

Spatial Management of Data

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Appendix 3 - Videotape Demonstration of the SDMS . Attached

The complete thesis consists of both the text and a ten minute videotape in color with stereophonic sound.

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Abstract

This thesis addresses the notion of spatiality in data bases and describes a computer based system for the storage and retrieval of pictorial and recorded (sound) information. The system uses the spatial concept of data management, as well as the familiar concepts of hierarchical data management.

The Spatial Data Management System (SDMS) has been implemented on a minicomputer network comprised of four sixteen-bit machines. The system is driven from an instrumented chair containing pressure sensitive joysticks which allow the user to drive through the data base much as a pilot flies an airplane. The chair is located in front of a six foot by eight foot color television display, upon which the images of the data base are displayed. The user may also hold a digital tablet on his lap for drawing and for menu selection of the various system functions.

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Introduction: Spatiality in Data Bases

The most common form of data management is not in the realm of computer scientists, or even in the sometimes gigantic file systems used by large organizations. Data management occurs most frequently in the personal ways in which we organize our own collections of information, be they invoices, accounting statements, or the memos on our desk. This information is most often organized spatially, that is we tend to create stacks of similar information, with each stack placed in some convenient or easily remembered location. One's desk is a good example of this management strategy.

Automation has transformed this natural spatial allocation system into a syntactically accessed compendium of data. The user of such a system must remember the combination of written keys needed to retrieve each type of information. Although this allows the access of information in new ways, it has given up many of the clues by which people organize their own data: remembering the letter to your secretary because it was next to the telephone, locating a stack of memos by remembering that you have to stretch out your right arm, or finding a book by noting its proximity to the large red one. Spatial perceptions such as these are comprehensively discussed by Neisser.¹

This thesis discusses the use of three spatially informative

¹ Neisser, U. Cognition and Reality. San Francisco: W.H. Freeman, and Co., 1976.

senses - vision, hearing, and touch - in the context of a computer based Spatial Data Management System (SDMS).

Visual Space

Vision is the most common and possibly the most important means by which people access their personal data bases. Clues as to the location of information in the space may take on such visual aspects as position, shape, color, or texture. These clues, used independently or in combination with other sensory data, will allow for various types of searches for information in the data base.

The role of visual position in the search for particular items in the space may take either an absolute form, as in "the upper left corner of the desk", or a relative form where location is a function of some other item, as in "next to the telephone", or "under the calendar". Vision is often used in conjunction with the spatial memory of an item's location, i.e. the attention is first focused on the remembered spatial position, and then a visual search of that general area is made to determine the item's exact location.

Even if there is no spatial memory of the location of the item, an exhaustive visual search may be made rapidly by using the clues of color, texture, or shape.

Visual location of information often takes on associative aspects. This happens when a search is made for data which is known to be connected with the desired item in some way. An example: Looking for a card catalogue in a library because you want to know where to find a particular book.

In the SDMS, visual spatiality has been achieved on the sensory level by allowing the user to "zoom" around the information spaces of the data base. These spaces are composed of both digitized (via vidicon camera) and user painted images placed on two-dimensional areas called sheets.* The effect of zooming is created through user control of joysticks located in the arms of the chair. These joysticks direct the translation and scaling of sheets on the screen.

* A three-dimensional information space was considered initially, but was discarded due to the limited processing power available to us at that time.

Auditory Space

Although vision is a directed perception, the sense of hearing is more nearly "omnidirectional" and may be exploited for its special spatial qualities. As a navigational aid, sound has great potential for relaying information independent of the attention of our eyes. It would be very helpful if, for example, when scanning a map for a subway station one could actually hear the sounds of trains running at appropriate points on the map, or when searching for an airport one could hear the sound of airplanes to direct our attention to that area of the map.

In the SDMS, sound is used as a data type as well as a navigational aid. When an information sheet contains sounds as data, the sounds will be "displayed" in stereo at a volume which is proportional to their distance from each edge of the screen. If the data associated with athletics is to the right of the screen, then the user would hear the sound of cheering crowds there which would grow louder as he moved in that direction.

Haptic Space

Haptic space is that space in which physical sensations such as touch and motoric perceptions occur. These are very important clues used during our everyday lives which often go unnoticed. They involve situations such as locating data by remembering the stretching of an arm to the left, or by the feel of a rough texture as you put down a book, or by the sensation in the hand when one looks for a pair of scissors.

In the SDMS, haptic clues are limited to clues derivable from the use of joysticks when driving around data on the screen. Although these haptic sensations are limited to the fingers and hands, the clues do exist and are indeed helpful in navigating through the data base.

The Spatial Data Management System

The SDMS has been designed to include a set of attributes which are representative of the qualities needed for the spatial management of data. As a system, it is by no means complete and is intended only as a demonstration of the potential for the spatial concepts discussed in this thesis. The data base shown in the video tape is a collection of different types of information and is meant to be an example of a data base constructed along the lines of spatial and hierarchical data management techniques.

In the video tape the system has been started at the top level sheet. This sheet is approximately sixteen screens wide and twelve screens high, and has been created at four bits per pixel. This sheet is exemplary of a display technique we call "semi-infinite" scrolling. In this sheet, the display memory is configured as a sixteen screens wide by one screen high image. Translation in the left/right direction, and zooming into and out of the image requires no transfer of image data to or from the disk. In order to move in the vertical direction, however, new information must be scrolled into the top or bottom of the display memory, depending on the direction of movement. This is achieved by transferring the memory for rasters moving off one edge of the screen onto the other edge of the screen, and then reading the new image data from the disk into those relocated memory rasters. In this way it is possible to show a continuous

"semi-infinite" strip of image in real time and under user control.

An ancillary display containing a miniaturized version of the top level sheet, complete with a "you are here" marker, assists the user in navigating around the data space.

The top level sheet contains many colored areas, some of which contain sound information. The sound information is "displayed" stereophonically so that information which is off screen to the left or right may be heard, even when not seen. These off screen sounds are an important means of navigation on the sheet as they give clues to the distance and direction of unseen data. The volume of a sound also increases as the user zooms in towards the sound's location.

Some of the colored areas on the sheet are ports into other sheets of data. Ports are the basic constructs which allow hierarchically managed data within the SDMS. A port is entered by zooming into the area which defines it. This area is usually demarcated by a transparent rectangle for clarity, although the user may elect to keep the port invisible. Once a port is entered, diving forward will eventually pop the user through the port and into the next level of the data base. While in the port, the user may decide at any time to abort the dive by pulling back out of it.

Sheets below the top level are non-semi-infinite sheets, that is, they are limited to an area of 190k bytes.

This area may be configured to any rectangular shape, and may be defined to be composed of pixels of one, two, four, eight, or sixteen bits. In all other ways, the lower level sheets are like the top level sheet. They can have sounds and digitized or drawn images, and may have ports into still deeper levels of the data base. Sheets may also contain ports which pop back up into different areas of the top level, as well as cross links into other information structures.

User actions in the SDMS include routines for the creation, modification, and deletion of areas, ports, and sheets, as well as routines to record sound, digitize vidicon images, and to draw with transparent or opaque ink on any sheet.

Appendix 1 - The Hardware

The hardware used in the current implementation of the SDMS can be discussed in four parts: display and control, sound, vidicon camera input and visual aids, and interprocessor communications.

An Interdata Model 85 minicomputer is used for both control of the SDMS and for display of the visual spaces of the data base. User control of movement through the data base is affected by two pressure sensitive joysticks with eight bits of resolution in the X and Y directions. The right-hand joystick is used for X and Y translation on the screen, and the Y axis of the left-hand joystick is used for zooming in and out of the data sheet. The display is generated from a 206k byte memory which may be dynamically reconfigured to any aspect ratio at one, two, four, eight, or sixteen bits per pixel on screen.² The screen itself is a 640 pixel wide by 480 raster high image which is rear projected onto a six-foot by eight-foot screen. The projector is a General Electric Light Valve, a full color television projection system which is both RGB and NTSC signal compatible.

In addition to the joysticks, the user may hold a digital tablet in his lap for drawing on data sheets in either opaque or

² Stewart, L.C. Xerographic Output for a Color Raster Scan Display, Bachelor's Thesis, Massachusetts Institute of Technology, 1976.

transparent inks. The tablet also contains a menu for selection of the data base routines which allow creation, modification, and deletion of the sheets, ports, and sounds which make up the data base.

The sound system is implemented on an Interdata Model 7/32 which digitizes sounds and stores them onto a 20 megabyte disk. The bandwidth of the system is 4kHz, with each sample point having a resolution of eight bits. The playback software allows two continuous sounds to be played independently and in stereo through speakers located to each side of the display screen. The 20 megabyte disk has a capacity for about 42 minutes of sound information.

The vidicon camera is a black and white Picker Video Standard which is connected to a Ramtek RM9300 frame buffer and display system. The camera and frame buffer have a combined resolution of 640 pixels by 480 rasters at eight bits per pixel. The Ramtek is interfaced to another 7/32 which controls the digitization and selection of windowed vidicon images. Also on that 7/32 is a "navigational aids" system which uses the Ramtek frame buffer to display maps and data ancillary to the large screen. Output from the Ramtek is shown on a Tektronics color monitor next to the user's control chair.

The interprocessor communications system is based in a third 7/32 which is used as a file processor for the lab. It allows the 85 control system to direct and coordinate the operation of the sound system and the vidicon and visual aids systems.

MULTIPROCESSOR SYSTEM
DIAGRAM

