**National Center for Geographic Information and Analysis**

# An Annotated Bibliography on Human Computer Interaction for GIS

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**Introduction and Acknowledgements**

This document is a collection of references gathered by the instructor and students in a course on human computer interfaces for GIS offered by the Surveying Engineering Department at the University of Maine in the Fall of 1990. The class searched widely through the available literature to find any information that would be relevant to the design and implementation of user interfaces for GIS. The search was broad and inclusive rather than focused and systematic. We attempted to find literature with which the GIS community would be unlikely to be acquainted. The result is a somewhat scatological entrance to tile literature. It is neither systematic, nor comprehensive. Its best use might be to stimulate further search through unfamiliar literature.

The references contain,. d herein were collected by James Bosworth, Rong-Her Chang, Bob Cicogna, Sarah Clapham, Paul Haggerty, Claire Kiedrowski, Chris Knight, Matt McGranaghan. Dave Pollock, David Steiner, Gary Volta and XinYu Yang. Gary Volta and Matt McGranaghan did the final editing and formatting of the document, learning in the process the difficulty of coordinating such a broadly defined and largely unstructured compilation task. We have made every possible effort to assure that the citations included herein are correct but realize that there are bound to be inaccuracies. We apologize in advance to anyone that is inconvenienced by them, and hope that on the whole, you will find this to be a useful and stimulating collection.

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Ackermann, David, Jan Stelovsky, and Thomas Greutmann. 1990. Action Regulation and the Mental Operational Mapping Process in Human-Computer Interaction: Does the Interaction Reflect Dialogue Grammar? In Cognitive Ergonomics: Understanding, Learning, and Designing Human-Computer Interaction. Edited by P. Falzon. London, England: Academic Press Ltd: pp 107 - 132.

The tools' user-interface can be seen as generated from a dialogue grammar formed by a set of rules for accepted input and generated output. The dialogue grammar defines the objective degrees of freedom in the physical scope of action. In this paper, we will concentrate on the input rules only. On the human side the dialogue grammar is perceived and matched with the task. This matching process is influenced by cognition, motivation, action knowledge and intentions. We assume that this forms a kind of syntax and semantics in generating actions and the observed actions can be described grammatically. The last step in the action regulation - the mental-operational mapping process - generates an observable result - the action sequence. Thus, the action sequence allows us to infer the subjective mental scope of action.

Akscyn, Robert M., Elise Yoder, and Donald McCracken, 1988.The Data Model is the Heart of Interface Design. Human Factors in Computing Systems, CHI'88; Washington, D.C., Edited by E. Soloway: pp 115-120.

The data model underlying an interactive system is more important than the userinterface in shaping the overall system. In this paper, we show how the KMS data model had influenced important aspects of user interface. In particular, we show how the properties of KMS frames--their spatial nature, breadth-first view, homogeneity, small size, etc, affect the nature of the KMS user interface.

Allard, Lise, and M. John Hodgson. 1987. Interactive Graphics for Mapping Location Allocation Solutions; The American Cartographer, 14 (1) : pp 49-60.

Location-Allocation (LA) models, in which the optimal locations of facilities and the allocation of demand points to these facilities are determined, lend themselves well to cartographic representation. Traditional LA models assume allocation of demand points to the nearest facility, and pose no particular problems for cartography, manual or automated. A new breed of LA model employ probabilistic allocation of demand to facilities, imposing much more serious design problems on the cartographer. We demonstrate how the capabilities of the INTERGRAPH Interactive Graphics Design System may be used creatively to design maps for the new type of LA model.

Arnold, David B., and Peter R Bono. 1988. CGM and CGI: Metafile and Interface Standards for Computer Graphics. New York: Springer-Verlag.

Attneave, Fred. 1954. Some Informational Aspects of Visual Perception: Psychological Review, 61 (3): pp 183-193.

Avrahami, Gideon, Kenneth P. Brooks, and Marc H. Brown. 1989. A Two-View Approach to Constructing User Interfaces: Computer Graphics, 3 (3): pp 137-146.

This paper describes a system for constructing graphical user interfaces following a two-view paradigm: one view contains a textual representation of the interface in a special-purpose. "little" language, and the other view contains a direct manipulation. interactive editor for the user interface. The user interface can be edited in either view, and the changes are reflected in the other view. The language allows dialog boxes to be expressed in a simple and natural way, and has a well-defined mapping into the interactive editor.

Baecker, Ronald M., and William A. S. Buxton. 1987. Readings in Human-Computer Interaction: A Multidisciplinary Approach. Los Altos, California: Morgan Kaufmann Publishers, Inc.

This is a collection of selected papers and excerpts intended as a source book of outstanding papers in the field of human-computer interaction. It is organized into 3 major parts: The first deals with the context - historical, sociopolitical, and physical, within which human-computer interaction takes place: The second focuses on the user and the usage of interactive computer systems, on underlying cognitive processes, and on methods of modelling and evaluating users and systems. It also deals with the human sensory-motor systems through which a user interacts and with the technologies through which interaction takes place; The third looks at the process of system design - interaction techniques, design methodologies, tools to facilitate design and implementation, and issues to be considered in turning a design into a useful and usable system. The three parts are divided into thirteen chapters dealing with the above topics and four case studies analyzing specific systems and/or applications. The final chapter discusses research frontiers and unsolved problems. Indexed.

Bailey, Wayne A., Stephen T. Knox, and Eugene F. Lynch, 1988. Effects of Interface Design upon User Productivity, Human Factors in Computing Systems, CHI'88; Washington, D.C., Edited by E. Soloway. pp, 207-213.

Eight subjects experienced in the use of both 7000 and 11000 series oscilloscopes performed four typical tasks with each scope. The 7000 interface is a dedicated physical control system, while the 11000 system employs icons, pop-up menus, assignable controls, and a touch panel. On each trial the task time and measurement accuracy were recorded. Each experimental session was video recorded and verbal protocols were collected. These allowed decomposition of the subjects' behaviors into categories that would account for performance difference between the two scopes. A 77% performance difference is explained in terms of the cognitive factors of strategy selections and recall of operational details.

Barker, Philip, Mohsen NaJah, and Karim Manji, 1987. Pictorial Communication with Computers, Human-Computer Interaction - INTERACT87: Stuttgart, Federal Republic of Germany, Edited by H. J. Bullinger and B. Shackel: pp 605-609.

Human-computer interaction Involves the movement of information between a human and a computer by means of suitably designed interface systems. Conventional interfaces for the transmission of text and other basic forms of data are now well established. Increasingly, various types of pictorial interface are being used to fabricate 'user friendly' dialogues with computers. This paper describes some approaches to human-computer communication via the use of conventional paper-based pictorial forms. Some attempts at evaluating end-user reactions to the use of this type of interface are described.

Barnard, Philip, Allan MacLean, and Michael Wilson, 1988. Navigating Integrated Facilities: Initiation and Terminating Interaction Sequences, Human Factors in Computing Systems, CHI'88; Washington, D.C., Edited by E. Soloway. pp 121-126.

Human performance data are reported for two dialogue conventions involving menu interactions with integrated facilities. An initiation style of dialogue in a flexible menu hierarchy was compared with a strict hierarchy involving explicit termination of dialogue sequences. The results are discussed in relation to the trade-offs that need to be considered in designing for navigational flexibility and to requirements for modeling user behavior.

Barth, P. S., 1986. An Object-Oriented Approach to Graphical Interfaces: ACM Transactions on Graphics, 5 (2) : pp 142-172.

An object-oriented system for building graphical interfaces to programs is discussed. The system, called GROW. facilitates the process of creating interfaces that are highly interactive (including direct manipulation and animation), rich in layout structure, and effectively reusable across applications. These properties are achieved through three techniques: object-based graphics with taxonomic inheritance, inter-object relationships such as composition and graphical dependency, and separation of the interface and application. Experience with interfaces for several applications has provided insights on the effectiveness of these techniques. First, object-oriented programming yields significant leverage on specializing and reusing interfaces. Second, layout constraints (such as maintaining the connectivity of a graph) can be managed with simple data dependencies among the attributes of the graphical objects. Finally, separating the interface and application is essential to reusing interface components. This paper describes the techniques in detail, gives examples of interfaces built with GROW, and summarizes experiences using GROW with a variety of applications.

Bass, L. J. .1986. The Components of a Generalized User Interface. In Foundation for Human-Computer Communication. Edited by K. Hopper. IFIR pp, 293-308.

This paper describes a set of three interacting tools designed to allow the development of integrated. supportive systems. These tools are a structure for a command interpreter, an end user interface and, as a result of the requirement for a supportive system, a semantic monitoring tool which gathers information from the application, necessary for support. All of these tools are developed with a simple well-defined interface for the application programs which allows them to be written without concern for the details of the user or command interface. It allows them to be easily integrated into the existing system of such applications. The implementation of preliminary versions of these tools within the context of a relational database system is also described.

Bastin, F.. S. Capobianchi, S. Carlesso, and G.Mancini, 1986. An Intelligent Interface For Accessing A Technical Data Base. In Analysis, Design and Evaluation of ManMachine Systems. Edited by G. J. G.Mancini L. Martensson. Oxford: Permagon Press: pp 167-173.

The paper deals with the design of an intelligent Interface aimed at assisting end-users in accessing a large and complex technical data base in a friendly, correct, and effective way. The interface includes both natural language understanding and expert problem solving capabilities and features a modular architecture devoted to cope with the exigencies of both technical and non-technical users. in the paper a brief introduction to ERDS is first presented and the problems related to to its use are analyzed. The requirements of the users of ERDS are then investigated, and the basic architecture of an intelligent interface is Illustrated. The design criteria of the two main modules of the interface, namely the natural language query interface and the expert interface, are later discussed. At last, the present state of the project is reported and promising directions for future research are outlined.

Benbasat, I., A S. Dexter, and P. Todd. 1986. The Influence of Color and Graphical Information Presentation in a Managerial Decision Simulation: Human-Computer Interaction, 2 (1) : pp 65-92.

A laboratory experiment was conducted to assess the influence of graphical and color-enhanced information presentation on information use and decision quality in a simulation setting. This is the third in a series of studies examining the effects of color and graphics in a managerial decision-making task. The findings reported in this article indicate that graphical presentations are more useful when evaluating information in order to determine promising directions In the search for an optimal solution, but when the task requires the determination of exact values for computational purposes. graphical reports are less useful than tabular ones. Benefits of color include taking fewer iterations to complete the task. However, these benefits are associated more strongly with the graphical report as indicated by the significantly higher use of color are also restricted to the early stages in the decision task, with color graphic report usage dropping sharply over time.

Bender, W., R A Crespo, P. J. Kennedy, and R.Oakley. 1987. CRT Typeface Design and Evaluation, Proceedings of the Human Factors Society, 3 1 st Annual Meeting; pp 1311-1314.

Benest, 1. D., G. Morgan, and M.D. Smithurst, 1987. A Humanised Interface to an Electronic Library, Human-Computer Interaction - INTERACT'87; Stuttgart, Federal Republic of Germany, Edited by H. J. Bullinger and B. Shackel. vol. 1; pp 905-910.

This paper describes a library metaphor which closely models the mechanisms for conventional searching, acquiring and reading of paper documents and is based on the premise that models which already are well learnt will be easier to use when similarly presented on-line. The model for manipulating the library catalogues described in this paper is based upon a dictionary metaphor that is an extension of the more general book metaphor. The book metaphor provides an open book presentation, with animated page turning across the screen and all the functionality that would be provided by a real book. It is argued that this interface greatly eases the use of a computerised library as it is based upon established and intuitively obvious concepts.

Berk, Toby, Lee Brownston, and Arie Kaufman. 1982. A Human Factors Study of Color Notation Systems for Computer Graphics; Communications of the ACM, 25 (8): pp 547-550.

A human factors experiment was conducted that compared three color notation systems for use in computer graphics. Two of the systems represent colors as triples of real numbers [0, 1 ]. The third system is based on natural language color categories in English. It was found that users of the natural language based system were significantly more accurate in specifying colors, despite the coarse granularity of that system as compared to the other two. This demonstrates that giving a user choice from a small set of values that are carefully chosen and based on human factors principles works better than providing a much larger and apparently more flexible set of values that are not based on such principles.

Berry, Joseph, 1984. An Academic Package for Instruction in Computer Assisted Map Analysis, Annual Meeting of the American Congress on Surveying and Mapping; Washington, D.C., pp 458-465.

In response to the increasing interest in the use of computer-based geographical information systems, academic programs in many discipline have begun to recognize the need for more effective ways of presenting spatial data analysis techniques to students with a wide diversity of backgrounds. The most commonly used approach is the case study coupled with a limited exposure to computer mapping software. This chapter presents an alternative approach which relies on the development of a fundamental analytical theory coupled with extensive exercises which demonstrate the practical application of that theory. This experience is further enhanced by opportunities for students to design and

implement their own cartographic models. The approach used in conveying concepts of spatial data analysis develops a general framework of primitive map applications. This deductive approach appears to be effective in providing students with a basic knowledge of map analysis techniques and enables them to extend this knowledge to potential applications of their own design. This approach has been used for six terms in a graduate course at Yale University. The course has also been implemented at several other universities and serves as the basis of an intensive two-day workshop for professionals.

The paper further describes an instructional package in computer-assisted map analysis being made available at cost. The package includes source code of the Map Analysis Package (MAP) software system, data base, multiple-copy authorized student workbook, and instructor materials. The Map system is a set of programs that provide for encoding, storage, analysis and display of cartographic information in a grid-cell data structure. The package is wTitten in Fortran IV an may be implemented for both interactive and batch processing modes in most mainframe or large minicomputer environments. The Map software system has been acquired by over 140 organizations including seventy universities in the U.S. and abroad. The supporting instructional materials include a brief text, lecture notes, handouts, exercises and examination questions and their solutions.

Bertin, Jacques. 198 1. Graphics and Graphic Information Processing. Translated by Berg, William J. and Paul Scott. New York-Walter de Gruyter & Co.

An in depth discussion of the use of graphics and symbols to display and analyze quantitative and qualitative data. Explores the use of tables, graphs, and matrices, as well as ordered networks as ways to communicate information. Well illustrated with examples (both good and bad) of the effects of variations in size, shape and color of symbols on the understandability of the data. Especially of interest is the chapter on topography and cartography.

Bewley, William L., Teresa L. Roberts, David Schroit, and William L. Verplank, 1983. Human Factoes Testing in the Design of Xerox's 8010 "Star" Office Workstation, Human Factors in Computing Systems; Boston, Edited by A- Janda. pp 72-77.

Integral to the design process of the Xerox 8010 "Star" workstation was constant concern for the user interface. The design was driven by principles of human cognition. Prototyping of ideas, paper-and-pencil analyses, and human-factors experiments with potential users all aided in making design decisions. Three of the human-factors experiments are described in this paper. A selection schemes test determined the number of buttons on the mouse pointing device and the meanings of these of these buttons for doing text selection. An icon test showed us the significant parameters in the shape of objects on the display screen. A graphics test evaluated the user interface for making line drawings, and resulted in the redesign of that interface.

Blum, H. 1967. A Transformation for Extracting New Descriptors of Shape. In Models for the Perception of Speech and Visual Form. Edited by W. Wathen-Dunn. Cambridge, MA: MIT Press.

Bly, Sarah A., and JarTett K Rosenberg, 1986. A Comparison of Tiled and Overlapping Windows, Human Factors in Computing Systems; Boston, Massachusetts, Edited by M. Mantel and P. Orbeton. pp 101-106.

It is widely believed that overlapping windows are preferable to tiled (non-overlapping) ones, but there is very little research to support that belief. An analysis of the basic characteristics of windowing regimes predicts that there are, in fact, situations where overlapping windows are inferior to tiled. An experiment to test this prediction verified that there are indeed tasks and users for which tiled windows yield faster performance. This results suggests a need for closer study of the principles underlying window regimes, so that designers have a better understanding of the tradeoffs involved in using them.

Bly, Sara A., and Scott Minneman, 1990. Commune: A Shared Drawing Surface, Conference on Office Information Systems; Cambridge, Massachusetts, Edited by F. Lochovsky and R Allen; pp 184-192.

Careful observation of small-group design sessions suggests that the process of creating, referring to, and using drawings may be as important to the design process as the drawings themselves. Based on studies of the uses of drawing spaces, Commune was developed to allow designers working remotely to share a drawing surface and to engage in many of the interactions available in conventional face-to-face situations. The design of Commune makes marks and 2-dimensional cursor gestures visible simultaneously to all users. allows rapid transitions among drawing, writing, and gesturing. and provides a shared space with actions from multiple users occurring simultaneously. These capabilities support natural uses of the drawing surface during the interaction: the ability to interact on each other's marks, to emphasize talk with

marks and gestures, to reference previous illustrations and concepts, and to interweave talk and drawing functions fluidly.

Bolt, Richard A 1984. The Human Interface: Where People and Computers Meet. Belmont, CA: Lifetime Learning Publication.

Booch, G. 1986. Object-Oriented Development; IEEE Transactions on Software Engineering, 12 (2) : pp 211-221.

Borg, K., 1990. IShell: A Visual UNIX Shell. Human Factors in Computing Systems Empowering People CHI'90; Seattle, Washington, Edited by J. Chew and J. Whiteside. pp 201-207.

IShell is a visual user interface for interaction using gestures under the UNIX operating system. A visual script language for building commands -- IScript -- is an integral part of the IShell environment. The user can directly describe and execute pipelined command sequences using gestures. The user is constantly guided by visual cues.

Borning, A_ and R Duisberg. 1986. Constraint-Based Tools for Building User Interfaces; ACM Transactions on Graphics, 5 (4): pp 345-374.

A constraint describes a relation that must be maintained. Constraints provide a useful mechanism to aid in the construction of interactive graphical user interfaces. They can be used to maintain consistency between data and a view of the data, to maintain consistency among multiple views, to specify layout, and to specify relations between events and responses for describing animations of interactive systems and event-driven simulations. Object-oriented techniques for constraint representation and satisfaction are presented, and a range of examples that demonstrate the practical use of static and temporal constraints for such purposes is presented. These examples include animations of algorithms and physics simulations, and constructing user-interface elements such as file browsers, views onto statistical data, and an interactive monitor or a simulated operating system.

Bowen, Hugh M. 1967. The Imp in the System. In (Proceedings of the conference on) The Human Operator in Complex Systems. Edited by W. T. Singleton, R. S. Easterby and D. C. Whitfield. London: Taylor and Francis, Ltd.: pp 12-19.

Indicates that computers and people are best thought of as having different and complimentary functions, systems should take advantage of that. Man as a resource in the system. Gives two examples of exploring a multidimensional data sets for abnormalities. In each of these, a human operator easily isolates the problem because of the appearance in a graphic. The importance of the correct graphic is emphasized (y on x not informative, but dx on dt is). Ease of noting bulge on an otherwise smooth surface.

Braithwaite, Kenneth S. 1989. Systems Design in a Database Environment. New York: Intertext Publications.

Database analysis techniques; data models: logical and physical database design; data security; case studies.

Brooks, William D., 1979. A Teaching Version of the Computer Assisted Space Allocation Technique, Annual Meeting of the American Congress on Surveying and Mapping; Washington, D.C.: pp 416-424.

Although computer hardware and software continuously evolve there are many of us in academe who do not have access to the latest of either. We are faced with the problem of giving "hands-on" training to undergraduate cartography students without the benefits of CRTs or IMGRID. CASAT, therefore, remains a standard software package with those of us saddled with an "older" computer. Ibis paper presents a version of CASAT designed to illustrate concepts of spatial analysis necessary for geographers or planners and functional on -smaller" or "older" computers.

The program manipulates weighted grid-cell data in order to display the interactions of physical and cultural subsystems as a whole system combination. Thus the program can be used to present the techniques and characteristics of geographic information systems ranging from data collection and storage to data retrieval, analysis and display.

Brouwer, Onno, and Ron Exler, 1984. Mapping for the Handicapped: A Procedure from Data Collection to Final Products, Annual Meeting of the American Congress on Surveying and Mapping: Washington, D.C.: pp 319-340.

People with mobility impairments have unique map information needs. Numerous attempts have been made to define these needs by researchers outside the cartography field. However, little of this information has made its way onto maps, graphics or manuals aiding the mobility handicapped. Since these needs have been defined, data collection is the first stage of the cartographer's involvement in the process of creating visual aids. Decisions are made concerning data

intervals and map classes as well as methods to best display them. Continual concern is focussed on appropriate levels of information collected to obtain maximum usefulness from the final products. The process of data collection is intended to be performed by the lay-person volunteer belonging to a civic group interested in maps of their community for the handicapped. Tools are chosen that minimize cost, are easy to operate, yet provide data of the highest quality. A data collection manual outlines these necessary materials and activities. A final series of maps must be of optimal value to the user-audience. Since people with mobility impairment will use these maps for route and activity planning, special symbology and careful hue selection are essential elements of the design process. A balance between the amount of information and map readability is essential. The unique variables involved in mapping for the handicapped deserve extensive consideration in order to produce the most useful maps.

Brown, P. J. 1983. Error Messages: The Neglected Area of the Man/Machine Interface; Communications of the ACM, 26 (4): pp 247-249.

The quality of error messages produced by software used in the field was tested by a simple experiment: it was found to be far from adequate. The results of the experiment are analyzed, and some responses which tend to collaborate the original findings are discussed. Finally, some suggestions are made for improving the quality of error messages.

Brown, Gretchen P., Richard T. Carhng, Chrisopher F. Herot, David A. Kramlich. and Paul Souza. 1985. Program Visualization: Graphical Support for Software Development. IEEE Computer, 18(8): pp 27-35.

This paper discusses ten forms of graphic illustrations and their applicability to programming and system management.

Brown, Arthur, and Leonard Norton-Wayne. 1986. Vision and Information Processing for Automation. New York: Plenum Press.

Brings together in a single volume information on sensors, signal processing methods, electronic hardware, lighting, etc... for the purpose of creating an intelligent automation system.

Brown, Polly S., and John Gould. 1987. An Experimental Study of People Creating Spreadsheets: ACM Trans. on Office Information Systems, 5 (3) : pp 258-272.

Nine experienced users of electronic spreadsheets each created three spreadsheets. Although participants were quite confident that their spreadsheets were accurate, 44 percent of the spreadsheets contained user-generated programming errors. With regard to the spreadsheet creation process, we found that experienced spreadsheet users spend a large percentage of their time using the cursor keys, primarily for the purpose of moving the cursor around the spreadsheet. Users did not spend a lot of time planning before launching into spreadsheet creation, nor did they spend a lot of time in a separate, systematic debugging stage. Participants spent 21 percent of their time pausing, presumably reading and/or thinking, prior to the initial keystrokes of spreadsheet creation episodes.

Brown. C. Marlin "Lin". 1988. Human-computer Interface Design Guidelines. Norwood, NJ: Ablex Publishing Corp.

Brown, Marc H., 1988, Perspectives on Algorithm Animation, Human Factors in Computing Systems, CHI'88; Washington, D.C., Edited by E. Soloway. pp 33-38.

Systems for animating algorithms have received considerable interest of late. They are effective means for understanding the behavior of computer programs. This paper addresses the displays and the extent to which they can be created automatically. The first part presents a taxonomy of displays prevalent in algorithm animation systems. The second part uses the taxonomy to analyze those types of display.

Brown, M.L., S.L. Newsome, and E.P. Glinert, 1989, An Experiment into the Use of Auditory Cues to Reduce Visual Workload, Human Factors in Computing Systems, CHI'89; Austin, Texas, Edited by K. Bice and C. Lewis. pp 339-346.

The potential utility of dividing the information flowing from computer to human among several sensory modalities is investigated by means of a rigorous experiment which compares the effectiveness of auditory and visual cues in the performance of a visual search task. The results indicate that a complex auditory cue can be used to replace cues traditionally presented in the visual modality. Implications for the design of multimodal workstations are discussed.

Brown, J. R. and S. Cunningham. 1989. Programming the User interface: Principles and Examples. Wiley.

Burges, John H. 1986. Designing for Humans: The Human Factor in Engineering. Princeton, NJ: Petrocelli Books.

An introductory text aimed at the industrial human factors engineer. The book includes chapters on human abilities and limitations, on analytical approaches to human factors based product evaluation and design. Chapters also addresses issues of designing for product safety, Only one chapter directly addresses computer interface design. Mostly it is hopelessly dated but there are concise descriptions of the use of Chernoff Faces, Deviation Bar Charts and Circular Profiles in Nuclear Regulatory commission (NRC) Nuclear Safety Parameter Display System (SPDS). Also includes a summary of Bailey (1982) VDT specifications.

Burgess, John H. 1986. Human Factors and Computers. In Designing For Humans: The Human Factor in Engineering. Princeton, New Jersey: Petrocelli Books: pp 351 -376.

A fundamental reality of modern computers is that they are designed and operated by humans. Many computer proponents believe that computers will eventually be designed to do anything a person can do. However, whatever computer versatility there might be in the future, the ingenuity in achieving this must lie with the designers, even though computers might eventually be designed to design themselves. The book gives insight into human factors in general and various other human factors applications outside of computers.

Bury, Kevin F., James M. Boyle, James Evey, and Alan S. Neal. 198 1. Windowing vs. Scrolling on a Visual Display Terminal: Human Factors, 24 (3): pp 41-44.

To study a different star the astronomer moves his telescope. To study a different bacterium the biologist moves his microscope slide. In the case of the astronomer, it is the viewing instrument that is being moved, while in the case of the biologist it is the viewed object that is being moved. These scientists have no choice. the nature of their equipment requires that they operate in a pre-defined way. The user of a video display terminal (VDT), however, can be given a choice. The VDT user views a representation of an area of computer memory. In most cases the portion of memory the user wishes to examine is much larger than that which will fit on the screen at one time. For this reason almost all VDTs are equipped with some sort of -scroll function" that allows the user to display data that is located beyond the limits of the screen. The alternative way of conceptualizing the scroll function on a VDT involves visualizing the display screen as if it were a moveable -window" through which could be viewed the stationary data.

Buxton, W., and B. A. Myers, 1986. Creating Highly Interactive and Graphical User Interfaces by Demonstration, SIG-GRAPH '86 Conference Proceedings. pp 249-.

Calkins, Hugh W., and Holly J. Dickson, 1987. The Effective Use of Color in Cartographic Displays, International Geographic Information Symposium, Arlington, VA. Edited by R T. Aangeenbrug and Y. M. Schiffman. vol. 3; pp 189-199.

The expanding availability of color fur use with CRT and plotter displays is presenting greater flexibility in the design of cartographic output from geographic information systems. There now exists the potential to represent more information more effectively through the use of color. Both traditional cartographic displays and dynamic, spatio-temporal displays can benefit from the effective use of color. It well be important, however, to use color in a manner that enhances the information content of the output rather than just randomly choosing colors for display. Many current displays combine colors in a way which is not easily interpreted by the reader. Logical combination of color on traditional displays and logical sequences of color for dynamic displays need to be researched and described to achieve the maximum benefit from the current technology. Often, the color sequence that one generally thinks will be logical produces a display that is confusing and unreadable. Prior experiments with simple dynamic displays and the evaluation of selected cartographic software packages have demonstrated that the selection of color combinations for a single display or the determination of an appropriate sequence of colors to represent temporal information are complex tasks. Successful transition from traditional cartography to automated cartography will be partially dependent upon developing known strategies for color selection to optimize the utility of the display.

Callahan, Jack, Don Hopkins, and Ben Shneiderman. 1988, An Empirical Comparison of Pie vs. Linear Menus, Human Factors in Computing Systems, CHI'88: Washington, D.C., Edited by E. Soloway. pp 95- 100.

Menus are largely formatted in a linear fashion listing items from the top to bottom of the screen or window. Pull down menus are a common example of this format. Bitmapped computer displays, however, allow greater freedom in the

placement, font, and general presentation of menus. A pie menu is a format where the items are placed along the circumference of a circle at equal radial distances from the center. Pie menus gain over traditional linear menus by reducing target seek time, lowering error rates by fixing the distance factor and increasing the target size in Fitts's Law, minimizing the **drigty** distance after target selection, and are, in general, subjectively equivalent to the linear style.

Campion, John, 1989. Interfacing The Laboratory With The Real World: A Cognitive Approach To Color Assignment In Visual Displays. In Cognitive Ergonomics and Human-Computer Interaction. Edited by J. L. a. A. Whitefield. New York: Cambridge University Press: pp 35-65.

Describes a cognitive approach to research on the assignment and assessment of color on CRTs for naval command systems. Describes and illustrates the techniques use with reference to a research project set up to investigate color use on submarine tactical plan displays.

Carasik, R P., and C. E. Gruntham. 1988, A Case Study of CSCW in a Dispersed Organization, Human Factors in Computing Systems, CHI'88; Washington, D.C., Edited by E. Soloway. pp 61-66.

Pacific Bell conducted a trial of the Coordinator, a tool for computer-supported cooperative work- The trial group had diverse job functions and was dispersed across a variety of geographical locations and computing environments. The trial attempted to both measure the effectiveness of The Coordinator as a communications tool and to evaluate the speech act communications paradigm on which it is based. Only the first of these two goals was realized. An improved interface, more flexible terminology, and better implementation support is needed for successful installation of the Coordinator, or similar products.

Card, Stuart K, W. K. English, and B. J. Burr, 1978. Evaluation of Mouse, Rate Controlled Isometric Joystick, Step Keys. and Text Keys for Text Selection on a CRT, Ergonomics, 21(8): pp 601-613.

Card, Stuart F,, T. P. Moran, and A. Newell. 1980. The Keystroke-Level Model for User Performance Time with Interactive Systems; Communications of the ACM, 23(7): pp 396-4 10.

Card, Stuart K., Thomas P. Moran, and Allen Newell. 1983. The Psychology of Human Computer Interaction. 1983 ed. Hillsdale, New Jersey: Lawrence Erlbaum Associates.

Card, S. K., and D. A Henderson Jr. 1986. Rooms: The Use of Multiple Virtual Workspaces to Reduce Space Contention in a Window-Based Graphical User Interface; ACM Transactions on Graphics, 5 (3): pp 211-243. Carroll, John M. 1982. The Adventure of Getting to Know a Computer; IEEE Computer, 15 (11): pp 49-56.

The author draws a parallel between the player of a computer adventure game and a user trying to learn an application system. He does this by highlighting the commonalities of between the two, i.e. they are both struggling to cope with an unfamiliar environment and are experiencing certain types of learning disabilities. These difficulties are inevitable characteristics of human-computer interactions and are potential problems in any system. By examining the similarities and differences between the Adventure player and the inexperienced user, the author attempts to find some insights to use in designing application systems that are easier for the user to learn.

Carroll, John M., and Caroline Carrithers. 1984. Training Wheels in a User Interface-, Communications of the ACM, 27 (8): pp 800-806.

New users of high-function application systems can become frustrated and confused by the errors they make in the early stages of learning. A training interface for a commercial word processor was designed to make typical and troublesome error states "unreachable," thus eliminating the sources of some new-user learning problems. Creating a training environment from the basic function of the system itself afforded substantially faster learning coupled with better learning achievement and better performance on a comprehension post-test. A control group spent almost a quarter of their time recovering from the error states that the training interface blocked off. We speculate on how the training strategy might be refined, and more generally, on how function should be organized in a user interface.

Carroll, John M. 1989. Evaluation, Description and Invention: Paradigms for HumanComputer Interaction; Advances in Computers, vol. 29: pp 47-77.

JMC is at User Interface Institute, IBM T.J. Watson Watson Res. Center, Yorktown Heights, NY. In this he discusses the lack of theory in direct empirical contrast studies. He builds a theme around: to design by deduction. problems of ecological analysis, and the ecology of computing.

Cassel, Regina A., and H. Dennison Parker, 1989, Design and User Testing of a GIS User Interface, GIS/LIS'89: Orlando, Florida, vol. 2: pp 538-541.

A critical user acceptance factor of any software package is its user interface. The concept of a graphical user interface is now being adopted by many software developers and supported on almost all hardware. The Apple Macintosh was the first microcomputer to fully integrate a graphical user interface into its operating system and others are now following. The Cooperative GIS Technology Laboratory at Colorado State University developed a generic GIS User Interface in cooperation with the USDI laboratories (ETL). The objective of this development is to create a GIS user interface that is easy to learn and use, reduce training costs, and make GIS technology available to casual user. Prototypes have been designed and field tested on a Macintosh computer. User responses were used to refine the prototype at each stage of development. 'Me major elements of the interface were tested with the assistance of BLM and Army personnel, selected to be typical of field GIS users. The prototype will become a design specification for a future system which is expected to be implemented using the X Windows standard.

Chang, Kang-tsung, Chad Mullis, and James Antes. 1984. An Eye Movement Analysis of the Effects of Configuration in Map Design, Annual Meeting of the American Congress on Surveying and Mapping; Washington, D.C.; pp 157-165.

The objective for creating a thematic map is to effectively communicate the orientation of some spatial phenomena to a given audience. Although the cartographic literature is beginning to be liberally sprinkled with reports of research pertaining to communicative effectiveness of symbology and other map aspects, there exists a glaring void regarding the effects of the map as a whole and its configuration on the communication process. This paper synopsizes an experimental investigation into those configuration effects through an analysis of eye movements. An experimental design with a strong degree of internal control is used to obtain eye movement data from two distinctly varied map designs. Observed results are mixed when compared to expectations generated by traditional pictorial and cartographic eye movement analysis parameters. However, analysis of several fixation parameters shows a pattern that appears quite conclusive with regard to the effects of configuration on the perceptual process.

Chang, Shi-Kuo, Tadao Ichikawa, and Panos A. Ligomenides. 1986. Visual Languages. New York, New York: Plenum Press.

This book is intended as both an introduction to the state-of-the-art in visual languages, as well as an exposition of the frontiers of research in advanced visual languages. It is for computer scientists, computer engineers, information scientists, application programmers, and the technical managers responsible for software development projects who are interested in the methodology and manifold applications of visual languages and visual programming.
'Me contents of this book are drawn from invited papers, as well as selected papers from two workshops.

Chin, John P., Virginia A Diehl. and Kent L. Norman, 1988, Development of an Instrument Measuring User Satisfaction of the Human Computer Interface, Human Factors in Computing Systems, CHI'88; Washington, D.C., Edited by E. Soloway. pp 213-218.

This study is a part of research effort to develop the Questionnaire for User Interface Satisfaction (QUIS). Subjects rated their satisfaction with software that 1) was liked / disliked. and 2) used a standard command line interface (CLS) vs. a menu driven application (MDA). The reliability of the questionnaire was high, Cronbach's alpha=.94. The overall reaction ratings yielded significantly higher ratings for liked software and a CLS, respectively. Frequent and sophisticated PC users rated MDA more satisfying, powerful and flexible than CLS. Future applications of the QUIS on computers are discussed.

Chong, Diane, and Graham Dudley, 1988, Considerations in the Development of a GIS Interface, GIS/LIS '88; San Antonio, TX vol. 2; pp 665-672.

The wider acceptance of GIS technologies into the workplace has created a new class of problem with which the system designer must deal. Whereas a few years ago the potential operator of a GIS could spend many months training on a particular system before any output could be expected. the working environment of today does not permit this sort of

time allowance. Instead, what are demanded are systems which will allow a new user to begin producing tangible output within a matter of weeks or days. A key element in the satisfaction of this demand is the quality of the interface between the user and the GIS. During the course of an ongoing joint research project between the Institute for Market and Social Analysis and Ryerson Polytechnical Institute, School of Applied Geography, it became apparent that the nature of user interfaces available varies greatly as evidenced by the five different software packages we used. The purpose of this paper is to identify some important general considerations in the development of a user interface for a GIS. Issues include defining the interface, identifying available options. positive and negative aspects of these options, and illustrating how these options can be applied, particularly in a market research environment.

Clarisse, Ohvier, and Shi-Kuo Chang. 1986. VICON: A Visual Icon Manager. In Visual Languages. Edited by T. I. Shi-Kuo Chang Panos A. Ligomenides. New York, New York: Plenum Press: pp 151 - 205.

Visual representations seem to be the best and universal media for technical information exchange: many engineering concepts are precisely represented by circuits, schematics, diagrams, floor plans, and layouts and cannot be described and exchanged efficiently without appropriate graphical formats. Research in visual languages is also important because it promotes information exchange between man and machine (and between humans using machines) in the largest bandwidth communication channel humans have: a minutely organized and highly parallel architecture of neurons which constitute our vision system.

Cleal, D. M., and N. 0. Heaton. 1988. Knowledge-Based Systems: Implications for Human-Computer Interfaces. Chichester, England: Ellis Horwood Limited.

This book, written for all those having an active interest in information Technology, describes the guiding principles and provides a concise introduction to the potential power of key developments which enhance the practical user of computer-based tools. It shows how expert (intelligent) systems have become one of the most exciting fruits to be borne by Artificial Intelligence, and how they may be employed in everyday life.

Cockton, Gilbert. 1987. Interaction Ergonomics, Control and Separation: Open Problems in User Interface Management, Information and Software Technology, 29 (4): pp 176-191.

User Interface Management Systems (UIMS) offer many potential benefits, to users although problems still exist. Three main problems are discussed: interaction ergonomics, dialogue control and separation.

Cohen, P.R, M. Dalrymple, D.B. Moran. F.C.N. Pereira. J.W. Sullivan, R. A. Gargan Jr., J.L. Schlossberg, and S.W. Tyler. 1989. Synergistic Use of Direct Manipulation and Natural language, CHI'89; Austin, Texas, Edited by F, Bice and C. Lewis. pp 227-233.

This paper shows how the integration of natural language with direct manipulation produces a multimodal interface that overcomes limitations of these techniques when used separately. Natural language helps direct manipulation in being able to specify objects and actions by description, while direct manipulation enables users to learn which objects and actions are available in the system. Furthermore, graphical rendering and manipulation of context provides a partial solution to difficult problems of natural language anaphora.

Coutaz, Joelle. 1985. Abstractions for User interface Design; Computer, 18 (9): pp 21-34.

The author discusses the issue of separation of application and interface and examines a feasible approach to the task, the user interface toolkit. Such a toolkit expresses the user interface in a language common to all of the applications. The author examines what she feels are some of the minimum requirements for a user interface toolkit and the abstractions necessary for its design.

Coutaz, J. 1987. The Construction of User Interfaces and the Object Paradigm. In ECOOP '87 European Conference on Object-Oriented Programming. Edited by J. M. Hullot, P. Cointe and H. Lieberman. pp 121-130.

Cowan. William and Cohn Ware and Wiffiam. 1990. The RGYB Color Geometry; ACM Tran. On Graphics, 9 (2): pp 226-232.

The gamut of a color crt is defined by its three primary colors, each produced by a phosphor/electron gun combination. Light from the primaries combines additively, so the color gamut is a subset of a three dimensional vector space. With the primaries as basis vectors normalized to 1.0 the color gamut is a unit cube. known as the color geometry, since the three primaries are usually green, red and blue. User interaction via RG13 is generally thought to be counterintuitive, and

transformations of RGB, such as Smith's HSV geometry which is derived form centuries old artists models, are more popular. More recent color theories, based on psychophysical and physiological models of early visual processing, suggest that more intuitive geometries may be possible.

The RGYB geometry is base on two recent discoveries about the human visual system. First =, the three color signal form the cone receptors are organized into three opponent channels. A single achromatic channel indicates lightness or brightness. Two chromatic channels red/green and yellow/blue signal the chromatic quantities. Second, signals on the achromatic channel are easily distinguishable from signals on the chromatic ones. Consequently, it is usual to represent colors as a set of surfaces of color that vary in chromaticity, each at a different level of brightness. Examples are as diverse as CIE chromaticity coordinates, the CIELUV uniform color space, the Munsell color system. and computer graphics color spaces such as HSV and HLS.

Cowen, David J., Powel V. Crosley, and Michael Holland. 1979. Automated Mapping of South Carolina's Coastal Zone, Annual Meeting of the American Congress on Surveying and Mapping, Washington. D.C.; pp 247-267.

The state of South Carolina recently prepared a four-color land use and land cover map for its Coastal Zone Management Plan. The project involved combining USGS data with more detailed information collected locally. The screened negatives were photographically prepared from scribecoats plotted on a Kongsberg plotter. The plots and accompanying are statistics were generated by the USGS Geography Program's GIRAS software at the University of South Carolina. The prcject represents a successful example of the transfer of the GIRAS system and the land use and land cover data by a state for use in another Federal Program.

Cowen, David J., and Scott Reily Love, 1988. A HyperCard Based Workstation for a Distributed GIS Network, GIS/LIS '88; San Antonio, TX, vol. 1: pp 285-294.

Increasingly, geographical information systems (GIS) have become important tools for many public and private agencies that desire to use the analytical power of these systems to improve their spatial decision making. The shortage of technically oriented personnel, coupled with and the high initial costs for these systems and their associated databases. however, often makes it difficult for many organizations to implement useful GIS functions. This paper outlines the development of a prototype for a distributed,
personal computer based network workstation which contains a user friendly human-machine interface that allows easy access to a powerful set of geographic analysis tools. This system was developed for two small state agencies that plan to proceed with full scale implementation.

Cox, B., and B. Hunt. 1986. Objects, Icons, and Software ICs; Byte, 11 (8): pp 161-176.

Crosley, Powel, 1985, Creating User Friendly Geographic Information Systems Through User Friendly System Supports, Auto-Carto 7: Washington, D.C., vol. 1; pp 133-140.

User friendliness in GIS must have friendly supports, device independence, DBMS, human-machine interface, fault tolerance, highly available computing system. Comments on the factors mentioned above with respect to their importance and points to insure the overall goal of user-friendliness, which he does define but states it depends on the user and application and therefore can not be clearly defined.

Cuff. David J.. and Mark T. Mattson. 1982. Thematic Maps: Their Design and Production. New York: Methuen & Co.

Thematic map making, cartographic communication, symbolizing data (qualitative, ranked, quantitative), layout of map, map reproduction and production.

Cushman, W. H. 1986. Reading from microfiche, a VDT, and the printed page; subjective fatigue and performance, Human Factors. vol. 28: pp 63-73.

Dawsey, C.B., 1989, Two-Variable Color Mapping on a Microcomputer, Auto-Carto 9; Baltimore, Maryland, pp 15-20.

Though two-variable choropleth maps are useful for analyzing the direction, intensity and spatial pattern of a correlation, they are not frequently used because costs associated with conventional production are made high by color layout requirements and by the limited demand for maps of any particular combination of variables. Microcomputers with color output capability make such maps available to a potentially wider audience. A properly programmed system can create

an almost unlimited number of unique two-variable maps at little expense beyond the initial investments. This report describes the development and illustrates the results of two variable choropleth mapping on the Amiga microcomputer.

Dehning, Waltraud, Heidrun Essig, and Susanne Maass. 1981. The Adaptation of Virtual Man-Computer Interfaces to User Requirements. Berlin: Springer-Verlag.

This book studied the characteristics of "naive" users and their dialog with a computer in order to propose design criteria for man-machine dialog systems. To achieve this goal research was done in two directions: part one consists of an extensive list of statements about user needs and abilities at a man-computer interface which were extracted from literature in German and English. Part two gives a formal description of man-computer dialog and its content, especially for database systems. Three level of abstraction are introduced each of which allows a different viewpoint and a different characterization of dialog and its elements. In the third part both, user characteristics and dialog description, are combined to make decision suggestions for user oriented dialog systems. They are based on a detailed discussion of what user-orientation should mean for man-computer dialog.

DeSoi, J.F., W.M. Lively, and S.V. Sheppard, 1989. Graphical Specification of User Interfaces with Behavior Abstraction, CHI'89; Austin, Texas, Edited by K. Bice and C. Lewis. pp 139-144.

The Application Display Generator (ADG) is a graphical environment for the design and implementation of embedded system user interfaces. It is a major component of the Graphical Specification Subsystem (GSS) in Lockheed's Express knowledge-based software development environment. ADG gives nonprogrammers simple and flexible methods for graphically specifying the presentation and behavior of embedded system user interfaces. In the ADG methodology arbitrary presentations are attached to abstract object behaviors. This approach makes it possible to provide unconstrained presentations, intelligent user support, rapid prototyping, and flexible facilities for composing complex objects.

Diaper, Dan, and Russel Winder. 1987. People and Computers 3. Cambridge: Cambridge University Press.

This book contains the conference papers to be presented at "HCF87: People and Computers (Exeter University, 7th-1 lth of September 1987). To provide the delegates with copies of the papers during the conference, the book was prepared before the event and therefore only contains the formal papers accepted for presentation. Although still in its infancy, the field of HCI is growing and maturing, Computer Scientists, Psychologists, Ergonomists, and Electronic Engineers are now working together in this exciting multidisciplinary area to make computers useful and useable for all members of society.

Dillon, Andrew, 1987. Knowledge Acquisition and Conceptual Models: a Cognitive Analysis of the Interface. In People and Computers 3. Edited by D. Diaper and R. Winder. Cambridge: Cambridge University Press: pp 371 - 379.

Understanding how users process the information available to them through the computer interface can greatly enhance our abilities to design usable systems. This paper details the results of a longitudinal psychological experiment investigating the effect of interface style on user performance, knowledge acquisition and conceptual model development. Through the use of standard performance measures, interactive error scoring and protocol analysis techniques it becomes possible to identify crucial psychological factors in successful human computer use. Result indicate that a distinction between "deep" and "shallow" knowledge of system functioning can be drawn where both types of user appear to interact identically with the machine although significant differences in their respective knowledge exists. The effect of these differences on user ability to perform under stress and transfer to similar systems is noted. Implications for the design of usable systems are discussed.

Dipietro, Stephen M. 1990. A Graphical User Interface to Support a Production Team: SIGCHI Bulletin, 22 (1): pp 36-39.

This paper describes the user interface of a software system that supports production of a large geographic database. The user interface of the system facilitates coordination of a production team whose activities are separated in time and space. The user interface provides visibility into the status and organization of the production effort and provides easy access tools and data required to perform the work.

Dobson. Michael. 1983. A High Resolution Microcomputer Based Colour System for Examining the Human Factors Aspects of Cartographic Displays in a Real-Time User Environment, Sixth International Symposium on Automated Cartography; Ottawa, Ontario, Canada, Edited by B. S. Wellar. vol. 1; pp 352-361.

For purposes of experimentation on the human factors of real-time, color, cartographic display, we have configured a high resolution microcomputer based image display system. The system provides the basic image device for a series of studies aimed at examining the practical use of color on cartographic displays. Human factors and color display, the graphics hardware, and some initial experiments involving the human factors aspects of using real-time. color displays for purposes for spatial problem solving the performance of map use tasks.

Docherty, P., K. Fuchs-Kittowski, P. Kolm, and L. Mathiassen. 1987. System Design for Human Development and Productivity: Participation and Beyond (Proceedings of the IFIP TC 9/WG 9.1 Working Conference on System Design for Human Development and Productivity: Participation and Beyond, Berlin, GDR, 12-15 May 1986. New York: North-Holland.

Dreyfus, Hubert and Stuart Dreyfus. 1989. Why Computers May Never Think Like People. In Computers in the Human Context. Edited by T. Forrester. Cambridge, MA: The MIT Press: pp 125-143.

Minds and machines: The Al Debate, acquiring human know-how, intuition of experts. Is Intelligence based on facts?, microworlds vs. the real world, thinking with images not words.

Dudley, T., 1987. Report Generation Using a Visual Programming Interface, Human Computer Interaction – INTERACT'87; Stuttgart, Federal Republic of Germany, Edited by H. J. Bullinger and B. Shackel. vol. 1; pp 521-528.

Command language interfaces are not always the most appropriate tool at the initial stages of report design. A loosely constrained graphical notation can be much more useful. Visual programming techniques introduced on the Xerox Star(TM), and popularized by the Apple Lisa(TM) and the Macintosh(TM), have now made the use of such a graphical notation much more feasible. Also, the direct manipulation techniques described by Schneiderman are now viable because of the wide-spread availability of bitmapped graphics screens and pointing devices such as the mouse.

This paper briefly discusses visual programming concepts, and then describes the implementation of a visual programming interface (VPI) for a 4GL report writer. The basis for the design is an object-action syntax. A set of icons was designed which represent atomic report entities, and a graphic editor built to manipulate these entities into a report structure. Attribute sheets associated with each of the report entities allow definition of the report entities to the data dictionary. A menu bar controls menus of all possible actions to be performed on the objects. A facility to switch easily between the graphical and textual representation of the report is provided, with direct manipulation editing available in both representations. Modifications made in one representation are automatically reflected in the other. The combination of VPI with af 4GL makes the design and modification of reports remarkably straightforward, and suitable both for end users and application programmers.

Dumas, Joseph S. 1988. Designing User Interfaces for Software. Englewood Cliffs, NJ: Prentice Hall.

Durrett, John H. 1987. Color and the Computer. Orlando, FL: Academic Press, Inc.

This book brings together a substantial collection of fundamental information on color, color displays, and color perception as it relates to the use of color video displays for the presentation of computer generated information.

Dzida, Wolfgang. 1989. The Development of Ergonomic Standards; SIGCH1 Bulletin, 20 (3): pp 35-43.

This paper is an attempt to introduce a conception for the development of human factors standards. Most propositions and assertions presented here rely upon experiences made in German standardization groups. Discusses the man-machine relationship and introduces a task-interface-result flow chart.

Earle. James H. 1977. Engineering Design Graphics. Reading, MA: Addison-Wesley Publishing Company.

The use of engineering graphics and descriptive geometry principles as the fundamental tools of design. This book covers the design process using the following six steps: identification. preliminary ideas, refinement, analysis, decision and implementation.

Easterby, Ronald. 1987. Trillium: an Interface Design Prototyping Tool; Information and Software Technology, 29 (4) : pp 207-213.

Trillium was originally developed at Xerox PARC. A UK company has undertaken a number of software refinements. This paper looks at the history of the design tool and how it is used.

The Trillium environment provides a means of interactively designing user interfaces through the exploitation of some key abstractions from the language of interface design. It uses a virtual machine representation and an interface which facilitates easy and rapid changes to both the surface and behavioral representation. This facilitates design prototyping by enabling alternative or successive Iterations of the design to be appraised by clients, system designers, human factors specialists and the end users of the interface. These iterations are desirable steps in the design of a man-machine interface.

Ebner, Rainer, Gunter Haring, Franz Penz, and Gerhard Weichselberger. 1990. A Comparative Evaluation of Graphical User-Interfaces; SIGCHI Bulletin, 22 (1): pp 12-15.

Today an increasing number of inexperienced users begin to work with personal computers. The operating system is frequently the first program the users are confronted with. Therefore its user interface for the operating system commands eases the interaction with the computer and makes computer work more attractive for computer novices.

In a study based on a questionnaire and an empirical tests three graphical system commands (GEM, Windows 1.04, Windows 2.01) are compared.

Edwards, Allen L. 1950. Experimental Design. New York: Rinehart & Company, Inc.

This book covers the research and principles of experimental designs in psychology. It explains the many variables that affect a design and explains how to analyze and manipulate the results of an experiment in great detail.

Edwards, Alistair D. N., 1988, The Design of Auditory Interfaces for Visually Disabled Users, Human Factors in Computing Systems, CHI'88: Washington, D.C., Edited by E. Soloway. pp 83-88.

Recent developments in the design of human-machine interfaces have resulted in interfaces which make access to computer-based equipment more difficult for visually disabled people. The aim of this project was to explore whether it is possible to adapt such interfaces so as to make them usable by people who cannot see a screen. Two forms of sound were used to embody the auditory interface: musical tones and synthetic speech. In order to test the principles a word processing program was implemented which demonstrated that a visual program might be adapted to accessed through such an interface.

Egenhofer. Max J., and Andrew U. Frardr., 1988, Designing Object-Oriented Query Languages for GIS: Human Interface Aspects, Third International Symposium on Spatial Data Handling; Sydney, Australia, Edited by D. Marble. pp 79-96.

Spatial information systems deal with large, heterogeneous collections of spatial and non-spatial data which require flexible methods for interactive inquiries and representation. Current databases query languages, which are well-suited to treat alphanumeric data, do not reflect the properties of spatial data. Due to these properties, query languages and interfaces for spatial information systems are more complex than purely lexical systems. In order to visualize the power needed for a spatial query language, a user interface is designed which gives specific considerations to the coexistence of representation, such as graphical renderings and lexical tables. The different properties of spatial and non-spatial data give rise to lexical formulations of queries in combination with references to graphical 'objects' or areas on maps. In particular, immediate reference to objects on drawings, with direct manipulation devices, as a crucial technique must be embedded in the interaction. Variation of graphical presentation by colors. patterns etc. demands for appropriate tools in the interface to manipulate the presentation of spatial objects. Interface snapshots are used to simulate the interaction, giving prospective users a close impression of the actual interaction during the design phase.

Egenhofer, Max J., and Andrew U. Frank, 1988, Towards a Spatial Query Language: User Interface Considerations, 14th International Conference on Very Large Data Bases: Los Angeles, CA, Edited by D. DeWitt and F. Bancilhon. pp 124-133.

Egenhofer, Max J., 1988, Designing a User Interface for Spatial Information Systems, ASPRS-ACSM Annual Convention: St. Louis, MO, vol. 5: pp 149 - 161.

Egenhofer, Max J. , and Andrew U. Frank. 1989 (in press). User Interfaces for Spatial Information Systems: Manipulating the Graphical Representation. In Geologisches Jahrbuch. Hannover, FRG:

Egenhofer, Max J., 1990, Manipulating the Graphical Representation of Query Results in Geographic Information Systems, 1990 IEEE Workshop on Visual Languages; Skokie, Illinois, pp 119-124.

GIS must frequently present query results in graphical form. The user may manipulate the graphic expression, not the database. to present the query result in various ways. Complementary functions to examine the graphical representation are necessary. The dualism between manipulation and examination is investigated and an interface employing them is described.

Egido, Carmen, and John Patterson, 1988, Pictures and Category Labels as Navigational Aids for Catalog Browsing, Human Factors in Computing Systems, CHI'88; Washington, D.C., Edited by E. Soloway. pp 127-132.

We describe two experiments that compare the relative utility of pictures, labels, and the combination for both as navigational aids for computerized catalog browsing. The results point to the usefulness of menu traversal through hierarchically structured pictorial databases. We take this outcome to be a reflection of the disambiguating role that pictures can play for verbal category labels.

Ehrich, Roger W., and Robert C. Willeges. 1986. Human-Computer Dialogue Design. New York: Elsevier Science Publishing Company.

Embretson, Susan E. 1985. Test Design: Developments in Psychology. London: Academic Press, Inc.

Examines the current problems that question the validity of psychological tests, and then goes on to recommend methods of performing trustworthy experiments for dependable results.

England, D. A- 1987. A User Interface Design Tool. In ESEC'87 lst European Software Engineering Conference. Edited by H. K. Nichols and D. Simpson. pp 110- 117.



Evans, David L., and John M. Hill. 1990. A Computer Mapping/Inquiry System for Protection of Underground Facilities. Surveying and LIS, 50 (3): pp 197-200.

An automated mapping/inquiry system was developed to demonstrate the use of GIS technology for one-call services. U.S. Geological Survey digital line graphs and a grid were incorporated into a geographic data base of West Baton Rouge Parish, Louisiana. The system was developed by use of ARC/INFO software. Menus were used to make the system "user friendly" so that operators could be quickly trained. Geographic queries for road intersections and grid locations were demonstrated. It was estimated that 60,000-plus calls per year could be processed on each workstation with this system.

Falzon, Pierre. 1990. Human Computer Interaction: Lessons From Human-Human Communication. In Cognitive Ergonomics: Understanding, Learning, and Designing Human-Computer Interaction. Edited by P. Falzon. London, England: Academic Press Ltd.: pp 51 - 66.

This chapter is dedicated to the lessons that can be learnt from studies in human-human communication to Improve human-computer interaction. The first question to consider is the applicability (or relevance) of the human-human communication model to human-computer interaction. The following questions will then be addressed:

- What type of language is used?
- What interaction mode is used?
- What dialogue strategies are used?

Since written (or typed) dialogue is not natural in human-human communication, speech communication is focused on.

Falzon, Pierre. 1990. Cognitive Ergonomics: Understanding, Learning, and Designing Human-Computer Interaction. London, England: Academic Press Ltd.

This book gathers selected papers submitted at the Third European Conference on Cognitive Ergonomics held in Paris in 1986. The book is divided into three sections: models for design, learning processes, planning and understanding. Cognitive ergonomics can be defined as the subfield of cognitive science especially concerned with human task-oriented

activity. A book on the cognitive ergonomics of human-computer interaction can thus be viewed from two standpoints: either from the standpoint of the tasks being performed (or application domains dealt with), or from the standpoint of the cognitive activities involved in completing the tasks.

Fisher, Peter F., 1989, The Institutional Context of GIS: A Model for Development, AUTO-CARTO 9; Baltimore; pp 775-779.

Proposes how a network of GIS operations might be arranged; accommodations of software packages into the GIS, proposes a general model of the idealized institutional setting of GIS.

Fisher, Scott S., and Jane Morrill. Tazelar. 1990. Living in a Virtual World. Byte, 15(7): pp 215-.

The development of a three-dimensional virtual space interface, which involves stereoscopic vision through the user of head-mounted devices, which enable the user to work in a 360 degree, 3-D environment.

Fishman, D.H., and others. 1989. Overview of the Iris DBMS. In Object-Oriented Concepts, Databases, and Applications. Edited by Won Kim and F. H. Lochovsky. Addison Wesley.

Fogel, Lawrence J. 1967. Human Information Processing. Englewood Cliffs, NJ: Prentice-Hall.

Contains an extensive review of the human sensory channels, models of decision processes and data on operator outputs. Not computer oriented. but lots of engineering data. sense(vision) smallest detectable intensity (2.2 to 5.7 X lOE-10 ergs) largest practical intensity (roughly the brightness of snow in the midday sun, or about 10E9 times the threshold) relative intensity discrimination (w/ white light there are about 570 discriminable intensity differences in a practical range) absolute intensity discrimination (w/ white light, 3 to 5 identifiable intensities in a range of 0. 1 to 50 ml). ** These data are from Mowbray and Gebhard 1958, and also reproduced in Salvendy's Handbook.

Foley, James, Christina Gibbs, Won Chul Kim, and Srdjan Kovacevic, 1988. A Knowledge-Based User Interface Management System, Human Factors in Computing Systems CHI'88; Washington DC, pp 67-72.

A knowledge base which defines a user-computer interface is described. The knowledge base serves as input to a user interface management system, which implements the user interface. However, the knowledge base represents user interface design knowledge at a level of abstraction higher than is typical of UIMS. In particular, it represents objects, actions, attributes of objects, an object class hierarchy and pre- and post-conditions on the actions. The Knowledge base can be algorithmically transformed into a number of functionally equivalent interfaces, each of which is slightly different from the original interface. The transformed interface definition can be input to the UIMS, providing a way to quickly experiment with a family of related interfaces.

Foltz, Peter W., Susan E. Davies, and Peter G. Polson, 1988. Transfer Between Menu Systems, Human Factors in Computing Systems, CHF88; Washington, D.C., Edited by E. Soloway. pp 107-112.

This paper investigates whether changes in the user/computer dialogue structure will affect the performance of users who are familiar with an earlier version of the product. Quantitative predictions using the Kieras and Polson (1985) production system model were derived to test whether changing the lexical attributes and structure of a popular menu-driven word-processor would permit transfer of existing knowledge of the word-processor to a new version. The results show that changes to the dialogue structure of the menusystem are not detrimental, while changes to the lexical attributes of the menus will hinder user performance.

Freburger, K., 1987. RAPID: Prototyping Control Panel Interfaces, OOPSIA'87; Orlando, FL, pp 416-422.

Frutiger, Adrian. 1989. Signs and Symbols: Their Design and Meaning. Translated by Andrew Bluhm. New York: Van Nostrand Reinhold.

Frutiger writes about signs and symbols in general and about the development of writing in particular. The basic principles and components of graphics are related to a wide range of considerations - historical, physical, linguistic, and practical.

Gabay, John. 1990. How Much Can Design-for-Test Reduce the Need for Testing? Computer Design, 29(17): pp 94-112.

Concepts of how the design and testing of computer products can be more closely integrated to make the production of the design more efficient.

Gagne, Robert M. 1963. Psychological Principles in System Design. New York: Holt, Rinehart, and Winston.

One of the first books on human factors engineering. It examines the psychologies behind system design, and analyzes man and machine and how they work together as a system.

Galitz, Wilbert 0. 1985. Handbook of Screen Format Design. 2 ed. Wellesley Hills, Massachusetts: QED Information Systems.

The purpose of this handbook is to provide materials to assist a designer in developing an effective screen interface between a program and its users. It is intended as a reference source for all screen design. The first two sections deal with the human considerations when designing an interface for a computer system.

Ganter, John H., 1988. Interactive Graphics: Linking the Human to the Model, GIS/LIS '88; San Antonio, TX, pp 230-239.

Discovery and innovation, which have traditionally involved thinking visually and producing images, increasingly benefit from labor-saving devices like GIS and CAD. As new visualization technologies are implemented, it is particularly important to understand the human faculties which use pictures as tools in thinking. Science and engineering define problems, explain processes, and sensing solutions through observation, imaging and logic. This conceptual thought relies on cognitive 'database' of sensed verbal and non-verbal information retained, managed, and updated within the short and long-term human memories. Research suggests that the individual must actively manipulate a phenomenon under study, and its representation. to enhance and maintain this database, and to produce abstractions and generalizations. Graphics are particularly important in this process of discovering correlation, contradiction and connection, and subsequent communication to others. Graphics offer high information density, simultaneity, variable detail and the capacity for showing multivariate relations. A 'gestalt' property leads to the discovery of new relationships since the graphic whole always exceeds the sum of its parts. A cycle occurs in which the individual interacts with the phenomenon and produces explicit knowledge in the form of graphics and text, testing and refining each against knowledge and abstraction held in the mind.

Gardiner, Margaret M., and Bruce Christie. 1987. Applying Cognitive Psychology to User-Interface Design. Chichester, England: John Wiley and Sons.

We are now seeing a trend in systems designed towards adding sophisticated "user interfaces" to the "basic machine" which effectively means that the "basic machine" can fit better with what the human finds natural and easy to do. The benefits of this trend is many. Less training is needed to use the machines. errors in using them is less likely, more complex operations can be carried out by more people. Work can be done faster, and more interesting work can be done with little or undesirable stress on the user. The design adopted for the user interface is the key to this trend. It is with the user interface that the user conducts the "dialogue" by which the work is done. The user interface is the machine, as the user sees it. This book is concerned with the relevance of what we know about human information processing to the design of the user interface, in order to achieve human-machine cognitive compatibility.

Gargan, Robert A., Joseph W. Sullivan Jr., and Sherman W. Tyler, 1988, Multimodal Response Planning: An Adaptive Rule Based Approach, Human Factors in Computing Systems, CHI'88: Washington. D.C., Edited by E. Soloway. pp 229-235.

This paper describes the architecture and prototype of a system which dynamically determines how to present information to a user. The system utilizes a rule based approach to select one or more modalities for presenting information. Next the system determines one or more techniques to present the information within each of the previously selected modalities. This system also adapts to individual user providing flexibility not found in traditional presentation systems. Finally, models are used for storing knowledge about the user resulting in a system which can be easily enhanced as new data is obtained and can adapt to the needs of its users.

Gaver, W.W. 1986. Auditory Icons: Using Sound in Computer Interfaces; HumanComputer Interaction, 2 (2) : pp 167-177.

There is growing interest in the use of sound to convey information in computer interfaces. The strategies employed thus far have been based on an understanding of sound that leads to either an arbitrary or metaphysical relation between the sounds used and the data to be represented. in this article, and alternative approach to use of sound in computer

interfaces is outlined, one that emphasizes the role of sound in conveying information about the world to the listener. According to this approach, auditory Icons, caricatures of naturally occurring sounds, could be used to provide information about sources of data. Auditory icons provide a natural way to represent dimensional data as well as conceptual objects in a computer system. They allow categorization of data into distinct families, using a single sound. Perhaps the most important advantage of this strategy is that it is based on the way people listen to the world in their everyday lives.

Gentles, Michael E.. 1989. The Power of Symbology in the GIS World, Auto-Carto 9-. Baltimore, MD, pp 781-788.

'Ibis paper examines and explains some unique ways for analyzing data with the use of symbols. Symbolic maps are an effective way of displaying data. Symbols can show a number of variables with the same display. Sixty to seventy percent of the data within an organization is geographic related and has a geographic identifier. Types of data that can be displayed using creative symbology are land- information /parcel data, socio-economic data, load studies using meters and transformers, and incident reports for crime, such as the locations where cars were stolen and recovered and violent crime has occurred.

When analyzing data with a geographic spatial placement and location, the power of the symbol is much greater than the standard 2-dimensional or 3dimensional perspectives of thematic analysis. This paper explains the uses of symbol shape, size and color to assist in the analysis of data.

Gettys, J., and R.W. Scheifler. 1986. The X Window System: ACM Transactions on Graphics, 5 (3): pp 79-109.

Gibson, J. J. 1950. The Perception of the Visual World. Boston: Houghton Mifflin.

An examination of perception as a process embedded in a dynamic 3dimensional world. Good background reading for those interested in perception in the interface.

Gillan, Douglas J., Kritina Holden. Susan Adam, Marianne Rudisill, and Laura Magee, 1990, How Does Fitts' Law Fit Pointing and Dragging, Human Factors in Computing Systems - Empowering People, CHI'90; Seattle, Washington, Edited by J. C. Chew and J. Whiteside. pp 227-234.

Two experiments examined selecting text using a movement sequence of pointing and dragging. Experiment 1 showed that, in the Point-Drag sequence, the pointing time was related to the pointing distance but not to the width of the text to be selected; in contrast, pointing time was related to the pointing distance and the width of the text in the Point-Click sequence. Experiment 2 demonstrated that both pointing and dragging times for the Point-Drag sequence were sensitive to the height of the text to be selected. The discussion of the results center around the application of Fitts' Law to pointing and dragging in a point-drag sequence, proposing that the target for pointing is the leftmost edge of the text to be selected, and the target for dragging is the rightmost edge of the text.

Gilmartin, Patricia, and Elisabeth Shelton. 1989. Choropleth Maps on High Resolution CRT: The Effects of Number of Classes and Hue on Communication: Cartographica, 26 (2): pp 40-52.

The research reported here was designed to determine how quickly and accurately map readers viewing choropleth maps on a high-resolution computer monitor are able to identify to which class an areal unit on the map belongs, when the map has between four and eight classes and is produced in shades of either gray, green or magenta. As expected, accuracy rates decreased and reaction times increased as the number of classes on the map increased. Accuracy rates ranged from 91.9% for four-class maps to 68.2% for eight-class maps (averaged for all three colors used in the study). Hue also affected accuracy rates and reaction times, the best result being obtained with achromatic (gray-shaded) maps: 84.5% correct, averaged over all numbers of classes. Maps shades with magenta proved to be the least satisfactory with an accuracy rate of 72.8%. The study provides cartographers with empirical guidelines regarding what level of map-reading accuracy might be expected for choropleth maps designed with a given number of map classes, in a specific hue, and displayed on a high-resolution graphics monitor.

Gilmore, Walter E., David I. Gertman, and Harold S. Blackman. 1989. The User Computer Interface in Process Control: a Human Factors Engineering Handbook. Boston: Academic Press.

Glegg, Gordon L. 197 1. The Design of Design. Cambridge: Cambridge University Press.

The purpose of this book is to give the young engineer some guiding principles behind designs. The book explains some thought techniques to be used in formulating a design.

Glegg, Gordon L. 1981. The Development of Design. Cambridge: Cambridge University Press.

This book focuses on the testing of a design. It explores methods of direct and indirect testing of a design. and how to expand on a prototype model.

Glinert, E.P., and J. Gonczarowski, 1987. A (Formal) Model for (Iconic) Programming Environments, Human-Computer Interaction - INTERACT'87, Stuttgart, Federal Republic of Germany, Edited by H. J. Bullinger and B. Shackel. 1: pp 283-290.

Our objective in this paper is to motivate and develop a formal model for iconic programming environments. our model for these highly visual environments is based on the concept of class-instance pairs, and is therefore named CLIP. After the exposition, we enumerate several important applications which attest to the model's utility and broad scope.

Good, Michael D., John A- Whiteside, Dennis R Wixon, and Sandra J. Jones, 1984. Building a User-Derived Interface; Communications of the ACM, 27 (10): pp 10321043.

Many human-computer interfaces are designed with the assumption that the user must adapt to the system, that the users must be trained and their behavior altered to fit a given interface. The research presented here proceeds from the alternative assumption: Novice behavior is Inherently sensible, and the computer system can be made to adapt to it. Specifically, a measurably easy-to-use interface was built to accommodate the actual behavior of novice users. Novices attempted an electronic mail task using a command-line interface, containing no help, no menus, no documentation, and no instruction. A hidden operator intercepted commands when necessary, creating the illusion of an interactive session. The software was repeatedly revised to recognize the users' new commands; in essence, the interface was derived from user behavior. This procedure was used on 67 subjects. The first version of the software could recognize only 7 percent of all the subjects' spontaneously generated commands; the final version could recognize 76 percent of these commands. This experience contradicts the idea that user input is irrelevant to the design of command languages. Through careful observation and analysis of user behavior, a mail interface unusable by novices evolved into one that let novices do useful work within minutes.

Goodwin, Nancy C. 1987. Functionality and Usability; Communications of the ACM, 30 (3): pp 229-233.

This article defines perspectives on usability and functionality as two separate issues. then draws them together by showing that instead of limiting functionality, usability complements functionality. Studies show that there is no simple answer to user interface design. Not only do different users have different requirements, but the requirements change over time. Usability and functionality determine the overall effectiveness of a system.

Gosling. W. 1962. The Design of Engineering Systems. New York.- John Wiley and Sons, Inc.

Explains the background information used in a system design, then goes into the process used. It examines the feasibility and reliability of a system as well as the human elements used in system design.

Gould, J. D., and N. Grischkowsky. 1984. Doing the Same Work with Hard Copy and with Cathode-Ray Tube (CRT) Computer Terminals: Human Factors, 26 (3): pp 323337.

Gould, John D., Clayton Lewis, and Vincent Barnes. 1985. Cursor Movement During Text Editing; ACMTrans. on Office Information Systems. 3 (1) : pp 22-34.

Nine participants used a full-screen computer text editor (XEDIT) with an IBM 3277 terminal to edit marked-up documents at each of three cursor speeds (3.3, 4.7, and 11.0 cm/s). These speeds occur when a user continuously holds down an arrow key to move the cursor more than one character position (i.e., in repeat or typamatic mode). Results show that cursor speed did not seem to act as a pacing device for the entire editing task. Since cursor speed is a form of system response, this finding is in contrast with the generally found positive relation between system-response time and user-response time. Participants preferred the Fast cursor speed, however. Overall, more than one-third of all keystrokes

were used to move the cursor. We estimate that 9-14 percent of editing time was spent controlling and moving the cursor, regardless of cursor speed.

Gould, John D., and Clayton Lewis. 1985. Designing for Usability: Key Principles and What Designers Think; Communications of the ACM, 28 (3): pp 300-311.

This article is both theoretical and empirical. Theoretically, it describes three principles of system design which the authors believe must be followed to produce a useful and easy to use computer system. These principles are: early and continual focus on users: empirical measurement of usage; and interactive design whereby the system (simulated, prototype and real) is modified, tested, modified again, tested again, and the cycle is repeated again and again. This approach is contrasted to other principled design approaches, for example, get it right the first time, reliance on design guidelines. Empirically, the article presents data which show that their design principles are not always intuitive to designers; identifies the arguments which designers often offer for not using these principles - and answers them; and provides an example in which their principles have been used successfully.

Gould, J. D., 1986, Why is Reading Slower From CRT Displays Than From Paper?,
Proceedings of the Annual Human Factors Society Meeting, Dayton, Ohio, October, 1986, pp 834-836.

Gould, John D., and Josiane Salaun. 1987. Behavioral Experiments on Handmarkings; ACM Trans. on Office Information Systems, 5 (4): pp 358-377.

Handmarkings or handwritten editing marks can be used as direct editing commands to an interactive computer system. Five exploratory experiments studied the potential value of handmarkings for editing text and pictures, as well as for some specific results. Circles are the most frequently used scoping mark, and arrows are the most frequently used operator and target indicators. Experimental comparisons showed that handmarkings have the potential to be faster than keyboards and mice for editing tasks. Their ultimate value will, however, depend on the style and details of their user-interface implementation.

Gould, J.D.. L. Alfaro, R Firm, B. Haupt, A. Minuto, and J. Salaun, 1987, Why Reading Was Slower From CRT Displays Than From Paper, Proceedings of ACM CHI + GI-' pp 7-11.

Gould. J. D., L. Alfaro , V. Barnes, R_ Finn, N. Grischkowsky, and A. Minuto, 1987. Reading is Slower from CRT Displays than from Paper: Attempts to lsolate a SingleVariable Explanation; Human Factors, 29 (3) : pp 269-299.

Gould, Michael D., and Scott Reily Love, 1988. An Easily-Customized User Interface For GIS And Map Display Systems, ASPRS/ACSM Fall 1988; Virginia Beach, Virginia, USA., 1, pp 255-264.

The user interface is the most visible yet often least optimized aspect of GIS and map display systems. Though several interface strategies have appeared in recent literature, an optimal solution has not been agreed upon. This paper suggests the use of a new programming environment, based upon the intelligent picture, for creating flexible, easily- customized. graphic- or text-oriented interfaces. Two prototype applications of this environment are discussed, each demonstrating an information system "front end" that may be optimized to suit the need of the individual user.

Gould, Michael D., 1989. Human Factors Research and Its Value to GIS User Interface
Design, GIS/LIS'89; Orlando, Florida, 2; pp 542-550.

Innovative, optimized computer systems have been developed in the fields of engineering and business, partly due to attention paid to preceding human factors research. An argument is made here for the application of relevant human factors to the design of the first truly spatially- oriented user interface, optimized to real world geographic problems and the manner in which users perceive them. Issues in human computer interaction are reviewed, with special attention paid to direct manipulation interfaces. User interfaces of the "next generation" of GIS will better exploit direct manipulation, natural language, and multi-modal input/output concepts.

Grandjean, E., and E. Vigliani. 1980. Ergonomic Aspects of Visual Display Terminals. London: Taylor and Francis.

Greenberg, Saul, and Jan H. Witten, 1988. How Users Repeat Their Actions On Computers: Principles for Design of History Mechanisms, Human Factors in Computing Systems, CHI'88; Washington, D.C., Edited by E. Soloway. pp 171-178.

Several striking characteristics of how often people repeat their actions on interactive systems are abstracted from usage data gleaned from many users of different classes over a period of months. Reformulated as guidelines for history mechanisms specifically and modern user interfaces generally. Particular attention is paid to the repetition of command lines, and to the probability distribution of the next line given a sequential "history list" of previous ones. Several ways are examined of conditioning this distribution to enhance predictive power. A brief case study of actual use of a widely-used history system is also included.

Greenberg, Saul. 1990. Sharing Views and Interactions with Single-User Applications, Conference on Office Information Systems; Cambridge, MA, 1; pp 227-.

Although work is frequently collaborative, most computer-base activities revolve around software packages designed to be used by one person at a time. To get around this, people working together often talk and gesture around a computer screen, perhaps taking turns interacting with the "single user" application by passing the keyboard around. However, it is technically possible to share these unaltered applications-even though they were designed for a single user only-across physically different workstations through special view-sharing software. Each person sees the same image of the running application on their own screen, and has the opportunity to interact with it by taking turns. This paper discusses the various roles and responsibilities of the view-sharing software that must be considered during its design and evaluation: view management, floor control, conference registration by participants, and handling of meta-level communication. A brief survey of existing shared view systems is provided for background.

Greenstein, Joel S. and Lynn Y. Arnaut. 1987. Human Factors Aspects of Manual Computer Input Devices. In Handbook of Human Factors. Edited by G. Salvendy. New York: John Wiley & Sons: pp 1451-1489.

A list of the more common computer input devices would include keyboards, touch screen devices, graphic tablets, mice, trackballs, joysticks, and light pens. Additionally, although the ability of computers to recognize speech is limited at this time, speech recognition systems are now being employed effectively certain applications, particularly those in which it is not possible or desirable to dedicate the hands to computer data entry. This chapter presents recommendations for the design and selection of manual computer input devices. In Section 11. 4.2, the human factors consider-actions affecting the design of each type of input device are considered in turn. Section 11.4.3 presents comparison data to aid in the selection of an appropriate device type for a given application. Chapter 11.5 considers the use of voice as an alternative or additional medium for the input of information to a computer.

Greenstein, Joel S., and Lynn Y. Arnaut. 1990. Input Devices. In Handbook of Human Computer Interaction. Edited by M. Helander. New York: North-Holland: pp 495519.

Reviews a range of devices and technologies (touch screen, mouse, track-ball, light pen, joy-stick, graphic tablet). Reviews literature of studies which compares these devices. Shows advantages and disadvantages for each and indicates appropriate applications. Cautions to consider the task in an experimental comparison. Considers other, innovative input devices (foot mouse, eye-tracking, gesture-based input).

Gribb, William J., 1984. The Combining of Geographical and Other information Systems to Create a New Type of Information System, Annual Meeting of the American Congress on Surveying and Mapping; Washington, D.C.; pp 14-19.

Computer technology and advanced techniques have made it possible to adapt a wide range of information for computer storage, retrieval and analysis. A problem has developed between data collectors, system users and researchers. They have not explored the interactions of similar information in the full range of mediums. Because of this lack of comprehensive planning, redundant information systems have been developed. This project dealt with combining three information systems to create an intelligent system designed to assist the researcher. The three information systems were: an environmental data base of soils and productivity indexes: a bibliographic referencing system; and a cartographic imagery system. The pilot project was concerned with soil information in Dona Ana County, New Mexico.

Grudin, Jonathan. 1989. The Case Against User Interface Consistency; Communications of the ACM. 32 (10): pp 1164-1173.

Many writers have presented the case for user interface consistency. This article argues for a shift in perspective, suggesting that when user interface consistency becomes our primary concern, our attention is directed away from its proper focus: users and their work. Interface consistency is a largely unworkable concept; the more closely one looks, the

less substance one finds. The studies that appear to support particular applications of consistency are not wrong, but their proper interpretation may be more contextually bound, less general than is explicitly recognized. Shifting the focus from general interface properties to the users' tasks and work context, to physical constraints, and to psychology does not mean defocusing.

Grudin, Jonathan. 1990. A Foolish Consistency. Byte, 15(3): pp, 364.

Guidelines for user interface designers stress consistency above other considerations. But "Consistency" is an unreliable guide. The greatest danger is that advocating user interface consistency can distract designers from the best approach to design: learning as much as possible about the application's eventual users. Consistency makes sense only if it makes users' work easier.

Grzeda, Stanislaw, 1977. Gray Scale Analysis of Cartographically Applied Line Printer Symbols, Proceedings of the American Congress on Surveying And Mapping;
Washington, D.C.; pp 293-304.

The value, percentage of area inked, of selected computer line-printer symbols may be measured. These percentages, in turn, can be utilized to test user perception based upon various gray scale theories. Such results can provide an indication of the optimal curve to which measured symbols may be related for more effective map to user communication.

This paper reports the methodology and results of such an analysis. One hundred selected line printer symbols were measured in terms of the percentage of area each covered in high contrast (offset) form. This series of measurements, in turn, provided the basis for producing classed computer line-printer maps according to four selected gray scale theories. Three hundred sixty-three college students were tested to determine if any of the gray scale theory maps were significantly chosen over the others for their ease of class differentiation.

Guedj, R A., 1986. The Evolution of Style of Interaction, Seventh International Conference on the Computer as a Design Tool;
London, Edited by A. Smith. pp 1-6.

Interactive systems are attractive to a wide range of users. They have evolved with technological advances in hardware and software. Understanding interaction has two related goals: increasing cooperation, therefore productivity, automating the design of satisfactory user interfaces. From the recent past, characteristics and features of modern interactive systems are delineated, current principals for interface design are given. Three areas of research which may influence style of interaction are considered: formal specification techniques, multimedia interaction, artificial intelligence. In conclusion. for user interface design, one particular area of importance is stressed: selection of appropriate abstractions.

Guevara, J. Armando, 1989. On The Design of Geographic Information System Procedures, Auto-Carto 9; Baltimore. Md.: pp 789-796.

This paper identifies the building blocks that have played a major role in the design and implementation of current geographic information system procedures. It then examines and proposes the following six continuity concepts as unifying elements of an evolutionary GIS.
1. Functional Continuity- the ability of a GIS to have a transparent functional flow of control.
2. Database continuity- the ability of a GIS to manage giant amounts of data on a distributed system as one logical database and have multi-user access.
3. Data structure continuity- the coexistence of vector, lattice, and raster data structures under one data model.
4. Knowledge Continuity- the utilization of artificial intelligence techniques to create database model usage schemas and create application procedures.
5. Human Interface Continuity- what makes a good GIS interface
6. Data Transfer Continuity- the ability of a GIS to exist and transfer data independent of the hardware platform.

Guindon, Raymonde, and Bill Curtis, 1988. Control of Cognitive Processes During Software Design: What Tools Are Needed?, Human Factors in Computing Systems, CHI'88; Washington, D.C., Edited by E. Soloway. pp 263-268.

Guindon, Raymonde, 1988. How To Interface To Advisory Systems? User Request Help With A Very Simple Language, Human Factors in Computing Systems, CHI'88; Washington, D.C., Edited by E. Soloway. pp 191-196.

Advisory systems can be very powerful general tools for users. Formal query languages, menus, and direct manipulation interfaces might not suffice to access natural language interfaces could be required. Unfortunately, natural language

interfaces are not meeting the needs yet. However, this study shows that users request help with a very simple and restricted English, characteristic of unplanned or of child language. Moreover, users' utterances are frequently ungrammatical. Natural language interfaces to advisory systems need not cover a wide variety of syntactic constructions but they must emphasize robust parsing.

Haggerty, Paul D., J. Jackson, and M. Ehlers, 1990. The Dirigo System: Image Processing for the Macintosh H, 13th Canadian Symposium on Remote Sensing; Frederickton, New Brunswick, Canada. pp 215-218.

While image processing systems have been available for several years, these systems have been limited primarily to the IBM PC and compatible system of computers. Image Processing systems for the Macintosh line of computers has typically been restricted to desk-top publishing and medical imaging applications. Now, with the release of standard color displays for the Macintosh Il series of computers. a 4th generation image processing system combining the power of remotely sensed data, and a graphically oriented, user-friendly interface can be realized. During a course in Image Processing. students in the Department of Surveying Engineering at the University of Maine, created Dirigo, an image processing software system designed to run on an off-the-shelf Macintosh 11 computer. This paper describes the some of the specifications and requirements which were developed for the creation of Dirigo.

Hammainen, Heikki, Juha Jahkola, and Ari Kyhala. 1986. The Intelligent Form as User Interface. In Foundation of Human-Computer Communication. IFIP. pp 424439.

End users are getting more familiar with computers and computer systems are getting more intelligent. In the near future It seems possible for endusers without technical education to utilize computers even in creative and planning oriented tasks. Simple basic concepts are needed. The Intelligent Form is a proposition for such a concept. It is an object having both visual features and processing rules. The Intelligent Form is easy to create and manipulate. It can be sent to another user or to a background server for automatic processing and it accommodates to various data types. The Intelligent Form can be seen as a high level standardised and flexible basic object for an information system.

Hammond, Nick, and Lesley Allinson, 1988. Travels Around a Learning Support Environment: Rambling, Orienteering or Touring, Human Factors in Computing Systems, CHI'88; Washington, D.C., Edited by E. Soloway. pp 269-274.

The traditionally separate application areas supported by database systems and instructional systems are merging in the area of learning support environments (LSEs). We discuss the provision of tools in LSEs for navigating around large knowledge bases. The optimal form of navigation will depend on the nature of the user and of the learning requirements, and thus a variety of tools must be provided. We propose the use of a travel holiday metaphor as a means for structuring a set of navigation tools and illustrate its use in a system for teaching non-formal fields of knowledge.

Hancock, P. A., and M. H. Chignell. 1989. Intelligent Interfaces: Theory, Research, and Design. New York: Elsevier Science Pub.

Hansen, Wilfred J., and Christina Haas. 1988. Reading and Writing With Computers: A Framework for Explaining Differences in Performance; Communications of the ACM, 31 (9): pp 1080-1089.

Seven factors are sketched that affect user performance when reading and writing with computers. Recent research indicates that both quality and quantity depend upon page size, legibility, responsiveness, and tangibility.

Hanson, Stephen Jose, and Carl R Olson. 1990. Connectionist Modeling and Brain Function: The Developing Interface. Cambridge, MA: MIT Press.

Harris, R Allen. 1990. Linguistic Guidelines for Graphic Interfaces; IEEE Trans. on Professional Communication, 33 (1) : pp 46-53.

This paper presents a series of ten principles to help cope with this new challenge-dealing with lexical, syntactic, and display issues of writing for the graphic interface.

Hartal, Paul Z. 1988. The Brush and the Compass: The Interface of Art and Science. Lanham: University Press of America.

Hartson, H. R and D. Dix. 1989. Human Computer Interface Development; ACM Computing Surveys, 21 (1): pp 92.

As the "Gestalt of the computer" [Rosenburg 1974] becomes more pervasive in our society. the key to the real effectiveness of computers is usability by people other than computer professionals. As the above quotation suggests, the possibilities of this amazing machine are limited not by its power to compute, but rather by its power to communicate

with its human users. Relative to advances in approaches to software design, the important issue of human-computer interface development has begun to be addressed only recently. The increasing interest in this area has been diverse and, at times, disorganized. Although many researchers have proposed viable solutions to specific issues. these issues have generally been addressed without a framework or a broader strategy for managing the whole development of human-computer interfaces.

A key to building such a framework lies in reassessing the entire software development process, with particular emphasis on development of the human-computer interface as an integrated part of that process. That reassessment has begun, and this article identifies and examines the major concepts in human-computer interface management that have emerged. It uses specific systems to illustrate these concepts, which can be used to classify and describe system features and approaches.

This paper has been a long time in the writing. When it was started in 1982, its intent was to explain some of the basic early concepts in an embryonic field. Most of what is now in the field did not exist then. There was almost no common terminology; even now terminology is not consistently established. The ACM SIGCHI (Special Interest Group on Computer-Human Interaction) was formed during the time this manuscript was being written and revised. Human-computer interaction is now an area of research and practice with broadly recognized impact and increasing rate of growth. Like any survey, this paper is a representative snapshot of the subject
at a given point in time.

Hary, Joseph M., Lori A. Cohan, and Michael J. Darnell, 1988. Users' Preferences Among Different Techniques for Displaying the Evaluation of Lisp Functions in an Interactive Debugger, Human Factors in Computing Systems, CHI'88; Washington, D.C., Edited by E. Soloway. pp 45-50.

Two experiments investigated various techniques for displaying the evaluation of LISP functions in an interactive debugger. The studies examined three techniques of highlighting the flow of evaluation in a LISP function and two display formats for displaying LISP function information. The subjects in both experiments included highly experienced LISP programmers and occasional LISP users with moderate to little LISP experience. The results showed that occasional LISP users preferred range highlighting, an interlaced display of called functions.

Havens. William, and Alan Mackworth. 1983. Representing and Using Knowledge of the Visual World; Computer, 16 (10): pp 90-96.

Methodology for the representation of knowledge is a fundamental aspect of research in computational vision. The properties of objects and the relationships among objects must be represented for a given task domain and the representation must also support efficient processes of recognition and search. These twin criteria for evaluation knowledge representations are called descriptive adequacy and procedural adequacy respectively and are applicable to both early visual processing and high-level visual recognition. All vision requires knowledge representations which exhibit both descriptive and procedural adequacy. The knowledge representations which have been used in high level vision are examined. In particular, well-understood network consistency representations are shown to have a number of inherent limitations. The use of schemata as a unifying representational formalism is proposed. Mapsee2, uses this representation and is used to illustrate the advantages of schema based techniques.

Hayes, Frank and Nick Bar-an, 1989. A Guide to GUls; Byte, 14 (July) : pp 250-257.

Heckel, Paul. 1984. The Elements of Friendly Software Design. , New York: Warner Books.

'Ibis book helps provide some useful meaning to the term "friendly" software, both for the customer, who should know what to expect, and for the software designer who wants to make software "friendly", but is unsure of how to go about it.

Hendar, James A. 1988. Expert Systems: The User Interface. Norwood, NJ: Ablex Publishing Corporation.

Henderson, D.Austin and Stuart K. Card. 1987. Rooms: The Use of Multiple Virtual Workspaces to Reduce Space Contention in a Window-Based Graphical User Interface; ACM Trans. On Graphics, 5 (3): pp 211-243.

A key constraint on the effectiveness of window-based human-computer interfaces is that the display screen is too small for many applications. This results in "window thrashing", in which the user must expend considerable effort to keep desired windows visible. Rooms is a window manager that overcomes small screen size by exploiting the statistics of window access, dividing the user's workspace into a suite of virtual workspaces with transitions among them.

Mechanisms are described for solving the problems of navigation and simultaneous access to separated information that arise from multiple workspaces.

Henry, Bradford B., 1981. Automated Mapping in Minneapolis and Hennepin County Minnesota, Annual Meeting of the American Congress on Surveying and Mapping: Washington, D.C., pp 194-200.

The paper describes the engineering design and interactive graphics system called MAPS jointly developed and used by the City of Minneapolis and Hennepin County, Minnesota. The system was initially used solely for the production of automated plan and profile engineering plan sheets. Data for the plan sheets is digitized from aerial photos, processed by the computer and updated by hand coded data or interactive graphics. Automation if the engineering plans has halved manpower requirements between 1974 and the present. MAPS is now taking advantage of the ability of computers to store and selectively reproduce large amounts of data. A county-wide property basemap tied into state plane coordinates is being built. A trial project is now underway with the local gas, telephone and electric utilities analyzing the benefits of storing their facilities within this property map framework. MAPS is also capable of producing an unlimited variety of planning maps.

Henry, Tyson P_ and Hudson Scott E. 1990. Multidimensional Icons; ACM Trans. On Graphics, 9 (1): pp 133-137.

Direct Manipulation interfaces, such as the Macintosh desktop, often represent objects with icons. For example, text files are represented by icons. Selection of the icon invokes an editor to view the file it represents. thus the icon not only represents the text file but also represents text editor used to view the text file. Each type of object is viewed by using a specific program. Diagram objects, for example, require a graphical editor to view. In a typical iconic interface, icons represent a single view of an object.

While the single-view single-icon model has proven very intuitive and easy to use, some objects have more than one logical view. Program code can be viewed as text by using a text editor or it can be viewed as program code by a compiler. The machine code that corresponds to the program can be thought of as another view, thus the execution of program can be thought of as another view of program code. This paper describes a mechanism for grouping a set of icons that depict several views of a single object into one multidimensional icon.

Multidimensional icons group sets of icons, each describing a unique view of an object, into a single entity. The individual icons are projected onto the sides of a simulated cube. there are two distinct advantages to using a cube instead of displaying all the icons in a menu. The first advantage is that since cubes are familiar objects, it is a natural mental model to think of the faces of a cube as views of the entire cube-views of the entire object. The second advantage is that by allowing rotation of the cube, several icons representing views of an object are accessible using only a fraction of the screen space required to display all the icons.

Hill, William C., and James R Miller, 1988. Justified Advice: A Semi-Naturalistic Study of Advisory Strategies, Human Factors in Computing Systems, CHI'88, Washington, D.C., Edited by E. Soloway. pp 185-190.

"Wizard of Oz" techniques were used to observe the interaction between users of a statistical package and a human playing the role of an simulated intelligent advisory system. The results emphasized the complexities of the advisory process. More than half of the clients' requests sought help on planning actions toward achieving task goals. The relevance of these findings to the development of intelligent advisory systems is discussed.

Hirakawa, Masahito. Noriaki Monden, Iwao Yoshitmoto, Minoru Tanaka, and Tadao Ichikawa. 1986. HI-VISUAL: A Language Supporting Visual Interaction in Programming. In Visual Languages. Edited by T. I. Shi-Kuo Chang Panos A. Ligomenides. New York: Plenum Press: pp 233 - 259.

A new concept for attaining a friendly interaction between user and computer in which the visual icon plays a particularly important role can be described as a process of "seeing and pointing". In this paper, they present a language named HI-VISUAL, which derives its name from "Hiroshima Visual" and is based on the hierarchical multiple window model. This model accurately represents the structure of pictures to be displayed in the multiple windows on a display terminal using the elements viewports, region-frames. and desks, and also makes it easy to control the appearance of those pictures.

Hoadley. Ellen D. 1990. Investigating the Effects of Color, Communications of the ACM, 33 (2): pp 120-125.

The purpose of this study is two-fold: theory development and practical application. Specifically. the study focuses on answering the following questions: (1) Is there a significant difference between subjects' performance in an information extraction task using multicolor vs. monocolor information presentations? and (2) Does the use of color have different effects on performance with different forms of information presentation when the colors are used in the same way across the various form? If so, what are these differences?

The experiment tested a number of subjects' response times and accuracies during a series of information extraction tasks in which the data was presented in a variety of forms. These forms consisted of mono- and multicolor pie charts, line graphs, bar charts and tables.

Results indicated that whether the use of color produced better accuracy or response times depended on the form of the data presentation, i.e. bar vs. pie charts.

Hoc, Jean-Michel. 1988. Towards Effective Computer Aids to Planning in Computer Programming: Theoretical Concerns and Empirical Evidence Drawn from Assessment of a Prototype. In Working with Computers: Theory versus Outcome. Edited by G. C. V. D. Veer. San Diego: Academic Press Inc: pp 215-247

Holahan. 1982. Environmental Psychology. New York: Random House.

The nature and history of environmental psychology; environmental perception, cognition, and attitudes: performance in learning and work environment: coping with environmental stress: privacy and territoriality-, personal space: environment and behaviour; a unifying framework.

HolInagel, Erik, Guiseppe Mancini, and David D. Woods. 1988. Cognitive Engineering in Complex Dynamic Worlds. San Diego, CA: Academic Press.

The book (derived from a special issue of the International Journal of ManMachine Studies) addresses the problem of how we should deploy the power available through developments in computational technology (e.g. object oriented programming, expert systems, natural language interfaces) to assist human performance in complex problem solving worlds, i.e., cognitive engineering. 17 authors.

Holynski, M. 1988. User-Adaptive Computer Graphics; International Journal of Man-Machine Studies, vol. 29: pp 539-548.

Discovering user preferences with respect to variables such as business, complexity. color variety. shape variety, balance, symmetry, etc.

Hopkins, Ronald H., Kenneth B. Campbell, and Nils S. Peterson. 1987. Representation of Perceived Relations Among the Properties and Variables of a Complex System, IEEE Trans. on System, Man, and Cybernetics, SMC- 17 (1): pp 52-60.

Three different techniques for representing human understanding of complex systems were compared. Novice veterinary students and cardiovascular research experts made judgements of the relations among the properties and variables of a complex system, the mechanical heart/blood vessel system. They also described the variables and properties by a series of bipolar ratings. A variety of analyses showed that the novices tended to conceptualize the system in static anatomic terms. Experts showed a more integrative conceptualization and distinguished more clearly than students between relations involving only system properties and those involving system variables. The methods of multidimensional scaling, agglomerative hierarchical clustering. and elementary digraphs were used to represent perceived relations among system variables and properties. It was concluded that the simplest form of representation, a digraph, has several advantages over the other representations.

Hoppe, H. U., 1988. Task-Oriented Parsing - A Diagnostic Method to Be Used by Adaptive Systems, Human Factors in Computing Systems, CHI'88: Washington, D.C., Edited by E. Soloway. pp 241-248.

In order to be able to show context-dependent responses to user's actual needs, adaptive systems have to be provided with models of possible task contexts. Existing methods for the representation of tasks in HCI are insufficient for this purpose as they do not support task-oriented parsing (i.e. analyzing the input steam in terms of higher level task units). This paper presents a Prolog implementation of a task-oriented parser (+ generator) based on a grammar notation called

LEXITAS. As an application, an online coach for a UNIX-like file management system is described. Further applications, such as automated macro detection from given interaction protocols, are discussed.

Hopper, K. and 1. A. Newman. 1986. Foundation for Human Computer Communication, Amsterdam: Elsevier Science Publishers.

This book covers the 1986 IBM convention on human-computer communication and the questions and discussion that followed. The authors hope that through these questions and discussion research in these areas shall be stimulated.

Horton, William. 1990. Visual Rhetoric for Online Documents; IEEE IYans. on Professional Communication, 33 (3) : pp 108-114.

Online documentation is primarily a visual medium. Many well-written online documents fail because their visual design does not account for the many differences between the paper page and the display screen. Nor do they take advantage of the display power of the computer. This article provides guidelines for practitioners based on extensive research on computer display.

Houghton, Raymond C. 1984. Online Help Systems: A Conspectus; Communications of the ACM, 27 (2): pp 126-133.

Online help systems provide a range of assistance from simple command assistance to elaborate and detailed tutoring. Specifically, the types of assistance offered include command, help and error assistance; prompting, online tutors; and online documentation. 'Ibis article examines the different types of currently available help systems, addressing the design issues involved in developing and implementing them and pointing to some remaining areas where more research is clearly in order.

Hudson. S.E., 1990. Adaptive Semantic Snapping - A Technique for Semantic Feedback at the Lexical Level, Human Factors in Computing Systems-Empowering People CHI'90, Seattle, Washington, Edited by J. Chew and J. Whiteside. pp 65-70.

This paper describes the implementation of semantic snapping -- an interaction technique that provides semantic feedback at the lexical level while dragging a graphical object on the screen. Like conventional snapping, or gravity fields, semantic snapping includes a geometric component where objects in close proximity are drawn together or "snap" into position. However, semantic snapping goes further by allowing non-geometric (semantic) properties of objects to place additional constraints on snapping. Semantic snapping also provides more complex lexical feedback which reflects potential semantic consequences of a snap. This paper motivates the use of semantic snapping and describes how this technique has been implemented in a window-based toolkit. This implementation works in an adaptive manner to provide the best interactive response in situations where semantic tests are very time consuming and strain the limits of acceptable performance.

Hunka, George, and Stanley Damon, 1979. Engineering Evaluation of an Aided-Track Digitizing Cursor System, Annual Meeting of the American Congress on Surveying and Mapping; Washington, D.C.. pp 522-546.

An aided-track cursor for digitizing cartographic material was interfaced with a Lineal Input System. and engineering tests were conducted to determine achievable accuracies and improvements in digitizing efficiency over the present tracing methods. The aided-track cursor tolerates operator tracing errors, correcting them by counts generated from a linear photosensitive array incorporated into the cursor. Features being digitized are imaged onto the array, and encoder outputs are then modified by the array counter prior to transfer onto a storage medium.

Developed by RADC, the Lineal Input System (LIS) is incorporated into the production centers of the Defense Mapping Agency. This system consists of a central computer hosting several digitizing stations, providing interactive operations for identifying, digitizing, editing, storing, and selective updating of cartographic information.

This paper describes the concepts and test results of an aided-track cursor system in conjunction with related fundamental features of the Lineal Input System. It presents results obtained during the engineering phase of the development program. These results are presented as comparative error histograms for the aided-track versus normal station tracking modes of operation. Comparative output plots and digitizing times of representative cartographic features are also shown.

Histograms show that the aided-track system outputs are consistently superior in accuracy when measured against the unaided-track outputs. Average standard deviation of error are 1.59 mils for the aided-track data versus 3.57 mils for normal trace data. Tracing speed tests further indicate that improvements of greater then 3:1 can be realized by the aided-track system.

Ichikawa, Tadoo and Masahito Hirakawa. 1990. Iconic Programming: Where to Go? IEEE Software, 7(6): pp 63-.

The advantages iconic languages can offer to software developers, if used with traditional textual languages. The article bases its theories on past research and observation.

Ives, Blake, Margrethe H. Olson, and Jack J. Baroudi. 1983. The Measurement of User Information Satisfaction; Communications of the ACM. 26 (10): pp 785-793.

This paper critically reviews measures of user information satisfaction and selects one for replication and extension. A survey of production managers is used to provide additional support for the instrument, eliminate scales that are psychometrically unsound, and develop a standard short form for use when only an overall assessment of information satisfaction is required and survey time is limited.

Jacob, Robert J. K. 1986. A Visual Programming Environment For Designing User Interfaces. In Visual Languages. Edited by Shi-Kuo Chang and Panos A. Ligomenides. New York- New York: Plenum Press: pp 87 - 107

People have long used iconic representations to describe algorithms to other people: mechanical diagrams and procedural flowcharts are examples. But most computers require that algorithms be converted to linear strings of symbols in order to be executed. so algorithms written for computers have been restricted to symbolic representations. The current technology of personal graphic-based workstations will permit people to revert to a more natural visual or iconic mode to describe their algorithms to computers. While linear, symbolic computer languages have been studied and refined over the last 30 years, the challenge facing computer language designers today is to provide convenient and natural visual programming languages.

Jacob, Robert J. K. 1986. A Specification Language for Direct-Manipulation User Interfaces; ACM Transactions on Graphics, 5 (4): pp 283-317.

A direct-manipulation user interface presents a set of visual representations on a display and a repertoire of manipulations that can be performed on any of them. Such representations might include screen buttons, scroll bars, spreadsheet cells, or flowchart boxes. Interaction techniques of this kind were first seen in interactive graphics systems; they are now proving effective in user interfaces for applications that are not inherently graphical. Although they are often easy to learn and use, these interfaces are also typically difficult to specify and program clearly.

Examination of direct-manipulation interfaces reveals that they have a coroutine-like structure and, despite their surface appearance, a peculiar, highly moded dialogue. This paper introduces a specification technique for direct-manipulation interfaces based on these observations. In it, each locus of dialogue is described as a separate object with a single-thread state diagram, which can be suspended and resumed, but retains state. The objects are then combined to define the overall user interface as a set of coroutines, rather than inappropriately as a single highly regular state transition diagram. An inheritance mechanism for the interaction objects is provided to avoid repetitiveness in the specifications. A prototype implementation of a user-interface management system based on this approach is described, and example specifications are given.

Jacober, Robert P., 1979. Standardization and Computerization of Symbology for Engineering Scale Maps, Annual Meeting of the American Congress on Surveying and Mapping; Washington, D.C.: pp 410-415.

This paper reports research towards the development of a set of computer compatible map symbols that could be adopted as a national standard for use on large scale engineering maps.

Jarvenpaa, Sirkka L., and Gerardine DeSanctis. 1988. Standard Scaling in Decision Graphs: An Empirical Investigation; IEEE Trans. on System, Man, and Cybernetics, SMC- 18 (5): pp, 824-83 1.

With the proliferation of workstation -based end-user technology, the generation of graphics is shifting to individuals who lack formal training in graphics design. This trend increases the possibility that poorly designed graphics will be used in decision making. An experiment is reported that examined graphs that conformed to and which violated existing graphics standards regarding scaling in the context of financial forecasting. The experiment found that these specific violations of the scaling standards were tolerable when graphs were used for decisionmaking.

Jenkins, Ian. 1988. Safety and Human Factors in Manned Space Flight Systems. In Human Factors and Design Making. Edited by B. A. Sayers. New York: Elevier
Science Publishers IAd: pp 23-38.

This paper summaries the NASA safety review process for Space Shuttle Payloads, showing trend and changes which have occurred since the Challenger accident. Technical safety requirements for different programs are presented. The Safety Program for the European manned space programs are outlined.

Jeyanandan. 1988. A Systems Approach to Land information Systems. Surveying and Mapping, 48(7): pp 161-171.

The systems concept is reviewed and applied to Land Information Systems. The nature of data, information and decision is reviewed and the need for classification of different LIS is presented.

Joffe, Bruce A., and William Wright, 1989, Simcity: Thematic Mapping + City Management Simulation = An Entertaining, Interactive, Gaming Tool, GIS/LIS'89 Proceedings, Orlando, FL, 2: pp 591-600.

A description of the SimCity microcomputer software. The program provides an interesting amalgam of GIS and simulation. The interface allows control and modification of a complex spatial system.

Johannsen, G., J.E. Rijnsdorp. H. Tamura. 1986. Matching User Needs and Technologies of Displays and Graphics. In Analysis, Design and Evaluation of Man-Machine Systems. Edited by G. J. G.Mancini L. Martensson. Oxford: Permagon Press: pp 5 1 -61.

This survey paper deals with the fundamental changes of user system interactions caused by new displays and graphics technologies. The information needs of users are explained with examples from industrial process control, train operation, aircraft piloting and computer aided design. These needs are contrasted with the state-of-the-art in display and graphics technology, particularly with that of visual display units, computer graphics systems and dialogue techniques. Further, perceptional and cognitive aspects such as readability of character sets. memorization of commands and icons, highlighting and windowing, degrees of abstraction, and information overload are discussed. All these relate to technological solutions for meeting human information needs.

Johnson, E. A. 1967. Touch Displays: A Programmed Man-Machine Interface. In (Proceedings of the conference on) The Human Operator in Complex Systems. Edited by W. T. Singleton, R. S. Easterby and D. C. Whitfield. London: Taylor and Francis, Ltd.: pp 171-177.

Contains "The idea of the Touch Display was conceived at R. R. E. [Royal Radar Establishment] in an attempt to overcome the limitations in manmachine communications indicated above [keyboard, function keys & alphanumeric commands]." Describes the touch screen as a method to select from a range of alternatives (couched in terms of selecting a letter or numeral). It is seen as a way to reduce the number of alternatives (all keys on the keyboard from which an operator must choose. Allows the meaning of a choice to change in different contexts. The R.R.E. system allowed bounce reject (100 msec delay) on touches and always provided a "step back" choice so that mistakes could be undone. Also provided for confirmation of destructive commands. They were very pleased with an air traffic control station in which the operator simply pointed to the call letters of an aircraft to signify that its flight plan was to be updated as opposed to the alternative of typing the call letters.

Johnson, Jeff, and Teresa L. Roberts. 1989. The Xerox Star; Computer, 22 (9) : pp 11 -26.

Xerox introduced the 8010 "Star" Information System in April of 198 1. That introduction was an important event in the history of personal computing because it changed notions of how interactive systems should be designed. Several of Star's designers, some responsible for the original design and others for recent improvements, describe in this article where Star came from, what is distinctive about it, and how the original design has changed. In doing so, we hope to correct some misconceptions about Star that we have seen in the trade press and to relate some of what we have learned from designing it. For brevity, the name "Star" refers to both Star and its successor. ViewPoint. "ViewPoint" refers exclusively to the current product.

Johnson, Jeff and Engelbeck, George. 1989. Modes Survey Results; ACM SIGCHI, 20 (4): pp 38-50.

Though user-interface researchers and designers give similar definitions for the concept of modes in interactive systems and devices, informal evidence suggests that they don't always agree on whether or not particular interfaces are moded. A

survey was conducted to determine the extent to which this is true. The results show that there is widespread disagreement among user interface designers and researchers about what modes are, independent of the issue of how modes affect users.

Jones, J. Christopher, 1970. Design Methods. New York: John Wiley & Sons Limited.

Book focuses on the methods used in developing a design process and focuses on design methods already being used. It encompasses a wide range of strategies used as well as methods for evaluating a design.

Jones, Christopher. Thomas 0. Tindall, and Richard L. Rosenthal, 198 1. ThreeDimensional Terrain Graphics for the Battlefield, Annual Meeting of the American Congress on Surveying and Mapping; Washington, D.C.; pp 538-545.

Research at the US Army Engineer Topographic Laboratories (ETL) have developed a mobile interactive computer graphics system which utilizes standard Defense Mapping Agency prepared digital elevation data bases to produce 3-D representations of the terrain. The system's minicomputer and peripherals are capable of operation outside of a controlled environment. This van-mounted experimental system called the Field Exploitation of Elevation Data (FEED) system is designed to provide the developmental link between laboratory-generated graphics and battlefield-generated graphics. The motivation for the FEED program is discussed. FEED hardware, software and demonstration van are described and examples of FEED graphics are included. Application of FEED system graphics on the battlefield is also discussed.

Jones, Dylan, Kevin Hapeshi, and Clive Frankish. 1987. Human Factors and the Problems of Evaluation in Design of Speech Systems Interfaces. In People and Computers 3. Edited by D. Diaper and R Winder. Cambridge: Cambridge University Press: pp 41 - 49.

As part of a project in the Alvey programme, during the next two years we will be carrying out experimental studies aimed at generating human factor guidelines for the design of automatic speech recognition systems for avionics and office applications. The planning of the programme of experimental work has thrown up some unique and interesting methodological issues. Firstly, there are a range of factors which can affect performance in the speech recognition system. Secondly. the choice of dependent variable is not easy, since there are a number of possible "yardsticks" by which recognition performance can be assessed. none of which are, on their own, entirely satisfactory. In this paper we describe these methodological problems and suggest some possible solutions.

Kairam, R., 1989. Software Design for Display and Analysis of Integrated Spatial and Non-Spatial Data, GIS/LIS'89; Orlando, FL, 2; pp 761-770.

Geographic Information Systems that manage large volumes of spatially oriented information are maintained by departments and organizations that could afford and support mainframes or minicomputers. Microcomputer based GISs are now providing the functionality that was previously possible on the larger machines. However, these systems tend to be rather complex and, for certain categories of users, are not most effective. Once the needs of users /organizations are evaluated and the requirements are established, it is possible to design and develop an application to provide the environment and functionality those users are likely to benefit from. This paper presents, based on experience, a description of the planning and design of various components that constitute the development of such a system.

Kantorowitz, Eliezer, and Oded Sudarsky. 1989. The Adaptable User Interface; Communications of the ACM, 32 (11): pp 1352-1358.

A single adaptable user interface (AUI) which allows the user to switch between any number of different dialogue modes at any time - even in the middle of a command - can be useful to a variety of users who are neither beginners nor experts. It can also be used in applications where different dialogue modes are appropriate for the various parameters of a single command.

Kantowitz, Barry H., and Robert D. Sorkin. 1983. Human Factors: Understanding People Systems Relationships. New York, New York: John Wiley arid Sons.

Human factors specialists can be crudely arranged along a spectrum ranging from psychologists - who are so concerned with theory that they never solve any problem - to engineers - who are so anxious to solve the problem they solve the wrong one. This text balances these two extremes while believing the judicious application of theory offers the best hope for rapid progress in human factors. The text emphasizes the important topics of human computer interaction, human information processing, environmental aspects of human factors, and the legal issues in human factors. Serves as a very solid introductory text. Good sections on vision and target detection and identification. Good treatment of history of RT

paradigm. Good chapter on visual displays. Has picture of Brassel and Utano's crime map. sections on text and program editing environments. Treats also physical anthropomorphometric design, but is very cognitively oriented..

Karat, John, James E. McDonald, and Matt Anderson. 1986. A Comparison of Menu Selection Techniques: Touch Panel, Mouse and Keyboard, Int. Journ. Man-Machine Studies. 25: pp 73-88.

Two studies compared user performance and preference for menu selection using touch panel, mouse. and keyboard. One study was menu selection only-, the other mixed menu selection with entering text. Touch panel performance was better, possibly because it is more natural, involving less cognitive processing to use.

Kass, Robert, 1988, A General User Modelling Facility, Human Factors in Computing Systems, CHI'88; Washington, D.C., Edited by E. Soloway. pp 145-150.

An important component of adaptable interactive systems is the ability to model the system's users. Previous systems have relied on user model, and describes some of our research on building a general user modelling facility that could be used by a variety of applications. This work focused on the representation, maintenance, and acquisition issues of modelling long-term beliefs of the user, and describes a general facility for accomplishing these tasks.

Kelly, J. F. 1984. An Iterative Design Methodology for User-Friendly Natural Language Office Applications; ACM Trans.on Office Information Systems, 2 (1): pp 26-41.

A six-step, iterative, empirical human factors design methodology was used to develop CAL, a natural language computer application to help computernaive business professionals manage their personal calendars. Input language is processed by a simple, nonparsing algorithm with limited storage requirements and a quick response time. CAL allows unconstrained English inputs from users with no training (except for a five minute introduction to the keyboard and display) and no manual (except for a twopage overview of the system). In a controlled test of performance, CAL correctly responded to between 86 percent and 97 percent of the storage and retrieval requests it received. according to various criteria. This level of performance could never have been achieved with such a simple processing model were It not for the empirical approach used in the development of the program and its dictionaries. The tools of the engineering psychologist are clearly invaluable in the development of user-friendly software, if that software is to accommodate the unruly language of computer-naive, firsttime users. The key is to elicit the cooperation of such users in an iterative, empirical development process.

Kelly, C.D., R. N. Taylor, and others, 1988. Design Principles Behind Chiron: A UIMS for Software Environments, Proceedings, 10th International Conference on Software Engineering: pp 367-376.

Kempson, Ruth M. 1988. Mental Representations: The Interface Between Language and Reality. New York: Cambridge University Press.

Kim, Won S.. Stephen R. Ellis. Mitchell E. Tyler, Blake Hannaford, and Lawrence W. Stark- 1987. Quantitative Evaluation of Perspective and Stereoscopic Displays in Three-Axis Manual Tracking Tasks: IEEE Trans. on System, Man, and Cybernetics, 17 (1): pp 61-72.

Optimal presentation of three-dimensional information on a twodimensional display screen requires careful design of the projection to the display surface. Monoscopic perspective projection alone is usually not sufficient to represent three-dimensional spatial information. It can, however, be improved by the adjustment of the perspective parameters and by geometric visual enhancements such as reference lines and a background grid. Stereoscopic display is another method of providing three-dimensional information the human operator. Two experiments are performed with three-axis manual tracking tasks. The first experiment investigates the effects of perspective parameters on tracking performance. The second experiment investigates the effects of visual enhancements for both monoscopic and stereoscopic displays. Results indicate that, though stereoscopic displays do generally permit superior tracking performance. monoscopic displays can allow equivalent performance when they are defined with optimal perspective parameters and provided with adequate visual enhancements.

Kimura, Kenji, Yoshimasa Osumi, and Yoshihiro Nagai. 1990. CRT Display Visibility in Automobiles; Ergonomics, 33 (6): pp 707-718.

Three experiments were carried out into aspects of CRT display in the context of driving automobiles. The first focused on the combination of colours which renders information 'east-to-read', and determined the relationship between luminance contrast and chromaticity difference. In the second a background luminance which was not dazzling at night was expressed in a chromaticity diagram. In the third the amount of information which can be read 'at-a- glance' was investigated.

Kindborg. Mikael, and Anita Kollerbaur. 1987. Visual Languages and Human Computer Interaction. In People and Computers 3. Edited by D. Diaper and R. Winder. Cambridge: Cambridge University Press: pp 41 - 49.

Graphical interfaces have made computers easier to use for people who are not computer experts. Visualization of system status and ongoing processes has enhanced the user's understanding of how various computer-based tools work and can be used. In addition, the interaction via pointing and direct manipulation of symbols and images (for example dynamic windowing and rubberbanding), is often considered to be stimulating and enjoyable.

However, most existing systems employ only a limited number of those graphical techniques and visual effects available. Several other media use sophisticated languages. Comics for example, use voice balloons, visual symbols and graphical effects to communicate actions. events, feelings etc to the reader. Their integration of text and pictures into lexivisual presentation is well suited for communicating information and instructions. the paper discusses how modes of expression in lexivisual presentation and comics enhance the communication process between the human and the computer.

Kirk, Roger E. 1968. Experimental Design: Procedures for the Behavioral Sciences. Belmont, CA: Brook/Cole Publishing Company.

A detailed coverage of the complex designs and techniques available in behavioral science.

Kobsa, Alfred. 1989. User Models in Dialog Systems. New York: Springer-Verlag.

This volume consists of four parts: Part 1 contains three survey chapters, the first introducing the field of user modeling, and the two others analyzing important modeling techniques and user models, respectively. Part 2 deals with the construction, and part 3 with the exploitation, of user models by a dialog system in an ongoing dialog. Part 4 analyzes shortcomings of user models as developed to date and outlines promising directions for future research.

Korf, Richard. 1988. Search: A Survey of Recent Results,. In Exploring Artificial Intelligence. Edited by H. Shrobe. Morgan Kaufmann: pp 197-238.

Korf, Richard. 1988. Optimal Path Finding Algorithms. In Search in Artificial Intelligence. Edited by Kanal and Kumar. Springer-Verlag.

Kosslyn, Stephen M., and Christopher F. Chabris. 1990. Naming Pictures; Journal of Visual Languages and Computing, 1 (1) : pp 77-95.

Picture are inherently ambiguous but people categorize and name pictured objects with remarkable consistency. However, the time to assign a name to a picture depends on a large number of variables, ranging from the quality of the picture itself to the level of hierarchy and frequency of the name. We review the empirical results in the psychological literature on how people name pictured objects, summarizing the major variables that affect the name assigned and the time spent assigning it. The underlying regularities in these data are explained by properties of three mechanisms used in picture naming: bottom-up perceptual encoding; hierarchical associative memory; and top-down knowledge-based search. The properties ascribed to these mechanisms are hypothesized on the basis of computational analyses and considerations of characteristics of the neural systems underlying vision.

Koved, Larry, and Ben Shneiderman. 1986. Embedded Menus: Selecting Items In Context; Communications of the ACM, 29 (4): pp 312-318.

In many situations, embedded menus represent an attractive alternative to the more traditional explicit menus, particularly in touchtext, spelling checkers, language-based program editors, and graphics-based systems. Using embedded menus makes it easier to avoid computer-related syntax and semantics issues when referring directly to the

object being manipulated. When compared to command driven systems, computer menu systems are appealing because they reduce memorization of commands, reduce training, and structure the user's decision making.

Krammer, G., 1986. The Interface Between Humans and Their Computer Work-Stations. Seventh International Conference on the Computer as a Design Tool; London,
Edited by A. Smith. pp 15-19.

Interactive work-stations are computers installed in an office environment and equipped with a collection of software to be able to perform a variety of tasks. In some cases a work-station is used like a tool. e.g., when typing a letter, in some others it is more like a partner. The capabilities and the role of user's partner should be clearly identified and a consistent interaction interface developed.

Kroemer, K. H. E., H. J. Kroemer, and K. E. Kroemer-Elbert. 1990. Engineering Physiology: Bases of Human Factors/Ergonomics (2nd ed). New York: van Nostrand Reinhold.

An interesting book on engineering physiology. For those interested in human computer interaction, the first chapter, on anthropometry, provides a good concise review of statistical measures used in human factors research and some guidelines on selecting sample sizes and calibrating models.

Kuhn, Werner, 1990. Are Displays Maps or Views?, Auto-Carto 10; Baltimore, Maryland. pp 261-274.

Metaphors are powerful means to structure and learn user interfaces of computer systems. This paper discusses metaphors for display operations in Geographic Information Systems (GIS). Specifically, the metaphor DISPLAYS ARE VIEWS is proposed and analyzed. It is claimed to be superior to the metaphor DISPLAYS ARE MAPS, which is consciously or unconsciously adopted by designers and users of most GIS interfaces. Views are understood here as visual fields, containing what humans see in a given situation. The major advantage of the visual field as a metaphor source is that it naturally accommodates scale changes. Thus, analyzing its structure also sheds new light on the generalization problem for displays.

Kuhn, Werner, and Andrew U. Frank. 199 1. A Formalization of Metaphors and ImageSchemas in User Interfaces. In Cognitive and Linguistic Aspects of Geographic Space. Edited by D. M. M. a. A. U. Frank. Kluwer Academic Press.

Kunii, Tosiyasu L. 1986. Computer Graphics. Academic Press, Inc.

This book covers the following eight major frontiers of computer graphics: 1) geometry modeling, 2) graphic languages, 3) visualization, 4) human factors, 5) interactive graphics design, 6) CAD/CAM, 7) graphics displays, peripherals, and graphics standardization.

Kunkel, Klauss, and Thomas Strothotte. 1990. Visualization and Direct Manipulation in User Interfaces: Are We Overdo. In Visualization in Human-Computer Interaction. Edited by P. Gomy. Springer-Verlag: pp 183-193.

This paper proposes the use of bimodal input (speech coupled with direct manipulation) as a means of allowing users to take fuller advantage of the visualization of information. It describes an empirical study with 72 senior high school students and manufacturing apprentices working with two prototypical interfaces for a program to produce technical diagrams. One allowed bimodal interaction. An improvement of over 15% in the subjects working-speed was attained with the bimodal interface. Further, no significant increase in their cognitive workload was observed. These results suggest that speech may be a viable complement to direct manipulation techniques in user interfaces.

Lai, Poh-Chin, 1984. Geocartographic Education Responsibilities In Automated Mapping, Annual Meeting of the American Congress on Surveying and Mapping; Washington, D.C.; pp 467-474.

Computer involvement in cartography has begun to show signs of established significance. Many government agencies and private enterprises are already in the midst of automating their mapping routines and. as a result, there is an increased tendency to involve individuals with insufficient training in the use of sophisticated cartographic displays in automated map production. Maps are traditionally created by cartographers. who have adequate knowledge of map production, by means of conventional cartographic methods which lack consistency and assessment criteria. Automation requires spelling out the exact sequence and rules throughout the process of making maps and, in many cases. traditional cartographic conventions cannot be imitated by machines. There is an urgent need for the education of users of automated mapping systems in the necessary background and art of map making along with the various restrictions

brought on by automation. The process of automated map production is a highly complex one. At the lowest level it consists of two primary constituents: (1) geocartographic principles and (2) programming logic. A successful computer cartographer should possess sufficient expertise in both distinct fields of knowledge. The ultimate product of such expertise is the ability to create readable maps without abusing the flexibility and versatility factors made possible by automation.

Lakoff, George, and Mark Turner. 1989. More than Cool Reason. Chicago: Universtiy of Chicago Press.

The book examines poetic metaphors on Life, Death and Time, and seeks to explain the power and function of metaphor. One thesis is that simple metaphors are built into structures "composites." Distinguishes metaphor and metonymy on page 103 (metaphor maps a schematic structure in one domain into one in another domain -- metonymy is where a part of one schema is used to activate another part or the whole of the same schema. metaphor is central to thought, not just a poetic device. 19 ref. Index of metaphors.

Lamberti, Donna M., and William A. Wallace. 1990. Intelligent Interface Design: An Empirical Assessment of Knowledge Presentation in Expert Systems: MIS Quarterly, 14(3): pp 279.

Lantz, Keith A. 1986. An Architecture for Configurable User Interfaces. In Foundation for Human-Computer Communication. Edited by K. hopper. IFIR pp 257-275.

An architecture for user interface design and implementation is presented which is based upon two basic principles. First, software is decomposed into modules corresponding to four basic classes of user interaction, namely lowlevel terminal 1/0. command specification and response handling, application- specific interaction and multi-application management. This decomposition helps to localize software changes, regardless of the stage to which design and development has progressed. It also contributes to the realization of the second principle, which is that it should be possible to configure the user interface by dynamic replacement of modules as well as by table-driven tuning. For most operating system and programming language environments, the ability to replace models dynamically should lead to more rapid prototyping. Two implementations of these concepts are presented, both within the framework of a workstation-based distributed system. A number of refinements to the basic architecture are also presented.

Larkin, I. N. 1987. The User Is Always Right; Info. & Softw. Tech., 29 (4): pp 214-218.

An interface should offer more facilities than just the ability to get data in and out. Each user has different preferences such as icons, mouse or prompt commands. A UK management consultancy has developed a user interface management system which gives the user a variety of options. At present, the Software Engineering Toolkit has six components, others are under development.

The six components are: inSET- an interaction handler with associated development utilities, windowSET - a window manager with programmable input translation, onSET - a host-independent operating system interface, dataSET - a data management system, sqISET - a database enquiry language built on top of dataSET, and graphicSET - a 3D graphics package with lines, areas. text, shading and color.

The paper discusses inSET and windowSET in some detail.

Larson, James A. 1986. Visual Languages For Database Users. In Visual Languages. Edited by Shi-Kuo Chang and Panos A. Ligomenides. New York: Plenum Press: pp 127-147.

Graphs representing a description of a database can be used as the basis for various types of interfaces, with each interface suitable to a different type of database user. Manipulating graphs is a powerful tool for database administrators in database design. This paper describes four interfaces that use entity relationship (E-R) graphs: Interface for forms administrators to create forms templates used to display data from a database; Interface of DBMS users to formulate requests by directly manipulating the E-R graph; Interface for novice users learning a traditional DBMS command language; and Interface for database administrators to design databases.

Ledgard, Henry, Andrew Singer, and John Whiteside. 198 1. Directions in Human Factors in Interactive Systems; New York, Springer-Verlag.

This book is organized in two major parts. The first part, Chapter 1 through 4, discusses issues in the design of interactive systems. By "interactive" we mean any system where the user and computer engage in a dialogue. The second part, Chapter 5 through 8, discusses the design of experiments. Ultimately, validation of any design principle requires that it be tested, and experimentation is beginning to play an important role in computer science.

Leveson, Nancy G. 1986. Software Safety: Why, What, and How; ACM Computing Surveys, 18 (2): pp 125-163.

Software safety issues become important when computers are used to control real-time, safety-critical processes. This survey attempts to explain why there is a problem, what the problem is and what is known about how to solve it. Emphasis is placed on delineating the outstanding issues and research topics.

Levy, Steven. 1990. Mitch's Manifesto; Macworld, 7(10): pp 57-68.

This article is a look at Mitch Kapor, creator of Lotus and a software entrepreneur, and his feelings on the design of a good user interface and its relationship to good software design. Kapor advocates complete software design and not just production, a good user interface on a bad program is not acceptable.

Also discussed in the proliferation of featuritis, a phenomenon which results in programs that are no longer intuitive to use. Ibis is the case even for programs designed to run on the Mac. long touted as having the most friendly of interfaces.

The article also includes a discussion of Kapor's efforts to convince the academic community that the study of software design should be treated as a discipline with the same stature as, perhaps, architectural design.

Lien, Y. Edmund, and Susan K Harris. 1980. Structured Implementation of an image Query Language. In Pictorial Information Systems. Edited by S. K. Chang and K. S. Fu. Berlin: Springer-Verlag: pp 416 - 427.

An image data base management system and its query language, IQ, are presented. Facilities for the user to create, store, retrieve, manipulate, and display images are provided. Among the basic manipulation operations are windowing, overlaying, pixel transformation, false coloring, and zooming. The capability of the system is furthered by allowing the user to define his own windows, pixel transformations, color functions, and zoom scales. Structured top-down programming was used to enhance readability and manageability of the software. This approach also permits ease of expansion in either new graphic devices or new software capabilities. Above all, the approach helps to localize device dependencies and operating system dependencies.

Lindbloom, Bruce J. July 1989. Accurate Color Reproduction for Computer Graphics Applications; Computer Graphics, 23 (3): pp 117-126.

A method is presented for accurate color reproduction among a wide variety of display devices. The method is very general, in that it may be applied to virtually any color display devices. Its generality has been demonstrated by application to color monitors, film recorders, electronic pre-press systems and color hardcopy devices. The algorithm has been used to accurately translate between device dependent and device independent color specifications and to translate from one device dependent color specification to another. The method separate the color reproduction process into two distinct components: device characterization, which accounts for the colorimetric properties of each class of display device, and device calibration, which accounts for local variations from one instance of a device to another. A new RGB color space is introduced, which is used with trivariate parametric polynomial volumes (i.e. hyperpatches) to perform accurate color transformations. A color separation algorithm is presented which converts RGB to and from the subtractive printing colors (cyan, magenta, yellow, black) using gray component replacement.

Lloyd, Robert. 1988. Searching for Map Symbols: The Cognitive Process; The American Cartographer].5 (4): pp 363-377.

Map images can be used to solve spatial tasks by employing processes similar to those used when looking at a cartographic map. Information encoded from a map, however, may not necessarily be stored as an analogue image of the map. This is likely to be the case when a person encodes information from a map to be used for a particular task. An experiment was performed where subjects searched cartographic maps displayed on a monitor to determine if particular map symbols were present. Relationships between the reaction time and the number of symbols on the map indicated that

subjects who were viewing the maps were using a serial self-terminating search process. A similar experiment was conducted with subjects who encoded the information on maps into memory and then determined if a particular map symbol has been on the memorized maps. Relationships between reaction times and the number of symbols on the memorized maps indicated that a parallel search process was used by the memory subjects. Error rates were much higher for the memory subjects compared to the perception subject. Figure-ground relationships on the maps did not significantly affect reaction times for either the perception or memory subjects.

Lloyd, Robert. 1989. The Estimation of Distance and Direction from Cognitive Maps; The American Cartographer, 16 (2) : pp 335-3109-12244.

Theories to explain errors in cognitive maps typically have been related to characteristics of environments and cognitive mappers. Other sources of error are the processes used to learn and recall spatial information. this study investigated the effects of encoding and decoding processing on errors in cognitive maps when spatial knowledge was acquired only from a cartographic map. Subjects estimated distance and direction from routes on a map of a hypothetical environment that was part urban and part rural, while looking at the map and from memory.. Memory groups acquired the spatial information by writing verbal directions for traversing routes and by sketching routes. Subjects who looked at the map to make their estimates were faster and more accurate than memory subjects. The memory subjects overestimated shorter distances and underestimated longer distances. Perception subjects consistently overestimated distances. Perception subjects and memory subjects appeared to be using different cognitive process to make some estimates. Subjects generally took longer and were less accurate when making estimations for urban routes compared to rural routes. This would appear to be caused by the turns, cross streets and additional verbal information associated with the urban part of the map.

Logan, Thomas L., Nevin A Bryant, Richard K. Fretz, Barbara A. McGuffle, K. Franklin Evans, and Lee F. Johnson, 1987, CAD/CAM/hUpping Interfaces with the VICAR/EEIIS Image Processing and GIS System, ASPRS-ACSM Annual Convention; Baltimore, MA, 5; pp 130-140.

Long, J., and A. Whitefield. 1989. Cognitive Ergonomics and Human-Computer Interaction. Cambridge, England: Cambridge University Press.

The book provides detailed reports of a number of long-term research projects, set within a framework for describing cognitive ergonomics activities and understanding their relationships. It reports in detail on substantial empirical investigations, rather than being a summary of specific areas or theoretical speculations.

Luce, R Duncan. 1959. Individual Choice Behavior. New York: John Wiley and Sons, Inc.

The psychology of making choices from a set of well-defined alternatives.

MacGregor, D., and P. Slovic. 1986. Graphic Representation of Judgmental Information; Human-Computer Interaction, 2 (3): pp 179-200.

Graphic displays are important for organizing information for decision making. Research has produced mixed results; graphic formats appear to facilitate Judgmental performance in some contexts, but not in others. The two studies reported here examine the relative efficacy of a set of basic graphic display formats, such as might be used to summarize data in an information system. in a task calling for individuals to integrate a set of information cues into an overall judgment. A "lens model" is used as a decompositional framework for representing the relationship between the elements of the information displays and the psychological properties of the multicue judgment task. Combined results from the two studies suggest that judgmental performance is markedly enhanced or degraded by the degree to which the display format provides the user with an organizing structure that facilitates a matching between the relative importance of information and the psychological salience of the display's graphic features.

Machlis, Sharon. 1990. Visualization Simplifies Data Interpretation: Design News, 46(20): pp 25-26.

This work examines the growth and use of visualization in simulation software to give engineers quick feedback on designs.

Mack, Robert L., Clayton H. Lewis, and John M. Carroll. 1983. Learning to Use Word Processors: Problems and Prospects; ACM Trans. on Office Information Systems, 1 (3): pp 254-271.

Computer text editors are powerful, but complex, tools. Particularly in the early stages of learning, the complexity of these tools can cause serious problems for users who are not experienced with computers. The problems of new users were studied by asking the users to think out loud while learning to use word-processing systems. In this paper several of the most typical and debilitating problems these users had understanding and following directions in using training manuals, as well as problems understanding and using interface functions to accomplish word processing tasks. are taxonornized and analyzed. Approaches for improving design features of the interface functions and the training methods used for learning are discussed.

Mackinlay, J. 1986. Automating the Design of Graphical Presentations of Relational Information; ACM Transactions on Graphics, 5 (2) : pp 110- 14 1.

The goal of the research described in this paper is to develop an application-independent presentation tool that automatically designs effective graphical presentations (such as bar charts, scatter plots, and connected graphs) of relational information. Two problems are raised by this goal: The codification of graphic design criteria in a form that can be used by the presentation tool, and the generation of a wide variety of designs so that the presentation tool can accommodate a wide variety of information. The approach described in this paper is based on the view that graphical presentations are sentences of graphical languages. The graphic design issues are codified as expressiveness and effectiveness criteria for graphical languages. Expressiveness criteria determine whether a graphical language can express the desired information. Effectiveness criteria determine whether a graphical language exploits the capabilities of the output medium and the human visual system. A wide variety of designs can be systematically generated by using a composition algebra that composes a small set of primitive graphical languages. Artificial intelligence techniques are used to implement a prototype presentation tool called APT (A Presentation Tool), which is based on the composition algebra and the graphic design criteria.

MacLean, Allan. 1987. Human Factors and the Design of User Interface Systems: EASIE as a Case Study; Information and Software Technology, 29 (4): pp 192-201.

The design and role of User Interface Management Systems (UIMS) is discussed from a human factors perspective. In particular, attributes which are typically considered to be important for UIMS design are discussed in relation to different types of tasks which a UIMS might be expected to facilitate. This helps us to understand why current systems are not necessarily as successful as one might hope. The design of the Experimental Applications System for Integrated Environments (EASIE) is outlined. This system, specifically designed to ease the implementation of user interfaces for carrying out human factors research, has two distinct layers of dialogue specification to maximize both simplicity and flexibility in producing dialogues. The MUltiple Structured Levels of Interface (MUSLI) is introduced to show how the design principles behind EASIE may be used more generally in designing UIMS for other families of applications.

Macworth, Alan K., 1977, On Reading Sketch Maps, International Conference Artificial Intelligence; pp 598-606.

A computer program, named MAPSEE. for interpreting maps sketched freehand on a graphical tablet is described. The emphasis in the program is on discovering cues that invoke descriptive models which capture the requisite cartographic and geographic knowledge. A model interprets ambiguously the local environment of a cue. By resolving these interpretations using a new network consistency algorithm for n-ary relations, MAPSEE achieves an interpretation of the map. It is demonstrated that this approach can be made viable even though the map cannot initially be properly segmented. A thoroughly conservative, initial, partial segmentation is describe. The effects of its necessary deficiencies on the interpretation process are shown. The ways in which the interpretation can refine the segmentation are indicated.

Mahling, Dirk E. and W.Bruce Croft, 1990, An Interface for the Acquisition and Display of Office Procedures, Conference on Office Information Systems; Cambridge, MA, 1: pp 123-130.

A central problem in the design of intelligent office systems is the acquisition of knowledge about office procedures. In this paper we describe a graphical interface for the acquisition and display of office procedures from a goal- and plan-based perspective. The DACRON interface is based on a model of the office workers view of work. DACRON supports the acquisition of plan knowledge by providing graphical representations of domain entities from the users point

of view. It allows the display and view of office procedures graphically. An experimental usability study, involving more than twenty subjects, shows that DACRON can be used to acquire plan knowledge and give relevant advice.

Mainguenaud, Michel, and Marie-Aude Portier, 1990, CIGALES: A Graphical Query Language for Geographical information System, 4th International Symposium on Spatial Data Handling, Zurich, Switzerland, pp 393-404.

In this paper we present a graphical query language for Geographical Information Systems. This language is based on a graphical Query-By-Example-like (QBE) philosophy. A set of graphical primitives (icons) represents data or operations such as inclusion, intersection, etc. The user-defined query is made by composition of these icons. The application of the icons defines the query as the data are supposed to be. This graphical query is then transformed into a functional-based -language query. This expression is compiled into specific Data Management System orders or graphical operators. The main contributions of this language are its simplicity to express a query and its representative power.

Malone, Thomas W. 1983. How Do People Organize Their Desks? implications for the Design of Office Information Systems; ACM IYans. on Office Information Systems, 1 (1): pp 99-112.

This paper describes a series of interviews focusing on the way professional and clerical office workers organize the information in their desks and offices. A number of implications for designing "natural" and convenient computer-based information systems are discussed. Two principal claims are made: (1) A very important function of desk organization is to remind the user of things to do, not just to help the user find desired information. Failing to support this function may seriously impair the usefulness of electronic office systems, and explicitly facilitating it may provide an important advantage for automated office systems over their nonautomated predecessors. (2) The cognitive difficulty of categorizing information is an important factor in explaining how people organize their desks. Computer-based systems may help with this difficulty by (a) doing as much automatic classification as possible (e.g., based on access dates), and (b) including untitled "piles" of information arranged by physical location as well as explicitly titled and logically arranged "files." Several other implications for the design of electronic office systems are discussed, and some differences in how people organize their desks are described.

Mandl, Peter, 1990. A Shell for a Geographical Data Visualization System (GDVS) on PC Using Some Commercial Available Programs, 4th International Symposium on Spatial Data Handling; Zurich, Switzerland, Edited by K. Brassel and H. Kishimoto. Vol 1; pp 443-449.

The concepts and the structure of the first version of a Geographical Data Visualization System (GDVS) is presented. In this system a dozen of commercial available programs running on PC under MS-DOS are combined for the processing of geographical data. Special importance is attached to the creation of a user friendly shell to manage all the programs including detailed but well structured help libraries. The linkages between an the different data structures is provided by the relations databank dBASE IV and already existing or self-written interface programs. The visualization aspect for geographical data is discussed in a conceptual way. Finally planned expansions of the system are outlined.

Mark, David, 1987. On Giving and Receiving Directions: Cartographic and Cognitive Issues, Auto-Carto 8: Baltimore, MA, Edited by N. R Chrisman. pp 562-571.

Analysis of 20 sets of navigation directions, prepared to accompany invitations to events, is used to examine both cartographic and cognitive issues related to intra-urban navigation. First, maps are more commonly used(18 out of 20 examples) than are verbal- procedural instructions (7- 19) . even when a common trip-origin can be assumed. It appears that correct street orientation and a north arrow, are highly desirable features of a navigation aid. whereas neither an absolute scale nor even correct relative scale is important. Landmarks were present on 14 of the 18 maps; these included traffic lights, fast food outlets, gas stations, supermarkets, etc. Implications of these results both for automated in-car navigation aids and for acquisition of spatial knowledge, are presented.

Mark, David M., 1989. Cognitive Image-Schemate for Geographic Information: Relations to User Views and GIS Interfaces, GIS/LIS'89; Orlando, Florida, 2; pp 551560.

Image-schemata are idealized conceptual models for human perception and cognition. Many such schemata are spatial, and some are geographic. Users interact with Geographic Information Systems (GISs) in order to learn about, or make decisions about the world. This paper contends that optimal user interfaces for GIS will be based on image-schemata for geographic and other spatial phenomena. The concept of user views also relates to this schemabased approach. An early focus on users and interfaces is important in systems design, especially for systems to be used by people for different disciplines. cultures, and languages.

Marr, David. 1980. Vision. New York: W. H. Freeman and Co.

This is a classic in computational vision, treating in detail information processing and information representation issues in getting from raw image input to higher level scene understanding. It contains algorithms, and equations sufficient to implement most of the ideas presented.

Marsh, Shaun. 1990. Human-Computer Interaction: An Operational Definition; ACM SIGCHL 22 (1): pp 16 - 22.

This paper poses an operational definition for the term Human-Computer Interaction and distinguishes it from the term Human Interface. HumanComputer Interaction includes several separate communication paths between the human and the computer's natural environment, the computer's own ergonomics, an operating environment, and an application environment. Each of these paths occur in parallel and have a dialog and interface component. A distinction is made between those dialog stages which allow multiple interpretation of symbols (soft-dialog) and those that allow only one interpretation for each symbol (hard-dialog). The term User Dialog includes only the soft-dialog stages and the User Interface consists of the mechanisms for communicating the user dialog.

Martin, James. 1973. Design of Man-Computer Dialogues. Edited by G. E. Forsythe. Automatic Computation. Englewood Cliffs, New Jersey: Prentice-Hall.

A guide to the design of man-machine dialogues: detailed examination of the many types of real-time man-computer interface, especially for commercial and management-information systems.

Masson, Michael E.J., 1988. Misconceived Misconceptions?, Human Factors in Computing Systems, CHI'88; Washington, D.C., Edited by E. Soloway. pp 151-156.

Detailed user activity scripts from two previous studies of novice users working at a command language or a direct representation interface were submitted to independent expert judges for the justified ascription of misconceptions. Our initial hypothesis was that behavioral evidence for such misconceptions comes about as a result of well articulated hypothetical reasoning. Although the evidence we obtained supports this view, it also suggests that for the direct representation case some activity normally attributed to misconceptions is non-reasoned in nature and governed by inherent powers of the representation.

Massone, G. Adorni and L. 1986. Graphic and Natural Language: An Integrated Interface for Man-Machine Interaction. In Analysis, Design and Evaluation of Man-Machine Systems. Edited by G. J. G.Mancini L. Martensson. Oxford: Permagon Press: pp 267-274.

This work presents a system which integrates a flexible natural language interface with interactive graphics. A user can interact with the system through either 1) a world modelling system CWMS) or ii) a natural language interface. VTMS allows definition of physical objects by means of a concept description language and storage of their properties in a conceptual database as well as execution of graphic and geometric operations on defined objects(graphic language).GL can also be accessed by the NLI by means of declarative sentences. NLI is a general purpose tool which can be configured by the user for a specific application domain modelling interactively the semantics of the Italian language. The application domain considered in this work is the synthesis of scenographics

Maulsby, D.L., and I.H. Witten, 1989. Including Programs in a Direct-Manipulation Environment. CHI'89; Austin. Texas, Edited by K. Bice and C. Lewis. pp 57-62.

End users who need to program within highly interactive direct-manipulation interfaces should be able to communicate their intentions through concrete demonstration rather than in terms of symbolic abstraction. This paper describes a system that learns procedures in interactive graphics taught to it "by example" by minimally trained users. It shows how techniques of machine learning and reactive interfaces can support one another-the former providing generalization heuristics to identify constraints implicit In user actions, the latter offering immediate feedback to help the user clarify hidden constraints and correct errors before they are planted into the procedure. the teacher's attention is focused on the learning system's perceptual and inferential shortcomings through a metaphorical apprentice called Metamouse, which generalizes action sequences on the fly and eagerly carries out any actions it can predict. The success of the induction process is assessed quantitatively by counting erroneous predictions made during example tasks.

Maulsby, David L., Ian H. Witten, and Kenneth A. Kittlitz. July 1989. Metamouse Specifying Graphical Procedures by Example; Computer Graphics, 23 (3): pp, 127136.

Metamouse is a device enabling the user of a drawing program to specify graphical procedures by supplying example execution traces. The user manipulates objects directly on the screen, creating graphical tools where necessary to help make constraints explicit; the system records the sequence of actions and induces a procedure. Generalization is used both to identify the key features of individual program steps, disregarding coincidental events; and to connect the steps into a program graph, creating loops and conditional branches as appropriate. Metamouse operates within a 2D click-and drag drafting package, and incorporates a strong model of the relative importance of different types of graphical constraint. Close attention is paid to user Interface aspects, and Metamouse helps the user by predicating and performing actions, thus reducing the tedium of repetitive graphical editing tasks.

McAleese, R, 1987. The Graphical Representation of Knowledge as an Interface to Knowledge Based Systems, Human-Computer Interaction - INTERAC-r87; Stuttgart, Federal Republic of Germany. Edited by H. J. Bullinger and B. Shackel. 1; pp 1089-1093.

This paper reports on a technique for portraying the detail and the extent of knowledge on a graphical interface. Research has centered on concept maps which derive from ideas such as "hypertext". Such maps represent the structure and inter-connections between concept labels in knowledge structures. A "map" is a bounded view of one aspect of the overall knowledgedata structure. A map is a synonym for a browser. Users can decompress (expand) or compress (reduce to a minimal level) concept relationships based on selection criteria. This map metaphor is based on cognitive theory that supports the representation of knowledge. In knowledge elicitation the chosen interface gives the expert a network metaphor of their knowledge. Each concept (concept label) can be seen as a label with a finite set of links. As the knowledge structure grows a variety of browsers allow the user to see all or part of the knowledge base. Users can select a topic label as the starting point for a browser, define its limits and specify the type of links (relationships) to be included. Such an interface is a powerful tool as it uses the human eye, which has under used channel capacity, to process complex data structures. The system has been implemented on a workstation which allows multiple windows in a WIMP environment. Knowledge can be entered at any level, compressed (top to down) or decompressed (bottom to up). The system (called KIM: Knowledge and Information Mapping) keeps integrity between different views. The paper reports on user trials with the system. It suggests that problems can arise when the user can not easily reconcile different views and perspectives. The paper highlights the importance of "terrain knowledge" of knowledge based systems (global views), in addition to "street knowledge" (local views).

McAvinney, Paul. 1990. Telltale Gestures; Byte, 15 (7): pp 237-240.

Most workstations available today allow (in the case of a mouse) simultaneous manipulation of only two parameters. While it’s possible to specify and manipulate representations of 3-D objects with a mouse, decomposing a six-parameter task into at least three sequential two-parameter tasks is time- consuming, counter- intuitive and error prone. It is also a waste of time, given advances in the field of gesture-based input devices.

Transferring spatial knowledge from people to computers has been an intractable bottleneck in CAD applications, possibly because today’s formal computer languages represent that knowledge inappropriately. By gaining the ability to gain human expression, computers can provide a better alternative to traditional methods of design.

McDonald, James E., Mark E. Molander, and Ronald W. Noel, 1988. Color-Coding Categories in Menus, Human Factors in Computing Systems, CHY88; Washington, D. C., Edited by E. Soloway. pp 10 1 - 106.

Categorical menu layouts are currently designed according to conventions and opinions, rather than by employing formal techniques. In this paper we describe a formal methodology for categorically organizing menus. We go on to show how color-coding can be applied to these layouts either to emphasize organization or to provide additional information. The results of a controlled study comparing layouts based on frequency of co-occurrence and similarity show that the formal menu-layout methodology is effective.

McGranaghan, Matthew, 1985. Symbol and Background Value Effects in Choropleth Maps for Color CRT Display. Annual Meeting American Conference On Surveying and Mapping; Washington, D.C.: pp 356-363.

Ain experiment is reported which tested the applicability of traditional color use guidelines to the design of choropleth maps for display in the color CRT environment. The experiment explored the interplay of choropleth map symbol color

values and the value of the background upon which the map is presented. The empirical evidence gathered indicates that the guideline of using darker symbols to represent areas with more of a phenomenon is generally appropriate, but that the use of a dark ground for the map will tend to lessen the effect. The use of the binary combinations of the three CRT primaries as choropleth map symbols is discouraged as map readers tend not to order these colors well.

McGranaghan, Matthew, David M. Mark and Michael D. Gould, 1987. Automated Provision of Navigation Assistance for Drivers, American Cartographer, 14(2): pp 121-138.

Advancing computer technology has made possible automated navigation aids for drivers. These aids are supported by sufficient positioning and data storage technology. The most crucial component of these systems, the user interface, is also the least understood. Few cartographers have anticipated and concerned themselves with the unique design demands of information display in this environment. Several questions about the suitability of current user interfaces are raised and future research needs identified.

McGranaghan, Matthew, 1988. Effects of Background Chromaticity and Luminance on interpreting Color-Coded Area Symbols in maps and other CRT Displays, Society for Information Display, International Symposium Digest of Technical Papers, Anaheim, CA. May 23-27: pp 81-84.

McGranaghan, Matthew, 1988. Symbolizing Quantitative Differences on Color CRTs, NSMRL Report # 1115, Naval Submarine Medical Research Laboratory, New
London, CT.

McGranaghan, Matthew, 1989. Ordering Chloropleth Map Symbols: The Effect of Background, American Cartographer, 16(4): pp 279-285.

Guidelines for chloropleth map design have concentrated on printed maps. This paper examines whether the conventional use of darker symbols to mean "more" is applicable on maps presented In other media. Forty-seven subjects performed map reading tasks using slides photographed from a CRT screen. Results indicate that map readers take darker symbols for ..more" in these displays. Further, the tendency for map readers to take darker symbols to represent greater magnitudes is modified by the value of a map's background. Approximately one-fifth of the experimental subjects reversed symbol order because of background value. Backgrounds of intermediated value impeded symbol ordering. This evidence suggests that for at least some subjects, a map's background anchors map symbols and influences their apparent order.

McGuigan, F. J. 1990. Experimental Psychology. Englewood Cliffs, New Jersey: Prentice Hall.

Describes methods of research used to examine and design various types of experiments in the field of psychology.

McKendree, Jean, and Jay Zaback, 1988. Planning for Advising, Human Factors in Computing Systems. CHI'88; Washington, D.C., Edited by E. Soloway. pp 179-184.

Effective advice depends on knowledge of the plans and goals of the person requiring help. Planning advice must be at a cognitively appropriate level for the user. HICCUPS. a dynamic playing system for a direct manipulation statistics program, is based on an ideal user model. Plans are generated from goals inferred from explicit goal statements from the user, knowledge about the statistics program, and the recent interactions with the interface. This exploitation of environmental information and inherent domain structure to restrict the amount of search and inferencing is a vital part of intelligent reasoning which is both fast and effective.

McLaren. R. A., 1989, Visualization Techniques and Applications within GIS, AutoCarto 9; Baltimore, Maryland. pp 5-14.

The recent advances in computer graphics rendering techniques coupled with the availability of digital terrain model information have opened up new possibilities in viewing and analyzing spatial information within a GIS environment. Terrain and landscape visualization techniques ranging from simple wire-frame models through to photorealistic rendering approaches such as ray tracing and radiosity are reviewed. The techniques are then placed within the context of a variety of GIS applications including: spatial analysis, urban planning, architectural design, cartography, highway and traffic engineering, and environmental impact assessment.

McMaster, R B., and M. Monmonier, 1989. Graphic Scripts for the Sequenced Visualization of Geographic Data, GIS/LIS'89; Orlando, FL, 2; pp 390-403.

Spatial filters and other raster-mode generalization techniques have received a great deal of attention in the literature on geographic information systems. These techniques fall into four principal categories: (1) structural generalization, (2) numerical generalization, (3) numerical categorization, and (4) categorical generalization. With a focus on the visual effects of generalization, this paper identifies fundamental operators and both reviews and evaluates the variety of techniques used for generalizing rastermode images. Additionally, it presents a conceptual framework for rastermode generalization, which can guide the development of a generalization subsystem useful in GIS applications.

McRae, Stephen D., 1989. GIS Design and the Questions Users Should Be Asking, GIS/LIS'89 Proceedings, Orlando, Florida, 2: pp 528-537.

In my work, I find many potential or new GIS users seriously underestimate the complexity of implementing a GIS. By raising warning flags, I wish to alert this group to potential problems and arm them with specific questions to which they should receive answers. Additionally, I wish to lay out a systematic way of looking both at geographic information systems (GIS) as a system per se and at the GIS design process in order to provide conceptual aids which may help in dealing with that complexity.

Meister, David . 197 1. Human Factors: Theory and Practice. New York: John Wiley & Sons,Inc.

Describes and guides the human factors specialist for his specific discipline.

Meister, David. 1989. Conceptual Aspects of Human Factors. Baltimore, MD: The Johns Hopkins University Press.

A description of the technical and nontechnical factors and the conceptual and attitudinal variables influencing the discipline of Human Factors. A philosophical orientation, with suggestions for overcoming problems.

Meyer, Gary W., Holly E. Rushmeier, Michael F. Cohen, Donald P. Greenberg, and Kenneth E. Torrance. 1986. An Experimental Evaluation of Computer Graphics Imagery: ACM Transactions on Graphics, 5 (1): pp 30-50.

Accurate simulation of light propagation within an environment. and perceptually based imaging techniques are necessary for the creation of realistic images. A physical experiment that verifies the simulation of reflected light intensities for diffuse environments was conducted. Measurements of radiant energy flux densities are compared with predictions using the radiosity method for those physical environments. By using color science procedures the results of the light model simulation are then transformed to produce a color television image. The final image compares favorably with the original physical model. The experiment indicates that, when the physical model and the simulation were viewed through a camena, subjects could not distinguish between them. The results and comparisons of both test procedures are presented within this paper.

Mills, Carol Bergfield, and Linda J. Weldon. 1987. Reading Text from Computer Screens; ACM Computing Surveys, 19 (4): pp 329-358.

This paper reviews empirical studies concerning the readability of text from computer screens. The review focuses on the form and physical attributes of complex, realistic displays of text material. Most studies comparing paper and computer screen readability show that screens are less readable than paper. There are many factors that could affect the readability of computer screens. The factors explored in this review are the features of characters, the formatting of the screen. the contrast and color of the characters and background, and dynamic aspects of the screen. Numerous areas for future research are indicated.

Mitchell, Christine M., and Donna L. Saisi. 1987. Use of Model-Based Qualitative Icons and Adaptive Windows in Workstations for Supervisory Control Systems; IEEE Trans. on System, Man, and Cybernetics. SMC- 17 (4): pp 573-593.

Model-based qualitative icons and adaptive window display interfaces may be valuable tools to enhance the effectiveness of operators in real-time data-intensive supervisory control systems. Qualitative icons may be used to integrate low-level quantitative data into high-level qualitative error detection mechanisms. Using windowing technology, multiple data sources that reflect different aspects of system state can be displayed simultaneously on a single screen. Both

technologies were combined and implemented to design an operator interface to the Georgia TechMultisatellite Operation Control Center (GT-MSOCC). An operator function model for GT-MSOCC was used to derive workstation features, including hardware configuration, the function of qualitative icons for monitoring, fault detection and identification. and the contents and placement of computer windows. The model also determined sets of windows needed by the operator to undertake major operator control functions. An experiment was performed to evaluate the effectiveness of a workstation incorporating model-based qualitative icons and dynamic operator function window sets. Subject controlled GT-MSOCC via either a conventional operator interface or the model-based interface. Eleven measures that reflected operator performance were analyzed. Subjects using the model-based workstation operated the system significantly better on nine of these measures. On all measures, performance with the model-based workstation was uniformly better on average and had less variability than performance with the conventional workstation.

Moeller, John, J. 1990. Land Information Management; Surveying and LIS, 50(2

An overview of surveying and mapping technologies and how they are used within a land information system as well as where LIS's are heading in the future.

Moellering, Harold, 1977. Interactive Cartographic Design, Proceedings of the American Congress on Surveying And Mapping; Washington, D.C.; pp 516-530.

In recent years the potential of utilizing computer-assisted methods has been generally recognized in cartography. The problem of solving analytical geographic problems with interactive analytical and graphic methods which include cartographic displays is also receiving wider application. The utilization of such methods raises questions about cartographic design for the creation of static real maps. However, with the development of more recent interactive cartographic display techniques, the concept of cartographic design can be extended to certain kinds of virtual maps. Thus, virtual maps when necessary, or at appropriate stages can be converted into real maps, as required for the geographical analysis.

Moellering, Harold, 1989. A Practical and Efficient Approach to the Stereoscopic Display and Manipulation of Cartographic Objects, Proceedings Ninth International Symposium on Computer-Assisted Cartography; Baltimore Maryland, Edited by E. Anderson. pp 1-4.

Until now the direct stereoscopic display of computer generated cartographic objects produced in real time has been either expensive or very difficult. This paper presents an approach that is both more efficient than earlier methods and more practical. Several examples of cartographic surfaces will be shown where the stereoscopic vision aspect of the display can be used to more efficiently show the true character of the surfaces involved.

Molich, Rolf, and Jakob Nielsen. 1990. Improving a Human-Computer Dialogue; Communications of the ACM, 33 (3): pp 338-350.

Any system designed for people to use should be easy to learn and remember, effective, and pleasant to use. Past experience in designing interfaces that score highly in these areas has resulted in guidelines for the design of good interfaces. However, these guidelines are often contained in lengthy documents, which due to their size, are not consulted during the design process due to the effort involved.

This article describes a survey that the authors undertook to investigate whether industrial data processing professionals would be able to recognize serious interface problems in simple but realistic dialogues. The interface chosen was a hypothetical system designed for a standard text display using no mouse. no color, and no graphics.

The study indicates that many professionals have difficulty in recognizing interface design problems and may not be sufficiently aware of the importance of designing dialogues which would either prevent or tolerate errors.

Monk, Andrew. 1984. Fundamentals of Human-Computer Interaction. New York: Academic Press.

The book is an assembly of lecture materials from a course in HCL 13 authors cover 14 topics in 3 sections. These are: The user as a processor of information( visual perception. reading, memory. thinking and reasoning), Use of behavioral data (how and when to collect it, statistical evaluation, example experiment) and User interface (workstation design, activities and display technologies, dialogue design, generative processes for interface design, future users of of future offices speech communication, human factors problems in the design and use of expert systems). Presentations are well organized. Would make an excellent course text.

Monmonier, M., 1989. Graphic Scripts for the Sequenced Visualization of Geographic Data, GIS/LIS'89; Orlando, FL, 2: pp 381-389.

A graphic script is a temporally sequenced multi-window graphic presentation. An individual window might contain a map, text with a definition or numerical statement, or an aspatial statistical graphic such as a histogram or scatterplot. The script controls the information content and symbolization of the display. Ibis paper describes the concept of the graphic script and examines the role of graphic scripts in both cartographic animation and the interactive exploratory analysis of geographic data. It also suggests strategies for the automated generation of graphic scripts. As a coding strategy, the graphic script is a starting point for the development of an automated method for selecting a meaningful sequence of views of a multivariate spatial-temporal dataset.

Moran, T.P., and S.K. Card, 1982. Applying Cognitive Psychology to Computer Interaction, Conference on Human Factors in Computer Systems; Gaithersburg, Maryland,

Morris, Peter E. and Mary M. Smith. 1987. Cognition in Action. Hillsdale, New Jersey: Lawrence Eilbaum Associates, Publishers.

The study of cognitive psychology and how it affects peoples' everyday lives.

Muller, Michael J.. and Bellcore, 1988. Multifunctional Cursor for Direct Manipulation User Interfaces, Human Factors in Computing Systems, CHI'88; Washington, D.C., Edited by E. Soloway. pp 89-94.

The multifunctional cursor (MC) is a technique for representing multiple operations in direct manipulation user interfaces. Icons for each of several simultaneously-available operations are overlaid into the cursor image. The MC improves user interface practice by removing syntactic inconsistencies, by reducing cognitive load, and by providing support for repeated operations.

Myers, Brad A. and Buxton, William. 1986. Creating Highly4nteractive and Graphical User Interfaces by Demonstration: ACM Computer Graphics, 20 (4): pp 249-258.

It is very time consuming and expensive to create the graphical, highlyinteractive styles of user interfaces that are increasingly common. User interface management systems attempt to make the creation of user interfaces easier, but most existing UIMS cannot create the low-level interaction techniques (pop-up, pull-down, and fixed menus, on screen buttons, scroll bars, etc.) that are frequently used. This paper describes Peridot, a system that automatically creates the code for these user interfaces while the designer demonstrates to the system how the interface should look and work. Peridot uses rule-based inferencing so no programming by the designer is required and Direct Manipulation techniques are used to create Direct Manipulation interfaces, which can make full use of a mouse and other input devices. This allows extremely rapid prototyping of user interfaces.

Myers, Brad A. 1988. A Taxonomy of Window Manager User Interfaces; IEEE Computer Graphics & Applications, 8(5) : pp 65-84.

This article presents a taxonomy for the user-visible parts of window managers. It is interesting that there are actually very few significant differences, and the differences can be classified in a taxonomy with fairly limited branching. This taxonomy should be useful in evaluating the similarities and differences of various window managers, and it win also serve as a guide for the issues that need to be addressed by designers of future window manager user interfaces. The advantages and disadvantages of the various options are also presented. Since many modern window managers allow the user interface to be customized to a large degree, it is important to study the choices available.

Myers, Brad A 1988. Creating User Interfaces by Demonstration. Boston: Academic Press.

Myers, B., and P. Szekely, 1988. A User Interface Toolldt Based on Graphical Objects and Constraints, Proceedings OOPLSA'88:

Myers, Brad. 1989. User-interface Tools: introduction and Survey; IEEE Software, 6 (1) pp 15-23.

Creating good user interfaces for software is very difficult. There are no guidelines or techniques that guarantee the software will be easy to use, and software implementations have generally proven to be poor at providing interfaces that people like. Consequently, interface software must often be prototyped and modified repeatedly.

Interface software is inherently difficult to write because frequently it must control many devices, each of which may be sending streams of input events asynchronously. Also, interfaces typically have stringent performance requirements to ensure that there is no perceived lag between a user's actions and the system's response.

Therefore, there is a great interest in developing tools to help design and implement interfaces. This article explains the advantages of user-interface tools, surveys the state of the art, and details the current systems' shortcomings that must be overcome.

Myers, BA, 1989, Encapsulating Interactive Behaviors, CHI'89; Austin. Texas, Edited by K. Bice and C. Lewis. pp 319-324.

Although there has been important progress in models and packages for the output of graphics to computer screens, -here has been little change in the way that input from the mouse, keyboard and other input devices is handled. New graphics standards are still using a ten year old model even though it is widely accepted as inadequate, and most modem window managers simply return a stream of device-dependent input events. This paper presents a new model for how input devices can be handled for highly interactive, direct manipulation, graphical user interfaces. This model encapsulates interactive behaviors into a few "interactor" object types. Application programs can then create instances of these interactor objects, and the details of the handling of the input devices are separated from the application and from the output graphics.

Nasar, J. L. .198 1. Responses to Different Spatial Conflgurations; Human Factors. 23 (4) : pp 439-446.

Neelamkavil, F., and 0. Mullarney. 1990. Separating Graphics from Application in the Design of User Interfaces; The Computer Journal, 33 (5): pp 437-443.

Until recently work in the area of user interface development has been almost entirely ad. hoe. Implementors have had to rely on their own judgement not only in the area of the interface appearance and dynamics, but also in the Internal structure of interaction management. Considerable confusion exists in defining what constitutes a good User Interface, and in the management processes required to construct them. Insufficient software foundations and a lack of formalism tools and methodologies are contributing factors. To some extent these problems have been addressed by the User Interface Management System (UIMS) community, primarily for those working on large systems. This paper describes a methodology, developed as part of the design of a User Interface Manager aimed at providing implementors with a structure for building interfaces which are separable from their applications.

In the past, interfaces have been buried in the code. This inhibits maintenance and reconfigurability. the authors have developed a methodology for the production of user interfaces which are separate from and built on top of structured, object oriented applications.

Newsome, Sandra L., W. R Spillers, and Susan Fingers. 1989. Design Theory'88. Springer-Verlag.

The book is based on the NSF Workshop on Design Theory and Methodology. It covers engineering design with relation to its cognitive and social aspects as well as focusing on the computational and analysis part of design.

Nichols, Bill. 1990. Looking at the Graphical User Interface; Byte, 15(11): pp 161-166.

A look at where graphical user interfaces are heading, the hardware available, the software capabilities and the upgrades needed to make them a success.

Nicholson, Andrew S., and John E. Ridd. 1988. Health Safety and Ergonomics. London: Butterworth & Co.

List of sections: The role of ergonomics. The operator in the system. Usercentered design. Perspectives on current issues.

Niebel, Benjamin W., and Alan B. Draper. 1974. Product Design and Process Engineering. New York: McGraw-Hill, Inc.

A design-oriented text providing a background of how to design to ensure product success, by providing fundamental engineering hints.

Nielsen, Jakob. 1989. Coordinating User Interfaces for Consistency. New York: Harcourt Brace Jovanovich.

A collection of papers by Jakob Nielsen, Wendy Kellog, Daniel Rosenberg, Gary Perlman, Bruce Tognazzini. Michael Good, Richard Wolf, Ianne Howads Koritzinsky, and (Charles Weicha, William Bennett, Stephen Bois, and John Gould). The book is aimed at strategies for managing user interface development. The view is toward coordinating programming teams to end up with a consistent interface. It provides a bibliography on consistency and is indexed.

Nievergelt, J., and J. Weydert. 1980. Sites, Modes, and Trails: Telling the User of an Interactive System Where He Is, What He Can Do and How To Get Places. In Methodology of Interaction. Edited by R. A. Guedj, P. J. W. ten Hagen, F. R. A. Hopgood, H. A. Tucker and D. A. Duce. North Holland Publishing Co.

Observations of the behavior of casual users allows characterization of difficulties experienced by users of interactive systems through the questions: Where am 1?; What can I do here?: How did I get here?; Where can I go and how? A well designed system allows the user to conveniently answer these questions.

A framework for the design of a user interface based on three concepts that mirror the questions above: Site. Mode and Trail. In terms of these concepts many common user operations appear naturally as special cases of general features. An interactive system based on these concepts has been implemented.

Norman, Donald A. 1969. Memory and Attention. New York: John Wiley and Sons, Inc.

Looks at the human as a complex system, and trys to observe how it attempts to impose organization on the information it receives.

Norman, Donald A_ and David E. Rumelhart. 1975. Explorations in Cognition. San Francisco: W. H. Freeman and Company.

A study of mental processes. Attempts to better understand human cognitive processes and how an individual takes in and stores information.

Norman, Donald A, 1983. Design Principles for Human-Computer Interfaces, Human Factors in Computing Systems; Boston, Edited by A. Janda. pp I - 10.

If the field of Human Factors in Computer Systems is to be a success it must develop design principles that are useful, principles that apply across a wide range of technologies. In the first part of this paper I discuss some of the properties that useful principles should have. The second part of the paper is intended to illustrate the first part through the example of tradeoff analysis. Any single design technique is apt to have its virtues along one dimension compensated by deficiencies along another. Tradeoff analysis is used to determine user satisfaction. The analysis is used to examine two different tradeoffs of information versus time and editor workspace versus menu size, Tradeoffs involving command languages versus menu-based systems, choices of names, and handheld computers versus workstations are examined briefly.

Norman, Donald A. 1983. Design Rules Based on Analyses of Human Error: Communications of the ACM, 26 (4): pp 254-258.

By analyzing the classes of errors that people make with systems. it is possible to develop principles of system design that minimize both the occurrence of error and the effects. 'Ibis paper demonstrates some of these principles through the analysis of one class of errors: slips of action. Slips are defined to be situations in which the user's intention was proper, but the results did not conform to that intention. Many properties of existing systems are conducive to slips; from the classification of these errors, some procedure to minimize the occurrence of slips are developed.

Norman, Kent L., Linda J. Weldon, and Ben Schneiderman, 1986. Cognitive Layouts of Windows and Multiple Screens for User Interfaces; International Journal of Man-Machine Studies, vol. 25: pp 229-248.

This paper develops a theory of the "cognitive layout" of information presented in multiple windows or screens. It is assumed that users adopt a cognitive representation of layout of information and windows. Layouts for different cognitive models are examined.

Norman, Donald A. 1990. Commentary: Human Error and the Design of Computer Systems.; Communications of the ACM, 33 (1): pp 4-7.

A discussion of whether system failures are the result of human error or are really the product of poor design. Several examples of system failures are highlighted. The causes of these failures were attributed to "human error", however, the author suggests that the cause was more likely poor design. He advocates the study of design failures as a valuable tool to design of systems particularly in the area of human-machine interaction. He suggests that "ACM could take the lead in establishing some positive and constructive actions to elevate the humanside of computing..."

Olsen, D. B. 1986. MIKE: The Menu Interaction Control Environment; ACM Transactions on Graphics, 5 (4): pp 318-.

Olsen, D.R. 1990. Propositional Production Systems for Dialog Description, Human Factors in Computing Systems-Empowering People CHI'90;: Seattle, Washington, Edited by J. Chew and J. Whiteside. pp 57-63.

The Propositional Production System (PPS) for describing interactive dialogs is defined. It is shown to be a superset of state machines, window event translation tables and event response systems. It is shown how dialogs can be expanded by means of inheritance and how semantic control information can be uniformly integrated Into the dialog model. Optimizations are defined which can tune the executable machine for either minimal space or minimal execution time.

Osborne, David J., and Doreen Holton. 1988. Reading from Screen Versus Paper: There is No Difference: Int. J. Man-Machine Studies. vol. 28: pp 1-9.

Study compared reading speed, comprehension and preference for reading from CRT vs paper, with dark on light vs light on dark characters. Sixteen subjects, within subjects design. No significant differences were found in reading speed or comprehension. There was a clear preference for dark characters on a normal paper page. Has a good review of the literature comparing reading from screens and paper up to 1985.

Palmer, Dave, and John McLaughlin, 1984. Land-Related Information Networks: Assessing User Requirements, Annual Meeting of the American Congress on Surveying and Mapping, Washington, D.C.: pp 10 1 - 109.

Recent interest in the development of land-related information networks has focussed largely on the technology and systems requirements. At least as important is the need to effectively address the user requirements for landrelated information. This paper provides a brief review of the pioneering effort in New Brunswick to develop a land-related information network and discuss the efforts which have been made to develop an in depth understanding of user requirements.

Palmer, T. R_ 1987. GRAPE Programming Environment; Info. & Softw. Tech., 29 (4): pp 219-225.

A system based on established theoretical techniques which provides automatic code generation of interface management software is discussed and its implementation within a device-independent HCI design module. This makes the techniques readily available to a wider audience of system builders who are non-experts in language design techniques and interface design. The system described is the Graphics Programming Environment (GRAPE) which provides advanced facilities in both of these areas and handles them within a unified conceptual framework.

Palvin, Jasmina. 1990. Task-Aware User Interfaces; SIGCHI Bulletin, 22 (1): pp 55 - 60.

While the demand for computer systems that are more and more complex in terms of size and variety of applications is steadily increasing, design support tools and abstraction mechanisms for such systems are lagging badly behind. This places an increased burden on users and software developers alike. Making the knowledge about user tasks and the system's functionality explicit can reduce this burden significantly.

Parrington, Norman. 1989. Understanding Software Testing. Chicester: Ellis Horwood Limited.

Looks at the testing process and quality; testing requirements and specifications; design stages: a case study.

Pascoe, R T., and J. P. Penny. 1990. Construction of Interfaces for the Exchange of Geographic Data; International Journal of Geographical Information Systems, 4 (2) : pp 147-156.

Patterson, Marvin L. 1983. Graphical Interface Design Considerations; Computer Graphics World, vol. 11: pp 75-82.

Payne, Stephen J. 1989. A Notation for Reasoning About Learning. In Cognitive Ergonomics and Human-Computer Interaction. Edited by J. L. a. A. Whitefield. New York: Cambridge University Press: pp 134-165.

Pazner, M., and L. Dalla Bona, 1989. Map Processors, GIS/LIS'89; Orlando, FL, 2: pp 751-760.

This paper introduces map processors. A new software concept, the map processor is a user friendly program for manipulating spatial information in both visual and quantitative ways. The idea is simple: a map processor is like a word processor-but for maps. It is used for map reading, marking, measuring and transforming. The paper places map processing in the context of map use in general. An example of a map processing application is provided. The example focuses on an ongoing archaeological study in the Thompson River Valley of British Columbia, Canada. The map processor used in this study is MAP II. Several types of visual effects and spatial processing are presented. These include creating pseudo shaded-relief and landscape map layers, generating hunting site viewsheds, and performing spatial analysis for locating likely prehistoric settlement sites. The map processor is then characterized as a GIS offshoot. It departs from traditional GIS in its friendly user interface, availability on graphic personal computers, emphasis on coupled map visualization and transformation, and ease of input and output. It is concluded that map processors are especially appropriate in cases that emphasize case of use and stress fast turnaround time. Whereas GIS are mainly limited to use by professionals. map processors are geographic tools with the potential to reach a much expanded user group.

Pazner, Michael and Chris Kirby, 1990. Graphic Map Algebra, 4th International Symposium on Spatial Data Handling; Zurich, Switzerland, Edited by K. Brassel and H. Kishimoto. 1: pp 413-422.

This paper deals with the specification of cartographic modeling components in GIS or digital map processing environments. Producing such a model normally requires the use of a structured text-based "map algebra" language. We present what can be done to simplify this interface and make the process of creating cartographic models more intuitive. The graphic interface is composed of icons that represent operations and data sources (map layers). Models are constructed by connecting these icons into a flowchart-like representation. Data flows from data sources such as existing map layers, or from map layers produced by operations, into a sequence of operations and ultimately back to the user in the form of a resulting map layer. The advantages of such an interface lie in giving the users the ability to visualize the model as well as compose such models without having to worry about syntax and language constructs. A key advantage is the ability to build the model with an emphasis on the visual flow of data. This generally leads to the user making fewer mistakes during construction of the model.

Pearson, Glenn, and Mark Weiser, 1986. Of Moles and Men: The Design of Foot Controls for Workstations. Human Factors in Computing Systems; Boston, Massachusetts, Edited by M. Mantei and P. Orbeton. pp 333-339.

Workstations require use of the hands both for text entry and for cursor-positioning or menu-selection. The physical arrangement does not allow these two tasks to be done concurrently. To remove this restriction, various alternative input devices have been investigated. This work focuses on the class of foot-operated computer input devices, called moles here. Appropriate topologies for foot movement are identified, and several designs for realising them are discussed.

Pearson, Glenn, and Mark Weiser, 1988. Exploratory Evaluation of a Planar Foot-Operated Cursor-Positioning Device, Human Factors in Computing Systems. CHI'88; Washington, D.C., Edited by E. Soloway. pp 13-18.

The use of feet instead of hands to perform workstation cursor-positioning and related functions has been the subject of an on-going investigation. A particular foot-operated device, the planar slide mole, was assessed against a mouse in a target-selection task.

Perkins, Scheherazade, 1990. Down with DeJaVu--Making Change Stick in Your Organization, 1990 Urban and Regional Information Systems Association; Edmonton, Alberta, 2;

Petajan, Eric, Bradford Bischoff, David Bodoff, and N. Michael Brooke, 1988. An Improved Automatic Lipreading, Human Factors in Computing Systems. CHI'88; Washington, D.C., Edited by E. Soloway. pp 19-26.

Petersen, Annelise M., and L.P. Goodstein. 1990. Beyond the Desk Top Metaphor: Information Retrieval with an Icon-Base. In Visualization in Human-Computer Interaction. Edited by P. Gorny. Springer-Verlag: pp 149-182.

This paper investigates how an interface with icons can support the user's navigation in databases by a graphical representation of the function of the system as well as its information contents in relation to the user's task. The particular context chosen is the retrieval of fiction in public libraries.

Pfaff, G.E. 1985. Proceedings Seeheirn Workshop on User Interface Management Systems, (Seeheim, West Germany, Nov. 1-3, 1983). Edited by G. E. Pfaff. New York, NY: Springer-Verlag.

Pinto, Jeannine, and Elliot Soloway, 1988. Providing the Requisite Knowledge via Software Documentation, Human Factors in Computing Systems, CHI'88; Washington, D.C., Edited by E. Soloway. pp 257-262.

Pollitt. A. S. 1989. Information Storage and Retrieval Systems. West Sussex: Ellis Horwood Limited.

Book concentrates on the handling of information and its storage within the computer system. It looks at assemblers, compilers, interpreters and operating systems from the user's point of view.

Popov, Edward V. 1982. Talking with Computers in Natural Language. Moscow: Nauka.

Trys to make computer language more understandable to the common individual by recommending methods of making computer language similar to the natural languages.

Potter, Richard L., Linda J. Weldon, and Ben Shneiderman, 1988. Improving the Accuracy of Touch Screens: An Experimental Evaluation of Three Strategies, Conference on Human Factors in Computing Systems; Washington DC, pp 27-32.

A study comparing the speed, accuracy and user satisfaction of three different touch screen strategies was performed. Compared "land-on" (cursor under finger. position of first contact used, selection made on impact with target) "first-contact" (cursor under finger, all position data used until first contact with a target, selection on first contact with any target) "take-off' (cursor 1/2" above finger, all position data used, selection upon release if on a target, jitter stabilization, target highlighted when cursor is on it).

Potts, Cohn. 1988. The Other Interface: Specifying and Visualising Computer Systems. In Working with Computers: Theory versus Outcome. Edited by G. C. V. D. Veer. San Diego: Academic Press Inc.: pp 145-175.

Critiques and describes current design specifications, outlines new ways to present formal specifications and dynamic interactions so that the focus is on human considerations.

Puterski, Robert, 1985. "Electronic Atlas" Spatial Data Bases for the General Public, Proceedings of the American Congress on Surveying And Mapping; Washington, D.C.: pp 265-263.

In the 1980's computer assisted cartography has emerged from the research and large inventory based system of the seventies to become diffused throughout every professional community which uses maps. There still remains one group with which the use of automated mapping is still in its infancy-the general public. This discussion will focus on a cooperative project between the State of Colorado, a typical generator of digital map data, and he Denver Public Library, a traditional provider and disseminator of paper and now electronic information to the public. The implementation of yet another easy to use spatial analysis and display system can certainly be met with some skepticism. The success of this system to date has been the ability to provide a perceived customized, real map at a a reasonable cost that the user can keep. With greater numbers of people being exposed to digital representations of increased contribution to the field.

Raper, J.F., and N.PA Green, 1989. GIST: An Object-Oriented Approach to a Geographical Information System Tutor, Auto-Carto 9; pp 610-619.

Experience gained in the construction of the world's first GIS tutor, ARCDEMO (GREEN 1987), has emphasized the importance of accommodating different student learning strategies. ARCDEMO, while highly successful (it has been accessed over 2000 times via JANET-the UK joint Academic Network) suffered from static graphic displays, a single predetermined access path, and an overall design which made alteration and updating of its material problematic. Object-oriented programming languages offered a means of addressing these problems and were also attractive in respect of the low development resources required. The Geographical Information System Tutor (GIST) exploits this

approach using Apple's HyperCard software and incorporates a "point-and -click" interface with graphical cues to initiate operations which include animated demonstrations, step-by-step illustrative graphics and graphical displays capable of user modification. The topics covered by GIST, when taken together, define a set of core activities within GIS which can be used as the basis for a curriculum.

Raper. Jonathan, and David Rhind, 1990. UGEK (A): The Design of a Spatial Language Interface for a Topological Vector GIS, 4th International Symposium on Spatial Data Handling; Zurich, Switzerland, Edited by K. Brassel and H. Kishimoto. 1; pp 405-412.

At a time of rapidly expanding use of GIS and widespread attempts to make them easier to use, the interface to a GIS has taken on a new importance. Whilst many GIS now incorporate Graphical User Interfaces (GUI's) to specify operations in the system, the central problems of specifically spatial interaction and task orientation have not been addressed. This paper discusses the design of a user environment for the GIS called the Universal Geographic Information executive (UGI)Q, and focuses on the interface aspects in module (A). Experiences with a first generation implementation are reported for the GIS's ARC/INFO.

Rasmussen, Jens. 1984. Strategies for State Identification and Diagnosis In Supervisory Control Tasks and Design of Computer-Based Systems. In Advances in Man-Machine Systems Research. Edited by W. B. Rouse. Greenwich Connecticut: JAI Press: pp 139 - 193.

A framework useful for understanding and designing supervisory control systems is presented. Topics discussed include cognitive task analysis, hierarchical system representations, descriptive and prescriptive strategies for diagnosis, and phases of the system design process. The proposed framework is used to provided an integrated perspective of these topics in terms of implications of trends towards increasingly complex systems and sophisticated computer-based information technology.

Rasmussen, Jens. 1986. Information Processing and Human-Machine Interaction. New York: Elsevier Science Publishing Co., Inc.

Modem industrial control systems use advanced information technology for support of human decision making during supervisory control tasks and emergency management. Models of human information-processing abilities and limitations are prerequisites for the basic conceptual design of such systems. The author developed a conceptual frame of reference that served us well in formulating our problems in concepts that could be related to control system design.

Rathke. C., 1987. Human-Computer Communication Meets Software Engineering. 9th International Conference on Software Engineering; pp 216-224.

Ravden, Susannah, and Graham Johnson. 1989. Evaluating Usability of Human-Computer Interfaces. Chichester, England: Ellis Horwood Limited.

This book describes a practical method for assessing human-computer interface usability. It is based on a practical tool, in the form of a checklist, which can be used to evaluate user interface both during and after design and development. A number of fundamental software ergonomics criteria form the basis of the checklist, and represent goals which a well-designed human-computer interfaces should aim to meet.

Reilly, Ronan. 1987. Ill-Formedness and Miscommunication in Person-Machine Dialogue.; Information and Software Technology, 29 (2) : pp 69-74.

This paper describes work carried out by the Communication Failure in Dialogue project. The paper presents a broad classification of the types of ill-formedness that can occur in person-machine communication. A corpus of natural language dialogue is analysed from a variety of perspectives. Implications for the development of natural language dialogue interfaces are discussed. The analysis indicates that a high priority in the development of a natural language interface should be given to the treatment of misspelling, fragmentary Input and ellipsis.

Reiser, Brian J., Patricia Friedmann, Jody Gevins, Daniel Y. Kimberg, Michael Ranney, and Antonio Romero, 1988. A Graphical Programming Language interface for an Intelligent Lisp Tutor, Human Factors in Computing Systems, CHI'88: Washington, D.C., Edited by E. Soloway. pp 39-45.

Reynolds, Christopher F. 1987. Human Factors in Systems Design: A Case Study. in People and Computers 3. Edited by D. Diaper and R Winder. Cambridge: Cambridge University Press: pp 93 - 102.

MicroCODIL is a teaching package which also acts as a test bed for human factors research in the CODIL project. Ibis paper shows how human factors can be considered at all levels of system design, starting with the way that poorly designed structured information is represented and processed, through the provisions of diagnostic windows. to the use of color to syntax check lazy input. The need to minimize the effects on the user of the limitations of low cost hardware is also considered.

Rivlin, Christopher, Robert Lewis, and Rachel Davies-Cooper. 1990. Guidelines for Screen Design. Cambridge, England: Blackwell Scientific Publications.

This publication is the result of work done in a seminar on screen design sponsored by the Information Technology in Education Programme (England). The book provides guidelines on the way in which visual displays should be designed in order to enhance communication between a human operator and a computer. The guidelines draw heavily on interactions with software created to support learning but can be applied to interface design for all types of applications.

The book is divided into five chapters presenting guidelines for communication, layout, text, graphics and interaction. In each chapter, on each set of facing pages, an issue or issues is presented. Along with it, a relevant guideline and a rationale are given. The guidelines and rationales are generally relatively short and to the point with some sort of graphic example.

Each chapter deals with questions relevant to the major topic.
Communication: What needs to be known about the users and the context of use? Which activities need to be promoted? What needs to be known about the hardware and software? How should the production of the software be organized?
Layout: How should the information to be conveyed be analyzed? Graphics or text? How to use principles of visual perception in the design?
Text: How should test be written to the screen and how much? When should text variations be used? How to effectively use color-9. Factors enabling easy interpretation of lists and tables.
Graphics: Functions of graphics and animation. How to create and display pictures. What design principles apply to graphics?
Interaction: How can the active participation of the user be achieved? How and when should the display be updated? How should menus be designed? What makes the cursor easy to use?

Robertson, Philip K., and John F. O'Callaghan. 1986. The Generation of Color Sequences for Univariate and Bivariate Mapping; IEEE Computer Graphics and Applications. 6(2): pp 24-32.

Recent technological advances have made it feasible to produce full color statistical maps on computer-controlled display systems. This has caused an appraisal of the use of color to represent statistical variables, and the development of a theoretical structure for the choice of suitable univariate and bivariate map coloring schemes. Realizations of such schemes in an intuitive and controlled way is important to the comprehensions of statistical variables from maps. Therefore. we present a method of generating specific color sequences within the framework of a uniform color space, allowing for the intuitive specification of color sequences and for their realization on various display systems.

Robertson, Philip K 1988. Visualizing Color Gamuts: A User Interface for the Effective Use of Perceptual Color Spaces in Data Displays; IEEE Computer Graphics & Applications. 8(5): pp 50-64.

The value of being able to specify and control color representations in perceptual terms is widely recognized. Effective use of perceptual color specification, however, depends on being able to visualize the range of colors (the 3D color gamut) that can be produced on particular display devices. Achieving this visualization is an essential part of providing a user interface to color in computational systems. This article outlines the advantages of using perceptually uniform color spaces in data display and describes methods of display-device modeling to realize them in practice. It shows how ID, 213, and 3D representations of color gamuts can provide an understanding, at various visualization levels, of the colors that can be produced on display devices, of how they restrict color displays in practice, and how they form an essential part of a user interface to the design of color displays.

Rosenberg, Jarrett, 1983. A Featural Approach to Command Names, Human Factors in Computing Systems, Boston, Edited by A. Janda. pp 116- 119.

A variety of aspects of command names have been studied, such as suggestiveness, memorability, and the use of icons. A single framework for these disparate studies is desirable, and It is proposed that the concept of featural analysis prevalent in linguistics and psycholinguistics be adopted as an approach to command name design. Examples of the breadth of application of this approach are given for the naming issues suggestiveness, learning and memory, congruence and "hierarchicalness", universal commands, the relationship of names to the command language syntax, and the use of non-words as names.

Rosenberg, Daniel J., and Gale Martin. 1988. Human Performance Evaluation of Digitizer Pucks for Computer Input of Spatial Information; Human Factors, 30 (2): pp 231-235.

Two experiments were performed to measure and find ways of improving the accuracy with which people can enter spatial coordinates into a computer with a digitizer puck. The first experiment studied the effect of the type of optical sight (cross-hair. 2 cross-hairs at 45 degrees, cross-hair with concentric circles): type of sight did not matter. The second experiment examined effect of a 2.5X magnifier: it significantly improved accuracy. Ss were within +/- 0. 125 -- +/- 0.250 nm of true target position. Magnification drove them to the lower end of this range. Eastman Kodak employees as subjects. 90% of Ss were within =/- 0.25 nun of "true" position of a point.

Rosson, Mary Beth, Susanne Maass, and Wendy A. KeUogg. 1988. The Designer as User: Building Requirements for Design Tools from Design Practice; Communications of the ACM. 31 R 1) : pp 1288-1298.

Software tools that support the design and development of interactive computer systems are an exciting possibility. The potential pay-off is great; user interface management systems, for example, promise not only to speed the process of specifying, implementing and maintaining user interface code, but also to guide the content of the user interfaces they support. As for any tool intended for human use, however, the success of software design tools will hinge on a thorough understanding of the problems they seek to address- design as it is practiced in the real world.

Roth, Alan, and Mary Burton, 1985. Integrating Surveying and Computer Aided Technologies, Annual Meeting American Conference On Surveying and Mapping; Washington, D.C.; pp 558-564.

Automation of surveying instruments is currently progressing rapidly, particularly in regard to survey total stations. Electronic technology has become available to the surveying profession in the form of electronic field book, distance meter, and recording theodolite. Simultaneously, but unrelated heretofore, computer aided design (CAD) technology has been under development for over two decades and its effectiveness has been well established in numerous design and engineering/ architectural applications. With regard to linking the two technologies, an important advance has been made in the development of a software package which provides a convenient inter-face between the electronic field instruments and a CAD system. With a CAD program, the surveyor can edit the survey data as well as add text and and directly produce the desired planimetric and contour maps.

Roth. Steven F., and Joe Mattis, 1990, Data Characterization for Intelligent Graphic Presentation, Human Factors in Computing Systems-Empowering People CHI'90;; Seattle, Washington, Edited by J. Chew and J. Whiteside. pp 193-200.

An automatic presentation system is an intelligent interface component which receives information from a user or application program and designs a combination of graphics and text that effectively conveys it. It is a facility that assumes the presentation responsibilities for other programs. An important research question has been how information should be specified or described by an application program for it to be presented by an automatic presenter. This paper proposes a taxonomy of information characteristics which would need to be provided to either human or computer designers for them to create presentations reflecting the individual needs of a diverse group of user. The proposed taxonomy of characteristics defines the representational goals for intelligent interfaces which reason about graphical displays.

Rubin, Tony. 1988. User Interface Design for Computer Systems. New York: Halsted Press.

Good introduction to the issues of human factors in interface design. Section on users and tasks treats user model vs; design model vs, system model, finding out about users and their tasks. and Norman's task model. Common design issues (system response time, providing help, error messages, and command names) are treated, as are menuing systems. Input devices and WIMP interfaces are treated. There is a good, thoughtful discussion of the use of color in displays.

Interface evaluation strategies are placed in a useful contextual structure. A final section gives the reader a glimpse into the career / work of a human factors professional. - 150 references. [QA 76.9 U83 R83 19831.

Rushinek, Avi and Rushine1r, and Sara F., 1986. What Makes Users Happy?; Communications of the ACM, 29 (7): pp 594-.

Past studies have found that human-factors design, interfaces, user friendliness, lower costs, application development software as a productivity aid, and efficient database languages are important factors in establishing user satisfaction with a computer system. the current study confirms the literature, but also finds some new factors that may send designers back to the drawing board, among them response time, number of users, and systems and the degree to which a system meets user expectations. This study quantifies these factors and uses them to evaluate the extent to which various kinds of computers are likely to satisfy users.

Salvendy, Gavriel. 1987. Handbook of Human Factors. New York: John Wiley & Sons.

On a par with Hellander's handbook, more general in its outlook. Treats a number of non-computer interaction issues as well.

Schackel, B., S.J. Richardson (eds), 199 1. Human Factors for Informatics Usability, Cambridge University Press, New York.

Sixteen chapters by different authors providing an overview of the application of humna factors approaches to improving the usability of infromation technology (IT) systems. Perhaps the n=most interesting chapters are Alphonse Cahpanis on 'The Business Case for Human Factors in Informatics" : Phil Barnard's chapter reviewing the contribuions of applied cognitive psychology to HCI; and Ben Shneiderman's chapter on "A Taxonomy and Rule Base for the Selection of Interaction Styles". These and other chapters lay out why HCI should be considered in any IT project and show what can be gained. The level of detail varries between the pieces.

Scheeps, C. F., 1988. Computer-Assisted Map Symbolism. 1988 ACSM/ASPRS Annual Convention; St. Louis, Edited by ACSM/ASPRS. 2; pp 47-56.

Map symbolism; graphic objectives; symbol description (vector approach) and construction.

Scheifler, Robert W., and Jim Gettys. 1986. The X Window System-, ACM Transactions on Graphics, 5 (2): pp 79-109.

An overview of the X Window System is presented, focusing on the system substrate and the low-level facilities provided to build applications and to manage the desktop. The system provides high performance, high-level, device-independent graphics. A hierarchy of resizable, overlapping windows allows a wide variety of application and user interfaces to be built easily. Network-transparent access to the display provides an important degree of functional separation, without significantly affecting performance, which is crucial to building applications for a distributed environment. To a reasonable extent, desktop management can be custom-tailored to individual environments without modifying the base system and typically without affecting applications.

Schwarz, Michael W., William B. Cowan, and John C. Beatty. 1987. An Experimental Comparison of RGB, YIQ, LAB, HSV, and Opponent Color Models; ACM Transactions on Graphics, 6 (2): pp 123-158.

The increasing availability of affordable color raster graphics displays has made it important to develop a better understanding of how color can be used effectively in an interactive environment. Most contemporary graphics displays offer a choice of some 16 million colors; the user's problem is to find the right color. Folklore has it that the RGB color space arising naturally from color display hardware is user-hostile and that other color models such as the HSV scheme are preferable. Until now there has been virtually no experimental evidence addressing this point. We describe a color matching experiment in which subjects used one of two tablet-based input techniques, interfaced through one of five color models, to interactively match target colors displayed on a CRT. 'Me data collected show small but significant differences between models in the ability of subjects to match the five target colors used in this experiment. Subjects using the RGB color model matched quickly but inaccurately compared with those using the other models. The largest speed difference occurred during the early convergence phase of matching. Users of the HSV color model were the slowest in this experiment. both during the convergence phase and in the total time to match, but were relatively accurate. There was less variation in performance during the second refinement phase of a match than during the convergence phase. Two-dimensional use of the tablet resulted in faster but less accurate performance than did strictly one-dimensional usage. Significant learning occurred for users of the Opponent, YIQ, LAB, and HSV color models, and not for users of the RG13 model.

Scott, Michael L., and Sue-Ken Yap, 1988. A Grammar-Based Approach to the Automatic Generation of User-Interface Dialogues, Human Factors in Computing Systems, CHI'88; Washington. D.C., Edited by E. Soloway. pp 73-78.

An effective user interface requires a dialogue layer that can handle multiple threads of inter-action simultaneously. We propose a notation for specifying dialogues based on context-free attributed grammars with two extensions: fork operators for specifying sub-dialogues and context attributes for dispatching tokens. The notation is useful both as a means of communicating the behavior of the dialogue layer to designers and as input to a dialogue compiler that generates program code. In this paper we explain the motivation for our work and provide practical examples of the use of fork and context. In addition, we outline algorithms for parsing and for generating parser tables.

Seminar, Kudang B.. and Robert N. Robson. 1990. An Iconic Description Language: Programming Support for Data Structure Visualization, SlGCHI Bulletin, 22 (1) pp 70-72.

An icon description language, named DSIL (Data Structure Iconic Language), is described which facilitates the design icons depicting data structures and accelerates the development of iconic interfacing tools for the program visualization and debugging. By using the DSIL, different users can define and redefine their own icons to satisfy their needs. The DSIL has features of modem programming languages. It is hierarchical, modular, and provides adoption (inheritance). The design of the DSIL is based on the features of data structures in MODULA-2. The implementation of the DSIL in a data structure editor is presented.

Sheppard, Stephen R J. 1989. Visual Simulation: A User's Guide for Architects, Engineers, and Planners. New York: Van Nostrand Reinhold.

Shnedeirman, Ben. 1987. Designing the User Interface: Strategies for Effective Human-computer Interaction. Reading, Mass.: Addison-Wesley.

One of the standard HCI texts. Too popular in tone but should be on everyone's shelf.

Shneiderman. Ben. 1984. Response Time and Display Rate in Human Performance with Computers: ACM Computing Surveys, 16 (3): pp 265-285.

The pace of human-computer interaction is an important issue to computer scientists and computer users alike. Experimental results have begun to shed some light on this complex, controversial, and vital subject. This paper reviews the theory and reports on experimental results concerning display rates, response time expectations and attitudes, user productivity, and variability. The decomposition of concerns and tasks helps to clarify the issues. but substantial effort remains before a predictive model can emerge.

In general, the results indicate that frequent users prefer response time of less than a second for most tasks, and that productivity does increase as response time decreases. However, error rates increase with too short or too long a response time. Users pick up the pace of the system, but the profile of commands may change with the speed of the system.

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Shu, Nan C. 1988. Visual Programming. New York: Van Nostrand Reinhold Company.

The challenge of this decade is to bring computer capabilities, simply and usefully, to people without special training in programming. Visual Programming represents a conceptually revolutionary approach to meet this challenge. The purpose of this book is manyfold: to shed light on the state of the art on this new frontier; to establish common understanding: to assimilate what we have; and to lay a foundation upon which various aspects of visual programming can be focused and examined. The book is aimed at people who are interested in learning something about visual programming. Potential users may find it useful to know what visual programming is. Researchers and software developers in this wide area may find it useful to relate their own work to other efforts. People whose expertise is not in this field may want to satisfy their curiosity regarding the state of the art.

Siddall, James N. 1982. Optimal Engineering Design. New York: Marcel Dekker, Inc.

This book focuses on optimization for engineers in the formulation and execution of problems. It uses optimization in developing strategies in the engineering design process.

Simon, Harold A- 1975. A Students Introduction to Engineering Design. New York: Pergamon Press Inc.

A guide to engineering design. The book is a textbook for the undergraduate engineer. It focuses on the basic elements involved in the design process, from modeling a design to its testing.

Singh, G., and M. Green, 1989. A High-Level User Interface Management System,CHI'89: Austin, Texas, Edited by K Bice and C. Lewis. pp 133-138.

A high-level UIMS which automatically generates the lexical and syntactic design of graphical user interfaces is presented. The interfaces generated by the UIMS can easily and rapidly be refined by the designer by using highly interactive and graphical facilities. The UIMS accepts a high-level description of the semantic commands supported by the application, a description of the implementation device, and optionally, the end user's preferences. Based on these inputs the UIMS generates graphical user interfaces in which the commands are selected from menus and command arguments are provided through interaction with graphical interaction techniques.

Singleton, W. T., R. S. Easterby, and D. C. Whitfield. 1967. (Proceedings of the conference on) The Human Operator in Complex Systems. London: Taylor and Francis, Ltd.

Contains a description of an early Touch-Screen system and an early "visualization" piece.

Smith, Richard M., and Merle E. Johnson, 1979. Computer Generated Areal Symbols: Some Design Considerations, Annual Meeting of the American Congress on Surveying and Mapping; Washington, D.C.; pp 161-179.

Individuals producing computer maps should have two principal concerns: (1) getting the program to operate successfully, and (2) designing the map so that it portrays the data in the most effective manner. User's manuals which accompany widely used programs such as SYMAP, GRIDS, CALFORM, or CORMAP generally provide adequate operating instructions to fulfil the first concern. They do not, however, offer reliable advice regarding map design. This study examines the problem of areal symbolization as it relates to computer maps. Research on the visual properties of computer produced areal symbols will be summarized and suggestions for the solution of some related map design problems will be presented.

Smith, David Canfield, Charles Irby, Ralph Kimball, Bill Verplank, and Eric Harslem. 1982. Designing the Star User Interface, Byte, 7(4): pp 297-313.

The Star user interface rigorously adheres to a small set of design principles. These principles make the system seem familiar and friendly, simplify the human-machine interaction, unify the nearly two dozen functional areas of Star, and allow user experience in one area to apply in others. In a companion paper we presented an overview of the features in Star. Here we describe the principles behind those features and illustrate the principles with examples. This discussion is addressed to the designers of other computer programs and systems--large and small.

Sorkin, Robert D., Barry H. Kantowitz, and Susan C. Kantowitz. 1988. Likelihood Alarm Displays; Human Factors, 30 (4): pp 445-459.

In a likelihood alarm display (LAD) information about event likelihood is computed by an automated monitoring system and encoded into an alerting signal for the human operator. Operator performance within a dual-task paradigm was evaluated with a color-coded visual versus a linguistically coded synthetic speech alarm. The results indicate that 1) automated monitoring systems can improve performance on primary and secondary tasks; 2) LADs can improve the allocation of attention among tasks and provide information integrated into operator decisions; 3) LADs do not necessarily add to the operator's attentional load.

Sukaviriya, Pinyawadee, and Lucy Moran. 1990. User Interfaces for Asian Countries. In Designing Interfaces for International Use. Edited by J. Nielson. Elsevier Science Publishers.

Discusses the interaction style differences due to different linguistic and cultural familiarities. These must be considered in creating software for the various world markets.

Sutcliffe, Alistair, and Linda Macaulay. 1989. People and Computers V. Cambridge, England: Cambridge University Press.

This volume contains the invited papers and the refereed submitted papers presented at the "HCI'89: People and Computers" conference. This conference is the annual conference of the British Computer Society HumanComputer Interaction Specialist Group. The conference was held at Nottingham University, September 5 - 8.

Talbot, Mike and John A Waterworth. 1987. Speech and Language-Based Interaction with Machines. West Sussex, England: Ellis Horwood Limited.

Covers the strategies of producing complex information systems and identifies mans needs and ability to communicate and work with these systems.

Tanaka, M., and T. Ichikawa. 1988. A Visual User Interface for Map Information Retrieval Based on Semantic Significance, IEEE Trans. on Software Engineering, 14 (5): pp 666-670.

This paper presents user-interface facilities of a map information system (HI-MAP) which provides visual feedback to the user. The facilities include semantic panning and zooming, overlaying of thematic maps, etc., and are available to the user through an interactive menu system.

In accordance with the user's requirements, HI-MAP retrieves map elements in a specified region on the basis of their relevance and their categorical classification. It has a data structure which includes logical and physical hierarchies for the management of semantic relationships and graphic map elements. The software for implementing these facilities is well modularized, and a variety of interfacing modes can be realized by simple communication between modules. The system contributes toward a reduction of the difficulties in obtaining what is really required from databases.

Our trial can be seen as a step toward visualization of database manipulation languages to reduce semantic gaps between the user's view and the system's functions, and supports our general research in this field.

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Tauber, Michael J. 1986. Top-Down Design of Human-Computer Interfaces. In Visual Languages. Edited by T. I. Shi-Kuo Chang Panos A. Ligomenides. New York. New York- Plenum Press: pp 393 - 429.

The human-computer interface is a new topic and a systematic method to design such interfaces has to be found. Designers cannot assume that the "mental world" of users is identical to their own or that It can be made identical. Transfer of the concepts of designers to the user can be harmful unless those conceptions are based on a systematic view of the human-computer interface that reveals the user-relevant concepts of a machine with which the machine can be specified and evaluated. The current method of designing interfaces is comparable to unsystematic programming of 20 years ago. The aim of this chapter is to discuss how a human-computer interface can be defined and what principal design method for human-computer interfaces is needed.

Tauber, Michael J. 1988. On Mental Models and the User Interface. In Working with Computers: Theory versus Outcome. Edited by G. C. V. D. Veer. San Diego: Academic Press Inc.: pp 89-119.

Looks at the following: mental models, their nature and importance; model theory: mental model systems; model of human cognition and conceptual structure.

Telles, Marcy, 1990. Updating an Older Interface, Human Factors in Computing Systems - Empowering People CHI'90: Seattle, Washington, Edited by J. C. Chew and J. Whiteside. pp 243-247.

Much of the research in the field of human/computer interface is aimed at the interface designer who begins from scratch. A different set of needs confronts the designer who must update an existing interface without throwing away the good elements of the old design and the knowledge base of experienced users. In this paper, the factors that contribute to the need for interface changes are presented, along with the special challenges that make change more difficult than new design. Approaches are suggested for dealing with the problems of updating an interface to make it effective for both old and new users.

Thomas, J. C. 1983. Psychological Issues in the Design of Database Query Languages. In Designing for Human-Computer Communication. Edited by M. E. Sime. London: Academic Press Inc.: pp 173-206.

This paper reviewed studies which have been directed at examining and comparing human performance with various specific query languages. Also important are a number of psychological findings which are relevant to database query language design. They should serve as general background knowledge which the systems designer(s) must integrate with other technical information.

Thompson, Derek, 1984.The Establishment and Operation of a Student Laboratory for Computer Mapping and Spatial Analysis, Annual Meeting of the American Congress on Surveying and Mapping; Washington. D.C.; pp 157-165.

The department of Geography has developed a student laboratory for computer mapping and spatial analysis over the six years from 1978. The facility has a broad range of easily accessed software for handling point, network, grid cell. line segment, and polygon data. Oriented to vector rather than raster graphics at this time, the Laboratory has a substantial minicomputer. two monochromatic graphics terminals, three digitizing tables, and a pen plotter. Used by over 200 students per year for different purposes, the facility is a locally controlled and managed facility with continuing substantial budget support. An initial investment of about $30,000 for software and hardware is supported by annual operating expenditures by the Geography Department and Social Science Laboratory of about $70,000. Critical factors in the successful creation and operation of the facility have been administrative support for a decentralized computing center, faculty leadership over many years, initial funds for hardware and software, and the unusual organizational setting for the facility in the Social Science Computer Laboratory. Notwithstanding difficulties in establishing good facilities, we now have a solid means to teach and train students to meet future challenges in a steadily changing environment of computer technology.

Thompson, Craig Warren. 1984. Using Menu-based Natural Language Understanding to Avoid Problems Associated with Traditional Natural Language Interfaces to
Databases, Unpublished Thesis, The University of Texas at Austin.

Turner, Scott, and Harold Moellering, 1979. ICMS: An Interactive Choropleth Mapping System, Annual Meeting of the American Congress on Surveying and Mapping; Washington, D.C.; pp 255-267.

lCMS is an interactive choropleth mapping program designed for use in a multiuser environment such as a university where base map information may have been digitized in several different data structures. The maps are drawn on a storage tube CRT face, using either the preliminary map design information. or parameters saved from an earlier map. 'Me system allows interactive data manipulation, five methods of choropleth class choice and two methods of shading level choice. The map may be drawn at any time during a session, and any parameter, such as screen design or class choice may be changed at will. When the map is finished, the parameters necessary for the recreation of the map may be saved, and the map may be plotted on a hard copy device at any size desired. As many maps as desired may be made at one session.

Tyler, Sherman W.. and Lockheed, 1988. SAUCI: A Knowledge-Based Interface Architecture, Human Factors in Computing Systems, CHI'88; Washington, D.C., Edited by E. Soloway. pp 235-241.

Most current approaches to the design of the human-computer interface result in systems that are difficult for users to master. Ibis can be attributed to the absence of several key features, including: interface modularity; adaptability to the individual user; direct support of user intentions; and an intelligent advising capability. An architecture for the interface which facilitates the attainment of these four criteria is proposed. The architecture relies upon production system rules and various kinds of knowledge bases to tailor the user-computer dialogue to the ongoing context of the interaction. A prototype of this architecture has been implemented in LOOPS on a UNIX system, and has been shown to enhance substantially the performance of novice users of the system.

Umanath. Narayan S., and Richard W. Scamell. 1988. An Experimental Evaluation of the Impact of Data Display Format on Recall Performance, Communications of the ACM, 31 (5): pp 563-570.

Recall, while an important topic in the study of learning and memory, has received relatively little attention as a dependent variable in studies that investigate alternative formats for presenting information. This paper describes two experiments, performed back to back, that examined the relationship between data display format and recall performance across different task categories. The results of Experiment 1 were reaffirmed by Experiment 2 and collectively suggest that a graphical presentation enhances recall when the task possesses a spatial orientation while the recall of specific facts is indifferent to data display format.

van Nes, F.L., J.F. Juola, and RJ.A.M. Moonen, 1987. Attraction and Distraction by Text Colours on Displays, Human-Computer Interaction - INTERACT'87; Stuttgart, Federal Republic of Germany, Edited by H. J. Bullinger and B. Shackel. 1; pp 625630.

The effect of color differences on visual searching in videotext displays has been investigated in several experiments, including one with accurate measurements of eye movements. Subjects had to search for specific target words on display pages with normal text in one, two or four colors. The target-word color was either known or unknown to the subjects. Objective and subjective data from the experiments show the existence of two basic visual search modes in tasks of this type. The results of the reported research show the extent to which colour may attract or. alternatively, distract the reader's eyes while he/she is reading or searching a text. Some practical conclusions are drawn for information presentation on multicolor text displays.

van Overveld, Cwan. 1989. Application of a Perspective Cursor as a 3D Iocator Device; Computer-Aided Design, 21 (10): pp 619-629.

The functionality of a 3D cursor is described. it can be used as a 3D-locator device in such applications as interactive path planning (robotics), motion specification in 3D computer animation design, and wireframe modeling. With respect to the last of these applications, it is important that the cursor can be used either in constructive mode, as a set of three mutually orthogonal rulers, or in trace mode to copy a 2D perspective view of an object while resconstructing its 3D shape. As a special feature, the cursor may be equipped with a mirror symmetric counterpart. which facilitates the identification of locations in scenes that are (partially) symmetric, but also allows 3D symmetric objects to be entered from 2D (perspective) view, while making use of symmetry as a clue for reconstructing z-coordinates.

van der Veer, Gerrit C., Robert Wijk, and Michael A. M. Felt. 1990. Metaphors and Metacommunication in the Development of Mental Models. In Cognitive Ergonomics: Understanding, Learning, and Designing Human-Computer Interaction. Edited by P. Falzon. London, England: Academic Press Ltd.: pp 133 -149.

In this chapter the use of computer systems or computer applications will be analysed from the viewpoint of human learning. Any use of a computer presupposes a model of the system inside the mind of the user. In order to start with a feasible mental model, adequate analogies and metaphors will have to be provided. The user interface will be described as the location of communication and metacornmunication, providing a framework to separate the functions of the application system and the human-computer interaction component. Both the development of metaphors for initial introduction of a system, and the application of metacommunication will be illustrated with examples.

Vogel, H. J., 1989. GIS - Related Education and Training At Siemens, Proceedings Ninth International Symposium on Computer-Assisted Cartography; Baltimore Maryland, Edited by E. Anderson. pp 47-55.

With its wide range of various software modules SICAD has become a recognized and approved tool for the creation, maintenance, and extension of Geographic Information Systems. SICAD programs may run on microcomputer based graphic workstations in stand-alone mode as well as on large mainframes. The activities and facilities of the company to deliver the necessary education and training to the users of SICAD in order to enable them to master that tool are described. The important role played by the Siemans School for Data Processing and Communication Techniques in this regard is highlighted. The School's offer for professional training and education does not only comprise trainee programmes and courses for customers and Siemans staff. There are also courses held of up to two years that will lead to official qualifications and publicly recognized professional degrees. Efforts are also undertaken in the field of the unemployed. The contributions of the company's consultants and site engineers toward individual project support for GIS are mentioned. Finally, a brief outlook is given on future strategies for education and training.

Vonderohe, Alan P., and Raymond J. Hintz, 1984. A General-Purpose Computer Language for the Analysis and Adjustment of Horizontal Control Surveys, Annual Meeting of the American Congress on Surveying and Mapping; Washington, D.C.; pp 374-380.

A computer program for the pre-analysis and adjustment of local horizontal control surveys has been developed. Design criteria included ease of use and numerical efficiency. Although the method of observation equations is used in the adjustment. users need not provide initial approximations for station coordinates because the program generates its own. Input observations can be reduced to a user-selected state plane grid, and a pre-adjustment blunder detection and isolation algorithm ensures the integrity of the data. Various forms of post-adjustment statistics on the adjusted parameters and the standard error of unit weight are available. The English language is used to communicate with the program.

von Papstein, Patricia, Bayerische Motoren Werke AG, and Michael Frese, 1988. Transferring Skills From Training to the Actual Work Situation: The Role of Task Application Knowledge, Action Styles and Job Decision Latitude, Human Factors in Computing Systems. CHI'88; Washington, D.C., Edited by E. Soloway. pp 55-60.

In a field study (29 engineers), the transfer of expertise acquired in training to software use at work was shown to mediated by task application knowledge (i.e. knowledge used to connect skills learned in training with tasks at work). Moreover, person variables like setting long range goals and developing detailed plans and an organizational variable like job decision latitude (i.e. how much freedom do workers have to do their work) influenced the transfer process. People with high goal orientation and planfulness and with high job decision latitude showed a higher transfer.

Waern, Y. 1990. Human Learning of Human Computer Interaction: An Introduction. In Cognitive Ergonomics: Understanding, Learning, and Designing Human-Computer Interaction. Edited by P. Falzon. London, England: Academic Press Ltd.: pp 69 - 84.

The topic of human-computer interaction can be expected to require new concepts, new learning principles. At the same time we can expect at least some old principles to be valid. Two different research topics arise: one consists in studying the applicability of "old" concepts and principles to the new field, the other consists in studying the new field as it is, redetect the "old" principles as well as detect new principles. Both strategies have their strengths and weaknesses. In the research of learning within the field of human-computer interaction we find both strategies. The first strategy is the main focus of the chapter.

Walker, Neff, and Judith Reitman Olson, 1988. Designing Keybindings to be Easy to Learn and Resistant to Forgetting Even When the Set of Commands is Large, Human Factors in Computing Systems, CHI'88; Washington, D.C., Edited by E. Soloway. pp 201-206.

We formulated a set of rules for producing key-commands that are alternatives for activating commands with a mouse from menu. Because software is getting increasingly complex, it was important that the rules cover a wide variety of commands. The rules combined verb-modifier-object order and mnemonic abbreviations for the words in each slot. Our keybindings were shown not only to cover a wide set, but to be far easier to learn than EMACs (a common keybinding set) and a more robust form with respect negative interference from prior and post-learning of another set.

Walker, Neff, and John B. Smelcer, 1990. A Comparison of Selection Times from Walking and Pull-Down Menus, Human Factors in Computing Systems - Empowering People CHI '90; Seattle, Washington, Edited by J. C. Chew and J. Whiteside. pp 221-225.

This paper reports on an experiment that investigated factors which effect selection from walking menus and bar or pull-down menus. The primary focus was on the use of impenetrable borders and on expanding target areas on the two menu types. The results show that both factors can be used to facilitate menu selection, with the use of borders being most beneficial. In addition, the results suggest that even on large monitors. the time required to access items from a bar menu is less than that required for the best walking menu.

Ware, Colin. 1988. Color Sequences for Univariate Maps: Theory, Experiments, and Principles., IEEE Computer Graphics and Applications, 8 (5): pp 41-49.

Psuedocoloring is a widely used technique for presenting univariate map information on a graphic display system. This article divides the kinds of information] available in maps into two classes. Metric information] denotes the quantify stored at each point on the surface, and form information denotes the shape or structure of the surface. Theoretical principles are proposed to predict which color sequences will be effective in conveying value and form information respectively. According to this theory a scale that approximates the physical spectrum should be good at conveying value information, because of the reduced effects of simultaneous contrast. It should be poor at conveying form information, however, because the brain prefers form information to come through the lightness- processing "luminance" channel. Conversely, a gnay scale should be poor at conveying value information and good at conveying form information according to the same theory. These predictions are tested in a series of psychophysical experiments which test five color sequences. The results show that simultaneous contrast can be a major source of error when reading maps, but only partially confirm the form hypothesis. Guidelines are given, based on the theory, for designing color sequences to be effective in both conveying form and value information. An experimental color sequence is presented to illustrate these guidelines.

Weimer, D., and S.K. Ganapathy, 1989 A Synthetic Visual Environment with Hand Gesturing and Voice Input, CHI'89; Austin, Texas, Edited by I, Bice and C. Lewis. pp 235-240.

This paper describes a practical synthetic visual environment for use in CAD and teleoperation. Instead of using expensive head mounted display systems, we use a standard display and compute smooth shaded images using an AT&T Pixel Machine. The interface uses a VPL DataGlove to track the hand, bringing the synthetic world into the same space as the hand. Hand gesturing is used to implement a virtual control panel, and some 3D modeling tasks. When simple speech recognition was added it markedly improved the interface. We also outline what extensions might be needed for using this kind of inter-face for teleoperation.

White, Denis, Jonathon Corson-Rikert. and Margaret Maizel, 1987. WYSIWYG Digitizing: Real Time Geometric Correction and Topological Encoding, Auto-Carto 8; Baltimore, MA, Edited by N. R. Chrisman. pp 739-743.

Map input by manual digitizing no longer needs to be a multi-step process in which line gaps, overshoots, and topological coding errors are iteratively and painstakingly corrected. We have developed a " what you see is what you get" approach to map digitizing that continuously displays on the computer screen a geometrically corrected and topologically structured representation of a map. This approach is analogous to the WYSIWYG style of word processing where insertions and deletions automatically cause lines, paragraphs and pages to be adjusted such that a document is always displayed in its final form.

Whitefield, Andy. 1990. Human-Computer Interaction Models and Their Roles in the Design of Interactive Systems. In Cognitive Ergonomics: Understanding, Learning, and Designing Human-Computer Interaction. Edited by P. Falzon. London, England: Academic Press Ltd.: pp, 7 - 25.

This chapter critically examines the potential use of human-computer interaction models in the design of interactive computer systems. Two necessary initial steps are to consider the classes of human-computer interaction models that exist and the nature of the design. The classes of model that might be useful in system design are then outlined and the roles of two particular models described. Finally. these roles are considered from a number of perspectives.

Wiecha, C., W. Bennett, S. Boies, and J. Gould, 1989. Generating Highly Interactive User Interfaces, CHI'89, Austin, Texas, Edited by K. Bice and C. Lewis. pp 277-282.

Developers of User Interface Management Systems (UIMS) have demonstrated that separating the application from Its user interface supports device independence and customization. Interfaces produced in UIMS are typically crafted by designers expert in human factors and graphic arts. Little attention has been paid, however, to capturing the knowledge of such experts so that interfaces might be automatically generated by the application of style rules to additional applications. Ibis paper considers how toolkits and style rules can be structured so that the resulting interfaces take advantage of the best human factors and graphic arts knowledge, and are consistently styled.

Williams, R-J., 1989. Geographic information: Aspects of Phenomenology and Cognition, Auto-Carto 9; Baltimore, MA, Edited by E. Anderson. pp 557-566.

The disciplines of geography and cartography have experienced an on-going debate on the importance of topological structure in geographic data for the past two decades. It is only now that many organizations are realizing the importance of such structures. Therefore, having crossed the topology hurdle the current trend in research is towards integration of various data types and the object orientation of geographic features. This paper discusses phenomenological structures of geographic information and aspects of interpretation. Fundamental to this approach is the knowledge representation of phenomenons of the real world independent of any specific application, and that analysis is based on actual geographic structure and location and not on graphical representations of that data.

Williams, Tom. 1990. Graphics Interfaces Make Knobs and Switches Obsolete; Computer Design, 29(15):pp 78-94.

The article focuses on the move from control hardware to graphic user interfaces in industrial automation. How GUI's are being used in industry for process control and system design.

Williamson, Ian P., and Gary J. Hunter, 1989. The Importance of Conceptual Modelling in the Design of Land and Geographical Information Systems, Urban and Regional Information Systems Association Proceedings; Boston, Edited by A. H. Razer. II; pp 7-15.

Wilson, Warren E. 1965. Concepts of Engineering System Design. New York: Mcgraw Hill Book Company.

An introductory book for the engineer in system design. It examines the use of computers in engineering design as well as explaining how to test and evaluate a design. It serves as a basic guide for the general procedures used in system design.

Wilson, Kathleen S.. 1988. Using Latent Semantic Analysis to Improve Access to Textual Information, Human Factors in Computing Systems, CHI'88; Washington, D.C., Edited by E. Soloway. pp 281-286.

Wilson, Paul M., 1990. Get Your Desktop Metaphor off my Drafting Table: User Interface Design for Spatial Data Handling, 4th International Symposium on Spatial Data Handling; Zurich, Switzerland, Edited by K. Brassel. 1: pp 455-464.

Wozny. L. A. 1986. The Application of Metaphor, Analogy, and Conceptual Models in Computer Systems; Interacting with Computers, 1 (3): pp 273-283.

People using computer systems naturally relate what they are experiencing to what they already know. Ibis general cognitive process can be classified into metaphoric. analogical. and modelling processes. Metaphor, a term applied often to today's computer systems, is the process of representing the computer system with objects and events from a noncomputer domain, such as the popular desktop metaphor. Analogy is a comparison between objects or events that serve the same purpose but have different representations. Models are representations of the abstract conceptual structure of a computer system. This paper outlines the differences between these three processes and applies them to the computer domain. Implications for computer systems design are also discussed.

Wyszechki, Gunter, and W. S. Stiles. 1982. Color Science: Concepts and Methods, Quantitative Data and Formulae. New York: John Wiley & Sons.

This is the bible of color science. It covers physical color measurement, the working of the eye, calorimetry, photometry, visual matching, uniform color scales, visual thresholds, and theories and models of color vision. The volume contains an extended set of tables of data and an extensive set of references, with both subject and author indices.

Yang, Yiya, 1988. A New Conceptual Model for Interactive User Recovery and Command Reuse Facilities, Human Factors in Computing Systems, CHI'88; Washington, D.C., Edited by E. Soloway. pp 165-170.

Young, Richard M., and Tony Simon, 1987. Planning in the Context of Human-Computer Interaction. In People and Computers 3. Edited by D. Diaper and R Winder. 363 - 370. Cambridge: Cambridge University Press.

Interacting with a computer system requires the user to undertake a certain amount of planning, although good interactive systems minimize the need for this kind of cognitive activity. The planning relevant in an HCI context differs in emphasis from studied in Artificial Intelligence. The very nature of interactive computing environments generates a number of implications for the planning process, the chief of which are (1) that the activity of planning is intimately interleaved with the execution of the plans, and (2) that simple, practical plans are more appropriate than complex, detailed ones. Such an approach to planning yields behaviour bridging the spectrum from backwards- chaining puzzle-like problem solving at one extreme. to the smooth execution of routine methods at the other.

Young, Richard M.. and Allan MacLean, 1988. Choosing Between Methods: Analyzing the User's Decision Space in Terms of Schemas and Linear Models, Human Factors in Computing Systems. CHI'88; Washington, D.C., Edited by E. Soloway. pp 139-144.

Yuill, Charles B., Thomas L. Millette, and Gregory A. Elmes, 1990, Prototyping an Intelligent Geographic Information System Using Hypertext, ACSM/ASPRS Annual Convention; Denver, Colorado, 7, pp 307-316.

Role of prototyping, role of hypertext, examples of prototype utility.

Zanden. B.V., and BA Myers, 1990. Automatic, Look-and-Feel Independent Dialog Creation for Graphical User Interfaces, Human Factors in Computing Systems Empowering People CHI'90, Seattle, Washington, Edited by J. Chew and J. Whiteside. pp 27-34.

Jade is a new interactive tool that automatically creates graphical input dialogs such as dialog boxes and menus. Application programmers write a textual specification of a dialog's contents. This specification contains absolutely no graphical information and thus is look-and-feel independent. The graphic artist uses a direct manipulation graphical editor to define the rules, graphical objects, interaction techniques, and decorations that will govern the dialog's look-and-feel, and stores the results in a look and feel database. Jade combines the application programmer's specification with the look-and-feel database to automatically generate a graphical dialog. If necessary, the graphic artist can then edit the resulting dialog using a graphical editor and these edits will be remembered by Jade, even if the original textual specification is modified. By eliminating all graphical references from the dialog's content specification, Jade requires only the absolutely minimum specification from the application programmer. This also allows a dialog box or menu's look and feel to be rapidly and effortlessly changed by simply switching look and feel databases. Finally, Jade permits complex inter-field relationships to be specified in a simple manner.

Zetlan, Andrew J., 1989,.The Methodology of Prototyping: Shortcut to Success, GIS/LIS '89 Proceedings; Orlando, FL, 2: pp 620-628.

Ziegler, J.E., P.H. Vossen, and H.U. Hoppe. 1990. Cognitive Complexity of Human-Computer Interfaces: An Application and Evaluation of Cognitive Complexity Theory for Research on Direct Manipulation-Style Interaction. In Cognitive Ergonomics: Understanding, Learning, and Designing Human-Computer Interaction. Edited by P. Falzon. London, England: Academic Press Ltd.: pp 27 - 38.

Usability is a multifaceted concept which has to be broken down into more elementary notions referring to observable and measurable phenomena at the human-computer interface. Also, these phenomena have to be related to psychological models of performance, learning, transfer of learning and development of cognitive skills and competence. Only in this manner can we establish predictive measures of usability which are needed to complement the costly empirical evaluation of prototypes and products. The development of such a methodological framework, particularity for the analysis of direct manipulation interfaces, forms part of the project HUFIT, which is pursued in the European ESPIRT programme. This chapter deals with the establishment of predictive measures for learning and transfer of skills, the latter being a major indicator for the consistency of an interface. Cognitive complexity theory developed by Polson and Kieras (1985) offers a framework for the modelling of cognitive tasks and for deriving such predictions.