Interactive Electronic Technical Manuals (IETMs)
Annotated Bibliography

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Abstract

This annotated bibliography is a collection of relevant literature for researchers, designers, and developers of advanced Interactive Electronic Technical Manuals (IETMs). It focuses especially on natural language dialog and speech recognition for use in tutoring, training, and performance aiding systems to support military or civilian technicians or mechanics engaged in inspection, diagnosis, or repair of aircraft, ships, etc.. Books, articles, and standards documents are briefly described and evaluated to provide professionals with an efficient means to identify resources for use in IETM development, natural language dialog prototyping, and evaluation of such systems.

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Keywords: Natural Language Dialog, Performance Aiding, Speech Recognition, Hypertext, Intelligent Tutors, Navigation, Typography, Usability, Evaluation, Visualization, Training, Interactive Electronic Technical Manuals.

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Preface

This bibliography is organized into three major sections: (1) Academic research, (2) Government documents, and (3) Standards.

Within the first section there are nine subcategories: (a) Hypertext, (b) Intelligent Tutors, (c) Performance Aiding, (d) Speech Recognition/Natural Language Dialog, (e) Typography, (f) Usability and Evaluation, (g) User Interface Design and Navigation, (h) Visualization, and (i) Other.

In sections one and two, entries are ordered within each subcategory alphabetically by author's last name. The third section, Standards, is divided into two subcategories: (a) Government [entries 219-247 are sorted numerically by Standard number; entries 248-252 are sorted alphabetically by author's last name], and (b) ISO [entries 253-259 are sorted chronologically; entries 260-272 are sorted alphabetically by author's last name].

Databases used for this research are: Association of Computing Machinery (ACM), FirstSearch (World Catalog, Article First, Dissertations, Wilson Select Plus, Readers Guide to Abstracts, and ECO [collection of scholarly journals]), ProQuest Direct, and Web of Science.

Where appropriate, copies of papers are available from: Dr. Jane Siegel, Human-Computer Interaction Institute, 3603 Newell Simon Hall, 5000 Forbes Avenue, Pittsburgh, PA 15213, or via e-mail at jals@cs.cmu.edu.

1. ACADEMIC RESEARCH

a. Hypertext

[1] Askwall, S. (1985) "Computer Supported Reading Vs. Reading Text on Paper: A Comparison of Two Reading Situations." International Journal of Man-Machine Studies **22**: 425-439.

The effects of presentation mode on subjects' performance of a reasoning task was tested by comparing four different modes of presentation. Subjects were required to search and integrate information that was presented in short texts (22 sentences long). The texts were presented via a VDU (computerized reading situation) or on a paper (non-computerized reading situation), in their entirety or as separate sentences. Sixteen psychology students participated in the study. Reading speed and accuracy of judgment were unaffected by presentation medium (VDU or paper). Moreover, in both situations search times were longer when little information was available and when search demands were increased. Negative information had a similar effect on subjects' ratings of difficulty in the two situations. The way information was searched differed, however, in the computerized and the non-computerized reading situations when the texts were presented as separate sentences. Four different search strategies were found; they were unevenly distributed in the two situations. In the non-computerized situation, subjects searched almost twice as much information as they did in the computerized situation. On the other hand, in the computerized situation search times were almost twice as long. The results suggest that psychological studies on how existing cognitive skills are applied to computerized situations could provide a valuable source of information for designers of computer systems.

[2] Boroni, C.M., Goosey, F.W., Grinder, M.T., and Ross, J. R. (February 2001) "Engaging Students with Active Learning Resources: Hypertextbooks for the Web." ACM, *SIGCSE*, pgs. 65-69.

The World Wide Web has mesmerized educators for over a decade now with its tacit promise of platform independent, universal educational resource delivery. Indeed, many useful and exciting educational tools and distance learning courseware have been developed for the Web. On the other hand, some of the really fascinating educational resources – envisioned some years ago – remain elusive. One of these is the active learning hypertextbook. In this paper, the authors discuss the concept of an active learning hypertextbook, point out the state of the art, the technical problems to be surmounted, and the authors own research and development leading to hypertextbook resources in the Webworks Laboratory at Montana State University.

[3] Brockmann, R. J. (1990) Writing Better Computer User Documentation: From Paper to Hypertext, Version 2.0. New York, NY, John Wiley & Sons.

Revised edition (first edition, 1986) of a systematic approach to writing paper and on-line documents follows the process of creating materials from the inception of the documentation project to updating after publication. Designed to help processing professionals and technical writers write clear, accurate computer user documentation. Presents a systematic approach to writing paper and online documentation. Version 2 retains much essential material from the first edition, while offering new information on desktop publishing, CASE tools and the "software factory" programming technologies. Also covers new techniques such as team writing, hypertext, and mass storage.

[4] Chen, C. and Rada, R. (1996) "Interacting With Hypertext: A Meta-Analysis of Experimental Studies." Human-Computer Interaction **11**: 125-156.
This meta-analysis compared and synthesized the results of 23 experimental studies on hypertext. The analysis was based on 56 pairs of effect sizes and significance levels of the impact of users, tasks, and tools on interactions with hypertext. This analysis focused on three factors that prevailingly influence the use of hypertext: the cognitive styles and spatial ability of users; the complexity of tasks; and the structure of information organization and the visualization of the structure. The meta-analysis found that this group of experimental studies reported significantly discrepant findings, indicating that substantial differences exist among individual experiments. Individual differences in cognition did not yield enough evidence to conclude that the effect sizes are significantly apart from zero. The meta-analysis showed that the overall performance of hypertext users tended to be more effective than that of nonhypertext users, but the differences in efficiency measures were consistently in favor of nonhypertext users. Users benefited more from hypertext tools for open tasks. Overall, the complexity of tasks has the largest combined effect sizes. Graphical maps that visualize the organization of hypertext have significant impact on the usefulness of a hypertext system.

[5] Cubaud, P., and Topol, A. (2001). "A VRML-based User Interface for an Online Digitalized Antiquarian Collection." ACM, *Web3D '2001*, pgs. 51-59.
This paper presents a prototypal 3D application for the access to a digital library. It is mainly written in Java and relying on the 3D engine enclosed in a VRML browser. By describing the basic interactions we have included in this prototype and how they are implemented, the authors show that, with the actual Virtual Reality Modeling Language specification (VRML97) and even with the new Extented 3D (X3D) draft, it is too difficult to create some highly interactive virtual worlds. The effort needed to program basic behaviors with a script language raises some important problems. For solving them, the authors propose to work on adding some generic behavior nodes into the VRML specification.

[6] Dietrich, S.W., Suceava, D., Cherukuri, C., and Urban, S.D. (February 2001). "A Reusable Graphical User Interface for Manipulating Object-Oriented Databases using Java and XML." ACM, *SIGCSE 2001*, pgs. 362-366.
This paper describes the design and functionality of a graphical user interface (GUI) written in Java Swing that is used to support instructional activities associated with teaching object-oriented database (OODB) concepts. The GUI supports the manipulation of objects in an OODB, assuming the implementation of a specified interface for interacting with an OODB. By using the interface, students can focus on object-oriented design and programming concepts associated with OODB concepts rather than the development of a user interface. Since the GUI uses the Extensible Markup Language (XML) for defining the database schema and data import/export, the use of the GUI provides the added benefit of demonstrating the manner in which XML interacts with database technology.

[7] Konstantinou, V. and Morse, P. (1992) Electronic Document System: Using Automated Hypertext Techniques for Technical Support Services. Proceedings of the 10th Annual International Conference on Systems Documentation, SIGDOC '92.
The Electronic Documentation System was developed to provide fast, easy, online information retrieval, meeting a specific need for engineering industries. It addresses the requirements of

both the user and the author of electronic documentation and provides a viewing system that can be used across a variety of platforms. It also takes advantage of sophisticated cross-referencing techniques to automate the development of electronic documents.

[8] Landauer, T. Egan, D. Remde, J. Lesk, M. Lochbaum, C. and Ketchum, D. Enhancing the Usability of Text Through Computer Delivery and Formative Evaluation: the SuperBook Project. HYPERTEXT: A Psychological Perspective. C. McKnight, Dillon, A. and Richardson, J. New York, Ellis Horwood: 71-136.
The SuperBook project grew out of the convergence of two sources of interest in the use of computers for the delivery of text. The first was a set of research studies concerned with the psychology of information access by humans, studies initially done in the context of document retrieval and interfaces to databases. These studies attempted to analyze the factors involved when people look for and assimilate information, and in particular to identify important reasons for failures. Out of these studies, in turn, grew a number of schemes for improving human performance in search tasks. These schemes used computers to support indexing, querying, navigation and display in new ways that are difficult, if not impossible, to accomplish with paper and ink technology. The other source of the SuperBook concept was the ongoing evolution of computer-based methods for composing and publishing textual materials. Word processing and automated printing technology now make the vast majority of newly produced textual materials potentially available in machine-readable form. Moreover, the option of storing and distributing large volumes of text electronically has become not only feasible but economically attractive. The authors found that the design of text-delivery tools can depend heavily on the kind of text and what the user wants to do with it – no surprise – and they illustrate some of the design issues that result. The authors also briefly describe ports of the SuperBook system to a number of different platforms, and some of the usability design problems that have been raised, although not necessarily solved as yet, by dealing with hardware, software and standards constraints. Finally, the authors describe a new set of experiments, including new prototype delivery interfaces that incorporate some rather different techniques from those expressed in SuperBook. This last study is part of a cooperative research project in which substantial quantities of text in the field of chemistry will be delivered to faculty and students at Cornell University in electronic form.

[9] Narayanan, N. H. and Hegarty, M. (1998) "On Designing Comprehensible Interactive Hypermedia Manuals." International Journal of Human-Computer Studies **48**(2): 267-301.
User's mental representations and cognitive strategies can have a profound influence on how they interact with computer interfaces (Janosky, Smith & Hildreth, 1986). However, there is very little research that elucidates such mental representations and strategies in the context of interactive hypermedia. Furthermore, interface design for hypermedia information presentation systems is rarely driven by what is known of users' mental models and strategies. This paper makes three contributions toward addressing these problems. First, it describes a novel cognitive model of comprehension of multimodal presentations for the specific application of explaining how machines work, and proposed guidelines for hypermedia design derived from this model. Since the development of this model draws heavily upon research in both cognitive science and computational modeling, a second contribution is that it contains a detailed review of literature in these fields on comprehension from static multimodal presentations. Third, it illustrates how cognitive and computational modeling is being used to inform the design of hypermedia

information presentation systems about machines. This includes a framework for empirical validation of the model and evaluation of hypermedia design so that both theory and design can be refined iteratively.

[10] Nielsen, J. (1989) The Matters that Really Matter for Hypertext Usability. Proceedings of the Second Annual ACM Conference on Hypertext, Pittsburgh, PA, pgs. 239-248.
Comparison of 92 benchmark measurements of various usability issues related to hypertext which have been published in the hypertext literature in order to find which ones have shown the largest effects.

[11] Patankar, M. S. (1997) "A Framework for the Design of a Voice-activated, Intelligent, and Hypermedia-based Aircraft Maintenance Manual." Doctoral Dissertation, School of Computer and Information Sciences, Nova Southeastern University.
Federal Aviation Regulations require Aviation Maintenance Technicians (AMTs) to refer to approved maintenance manuals when performing maintenance on airworthy aircraft. Because these manuals are paper-based, the larger the size of the aircraft, the more cumbersome are the manuals. Federal Aviation Administration (FAA) recognized the difficulties associated with the use of large manuals and conducted studies on the use of electronic media as an alternative to the traditional paper format. However, these techniques do not employ any artificial intelligence technologies and the user interface is limited to either a keyboard or a stylus pen. The primary emphasis of this research was to design a generic framework that would allow future development of voice-activated, intelligent, and hypermedia-based aircraft maintenance manuals. A prototype (VIHAMS—Voice-activated, Intelligent, and Hypermedia-based Aircraft Maintenance System) was developed, as a secondary emphasis, using the design and development techniques that evolved from this research. An evolutionary software design approach was used to design the proposed framework and the structured rapid prototyping technique was used to produce the VIHAMS prototype. VoiceAssist by Creative Labs was used to provide the voice interface so that the users (AMTs) could keep their hands free to work on the aircraft while maintaining complete control over the computer through discrete voice commands. KnowledgePro for Windows, an expert system shell, provided "intelligence" to the prototype. As a result of this intelligence, the system provided expert guidance to the user. The core information contained in conventional manuals was available in a hypermedia format. The prototype's operating hardware included a notebook computer with a fully functional audio system. An external microphone and the built-in speaker served as the input and output devices (along with the color monitor), respectively. FAA estimates that U.S. air carriers operated 3,991 large jet aircraft in the year 1996 (FAA Aviation Forecasts, 1987-1998). With an estimate of seventy manuals per such aircraft, the development of intelligent manuals is expected to impact 279,370 manuals in this country. Soon, over 55 thousand maintenance technicians will be able to carry the seven pound system to an aircraft, use voice commands to access the aircraft's files on the system, seek assistance from the expert system to diagnose the fault, and obtain instructions on how to rectify the fault. An evolutionary design approach and the rapid prototyping techniques were used to test the structural and functional validity of this research. Evaluators used standard testing tools and evaluated the prototype under field conditions. They concluded that the VIHAMS prototype used a valid fault diagnosis strategy, the system architecture could be used to develop similar systems using off-the-shelf tools, and the voice input system could be refined to improve its usability.

[12] Weinreich, H., Obendorf, H., and Lamersdorf, W. (August 2001). "The Look of the Link – Concepts for the User Interface of Extended Hyperlinks." ACM, *HT '01*, pgs. 19-28.
The design of hypertext systems has been subject to intense research. Apparently, one topic was mostly neglected: how to visualize and interact with link markers. The paper presents an overview of pragmatic historical approaches, and discusses problems evolving from sophisticated hypertext linking features. Blending the potential of an Xlink-enhance Web with old ideas and recent GUI techniques, a vision for browser link interfaces of the future is being developed. The authors hope to stimulate the development of a standard for hyperlink marker interfaces, which is easy-to-use, feasible for extended linking features, and more consistent with current approaches.

[13] Zizi, M. and Beaudouin-Lafon, M. (1994) Accessing Hyperdocuments through Interactive Dynamic Maps. Proceedings of the 1994 ACM European Conference on Hypermedia Technology.
The authors proposed a new navigation paradigm based on a spatial metaphor to help users access and navigate within large sets of documents. This metaphor is implemented by a computer artifact called an Interactive Dynamic Map (IDM). An IDM plays a role similar to the role of a real map with respect to physical space. Two types of IDMs are computed from the documents: Topic IDMs represent the semantic contents of a set of documents while Document IDMs visualize a subset of documents such as those resulting from a query. IDMs can be used for navigating, browsing, and querying. They can be made active, they can be customized and they can be shared among users. The article presents the SHADOCS document retrieval system and describes the role, use and generation of IDMs in SHADOCS.

b. Intelligent Tutors

[14] Aleven, V.A.W.M.M, and K.R. Koedinger. (2002). "An Effective Metacognitive Strategy: Learning by Doing and Explaining with a Computer-based Cognitive Tutor." *Cognitive Science*, **26**(2).
The authors investigated whether self-explanation can be scaffolded effectively in a classroom environment using Cognitive Tutor, which is intelligent instructional software that supports guided learning by doing. Their research demonstrates that the benefits of self-explanation can be achieved in a relatively simple computer-based approach that scales well for classroom use.

[15] Aleven, V., and K.R. Koedinger. (2000). "The Need for Tutorial Dialog to Support Self-Explanation." In C.P. Rose and R. Freedman (Eds.), *Building Dialogue Systems for Tutorial Applications*, Papers of the 2000 AAAI Fall Symposium (pp. 65-73). Technical Report FS-00-01. Menlo Park, CA: AAAI Press.
What are good ways of using natural language dialog in intelligent tutoring systems? A role with high potential pay-off is to support the meta-cognitive process of self-explanation. In previous experiments involving the PACT Geometry Tutor, we found that students learn with greater understanding, when they are required to explain their solutions steps "by reference", that is, by naming the rule that was used. However, the tutor may be even more effective if students explain their solution steps in their own words and if the tutor helps them, through dialog, to improve

their explanations. An exploratory experiment with a tutor version that did not do any natural language processing, strongly suggested the need for natural language dialog. Without feedback from the tutor, students provided few free-form explanations in response to the tutor's prompts. Of the explanations that they did provide, only a small portion were correct and complete. During the experiment, we also identified a number of dialog strategies that we plan to implement in the tutor.

[16] Anderson, J.R., A.T. Corbett, K.R. Koedinger, and R. Pelletier. (1995). "Cognitive Tutors: Lessons Learned." *The Journal of the Learning Sciences*, **4**(2), pgs. 167-207.
This paper reviews the ten year history of tutor development based on the ACT theory (Anderson, 1983, 1993). We developed production system models in ACT of how students solved problems in LISP, geometry, and algebra. Computer tutors were developed around these cognitive models. Construction of these tutors was guided by a set of eight principles loosely based on the ACT theory. Early evaluations of these tutors usually but not always showed significant achievement gains. Best case evaluations showed that students could achieve at least the same level of proficiency as conventional instruction in one-third of the time. Empirical studies showed that students were learning skills in production-rule units and that the best tutorial interaction style was one in which the tutor provides immediate feedback, consisting of short and directed error messages. The tutors appear to work better if they present themselves to students as non human tools to assist learning rather than as emulations of human tutors. Students working with these tutors display transfer to other environments to the degree that they can map the tutor environment into the test environment. These experiences have coalesced into a new system for developing and deploying tutors. This system involves first selecting a problem-solving interface, then constructing a curriculum under the guidance of a domain expert, then designing a cognitive model for solving problems in that environment, then building instruction around the productions in that model, and finally deploying the tutor in the classroom. New tutors are being built in this system to achieve the NCTM standards for high school mathematics in an urban setting.

[17] Baker, R.S., A.T. Corbett, and K.R. Koedinger. (2002). "The Resilience of Overgeneralization of Knowledge about Data Representations." Presented at the *American Educational Research Association Conference*.
In this paper, the authors present a study that they conducted to explore the depth of transfer and to investigate methods for reducing its occurrence in generation, where it is clearly inappropriate. Given the strength of the student desire to choose axes appropriate to a bar graph when generating scatterplots and histograms, the authors decided to investigate whether there were ways to induce these students to instead draw the correct axes, and if there was further mistransfer of bar graph knowledge once the students had the correct exes, as the effect in Lehrer et al suggests. Therefore, the authors chose the general intervention of drawing the students' attention to the variables, in order to attempt to express each of these factors.

[18] Baker, R.S., A.T. Corbett, and K.R. Koedinger. "Toward a Model of Learning Data Representations."
The use of graphs to represent and reason about data is of growing importance in pre-high school mathematics curricula. This study examines middle school students' skills in reasoning about three graphical representations: histograms, scatterplots and stem-and-leaf plots. Students were

asked to interpret graphs, select an appropriate graph type to represent a relationship and to generate graphs. Accuracy levels varied substantially across the three tasks and three graph types. The overall pattern of results is largely explained by the varying ease of transfer of student knowledge from a simpler graph type, based on surface similarity.

[19] Koedinger, K.R., J.R. Anderson, W.H. Hadley, and M. Mark. (1997). "Intelligent Tutoring Goes to School in the Big City." *International Journal of Artificial Intelligence in Education*, 8, 30-43.
This paper reports on a large-scale experiment introducing and evaluating intelligent tutoring in an urban High School setting. Critical to the success of this project has been a client-centered design approach that has matched their client's expertise in curricular objectives and classroom teaching with their expertise in artificial intelligence and cognitive psychology. The Pittsburgh Urban Mathematics Project (PUMP) has produced an algebra curriculum that is centrally focused on mathematical analysis of real world situations and the use of computational tools. The authors have built an intelligent tutor, called PAT, that supports this curriculum and has been made a regular part of 9th grade Algebra in 3 Pittsburgh schools. In the 1993-94 school year, the authors evaluated the effect of the PUMP curriculum and PAT tutor use. On average the 470 students in experimental classes outperformed students in comparison classes by 15% on standardized tests and 100% on tests targeting the PUMP objectives. This study provides further evidence that laboratory tutoring systems can be scaled up and made to work, both technically and pedagogically, in real and unforgiving settings like urban high schools.

[20] Koedinger, K.R., and M.J. Nathan. (in press). "The Real Story Behind Story Problems: Effects of Representations on Quantitative Reasoning." *International Journal of the Learning Sciences*.
The authors explored how differences in problem representations change both the performance and underlying cognitive processes of beginning algebra students engaged in quantitative reasoning. Contrary to beliefs held by practitioners and researchers in mathematics education, the authors found that students were more successful solving simple algebra story problems than solving mathematically equivalent equations. Contrary to some views of situated cognition, this result is not simply a consequence of situated world knowledge facilitating problem solving performance, but rather a consequence of student difficulties with comprehending the formal symbolic representation of quantitative relations. The authors draw on analyses of students' strategies and errors as the basis for a cognitive process explanation of when, why, and how differences in problem representation affect problem solving.

c. Performance Aiding

[21] Brusilovsky, P., and Cooper, D.W. (January 13, 2002). "Domain, Task, and User Models for an Adaptive Hypermedia Performance Support System." ACM, *IUI '02*, pgs. 23-30.
Electronic Performance Support Systems (EPSS) is a challenging application area for developing intelligent interfaces. Some possible scenarios for using domain, task, and user models for adaptive performance support were explored in the context of the Adaptive Diagnostics and Personalized Technical Support (ADAPTS) project. ADAPTS provides an intelligent, adaptive EPSS for maintaining complex equipment.

[22] Cavazza, M., F. Charles, and S.J. Mead. (July 15-19, 2002). "Interacting with Virtual Characters in Interactive Storytelling." *AAMAS '02*, ACM: 318-325.
In recent years, several paradigms have emerged for interactive storytelling. In character-based storytelling, plot generation is based on the behavior of autonomous characters. In this paper, the authors describe user interaction in a fully implemented prototype of an interactive storytelling system. The authors describe the planning techniques used to control autonomous characters, which derive from HTN planning. The hierarchical task network representing a characters' potential behavior constitute a target for user intervention, both in terms of narrative goals and in terms of physical actions carried out on stage. The authors introduce two different mechanisms for user interaction: direct physical interaction with virtual objects and interaction with synthetic characters through speech understanding. The authors illustrate these functionalities with examples of system-generated behavior and conclude with a discussion of scalability issues.

[23] Franklin, D., Budzik, J., and Hammond, K. (January 13, 2002). "Plan-based Interfaces: Keeping Track of User Tasks and Acting to Cooperate." ACM, *IUI '02*, pgs. 79-86.
The ability to reason about the activity of a user is crucial to the implementation of any Intelligent User Interface. It if is able to recognize what a user is doing, a computer can act to cooperate. Most computer systems limit themselves to command-response interactions – their trivial understandings of their users cannot support a more complicated interaction. However, by looking at the tasks that their users are performing and reasoning about sequences of actions, a computer system can provide a more interesting level of interaction that is more efficient and does not demand as much of its users. Furthermore, the understanding of the user's activity provides a context within which to better understand future actions and to tune the sensing systems to look and listen for the actions that the user is most likely to take next. Finally, in many domains, such computer systems can recognize user tasks and act to cooperate without requiring a deep, goal-oriented understanding. In this paper, the authors look at the process-based interface used in the Intelligent Classroom, focusing on how a human lecturer can control it by simply going about her presentation. Also, the authors look at how the general ideas have been adapted to Jabberwocky, a speech-based interface to Microsoft PowerPoint that automatically switches slides, and how they are being applied to extend the functionality of Watson, an autonomous web research tool that uses the document a user is viewing as a search context.

[24] Hornbaek, K., and Frokjaer, E. (March 2001). "Reading of Electronic Documents: The Usability of Linear, Fisheye, and Overview+Detail Interfaces." ACM, *SIGCHI '01*, **3**: 293-300.
Reading of electronic documents is becoming increasingly important as more information is disseminated electronically. The authors present an experiment that compares the usability of a linear, a fisheye, and an overview+detail interface for electronic documents. Essays written using the overview+detail interface received higher grades, while subjects using the fisheye interface read documents faster. However, subjects used more time to answers questions with the overview+detail interface. The most common interface in practical use, the linear interface, is found to be inferior to the fisheye and overview+detail interfaces regarding most aspects of usability. The authors recommend using overview+detail interfaces for electronic documents, while fisheye interfaces mainly should be considered for time-critical tasks.

[25] Osborne, D. J. and Holton, D. (1988). "Reading From Screen Versus Paper: There Is No Difference." International Journal of Man-Machine Studies **28**: 1-9.
This paper considers the effect of presentation medium on reading speed and comprehension. By directly comparing performance using screen and paper presentations, it examines the argument that it takes longer to read from a screen-based display than from paper, and that comprehension will be lower. The hypothesis is also tested that it takes longer to read light characters on a dark background compared with dark characters on a light background, and that comprehension will be lower with light-character displays. Altogether four conditions were used, with two passages read in each condition: screen with dark characters, screen with light characters, paper with dark characters, and paper with light characters. Subjects also ranked the four conditions for preference. No significant difference was found in either reading speed or comprehension between screen and paper, or between dark and light character displays. Some preference differences were found, however. Reasons for the lack of reading and comprehension differences are discussed, and it is argued that this reflects the close attention to experimental detail paid in the present experiment, which has often been missing in past studies.

d. Speech Recognition / Natural Language Dialog

[26] Allan, J., and H. Raghavan. (2002). "Using Part-of-speech Patterns to Reduce Query Ambiguity." *SIGIR '02*, ACM: 307-314.
Query ambiguity is a generally recognized problem, particularly in Web environments where queries are commonly only one or two words in length. In this study, the authors explore one technique that finds commonly occurring patterns of parts of speech near a one-word query and allows them to be transformed into clarification questions. The authors use a technique derived from statistical language modeling to show that the clarification queries will reduce ambiguity much of the time, and often quite substantially.

[27] Boyce, S.J., and A.L. Gorin. "User Interface Issues for Natural Spoken Dialog Systems." *AT&T Laboratories*.
The authors are interested in building machines which can understand and act upon fluently spoken language. This is often not a single interaction, but rather involves a dialog to negotiate the proper outcome. The authors goal was to make such human-computer dialogs as natural as possible, so as to enable large populations of non-experts to use such systems. There are many user interface issues which then arise. The authors focus on a particular experimental vehicle, that of automatically routing telephone calls based on a user's fluently spoken request to *"How may I help you?"*. The authors describe several elements that are necessary in human-computer dialog which do not have ready analogs in the human-human case. Finally, the authors present preliminary experimental results evaluating user interface options for these elements.

[28] Dobroth, K. (February / March 2000). "Beyond Natural: Adding Appeal to Speech Recognition Applications?" *SpeechTechMag.com*
http://www.speechtechmag.com/pub/5_2/cover/191-1.html
Although humans engage in conversation with each other effortlessly, conversation is incredibly complex. For decades now, researchers have been trying to develop algorithms that capture the essence of conversation, and yet there still does not seem to be any commercially available

speech recognition systems that really behave as a person would in a conversation. If users expect that talking to a speech recognition application will be just like talking to a person, it is not clear that applications could ever measure up. But, for speech applications to be good, successful applications, do they have to resemble human conversation? And, should they?

[29] Ezzat, T., G. Geiger, and T. Poggio. (2002). "Trainable Videorealistic Speech Animation." ACM: 388-398.
The authors describe how to create with machine learning techniques a generative, Videorealistic, speech animation module. A human subject is first recorded using a videocamera as he/she utters a predetermined speech corpus. After processing the corpus automatically, a visual speech module is learned form the data that is capable of synthesizing the human subject's mouth uttering entirely novel utterances that were not recorded in the original video. The synthesized utterance is re-composited onto a background sequence which contains natural head and eye movement. The final output is videorealistic in the sense that it looks like a video camera recording of the subject. At run time, the input to the system can be either real audio sequences or synthetic audio produced by a text-to-speech system, as long as they have been phonetically aligned. The two key contributions of this paper are (1) a variant of the *multidimensional morphable model* (MMM) to synthesize new, previously unseen mouth configurations from a small set of mouth image prototypes; and (2) a *trajectory synthesis technique* based on regularization, which is automatically trained from the recorded video corpus, and which is capable of synthesizing trajectories in MMM space corresponding to any desired utterance.

[30] Hakulinen, J., and M. Turunen. (1999). "Prosodic Features for Speech User Interfaces." *ACHCI '99*: 1-7.
The designing of system utterances is a very crucial part of speech user interfaces, especially if speech synthesis is used. Although speech synthesis is quite intelligible in well formed and simple sentences it is very difficult for users to understand when complex structural elements like tables are spoken. Furthermore, most users do not like the way synthesizers use prosody. Most of the previous research has focused on what information should be presented to the user. Recent research has also brought up the question of how this information should be presented. In order to improve intelligibility and naturalness of synthetic speech the authors arranged an experiment to find new ways to use prosody. In this experiment subjects listened to three human readers and a speech synthesizer reading system utterances from their e-mail system. Questions were asked to measure how well the utterances were understood. Subjective evaluations of the voices were also collected. The authors used the results to find those prosodic elements that help users to better understand what they are hearing. Pauses were found to make a significant difference in comprehension. Good variation in pitch and speech seem to make a voice more pleasant to listen to but have only minor positive effect on comprehension.

[31] Hakulinen, J., M. Turunen, and K.-J. Raiha. "The Use of Prosodic Features to Help Users Extract Information From Structured Elements in Spoken Dialogue Systems." *Human-Computer Interaction Group*, Department of Computer Science, University of Tampere.
Most of the previous research on speech user interfaces has focused on what information should be presented to the user. Equally important is the question of *how* this information should be presented. Although speech synthesis is quite intelligible in well formed and simple sentences, it may be very difficult to understand when complex structural elements, like tables or URLs, are

spoken. The authors arranged a controlled experiment to identify the prosodic features that affect the intelligibility and pleasantness of synthetic speech. Pauses were found to make a significant difference in comprehension. Good variation in pitch and rate seem to make a voice more pleasant to listen to but have only minor positive effect on comprehension. The authors analyzed the exact ways in which human readers used prosodic elements so that they could construct unique and human like computer 'persons' for spoken dialogue applications.

[32] Huber, A., and B. Ludwig. (July 15-19, 2002). "Users Talk to their Model Trains: Interaction with a Speech-based Multi-Agent System." *AAMAS '02*, ACM: 800-801.
This paper presents an interactive multi-agent system (MAS) for controlling a model train installation. User intentions can be communicated to the system via speech and are processed by hierarchically organized autonomous agents with distributed knowledge and responsibilities in the application domain. Agents on deeper levels in the hierarchy execute, observe, and refine plans constructed by higher-level agents. Local planning and negotiating with the user resolve conflicts between requirements of tasks and the current application state. For this purpose a multi-model natural language dialogue system is incorporated as the user interface.

[33] Iovine, J. (May 2002). "Speech-Controlled Robotic Arm." Poptronics, pgs. 17-20.
In April 2002, the author built a PC interface for the OWI robotic arm. Now the author had added a speech-recognition interface. The interface uses the speech-recognition kit. This interface fits between the speech-recognition circuit and the robotic arm. It allows one to control all the robotic arm functions using verbal commands. The robotic arm has ten wired movement functions. Required is one verbal command for each function, plus one additional command for stopping all functions (movement). In total, there are 11 verbal commands. The speech-recognition kit can recognize up to 40 words. The second revision of the kit allows the user to choose, via a jumper setting, between recognizing 40 one-second words, or 20 two-second words; that setting improves the word recognition accuracy.

[34] Johnson, M.T. (August 2000). "Incorporating Prosodic Information and Language Structure into Speech Recognition Systems." Dissertation, Purdue University.
Some of the major research issues in the field of speech recognition revolve around methods of incorporating additional knowledge sources, beyond the short-time spectral information of the speech signal, into the recognition process. These knowledge sources, which may include information about prosody, language structures, semantics, and dialogue context, are difficult to quantify with regard to the task of language understanding, and are even more difficult to interface with the statistically motivated architectures such as Hidden Markov Models that are used for acoustic processing. The fundamental goal of this research is to further our understanding of how to incorporate prosodic features and language structure into recognition systems. Each of these two domains has proven to be particularly difficult to use effectively, especially for speaker independent tasks where most of the elements of these knowledge domains vary significantly between speakers. To accomplish this goal, the author looks at the effectiveness of using word graphs as an interface mechanism between recognition and language systems, develop the Observation Dependent Hidden Markov Model (ODHMM) which is able to adaptively alter transition probabilities based on the dynamics of spectral features, and apply temporal and suprasegmental information to the task of segmenting audio classes for broadcast news transcription.

[35] Jurafsky, D., and J.H. Martin. (2000). *Speech and Language Processing: An Introduction to Natural Language Processing, Speech Recognition, and Computational Linguistics*. Prentice-Hall.
Part I, “Words”, introduces concepts related to the processing of words: phonetics, phonology, morphology, and algorithms used to process them: finite automata, finite transducers, weighted transducers, N-grams, and Hidden Markov Models. Part II, “Syntax”, introduces parts-of-speech and phrase structure grammars for English and gives essential algorithms for processing word classes and structured relationships among words: part-of-speech taggers based on HMMs and transformation-based learning, the CYK and Earley algorithms for parsing, unification and typed feature structures, lexicalized and probabilistic parsing, and analytical tools like the Chomsky hierarchy and pumping lemma. Part III, “Semantics”, introduces first order predicate calculus and other ways of representing meaning, several approaches to compositional semantic analysis, along with applications to information retrieval, information extraction, speech understanding, and machine translation. Part IV, “Pragmatics”, covers reference resolution and discourse structure and coherence, spoken dialogue phenomena like dialogue and speech act modeling, dialogue structure and coherence, and dialogue managers, as well as a comprehensive treatment of natural language generation and of machine translation.

[36] Kaur, M. (October 2000). “Integration of Gaze and Speech for Multimodal Human Computer Interaction.” Dissertation, New Brunswick, Rutgers, The State University of New Jersey.
Most commonly used human-computer interfaces do not take advantage of the many communication channels humans use to communicate in verbal and non-verbal ways. The Rutgers University CAIP Center, under the NSF STIMULATE program, has been conducting research to establish, quantify, and evaluate techniques for designing synergistic combinations of human-machine communication modalities like sight, sound, and touch. An initial system using these modalities has been implemented at CAIP, and it has been seen that even with our simplistic integration scheme and imperfect component technologies, there are obvious performance advantages to be gained from the use of multiple modalities. The research described in this thesis is a systematic evaluation and characterization of gaze as an input modality, and its integration with speech. The overall goal of the research was to explore the use of gaze and speech as input modalities for HCI, and to understand the natural integration patterns typically occurring in the combined use of the two. Exhaustive characterization of the use of gaze as an input modality for human-computer interaction has been done. Relationship between object selection times with distance, size, and index of difficulty, as defined by Fitts law, have been studied. The speech and gaze experiments described in this work provide detailed timing correlations of speech and gaze, both in a natural environment, and a computer-based system which can be used to answer the questions of *when* and *how* to integrate the two modalities. The integration of speech and gaze has been studied under linguistically different command structures like the use of labels (Move *A* to *1*), descriptors (Move *triangular bar* to *triangular slot*) and anaphora (Move *This There*). It has been found that there are fundamental relationships between gaze and speech events, e.g., gaze always precedes speech, though the time is seen to vary with command structure. The effect of command structure is seen to decrease in a computer-based environment. Also, it has been demonstrated that the detailed knowledge of the timing relationship of the speech and gaze patterns for command specification and command execution can be used for error resolution for a more robust multimodal interface.

[37] Lin, W.-H., and A.G. Hauptmann. (July 13-17, 2002). "A Wearable Digital Library of Personal Conversations." *JCDL '02*, ACM: 277-278.
The authors have developed a wearable, personalized digital library system, which unobtrusively records the wearer's part of a conversation, recognizes the face of the current dialog partner and remembers his/her voice. The next time the system sees the same person and hears the same voice; it can replay parts of the last conversation in compressed form. Results from a prototype system show the effectiveness of combining of face recognition and speaker identification for retrieving conversations.

[38] ManE, A., S. Boyce, D. Karis, and N. Yankelovich. (1996). "Designing the User Interface for Speech Recognition Applications: A CHI 96 Workshop." Presented at a workshop of the ACM SIGCHI Conference.
http://www.acm.org/sigchi/bulletin/1996.4/boyce.html
The progress made over the last few years in speech technology has generated new opportunities and new challenges for designers. One common need that was expressed by the participants is for a rich set of tools for specifying and prototyping user interfaces, and for a rich exchange of information between the part of the application that governs the user interface and the part that analyzes the user's speech. The workshop successfully covered a gamut of issues that underlie the design of speech-based interfaces. One common sentiment was that after having this theoretical discussion as a background, the authors can now focus more on the practical challenges of designing speech based interfaces.

[39] McTear, M.F. (2002). "Spoken Dialogue Technology: Enabling the Conversational User Interface." ACM Computing Surveys **34**: 90-169.
Spoken dialogue systems allow users to interact with computer-based applications such as databases and expert systems by using natural spoken language. The origins of spoken dialogue systems can be traced back to Artificial Intelligence research in the 1950s concerned with developing conversational interfaces. However, it is only within the last decade or so, with major advances in speech technology, that large-scale working systems have been developed and, in some cases, introduced into commercial environments. As a result many telecommunications and software companies have become aware of the potential for spoken dialogue technology to provide solutions in newly developing areas such as computer-telephony integration. Voice portals, which provide a speech-based interface between a telephone user and Web-based services, are the most recent application of spoken dialogue technology. This article describes the main components of the technology – speech recognition, language understanding, dialogue management, communication with an external source such as a database, language generation, speech synthesis – and shows how these component technologies can be integrated into a spoken dialogue system. This article describes in detail the methods that have been adopted in some well-known dialogue systems, explores different system architectures, considers issues of specification, design, and evaluation, reviews some currently available dialogue development toolkits, and outlines prospects for future development.

[40] Nichols, J., B. Myers, T.K. Harris, R. Rosenfeld, S. Shriver, M. Higgins, and J. Hughes. (October 14-16, 2002). "Requirements for Automatically Generating Multi-Modal Interfaces for Complex Appliances." *Fourth IEEE ICMI '02 - International Conference on Multimodal Interfaces*, Pittsburgh, PA, pgs. 377-382.
Several industrial and academic research groups are working to simplify the control of appliances and services by creating a truly universal remote control. Unlike the preprogrammed remote controls available today, these new controllers download a specification from the appliance or service and use it to automatically generate a remote control interface. This promises to be a useful approach because the specification can be made detailed enough to generate both speech and graphical interfaces. Unfortunately, generating good user interfaces can be difficult. Based on user studies and prototype implementations, this paper presents a set of requirements that the authors have found are needed for automatic interface generation systems to create high-quality user interfaces.

[41] Oard, D.W. (June/July 2000). "User Interface Design for Speech-Based Retrieval." Bulletin of the American Society for Information Science, pgs. 20-22.
It is now quite practical to apply speech-based retrieval techniques to collections containing several thousand hours of retrieved audio, and Moore's Law assures us that those numbers will grow rapidly over the next few years. If we are to make the best use of these emerging capabilities, we will need to devote increased attention to the design of user interfaces that support effective search strategies. This will undoubtedly be an interactive process, since we cannot hope to understand which search strategies will be most effective until we have a rich set of user interfaces with which to experiment. This article briefly reviews the process of searching electronic text collections and then describes how the process can be adapted to support searching large audio collections based on speech contained in those collections.

[42] Oh, A.H., and A.I. Rudnicky. "Stochastic Natural Language Generation for Spoken Dialog Systems." Article submitted to *Computer Speech and Language*.
The authors describe a corpus-based approach to natural language generation (NLG). The approach has been implemented as a component of a spoken dialog system and a series of evaluations were carried out. The system uses n-gram language models, which have been found useful in other language technology applications, in a generative mode. It is not yet clear whether the simple n-grams can adequately model human language generation in general, but we show that we can successfully apply this ubiquitous modeling technique to the task of natural language generation for spoken dialog systems. In this paper, the authors discuss applying corpus-based stochastic language generation at two levels: content selection and sentence planning/realization. At the content selection level, output utterances are modeled by bigrams, and the appropriate attributes are chosen using bigram statistics. In sentence planning and realization, corpus utterances are modeled by n-grams of varying length, and new utterances are generated stochastically. Through this work, the authors show that a simple statistical model alone can generate appropriate language for a spoken dialog system. The results describe a promising avenue for using a statistical approach in future NLG systems.

[43] Oviatt, S., and P. Cohen. (2000). "Designing the User Interface for Multimodal Speech and Pen-Based Gesture Applications: State-of-the-Art Systems and Future Research Directions." Human-Computer Interaction **15**, pgs. 263-322.
The growing interest in multimodal interface design is inspired in large part by the goals of supporting more transparent, flexible, efficient, and powerfully expressive means of human-computer interaction than in the past. Multimodal interfaces are expected to support a wider range of diverse populations, be usable by a broader spectrum of the average population, and function more reliably under realistic and challenging usage conditions. In this article, the authors summarize the emerging architectural approaches for interpreting speech and pen-based gestural input in a robust manner – including early and lat fusion approaches, and the new hybrid symbolic-statistical approach. The authors also describe a diverse collection of state-of-the-art multimodal systems that process users' spoken and gestural input. These applications range from map-based and virtual reality systems for engaging in simulations and training, to field medec systems for mobile use in noisy environments, to web-based transactions and standard text-editing applications that will reshape daily computing and have a significant commercial impact. To realize successful multimodal systems for the future, many key research challenges remain to be addressed. Among these challenges are the development of cognitive theories to guide multimodal system design, and the development of effective natural language processing, dialogue processing, and error-handling techniques. In addition, new multimodal systems will be needed that can function more robustly and adaptively, and with support for collaborative multiperson use. Before this new class of systems can proliferate, toolkits also will be needed to promote software development for both simulated and functioning systems.

[44] Oviatt, S., M. MacEachern, and G.-A. Levow. "Predicting Hyperarticulate Speech During Human-Computer Error Resolution."
When speaking to interactive systems, people sometimes *Hyperarticulate* – or adopt a clarified form of speech that has been associated with increased recognition errors. The goals of the present study were: (1) to establish a flexible simulation method for studying users' reactions to system errors, (2) to analyze the type and magnitude of linguistic adaptations in speech during human-computer error resolution, (3) to provide a unified theoretical model for interpreting and predicting users' spoken adaptations during system error handling, and (4) to outline the implications for developing more robust interactive systems. A semi-automatic simulation method with a novel error generation capability was developed to compare users' speech immediately before and after system recognition errors, and under conditions varying in error base-rate. Matched original-repeat utterance pairs then were analyzed for type and magnitude of linguistic adaptation. When resolving errors with a computer, it was revealed that users actively tailor their speech along a spectrum of hyperarticulation, and as a predictable reaction to their perception of the computer as an "at risk" listener. During both lo and high error rates, durational changes were pervasive, including elongation of the speech segment and large relative increases in the number and duration of pauses. During a high error rate, speech also was adapted to include more hyper-clear phonological features, fewer disfluencies, and change in fundamental frequency. The two-stage CHAM model (Computer-elicited Hyperarticulate Adaptation Model) is proposed to account for these changes in users' speech during interactive error resolution.

[45] Owei, V. (July 2002). "An Intelligent Approach to Handling Imperfect Information In Concept-Based Natural Language Queries." ACM Transactions on Information Systems **20**: 291-328.
Missing information, imprecision, inconsistency, vagueness, uncertainty, and ignorance abound in information systems. Such imperfection is a fact of life in database systems. Although these problems are widely studied in relational database systems, this is not the case in conceptual query systems. And yet, concept-based query languages have been proposed and some are already commercial products. It is therefore imperative to study these problems in concept-based query languages, with a view to prescribing formal approaches to dealing with the problems. In this article, the author has done just that for a concept-based natural language query system that he developed. A methodology for handling and resolving each type of imperfection is developed. The proposed approaches are automated as much as possible, with the user mainly serving an assistive function.

[46] Quek, F., D. McNeill, R. Bryll, S. Duncan, X.-F. Ma, C. Kirbas, K.E. McCullough, and R. Ansari. (September 2002). "Multimodal Human Discourse: Gesture and Speech." ACM Transactions on Computer-Human Interaction **9**: 171-193.
Gesture and speech combine to form a rich basis for human conversational interaction. To exploit these modalities in HCI, we need to understand the interplay between them and the way in which they support communication. The authors propose a framework for the gesture research done to date, and present their work on the cross-modal cues for discourse segmentation in free-form gesticulation accompanying speech in natural conversation as a new paradigm for such multimodal interaction. The basis for this integration is the psycholinguistic concept of the coequal generation of gesture and speech from the same semantic intent. The authors present a detailed case study of a gesture and speech elicitation experiment in which a subject describes her living space to an interlocutor. The authors perform two independent sets of analyses on the video and audio data: video and audio analysis to extract segmentation cues, and expert transcription of the speech and gesture data by microanalyzing the videotape using a frame-accurate videoplayer to correlate the speech with the gestural entities. The authors compare the results of both analyses to identify the cues accessible in the gestural and audio data that correlate well with the expert psycholinguistic analysis. The authors show that "handedness" and the kind of symmetry in two-handed gestures provide effective supersegmental discourse cues.

[47] Sun Microsystems. (October 26, 1998). "Designing Effective Speech Applications" Chapter 3 in *Java Speech API Programmer's Guide*,
http://java.sun.com/products/java-media/speech/forDevelopers/jsapi-guide/UserInterface.html
Speech applications are like conversations between the user and the computer. Conversations are characterized by turn-taking, shifts in initiative, and verbal and non-verbal feedback to indicate understanding. A major benefit of incorporating speech in an application is that speech is natural: people find speaking easy, conversation is a skill most master early in life and then practice frequently. At a deeper level, naturalness refers to the many subtle ways people cooperate with one another to ensure successful communication. An effective speech application is one that simulates some of these core aspects of human-human conversation. Since language use is deeply ingrained in human behavior, successful speech interfaces should be based on an understanding of the different ways that people use language to communicate. Speech applications should adopt language conventions that help people know what they should say next and that avoid conversational patterns that violate standards of polite, cooperative behavior. This

chapter discusses when a speech interface is and is not appropriate, and then provides some concrete design ideas for creating effective speech applications that adhere to conversational conventions.

[48] Ton, L., and Rothkrantz, L.J.M. (2001). "Determining User Interface Semantics Using Communicating Agents." TSD, Springer-Verlag, Berlin, pgs. 349-356.
The Internet offers remote access to many information systems to users independent of time and location. This paper describes an agent based approach to deal with issues that rise from the difference between user interfaces to functionally similar information systems. The approach yields agents that interact with user interfaces to extract the model of the underlying information system. The model is represented by labeling input fields of the interface with their meaning. The agents are modeled after human dialogue behavior and human computer interaction. The interaction agents are capable of independently and robustly querying the information system without explicit instructions. Two types of agents are implemented and tested on European sites of rail travel planners. A corpus of seven rail planners was created. The authors modeled human computer interaction based on the analysis of these planners. A notation that can be used to describe start pages based on their functionality was defined. A framework to use the start page description language to fill out a start page form and to retrieve the results was created. A testing module for testing result pages was implemented. Two example agents for extracting user interface semantics was developed. These agents are programmed as expert systems that have rules to take action based on intermediate and result pages. A testing environment was created.

[49] Traum, D., and J. Rickel. (July 15-19, 2002). "Embodied Agents for Multi-party Dialogue in Immersive Virtual Worlds." *AAMAS '02*, ACM: 766-773.
Immersive virtual worlds are increasingly being used for education, training, and entertainment, and virtual humans that can interact with human users in these worlds play many important roles. However, current computational models of dialogue do not address the issues that arise with face-to-face communication situated in three-dimensional worlds, such as the proximity and attentional focus of others, the ability to maintain multi-party conversations, and the interplay between speech and nonverbal signals. This paper presents a new model that integrates and extends prior work on spoken dialogue and embodied conversational agents, and describes an initial implementation that has been applied to training in virtual reality.

[50] Wactlar, H.D., and C.-C. Chen. (July 13-17, 2002). "Enhanced Perspectives for Historical and Cultural Documentaries Using Informedia Technologies." *JCDL '02*, ACM: 338-339.
Speech recognition, image processing, and language understanding technologies have successfully been applied to broadcast news corpora to automate the extraction of metadata and make use of it in building effective video news retrieval interfaces. This paper discusses how these technologies can be adapted to cultural documentaries as represented by awarding-winning First Emperor of China videodisc and multimedia CD. Through automated means, efficient interfaces into documentary contents can be build dynamically based on user needs. Such interfaces enable the assemblage of large video documentary libraries from component videodisc, CD, and videotape projects, with alternative views into the material complementing the original sequences authored by the materials' producers.

[51] Walker, M.A., D.J. Litman, C.A. Kamm, and A. Abella. "PARADISE: A Framework for Evaluating Spoken Dialogue Agents." *AT&T Labs – Research*, pgs. 271-280.
This paper presents PARADISE (PARAdigm for DIalogue System Evaluation), a general framework for evaluating spoken dialogue agents. The framework decouples task requirements from an agent's dialogue behaviors, supports comparisons among dialogue strategies, enables the calculation of performance over subdialogues and whole dialogues, specifies the relative contribution of various factors to performance, and makes it possible to compare agents performing different tasks by normalizing for task complexity.

[52] Weinschenk, S., and D.T. Barker. (April 2000). Designing Effective Speech Interfaces. John Wiley & Sons, Inc.
The authors focus on S/GUI interfaces, where speech is part of a multi-modal interface, as well as several types of AUI interfaces, where the user interacts with the software primarily through speech. They clearly explain the interface design principles that are applied to speech interfaces and describe the latest practices of leading experts. The authors also provide coverage of the special issues involved in interface design for disabled persons. Along with its in-depth look at speech technologies and the different types of user interfaces, this book: (1) Gives an overview of the field of human factors and defines the basic concepts of human computer interaction. (2) Discusses the current state of speech technology applications. (3) Explains the laws of human factors that apply to speech interfaces. (4) Contains guidelines and examples for user control, human limitation, model integrity accommodation, clear dialogue, and aesthetic integrity. (5) Details the best practices in interface design and usability engineering

[53] Yankelovich, N. (1997). "Using Natural Dialogs as the Basis for Speech Interface Design." Chapter in *Automated Spoken Dialog Systems*, edited by S. Luperfoy, MIT Press.
In sum, this experience has shown that natural dialogs can serve as an effective starting point for a speech user interface design. Not only do they help in the design of grammars, feedback, and prompts, but they also point out instances where speech technology cannot be effectively applied. These case studies are intended to demonstrate that extremely useful data can be collected without an elaborate setup or software development effort. Both the Office Monitor and the Drawing studies involved minimal preparation, no software development, and less than an hour of recorded data. With some creative thinking about the study design, it is usually easy to construct a setting for interaction that approximates the interaction that will occur in the software system.

[54] Yankelovich, N., and K. Ehrlich. (November/December 1996). "How Do Users Know What To Say?" ACM Interactions **3**: pgs. 33-43.
http://www.sun.com/research/speech/publications/
As speech recognition technology improves, many software designers are being challenged to design speech user interfaces. For the author, one of the most challenging issues is "How do users know what they can say?" A speech-only interface poses the same problems as a command-line interface. The functionality of application is hidden, and the boundaries of what can and cannot be done are invisible. Graphical interfaces were invented largely to make hidden functionality visible to the user. In a speech-only environment, such as over a telephone, it is not possible to display menus, show options, or highlight buttons. Instead, other techniques must be used to guide users through a successful interaction. To gather insight into ways of tackling this

difficult problem, the author asked a dozen respected speech user interface designers to give her examples of how they let their users know what they can say. The paper covers the following sections: Defining the Problem, Design Constraints, Techniques (Explicit Prompts, Implicit Prompts, Incremental and Expanded Prompts, Tapering, Hints, and Techniques Specific to Multimodal Systems). User experience coupled with thoughtful prompt design does not guarantee a successful speech interface. Other design issues play an equally important role. These include crafting grammars or command languages, providing appropriate feedback, and recovering from errors. In addition, a consistent "sound and feel" across speech applications can go a long way in helping users know what to say.

[55] Yankelovich, N., G.-A. Levow, and M. Marx. (1995). "Designing SpeechActs: Issues in Speech User Interfaces." *CHI '95 Proceedings*.
http://www.acm.org/sigchi/chi95/Electronic/documnts/papers/ny_bdy.htm
SpeechActs is an experimental conversational speech system. Experience with redesigning the system based on user feedback indicates the importance of adhering to conversional conventions when designing speech interfaces, particularly in the face of speech recognition errors. Study results also suggest that speech-only interfaces should be designed from scratch rather than directly translated from their graphical counterparts. This paper examines a set of challenging issues facing speech interface designers and describes approaches to address some of those challenges. Some design challenges consist of: simulating conversations, pacing of the conversation, transforming GUIs into SUIs, vocabulary, organization and flow of information, recognition / rejection/ substitution / insertion errors, the very nature of speech itself, lack of visual feedback, conversational speech and persistence, and ambiguous silence.

[56] Zhang, Y. (April 2000). "Information Fusion for Robust Audio-Visual Speech Recognition." Dissertation, University of Illinois at Urbana-Champaign.
Computer technologies have improved significantly in both capacity and speed. The human-computer interface still lags behind, in that human-computer interaction lacks the naturalness essential for efficient communication. In order to make human-computer interaction more natural, novel sensory modalities have been used. Speech, gestures, and emotional states can be detected and understood to some extent. However, integrating these information sources to achieve performance superior to any single modal alone remains a challenging problem. Humans naturally and effortlessly perform sensory information fusion. The most important human-to-human communication tool is speech. Automatic speech recognition by machines has been able to achieve very high recognition accuracy for large vocabulary sets and speaker-independent tasks. However, in some environments, unexpected sources of noise will degrade system performance. The author proposes a novel integration technique that can efficiently incorporate both visual and acoustic speech signals to achieve better speech recognition accuracy than that achieved by either of the single modalities alone. The proposed fusion schemes have been tested in different situations. The experiment results show consistently improved performance by using multimodal fusion schemes.

e. Typography

[57] Black, A. and Boag, A. (1992) Choosing Binary or Greyscale Bitmaps: some Consequences for Users. EP92, Cambridge University Press: 247-260.
Two studies investigated using binary or greyscale bitmap fonts in reading, proofreading with correction, and identifying typefaces. At a fixed size (10 pt) ease of reading, and proofreading, did not vary according to font type (binary or greyscale), but according to apparent size of the typefaces tested. Typeface identification was significantly more accurate with greyscale bitmaps than with binary bitmaps. We conclude that in contexts where legibility is essential, such as in electronic texts, greyscale bitmaps are subject to the same sorts of constraints as binary bitmaps, and typeface and size must be chosen carefully. However greyscaling is likely to improve the user interface for tasks such as designing paper documents on screen, where the accurate reproduction of letterforms is important. Further study should demonstrate which screen-based design decisions are supported well by greyscale representations.

[58] Boyarski, D. Neuwirth, C. Forlizzi, J. and Harkness Regli, S. (1998) "A Study of Fonts Designed for Screen Display." CHI '98 Papers: 87-93.
This study examined the readability and subjective preferences of a set of fonts designed for screen display. Two new binary bitmap fonts performed well, suggesting that designers should consider incorporating similar attributes into default fonts for on-line type.

[59]] Duesbury, R. T. and O'Neil, Jr. H.F. (1996) "Effect of Type of Practice in a Computer-Aided Design Environment in Visualizing Three-Dimensional Objects From Two-Dimensional Orthographic Projections." Journal Of Applied Psychology. **81**(3): 249-260.
The purpose of this study was to determine the effect of practice in manipulating 2- and 3-dimensional (D) wireframe images on a learner's ability to visualize 3-D objects. Practice, either rotational or not, consisted of visualizing 2- and 3-D objects generated by personal computer (PC)-based computer-assisted design software. Results indicated that participants in the rotation treatment group performed significantly better than those in either the nonrotation or control group on measures of spatial ability and 3-D visualization ability. Both treatment groups performed significantly better than the control group on measures of metacognition, effort, and worry. These results support a conclusion that spatial ability can be improved through practice that allows the learner to see the relationship between the 2-D and 3-D features of objects.

[60] Dumbeck, K. (1999) "Book Review: Typography on the Web." Technical Communication, Second Quarter: 263-265.
As if keeping ourselves educated on the rules of typography (if there are indeed actual rules) for the print media hasn't kept us busy enough, we must now begin the serious consideration of typography as it pertains to Web publications. While this may seem straightforward to some, on further consideration, you may find there is more to it than meets the naked, paper-trained eye. This book does an excellent job of providing a fairly comprehensive overview of many of the issues that designers and typographers must consider when creating Web publications. The book is divided into the following seven parts, moving logically from fundamental to more advanced topics: (1) Fundamentals of typography, (2) Digital typography, (3) Typography on the Web, (4) Cascading Style Sheets, (5) TrueDoc, (6) Font embedding, and (7) Advanced topics in Web typography.

[61] Durand, D. G. DeRose, S.J. and Mylonas, E. What Should Markup Really Be? Applying Theories of Text to the Design of Markup Systems.
http:://www.cs.bu.edu/students/grads/dgd/markup_abridged.htm
The issue of what text really is, and how it affects our notions of proper text representation has been with us almost from the beginning of text encoding [Goldbarb 1981, Reid 1980, Coombs, et al. 1987, DeRose, et al. 1990, Renear et al.]. The simplest reasonable view, that text is fundamentally an ordered hierarchical structure, determined by its editor and author, is an early one that has remained prominent, especially as reified by ISO 8879 (SGML). However, this simple model is not enough, which the TEI [Sperberg-McQueen and Burnard 1990, 1993] quickly discovered as it moved text encoding from the realm of print production to that of scholarship, textual editing, and linguistic analysis. The TEI metalanguage committee identified problems with SGML's simple hierarchical mechanisms, and developed and published techniques for working around them to encode non-hierarchical phenomena [Barnard et al, 1996].

[62] Gilreath, C. T. (1993) "Graphic Cueing of Text: The Typographic and Diagraphic Dimensions." Visible Language **27**(3): 336-361.
A new taxonomy is proposed for classifying the graphic cues commonly used in visually informative text. Previous approaches have focused on typographic and spatial cueing but have not formalized the concept which the author calls mark cueing. Mark cues are lines such as dividers, guidelines and network links and visual tags such as bullets and enumerators. Spatial and mark cueing are subsumed under a new concept called diagraphic cueing. Together, diagraphic and typographic cueing make up the broader concept of graphic cueing. The various forms of graphic cues are surveyed, with a brief look at products such as vertical lists, tables, network diagrams and text labels.

[63] Golovchinsky, G. Kamps, T. and Reichenberger, K. (1995) "Subverting Structure: Data-driven Diagram Generation." IEEE Conference Proceedings on Visualization '95: 217-223, 455. ISBN: 0-8186-7187-4, IEEE Catalog Number: 95CB35835.
Diagrams are data representations that convey information predominantly through combinations of graphical elements rather than through other channels such as text or interaction. The authors have implemented a prototype called AVE (Automatic Visualization Environment) that generates diagrams automatically based on a generative theory of diagram design. According to this theory, diagrams are constructed based on the data to be visualized rather than by selection from a predefined set of diagrams. This approach can be applied to knowledge represented by semantic networks. In this paper they give a brief introduction to the underlying theory, then describe the implementation and finally discuss strategies for extending the algorithm.

[64] Ishizaki, S. and Lokuge, I. (1995) Intelligent Interactive Dynamic Maps. Proceedings of AutoCarto 12. MIT Media Laboratory's Visible Language Workshop. Sponsored in part by ARPA, JNIDS, NYNEX and Alenia.
This paper presents an experimental intelligent map system - GeoSpace - which allows information seekers to explore complex spaces of geographic information using dialogue-like interaction. GeoSpace progressively and selectively provides information as an information

seeker enters queries while visually maintaining the larger context. Domain knowledge is represented in a form of information presentation plan modules, and an activation spreading network technique is used to determine the relevance of information based on information seeking queries. The reactive nature of the activation spreading network, combined with visual design techniques, such as typography, color, and transparency, enables the system to fluidly respond to the continuous changes in the information seeker's goals and intentions.

[65] Ishizaki, S. (1994) Adjusting Simultaneous Contrast Effect for Dynamic Information Display. IS&T and SID's 2nd Color Imaging Conference: Color Science, Systems and Applications. http://www.andrew.cmu.edu/user/suguru/me/publications.html
Simultaneous contrast effect often confuses the viewer's understanding of color coding scheme on information graphics, such as maps and diagrams. In particular, on a computer-based dynamic display, such as weather and air traffic, since background color and position of a graphical element are difficult to predict at run-time, we need to adjust the physical color of each element automatically so that all elements that are intended to appear the same color are perceived that way. This paper introduces experimental information graphics that automatically adjusts color differences based on Jameson and Hurvich's research. The results suggest that adjustment of simultaneous contrast effect can increase the reliability of dynamic information display and the flexibility of its design.

[66] Jansen, C. (1994) "Research in Technical Communication in the Netherlands." Technical Communication **41**(2): 234-239.
In the Netherlands, research in technical communication is a part of research in "functional text," which has concrete goals that must be achieved by lay readers. Three recent studies focus on the use of and failure to use software manuals, the minimalist approach and learning styles, and the effect of using decision tables.

[67] Keyes, E. (1993) "Typography, Color, and Information Structure." Technical Communication, Fourth Quarter: 638-654.
Typography and color significantly influence the communication effectiveness of technical documents. However, most research and design guidelines address typography and color separately without considering their spatial context or their function as complementary content signals. A broader, integrated perspective increases our understanding of underlying principles, simplifies guidelines, and enables us to make typography and color choices with confidence and control over the result. This articles focuses on: (1) How typography and color complement and differ from each other in signaling an underlying content structure, (2) The synergism between typography, color, and page layout (use of white space) that aids audience understanding and use, and (3) The characteristics of typography and of color that are most important in these contexts.

[68] Microsoft (1995) "Displaying Text on NTSC: A Research Summary." 10 pgs.
This document outlines the kinds of projects which will use NTSC font technology. It describes the basic problems associated with the display of text on TVs using the NTSC signal, and proposes three possible approaches towards a solution of these problems. It also includes an annotated source of references, and a list of further articles which may prove useful, but have not

yet been unearthed. The text of the document draws (fairly heavily at times) on the words of Charles Bigelow and Will Adams (among others) - its chief virtue being in the pulling together of as many separate sources as could be found in the research period. Finding fonts and techniques to provide a legible display on a TV or similar device using an NTSC signal as its input will allow Windows and other software to be run on a computer using a TV as its display device. As discussed, the difficulties of font design and employment for the TV are essentially very different from those facing the designer and user of screen fonts for the computer monitor. Projects which will use NTSC font technology include low cost PCs using a TV as a display device; set-top boxes for interaction TV; applications such as PowerPoint or video titling that output directly to video tape.

[69] Spyridakis, J. H., and Wenger, M.J. (1992). "Writing for Human Performance: Relating Reading Research to Document Design." Technical Communication, Second Quarter: 202-215.
This paper briefly reviews a few models of reading performance as a point of departure and as an organizing framework for understanding findings from empirical studies of text and reader factors. It then reviews numerous empirical studies of text design and reader variables and their effects on comprehension. Its goal is to help readers understand this research and identify the implications of such research in document design decisions.

[70] Van Der Waarde, K. (1999) "Typographic Dimensions and Conventional Wisdom: A Discrepancy?" Technical Communication, First Quarter: 67-74.
This article finds the x-height, line length, and line spacing in brochures, scientific journals, and novels do not reflect typographic guidelines. Also, the article demonstrates that the boundaries for these typographic dimensions differ by genre.

[71] Wendt, D. (August 1992) "Legibility of Print." Department of Psychology, University of Kiel, Germany, 18 pgs.
What do we mean by legibility? The main purpose of a type face is the transfer of information. To reach this goal, it has to be legible, i.e. the recipient of the information should be able to decode it with as little effort as possible, and re-assess the symbols to the objects and processes they represent. This is generally agreed upon, but it is more difficult to agree upon how this legibility can be assessed, or even measured.

[72] Wilkinson, R. T. and Robinshaw, H.M. (1987) "Proof-Reading: VDU and Paper Text Compared for Speed, Acuracy, and Fatigue." Behaviour and Information Technology **6**(2): 125-133.
Proof-reading on either a cathode ray tube visual display unit (VDU) of average quality or on conventional paper typescript was carried out for four 50-min sessions, two in each condition. The method of signaling errors in the script was identical in each case: verbally and by line reference. VDU scripts were presented in a standard Wordstar format; paper text was a normal print-out of that script. With the VDU as compared to paper, more proofreading errors were missed, fewer pages were read, and there was a greater accumulation of fatigue during the reading session as indexed by an increase in the number of errors missed. It is suggested that (i) material be printed for proof-reading, and (ii) the present technique be used for comparison of different VDUs for speed and accuracy of reading and resistance to fatigue.

[73] Wise, D. (1999) "The Need to Know; "Trivial Pursuit"; Conventional Wisdom about Typography." Technical Communication, Third Quarter: 309-314.
Nine pieces of correspondence regarding articles and reviews previously published in the journal.

f. Usability and Evaluation

[74] Barnett, M. (1998) "Testing a Digital Library of Technical Manuals." IEEE Transactions on Professional Communication **41**(2): 116-122.
This paper describes a methodology for testing the usability of a digital library. The paper also presents the results from using this methodology on a specific library of technical manuals. The testing process involves timing subjects while they look up facts in comparable libraries of online and paper documents. They are timed for both how long they take to find a desired manual in the library and how long they take to find a desired fact in a chosen manual. Next, the subjects fill out a questionnaire on which type library they prefer using and why. The objective time results and the subjective preferences are compared and analyzed.

[75] Bias, R. G. and Mayhew, D.J. (1994) Cost-Justifying Usability, Academic Press.
This book provides structured and proven techniques for usability engineering professionals and their managers for quantifying costs and benefits in order to make a convincing and successful business case for investment. The book provides a universal framework for cost justification; an examination of factors unique to vendor companies, internal development organizations, and contractors; case studies of successful cost justification efforts; and an overview of discount usability techniques, use of specialized tools for cost justification, and a look toward the future of usability engineering.

[76] Boy, G. A. (1998). Cognitive Function Analysis for Human-Centered Automation of Safety-Critical Systems. CHI '98 Papers. pgs. 265-272.
The Cognitive Function Analysis is a methodology supported by a mediating tool for the human-centered automation of safety-critical systems [4]. It is based on a socio-cognitive model linking the artifact being designed, the user's activity, the task to be performed, and the organizational environment. Cognitive functions can be allocated to humans or machines. They are characterized by their role, context definition and associated resources. The methodology is supported by active design documents as mediating representations of the artifact, the interaction description and cognitive function descriptors being designed, redesigned, and used as usability criteria to evaluate the distribution of cognitive functions among humans and machines. This methodology enhances user-centered and participatory design, and traceability of design decisions. It was successfully tested on three main applications in the aeronautics domain. One of them is presented.

[77] Carliner, S. (1997) “Demonstrating Effectiveness and Value: A Process for Evaluating Technical Communication Products and Services.” Technical Communication, Third Quarter: 252-265.
Just like the North American explorers seeking the elusive Northwest Passage, we technical communicators have been looking for a certain statistic that, if we were to find it and measure it, could prove without a doubt that our work was of high quality and that would demonstrate, without question, the value of a technical communicator’s services to an employer. We devised many approaches to assessing quality and demonstrating value beginning in the 1970s and 1980s. They include: (1) Counting comments on drafts, hoping to establish a correlation between the number of review comments and the quality of communication products, (2) Assessing conformance to requirements (Bandes, 1986). This approach reflects the industrial definition of quality because it is the same approach used to assess the quality of manufactured parts, like circuit boards, and (3) Devising lists of characteristics associated with quality communication products (such as the U-metric devised by Hewlett-Packard). Since the early 1990s, we have generally concluded that there is no single, unquestionable measure of quality and value. We reached that conclusion, in part, because we are increasingly distinguishing between the terms quality and value, and recognize that they are not synonymous.

[78] Dumas, J. and Redish, J. (1999). A Practical Guide to Usability Testing (Revised Edition), Intellect Ltd.
In this book, the authors begin by defining usability, advocating and explaining the methods of usability engineering and reviewing many techniques for assessing and assuring usability throughout the development process. The authors then take you through all the steps in planning and conducting a usability test, analyzing data, and using the results to improve both products and processes. This book discusses the full range of testing options from quick studies with a few subjects to more formal tests with carefully designed controls. The authors discuss the place of usability laboratories in testing as well as the skills you need to conduct a test. Included are forms that you can use or modify to conduct a usability test and layouts of existing labs that will help you build your own.

[79] Houser, S.A., Neisler, R.P., and Belcher, G.J. (November 2000). “Interactive Electronic Technical Manual Cost-Benefit Analysis Tool – User’s Guide.” *Logistics Management Institute*, McLean, VA.
This report is the user’s guide for the Interactive Electronic Technical Manual Cost-Benefit Tool. It provides a description of the tool’s layout and several tutorials that instruct the user how to operate the tool. The IETM Cost-Benefit Analysis Tool is an Excel spreadsheet-based model that compares the costs and benefits of candidate IETM deployment alternatives. The tool applies technology from previous LMI cost-benefit models for law enforcement and commercial aviation to IETMs. The current model has three modes of operation: standard analysis, sensitivity analysis, and simulation. The tool has a utility worksheet that helps the user to estimate the cost of converting a paper manual, or a low-level electronic manual (ETM), to a higher-level ETM or IETM.

[80] Ivory, M.Y., and Hearst, M.A. (December 2001). “The State of the Art in Automating Usability Evaluation of User Interfaces.” ACM Computing Surveys **33**: 470-516.
Usability evaluation is an increasingly important part of the user interface design process. However, usability evaluation can be expensive in terms of time and human resources, and

automation is therefore a promising way to augment existing approaches. This article presents an extensive survey of usability evaluation methods, organized according to a new taxonomy that emphasizes the role of automation. The survey analyzes existing techniques, identifies which aspects of usability evaluation automation are likely to be of use in future research, and suggests new ways to expand existing approaches to better support usability evaluation.

[81] Landauer, T. K. (1995). The Trouble With Computers: Usefulness, Usability, and Productivity. Cambridge, Mass. MIT Press.
This book pieces together a picture of a situation, of how and where computers and related information technologies have failed to fulfill their promise to be helpful. Actually, this book is not about just computers but about the whole range of electronic technologies used in business. Many examples and data the authors look at concern IT, or information technology – a grab-bag category of computers, telecommunications equipment, factory automation gadgets, and office gear. In dollars, computers are a very big part of this category, and many of the other things in it that don't have screens and flashing lights either contain hidden computers (copiers and cash registers) or rely on close friendships with computers (telephones and MRIs). It's this mix of stuff – computer-reliant or computer-associated information technology – that seems to be doing poorly. The author offers an analysis and diagnosis of why computers and friends are not doing better than they are and suggest a set of remedies. Finally, the author speculates a bit on what the world will be like when computer power is finally properly harnessed.

[82] Lumsden, J., and Gray, P. (2001). "SUIT – Context Sensitive Evaluation of User Interface Development Tools." DSV-IS, Springer-Verlag, Berlin, pgs. 79-95.
Developers of interactive software are confronted by a variety of software tools to help them design and implement user interfaces. They often resort to *ad hoc* means of tool selection and subsequently are dissatisfied with their chosen tool. In this paper the authors describe a framework, evaluation methodology, and associated tool for investigating the suitability of user interface development tools (UIDTs) for use in software development organizations and projects. The authors also present the results of two informal empirical studies carried out in support of the development of their framework and method.

[83] Nielsen, J. and Molich, R. (1990). Heuristic Evaluation of User Interfaces. ACM CHI '90 Conference Proceedings, Seattle, Washington, pgs. 249-256.
Heuristic evaluation is an informal method of usability analysis where a number of evaluators are presented with an interface design and asked to comment on it. Four experiments showed that individual evaluators were mostly quite bad at doing such heuristic evaluations and that they only found between 20 and 51% of the usability problems in the interfaces they evaluated. On the other hand, we could aggregate the evaluations from several evaluators to a single evaluation and such aggregates do rather well, even when they consist of only three to five people.

[84] Nielson, J. and Mack, R.L. (1994). Usability Inspection Methods, John Wiley and Sons, Inc.
This book is designed to get you quickly up and running with the full complement of Usability Interface (UI) strategies, tools, and techniques. With the help of numerous real-life case studies, the authors provide: (1) Step-by-step guidance on all important methods now in use, including the heuristic evaluation method, the pluralistic walkthrough method, and the cognitive

walkthrough method; (2) Proven techniques for integrating usability inspections with other methods now in use; (3) An in-depth, comparative analysis of UI versus user testing; (4) A cost-benefit analysis of US as compared to other approaches; (5) Program prototypes that provide UI computer support for interface designers; and (6) An important resource for user interface developers, software designers, as well as graduate students and researchers.

[85] Paterno, F., and Santoro, C. (2001). "Integrating Model Checking and HCI Tools to Help Designers Verify User Interface Properties." DSV-IS, Springer-Verlag, Berlin, pgs. 135-150.
In this paper the authors present a method that aims to integrate the use of formal techniques in the design process of interactive applications, with particular attention to those applications where both usability and safety are main concerns. The method is supported by a set of tools. The authors discuss how the resulting environment can be helpful in reasoning about multi-user interactions using the task model of an interactive application. Examples are provided from a case study in the field of air traffic control.

[86] Preece, J. (1993). A Guide to Usability: Human Factors in Computing. Addison-Wesley.
A revolution in usability is fueling the continued growth of the computer industry. Graphical user interfaces and improved input/output devices have helped non-specialists to master the awesome power and complexity of the modern computer. Despite these advances, there is still a need to raise awareness of the human factors in user interface design and this book is designed to meet that need. This book presents: (1) A clear, concise account of human factors in computing, illustrated with numerous examples, figures and cartoons, (2) An excellent balance between the technical and psychological issues in human-computer interaction (HCI), and (3) An extensive glossary and suggestions for further reading.

[87] Siewiorek, D., A. Smailagic, and M. Hornyak. (October 14-16, 2002). "Multimodal Contextual Car-Driver Interface." *Fourth IEEE ICMI '02 - International Conference on Multimodal Interfaces*, Pittsburgh, PA, pgs. 367-373.
This paper focuses on the design and implementation of a Companion Contextual Car Driver interface that proactively assists the driver in managing information and communication. The prototype combines a smart car environment and driver state monitoring, incorporating a wide range of input-output modalities and a display hierarchy. Intelligent agents link information from many contexts, such as location and schedule, and transparently learn from the driver, interacting with the driver only when it is necessary.

[88] Tinker, M. A. (1955). Examiner's Manual for Tinker Speed of Reading Test. Published by the University of Minnesota Press, Minneapolis, Minnesota.
This test was constructed to provide, first, a measure of speed of reading as a single variable uncomplicated by comprehension difficulties, i.e. speed of reading with comprehension held constant; and, second, a performance test which may be employed with any working time up to 30 minutes. This test has yielded valid and reliable speed of reading scores for a variety of time limits from 4 to 30 minutes on each form. The materials in the test are such that it may be used with high school and adult subjects. The test was developed for two main uses: (1) For carrying out research on visual functions, such as the effect of typographical variations on the speed of perception in reading or the effect of illumination on the speed of perception in reading. (2) For

measuring speed of sustained reading in situations where performance over a relatively long period of time is desirable, as in certain counseling setups in colleges and high schools.

g. User Interface Design and Navigation

[89] Arnau, R.C., Thompson, R.L., and Cook, C. (February 2001). "Do Different Response Formats Change the Latent Structure of Responses? An Empirical Investigation Using Taxometric Analysis." Educational and Psychological Measurement, **61**: 23-44.
Although Web-based surveys are increasing in popularity, very little research has been conducted on the psychometric implications of using different user interfaces for eliciting responses to survey items. The purpose of this study was to compare the latent structures of responses to two different user interface response formats in a Web-based survey. Two different coherent cut kinetics Taxometric procedures – MAMBAC and L-mode factor analysis – were used to examine the latent structure of responses to a survey of library service quality using an unnumbered slider-bar user interface versus a radio-button user interface. Strong evidence was found for a pure dimensional latent structure of responses from both user interfaces, which replicated across both Taxometric procedures and across multiple survey items. It is concluded that the slider-bar and radio-button user interfaces both yield similar latent structures of survey item responses. These analyses, conducted on a very large data set, offer important information for Web-based survey designers because, although slider bars are more visually attractive, they require more sophisticated hardware and software. These findings suggest that radio buttons can be used instead of Java-based slider bars as a "lowest common denominator" that can be expected to work on almost any Web browser, potentially leading to higher response rates.

[90] Bass, L., Kasabach, C., Martin, R., Siewiorek, D., Smailagic, A., Stivoric, J. (1997) "The Design of a Wearable Computer." ACM CHI '97 Conference Proceedings on Human Factors in Computing Systems, Atlanta, GA. pgs. 139-146.
http://www.acm.org/pubs/citations/proceedings/chi/258549/p139-bass/
The design process used to produce an innovative computer system is presented. The computer system that resulted from the process uses a circular motif both for the user interface and the input device. The input device is a dial and the user interface is visually organized around the concept of a circle. The design process itself proceeded in the presence of a great many constraints and we discuss these constraints and how an innovative design was achieved in spite of the constraints.

[91] Baus, J., Kruger, A., and Wahlster, W. (January 13, 2002). "A Resource-Adaptive Mobile Navigation System." ACM, *IUI '02*, pgs. 13-22.
The design of mobile navigation systems adapting to limited resources will be an important future challenge. Since typically several different means of transportation have to be combined in order to reach a destination, the user interface of such a system has to adapt to the user's changing situation. This applies especially to the alternating use of different technologies to detect the user's position, which should be as seamless as possible. This article presents a hybrid navigation system that relies on different technologies to determine the user's location and that

adapts the presentation of route directions to the limited technical resources of the output device and the limited cognitive resources of the user.

[92] Belloti, V., M. Back, W.K. Edwards, R.E. Grinter, A. Henderson, and C. Lopes. (April 20-25, 2002). "Making Sense of Sensing Systems: Five Questions for Designers and Researchers." *Presented at CHI 2002*, Minneapolis, MN, 415-422.
This paper borrows ideas from social science to inform the design of novel "sensing" user-interfaces for computing technology. Specifically, the authors present five design challenges inspired by analysis of human-human communication that are mundanely addressed by traditional graphical user interface designs (GUIs). Although classic GUI conventions allow us to finesse these questions, recent research into innovative interaction techniques such as 'Ubiquitous Computing' and 'Tangible Interfaces' has begun to expose the interaction challenges and problems they pose. By making them explicit the authors open a discourse on how an approach similar to that used by social scientists in studying human-human interaction might inform the design of novel interaction mechanisms that can be used to handle human-computer communication accomplishments.

[93] Buyukkokten, O., Kaljuvee, O., Garcia-Molina, H., Paepcke, A., and Winograd, T. (January 2002). "Efficient Web Browsing on Handheld Devices Using Page and Form Summarization." ACM Transactions on Information Systems **20**: 82-115.
The authors present a design and implementation for displaying and manipulating HTML pages on small handheld devices such as personal digital assistants (PDAs), or cellular phones. The authors introduce methods for summarizing parts of Web pages and HTML forms. Each Web page is broken into text units that can each be hidden, partially displayed, made fully visible, or summarized. A variety of methods are introduced that summarize the text units. In addition, HTML forms are also summarized by displaying just the text labels that prompt the use for input. The authors tested the relative performance of the summarization methods by asking human subjects to accomplish single-page information search tasks. The authors found that the combination of keywords and single-sentence summaries provides significant improvements in access times and number of required pen actions, as compared to other schemes. The experiments also show that their algorithms can identify the appropriate labels for forms in 95% of the cases, allowing effective form support for small screens.

[94] Camarata, K., Do, E. Y.-L., Johnson, B.R., and Gross, M.D. (January 13, 2002). "Navigational Blocks – Navigating Information Space with Tangible Media." ACM, *IUI '02*, 31-38.
The Navigational Blocks project demonstrates a tangible user interface that facilitates retrieval of historical stories in a tourist spot. Orientation, movement, and relative positions of physical Blocks support visitor navigation and exploration in a virtual gallery. The Navigational Blocks systems provides a physical embodiment of digital information through tactile manipulation and haptic feedback. The simple cubic form of the Blocks is easy to understand and therefore easy to use to manipulate complex digital information. Electromagnets embedded in the Blocks and wireless communication encourages users to quickly rearrange the Blocks to form different database queries.

[95] Carpineto, C., G. Romano, and V. Giannini. (July 2002). "Improving Retrieval Feedback with Multiple Term-Ranking Function Combination." ACM Transactions on Information Systems **20**: 259-290.
In this article the authors consider methods for automatic query expansion from top retrieved documents (i.e., retrieval feedback) that make use of various functions for scoring expansion terms within Rocchio's classical reweighting scheme. An analytical comparison shows that the retrieval performance of methods based on distinct term-scoring functions is comparable on the whole query set but differs considerably on single queries, consistent with the fact that the ordered sets of expansion terms suggested for each query by the different functions are largely uncorrelated. Motivated by these findings, the authors argue that the results of multiple functions can be merged, by analogy with ensembling classifiers, and present a simple combination technique based on the rank values of the suggested terms. The combined retrieval feedback method is effective not only with respect to unexpanded queries but also to any individual method, with notable improvements on the system's precision. Furthermore, the combined method is robust with respect to variation of experimental parameters and it is beneficial even when the same information needs are expressed with shorter queries.

[96] Chen, X., and Wahls, T. (2001). "A Graphical User Interface for Executing Formal Specifications." ACM, *SAC*, pgs. 648-652.
In software development, specification errors can cause budget overruns or complete failure of development projects. In an effort to reduce such risk in software development, formal and model-based specification languages have been developed and applied. Once such specification language is SPECS-C++, which is used to specify C++ classes. A large subset of SPECS-C++ can be executed by translating specifications to concurrent constraint programs. In this work, the authors describe a graphical user interface that controls both the translation and the execution of the resulting constraint program. This graphical user interface provides a convenient tool for constructing test cases, modifying specifications, and validating original or modified specifications. The interface can be extended to accommodate other specification languages, as well as more complex test cases and specifications.

[97] Chittaro, L., and Scagnetto, I. (November 15, 2001). "Is Semitransparency Useful for Navigating Virtual Environments?" ACM, *VRST '01*, pgs. 159-166.
A relevant issue for any Virtual Environment (VE) is the navigational support provided to users who are exploring it. Semitransparency is sometimes exploited as a means to see through occluding surfaces with the aim of improving user navigation abilities and awareness of the VE structure. Designers who make this choice assume that it is useful, especially in the case of VEs with many levels of occluding surfaces, e.g., virtual buildings or cities. This paper is devoted to investigate this assumption with a proper experimental evaluation on users. First, the authors discuss possible ways for improving navigation, and focus on implementation choices for semitransparency as a navigation aid. Then, the authors present and discuss the experimental evaluation they carried out. The author's compared subjects' performance in three conditions: local exploitation of semitransparency inside the VE, a more global exploitation provided by a bird's-eye-view, and a control condition where neither of the two features was available.

[98] Cooper, A. (1995). About Face: The Essentials of User Interface Design, IDG Books.
The "father" of Visual Basic, Alan Cooper, presents a methodology of user interface design that he has distilled from many years of creating award-winning personal computer software. This book does not focus on code; instead it discusses highly technical topics in clear English. Readers may not agree with everything Cooper has to say about software design, but they will find his ideas pertinent, thought-provoking, and perceptive.

[99] da Silva, P.P. (2001). "User Interface Declarative Models and Development Environments: A Survey." DSV-IS, Springer-Verlag, Berlin, pgs. 207-226.
Model-Based User Interface Development Environments (MB-UIDEs) provide a context without which user interface declarative models can be constructed and related, as part of the user interface design process. This paper provides a review of MB-UIDE technologies and a framework for describing the elements of a MB-UIDE. A representative collection of 14 MB-UIDEs are selected, described in terms of the framework, compared and analyzed from the information available in the literature. The framework can be used as an introduction to the MB-UIDE technology since it relates and provides a description for the terms used in MB-UIDE papers. There are three major advantages that derive from the declarative user interface models (UIMs): (1) They can provide a more abstract description of the UI than UI descriptions provided by the other UI development tools; (2) They facilitate the creation of methods to design and implement the UI in a systematic way since they offer capabilities: (a) to model user interfaces using different levels of abstraction; (b) to incrementally refine the models; and (3) to re-use UI specifications; and (3) They provide the infrastructure required to automate tasks related to the UI design and implementation processes. A major disadvantage of UIMs is the complexity of the models and their notations, which are often hard to learn and use. However, it is expected that an appropriate environment should help to overcome the UIM's complexity, providing features such as graphical editors, assistants and design critics to support UI designers. The development of model-based user interface development environments (MB-UIDEs) is still challenging since some essential problems related to this technology are not completely solved.

[100] Dumais, S., M. Banko, E. Brill, J. Lin, and A. Ng. (August 11-15- 2002). "Web Question Answering: Is More Always Better?" *SIGIR '02*, ACM: 291-298.
This paper describes a question answering system that is designed to capitalize on the tremendous amount of data that is now available online. Most question answering systems use a wide variety of linguistic resources. We focus instead on the redundancy available in large corpora as an important resource. The authors use this redundancy to simplify the query rewrites that are needed to use, and to support answer mining from returned snippets. This system performs quite well given the simplicity of the techniques being utilized. Experimental results show that question answering accuracy can be greatly improved by analyzing more and more matching passages. Simple passage ranking and n-gram extraction techniques work well in this system making it efficient to use with many backend retrieval engines.

[101] Dumais, S. T. and Schmitt, D.G. (1991). "Iterative Searching in an Online Database." Human Factors Society: 398-402.
An experiment examined how people use an online retrieval system. Subjects solved general topical search problems using a database containing the full text of news articles (e.g. find articles about the "Background of the new prime minister of Great Britain"). Time, accuracy and

content of the searches were recorded. Of particular interest was one of two iterative search methods available in the interface - a Lookup function that allowed users to explicitly specify an alternative query; and a LikeThese function that could be used to automatically generate a new query using articles the user marked as relevant. Results showed that subjects could easily use both query reformulation methods. Subjects generated much more effective LikeThese searches than Lookup searches. An analysis of individual subject differences suggests that the LikeThese method is more accessible to a wide range of users.

[102] Fabre, J., Howard, S., and Smith, S. (February 2001). "Designing the Temporal Aspects of the User Interface: View from the Coal Face." Journal of Research and Practice in Information Technology, **33**: 54-67.
The authors aim to support user interface designers in capturing, representing and reasoning about temporal information. They have developed a method to support user interface designers in considering how the temporal aspects of software impact the user. Importantly the method is based on a detailed analysis of data from a set of situated interviews that capture the views of practicing user interface designers. The paper discusses the background research and motivation for the method. The evidence from this study suggests that temporal aspects of usability are problematic in design partly because they are neither given properties of the user, nor the interactive system. The perception of time then happens at a higher level than the physical, and is almost certainly an emergent feature of the 'human in the world'. The complementarity across interviewees could be enhanced if designers, regardless of discipline, could articulate use of TAU specific knowledge and methods for use when designing. This research is intended to help designers incorporate the four elements of TAU – Task Duration, Task Location, Task Contingency, and Task Location into a method, such that, the emerging user experience is consistent with the intended design goals. The process needs to allow designers to make explicit choices about temporal aspects of interaction and the context in which their designs are intended to be used.

[103] Frank, M., Muslea, M., Oh, J., Minton, S., and Knoblock, C. (January 14, 2001). "An Intelligent User Interface for Mixed-Initiative Multi-Source Travel Planning." ACM, *IUI '01*, pgs. 85-86.
A mixed-initiative planner in the author's context is one in which either the human or the computer can spontaneously provide the content of the same input fields. A multi-source planner is one that accesses multiple external information sources in parallel, using separate threads. This type of highly dynamic user interface is desirable but presents a challenge in "keeping the user in control" because it can be confusing to understand which fields of the form currently "belong" to the user, which ones "belong" to the system, how these two interact, and when and how their ownership changes.

[104] Gee, K. (February 2001) "The Ergonomics of Hypertext Narrative: Usability Testing as a Tool for Evaluation and Redesign." ACM Journal of Computer Documentation **25**: 3-16.
While usability research concentrates on evaluating informational documents and Web sites, significant insights can be gained from performing usability testing on texts designed for pleasure reading, such as hypertext narratives. This article describes the results of such a test. The results demonstrate that the navigation systems required for such texts can significantly interfere with readers' ability to derive value or pleasure from the fiction. The results emphasize

the importance of hypertext authors providing more linear paths through texts and of simplifying the navigational apparatus required to read them.

[105] Hackos, J. T. and Redish, J.C. (1998). User and Task Analysis for Interface Design. New York, NY. Wiley Computer Publishing.
User and Task Analysis for Interface Design helps you design a great user interface by focusing on the most important step in the process - the first one. You learn to go out and observe your users at work, whether they are employees of your company or people in customer organizations. You learn to find out what your users really need, not by asking them what they want, but by going through a process of understanding what they are trying to accomplish. This book includes many examples of design successes and challenges for products of every kind.

[106] Haik, E., Barker, T., Sapsford, J., and Trainis, S. (February 24, 2002). "Investigation into Effective Navigation in Desktop Virtual Interfaces." ACM, *Web 3D '02*, pgs. 59-66.
The study reported in this paper is concerned with understanding and providing solutions to commonly reported navigation and orientation issues in virtual 3D desktop environments. An experiment was performed to investigate some of these issues. Twelve subjects performed simple tasks within a virtual desktop environment using navigational tools developed specifically for the research. Tasks were based on locating information in simple environments. Time to complete tasks, ability to remember the locations of information within the environment and user attitude were measured and recorded, along with several other important variables. Performance on tasks and attitude to the environments was found in many cases to be related to the navigational tools used within the environments. The results demonstrated that constraining and guiding the navigation produces more effective navigation and orientation. It was found that the use of a 3D map to assist navigation was most effective in terms of time to perform tasks ($p<0.01$). The development of the navigational tools, the method used in the experiment and the results of the experiment are reported in this paper. The paper concludes with a discussion on how the findings of this research relate to the solution to general navigational and orientational issues in 3D virtual environments.

[107] Hollerer, T., Feiner, S., Hallaway, D., Bell, B., Lanzagorta, M., Brown, D., Julier, S., Baillot, Y., and Rosenblum, L. (2001). "User Interface Management Techniques for Collaborative Mobile Augmented Reality." Computers & Graphics, **25**: 799-810.
Mobile augmented reality systems (MARS) have the potential to revolutionize the way in which information is provided to users. Virtual information can be directly integrated with the real world surrounding the mobile user, who can interact with it to display related information, to pose and resolve queries, and to collaborate with other users. However, the authors believe that the benefits of MARS will only be achieved if the user interface (UI) is actively managed so as to maximize the relevance and minimize the confusion of the virtual material relative to the real world. This article addresses some of the steps involved in this process, focusing on the design and layout of the mobile user's overlaid virtual environment. The augmented view of the user's surroundings presents an interface to context-dependent operations, many of which are related to the objects in view – the augmented world is the user interface. The authors present three UI design techniques that are intended to make this interface as obvious and clear to the user as possible: information filtering, UI component design, and view management. *Information filtering* helps select the most relevant information to present to the user. *UI component design*

determines the format in which this information should be conveyed, based on the available display resources and tracking accuracy. For example, the absence of high accuracy position tracking would favor body- or screen-stabilized components over world-stabilized ones that would need to be exactly registered with the physical objects to which they refer. *View management* attempts to ensure that the virtual objects that are displayed visually are arranged appropriately with regard to their projections on the view plane. For example, the relationships among objects should be an unambiguous as possible, and physical and virtual objects should not obstruct the user's view of more important physical or virtual objects in the scene. The authors illustrate these interface design techniques using our prototype collaborative, cross-site MARS environment, which is composed of mobile and non-mobile augmented reality and virtual reality systems.

[108] Jones, M. K. (1989). Human-Computer Interaction: A Design Guide. Educational Technology Publications, Englewood Cliffs, NJ. ISBN 0-87778-207-5.
This book provides guidelines for the design of effective computer-user interfaces, intended primarily for teams designing instructional software and related uses. Examples are provided of how the computer screen should be organized.

[109] Kan, M.-Y., and J.L. Klavans. (July 13-17, 2002). "Using Librarian Techniques in Automatic Test Summarization for Information Retrieval." *JCDL '02*, ACM: pgs 36-45.
A current application of automatic text summarization is to provide an overview of relevant documents coming from an information retrieval (IR) system. This paper examines how Centrifuser, one such summarization system, was designed with respect to methods used in the library community. The authors have reviewed these librarian expert techniques to assist information seekers and codified them into eight distinct strategies. The authors detail how they have operationalized six of these strategies in Centrifuser by computing an information extract, indicative differences between documents, as well as navigational links to narrow or broaden a user's query. An initial evaluation of the system indicates several results are promising. Centrifuser's post-processing yields an improvement over the baseline user interface of presenting output in the standard IR framework user interface (as a ranked list of relevant documents). Results hint that fully automatic post-processed output approaches the same level of satisfaction for systems that require human intervention. Text is a powerful output modality since it is easy to understand and is also a prerequisite for advanced user interfaces involving speech. Centrifuser's ATS framework is based on topic structure, and allows results to be reported at different levels of granularity, resulting in longer or short summaries. This flexibility is being utilized in the author's current user interface project that allows the summaries to be tailored lengthwise for different screen sizes (desktop screens, PDAs, and cell phone displays) and allows contextual zooming on specific subtopics.

[110] Landay, J.A., and Myers, B.A. (March 2001). "Sketching Interfaces: Toward More Human Interface Design." Computer, pgs. 56-64.
An interactive user-interface design tool supports electronic sketching, giving designers more freedom to change sketches and more flexibility in creating and evaluating a design prototype.

[111] Landay, J. A. and Myers, B.A. (1995). Interactive Sketching for the Early Stages of User Interface Design. ACM CHI '95 Conference Proceedings, Denver, Colorado, pp. 43-50.
Current interactive user interface construction tools are often more of a hindrance than a benefit during the early stages of user interface design. These tools take too much time to use and force designers to specify more of the design details than they wish at this early stage. Most interface designers, especially those who have a background in graphic design, prefer to sketch early interface ideas on paper or on a whiteboard. We are developing an interactive tool called SILK that allows designers to quickly sketch an interface using an electronic pad and stylus. SILK preserves the important properties of pencil and paper: a rough drawing can be produced very quickly and the medium is very flexible. However, unlike a paper sketch, this electronic sketch is interactive and can easily be modified. In addition, our system allows designers to examine, annotate, and edit a complete history of the design. When the designer is satisfied with this early prototype, SILK can transform the sketch into a complete, operational interface in a specified look-and-feel. This transformation is guided by the designer. By supporting the early phases of the interface design life cycle, our tool should both ease the development of user interface prototypes and reduce the time needed to create a final interface. This paper describes our prototype and provides design ideas for a production-level system.

[112] Lauesen, S., and Harning, M.B. (July/August 2001). "Virtual Windows: Linking User Tasks, Data Models, and Interface Design." IEEE Software, pgs. 67-75.
User interface design comprises three major activities: organizing data into a set of windows or frames, defining functions that let the user control the system, and designing the graphical appearance of windows and functions. These design activities can build on analysis results such as task analysis and data modeling, and they can include checking activities such as reviews and usability tests. The goal is to create a system that is easy to learn, is easy to understand, and supports user tasks efficiently. The virtual-windows technique is an approach based on employing data and tasks at the same time. Part of the approach is to design and test the graphical appearance before the functions are defined. A virtual window is a picture on an idealized screen. Compared to user interfaces designed traditionally, the ones based on virtual windows appear to have several advantages: (1) there are fewer windows; (2) there is efficient task support (also for task variants); (3) users can validate the database; and (4) users better understand the final system.

[113] Marcus, A. Ferrante, J.V. Kinnunen, T. Kuutti, K. and Sparre, E. (1998). Baby Faces: User-Interface Design for Small Displays. ACM CHI '98, Proceedings of Human Factors in Computing Systems Summary. pgs. 96-97.
User interface conferences and literature dwell upon projects in which large color palettes, high spatial resolution, and large-size displays are presumed to be available. Many consumer information appliances and hand-held devices are often more limited in their characteristics, yet are increasingly important to bring the power of the Web, productivity tools, databases, transactions, and entertainment to more and more people on the go, or at least not in front of higher-performance PCs, NCs, or workstations. Professionals with insight into the challenges and achievements of designing graphical user interfaces for small displays will debate the best way to design for products in which many characteristics are significantly limited, e.g. fonts, color resolution, spatial resolution, and graphics. These user interfaces, which might be called

"baby faces" seem simpler in some ways, but also are actually quite complex as a design challenge when one designs to account for their limited characteristics.

[114] Mason, L. D. (1997). "Design Issues for Producing Effective Multimedia Presentations." Technical Communication, First Quarter: 65-71.
When designing multimedia presentations, technical communicators must consider navigational aids and the degree of user control, audio cues, color and typographical elements, visual elements, and copyright issues. Understanding these issues will help us develop guidelines for effective use of multimedia.

[115] McDonald, S., Lai, T-S., and Tait, J. (September 9, 2001) "Evaluating a Content Based Image Retrieval System." ACM, *SIGIR '01*, pgs. 232-240.
Content Based Image Retrieval (CBIR) presents special challenges in terms of how image data is indexed, accessed, and how end systems are evaluated. This paper discusses the design of a CBIR system that uses global colour as the primary indexing key, and a user centered evaluation of the system's visual search tools. The results indicate that users are able to make use of a range of visual search tools, and that different tools are used at different points in the search process. The results also show that the provision of a structured navigation and browsing tool can support image retrieval, particularly in situations in which the user does not have a target image in mind. The results are discussed in terms of their implications for the design of visual search tools, and their implications for the use of user-centered evaluation for CBIR systems.

[116] Mehlenbacher, B. (1992). Navigating Online Information: A Characterization of Extralinguistic Factors That Influence User Behavior. ACM SIGDOC '92, Proceedings of the 10th Annual International Conference on Systems Documentation, Ottawa, Canada.
This paper examines the extralinguistic factors that influence user behavior with online information systems. Extralinguistic factors include any interface features that are "outside" how users understand and comprehend written texts online. Extralinguistic features, therefore, are interface features that support (1) how users formulate their information goals or represent their tasks, (2) how users navigate to new or related topics of interest to them, and (3) how users quickly scan (rather than read) online information. It is argued that text comprehension is only one task that users engage in when using online information systems. A model of online user behavior that includes goal setting, navigating, scanning, and text comprehension is outlined. The author argues that a broader definition of online information use is necessary and discusses various design principles for avoiding communication breakdowns before users reach their desired information. Finally, the author concludes by suggesting that a Participatory Design Approach to the design of human-computer interfaces is one method of undermining our tendency, as software designers, to apply design advice and guidelines without first accounting for user tasks and information goals.

[117] Mullet, K. and Sano, D. (1995). Designing User Interfaces, SunSoft Press.
This book describes fundamental techniques that can be used to enhance the visual quality of graphical user interfaces, data displays, and multimedia productions. The authors approach interface design from the perspective of communication-oriented graphic design, industrial design, and architecture. The skills, practice, and orientation of these design disciplines are

essential to the success of every graphical interface, yet few software developers, human factors professionals, or product managers receive any training in these areas. This book addresses this shortcoming by describing essential design concepts as manifested in the graphical user interface.

[118] Riedl, M.O., and Amant, R.S. (January 13, 2002). “Toward Automated Exploration of Interactive Systems.” ACM, *IUI ’02*,pgs. 135-142.
The ease with which a user interface can be navigated strongly contributes to its usability. In this paper the authors describe preliminary results of a project aimed at making the evaluation of user interfaces form this perspective more routine. The authors have designed a system to carry out an autonomous, exploratory navigation through the graphical user interface of interactive, off-the-shelf software applications. The system is not a robust tool, but rather a proof of concept that can exhibit interesting behaviors. The traversal process generates a representation of the connectivity of the user interface, as well as navigational paths to specific commands. The reasoning component of the system is based on the ACT-R architecture, while the perceptual and motor components of the system are built on top of the SegMan perception/action substrate. The authors present the design of the system and its use in exploring a simple user interface.

[119] Shneiderman, B. (1998). *Designing the User Interface: Strategies for Effective Human-Computer Interaction, Third Edition*. Addison Wesley Longman, Inc., Reading, MA.
This book is intended primarily for designers, managers, and evaluators of interactive systems. The author presents a broad survey of designing, implementing, managing, maintaining, training, and refining the user interface of interactive systems. The author offers practical techniques and guidelines for interface design and discusses underlying issues and supports conclusions with empirical results. Coverage includes the human factors of interactive software (with a discussion of diverse user communities), tested methods to develop and assess interfaces, interaction styles such as direct manipulation for graphical user interfaces, and design considerations such as effective messages, consistent screen design, and appropriate color.

[120] Stoll, G., Eldridge, M., Patterson, D., Webb, A., Berman, S., Levy, R., Caywood, C., Taveira, M., Hunt, S., and Hanrahan, P. (August 2001). “Lightning-2: A High-Performance Display Subsystem for PC Clusters.” ACM, *SigGraph 2001*, pgs. 141-148.
Clusters of PCs are increasingly popular as cost-effective platforms for supercomputer-class applications. Given recent performance improvements in graphics accelerators, clusters are similarly attractive for demanding graphics applications. The authors describe the design and implementation of Lightning-2, a display subsystem for such a cluster. The system scales in both the number of rendering nodes and the number of displays supported, and allows any pixel data generated from any node to be dynamically mapped to any location on any display. A number of image-compositing functions are supported, including color-keying and depth-compositing. A distinguishing feature of the system is its platform independence: it connects to graphics accelerators via an industry-standard digital video port and requires no modifications to accelerator hardware or device drivers. As a result, rendering clusters that utilize Lightning-2 can be upgraded across multiple generations of graphics accelerators with little effort.

[121] Wu, H., de Kort, E., and De Bra, P. (August 2001). "Design Issues for General-Purpose Adaptive Hypermedia Systems." ACM, *HT '01*, pgs. 141-150.
A hypermedia application offers its users much freedom to navigate through a large hyperspace. For authors finding a good compromise between offering navigational freedom and offering guidance is difficult, especially in applications that target a broad audience. Adaptive hypermedia (AH) offers (automatically generated) personalized content and navigation support, so the choice between freedom and guidance can be made on an individual basis. Many adaptive hypermedia systems (AHS) are tightly integrated with one specific application. In this paper the authors study design issues for general-purpose adaptive hypermedia systems, built according to an application-independent architecture. They use the Dexter-based AHAM reference model for adaptive hypermedia to describe the functionality of such systems at the conceptual level. The authors concentrate on the architecture and behavior of a general-purpose adaptive engine. Such an engine performs adaptation and updates the user model according to a set of adaptation rules specified in an adaptation model. The authors study the behavior of such a system and concentrate on the issues of termination and confluence, which are important to detect potential problems in an adaptive hypermedia application. The authors draw parallels with static rule analysis in active database systems. By using common properties of AHS we are able to obtain more precise (less conservative) results for AHS than for active databases in general, especially for the problem of termination.

h. Visualization

[122] Ames, A.L. (October 21, 2001). "Communicating Effectively with Interaction." ACM, *SIGDOC '01*, pgs. 1-6.
The ability to build interactions that support, enable, and improve communication is a valuable skill for help developers, Web-site designers, multimedia content developers, information-rich user interface designers – anyone who designs and develops information to be used online. This paper presents the basics of interaction design for information products and describes some basic underlying human factors and user-interface design principles.

[123] Anderson, D. Anderson, E. Lesh, N. Marks, J. Perlin, K. Ratajczak, D. and Ryall, K. (1999) Human-Guided Simple Search: Combining Information Visualization and Heuristic Search. Proceedings of the Workshop on New Paradigms in Information Visualization and Manipulation in Conjunction with the Eighth ACM International Conference on Information and Knowledge Management, Kansas City, MO.
Scheduling, routing, and layout tasks are examples of hard operations-research problems that have broad application in industry. Typical algorithms for these problems combine some form of gradient descent to find local minima with some strategy for escaping nonoptimal local minima and traversing the search space. Our idea is to divide these two subtasks cleanly between human and computer: in our paradigm of human-guided simple search the computer is responsible only for finding local minima using a simple search method; using information visualization, the human identifies promising regions of the search space for the computer to explore, and also intervenes to help it escape nonoptimal local minima. This is a specific example of a more

general strategy, that of combining heuristic-search and information-visualization techniques in an interactive system. The authors are applying this approach to the problem of capacitated vehicle routing with time windows (CVRTW). They describe the design and implementation of an initial prototype, some preliminary results, and their plans for future work.

[124] Au, P. Carey, M. Sewraz, S. Guo, Y. and Ruger, S.M. (2000) New Paradigms in Information Visualization. Proceedings of the 23rd Annual International ACM SIGIR Conference on Research and Development in Formation Retrieval, Athens, Greece.
www.acm.org/pubs/citations/proceedings/ir/344657/p307-au/

[125] Barstow, D. Frost, E. Liben, L. Ride, S. and Souviney, R. (1997) "Visualizing Earth." TERC Hand's On, Volume 20, No. 1.
http://www.terc.edu/handson/s97/visearth.html
"Visualizing Earth" addresses four primary goals: (1) Promote fundamental research in cognition and visualization, (2) Adapt existing GIS technology and data sources for ease of use in schools, (3) Develop model curriculum at the middle school level to support cognition and visualization research, and (4) Support implementation of national education standards in science, math, and geography.

[126] Borner, K., Y. Feng, and T. McMahon. (July 13-17, 2002). "Collaborative Visual Interfaces to Digital Libraries." *JCDL '02*, ACM: 279-280.
This paper argues for the design of collaborative visual interfaces to digital libraries that support social navigation. As an illustrative example, the authors present work in progress on the design of a three-dimensional document space for a scholarly community – namely faculty, staff, and students at the School of Library and Information Science, Indiana University.

[127] Brown, M. E. and Gallimore, J.J. (1995) "Visualization of Three-Dimensional Structure During Computer-Aided Design." International Journal of Human-Computer Interaction **7**(1): 37-56.
The visual image presented to an engineer using a computer-aided design (CAD) system influences design activities such as decision making, problem solving, cognizance of complex relationships, and error correction. Because of the three-dimensional (3-D) nature of the object being created, an important attribute of the CAD visual interface concerns the various methods of presenting depth on the display's two-dimensional (2-D) surface. The objective of this research is to examine the effects of stereopsis on subjects' ability to (a) accurately transfer to, and retrieve from, long-term memory spatial information about 3-D objects; and (b) visualize spatial characteristics in a quick and direct manner. Subjects were instructed to memorize the shape of a 3-D object presented on a stereoscopic CRT during a study period. Following the study period, a series of static trial stimuli were shown. Each trial stimulus was rotated (relative to the original) about the vertical axis in one of six 36 degree increments between 0 degree and 180 degrees. In each trial, the subject's task was to determine, as quickly and as accurately as possible, whether the trial object was the same shape as the memorized object or its mirrored image. One of the two cases was always true. To assess the relative merits associated with disparity and interposition, the two depth cues were manipulated in a within-subject manner during the study period and during the trials that followed. Subject response time and error rate were evaluated. Improved performance due to hidden surface is the most convincing

experimental finding. Interposition is a powerful cue to object structure and should not be limited to late stages of design. This study also found a significant, albeit limited, effect of stereopsis. Under specific study object conditions, adding disparity to monocular trial objects significantly decreased response time. Response latency was also decreased by adding disparity information to stimuli in the study session.

[128] Card, S. K. Mackinlay, J.D. and Shneiderman, B. (1999) Readings in Information Visualization: Using Vision to Think. San Francisco, California. Morgan Kaufmann Publishers, Inc.
This book defines the emerging field of information visualization and offers the first-ever collection of the classic papers of the discipline, with introductions and analytical discussions of each topic and paper. The authors' intention is to present papers that focus on the use of visualization to discover relationships, using interactive graphics to amplify thought.

[129] Chuah, M. C. Roth, S.F. Kolojejchick, J. Mattis, J. and Juarez, O. (1995) "SageBook: Searching Data-Graphics by Content." ACM CHI '95, Proceedings on Human Factors in Computing Systems, Denver, Colorado: 338-345.
http://www.acm.org/pubs/articles/proceedings/chi/223904/p338-chuah/p338-chuah.html
Currently, there are many typertext-like tools and database retrieval systems that use keyword search as a means of navigation. While useful for certain tasks, keyword search is insufficient for browsing databases of data-graphics. SageBook is a system that searches among existing datagraphics, so that they can be reused with new data. In order to fulfill the needs of retrieval and reuse, it provides: 1) a direct manipulation, graphical query interface; 2) a content description language that can express important relationships for retrieving data-graphics; 3) automatic description of stored data-graphics based on their content; 4) search techniques sensitive to the structure and similarity among data graphics; 5) manual and automatic adaptation tools for altering data-graphics so that they can be reused with new data.

[130] Colet, E. and Aaronson, D. (1995) "Visualization of Multivariate Data: Human-Factors Considerations." Behavior Research Methods, Instruments, & Computers **27**(2): 257-263.
Recent software provides new tools for visualizing multivariate data that facilitate data analysis. We focus on (1) the learnability and use of visualization systems, and (2) the perceptual and cognitive processes involved in viewing visualizations. Effective visualization systems support a broad range of user tasks and abilities, are easy to learn, and provide powerful and flexible output formatting. Effective visualizations incorporate Gestalt and other perceptual and cognitive principles that encourage more rapid, automatic processing, and less slow, controlled processing.

[131] Gallimore, J. J. and Brown, M.E. (1993) "Visualization of 3-D Computer-Aided Design Objects." International Journal of Human-Computer Interaction **5**(4): 361-382.
There are many significant human factors issues associated with the design and visualization of complex, computer-generated images. One such issue is to determine the most effective techniques for providing engineers with realistic three-dimensional (3-D) objects. Differences in subjects' ability to discriminate between the shape of two 3-D, perspective, computer-aided design-type (CAD-type) objects were investigated for various levels of monocular coding techniques and the binocular cue stereopsis. Performance was assessed at all combinations of five levels of monocular cues and two levels of disparity. The task was similar to the classic

mental rotation paradigm except that subjects were provided with the ability to rotate one of the objects using a two-dimensional (2-D) joystick. Results indicate that interposition was the only depth cue that significantly enhanced subjects' performance. One explanation for the lack of significance of stereopsis is that, for this particular task, depth information provided by disparity was not needed. Detailed analysis of object rotation data using an orientation index (OI) suggests that subjects employed a feature-by-feature comparison task strategy. With tools that can evaluate cognitive activity such as the mental rotation paradigm and orientation index, researchers can learn more about how designers visualize and understand 3-D CAD objects.

[132] Ingram, R. and Benford, S. (1995) "Legibility Enhancement for Information Visualization." IEEE Conference Proceedings Visualization '95: 209-215. http://ieeexplore.ieee.org/iel2/3467/10213/00480814.pdf
Navigation in computer generated information spaces may be difficult, resulting in users getting "lost in hyperspace." This work aims to build on research from the area of city planning to try to solve this problem. The authors introduced the concepts of legibility and cognitive maps and the five features of urban landscape with which they are associated. Following this are descriptions of techniques and algorithms which we have developed to allow these features to be introduced to three dimensional spaces for information visualization. Then they describe a specific application of these techniques in the visualization of the World Wide Web and conclude with a look at future development of the system.

[133] Ishizaki, S. (1996) Multiagent Model of Dynamic Design: Visualization as an Emergent Behavior of Active Design Agents. Proceedings of ACM SIGCHI '96, pgs. 347-354.
This research was motivated by the lack of models and languages in the visual design field that are able to address design solutions, which continuously adapt in response to the dynamic changes both in the information itself and in the goals or intentions of the information recipient. This paper postulates a multiagent model of dynamic design - a theoretical framework of design that provides a model with which the visual designer can think during the course of designing. The model employs a decentralized model of design as a premise, and borrows its conceptual model from the improvisational performance, such as dance and music, and bases its theoretical and technical framework on the field of multiagent systems. A design solution is considered an emergent behavior of a collection of active design agents, or performers, each of which is responsible for presenting a particular segment of information. The graphical behaviors of design agents are described by their dynamic activities - rather than by the traditional method of fixed attributes. The model is illustrated with two design projects, Dynamic News Display System and E-Mail Display, both of which were implemented using a multiagent design simulation system, perForm, along with an agent description language, persona.

[134] Johnson, B. and Shneiderman, B. (1991) "Tree-Maps: A Space-Filling Approach to the Visualization of Hierarchical Information Structures." IEEE Conference Proceedings Visualization '91: 284-291. ISBN: 0-8186-2245-8.
This paper describes a novel method for the visualization of hierarchically structured information. The Tree-Map visualization technique makes 100% use of the available display space, mapping the full hierarchy onto a rectangular region in a space-filling manner. This

efficient use of space allows very large hierarchies to be displayed in their entirety and facilitates the presentation of semantic information.

[135] Kreuseler, M. and Schumann, H. (1999) Information Visualization Using a New Focus+Context Technique in Combination with Dynamic Clustering of Information Space. Conference on Information and Knowledge Management, Kansas City, MO.
www.acm.org/pubs/citations/proceedings/cikm/331770/p1-kreuseler/

[136] Lokuge, I. and Ishizaki, S. (1995) "GeoSpace: An Interactive Visualization System for Exploring Complex Information Spaces." Conference Proceedings on Human Factors in Computing Systems, Denver, Colorado.
http://www.acm.org/pubs/citations/proceedings/chi/223904/p409-lokuge/
This paper presents a reactive interface display which allows information seekers to explore complex information spaces. We have adopted information seeking dialogue as a fundamental model of interaction and implemented a prototype system in the mapping domain—GeoSpace—which progressively provides information upon a user's input queries. Domain knowledge is represented in a form of information presentation plan modules, and an activation spreading network technique is used to determine the relevance of information. The reactive nature of the activation spreading network, combined with visual design techniques, such as typography, color and transparency enables the system to support the information seeker in exploring the complex information space. The system also incorporates a simple learning mechanism which enables the system to adapt the display to a particular user's preferences. GeoSpace allows users to rapidly identify information in a dense display and it can guide a users' attention in a fluid manner while preserving overall context.

[137] Lux, M. (1997) Visualization of Financial Information. Proceedings of the Workshop on New Paradigms in Information Visualization and Manipulation, Las Vegas, NV USA.
This paper has the intention to present new ideas for data mining and visualization of financial information. On this occasion new methods for the graphical representation of abstract and multi-dimensional information and information structures are discussed. This will enable users to get an overview of the global economy or an insight in the development of economic key data.

[138] McKinney, K. Fischer, M. and Kunz, J. (1998) Visualization of Construction Planning Information. Proceedings of the 1998 International Conference on Intelligent User Interfaces, San Francisco, CA USA.
http://www.acm.org/pubs/citations/proceedings/uist/268389/p135-mckinney/
Visualizing a construction schedule helps planners to identity potential construction problems prior to actual building construction. Planners must envision the sequence of construction, the workspace logistics, and utilization of resources and equipment in space and over time. This paper discusses methods of generating, visualizing, and evaluating construction planning information with CAD based tools. We use a construction example to illustrate how feature extraction of 3D CAD models can help identify construction problems and evaluate the quality of a construction plan through 4D analysis and 4D annotation.

[139] Mukherjea, S. and Foley, J.D. Visualizing the World-Wide Web with the Navigational View Builder.
http://www.cc.gatech.edu/gvu/people/Phd/Sougata.Mukherjea.html
http://www.cc.gatech.edu/gvu/people/Faculty/James.D.Foley.html
Overview diagrams are one of the best tools for orientation and navigation in hypermedia systems. However, constructing effective overview diagrams is a challenging task. This paper describes the Navigational View Builder, a tool which allows the user to interactively create useful visualizations of the information space. It uses four strategies to form effective views. These are binding, clustering, filtering and hierarchization. These strategies use a combination of structure and content analysis of the underlying space for forming the visualizations. This paper discusses these strategies and shows how they can be applied for forming visualizations for the World-Wide Web.

[140] Palfreyman, K. End of First Year Report. Section 5: Information Visualization Systems.
www.comp.lancs.ac.uk/computing/users/kev/computing/project/project.html
This section of the report takes a look at a few of the information visualization systems available. It is split into two areas, the first being 2D systems and the second being 3D systems. To analyze every single graphical information display system would require a book, so this section takes a look at those methods which are either new or of direct relevance to this research.

[141] Rieber, L. P. (1995). "A Historical Review of Visualization in Human Cognition." Educational Technology Research and Development (ETR&D) **43**(1): 45-56.
This paper presents a historical overview of visualization as a cognitive strategy in human creativity, discovery, and problem-solving. Visualization strategies, such as mental imagery, pervade historical accounts of scientific discovery and invention. A selected number of historical examples are presented and discussed on topics such as physics, aviation, and the science of chaos. Everyday examples are also discussed to show the value of visualization in cognition for all people. Several counter examples are also discussed showing that visualization can also lead to erroneous conclusions. Many educational implications are discussed, such as reconsidering the dominant role and value schools place on verbal, abstract thinking. These issues are also considered in light of emerging computer-based technologies, such as virtual reality.

[142] Schon, D. A. and Wiggins, G. (1992). "Kinds of Seeing and Their Functions in Designing." Design Studies **13**(2): 135-156.
We consider designing as a conversation with materials conducted in the medium of drawing and crucially dependent on seeing, of which we distinguish several kinds: literal visual apprehension of (in this instance) marks on a page; appreciative judgments of quality (such as 'too small in scale'); apprehension of spatial gestalts (such as 'two L's back to back'). We describe the functions of several kinds of seeing in designers' move experiments, their reasoning, and the learning that results from and feeds into episodes of designing. From this analysis, we draw implications for epistemology, education and computation in design.

[143] Tufte, E. (1997). Visual Explanations. Graphics Press: Cheshire, Connecticut.
This book describes design strategies - the proper arrangement in space and time of images, words, and numbers - for presenting information about motion, process, mechanism, cause and

effect. These strategies are found again and again in portrayals of explanations, quite independent of the particular substantive content or technology of display. The first part of the book examines the logic of depicting quantitative evidence. The second part considers design strategies, often for the arrangement of images as narrative.

[144] ---------- "Points to Consider in Evaluating Dynamic Data Visualization Tools (DDVTs)." www.telsa.hl.com.au/ddvt.htm
Ease of use is a primary concern of serious developers faced with integrating a dynamic graphics software product into interactive applications. Specifically, the developer must understand how easy it will be to attain the desired result while maintaining maximum application performance. This paper defines six categories for consideration when evaluating a dynamic graphics subsystem for ease-of-lee: optimal performance, minimal programming, design openness/flexibility, integration with native widgets, advanced tools and features, and portability.

[145] Tufte, E. (1990). Envisioning Information. Graphics Press: Cheshire, Connecticut.
The world is complex, dynamic, multidimensional; the paper is static, flat. How are we to present the rich visual world of experience and measurement on mere flatland? This book celebrates escapes from flatland, rendering several hundred superb displays of complex data. The author's investigation yields general principles that have specific visual consequences, governing the design, editing, analysis, and critique of data representations. These principles help to identify and to explain design excellence - why some displays are better than others. Charts, diagrams, graphs, tables, guides, instructions, directories, and maps comprise an enormous accumulation of material. This book arrays exemplary designs - this time over a broader spectrum, for all types of information.

[146] Tufte, E. (1983). The Visual Display of Quantitative Information. Graphics Press: Cheshire, Connecticut.
Data graphics visually display measured quantities by means of the combined use of points, lines, a coordinate system, numbers, symbols, words, shading, and color. The first part of this book reviews the graphical practice of the two centuries since Playfair. The second part of the book provides a language for discussing graphics and a practical theory of data graphics. Applying to most visual displays of quantitative information, the theory leads to changes and improvements in design, suggests why some graphics might be better than others, and generates new types of graphics. This is a book about the design of statistical graphics and, as such, it is concerned both with design and with statistics. But it is also about how to communicate information through the simultaneous presentation of words, numbers, and pictures.

[147] Wagner, I., M. Kompast, and R. Lainer. (September / October 2002). "Visualization Strategies for the Design of Interactive Navigable 3-D Worlds." ACM Interactions, pgs 25-34.
Designing navigable, interactive 3-D worlds is partly an aesthetic and partly a technical question. While having to solve the technical problems of optimizing performance in practice, the authors focused on the challenge of creating designs that generate a different view on things, helping perceive the novel in the familiar, discover relationships between seemingly incongruous objects, and relate the unrelatable. Obviously realism is not an answer to this challenge. The designer team approached it through bringing different design principles together, pooling their

knowledges and expertise. The design principles the author present in this article are a result of this work. At the core of their development was an intense discussion of a great diversity of visual examples of artwork: paintings, film, stage design, comics. The designer team experimented with different strategies of combing the visual languages of these artworks into 3-D scenographies. The design principles, although described textually, have been made visible through particularly telling views of the 3-D worlds. The authors look at these screenshots as visual examples of directions to take in 3-D design rather than as accomplished prototypes.

i. Other

[148] Benoff, D. (November 2000). "Interactive Electronic Technical Manuals." *Maintenance*, **87**: 88-93.
Electronic publications can increase the efficiency of your digital aircraft and analog technicians. Computerized technical manuals are silently revolutionizing the aircraft maintenance industry by helping the technician isolate problems quickly, and in the process reduce downtime and costs by more than 10 percent. These electronic publications can reduce the numerous volumes of maintenance manuals, microfiche and work cards that are used to maintain engines, airframes, avionics, and their associated components.

[149] Blue, R.S., J. Wampler, G. Bowden Wise, L.J. Hoebel, B. Yamrom, C.R. Volpe, B. Wilde, P. Rondot, A.E. Kelly, A. Gilman, W. Turner, S. Linthicum, G. Ryon. (April 20-25, 2002). "An Automated Approach and Virtual Environment for Generating Maintenance Instructions." *CHI 2002*, ACM, pgs. 494-495.
Maintenance of complex machinery such as aircraft engines requires reliable and accurate documentation, including illustrated parts catalogs (IPCs), exploded views, and technical manuals describing how to remove, inspect, repair and install parts. For new designs, there are often time constraints for getting a new engine to the field, and the available documentation must go with it. Authoring technical manuals is a complex process involving technical writers, engineers, as well as domain experts (mechanics and designers). Often, several revisions are required before a manual has correct IPC figures and maintenance instructions. Compounding this problem is that technical writers often perform tasks better suited for computers, leading to increased costs and errors. In this demonstration, the authors describe a new framework to generate maintenance instructions from solid models (Computer Aided Design/CAD data) and then validate these instructions in a haptics-enabled virtual environment. The authors approach utilizes natural language processing techniques to generate a presentation-independent logical form, which can be transformed for display within the virtual environment. During the development of the system, task analyses, human models, usability studies, and domain experts were used to gain insights. The end result is a more integrated and human-centered process for developing technical manuals, providing higher quality documents with less cost.

[150] Bursky, D. (June 18, 2001). "Single Instrument Analyze Protocols and Logic." Electronic Design, pgs. 66-72.
By combining intelligence and an easy-to-learn user interface, the Bus Doctor simplifies system diagnostics. System designers today must deal with complex buses and equally complex bus-signaling protocols. This often requires using separate instruments, each optimized for either

logic analysis or protocol analysis. But advances in bus operating speeds and changes in protocols frequently cut the instrument's life short. The ideal solution would combine the ability to handle both logic and protocols, while also allowing easy upgrades to support higher speeds and multiple protocols. Designers at Data Transit have crafted exactly this combination. Known as the Bus Doctor, it performs both logic and protocol analysis. To do this, the instrument leverages programmable logic and software-based control to allow instant reconfiguration and feature upgrades.

[151] Creed, A. Dennis, I. and Newstead, S. (1987) "Proof-reading on VDUs." Behaviour and Information Technology **6**(1): 3-13.
Two experiments are reported which compared proofreading performance across three different modes of presentation. The results of Experiment 1 indicated that proofreading accuracy was significantly worse on a VDU than on paper, with a photograph of the VDU display producing intermediate performance. It was also demonstrated that substitutions of visually similar errors were harder to detect than other error types. The results of Experiment 2 replicated these findings, but failed to find any difference between twin-column and single-column presentation. The findings are interpreted as indicating that character font may be a major factor in the poor performance with the VDU. It is suggested that the present experimental paradigm could be a useful assessment tool for the evaluation of display design.

[152] Cronen-Townsend, S., Y. Zhou, and W.B. Croft. (August 11-15, 2002). "Predicting Query Performance." *SIGIR '02*, ACM: 299-306.
The authors develop a method for predicting query performance by computing the relative entropy between a query language model and the corresponding collection language model. The resulting *clarity score* measures the coherence of the language usage in documents whose models are likely to generate the query. The authors suggest that clarity scores measure the ambiguity of a query with respect to a collection of documents and show that they correlate positively with average precision in a variety of TREC test sets. Thus, the clarity score may be used to identify ineffective queries, on average, without relevance information. The authors develop an algorithm for automatically setting the clarity score threshold between predicted poorly-performing queries and acceptable queries and validate it using TREC data. In particular, the authors compare the automatic thresholds to optimum thresholds and also check how frequently results as good are achieved in sampling experiments that randomly assign queries to the two classes.

[153] Dodson, D. Diagrammatic Interaction Group (DIG).
web.soi.city.ac.uk/research/dig/dig.html
DIG conducts research into human-computer interaction through node-and-link diagrams. Its work has mainly concerned 3D interactive diagrams and diagrams that 'self-organize' to accommodate ongoing change their contents. Its interests span theory, supporting technology and applications, notably in user interfaces for knowledge-system developers and end-users.

[154] Gemperle, F., C. Kasabach, J. Stivoric, M. Bauer, and R. Martin. (October 1998). "Design for Wearability." *Institute for Complex Engineered Systems*, Carnegie Mellon University. Second International Symposium on Wearable Computing, Pittsburgh, PA.
Digital Technology is constantly improving as information becomes wireless. These advances demand more wearable and mobile form factors for products that access information. A product that is wearable should have wear*ability*. This paper explores the concept of dynamic Wearability through design research. Wearability is defined as the interaction between the human body and the wearable object. *Dynamic* wearability extends that definition to include the human body in *motion*. This research has been to locate, understand, and define the spaces on the human body where solid and flexible forms can rest – without interfering with fluid human movement. The result is a set of design guidelines embodied in a set of wearable forms. These wearable forms describe the three dimensional spaces on the body best suited for comfortable and unobtrusive Wearability by design.

[155] Gustman, S., D. Soergel, D. Oard, W. Byrne, M. Picheny, B. Ramadhadran, and D. Greenberg. (July 13-17, 2002). "Supporting Access to Large Digital Oral History Archives." *JCDL '02*, ACM: 18-22.
This paper describes the authors' experiences with the creation, indexing, and provision of access to a very large archive of videotaped oral histories. The research identifies a set of critical research issues that must be addressed to be able to provide full and detailed access to collections of this size: issues in user requirement studies, automatic speech recognition, automatic classification, segmentation, summarization, retrieval, and user interfaces.

[156] Hackos, J. T. (1994). "Publications and Training: The Challenge of Working Together." Technical Communication **41**(3): 424-431.
When technical publications and technical training departments learn to work together effectively, everyone benefits. Technical writers learn from trainers the details about the users and their tasks; technical trainers get help in producing better training materials; users get training courses and technical manuals that are thoroughly integrated; the company displays a unified approach to training and information.

[157] Haydon, L. M. (1997). The Complete Guide to Writing and Producing Technical Manuals. New York, N.Y. A Wiley-Interscience Publication. John Wiley & Sons, Inc.
This book shows the reader how to create clear, well-organized technical manuals for any equipment, simple or complex. Requiring no specialized background knowledge, this unique guide lays out all the aspects of the job - from initial concept to final publication. The author draws on more than twenty-five years' experience as a technician and technical writer to provide authoritative, easy-to-follow instructions on how to organize detailed technical information into a finished, high-quality technical manual. Major topics include: planning procedures for technical manuals; manual types and arrangements, including operation manuals, maintenance and repair instructions, illustrated parts lists, and more; layout and format, including sample page layouts; writing style and technical editing techniques; front matter and introductions; illustration and table preparation, including typical charts, diagrams, and illustrations; preparing camera-ready copy; printing and binding; organizing a technical handbook department; and much more.

[158] Hegarty, M. (1992). “Mental Animation: Inferring Motion from Static Diagrams of Mechanical Systems.” Journal of Experimental Psychology: Learning, Memory and Cognition **18**(5): 1084-1102.
Reaction-time and eye-fixation data are analyzed to examine how people infer the kinematics of simple mechanical systems from diagrams showing their static configuration. The mental animation process reflects both capacity limitations and limitations of mechanical knowledge.

[159] Hiemstra, D. (August 11-15, 2002). “Term-Specific Smoothing for the Language Modeling Approach to Information Retrieval: The Importance of a Query Term.” *SIGIR ’02*, ACM: 35-41.
This paper follows a formal approach to information retrieval based on statistical language models. By introducing some simple reformulations of the basic language modeling approach the authors introduce the notion of *importance* of a query term. The importance of a query term is an unknown parameter that explicitly models which of the query terms are generated from the relevant documents (the important terms), and which are not (the unimportant terms). The new language modeling approach is shown to explain a number of practical facts of today’s information retrieval systems that are not very well explained by the current state of information retrieval theory, including stop words, mandatory terms, coordinator level ranking and retrieval using phrases.

[160] Hughes, M. A. (1997). “Online Documentation in Reference-based Instruction: A Practical Model for Integrating Help Systems into Product Training.” Technical Communication, First Quarter: 58-64.
Companies can improve customer satisfaction while reducing training time and product support costs by integrating online documentation with product training. Online documentation can be designed to be not only the reference at the point of use but also the primary instructional medium used during training. This use of the online document during training increases user acceptance of it and helps develop the required skills for its use. This expanded role for online documentation provides new opportunities for technical communicators to add value to their roles within their companies. This article defines reference-based instruction and outlines its benefits. It describes how reference-based instruction can be incorporated into an instructional system design (ISD) and provides specific examples of learning objectives and student exercises. It lists guidelines for how to structure usability tests for Help systems, and finally, it advises how technical communicators can use reference-based instruction to expand their perceived value in their organizations.

[161] McClintock, M. (1995). Electronic Text. Personal Technical Memorandum.
This memo is a brief review of current research on reading text from VDU screens. Instead of a complete review of the literature, this memo focuses on research about Preference for Paper, Display Variables, and Interaction Issues (Scrolling vs. Paging, Screen Size, Splitting Text, and Searching).

[162] McGee, D.R., P.R. Cohen, R.M. Wesson, and S. Horman. (April 20-25, 2002). “Comparing Paper and Tangible, Multimodal Tools.” *Presented at CHI 2002*, Minneapolis, MN, 407-414.
In command posts, officers maintain situational awareness using paper maps, Post-it notes, and hand-written annotations. They do so because paper is robust to failure, it is portable, it offers a flexible means of capturing information, it has ultra-high resolution, and it readily supports face-

to-face collaboration. The authors report herein on an evaluation comparing maps and Post-its with a tangible multimodal system called Rasa. Rasa augments these paper tools with sensors, enabling it to recognize the multimodal language (both written and spoken) that naturally occurs on them. In this study, the authors found that not only do users prefer Rasa to paper alone, they find it as easy or easier to use than paper tools. Moreover, Rasa introduces no discernible overhead in its operation other than error repair, yet grants the benefits inherent in digital systems. Finally, subjects confirmed that by combining physical and computational tools, Rasa is resistant to computational failure.

[163] Mitchell, W. J. and McCullogh, M. (1995). Integrated Design Environments. <u>Digital Design Media, Second Edition</u>, van Nostrand Rheinhold.
An integrated computer-aided design environment is one in which data files pertinent to a project, software tools, and physical devices can efficiently be put to many different uses - possibly by different members of a design team, working in different places, at different stages in a design process - and exploited to the maximum. Integration is achieved by carefully maintaining the currency, integrity, and security of data files and by organizing computer resources so that these files and appropriate tools for manipulating them are always accessible when and where they are needed by design team members or for use in automatic processes.

[164] Murphy, A. J. (Ed.) and Engstrom, D. (1997). "Book Review: A Guide to Publishing User Manuals by Ken Whitaker." <u>Technical Communication</u>, Second Quarter: 174-175.
This book cover of Ken Whitaker's *A Guide to Publishing User Manuals* describes it as "A total A-to-Z guide to creating professional-quality user manuals on time, on budget – on your PC." Well, the book doesn't quite accomplish that goal. But it does offer guidance for an experienced writer suddenly thrust into the role of page and document designer. The book touches on a wide variety of topics related to organizing, writing, producing, and printing software user documentation. The book's strongest area is the mechanics of desktop publishing. In many respects, the book is a kind of super manual for FrameMaker and Corel Ventura. The examples do an excellent job of demonstrating how to organize a dizzying array of features into tasks that you might actually want to do. Experienced writers who have lost their graphic designers to downsizing or outsourcing may find the book a lifesaver when stumbling through that first project without professional assistance.

[165] Murphy, A. J. (Ed.) (1997). "Book Reviews: Technical Communication." <u>Technical Communication</u>, Third Quarter: 307-325.
Twelve Book Reviews. (1) Substance & Style: Instruction and Practice in Copyediting, (2) Industrial-strength SGML: An Introduction to Enterprise Building, (3) The Scientific Voice, (4) Wired Style: Principles of English Usage in the Digital Age, (5) Designing Business: Multiple Media, Multiple Disciplines, (6) Writing in a Milieu of Utility: The Move to Technical Communication in American Engineering Programs, 1850-1950, (7) Digital Type Design Guide: The Page Designer's Guide to Working with Type, (8) Dictionary of PC Hardware and Data Communications Terms, (9) The Computer Contradictionary, (10) The Wired Neighborhood, (11) Shamans, Software, and Spleens: Law and the Construction of the Information Society, (12) SGML: The Billion Dollar Secret.

[166] Muter, P. and Maurutto, P. (1991). "Reading and Skimming From Computer Screens and Books: The Paperless Office Revisited?" Behaviour and Information Technology **10**(4): 257-266.
Past research has demonstrated that reading efficiency is lower from the standard computer displays on the 1980s than from paper. In the present experiments, subjects read or skimmed stories, sometimes from a high-quality CRT (cathode ray tube) and sometimes from a book. Skimming was 41% slower from the CRTs than from the book. Possible reasons for this finding are discussed. Reading speed and comprehension were equivalent for the high-quality CRTs and the book. The paperless office may be imminent after all.

[167] Osborne, J. (1995). "Paperless Wafer Fabs." European Semiconductor: 12-13.
Until recently, semiconductor fab managers had few alternatives to traditional paper manuals for accessing critical information on system operation, troubleshooting, and maintenance. With space at a premium and paper prohibited in the cleanroom due to particle concerns, technicians and engineers have been forced to physically leave the cleanroom each time they needed to consult an equipment manual. In many fabs, managers have also resorted to laminating the pages of entire maintenance manuals in order to bring sections into the cleanroom. Needless to say, neither procedure is acceptable in today's wafer fab production environment, where cost of ownership is a key issue. Equipment makers who are sensitive to cost of ownership variables such as mean-time-to-repair (MTTR) and mean-time-to-clean (MTTC) are taking advantage of the latest in multimedia and portable computing technologies to enhance access to critical equipment information and troubleshooting capabilities. In most cases, the technology of choice involves the conversion of hard copy manuals to cleanroom-compatible electronic media, notably multimedia-capable CD-ROMs, which can easily be brought into the cleanroom by means of a notebook computer, giving engineers access to vast amounts of critical data on demand.

[168] Oviatt, S. (November 1999). "Ten Myths of Multimodal Interaction." *Communications of the ACM* **42** (11).
http://www.cse.ogi.edu/CHCC/Papers/sharonPaper/Myths/myths.html
Multimodal systems process combined natural input modes- such as speech, pen, touch, manual gestures, gaze, and head and body movements- in a coordinated manner with multimedia system output. These systems represent a new direction for computing that draws from novel input and output technologies currently becoming available. In this article ten "myths" about multimodal interaction are identified as currently fashionable among computationalists, and they are discussed from the perspective of contrary empirical evidence. Current information is summarized about multimodal interaction from research on multimodal human-computer interaction, and from the linguistics literature on natural multimodal communication. In the process of uncovering misconceptions associated with each myth, information is highlighted on multimodal integration patterns and their temporal synchrony, the information carried by different input modes, the processability of users' multimodal language, differences among users in multimodal integration patterns, and the reliability and other general advantages of multimodal system design. This state-of-the-art information is designed to replace popularized myths with a more accurate foundation for guiding the design of next-generation multimodal systems.

[169] Paris, C. and Linden, K.V. (1996). "An Interactive Support Tool for Writing Multilingual Manuals." Computer **29**(7): 49-56.
Multilingual instructional manuals are important for companies throughout the world that have a significant volume of international business. Using automation in the production of these manuals is attractive because of the increased need for manuals and because of the cost and time involved in creating them.

[170] Redish, J. C. (1997). "Book Review: Dynamics in Document Design: Creating Texts for Readers by Karen A. Schriver." Technical Communication, Fourth Quarter: 430-434.
Dynamics in Document Design is several books in one – part history, part detailed information on typography and layout, part research and theory, part case studies – all presented in clear writing with lots of illustrative examples.

[171] Roccetti, M., and Salomoni, P. (2001). "A Web-based Synchronized Multimedia System for Distance Education." ACM, *SAC 2001*, pgs. 94-98.
The authors have developed a Web based multimedia educational system, which has been designed to provide support for both synchronous and asynchronous distance learning. On the one hand, the system enables the instructors to produce and the students to receive asynchronous customized educational material under the different form of HTML slides, digital audio/video lectures, software packages and simulating instruments for laboratory activities. On the other hand, the system allows users (students and educators) to establish synchronous communications through real time audio connections. In the paper, the authors show how by exploiting the potentiality of adaptive techniques, markup languages, and networked multimedia technologies, their educational tool is able to provide each different user with an educational support tailored to his/her personal profile and didactical needs.

[172] Schriver, K. A. (1989). "Document Design from 1980 to 1989: Challenges That Remain." Technical Communication, Fourth Quarter: 313-331.
Document design had its origins in the 1930s, but much of its development in theory, research, and practice has occurred in the past ten years (1980-1989). This article provides a snapshot of the evolution of document design, includes a comprehensive list of research references, and stresses the need to integrate theory and research with practice as we move into the 1990s. The author concludes by identifying critical challenges to the international growth of document design, both in the academy and in industry - challenges that must be met if document design is to flourish.

[173] Shlaer, S. and Mellor, S.J. (1989). Object-Oriented Systems Analysis: Modeling the World in Data. Englewood Cliffs, New Jersey, Yourdon Press, PTR Prentice Hall.
Why is it so difficult to build a large information processing system: to know exactly what we are doing as we progress through the many steps of the software development and to have at the end (on time and within budget, of course) a system that meets the user's requirements and expectations and is easy to maintain, modify, and understand? On the basis of experience, we have identified some problems that seem to be fundamental: They arise again and again; they plague both large and small development projects. In hindsight, they can frequently be seen as

major contributors to project failure. These problems are all based on information or misinformation in one way or another.

[174] Shoemaker, G.B.D., and Inkpen, K.M. (March 31, 2001). "Single Display Privacyware: Augmenting Public Displays with Private Information." ACM, *SIGCHI '01*, **3**: 522-529.
The research area of Single Display Groupware (SDG) confronts the standard model of computing interaction, one user working on one computer, by investigating how to best support groups of users interacting with a shared display. One problem that has arisen in SDG research concerns access to private information. Previously, private information could not be displayed on a shared display, it could only be accessed on external devices, such as private monitors or Personal Digital Assistants (PDAs). This paper discusses Single Display Privacyware (SDP), an interaction technique that allows private information to be shown within the context of a shared display. A description of the hardware and software components of our prototype SDP system is given. The results of a user study using a prototype SDP system indicated that SDP is a valid interface technique that is well-accepted by users. Only one of the sixteen subjects indicated discomfort working with the SDP system. This was a first attempt at choosing a domain and task suitable for a SDP system, as well as a first attempt at implementing such a system. It was observed that different users have different preferences concerning what information should be kept private, and what should be made public.

[175] Smailagic, A., D.P. Siewiorek, J. Anhalt, F. Gemperle, D. Salber, S. Weber, J. Beck, and J. Jennings. (May/June 2001). "Towards Context Aware Computing Experiences and Lessons." IEEE Intelligent Systems, pgs. 38-46.
This paper defines an activity/attention framework for context aware computing, and categorizes several applications the authors have developed in spatial and temporal contexts. These context aware applications utilize the services from the activity/attention framework. The paper also introduces a generic architecture for pervasive computing, explores and refines its design space, and describes specific instantiations of the architecture and provides initial evaluation of these applications. Two different user interfaces, visual and audio, have been implemented and contrasted for the same application.

[176] Trego, L. (1996). "Electronic Tech Manuals." Aerospace Engineering: pg 16.
Delta Air Lines has adopted the software of Jouve Data Management, along with the services of TransQest Information Solutions, Inc. for distributing airframe technical manuals in digital form for the B-757, B-767, and MD-11 fleets. Delta has implemented the Jouve Pinpoint for Windows retrieval application for its Atlanta line maintenance workstations, and has plans to install the application in its maintenance hangars and engineering facilities in Atlanta and at line stations throughout its system. Data will be distributed via LAN in seven Delta hub cities, with stand-alone CD-ROM stations installed in other locations. A total of 250 workstations will be installed by June 1996.

[177] von Koenigseck, E. Irvin, J.N. and Irvin, S.C. (1991). Technical Writing for Private Industry: The A-to-Z of O&M Manuals. Malabar, Florida, Krieger Publishing Company.
The "A-to-Z of O&M Manual - Technical Writing for Private Industry" contains three parts. Part I describes the process of creating the manual; Part II describes the typical chapters and drawings in the manual; Part III describes the subcontracting process and databased technical manuals.

[178] Whitefield, A. and Warren, C. (1989). "A Blackboard Framework for Modeling Designers' Behavior." Design Studies **10**(3): 179-187.
A framework for modeling designers' behavior is presented and discussed. After considering the empirical evidence of designers' behavior, and extant models of it, a modeling framework derived from artificial intelligence 'blackboard' systems is presented. Two particular models within this framework are then detailed, based on empirical studies of experienced designers. The paper concludes with a discussion of the strengths and weaknesses of the blackboard framework.

2. GOVERNMENT DOCUMENTS

[179] ---------- Advanced User Interface for IETMs.
http://www.nawcsti.navy.mil/aietm.htm
Electronic technical manuals revolutionized the way in which technical information is used. Fast information retrieval, economical production and distribution, and minuscule stowage requirements offer solutions to problems associated with the use of paper technical manuals. Interactive electronic technical manuals (IETMs) extended these advantages by improving the way in which information is presented to the user. In spite of these well-acknowledged benefits, current IETMs have limitations that impact their effectiveness within a maintenance environment: Most are desktop or laptop systems physically separated from the equipment being maintained; The technician must divert attention from the maintenance task to use the IETM. Most provide static information rather than assisting in repair and maintenance. Like their paper counterparts, current IETMs provide only a maintenance reference source rather than becoming an integral part of the maintenance process. Designed to support a variety of users regardless of environment, experience, or skill level, current IETMs do not automatically adjust to different user levels.

[180] ---------- Interactive Electronic Technical Manuals and Hypertext Markup Language, Dayton T. Brown Inc. Technical Communications.
http://www.daytontbrown.com/tc_ietm.html
The authors assert that the benefits of using IETMs to navigate rapidly through vast amounts of technical information are widely recognized by industry and the Government as time and cost savers. This is especially true when maintaining complex systems and equipment. IETMs employ interactive presentation techniques, hypertext linking, still photo capture, full motion video, video frame grabber, animated diagrams and keyed audio. IETM's can also interface with CBT programs. Dayton T. Brown, Inc. uses the most popular design software to develop IETM's to fulfill specific client requirements allowing linear and hierarchy based navigation. Our designers develop Class I through V IETMs for new or mature programs which will allow data base revisions by either developer or client. IETMs are written to CD for direct utilization. They can be down loaded to hard drives or accessed via the internet using HTML.

[181] ---------- (1999). IETM User-Interaction ("Look-and-Feel") Guidelines (MIL-PRF-87268A). Carderock, Maryland, Naval Surface Warfare Center: 12.
BACKGROUND. At the 1998 DoD Logistics Reform Day Symposium held at the Pentagon on 1 October 1998, there were a number of presentations and exhibits on Interactive Electronic Technical Manuals (IETMs). Individual Services and several Industrial activities displayed a number of exhibits showing state-of-the- art IETM Presentation Systems. In separate formal presentations, both the Assistant Deputy Undersecretary of Defense (Logistics Reinvention) and the Head of Technology and Business Integration of the Joint Electronic Commerce Project Office (JECPO) discussed efforts underway to achieve DoD-wide IETM Interoperability. At that Forum, a number of the participants suggested that an area in need of additional standardization was that of IETM user-interaction features; i.e. the look-and-feel of IETMs. At that time, representatives of the Aerospace Industries Association (AIA) Service Publications Committee and of the Tri-Service IETM Technology Working Group (IETMTWG) agreed it would be

desirable to hold a jointly sponsored Workshop to address this topic. The IETM User-Interaction ("Look-and-Feel") Workshop resulting from this agreement was held at the Naval Surface Warfare Center Carderock Division, West Bethesda, Maryland on 15-18 March 1999. Invitees included representatives selected from the membership of the AIA Service Publications Committee and two representatives each from the Army, Navy , Air Force and Marine Corps. This Report summarizes results of that Workshop and provides recommendations for further efforts to achieve DoD-wide standardization of IETMs, based on a common look-and-feel approach.

[182] ---------- (2000). Department of Defense Handbook for Interoperability of Interactive Electronic Technical Manuals (IETMs). Redstone Arsenal, AL 35898-7466, USAMC Logistics Support Activity: 72.
SCOPE. The purpose of this handbook is to outline issues associated with achieving IETM interoperability through the use of a common user interface, i.e. a browser. Not all areas of interoperability, i.e. data interoperability are covered in this handbook. The guidance contained herein specifically covers issues that may allow an IETM user access to IETMs via a common interface regardless of where, by who, and how the IETM was created.

[183] ---------- (1998). IETM Overview, Antech Systems (Specialists in Developmental Technology and Applications for Interactive Presentation of Technical Information on Digital Media) www.antechsystems.com/
An IETM Overview including these five topics: IETM Advantages. Providing the Right Data. IETM Software and Database Design. Standardizing IETMs. IETM Acquisition.

[184] ---------- Navy IETM Web Site (29 Links).
http://navysgml.dt.navy.mil/ietm/webstuff/Reports.htm

[185] Broemm, W. J. Ellner, P.M. and Lipp, J. (1996). A Case Study in the Use of Reliability Projection Methodology to Assess Technical Manuals. Proceedings - Institute of Environmental Sciences.
Whether or not it is initially planned that way, reliability testing becomes a growth process as system weaknesses are revealed. Corrective actions (termed fixes) are incorporated both during and at the end of testing. A major responsibility of reliability engineers is to assess the impact on system reliability of planned or implemented fixes to problem failure modes encountered during testing. This reliability assessment should provide input for management's decision with regard to whether the system is mature enough to exit the current text phase and enter the next test phase, e.g. exit the Pre-Production Qualification Test (PPQT) phase and enter the Initial Operational Test and Evaluation (IOT&E) phase. Projection methodology has been developed for making such system reliability hardware/software assessments. For the system considered in this paper, the technical manuals (TM's) were thought to be a major area for potential system improvement during the PPQT phase. This raised the general question as to whether reliability projection methodology could provide useful, quantitative measures of technical manual maturity and adequacy.

This paper presents a case study based on TM deficiencies observed during the PPQT phase for the mobile mass spectrometer (MM-1) subsystem of the FOX System - a nuclear, biological, chemical reconnaissance system. The MM-1 is the primary subsystem used for detection of chemical agents. This subsystem was fully mature as far as the hardware and software were concerned, and any failures of this nature were not candidates for redesign or reprogramming. Any improvement in MM-1 reliability would have to come from other sources such as training, manuals, maintenance and test equipment. In the reliability literature, deficiencies found during testing that are not candidates for improvement are referred to as A-modes, and those that are candidates are referred to as B-modes. In this paper, the proposed projection methodology shall be applied to a subcategory of the B-modes, terms B1 -modes, associated with the TM's for the MM-1 subsystem. Two types of improvements to the TM's were performed during extensive testing by the U.S. Army. The first concerned changes to the TM's due to errors in interpretation of the translation from German to English as well as operating procedures which were never placed in the German TM's. For the purposes of this paper, these types of corrections to the TM's were applied to deficiencies that we shall term B1 failure modes. The other type of improvement to the TM's pertain to B-modes caused by either customary practices or requirements. Changes that were made to help prevent failures from these causes were also placed in the TM's. We shall refer to these deficiencies as B2 failure modes. The distinctions between these modes are further discussed in the paper. Additional test information was obtained during the follow-on IOT&E. We shall use the IOT&E data to motivate our discussion of several issues that arise when attempting to apply reliability projection methodology to assess TM's.

[186] Dundas, M. Bigg, K. and Peckham, C. (1999). Electronic Technical Manuals.
http://lrc3.monmouth.army.mil/cecom/lrc/pie/tm-ietm.html
An Electronic Technical Manual (ETM) is a digitized and electronically presented Technical Manual. The functionality (level of interactivity) and structure of the data determines the type or class of ETM. An Interactive ETM (IETM) is a type of ETM that has more sophisticated means of interactivity and is formatted in a database. This topic will speak generally to ETMs with the understanding that the "I" in IETMs is based on selection of functionality/Interactivity requirements and is a program specific requirement. The Army is transitioning to acquiring ETMs developed to performance-based specifications and standards. The intent of this transition is to position ourselves for maximum use of the commercial technological base, wherever possible, in the development of our products. To accomplish this will require the development of acquisition requirements that enables the use of the most current publishing and delivery technology, without restricting its future reuse as legacy data. Maximum use will be made of resources and information furnished in the form of Intelligent Product Data (IPD). This will leverage cost paid to own/use/access this data and eliminate paying for redundant submittals of the same data to separate functional areas.

[187] Fuller, J. J. (1998). Plan for DoD Wide Demonstrations of a DoD Improved Interactive Electronic Technical Manual (IETM) Architecture. Carderock Division, West Bethesda, Maryland, Naval Surface Warfare Center: 84 pgs.
This Report describes the Pilot-Demonstration Phase of the development of a Joint IETM Architecture (JIA) designed to assure Service-wide interoperability of Interactive Electronic Technical Manuals (IETMs) based on emerging World Wide Web technology. The goal of the JIA is to provide an environment in which all legacy, and newly acquired, Electronic Technical

Manuals can be read by any end user with a common user-interface display system, regardless of authorship of the Technical Information. The JIA development program is being carried out by the Tri-Service IETM Technology Working Group (IETMTWG), chaired by the Naval Surface Warfare Center, Carderock Division (NSWCCD), in accordance with directives established by the Office of the Assistant Deputy Undersecretary of Defense (ADUSD(LRM)) and the Joint Commanders Group for Communications and Electronics (JCG-CE) of the Joint Logistics Commanders. The development effort will culminate in the promulgation of appropriate policy directives, user-guidance documentation, and appropriate MIL-PRF-acquisition documents to assure full-spectrum interoperability. The Pilot Demonstration Phase of the effort has been established to demonstrate that representative systems of the Army, Navy, Air Force, and Marine Corps can successfully be made JIA-compliant with a minimum of effort. The demonstration systems chosen for this purpose by Service members of the IETMTWG include a complete range of IETM complexity, from the simple forms of digitized legacy Technical Information to the most highly developed and integrated interactive Technical Information systems. Similarly, they include a broad spectrum of commercial technologies now in use for generation of IETMs.

[188] Fuller, J. J. (1997). Tri-Service Interactive Electronic Technical Manual (IETM) Technology Working Group. Naval Sea Systems Command. Naval Surface Warfare Center: Carderock Division. CALS Expo International 1997.
Slide presentation consists of: Working Group, Purpose, Membership, Responsibilities, FY97 Technical Initiatives, Points of Contact, What are IETMs?, NSWC/CD R&D in 70's and 80's Leading to IETMs, IETM Payoffs.

[189] Fuller, J. J. LeBeau, R.P. Mavor, A.S. Post, T.J. and Sawyer, C.R. (1988). Test and Evaluation of the Navy Technical Information Presentation Systems (NTIPS) AN/SPA-25D Field Test Results. Bethesda, MD, David Taylor Research Center: 89 pgs.
This document describes the results of the second Field Test of Navy System-related Technical Information (TI) developed by the Navy Technical Information Presentation System (NTIPS). Three types of experimental TI were compared with the conventional Technical Manual. For performing troubleshooting tasks, the NTIPS electronically displayed automated troubleshooting TI (called Fault Isolation by Nodal Dependency, FIND) was compared with the conventional Technical Manual, and for performing corrective maintenance, NTIPS electronically displayed TI was compared with NTIPS on paper and the conventional Technical Manual. Tests were carried out at the Naval Sea Combat Systems Engineering Station in Norfolk, VA. using two operational AN/SPA-25D radar repeaters (with introduced faults). Test subjects were Electronic Technicians stationed on ships and at shore based facilities in Norfolk, VA. All test objectives were achieved. Almost all (92%) of the subjects preferred electronically delivered TI to the conventional Technical Manual. They were able to use NTIPS TI to troubleshoot more accurately and with greater speed than with the conventional Technical Manual. For corrective maintenance, subjects performed at the same accuracy and speed regardless of the TI type.

[190] Fuller, J. J. Post, T.J. and Mavor, A.S. (1988). Test and Evaluation of the Navy Technical Information Presentation System (NTIPS) F-14A Field Test Results. Bethesda, MD, David Taylor Research Center: 94 pgs.
This document describes the results of one part of a full-scale system test of concepts for improvement of quality and of display of Navy System-related Technical Information developed by the Navy Technical Information Presentation System (NTIPS). The tests involved comparisons of three types of experimental Technical Information (TI) with the conventional paper work package. The three types of experimental TI were (1) NTIPS automated troubleshooting TI (called Fault Isolation by Nodal Dependency, FIND), electronically displayed; (2) NTIPS electronically displayed corrective-maintenance TI; and (3) NTIPS corrective-maintenance TI delivered on paper. Tests were carried out at Miramar Naval Air Station using an operational F-14A aircraft (with introduced "faults"). Test subjects were squadron Aviation Electricians Mates (AEs) both experienced and inexperienced. All test subjects were achieved. The test demonstrated that electronic display of maintenance TI is highly acceptable to fleet personnel (90% of the test subjects favored electronic display), that NTIPS-proposed modifications to TI are as effective or more effective than conventional TI in supporting troubleshooting and corrective maintenance, and that automated troubleshooting produced a highly significant improvement in fault-isolation success. The test provided valuable experience and indicated areas in which NTIPS and electronic display can be improved. Proposals resulting from the test are currently being implemented.

[191] Fuller, J. J. (October 1994). IETMs: From Research to Reality, Naval Surface Warfare Center, Carderock Division. AFEI CALS Expo International 1994.
http://navysgml.dt.navy.mil/ietm/ietm.html
In the late 1970s, the U.S. Military Services formulated concepts for Interactive Electronic Technical Manuals (IETMs) to replace Technical Manuals (TMs) presented on paper and microform. Comprehensive research and development programs were conducing, including Navy Technical Information Presentation System (NTIPS) and the Air Force Computer-based Maintenance Aid System (CMAS). In the 1980s, pilot systems were developed and tested under operational conditions. Significant quantitative payoffs were demonstrated, with overwhelming field-user preference for IETMs over paper-based TMs. Based on these successes, the Joint Industry/Government Pageless TM Committee was formed and worked to standardize IETM approaches and technology. The Tri-Service IETM Working Group developed DoD specifications for the acquisition of IETMs; and the CALS ISG Standards Division reviewed and concurred with these specifications. IETM authoring and presentation systems have emerged in the commercial marketplace. In the 1990s, DoD programs are acquiring IETMs to support weapon systems, such as Paladin, Apache, Comanche, AEGIS, FDS, BSY-2, F-22, JSTARS, and V-22. Commercial applications are underway in the airline, automotive, and railroad industries. Internationally, IETMs are proposed for the NATO NH-90 helicopter and the European Fighter Aircraft. Thus, IETMs have progressed from concepts, through pilot development, field testing, and standardization, to military and commercial implementations. Clearly, IETMs have moved "From Research to Reality."

[192]] Harvey, B. (May 1998) How STEP/SGML and XML/EDI Initiatives Will Impact Future Development of IETMs. Electronic Commerce Connection, Inc. Paper presented at XML Europe Conference in Paris, France.
http://www.eccnet.com/papers/ietm.html
The STEP/SGML initiative will enable information objects used within technical manuals to be created early in the manufacturing process and then used within paper manuals, Interactive Electronic Technical Manuals (IETMs), Computer Based Training (CBT), documents on demand, etc. This paper will describe how the ISO Preliminary Work Item (PWI) on SGML and Industrial Data, and recent initiatives towards using eXtensible Markup Language (XML) for Electronic Data Interchange (EDI), could ultimately impact and improve the IETM authoring and creation process.

[193] Harvey, B. (1997). "Interactive Electronic Technical Manuals and STEP." 1-39.
ISO STEP Conference, Chester, England - Slide Presentation. Slide material covers: Definition of IETMs (History, Concepts, and Specifications), How SGML/HyTime is used for IETMs, and How can STEP help in development of IETMs?

[194] Jorgensen, E.L. (1999). NSWCCD-20-TR-1999-12+TR Proposed DoD Guidelines for Implementation of a Web-Based Joint IETM Architecture (JIA) to Assure the Interoperability of DoD IETMs. West Bethesda, MD, Carderock Division, Naval Surface Warfare Center: 58 pgs.
This paper presents preliminary guidelines intended to serve as input to a planned DoD Handbook for the Acquisition and Deployment of DoD IETMs with the specific purpose of assuring interoperability of IETMs among various end-users.

[195] Jorgensen, E.L. (1998). CDNSWC-TSSD-98-10 Proposed Web-Based Joint IETM Architecture (JIA) for the Interoperability of DoD IETMs. West Bethesda, MD, Carderock Division, Naval Surface Warfare Center: 33 pgs.
This report documents the results of a study sponsored by the Assistant Deputy Secretary of Defense for Logistics Reinvention and Modernization (ADUSD (LR&M)) and the Joint Commanders Group for Communications and Electronics (JCG-CE). An Architecture is proposed for Interactive Electronic Technical Manuals (IETMs) based on the technology, industry standards, and commercial software products being developed for the World Wide Web.

[196] Jorgensen, E.L. (1998). CDNSWC-TSSD-98-005 Proposed Web-Based Architecture for the Interoperability of Naval Aviation IETMs. West Bethesda, MD, Carderock Division, Naval Surface Warfare Center: 32 pgs.
This report documents the results of a study sponsored by the Naval Air Systems Command (NAVAIR) which is recommending an Architecture for Naval Aviation Interactive Electronic Technical Manuals (IETMs) based on the technology, industry standards, and commercial software products being developed for the World Wide Web.

[197] Jorgensen, E.L. (1998). The Future Benefits of Utilizing a Web-Based Architecture for DoD IETMs, CALS EXPO 1998.
Slide presentation consisting of: Developing a Web-Based Approach to DoD IETMs, The JIA Foundation, Benefits to the User, Benefits to Authoring Organization, Future Expandability, Ad Hoc Aggregations of IETMs, Freebies Gained by Going Web, Objective Obtained IETM Interoperability+, Innovative Concept – Using Web Objects as Source Data, Authoring Process, User Site Process, Future Expansion, and Final Thoughts.

[198] Jorgensen, E.L. (1997). DoD IETM Interoperability Project, NSWC Carderock Division, Department of the Navy.
Slide presentation consisting of: DoD IETM Interoperability, Background, Issues with IETM Interoperability, Results, Proposed Approach to Solving the Interoperability Problem, Selected General Approach, IETM Interoperability, Interoperability applies to the entire IETM Community, Authoring Process, Infrastructure Process, User Site Process, User Site Interoperability, Specifications Needed, Initial Development, Projected Future Goals, Include Interface with Other Job Performance Aids, Web-Based Concept of Single Product Support Data Base, and Summary.

[199] Jorgensen, E.L. (1996). Achieving Interoperability Through a Proposed New Information Architecture for the Acquisition and Use of IETMs. Carderock Division, Naval Surface Warfare Center, Department of the Navy.
Slide presentations consisting of: Background, Issues with IETM Interoperability, Proposed Approach to Solving the Interoperability Problem for Suppliers and Users, Developments in Web/Internet Technology used in Developing the Proposed New IETM Process, Why Web Technology? Overview of the New Proposed IETM Process, How Interoperability is Achieved, and a Disclaimer.

[200] Jorgensen, E.L. (May 1996) The Move to Paperless Technical Manuals in the U.S. DoD. Caderock Division, Naval Surface Warfare Center, U.S. Department of the Navy: 1-7. CALS Europe.
http://navysgml.dt.navy.mil/ietm/ietm.html
In this paper Mr. Jorgensen attempted to categorize and describe the various moves in the US Department of Defense from paper-based Technical Manuals to a variety of forms of Electronic Technical Manuals (ETMs). The three principal Services have agreed to a categorization of five Classes of ETMs and this discussion will follow these five categories, which range form simple Class 1 "page-flippers" to a complete Class 5 Technical Information Systems under consideration which utilize a common data base derived from Logistic Support Analysis Records (LSAR) and support Maintenance, Operations, Training, and Logistics Support functions. In between these two extremes are the Interactive Electronic Technical Manuals (IETMs) specified by the two US Military Specifications MIL-M-87268 and MIL-D-87269. The paper concludes with some of Mr. Jorgensen's observations and opinions on the possibility of obtaining consensus on International Standards to guide the production of standard paperless and interactive electronic support systems which can be used across International borders.

[201] Jorgensen, E.L. (1995). Maturing, Migrating, Merging, or Mixing? The Future of the DoD IETM Specifications. AFEI CALS Expo International.
http://navysgml.dt.navy.mil/ietm/ietm.html
Slide presentation consisting of: Original Concept to Spec IETMs, The DoD IETM Specs Roadmap, Impact of the "Perry Memo", Current Plans for Specifications, Legacy Data Requirements, Some Recommendations, and Harmonization with Other Standards.

[202] Jorgensen, E.L. (1994). DoD Classes of Electronic Technical Manuals. Caderock Division, Naval Surface Warfare Center: 1-9.
Over the last two or three years the concept of electronically presenting Technical Manuals to end-users has gone from an experimental concept to one which is widely regarded as an idea whose time has come. Many DoD Acquisition Program Managers have already begun to implement Automated TM systems for their own programs because they make sense. However, these applications have not been centrally managed or developed to common specifications, and as a result many substantially different concepts and incompatible systems have emerged in demonstration programs and actual applications. Some of these are now being proposed as candidates for the "Standard System" for automated TM presentation systems, while other approaches are quietly being implemented as "tactical and mission-critical systems" so as to remain unimpeded by possible non-tactical standards and bureaucracies. It is in this environment that the Navy ATIS System as well as the new DoD IETM Specifications are proposed as the basis for the set of required DoD standards needed to avoid undesirable non-compatible proliferation of automated TM systems.

[203] Jorgensen, E.L. (October 1994). The Interactive Electronic Technical Manual Overview "Setting the Stage", Carderock Division, Naval Surface Warfare Center. AFEI CALS Expo International 1994.
http://navysgml.dt.navy.mil/ietm/ietm.html
The paper presents a general overview of DoD Interactive Electronic Technical Manuals (IETMs) and opens with a short discussion of the problems leading up to the need for IETMs, the general characteristics of an IETM, and an identification of the major research programs in the three Services leading up to IETMs.

[204] Jorgensen, E.L. (1991). DoD Specifications for Interactive Electronic Technical Manuals (IETM). Status Report on Draft Specifications and Handbooks Developed by the Tri-Service Working Group for IETMs, Department of the Navy.
Presentation slides consisting of: Working-Group Task and Membership, Draft Specifications, Current Releases and Status, Plans for FY-92, and Key Issues.

[205] Jorgensen, E.L. and Fuller, J.J. (October 19-21, 1998). A Web-Based Architecture for Interactive Electronic Technical Manuals (IETMs): 1-11. ASNE Naval Logistics Conference.
http://navysgml.dt.navy.mil/ietm/ietm.html
This paper presents a concept of a Web-based Architecture for achieving user-level interoperability of DoD Interactive Electronic Technical Manuals so that an end user can view any DoD IETM, no matter what the source, using only one electronic display device and common set of browser software. The particular solution presented is that developed by a study

performed for the Navy; however, the paper also discusses the effort to extend the Navy Architecture to all of DoD. The DoD effort is being undertaken by a Tri-Service team chartered by the Assistant Undersecretary of Defense (Logistics Reinvention and Modernization). The Architecture is being developed in response to a requirement from the Joint Logistics Commanders, which identifies that non-interoperability of IETMs as a major impediment in conducting Joint Operations.

[206] Jorgensen, E.L. and Fuller, J.J. (1996). New Approaches For Navy Technical Training And Job Performance Aiding Using Expanded IETM Technology. NSWCCD/TSS-97-01. Carderock Division, Code 2052, Naval Surface Warfare Center: 1-24.
As early as the 1970's, the Fleet User Systems Branch (2052) of the Carderock Division, Naval Surface Warfare Center (NSWC/CD) began to develop better ways to present Technical Information (TI) to Navy Fleet users needed for purposes of operating, maintaining, training, and logistically supporting the Navy's inventory of weapon systems. Prior to that time, with the exception of Training Films, virtually all Technical Information was based on paper media. This effort resulted in the formulation of new concepts and capabilities which permitted the replacement of traditional paper Technical Manuals with the Interactive Electronic Technical Manual (IETM). A series of laboratory and field tests conducted by the Air Force and the Navy in the late 1980's demonstrated the benefits of IETMs for performing Organizational-Level maintenance. Based on the experience and success of those initial tests, DoD IETM Specifications were developed by a Tri-Service Working Group chaired by NSWC/CD. The Specifications were initially promulgated in November, 1992. They were intentionally very forward looking and included provisions for including advanced Object-Oriented Technology and Interactive Multi-Media Technology as they matured and became more available in the future. Since that time, many Navy Programs have planned for and developed IETMs in one form or another, some conforming closely to the IETM Specifications and others using emerging COTS (Commercial-Off-the-Shelf) electronic document-viewing products when the legacy format of the existing paper-based TMs rendered the MIL-SPEC IETMs too costly.

[207] Jorgenson, E.L. and Fuller, J.J. (March 17-18, 1993). The Interactive Electronic Technical Manual. ASNE/SOLE Conference.
http://navysgml.dt.navy.mil/ietm/ietm.html
Paper consists of the following sections: The Existing Technical Manual Problem, Emerging Solutions, The IETM Concept, RDT&E Leading up to the IETM Concept, Measurable Benefits Resulting from Use of IETMs, The Development of IETM Specifications for DoD, Status of the DoD IETM Specifications, and The Future for IETMs.

[208] Jorgensen, E.L. Fuller, J.J. Post, T.J. and Rainey, S.C. (1995). Potential Benefits To Navy Training Programs Resulting From Increased Use of Interactive Electronic Technical Manuals. Carderock Division, Bethesda, Maryland 20084-5000, Naval Surface Warfare Center: 130 pgs.
This report summarizes the first phase of a study entitled Training Benefit Analysis of the Accelerated Use of Interactive Electronic Technical Manuals (IETMs). An initial evaluation of the potential effectiveness in Navy training of the use of the interactive, computer-controlled display of Technical Information has been carried out. Results indicate a widespread agreement in the Navy Training Community that the use of IETMs, integrated with automated courseware,

could be of significant benefit in producing greater effectiveness in training procedures. Fifteen IETM-use "Hypotheses", together with associated implementation scenarios, have been evaluated by the Training Community. In a detailed review, twelve of these possible applications were supported by more than two thirds of the participants; some by more than 90 percent. Forty-seven Candidate Projects for specific applications of IETMs in Navy training use have been elicited from Surface, Air, and Submarine warfare areas of the Navy. These Candidate Projects, which are summarized in this report, have been reviewed by the study team and found to provide a sound basis for the business-case-analysis phase of the study. This report also summarizes a number of technological and administrative issues, identified by the Training Community, which must be addressed prior to realizing the full potential of IETMs in Navy training. Measures needed for greater integration, infrastructure support, and standardization of IETMs in training are recommended. Phase II of the study will consist of a more detailed analysis of the selected Candidate Projects, particularly from the standpoint of Return on Investment, to provide the Chief of Naval Operations with the basis for a training input to the Program Objectives Memorandum for FY 98 (POM '98) preparation process.

[209] Karabulut, A.N., and Oz, H. (December 1998). "How to Develop an Interactive Electronic Technical Manual: An Industry Perspective - Thesis." Air Force Institute of Technology, *Department of the Air Force, Air University*, Wright-Patterson Air Force Base, Ohio, 126 pgs.
Improvements in technology, especially in computer science, in the last two decades have made it possible, and preferable to develop digital technical manuals. A digital manual, which is called an Interactive Electronic Technical Manual (IETM), is a package of information required for the diagnosis and maintenance of a weapon system, optimally arranged and formatted for interactive screen presentation to the end-user. Being the largest organization in the U.S., the Department of Defense has pioneered in the development of the IETM concept as well as in the establishment of its standards. There have been many researches done about different IETM applications and their effectiveness in the DoD environment. However, little research has been done in the area of how an IETM is developed in a civilian environment. This thesis identifies what it takes to develop an IETM in a civilian environment and investigates differentiating factors of the commercial industry. In addition to the identification of IETM development steps in a case study, IETM standards, IETM development specifications in industry as well as in the military, problem areas in today's IETM development environment, and DoD classification of IETMs are also discussed.

[210] Kramer, M.T. Post, T.J. and Rainey, S.C. (1993). Results of a Joint Navy/Air Force Operational Test to Evaluate USAF Integrated Maintenance Information Systems (IMIS) Interactive Electronic Technical Manual (IETM) Technology Applied to the F/A-18 Aircraft. Bethesda, MD, Carderock Division, Naval Surface Warfare Center: 143 pgs.
In a joint effort, the U.S. Navy and Air Force have tested under operational conditions a series of improved techniques developed under the Air Force Integrated Maintenance Information System (IMIS) program for delivering maintenance technical information to squadron technicians. These improvements included use of a portable maintenance aid (PMA) for technical information display. In this test, carried out in an F/A-18 fighter squadron at Marine Corps Air Station, Beaufort, South Carolina, each of 16 technicians performed six fault-isolation tasks, three supported by an Interactive Electronic Technical Manual (IETM) displayed on a PMA, and three supported by conventional paper-based work package (WP) technical manual ™. This report

presents a comparison of technician performance supported by the IETM/PMA combination with performance using conventional paper TMs. The performance data collected during the test showed considerable reduction in performance times for complex multiple fault isolations and maintenance errors, when technicians used the IETM/PMA combination. Also, technician-preference data based on questionnaires, showed strong support for virtually all IETM/PMA features. Technicians also made suggestions for improving the IETM and the PMA. The test results have been provided to both Services as one basis for evaluating and improving these IMIS technologies; specifically, (1) the specifically developed PMA; (2) preparation and automation of the IETM technical information by automated methods based on initial construction of an IETM data base, IETMDB; (3) the IMIS Presentation System (PS); (4) on-ground fault isolation using data from aircraft Built-in Test Equipment (BITE) coupled directly to the PMA through a 1553 bus; (5) the IMIS Diagnostic Module (DM), and (6) the IMIS Human Computer Interface (HCI) module. The IETMDB and the IETM technical information were constructed generally in accordance with the new DoD Specifications MIL-D-87269 and MIL-M-87268, respectively.

[211] Lane, K.W., and Metcalf, B.G. (April 1998). "Capturing Logistics from Simulations: DEPTH Technical Order Generation." United States Air Force Research Laboratory, *Hughes Missile Systems Company*, 144 pgs.
DEPTH uses a human figure model to visualize man-machine interaction and receive on-line human factors information simulations; such as simulating maintenance evaluations. The primary focus of the study is to investigate how DEPTH can support the automated generation of technical manuals in order to streamline the USAF technical order general process. DEPTH can produce text describing maintenance task steps suitable for Interactive Electronic Technical Manuals (IETMs). The language initially produced will consist of simple instructions, by using commercial IETM authoring tools.

[212] Li Pi Su, D. (1997). "Application of New Information Technology to DOD Legacy Paper Technical Manuals." IEEE: 18-22.
The Department of Defense is in the process of digitizing paper technical manuals (TMs). This consists, mainly, of direct copy to disk, with only a few being upgraded to Electronic Technical Manual (ETM) or Interactive Electronic Technical Manual (IETM). However, there is no clear-cut methodology for cost-effectively converting paper manual to various levels of upgrade. The Advanced Technology Office, the U.S. Army Test, Measurement, and Diagnostics Equipment Activity, the U.S. Army Missile Command, has investigated the conversion technologies/tools and developed conversion procedures that can achieve these goals: the most cost effective, value-added, and user-friendly ETM/IETM. This article will provide some guidelines to assist the ETMs/IETMs developers to achieve these goals.

[213] McMahon, P.T., McDaniel, N.A., and Riffee, J. (April 2000). "Interactive Electronic Training Manual (IETM) Guide, First Edition." Defense Systems Management College Press, Ft. Belvoir, VA.
The rapid integration of Interactive Electronic Technical Manuals (IETMs) into military workspaces throughout the Department of Defense has created an opportunity to enhance the comprehensive instruction provided to students of Defense Acquisition University (DAU) courses and to members of the defense acquisition workforce. Designed for use in DAU courses

and as an aid to acquisition managers, the text initially assumes the reader has little familiarity with IETMs. It presents fundamental material, and then addresses issues of immediate concern to the acquisition managers from both the government and industry perspective. This document is designed to be the primary desk reference for acquisition personnel who will be required to acquire, develop, deliver and/or manage IETMs. It incorporates the status of existing/planned DoD and Service-unique policy guidance; discusses current and projected technologies related to the production of IETMs; analyzes the relationship between IETMs and training; and addresses delivery vehicles – including the World Wide Web (WWW).

[214] Navy, Department of the. (2000). Training/Interactive Electronic Technical Manual Interface Guide, Department of the Navy, USA: 191 pgs.
This Training/Interactive Electronic Technical Manual Interface Guide (TIIG) is designed to: (1) Support the general IETM acquisition guidelines in the IETM Process Plan with more specific requirements for interfaces between IETMs and training development and delivery tools, (2) Present a business case structure for an interface between IETMs and training tools, (3) Supply business case analysis tools for Acquisition/Logistics Managers to assess the feasibility of expanding IETM functionality to support interfaces with training tools, and (4) Provide a checklist for those managers to define development and implementation of IETM functionality required to support the training interface.

[215] Rivera, G. A. (1996). Human Factor Issues in Interactive Electronic Technical Manuals for Aircraft Maintenance.
http://members.aol.com/geo13/ietm.htm
Advances in computer technology and Compact Disc-Read Only Memory (CD-ROM) have given way to the advent of the Interactive Electronic Technical Manual (IETM). IETMs have compressed the numerous volumes of text into just a hand full of CD-ROMs loaded with the text, sound and video. This brings into play new human factors issues. What is the proper and most comprehensive way to display this information? Is it safe to assume that the user can use the software efficiently? Can an electronic system be reliable enough to convey the information without being confusing or misleading? This paper will try to answer these questions and address other problems faced, with the introduction of IETMs.

[216] Scholtes, R. (April 17, 1999). "Interactive Electronic Technical Manuals: An End-Users' Perspective." *Thesis, Department of Industrial Technology, Eastern Michigan University*, Ypsilanti, Michigan.
The Department of Defense is converting its paper technical manuals to an interactive electronic format as a cost cutting measure. One of the first technical manuals to be converted to an electronic media by the U.S. Army is for the Palletized Load System. This research focused on evaluating the interactive electronic technical manual (IETM) for the Palletized Load System from an end-users' perspective. Input from the end-user is required to ensure that the usability of these technical manuals is not compromised. End-users' expectations were gathered through focus groups and questionnaires at six research sites. Research findings included the need to (a) provide provisions to update IETM information, (b) provide initial comprehensive IETM training with periodic on-site training updates, (c) improve diagnostic and troubleshooting capability, (d) provide color display, printing, data storage and retrieval capability, (e) provide procedures to maintain security, and (f) reduce the size and weight of the prototype IETM.

[217] Venntronix Interactive Electronic Technical Manual (IETM) Training Tutorial. (February 2000).
http://lrc3.monmouth.army.mil/cecom/lrc/pie/etm/ietm_1.html
Training Contents consist of: Module 1-Introduction and Background (Purpose, Scope, Assumptions, Terms and acronyms, Background, and CECOM Policy), and Module 2-ETM/IETM Learning/Refresher Module (ETMs, IETMs, Platforms, Operating System, and Authoring Systems).

[218] Zachary, W. Cannon-Bowers, J. Bilazarian, P. Krecker, D. Lardieri, P. and Burns, J. (1999). "The Advanced Embedded Training System (AETS): An Intelligent Embedded Tutoring System for Tactical Team Training." Journal of Artificial Intelligence in Education: 25 pgs.
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