Reviews

Pictorial Communication in Virtual and Real Environments, by Steve Ellis, Mary Kaiser, & Art Grunwald (Eds.). ISBN 0-74840-008-7, 1993, $95.00, 603 pp., hardbound or ISBN 0-74840-0082-6, $39.00, 615 pp., softbound. Available from Taylor and Francis Publishers, London and Washington, DC.

This book is a collection of true gems, each of which exposes an aspect of how humans know, act, and see in both real and computer-generated worlds. Emphasizing how human perceptual and cognitive systems drive the design of computer and real displays, this book runs the gamut from low-level studies of the human perceptual system through descriptions of existing computer systems to accounts of exotic real-world environments. Everything from motion sickness through cartography, through human studies on manipulation, through cockpit design, through stereo perception is represented. This is a very eclectic work. Throughout, the common emphasis is the optimal design of displays and interfaces for the performance of various tasks. This is not a pedagogical text: It is rather a snapshot of the state of knowledge in the design of displays for various environments. There are 39 articles written by leaders in their respective disciplines, with an average length of about 15 pages and many illustrations.

This book is for anyone who has a sincere interest in the human side of the human–computer interface problem, and who understands that this problem extends well beyond the design of a better GUI. Although this book is not the place to learn about human perception in any systematic way (for which I would recommend *The Handbook of Perception and Human Performance* edited by Boff, Kaufman, and Thomas), you will find many very accessible and entertaining articles on human perception.

Due to the breadth of this book, I can think of no better way to describe its contents than to describe each article with a sentence or two. I know that this will place unusual demands on you, the reader, but I ask your patience.

The book is organized into four parts, taking something of a top-down approach to the problem: Environments, Knowing, Acting, and Seeing.

Part I, Environments, is a short introduction to the overall topic of the book via two articles. The first entry, "Physics at the Edge of the Earth" by former astronaut Joseph P. Allen, is a wonderful description of how different "ordinary" tasks become in the exotic real-world environment of near-earth orbit. The dramatically nonintuitive dynamics of orbiting objects are revealed through a discussion of the use of the manned maneuvering unit to rendezvous with and capture satellites. This first section is rounded out by "Pictorial Communication: Pictures and the Synthetic Universe," a survey by Stephen R. Ellis of the many different types of display options that have become available for different tasks.

Part II, Knowing, discusses the use of visual images to provide information about an environment, focusing on the use of spatial relations and how they change over time. The first article, "Perceiving Environmental Properties from Motion Information: Minimal Conditions" by Dennis R. Proffitt and Mary K. Kaiser, discusses various perceptual illusions and how motion information can disambiguate such perceptions. The second

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article, "Distortions in Memory for Visual Displays" by Barbara Tversky, brings out several ways in which our memory of spatial patterns distort over time. Among the examples presented: We recall more symmetry than was actually present, and alignments tend to become more horizontal, vertical, or exactly between (at 45 degrees) than they actually were. George F. McCleary, Jr., George F. Jenks, and Stephen R. Ellis follow with a richly illustrated survey of mapping techniques in "Cartography and Map Displays," including speculations on three-dimensional maps. Dierdre Alla McConathy and Michael Doyle provide a similar treatment of "Interactive Displays in Medical Art," charting the ongoing revolution in medicine due to interactive computer displays. With "Efficiency of Graphical Perception" by Gordon E. Legge, Yuanchao Gu, and Andrew Luebker, we dive head first into a formal perceptual study, the first of several in this book. In this case the ability of observers to detect differences in the means and variances in various distributions is studied for three types of displays. These types of papers are valuable for nonpsychologists as examples of how such studies are done for the evaluation of display design. Gregory Russell and Richard Miles next provide an example of "Volumetric Visualization of 3D Data," emphasizing the use of such visualization techniques for three-dimensional data sets. Part II is rounded out by "The Making of the Mechanical Universe" by James Blinn, where the design principles and lessons learned in this well-known and very successful series are presented.

Part III, Acting, addresses how humans interact with the environment. The environment may be computer generated, a local real-world environment, or a remote teleoperated environment. This part is divided into four sections: Vehicular Control, Manipulative Control, Visual/Motor Mapping and Adaptation, and Orientation.

The Vehicular Control section starts with "Spatial Displays as a Means to Increase Pilot Situational Awareness," by Delmar M. Fadden, Rolf Braune, and John Wiedemann. It describes approaches to and user studies showing the effectiveness of the use of maps and other spatial displays in the cockpit. "Experience and Results in Teleoperation of Land Vehicles" by Douglas E. McGovern describes results and problems in driving at a distance. This section ends with two articles dealing with orbiting spacecraft: "A Computer Graphics System for Visualizing Spacecraft in Orbit," by Don E. Eyles, tells us of a simulation system that allows for the simulation of orbital maneuvers. "Design and Evaluation of a Visual Display Aid for Orbital Maneuvering," by Arthur J. Grunwald and Stephen R. Ellis, describes a computer program that provides significant planning information for orbital maneuvers, including thrust–plume constraints and easy interactive editing of where and how spacecraft thrust should be applied.

The next section, Manipulative Control, begins with "Telepresence, Time Delay and Adaptation" by Richard Held and Nathaniel Durlach. They introduce the general problem of telepresence including the sensors, displays and actuators, and closes with a discussion of the thorny problem of time delays. G. M. McKinnon and R. V. Kruk then discuss the use of multi-axis controllers for the control of spacecraft, helicopters, and remote manipulators in "Multi-Axis Control in Telemanipulation and Vehicle Guidance." This section ends with a discussion of an experiment investigating how various display options such as grid lines, drop lines, and stereoscopy effect the performance of spatial tasks in "Visual Enhancements in Pick and Place Tasks," by Won S. Kim, Frank Tendick, and Lawrence Stark.

The Visual/Motor Mapping and Adaptation section concentrates on the ways in which human performance interplays with what and how humans perceive. In "Target Axis Effects Under Transformed Visual-Motor Mappings," H. A. Cunningham and M. Pavel describe the effect (usually detrimental) of rotations and reflections of displays on spatial task performance. Robert B. Welch and Malcolm M. Cohen describe an experiment to measure the effect of static and variable offsets of the entire visual scene in "Adapting to Variable Prismatic Displacement." Bottom line: We adapt to static displacements, but if the displacement is variable the adaptation can be easily lost. After noting that in many cases automation has "ironically" made the supervisory human's task more complex, Wayne L. Shebilske briefly examines the issues arising when spatial displays are used to facilitate complex tasks in "Visuomotor Modularity, Ontogeny and Training High-Performance Skills with Spatial Instruments." In "Separate Visual Representations for Perception and for Visually Guided Behavior," Bruce Bridgeman studies, via an experiment, the remarkable fact that we seem to possess two maps of visual space: One for our cognitive interpretation of the visual scene where visual illusion occurs and another map for control of motor actions within the

visual scene. The upshot is that visual illusions do not seem to effect our performance of spatial tasks. In "Seeing by Exploring," Richard L. Gregory describes the thesis that visual perception is not at all passive, but involves high-level cognitive operations that constantly try and reject new assumptions and interpretations: Seeing is "learned."

The last section of Part III, Orientation, looks at issues in spatial orientation from (so to speak) several angles, ranging from self-orientation to the orientation of perceived objects. "Spatial Vision Within Egocentric and Exocentric Frames of Reference," by Ian P. Howard (with comments by Thomas Heckmann and Robert B. Post), discusses how our various coordinate systems (eye-, retina-, head-, and body-centric) interplay with our perceptions of the environment and performance of tasks. In "Sensory Conflict in Motion Sickness: An Observer Theory Approach," Charles M. Oman first summarizes then criticizes as incomplete the "sensory conflict" theory of motion (and simulator) sickness, also presenting a new point of view. The problem of an underlying model of how we perceive shapes at various orientations is addressed in Horst Mittelstaedt's "Interactions of Form and Orientation." Arnold E. Stoper and Malcolm M. Cohen describe several experiments that study the various ways in which we estimate eye level, critical to perceiving our own orientation in an environment, in "Optical, Gravitational and Kinesthetic Determinants of Judged Eye Level." An experiment measuring our ability to defeat the reflex by which we keep our eyes fixed on a target during head motions is described in "Voluntary Influences on the Stabilization of Gaze During Fast Head Motions" by Wolfgang H. Zangemeister.

Part IV, Seeing, is divided into two sections: The pictorial space section addresses issues of spatial perception in monoscopic two-dimensional pictures, in some cases indicating that subtle cues about spatial structure are superior to stereo cues, whereas the section on primary depth cues discuss depth perception in both stereoscopic displays and the real world.

The first article in the pictorial space section, "The Perception of Geometrical Structure From Congruence" by Joseph S. Lappin and Thomas D. Wason, considers how congruence between nearby similar objects or the same object moved in time contributes to our perception of that object's spatial structure. "The Perception of Three-Dimensionality Across Continuous Surfaces," by Kent A. Stevens, addresses how we perceive the three-dimensional structure of continuous surfaces in a picture. A theoretical discussion of how changing our viewpoint of a picture effects our perception of the spatial relationships in that picture is given in H. A. Sedgwick's "The Effects of Viewpoint on the Virtual Space of Pictures." "Perceived Orientation, Spatial Layout and the Geometry of Pictures," by E. Bruce Goldstein, presents empirical data on the same topic indicating that although the perceived spatial layout of objects in a picture is not strongly dependent on your viewing angle, the perceived orientations can be. In "On the Efficacy of Cinema, or What the Visual System Did Not Evolve To Do," James E. Cutting addresses how changes in our viewpoint of a picture effect our perception of the structure of objects (in particular whether or not they are rigid) in that picture. Cutting concludes that when the projection is parallel, the impact of the viewing angle is not very strong, which may help explain the popularity of telephoto lenses. The extent to which we misjudge the slant of surfaces in a picture is discussed and measured in "Visual Slant Underestimation" by John A. Perrone and Peter Wenderoth. "Direction Judgement Error in Computer Generated Displays and Actual Scenes," by Stephen R. Ellis, Stephen Smith, Arthur Grunwald, and Michael W. McGreevy, measures error in the estimation of relative angles between objects in computer graphics scenes. To close this section, Shojiro Nagata surveys and measures the efficacy of 15 depth cues in "How to Reinforce Perception of Depth in Single Two-Dimensional Pictures."

The last section, primary depth cues, starts with Clifton Schor's "Spatial Constraints of Stereopsis in Video Displays," in which various problems encountered in the design of stereoscopic images are discussed, such as disparity limits, high-frequency images, and spatial crowding. "Stereoscopic Distance Perception," by John M. Foley, discusses measurements of errors in distance estimation based on stereoscopic displays. The phenomenon of certain figures being perceived as having a compelling impression of depth when viewed by one eye (which is lost when viewed with both eyes) is addressed through experiments in J. T. Enright's "Paradoxical Monocular Stereopsis and Perspective Vergence." In "The Eye Prefers Real Images," Stanley N. Roscoe brings us back to earth by surveying the various problems and deficiencies with heads-up and head-mounted displays. In addition to the well-known

problems with display generation with these systems, Roscoe points out that various perceptual mismatches can cause several disorientation problems.

I hope that this utterly superficial summary has whetted your appetite: If you are already interested in human factors this book has something of the joy of a toy box. If you are curious about how humans interact with displays and environments, the less technical articles in this book will be very enjoyable and may give you inspiration to dive more deeply into this field.

Steve Bryson
NASA Ames Research Center
MS T27A-1
Moffett Field, CA 94035-1000

E-mail: bryson@nas.nasa.gov
Phone: (415) 604-4524