its parameters. The range of each camera is trapezium or quadrilateral and all polygons constitute a polygon layer, as shown in figure 4.

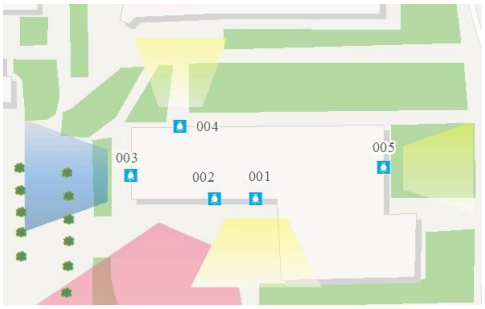

Figure 4. Cameras display in 2D GIS

B. The cross-mapping function

In video surveillance system, users often draw alert polylines or polygons. In videos, the graphs lack geospatial reference. Now the system can project the graphs in videos to 2D GIS and the geographic features can be projected to videos. Especially, the display of dynamic objects and its trajectories in 2D GIS is very important. User can view whole situation.

Figure 5. The cross-mapping function and dynamic tracking

For VSGIS, the display of dynamic objects is real-time. Here we design a dynamic layer which draws the mapping points of dynamic objects in all cameras. The points of the same object form a trajectory.

Figure 6. The display of dynamic objects in 2D GIS

VI. CONCLUSIONS

This paper designs a system framework of video surveillance GIS and propose a cross-mapping method between videos and 2D GIS. At the same time, we implement the test system which integrates the advantages of 2D GIS data and videos. VSGIS not only provides a novel method for video surveillance system, but also enriches the data and analysis method of geographic information science.

At present, there are a lot of problems to be solved in VSGIS. Firstly, the cross-mapping method is based on not only 2D GIS but also 3D GIS. The method should be automatic and precise. Secondly, we need to strengthen the research of the camera cooperation method. These will be our future steps.

ACKNOWLEDGMENT

The authors would like to express appreciations to colleagues in our laboratory for their valuable comments and other helps.

REFERENCES

[1] Bradshaw K J, Reid I D, Murray D W. The active recovery of 3d motion trajectories and their use in prediction[J]. Pattern Analysis and Machine Intelligence, IEEE Transactions on, 1997, 19(3): 219-234.

[2] Roller D, Daniilidis K, Nagel H H. Model-based object tracking in monocular image sequences of road traffic scenes[J]. International Journal of Computer Vision, 1993, 10(3): 257-281.

[3] Pavlidis I, Morellas V, Tsiamyrtzis P, et al. Urban surveillance systems: from the laboratory to the commercial world[J]. Proceedings of the IEEE, 2001, 89(10): 1478-1497.

[4] Kanade T, Collins R, Lipton A, et al. Advances in cooperative multi-sensor video surveillance[C]//Proceedings of DARPA Image Understanding Workshop. 1998, 1(3-24): 2.

[5] Collins R T, Tsin Y, Miller J R, et al. Using a DEM to determine geospatial object trajectories[M]. Carnegie Mellon University, The Robotics Institute, 1998.

[6] Wenshuai Y, Xuchu Y, Pengqiang Z, et al. Using of geospatial video surveillance networks for urban security and emergency applications[C]//Urban Remote Sensing Event, 2009 Joint. IEEE, 2009: 1-5.

[7] Lewis P, Fotheringham S, Winstanley A. Spatial video and GIS[J]. International Journal of Geographical Information Science, 2011, 25(5): 697-716.

[8] Milosavljević A, Dimitrijević A, Rančić D. GIS-augmented video surveillance[J]. International Journal of Geographical Information Science, 2010, 24(9): 1415-1433.