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Construction of Facilities Management System Using Airship Videographic System

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Abstract

Fast urbanization and industrialization have resulted in rapid changes in the urban environment. For effective monitoring and management of these changes, a new surveying methodology that is more inexpensive and timely than the conventional remote sensing system is required. This paper proposes an unmanned airship videographic system capable of acquiring stable video. In addition, it presents approaches to constructing a prototype facilities management system based on VideoGIS, which links GIS functions and video data to provide actual spatio-temporal information.

Keywords : *Video streams, Unmanned airship videographic system, VideoGIS, Spatio-temporal information*

1. Introduction

The ability to manage and monitor urban facilities using remote sensing data is a current problem in urban environment management. Unfortunately, the use of satellite data depends on weather conditions and uncontrollable observation time that do not contribute to timely and cost-effective urban management. Thus, applying high-resolution, low-altitude video sequences is very essential in the effective management of urban facilities. The flexibility of the airship videographic-system means that data can be acquired according to the exact requirement of the end-user.

This paper discusses the approaches to developing an unmanned airship videographic system to acquire video sequences and constructing a facilities management system based on the Video Geographic Information System(VideoGIS) concept. Some conclusions and perspectives for future works are also presented.

2. Unmanned Airship Videographic System

The use of unmanned airship videographic system is a promising way of satisfying the growing need for rapid and accurate data for urban environment monitoring. Although video data can be a disadvantage because of the huge amount of images needed to cover a selected area, their availability makes them more preferable to satellite imagery. Likewise, they provide a new GIS database with actual snapshots, streaming video, and audio that are linked to their map location.

Among several platforms, an unmanned airship has favorable characteristics capable of hovering and low-speed flight with less vibration and less noise unlike unmanned aircraft or helicopters. Therefore, the unmanned airship video imaging system is developed to promote the use of video data for various applications in many fields.

The airship videographic system development project is conducted jointly by researchers from the HanGIS Company of the Business Incubator Center and the Department of Urban Engineering at Gyeongsang National Universityin Jinju, Korea. The project aims to generate high-resolution, low-altitude video sequences and develop a VideoGIS methodology for managing urban facilities.

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2.1 System Overview

An unmanned airship system with a length of 12m is developed to acquire video sequences in various viewing angles without three-dimensional positioning functions. In the near future, however, an airship system based on mounted GPS and INS will be developed to implement accurate three-dimensional positioning as well as automatic flight control.

The airship system consists of the airship envelope, videographic unit, and autopilot unit.

The configuration of the airship system is shown in Fig. 1.

2.2 Airship Envelope

The airship envelope is made of polyurethane-coated mylar. Its length and height are 12m and 3m, respectively. Its upward buoyancy force is powered by helium. It has a maximum payload of 15kg. The total payload capability of this system is up to 55kg. The maximum flight altitude of the airship imaging system is 1km because of radio communication limits. Maximum flight speed is 80km/h.

2.3 Videographic Unit

The airship videographic unit is being developed mainly for monitoring facilities rather than for the purpose of photogrammetric surveying. Thus, it is mounted on the nonmetric camcorder Sony DSR-PD 150, a professional broadcasting camera. The camcorder records video data on 6-mm DV tape and subsequently acquires videoimages with image size of 720 (H)480 (V) pixels in the MPEG file.

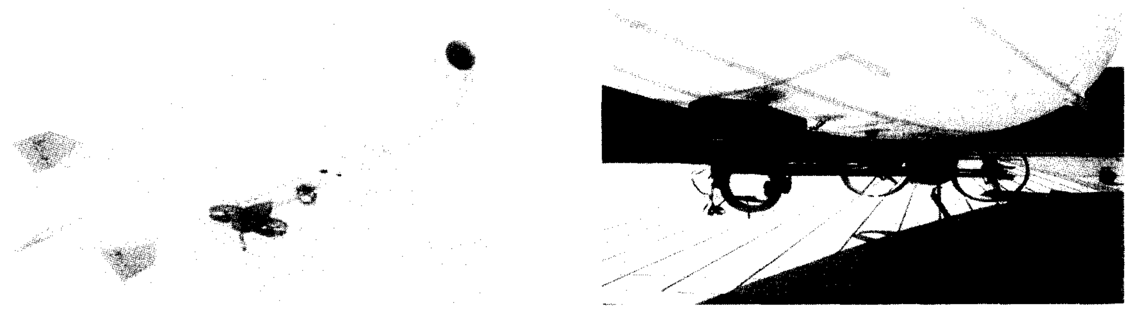
Camera gimbals are developed to allow 3-axis rotation to adjust the camcorder's view angle and manage its flight control unit on the ground(Fig. 2).

2.4 Autopilot Unit

The autopilot unit is an unmanned flight control unit that handles the airship and camera gimbals on the ground. It allows the airship to fly a designated flight course and confirm imaging areas using radio communication. As shown in Fig. 3(b), the ground control unit in this system is composed of a TV monitor and a ground control computer. The TV monitor shows video streams for current video imaging areas, whereas the ground control computer displays the planned flight path and current location of the airship.

2.4.1 Flight control unit (FCU)

The FCU consists of a flight control computer and



(a) Appearance of airship (b) Propulsion unit and camera gimbals

Fig. 1. Configuration of the airship system.

(a) Vertical viewing (b) Horizontal viewing

Fig. 2. Camera and gimbals.

(a) Flight control computer (b) Ground control unit

Fig. 3. Autopilot unit.

a GPS mounted on the airship. This unit has built-in functions to provide information for stable flight like automatic flight, warning alert for an unexpected incident, automatic landing, flight path modification, and self-test.

2.4.2 Ground control unit (GCU)

The GCU displays the flight path and instrument information such as location data, altitude data, and video imaging data in real time.

3. VideoGIS and Video Structuring

The VideoGIS combines video sequence and geographic information to generate dynamically hypervideos navigable by geographic content. Current GISs are in need of new spatio-temporal data models to represent empirical validations of geographic objects.

In general, spatial relationships among objects are represented by projecting objects on a two- or three-dimensional coordinate system(Arndt et al.,1989; Jungert, 1992), whereas temporal relationships are represented using temporal intervals(Hjelsvold et al., 1995; Little, 1993). Nonetheless, spatio-temporal interactions of objects have received less attention. Recent research in spatio-temporal representation in GIS and database has been done to develop a new GIS(Peuquetin, 2001). In this paper, the VideoGIS is considered a new GIS that can present the relationships of objects in time and space.

To construct a VideoGIS, the researchers implement first the video structuring process where video is structured according to its contents. Streaming video is recorded at 30 frames per second as shown in Fig.

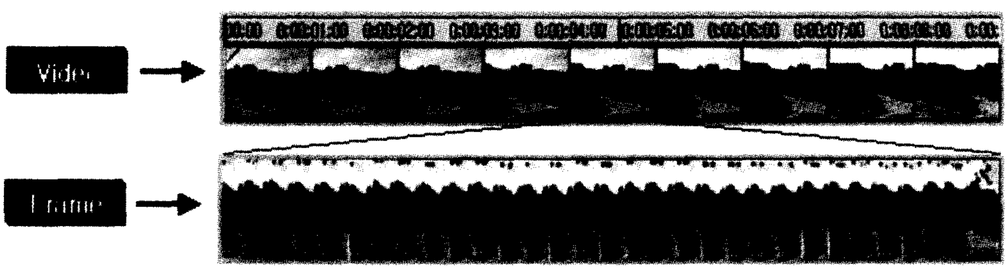


Fig. 4. Streaming video and frames.

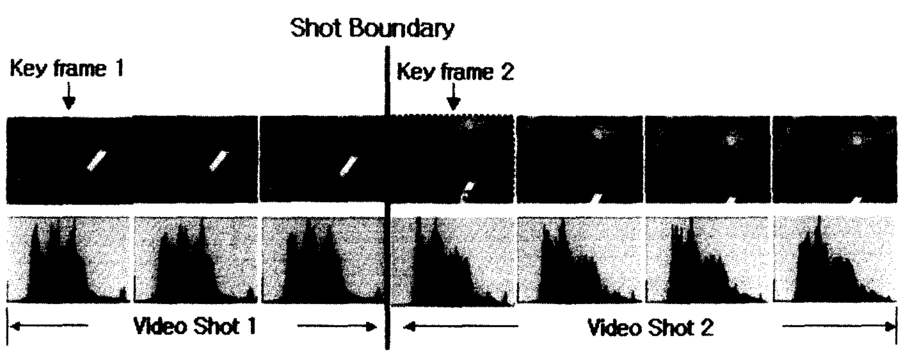


Fig. 5. Grouping similar shots using a threshold.

4, and it maybe divided into five levels of components: video key frames, video shots, video groups, video scenes, and whole video(Rui et al., 1999).

In the video structuring process, different video features, such as audio energy and color histograms, can be used to generate video components.

This research focuses mainly on the approach based on color histograms. For each input video frame, a color histogram is built for each frame. The shot boundary is then determined using a threshold(Fig. 5). After the shot boundary detection, the video is divided into video groups by grouping similar shots. The shots in a video group are visually similar and temporally close to each other. Thus, they have similar geographic features. In general, the information system using video is constructed using video groups generated from the video structuring process.

4. Video Data Acquisition and Processing

Video data are taken from study areas in Daejeon city, Korea. The near-vertical video data are acquired at 50-100 m altitude. The oblique data are taken in a side-looking and forward-looking direction from the street at an altitude of 30m.

To process the acquired video data, analogue video data recorded on 6-mm DV tape are converted into digital video data using the Canopus DVStorm 2 editing board and Adobe Premiere Pro s/w, producing a video image with 720×480 pixels and video sequences.

Rui's video data structuring theory is used in this research. A color histogram is first built for each input video frame. Once this is done, the video shot boundary is determined. A video is divided into several shots by the shot boundary and the shots structured into video groups(Rui et. al, 1999). The video group presents the same geographic features. Therefore, a video database for every geographic feature can be constructed using video structuring technologies.

5. Construction of Video Information System

5.1 System Architecture

The graphical user interface(GUI) system is designed using Visual Basic 6.0 language, MapObjects 2.1 components, and Microsoft DirectX s/w on a Windows 2000 server-based operating system. MapObjects 2.1, which is a set of ESRI's mapping software component, lets users add dynamic mapping and GIS capabilities to existing Window applications or build custom mapping and GIS solution(ESRI, 1999). Microsoft DirectX s/w is used to develop the GUI for displaying video sequences.

The architecture of the GUI is shown in Fig. 6. It consists of base map window, index map window, video playing window, still image grab window, map control tool bar, and attribute data box.

5.2 Major functions of the system

5.2.1 Displaying the Base Map and Location Information

The system provides a base map window to display the base map in a shape file format widely adopted as an ArcView's export file format and two-dimensional coordinates of assigned sites on the base map. The user can use the map control tool bar to zoom in, zoom out, and pan on the base map. The index map window

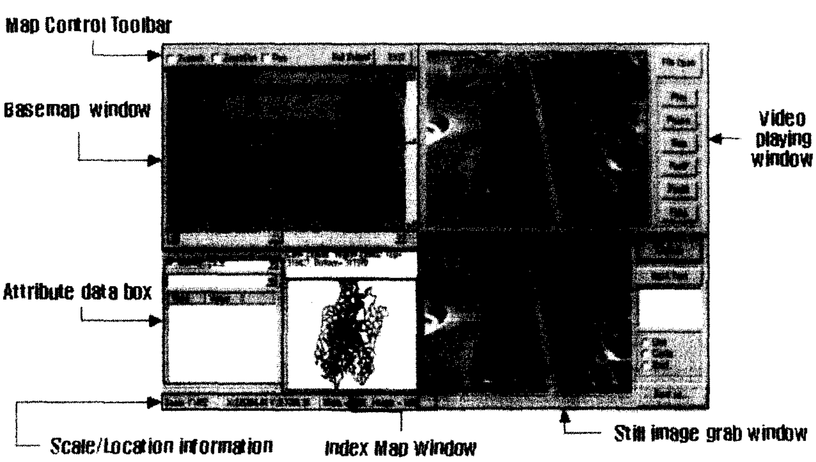
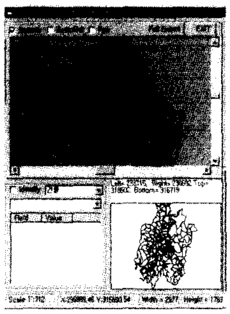
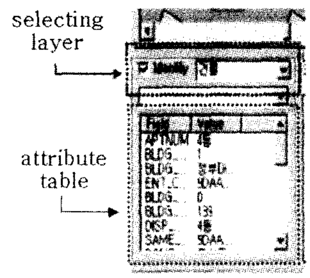


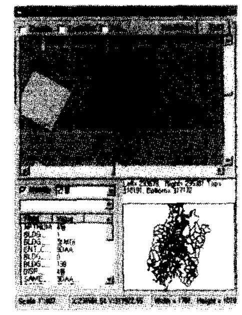
Fig. 6. Configuration of the GUI system.



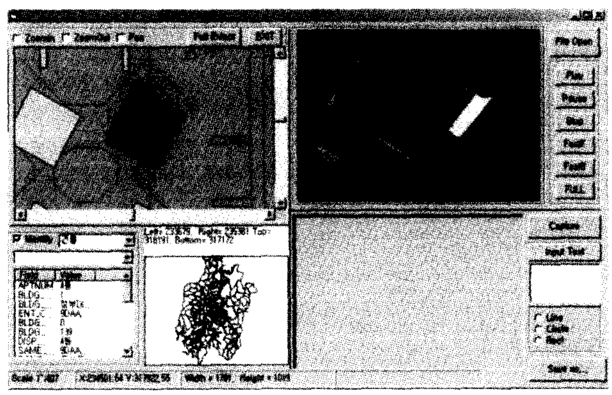
(a) Magnified view



(b) Selected Feature and attribute data



(c) Highlighted feature



(d) Playing video stream

Fig. 7. System operating procedure.

displays the current location of the magnified map with a red rectangular box in the whole administrative map of Daejeon.

5.2.2 Playing the Video Sequences

This system allows users to provide more actual geospatial information than traditional GIS linking geospatial objects like roads or buildings on the base map with their real video stream. The video stream is structured for every object using the video structuring process. The process is briefly described as follows:

First, a base map in the base map window is magnified. A feature layer where detailed information is needed is then determined. The object is highlighted, and its attribute data are simultaneously shown through the attribute data box. In addition, it displays the video stream of the selected object in the video-playing window.

5.2.3 Storing the Facilities Management Information with Still Images

This system provides a video-playing window with its basic functions of play, pause, move forward/backward, and full screen. To add contents for managing facilities, it allows a still image grabbed from the video stream to be stored and saves it in BMP format.

Moreover, users can assign simple graphics like line, circle, or rectangle to the selected objects and overlay detailed text information on the still image for the management of urban facilities.

A still image grabbed from the playing video stream is shown in the still image grab window at the bottom right of Fig. 8. Fig. 9 shows inputted text information with a yellow circle.

The system provides users with important information helpful for regulating the effective management of

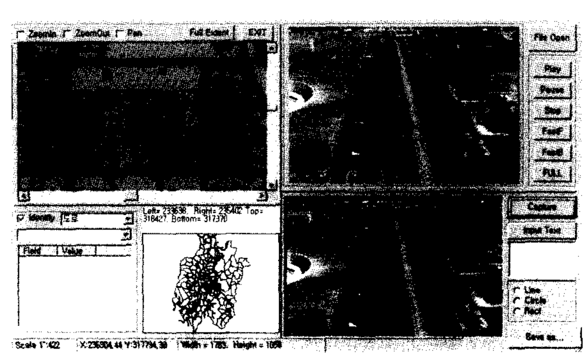


Fig. 8. Grabbing a still image.

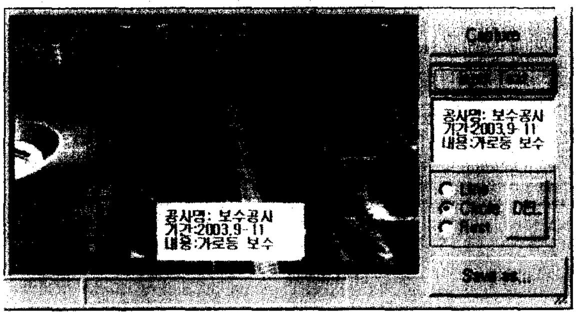


Fig. 9. Editing text information.

urban facilities such as signboards, utility holes, pavements, traffic facilities, facilities on sidewalks, and illegal buildings. Officers or interested users are able to do facilities management timely and effectively within an indoor office.

5.3 Future Works

A GPS with low accuracy(about 10m RMSE) is mounted on the developed airship system. It is impossible to accomplish an accurate three-dimensional positioning using sensor modeling. In the near future, however, an airship videographic system will be developed to reinforce GPS and INS so that a rigorous geometric model using high-precision GPS and INS data can be implemented. The flight stability of the airship tends to be weak, since it is affected by the wind particularly in windy weather. Hence, additional technical studies are needed to address such problem.

6. Conclusion

With the growing popularity of spatio-temporal applications, there is now a significant increase in the demand and use of multimedia information systems. This paper proposes an airship videographic system and video information system for video data applications.

First, an unmanned airship videographic system is developed to acquire actual video streams at various altitudes and view angles and monitor facilities in rapidly changing and complex urban areas.

Second, a new GIS with a spatio-temporal model is proposed by constructing a video information system based on VideoGIS.The system developed provides users with important information to monitor and guide urban planning regulations on the effective and timely management of urban facilities within an indoor office.

Future studies are still needed on how to implement a rigorous geometric model using precise sensor attribute data and a platform stabilization to minimize the effects of the wind.

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