UTILIZATION OF MULTIMEDIA TECHNOLOGY IN GIS EDUCATION

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ABSTRACT:

The National Center for Geographic Information and Analysis (NCGIA) in the U.S.A. has developed the NCGIA Core Curriculum for GIS instruction. However, teaching these materials, even selectively, cannot be easily done, and parts of these materials need to be updated from time to time because GIS is rapidly evolving. Students require to learn and review GIS at any time in a random and nonlinear knowledge-searching style. Computerizing NCGIA's educational GIS materials by utilizing the emerging multi-media technology can provide capabilities for random and nonlinear knowledge-searching by students, random access instruction by teachers, and regularly updating the NCGIA's GIS materials. In this project, parts of NCGIA's GIS materials were re-organized based on multimedia organization principles using a public-domain hyper-media tool, *Hyper-NeWS*. The slides associated with the NCGIA Core Curriculum were digitized into a graphic database in support of the computerized NCGIA educational GIS materials, which is named *Hyper-GIS*. In addition, graphics, images and even sounds helpful for teaching and understanding were added to Hyper-GIS. Local successful GIS applications were also included. With Hyper-GIS, students can do random and nonlinear knowledge-searching, and teachers can provide random access instruction according to students' knowledge of GIS. Computerizing the NCGIA's GIS materials can also provide capabilities for updating the materials matching the latest GIS developments and for incorporating local GIS applications.

KEY WORDS: GIS Education, Multimedia, Computer-Assisted Instruction.

1. INTRODUCTION

The National Center for Geographic Information and Analysis (NCGIA) in the U.S.A. has developed the NCGIA Core Curriculum (Goodchild and Kemp, 1990) for the instruction of Geographical Information Systems (GIS). The curriculum consists of seventy-five units of GIS materials associated with sixty slides covering topics from GIS components to GIS applications. However, teaching these materials, even selectively, cannot be easily done because of the complexity of GIS and because parts of these materials need to be updated from time to time in order to match the latest developments of GIS. Traditional methods of instruction rely on linear media such as textbooks and lectures (Nix and Spiro, 1990). Computer-assisted instruction has made practicable utilization of multimedia in instruction and is making impressive progress as an education approach. For educating people the problems and issues of environmental protection, Purdue University in cooperation with the U.S. Environmental Protection Agency (EPA) developed seventeen computed-based educational decision-support systems (Engel *et al.*, 1992). These systems are being used for the instruction of environmental issues in high schools and have been adopted for the National Network for Environmental Management Studies program supported by EPA. Hypertext and graphics have been used to present information in all of these systems.

As part of a project utilizing multimedia technology in GIS instruction, Srinivasan *et al.* (1991) have developed a system for teaching GIS applications in water resources management. The first application describes the integration of GIS with runoff estimation methods using the SCS (Soil Conservation Service) curve numbers techniques (Srinivasan and Engel, 1991). The second application shows how to assess agricultural non-point source pollution using the AGricultural Non-point Source Pollution model integrated with GIS (Srinivasan, 1992). The third application demonstrates the integration of GIS with the Aerial Non-point Source Watershed Environmental Response Simulation (ANSWERS) model (Rewerts and Engel, 1991). A multimedia development tool, *HyperNeWS*, was used to develop the multimedia systems for GIS instruction.

The NCGIA GIS materials have widely been adapted in GIS instruction. For example, the Department of Geography at San Diego State University uses most of these materials in their GIS courses (Wright, 1991). However, students can not learn themselves with the NCGIA Core Curriculum because these materials were not developed for self-teaching. In order to make the NCGIA Core Curriculum wel suited for self-paced learning, we need to incorporate multimedia technology and to create hyper-linkages among individual units of the materials, and we also need to digitize the associated slides and to link them with a corresponding unit.

The objective of this study was to incorporate multimedia technology into GIS education and thereby develop a GIS instruction system. We re-organized parts of the NCGIA Core Curriculum based on multimedia organization principles, digitized the associated slides and stored them in a graphic database in support of the re-organized materials, and created hyper-linkages among the materials and slides.

2. NCGIA CORE CURRICULUM

The NCGIA Core Curriculum includes three volumes of GIS materials, covering an Introduction to GIS, Technical Issues in GIS, and Application Issues in GIS, respectively. The first volume (Units 1-25) introduces hardware, software, and operations of GIS; The second volume (Units 26-50) describes GIS algorithms, data structures, advanced computational topics, and analysis of errors; The third volume (Units 51-75) deals with the applied aspects of spatial analysis, spatial decision making, and management issue. The electronic version of NCGIA Core Curriculum was written in plain text (ASCII) format without any graphics and hyper-linkages.

3. MULTIMEDIA

Multimedia (Hypermedia) refers to an evocative convergence of text, audio, graphics, still images, and moving pictures into a single, computer-controlled product. A multimedia system offers potential for linking knowledge units of interest, such as individual chapters or illustrations of a book. The hyper-linkage allows a user to access individual knowledge units in diverse approaches in a repeatable style. The access with educational materials improves students' ability learn. The knowledge to be learned can be best taught through a multimedia system in many cases.

The multimedia tool used in this project was Hyper-NeWS (The Turing Institute, 1990), which was developed by The Turing Institute, Glasgow, United Kingdom. It is a stand-alone hypercard-like multimedia tool. HyperNeWS runs under a computer-window environment of *OpenWindows2.0* or higher and is written in the *PostScript* language. It can be easily interfaced to external languages such as C, and the codes can be modified to enhance its ability since HyperNeWS is public domain.

4. HYPER-GIS INSTRUCTION SYSTEM

4.1 System Configuration

Based on the NCGIA Core Curriculum and our experience in GIS, we configured the multimedia system of GIS instruction (Hyper-GIS) in five parts, including an Introduction to GIS, GIS Applications in Water Resources Management, GIS Applications in Water Quality Control, GIS Applications in Soil Conservation, and GIS Applications in Other Natural Resources Management. The Hyper-GIS system is hierarchical. We re-organized the NCGIA Core Curriculum because we wanted the Hyper-GIS system to be suitable for the

graduate level courses taught in the Department of Agricultural Engineering at Purdue University. These courses are GIS and Watershed Systems Design (AGEN 526) and GIS Applications (AGEN 591s). The NCGIA materials incorporated into Hyper-GIS were from the first two volumes.

4.2 System Design

We used HyperNeWS to design the Hyper-GIS system. HyperNeWS is a hybrid object-oriented tool in the sense that the basic object types are created with a classing mechanism similar to that of the Smalltalk software and the C++ language, but user-defined types are created from object templates or prototypes. We designed Hyper-GIS as a *stack*, consisting of a groups of *cards*. A HyperNeWS stack consists of one or more cards, conceptually stacked on top of one another so that only one card is visible at a time. Behind a card resided the *background*, which belonged to one card or was shared among a number of cards in the stack. If a group of cards shared a graphic or a button, we only created it once and made it a shared background. Each card consisted of a number of objects. Currently, HyperNeWS supports six types of objects which can reside on a card, including buttons, menus, and textfields. According to the needs, objects were assigned to either a card, a background, or the system stack itself. By attaching an object to the stack, we always saw the object no matter which card or background was currently being displayed.

In order to make the feature of sound supportable in HyperNeWS, we programmed routines and interfaced them to HyperNeWS. Therefore, the enhanced HyperNeWS provided a variety of media, including *text, graphics, images, sound* (voice), and *animation* (motion pictures). A sound button was designed to control the volume of sound or turn off sound. Like other types of buttons, this button can be attached to stacks and cards. For example, the sound button is used to play the recorded water flowing through a gage while viewing the gage station.

We designed key terms or topics of GIS materials in *red* color fonts, which referred to a hyper-link behind each red textfield. It was also called a *hot key*. This ability allows students to click on a red textfield and reach the definition or the details about the text.

4.3 Hyper-GIS

Main Menu and Global Buttons: The Hyper-GIS system is menu-driven (Figure 1). The textfields of Section 1, Section 2, Section 3, and Section 4 contain hot keys so that students are guided to each section of Hyper-GIS by clicking on these hot keys. For example, students are guided to Section 1, *Introduction to GIS,* by clicking on the hot key *Section 1* (Figure 2). At the bottom of the menu, seven types of buttons were designed and attached to every text template. Button *Done* exits Hyper-GIS. Button *top* sends the current display to the main menu, as shown in Figure 1, no matter where the

previous display was located. Button *previous* sends the current display to a logically-previous object. Button *next* sends the current display to a logically-next object. Button *up* sends the current display to its parent-level menu. Button *recent* sends the current display to the object which happened most recently. Button *index* sends the current display to the index card. With the index button, students can search any term, section, or topic of interest and discover the corresponding details.

Graphics, Images and Intuitive Display: Graphics and images played an important role in Hyper-GIS. Graphics usually consisted of images. Hyper-GIS provides an intuitive illustration to the GIS component (Figure 3). Images were incorporated to make this figure intuitive. From this figure, students can learn how a GIS layer was stored in a spatial database, what types of data a DBMS deals with, what kinds of output we can get, etc. In teaching GIS, concepts of *Raster* and *Vector* (Figure 4) are not easy to be explained, especially for those students with little background with computer graphics. Figure 4 including two images, intuitively shows Raster and Vector side by side, and the difference of Raster and Vector can be easily visualized by students. Students can also learn what spatial data look like through a spatial image shown in Figure 5.

Hot Keys about Details: Hot keys take students to the details of the highlighted keys. For example, by clicking on the first hot key in Figure 6, students can get details about the maintenance and analysis of the spatial data (Figure 7). The hot keys can be added to or removed from Hyper-GIS based on requirements.

Indices and Random Access: Whenever students want to learn and review terms and topics, they can click on the index button anywhere in Hyper-GIS and then be taken to the index section. Form the index, they can choose a pre-designed item of interest. Index searching was implemented with hot keys in the index section (Figure 8). After the searching, students were sent back to the index card when clicking the *GoGIS* button. This section can also be updated based on requirements.

Animation and Sound: With animation, natural scenes can be created on a computer. Sound can be used as an auxiliary feature to enhance the animation. In Hyper-GIS, we used animation and sound to create a scene of the flowing water through a gage (Figure 9). Pre-recorded sound of the flowing was simultaneously played.

GIS Applications: As previously mentioned, three GIS applications describing watershed management models were incorporated to teach students each model and implementation of a GIS project. For example, Figure 10 shows how Hyper-GIS demonstrates that a runoff spatial map can be obtained with the addition of a curve-number map and a rainfall map.

5. SUMMARY

As a multimedia system for GIS instruction, Hyper-GIS showed the feasibility of utilizing multimedia technology and provided a new form of nonlinear and multidimensional learning and instruction of the NCGIA GIS materials. Through the hyper-linkages created in Hyper-GIS, a variety of media, including text, graphics, images, sound, and animation, interacted with one another, thereby enhancing the instruction of the NCGIA Core Curriculum. With Hyper-GIS, students can do random and nonlinear knowledge-searching, and teachers can provide random access instruction according to students' knowledge of GIS. Computerizing NCGIA GIS materials can also provide capabilities for updating the materials matching the latest GIS developments and for incorporating local GIS applications.

6. RECOMMENDATION

The NCGIA Core Curriculum could be presented as a multimedia system for GIS instruction. Once the system is built, not only can the NCGIA Core Curriculum be updated in a timely fashion, but the latest GIS developments are also easily included.

7. ACKNOWLEDGMENTS

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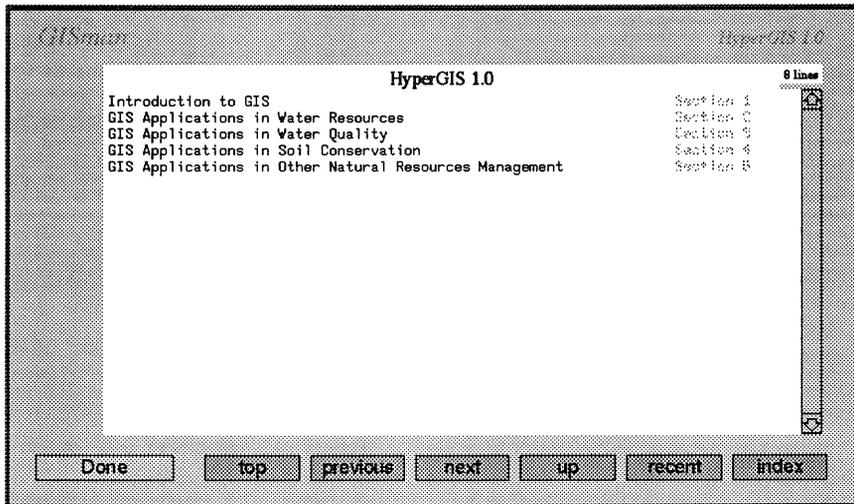
Figure 1. The main menu of Hyper-GIS.
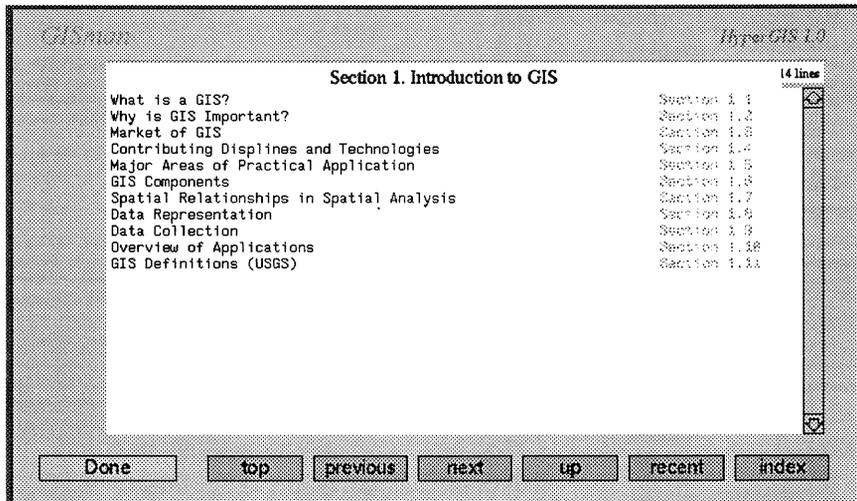

Figure 2. The menu of *Section 1* in Hyper-GIS.
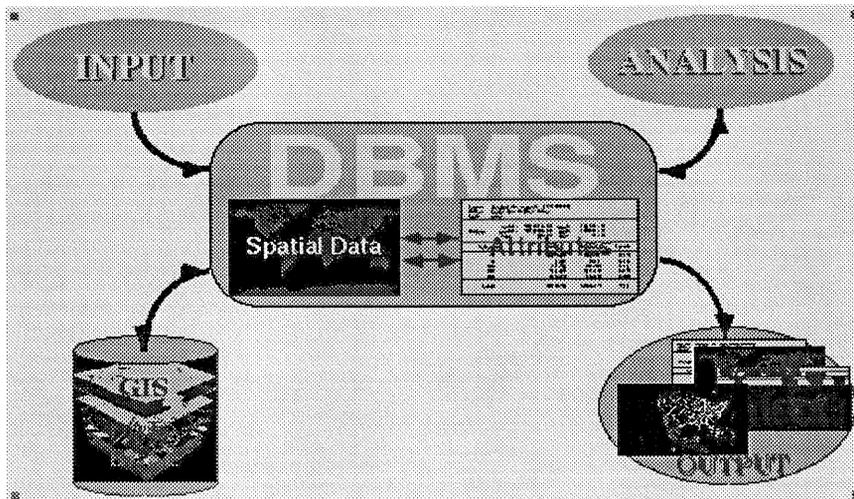
Figure 3. GIS components.
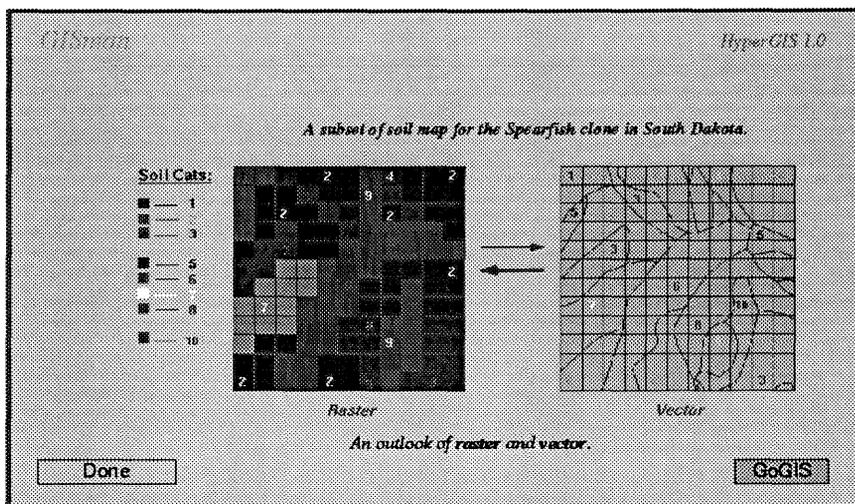
Figure 4. Concepts of *Raster* and *Vector*.
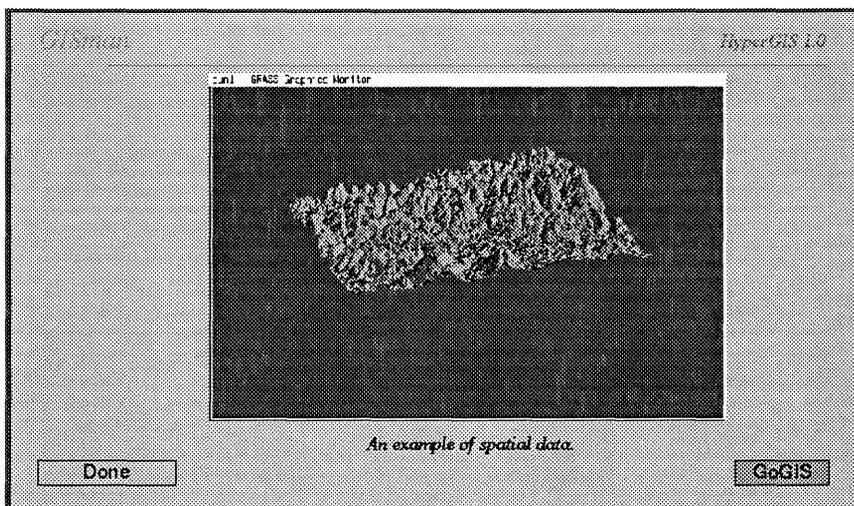
Figure 5. Spatial data.
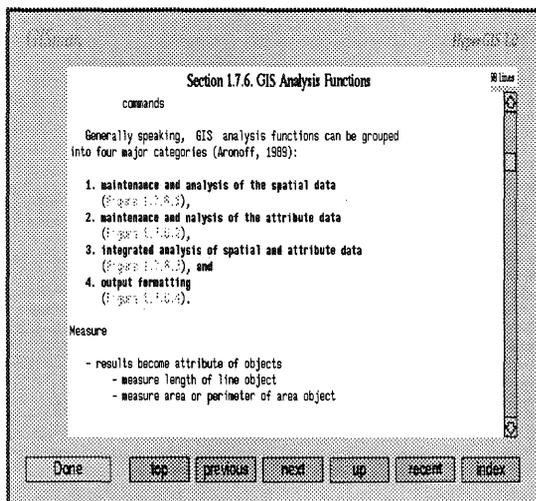

Figure 6. GIS analysis functions.
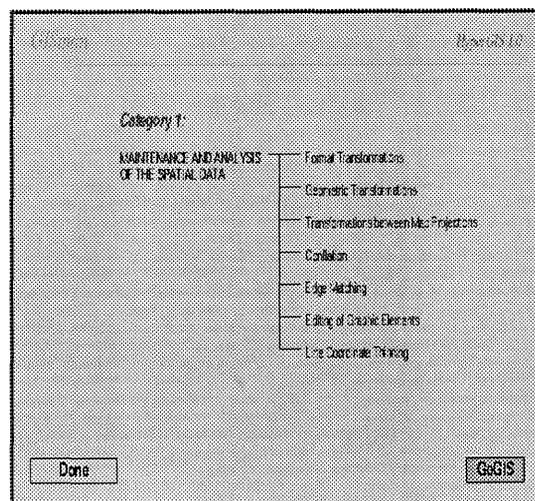
Figure 7. The content for maintenance analysis of the spatial data.

185
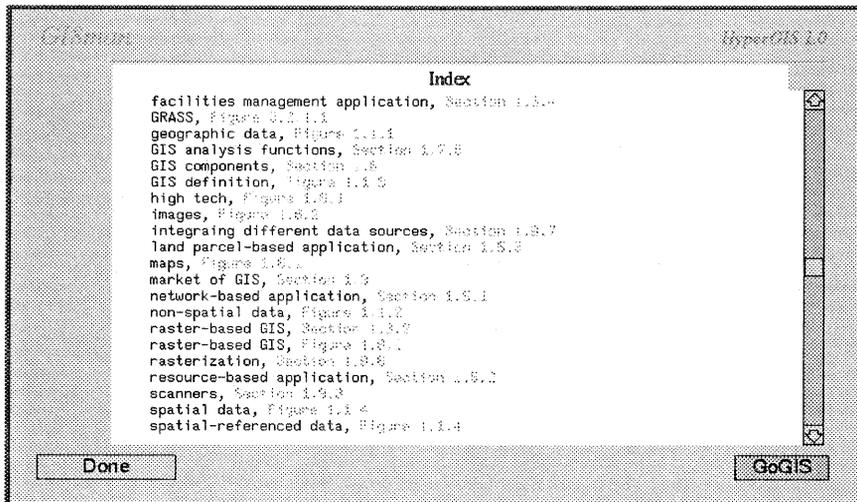
Figure 8. The *index* section for Hyper-GIS.
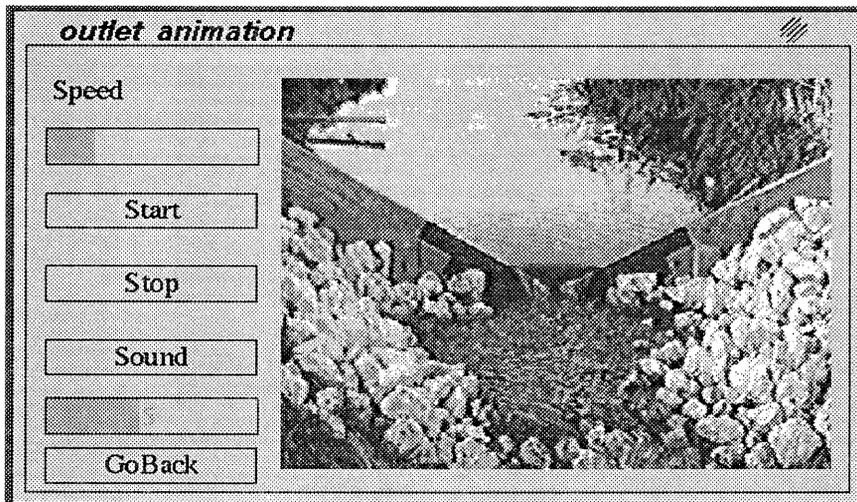
Figure 9. Water-flowing animation with pre-recorded sound.
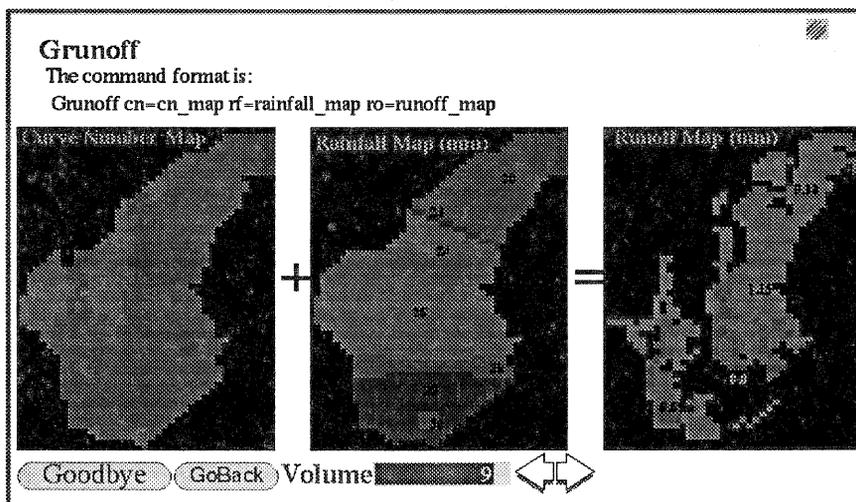
Figure 10. A demonstration of the SCS Curve Number method.