DEVELOPMENT OF A MULTIMEDIA SPATIAL INFORMATION SYSTEM

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ABSTRACT

This paper demonstrates a research project which is currently undertaken in designing and developing a prototype multimedia spatial information system. The system employs an data structure suitable for an integrated data base system. Dynamic information that is recorded in the forms of spatial data coverages, digital images, tabular attributes, video and audio signals is incorporated in the data base structure and can be easily retrieved and processed. In order to overcome the steep learning curve which is often associated with the spatial information system software, an effort has been made to incorporate the video and audio information in order to ease the data retrieval and presentation. The prototype system is currently developed using a low-cost computer platform with market-available hardware and system software; and a preliminary application is currently undertaken using the prototype system to demonstrate the capabilities and usefulness of the multimedia technology in spatial information processing.

KEY WORDS: Geographical Information Systems, Multimedia, Data Structure, System Design

INTRODUCTION

Historically, software designed to manipulate spatial information has been task-specific, with clear separation between programs built for different purposes. Software packages tended to fall into one of several categories, namely: *geographical information systems* (GIS) that combine cartographic data with tabular ancillary databases, *image processing systems* that manipulated image data, and *video and audio signal processing systems*. As the proliferation of spatial data processing systems increased, it becomes apparent that many applications would be best served by a combination of different data sources. Although the latest commercial software has attempted to address this need by packaging both GIS and image processing software together, this is only a temporary solution because the conceptual basis for each component still originated separately. The focus of research in spatial data analysis is therefore on the incorporation of all forms of spatial data into one truly integrated spatial information handling system (Ehlers, *et al.*, 1989).

The integration of vector cartographic data, tabular ancillary information, and raster image-based data is only an evolutionary step, consolidating components that from a geographical perspective were never separate. This concept can be extrapolated beyond static data to incorporate temporal information such as digital video and audio signals. Processes in geography, whether from an economic, human or physical perspective, occur over time. The incorporation of the temporal aspect into a spatial database is therefore a revolutionary progress in recognising that the term *process* is fundamentally a dynamic concept. Research in this field is in an early stage, partially due to the limitation and popularity of the suitable computer hardware. Some progress, however, has been reported by a number of researchers and organisations (Woelk and Kim, 1987; ESRI, 1989; Anon, 1990).

The current trend in the computer industry indicates that multimedia (or hypermedia) computer platforms will soon become general tools for information technology. Low-cost multimedia computer platforms have moved closer to commercial viability, providing the capabilities of incorporating voice, data, text, handwriting, images and video to potential applications (Shepherd, 1991). The incorporation of such multimedia systems into a carefully designed spatial information system will therefore provide the opportunity to use, manipulate and present both static and dynamic information in a truly integrated manner.

The proliferation of personal computers in the 1980's was precipitated by the advent of easy to use word and number processing packages that made the computer a useful tool in almost any field. The primary detraction of these systems was that each implementation had a different user interface that required a lengthy learning period before the tool could be used to its full extent. The current trend in the industry is towards system independent software that maintains a consistent user interface between programs. This trend can also be extrapolated to spatial information systems. An integrated spatial information system that employs a standard user interface similar to that of more general computer applications (e.g. word processing) would eventually eliminate the steep learning curve associated with present systems. This would break down the barrier between what is perceived as purpose-specific software and general-use software, promoting spatial information processing systems to become widely used by anyone who requires to access spatial information.

The project therefore, focuses on developing an integrated multimedia spatial information system following the research in developing an integrated spatial data structure (Zhou, 1989). The system represents a new-generation spatial data handling system, and it also yields great opportunities for potential applications which have been suffering from great difficulties in adopting spatial information technology due to data integration or/and educational issues. Together with the common strategy and standard procedure of establishing multimedia spatial data bases, the multimedia spatial information system will benefit not only geographical applications, but also any study fields that has a spatial component.

The project contains the following research components:

1) Design suitable data models and structures for spatial information derived from various data sources as well as real-time digital video and audio signals;

2) Implement the data models to a multimedia spatial information system with necessary tools to support integrated spatial data processing and dynamic information presentation; and

3) Develop a suitable strategy and procedure in establishing multimedia spatial data bases for a variety of potential application areas.

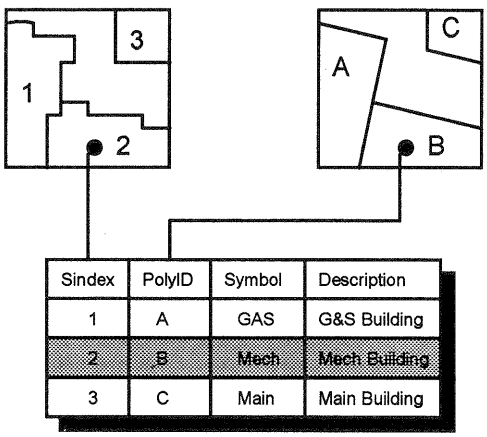
DATA STRUCTURE

The design of the data structure for the multimedia data base focuses on the linkage between data sets in different forms. A relational data base management system (RDBMS) interface is developed to incorporate non-spatial attribute information with vector cartographic data, raster image data, and pointers to data files of digital video and audio signals.

Data Structure for Vector and Raster Data

The structure for vector cartographic data is designed based on RDBMS technology. The primary point, line and polygon data is stored in a proprietary spatial data base which maintains the links between spatial objects and topological structures maintained by the RDBMS. Attribute information is stored as relational tables and pointers have been automatically created to link the attribute to the vector objects.

The data structure for raster data follows the method of relational image-based GIS described by Zhou (1989). Spatial objects are defined in the raster data base and spatial indices are created to link the objects to the corresponding attribute records in the relational data base. Using this structure, the attribute information can be shared between vector and raster spatial components of the data base and relational operations supported by the RDBMS can be performed on the attribute records, regardless if the relational table is linked to a raster or a vector coverage (Figure 1).



Sindex	PolyID	Symbol	Description
1	A	GAS	G&S Building
2	B	Mech	Mech Building
3	C	Main	Main Building

Figure 1. The linkage between raster and vector data sets.

Data structure for video and audio data

In the multimedia spatial data base, pointers have been created to link the spatial objects, which are defined in the forms of raster and vector coverages, and digital video and audio files. Since video and audio data sets usually present information at individual locations (i.e. no spatial dimension is associated with these data sets) and require large volumes of data storage, it is more appropriate to store them as external files, rather than incorporating these into the internal data structure of the data base. Within the internal structure of the data base, however, pointers are created to allow the retrieval of these video and audio information through spatial query processes (Figure 2).

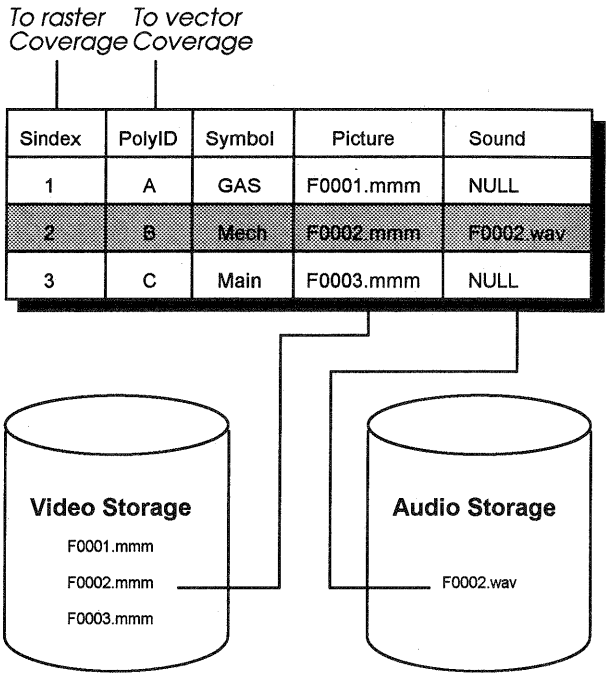


Figure 2. Linkage between video and audio information and the spatial data base.

SYSTEM IMPLEMENTATION

The configuration of current prototype system follows the Multimedia PC (MPC) specification (Microsoft, 1991) and hardware specifications of the experimental MPCs are listed in Appendix and can be illustrated in Figure 3. The software package are developed using *Microsoft Windows* graphical environment with *Multimedia Extensions* and *Microsoft Windows Multimedia Development Kit* (MDK) and *Software Development Kit* (SDK).

The design of the prototype is structured into three conceptual levels:

- *User level*: A consistent front-end which is independent of the operating system and data type. A common user interface is developed with modeless windows, icons, mouse-driven features and popup menus as specified by the *Common user Access* (CUA) advanced interface for software applications which is proposed by IBM's *System Application Architecture* (SAA) (IBM, 1989).

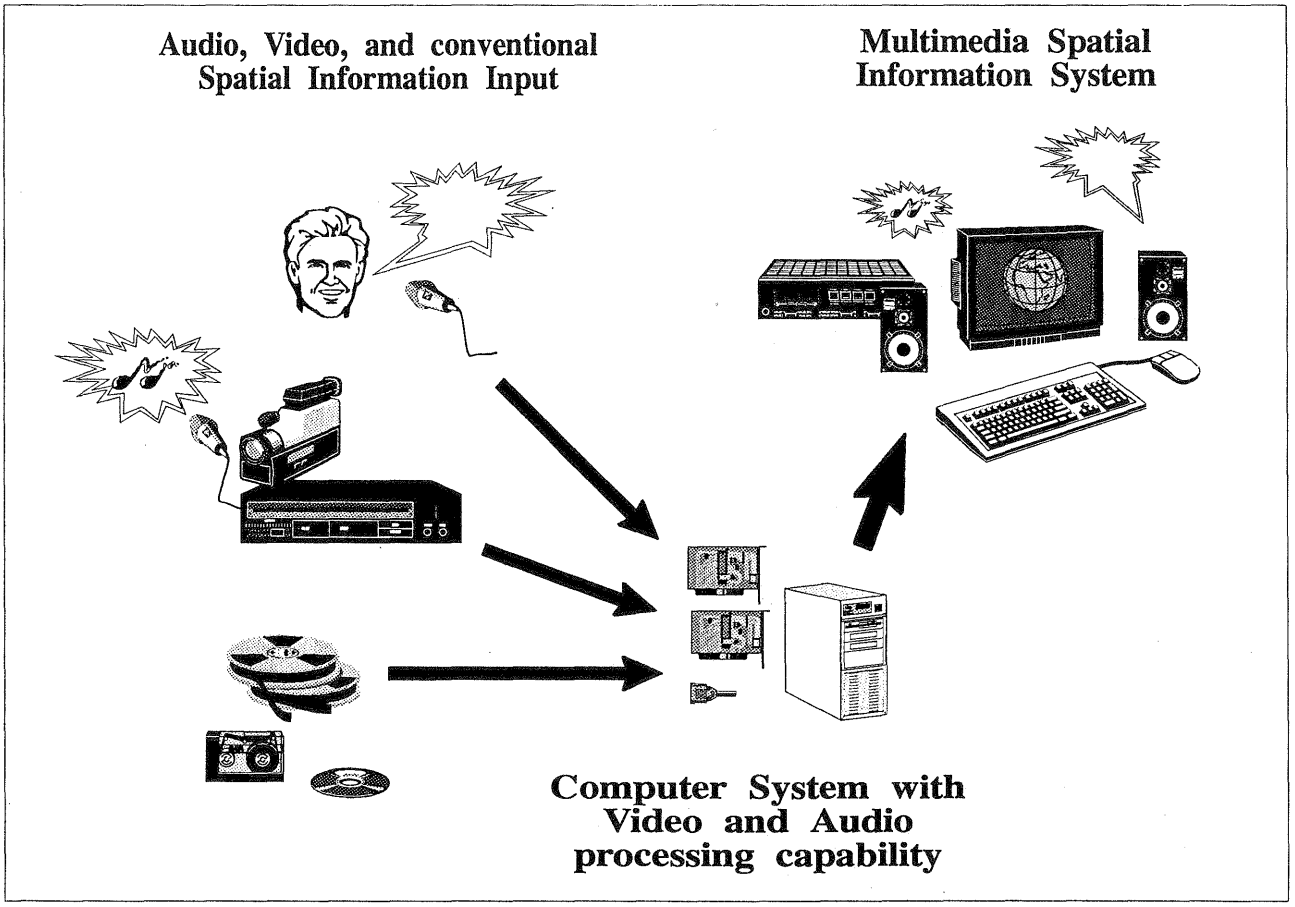


Figure 3. Hardware configuration of the experimental multimedia PC.

- *Data level*: Device-independent data query and processing algorithms and the interface between different data types. This includes data handling capabilities for raster and vector based data and attribute information managed by a relational data base engine. The relational data base also contains pointers to the video and audio data files or devices allowing retrieval of the multimedia information using relational query process.
- *Device level*: A device interface designed to communicate with the standard operating environment such as the Microsoft Windows with Multimedia Extensions. This provides the opportunity to port the prototype system into other operating environment in later developments.

The software structure of the system can be illustrated in Figure 4 shown as following:

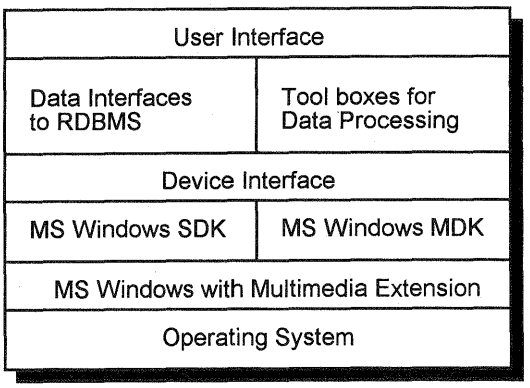


Figure 4. The software structure of the prototype multimedia spatial information system.

A PRELIMINARY APPLICATION

A multimedia data base has been set-up to demonstrate the capability of the multimedia spatial information system. The primary purpose of the data base is to present integrated views of the main campus of the University of New South Wales in order to provide information services for the University's Open Day when a large public crowd is anticipated.

The data base is composed of five categories of information:

1) Campus base maps: thematic maps showing the locations of buildings, departments, services, path ways, car parks, etc. These are digitised cartographic information and stored in the data base as vector coverages.

2) Scanned campus aerial photograph: A low-altitude aerial photography with a natural colour print is scanned and stored as a colour image coverage. It is then registered with the campus base map and stored in the data base with a raster format.

3) Text information: Information on various aspects of the campus is entered and managed by the RDBMS.

4) Video images: A number of video clips are captured for sites that have general interest including cafeterias, shops, the library, various buildings, bus stops, etc. These video clips are then digitised through a image grabber of the multimedia system to create digital images and animations. The video data are stored as separate image (or animated 'movies') files and attached to the spatial locations on the campus base maps using the corresponding attribute records maintained by a RDBMS.

5) Sound clips: Stereo sound clips are recorded including appropriate music clips, speeches, and special sound effects. The sound records are then digitised using the stereo sound interface and stored as separate sound files. These sound files are then linked to the corresponding attribute records of the campus base maps.

A sample view of the multimedia data base is shown in Figure 5.

SUMMARY

This paper demonstrates a research project in applying multimedia technology to a spatial information system. A data structure has been designed to incorporate vector- and raster-based spatial data, text information, and video and audio signals. This data structure is then implemented through a prototype spatial information system software in a PC-based environment.

To demonstrate the capabilities of the prototype system, a trial multimedia spatial data base is established to provide information services to the public for the University's Open Day. Using the prototype system, this multimedia data base can integrate information including cartographic base maps, scanned

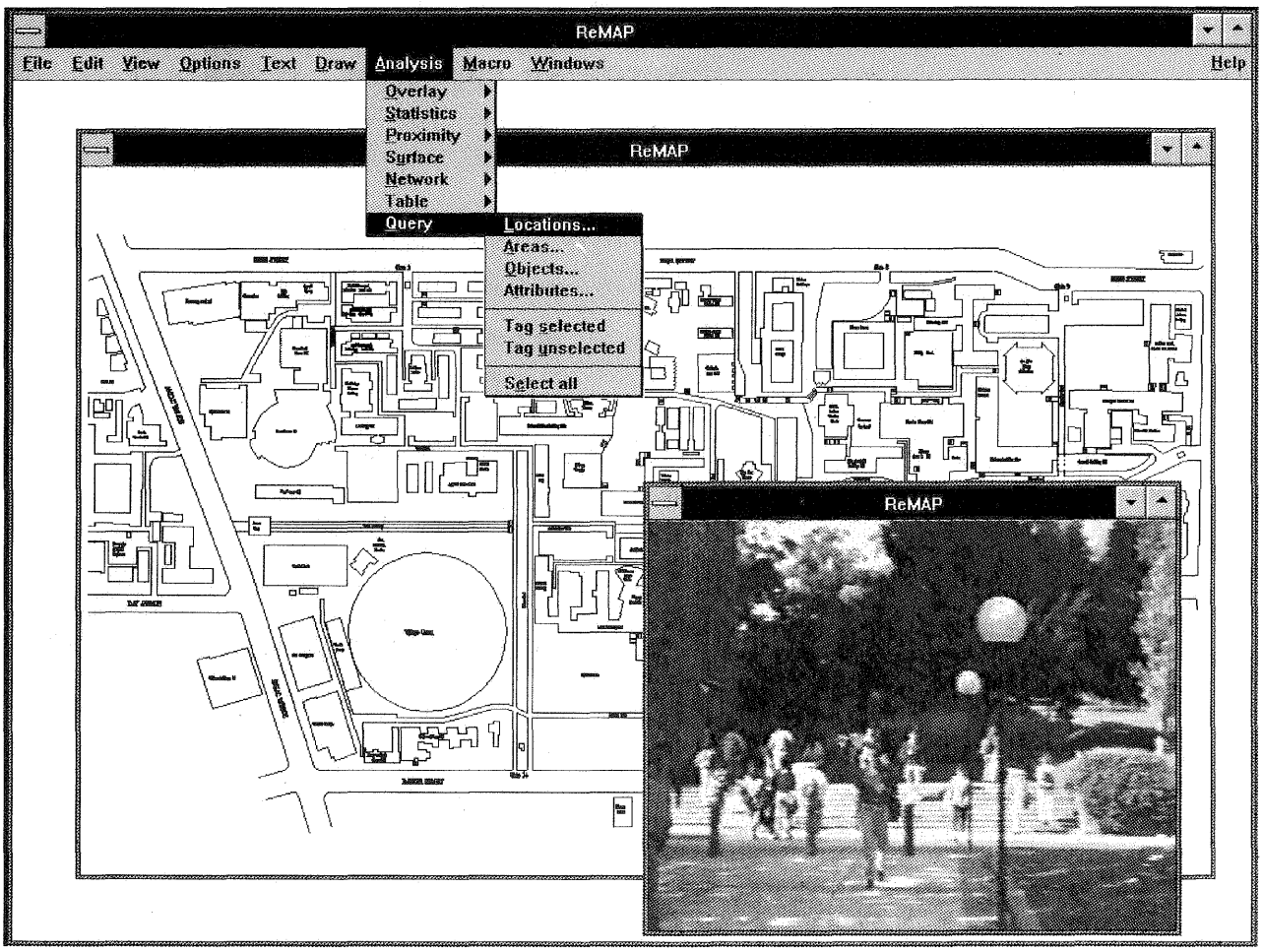


Figure 5. A sample view of the multimedia data base that illustrates the integration of a cartographic base map and a video image display corresponding to a spatial locational query.

aerial photography, text, digital video and audio clips, and present the information through interactive spatial query processes.

The potential uses of the multimedia spatial information system include commercial applications related to the spatial information such as real estate and tourism, education applications such as teaching geography in secondary schools and universities, and dynamic modelling of geo-processes.

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APPENDIX: Hardware and Software Configuration of the Prototype System

Hardware

Intel 80386 based IBM compatible PC with:
8 MB random access memory, 320 MB harddisk,
SuperVGA graphic display,
Createtive Labs' *Sound Blaster* Multimedia Kit including the *Sound Blaster Pro* sound card and CD-ROM, and Digital Vision's *ComputerEyes/RT* colour frame grabber.

Software

Operating system: *MS-DOS* 5.0

Operating environment: *Microsoft Windows* v3.1 with Multimedia Extention

Software device interface: *Microsoft Windows Software Development Kit* and *Multimedia Development Kit*

Programming Language: *Microsoft C* 6.0