



Research Article

ISSN : 0975-7384
CODEN(USA) : JCPRC5

Geographic Hypermedia System Model Design and Application

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ABSTRACT

Geographic Hypermedia (GH) is a rich and interactive map document with geo-tagged graphics, sound and video elements. A Geographic Hypermedia System (GHS) is designed to manage, query, display and explore GH resources. Recognizing emerging geo-tagged videos and measurable images as valuable geographic data resources, this paper aims to design a web-based GHS using web mapping, geoprocessing, video streaming and XMLHTTP services. These data can be integrated in HTML pages or used as Rich Internet Applications (RIA) using standard web technologies such as the AJAX, ASP.NET and RIA frameworks. An SOA-based GHS is designed using four types of web services: ArcGIS Server 9.3 web mapping and geoprocessing services, Flash FMS 3.0 video streaming services and GeoRSS XMLHTTP services.

Keywords: Geographic Video, Data Model, 3D, GIS

INTRODUCTION

Promoting dissemination and utilization of geo-graphic information in government, utilities, commerce and general public sectors, raises several challenges in geographic information science. The first challenge concerns the appropriate relation between the bird's eye view and the perspective view of geo-spatial reality. The bird's eye view offers a 2D geo-spatial model with an accurate representation of locations and spatial relationships. The perspective view offers a 3D model with intuitively 'true' visualization. The second challenge concerns defining the relative value of adopting a logical-spatial approach to geo-graphic information as opposed to a visual-spatial approach. The logical approach makes possible spatial statistical analysis, modeling and prediction, while the other approach appeals to direct visual understanding. These challenges must be met in both thematic mapping and multimedia presentation. The third challenge is to develop geographic applications not only for communication among professionals, but also for use by the general public. Many social issues are better resolved via public participation rather than via decision making without any consultation. In all cases, 3D modeling, geographic multimedia and virtual/augmented reality, Web 2.0 and other information technologies offer new approaches to meet these challenges. In this paper, it is argued that 3D GIS, multimedia cartography, Web 2.0 mapping and 'neo-geography' offer potentials for current geographic applications. [1-5]

Multimedia cartography presents geographic information in an intuitive manner.[6] Compared with the object-based map layer or field-based orthoimage, the multimedia map has advantages in the representation of the micro-level geographic world. With the development of digital multimedia technology, geographic researchers have continuously integrated various multimedia resources into maps using state-of-the-art information technologies.[7] Publication of a CDROM atlas with multimedia elements became very popular in the late 1980s and early 1990s. The integration of multimedia with GIS started during the mid-1990s, e.g. the Hotlink Tool in ESRI ArcView 3.0. Since the late 1990s, multimedia GIS using mainstream programming has become popular. Traditionally, the two

approaches to the design of multimedia mapping products are “maps in multimedia framework” and “multimedia in GIS”. The emerging new approach is to publish geospatial data and multimedia data as web services, and present the data in interactive HTML pages or RIA documents. Geographic Hypermedia (GH), as promoted by Stefanakis and Peterson, attempts to provide a new way for rich, open, flexible and interactive geographic representation.[9] This paper demonstrates a web-based Geographic Hypermedia System (GHS) design using web mapping, geoprocessing, video streaming and XML/HTTP services. The related data

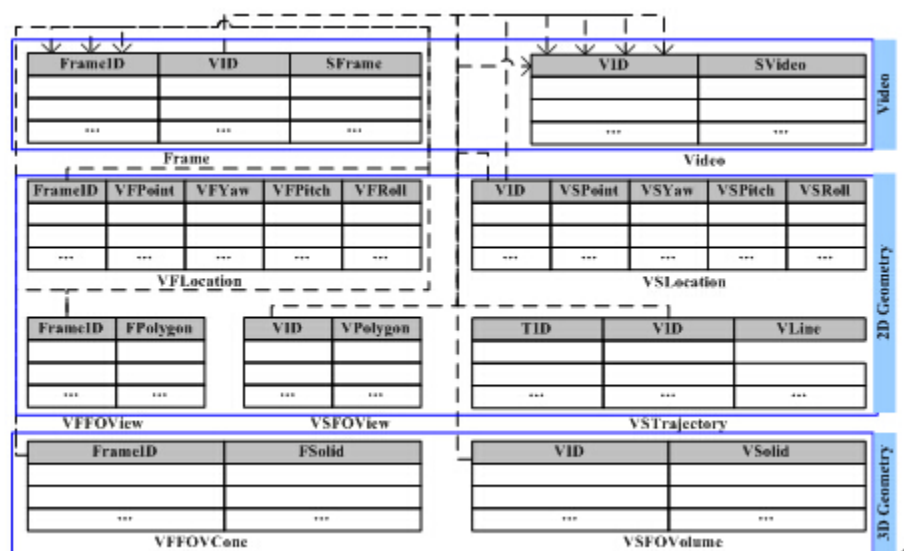


Fig.1: Database representation of 3DGV

Video tables include the frame table and the video table, which are linked by VID property. The primary key of the frame table is FrameID, which is used to link the geometry tables. The video and frame data are stored in the SVideo and SFrame property. The form of video or frame data can be the data path with string type or the LOB type in database.

Geometry tables include the VFLocation/VSLocation table, the VSTrajectory table, the VFFOVView/VSFOVView table and the VFFOVCone/VSFOVVolume table, which are used to store spatial information for the video and frame. The primary key of the VFLocation, VFFOVView and VFFOVCone table is FrameID, which refers to the Frame table primary key. The primary key of the VSLocation, VSTrajectory, VSFOVView and VSFOVVolume table is VID, which refers to the Video table. The spatial data is stored in VFPoint, VSPoint, FFPolygon, VFPolygon, VLine, FFSolid or VFSolid with related forms, such as Oracle SDO_Geometry. The camera attitude data is stored in FYaw, FPitch, and FRoll property.

DATA ACQUISITION OF 3DGV

In order to collect video data with spatial information, the video frame as well as its position and orientation should be collected synchronously. The GPS receiver is used to capture the position, the 3D digital compass is used to collect orientation, and the camera is used to capture video frame. These sensors sampled the data periodically. Due to each sensor having a different sampling rate, e.g., for each second 15 frames of video, 1 GPS position coordinate, and 4 orientation vectors, these raw data might be processed using some numerical methods. Based on the raw information captured by the GPS receiver, compass and camera, the three categories geometry object of 3DGV can be generated using certain methods or algorithms. VFLocation/VSLocation consists of two elements, one being the position of the frame or video segment, the other the orientation of the camera. For a position coordinate, a linear interpolation method is utilized to generate multiple coordinates (equaling with the video frame rate) between two sampling periods of GPS receivers. Given the sampling intervals are short and position changes are even smaller, the orientation information is similar to recent sampling points and might use them. VSTrajectory is the polyline, which consists of VFLocations along with the road. We can generate it directly according to the VFLocation's sequence.

VFFOVView/VSFOVView is one of the key pieces of data for video retrieval in 2D. Assuming the camera is set horizontally (the pitch and roll angle is 0), the theoretical field of view for a given frame is a pie-slice-shaped area

(fan) as shown in Fig.1. In an ideal situation, the video can be queried through the theoretical field of view based on spatial relationships. But the actual field of view is not a standard fan area because of the existing mutual occlusion relation between the objects (Fig.1). We can calculate the actual FOV via the stereo vision algorithm in the case of the stereoscopic cameras. The actual FOV is closer to the camera's actual field of view with respect to theoretical fan area. And the VFFOVViews of the same video segment can be combined to generate the VSFOView. There are the VFFOVCones and VSFOVolume data in 3DGV for video retrieval in 3D space. The theoretical 3D field of view for a given frame is a cone space as shown in Fig.2. The actual 3D field of view for frame or video segment can be generated by the similar methods via the stereo vision algorithm.

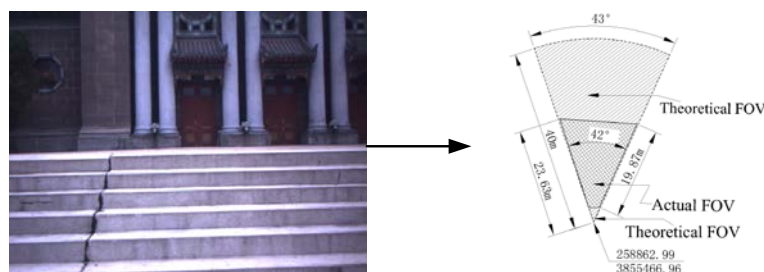


Fig.2: Comparison of the actual and theoretical FOV in 2D

Based on the discussion of 3DGV data acquisition, the data collected by the camera, GPS receiver and 3D digital compass are showed as Fig.3.

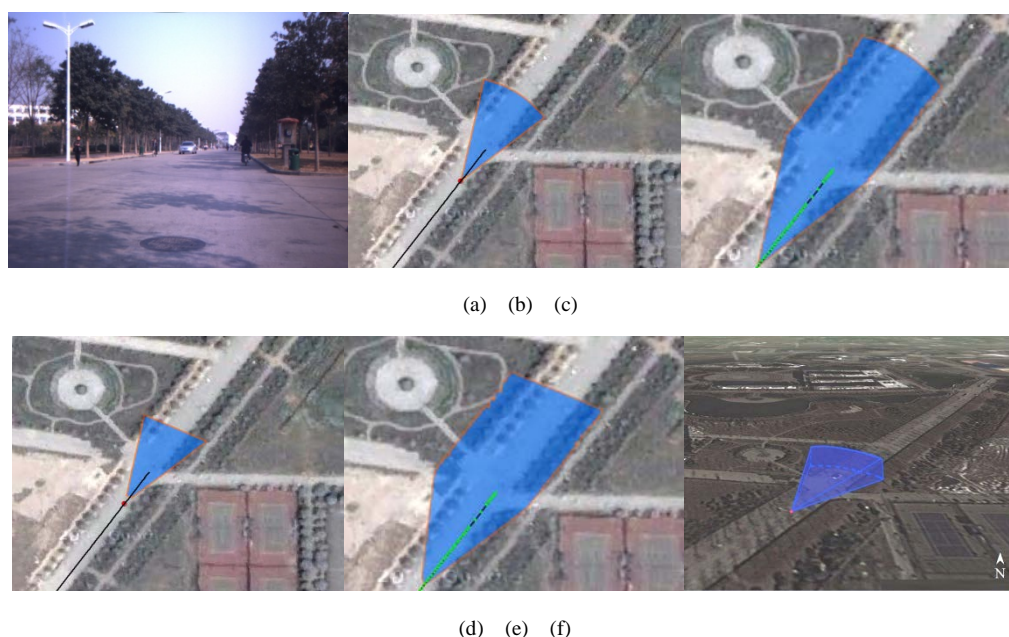


Fig.3: Example of the data of 3DGV

- (a. Video Frame Image; b. Location, Trajectory and TheoreticalFOV of Video Frame or Segment; c. Theoretical FOVof Video Segment;
- d. Actual FOV of Video Frame; e. Actual FOV of Video Segment; f. Video Frame FOV in 3D)

**APPLICATION CASE OF 3DGV
VIDEO QUERY USING GEOGRAPHIC INFORMATION**

Once the video data are adequately geo-referenced, the user can then create a query expression to find the relevant geographic video for a specific application (Galati, 2006). This spatial query enables the user to search videoby thelocation, trajectory and FOV in 2D/3D from a geo-database. The most fundamental test of geographic coincidence between data sources is a query by location through spatial relation expression. These spatial relations are computed between geometries using formal methods, such as the dimensionally extended nine-intersection model (DE-9IM) (Strobl, 2008).For example, In order to search the video that includes the point q, we should define the angular conditions for SQL statement(Fig.4). The SQL statement is:

Select $FrameID$, VID , $SFrame$, $SVideo$ from $Frame$, $Video$, $VFLocation$ where
 $ST_distance(q.Geometry, VFPoint) \leq d$ and $(abs(azimuthf(VFPoint, q.Geometry) - VFYaw) \leq 0.5 * \theta)$ and
 $(Frame.FrameID = VFLocation.FrameID)$ and $(Frame.VID = Video.VID)$

Where the θ is the camera horizontal FOV angular, $azimuthf$ denotes the function computing the azimuth of the line between q and $VFLocation$, and abs is the absolute value function.

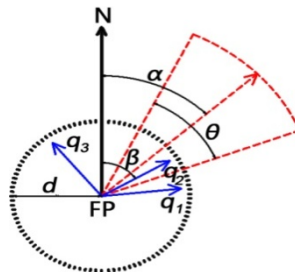


Fig.4: The direction constraint of the distance query

VIDEO PLAYING WITH GEOGRAPHIC INFORMATION

The video playing is the key for true geographic representation of the real world. Using the 3DGV, the video and its geographic information such as location, trajectories and FOV in 2D/3D can displayed synchronously. This feature is valuable for spatial cognition because of the abstract modeling approach to geographic information as well as the visual-spatial approach. The case is shown in Fig.5. When the video is playing, the current frame location and field of view are drawn on the map synchronously when the video is playing.

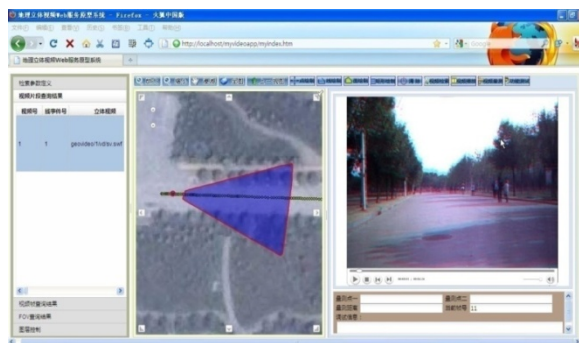


Fig.5: The video playing (the 11st frame)

CONCLUSION

In this study, the geographic video 3D data model and the application case with it was introduced. The model was composed of entities of video and geometry. The model objects and their relations were defined in Unified Model Language carefully. At logic levels, 9 core relation tables were designed for application purpose. The data acquisition of the data model was detailed, and then used the GPS receiver to capture the position, and the 3D digital compass to collect the attitude of the camera. We took an example of the field of view to illustrate the calculation of the theoretical and actual FOV. The application case shows that many of the fundamental aspects of our proposed data model can be effectively instantiated. Further development of this model is about the design and implementation of application system as well as the efficiency evaluation.

Acknowledgment

The authors would like to thank the anonymous reviewers for their valuable comments. The work described in this paper is supported by the National Natural Science Foundation of China (grant no. 41201402), China Postdoctoral Science Foundation (grant no. 2013M531666) and Henan University Science Foundation for Young Talents.

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