GeoVideo: A First Step to MediaGIS

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Abstract

MediaGIS is a concept of tightly integrated multimedia with spatial information. VideoGIS is an example of MediaGIS focused on the integration or interaction of video and spatial information. Our suggested GeoVideo, a new concept of VideoGIS has its key feature in interactiveness. In GeoVideo, the geographic tasks such as browsing, searching, querying, spatial analysis can be performed based on video itself. GeoVideo can have the meaning of paradigm shift from artificial, static, abstracted, and graphical paradigm to natural, dynamic, real, and image-based paradigm. We discuss about the integration of video and geography and also suggest the GeoVideo system design. Several considerations on expanding the functionalities of GeoVideo are explained for the future works.

Key Words: *MediaGIS, VideoGIS, GeoVideo, Interaction*

1. Introduction

The conventional 2D GIS is based on the map metaphor. So the geographic objects in real world is abstracted and symbolized in 2D GIS as a form of point, line, and polygon. The main purpose of map is to give information of location and identification("where" and "what") of geographic object, so the symbolization was the natural way of map presentation. However there is semantic gap between real world and the abstracted world, so some skill is needed to interpret map and infer the geographic meanings. In other words, the information written by cartographer could be delivered to user(or reader of map) with loss or distortion.

One of the important factors causing the semantic gap between map and real world is the reduction of dimension from 3D(or 4D) to 2D. For overcoming this dimensional gap, 3D GIS was introduced. In 3D GIS, geographic objects including terrain and man-made facilities are modeled and represented 3-dimensionally having the user understand the geographical relationship more easily. Recently, to enhance the interactivity and immersiveness of 3D geographic world, virtual reality technology is applied and the VRGIS is introduced newly. In VRGIS, people can navigate and control the geographic world more interactively in enhanced graphical environment equipped with natural input devices such as glove, trackball, and joystick and output devices such as CAVE, HMD, and stereo display.

While VRGIS provides the enhanced reality in geographic world, the reality is literally "virtual" implemented by graphical representation. To provide the more real geographical information, photographic image and video clip are used. Aerial photographic imagery may be the representative form providing ultimate reality in 2-dimension(or 2.5-dimension). Video clip can provide more dynamic information than a cut of still image. There are many systems using multimedia such as image and video as additional information to graphical world, but most of them are confined to using multimedia as a form of attributes linked to the geographic objects.

To meet the necessities required by this societies getting more complex and diverse, a new form of geographic environment have to be provided, and we expect this can be achieved by integrating the various kinds of multimedia tightly to the spatial information. We define this geographic environment in which various kinds of multimedia and spatial information are integrated tightly as the *MediaGIS*.

VideoGIS is an example of MediaGIS focused on the integration of video and spatial information. There are several studies on VideoGIS, but most of them use the video as an additional attributes to geographic objects.

We considered about using video itself as a GIS making it possible to do the conventional geographic tasks in the photorealistic environments. We named it as *GeoVideo* in which the various geographic tasks such as browsing, editing, searching, querying, and spatial analysis can be performed based on video itself. GeoVideo can be regarded as a prototype of VideoGIS which is a first step to MediaGIS providing ultimate interactivity, reality, and mobility in the future geographic environments(Figure 1)

2. Integrating video and geography

GeoVideo is an integrated system of video and 2D or

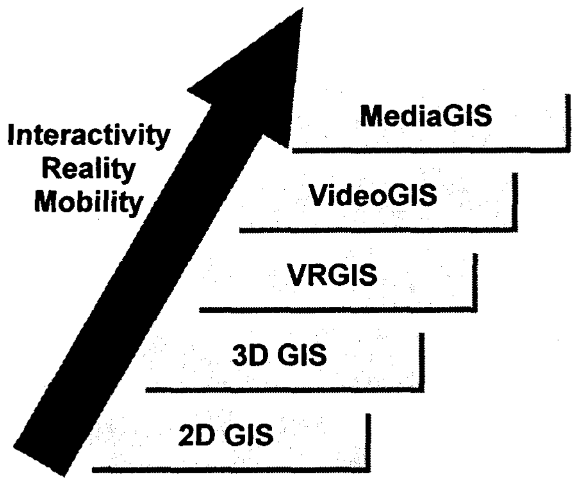

Figure 1. Steps in progress of GIS

3D map and it can be regarded as an instance of MediaGIS in which multimedia and geography are integrated(Figure 2).

2.1 Ways of interaction

Video and geography are integrated by interacting each other. There are three ways of interaction between video and geography as shown in Figure 3.

The first one is geography-to-video interaction. An example of this interaction is browsing video clips when user selects geographic object in 2D map or 3D world. Most of the systems introduced as VideoGIS are confined to this kind of interaction.

The second one is video-to-geography interaction. An example of this interaction is browsing attributes of geographic objects when user selects a point or region in video. The current version of our GeoVideo provides this kind of interaction.

The third one is the mutual interaction of video and geography. This level of interaction is the goal of GeoVideo that enables acquisition of attribute information of geographic objects selected in video, and video clips containing or linked to the selected objects

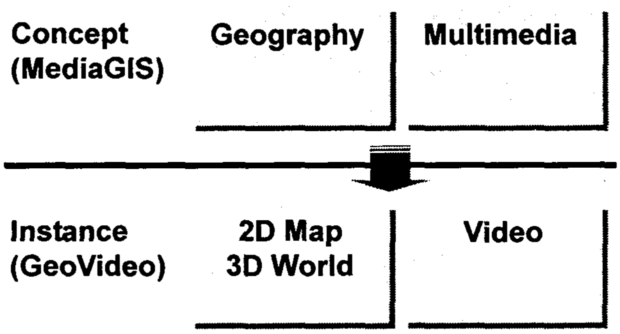

Figure 2. Conceptual model of MediaGIS and GeoVideo

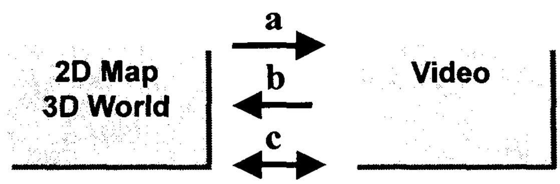

Figure 3. Ways of interaction between geography and video. a)geography-to-video interaction, b)video-to-geography interaction, c)mutual interaction of video and geography

in 2D map or 3D world. This level of interaction can be implemented on the technological basis of video indexing, searching, and editing.

2.2 Augmented reality(AR)

GeoVideo can be regarded as an application of augmented reality(AR) that merges 3D virtual objects(geographic objects) into a 3D real environment(video)(Azuma, 2001). GeoVideo belongs to the monitor-based AR among the several design choices such as optical see-through or video see-through. By this property of AR, GeoVideo has several problems of AR such as registration of virtual and real object, sensing and tracking(Holloway, 1995).

3. Considerations for system design

Designing GeoVideo, we considered the following factors:

- Utilizing GIS database
- Easy to build video data
- Running environment
- Scalability

Utilizing GIS database: There are a lot of GIS databases in legacy systems. To save the cost and time building GIS database for GeoVideo, we utilized database built for 3D GIS. The geographic objects in database are based on the 2D vectors with additional 3D attributes such as height of building and burial depth of pipeline. This database schema enables to keep 3D geographic data as compact as possible, to be expanded from 2D database easily, and to do fundamental graphic operations such as picking.

Building video data: Capturing video covering a citywide area will take much time and costs. It is necessary to provide easy way to build video and avoid post-processing procedure if possible. One of the important things capturing video is that each frame of video must be incorporated with the position and orientation of camera. Special vehicles such as GPS-Van equipped with GPS and tracking sensors are utilized well capturing video. Without the expensive special devices, people can also capture video with simple type of camcorder, and the position and orientation of camcorder may also be acquired without difficulty.

The fidelity of video lies in the error bound of position and orientation sensor output and the synchronization error between video frame and sensor output. To correct this error post-processing procedure on the video frame and sensor data could be required.

For the suggested GeoVideo, we captured video using 4S-Van a kind of GPS-Van mounted with CCD camera, DGPS and IMU(Inertial Measurement Unit). The posture data of camera acquired using DGPS and IMU are linked to each frame of video.

Running environment: GeoVideo performs geographic tasks based on video stream itself, the client system need to have only standard video browser. This thin client architecture is well adapted to Internet environment and further more mobile circumstance. To cope with the increasing number of users at the same time, user management functionality is required in server system.

Scalability: The number of geographic data in database and video stream need to be increased to cover expanded area without the change of the system. Managing database with spatial indexing system, insert, delete, and edit of records are efficiently performed to the extent that hardware storage permits. The number of video stream and the length of each video have also no limits. Streaming technology over the network is the main reason avoiding the limit on the length of video stream.

Considering these four factors, we designed the system architecture for GeoVideo, and the detail will be explained in the next chapter.

4. Our approach

4.1 Conceptual design

The conceptual strategy for GeoVideo is to link 3D geographic world to video frames on-line using position and orientation of each video frame as key value. Figure 4 shows the conceptual approach of GeoVideo. The first step is to prepare video stream of which each frame is linked to camera position and orientation. This step is done usually off-line. As a second step, if user clicks on a video, the position and orientation of camera at that frame is transferred to 3D GIS server. The camera in 3D GIS is located and postured according to the transferred camera data. If there is no error in the transferred data, the video frame and 3D scene will be matched exactly. As a final step, a ray is shot from the camera position to the mouse point in 3D world. Using the graphical

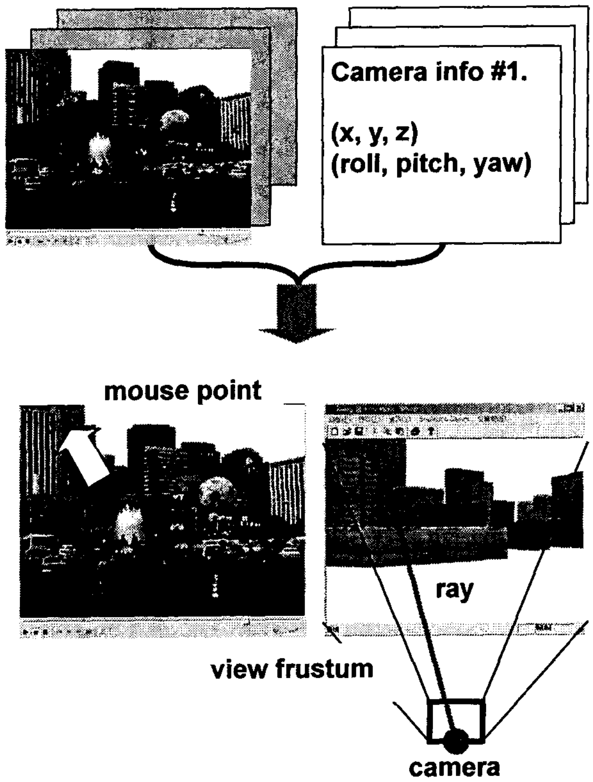

Figure 4. Conceptual approach of GeoVideo

picking operation, object in 3D world is selected and the related attributes can be displayed in the client side of video browser as a form of text or graphic.

4.2 System architecture

Based on the above conceptual design, we developed the beta version of GeoVideo. The overall system architecture is shown in Figure 5. GeoVideo is composed of the following four components:

- Media server
- GeoVideo server
- Media player
- GeoVideo player

Media server transmits video stream to Media player when requested. Media player display the streamed video If mouse click event occur on video, the mouse point coordinates and the frame number at that time are transmitted to GeoVideo server via back channel. GeoVideo server identifies the selected object using graphical picking operation with 3D database, camera parameters, and the transmitted mouse coordinate. Information about the selected object is transmitted to GeoVideo player and then is drawn on the video as textual or graphical form. Details on the system architecture and experiment can be found in Kim(2002).

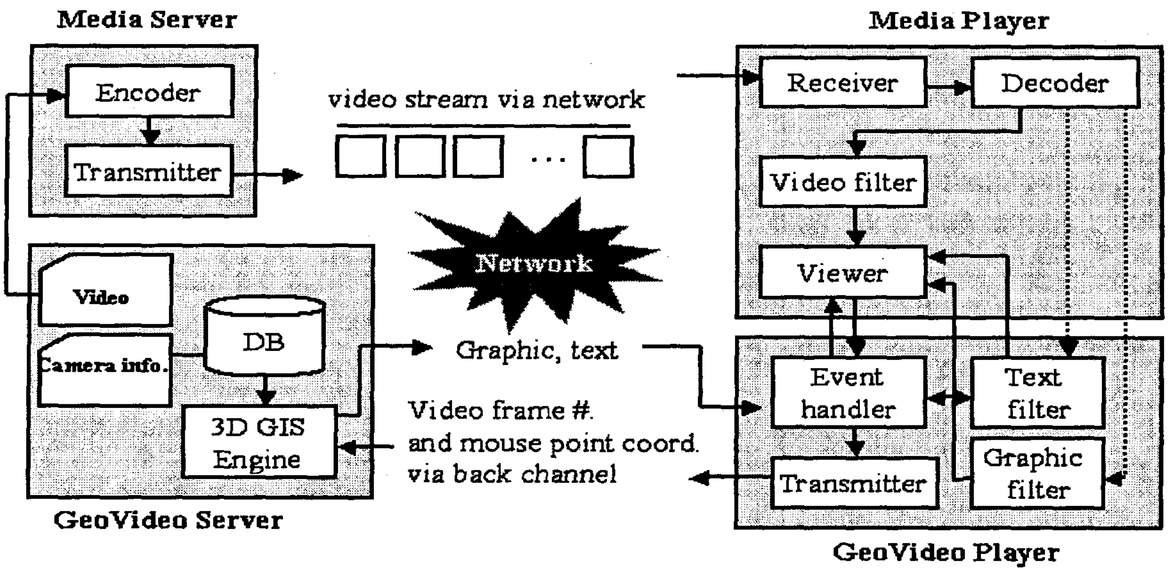

Figure 5. System architecture of GeoVideo

4.3 Assumptions

The suggested design of GeoVideo system works on the basis of several assumptions. The first one is that the 3D database of geographic objects appear in video is built in advance because the geographic object in video is identified by searching 3D database. If geographic data in 3D database are missed or not correct to those counterparts in video, errors may occur in identifying the selected object.

The second one is that the camera position and orientation are within the reasonable error bounds. Usually GPS has advantages in out-door environments to get the position data, there are errors in accuracy and above all, signal loss can occur especially in the downtown areas of moderate to large cities where a concentration of tall buildings at times occludes much of the sky from a street-level location(Loomis, 2001).

5. Conclusions

We expect that the MediaGIS will become the most attractive choice in the near future. As an instance of MediaGIS, VideoGIS can be available from the current technological level. We suggest the GeoVideo as an example of VideoGIS. GeoVideo is designed considering several facts such as utilization of GIS database, efficiency in building video data, running environment like web and mobile, and scalability. Our suggested GeoVideo can be regarded as a prototype of VideoGIS, and it gets several advantages and shortcomings looking from the system architecture point of view. There are so many future works that are interesting and hard to be solved at the same time. Anyway, it seems certain that our GeoVideo will make the first step to MediaGIS.

6. Future Works

GeoVideo is just a first step to MediaGIS. GeoVideo shows the possibility to MediaGIS as a new paradigm in the future GIS environment. Because it is just a beginning, it requires further research to produce improved systems.

Data Acquisition: GeoVideo works on the 3D geographic data and video stream with camera position and posture. In this approach, the accuracy of camera position and orientation are critical factors of performance. To guarantee the overall performance of GeoVideo, systematic procedures on acquiring video and camera position and orientation, linking them, and correcting error should be suggested.

Registration: GeoVideo can be regarded as an application of AR augmenting reality by merging virtual objects into real environment. One of the most difficult problems in AR is to align correctly the virtual object with respect to the real object. Because there are errors in sensor output(camera, GPS, tracker) and data transformation, the correct positioning of 3D object to video is hard to be achieved. To aid correct registration, some computer vision or image processing techniques can be used(Azuma, 2001).

Video indexing: To support two-way interaction between video and geography, efficient video searching mechanism should be provided. The current status for video-indexing can be found in MPEG(MPEG, 2001) Instead of developing the customized video indexing algorithm for GeoVideo, adopting or utilizing the MPEG's standard technology seems to be better for interoperability and compatibility.

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