Overview of Research Accomplishments and Supporting Materials

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The following discusses academic research efforts in human factor visualization. The first section summarizes the activities and the support materials presented for review. These materials include published papers, a seven minute videotape, and other visualization examples. The second section summarizes future research directions.

Section 1: Developing Human Factor Visualization

Like many in design education, this design educator and practitioner has led a multi-faceted career, covering architecture, project management, product and interior space design. The common thread which has linked them is the application of human factors.

Since 1988, that application has focused on visualizing the relationships between products, environments and humans. The pursuit of this direction of study is based upon two fundamental realities. First, visualizing - be it sketches, working drawings, or models is at the core of the design process. Second, human factors is playing an increasing role in defining design excellence, yet is often overlooked and unappreciated. Increasingly, designers are considering the context of product usage and humans. How designers have visualized the interaction between humans and their designs leaves much to be desired. The traditional orthographic elevation or top view can capture snapshots of interaction. They are, however, just snapshots of dynamic interactions with diverse populations, not just a 50 percentile male. Yet creating a more comprehensive set of visuals can be economically prohibitive.

The study to resolve the problems associated with human factor visualization began looking in new directions. At the core of this process was understanding and applying new computer-based tools and simulation techniques on economic computer platforms, such as Macintosh and PC. These techniques improve visualizing the interaction between humans and products. These goals have led to several grant awards. These grants have made possible a sequence of projects each building on the previous findings.

The first project:
"Anthropometric Simulation and Modeling Field Work", supported by a University Small Research Grant @ $876.00 on May 31, 1989,
funded three short trips to conduct site visitations to organizations making significant progress with these tools. The study gathered information on their current status and capabilities. Work was conducted during summer and autumn 1989.

Materials presented:
The results of the study were formally disseminated at a paper presentation at the IDSA Design Educators 1989 conference:
"Computer-aided Anthropometric Design and Assessment for Industrial Designers",
Papers - Conference on Design Education: Educating the 90's, 1989, pg. 206-211.

The paper also was the first opportunity to discuss the perceived needs of the design profession for improved human factors visualization. This led to the next project and grant award.

The second project:
"Visualizing the Human Body with Computer Models", Funded by College of the Arts Direct Faculty Support Grant @ $1452.00 on November 27, 1989. Work conducted during Winter and Spring Quarters, 1990 with a paid undergraduate research assistant.

This project was formulated following a series of informal and formal interviews with product designers. The project had two stages. The first stage used a mailed questionnaire instrument to 650 product designers to test a hypothesis. The hypothesis: product designers were dissatisfied with the information, tools and techniques available to them for solving human factors problems and would welcome a new tool. The second stage was initial conceptualization of a computer visualization tool for product designers. In addition, initial 3D computer models of 5, 50, and 95 percentile males and females were created.

Materials presented:
The results of the study were formally disseminated at a paper presentation at the Industrial Designers Society of America (IDSA) Design Educators 1990 conference:
"The Industrial Designer's Anthropometric Problem Solving Needs, A Survey of the Profession's Requirements for Anthropometric Information and Procedures",
Papers - Strategies for Educating Designers in the Post Industrial Society, 1990, pg. 224-230.

Additional results were presented at an Association of Computing Machinery Special Interest Group (ACM SIGUCCS) conference.

Examples of some of the human models developed include the coverpiece and are shown in Figures 1 - 3. These human models started as anthropometric, accurate link or skeletal versions. One of the first was called MondoMan. Subsequent versions began to model body surfaces, contact points and hands more accurately.

The third project:
"Development of a Computer-aided System for Anthropometric Workplace Design and Assessment" was funded by a University Seed Grant @ $12,500.00 on February 28, 1990. Work was conducted from June 1990 to June 1991 with a graduate research associate.

The next project was a logical continuation of the previous. Funding was provided, after external review, from the highest level available within the university. The project began development of the computer based visualization tool initially called "BuildFit" and later changed to "HumanFit". The fundamental premise of the project was to develop a reasonably economic tool in contrast to the existing very expensive computer-based tools. This objective and others were established from analysis of the survey data. The project utilized facilities and personnel at the Advanced Center for Computing in Art and Design on the OSU campus. The Work during the funding period accomplished 60% completion on the software with testing.

Materials presented:
Testing within the department utilized several undergraduate student projects during Spring Quarter 1991. Computer models of the projects were created and performance simulations completed. The first selection on the videotape, is a performance simulation for a wheelchair, designed by Joe Langan and Joe Mercanante.

Testing included application of the early human model "MondoMan" by Haworth Furniture Company to computer models of a new line of ergonomically adjustable tables called 'Trakker'. The application was featured on the weekly TV journal "First Look" on November 24, 1991. The second selection on the videotape shows two studies of the Trakker. One is a Trakker performance simulation and the other, an interaction study with a 50 percentile male in an office context.

The results of the project were formally disseminated at a paper presentation at the joint Human Factors Society and IDSA Biannual conference:

"HumanFit - The Next Generation Anthropometric Tool for Designers", Proceedings, Interface '91, the Seventh Symposium on Human Factors and Industrial Design in Consumer Products, 1991, Co-authored with Jong-ho Lee and Stephen Spencer;

and the IDSA Design Educators 1991 conference.

The fourth project:
At this point a critical decision was made to shift from developing software to studying the visualization process with existing software. The reasons: economically priced commercial software became available in late 1991 and early 1992 from several vendors. As a Beta testing site for HumanCAD 'Mannequin' software, it became apparent it and other software could meet the fundamental needs for human and product interaction visualization. Focus returned to studying the practice of human factors during conceptual product design. Interest continued with economic and timely visualization processes.

To test the basic visualization techniques and human models further it was necessary to study their application to real design problems. From a number of likely candidates, a satisfactory working arrangement developed with Crown Equipment Company, of New Breman, Ohio.

Crown is a manufacturer of materials handling equipment, such as forklifts. They are not formally sponsoring the work, yet are willing to help validate a variety of human factor analysis and visualization techniques. The working arrangement with the staff at the Crown Design Center - Robert Drobeck, Jack Tarasovitch, and William Davis, started in October of 1991. The staff are providing considerable time and complete access to facilities for testing and evaluating the application of computer generated models to their products.

A fundamental aspect to this stage of the research is the validation of computer-aided visualization techniques in terms of economics and fit into the design process.
A serious examination was conducted of the application of visualization to the early stages of the human factor design process. These stages include: link diagramming, task analysis, conceptualization, testing, and evaluation. For each stage there are sets of procedures which have been developed over time. In addition, each stage and set of procedures have varying levels of dependency on visualization. For example, link diagramming commonly uses abstract symbols to diagram the interaction of humans and their environment. Then, task analysis takes the abstract and develops more detail, but uses much more verbal description than visual. Conceptualization reverts to visual using orthographic views before moving to models and mockups. Testing and evaluation is done as much as possible in full scale mockup.

As the Crown project developed effort was made to examine the role of visualization in each stage. Diagramming and icons were introduced during the task analysis stage to help communicate the complex physical and cognitive interaction between operator and equipment. Three-dimensional computer models of the equipment provide opportunities to study dynamic interaction and also to quickly create diverse orthographic views. Existing two-dimensional drawing board mannequins were converted to CAD versions and fitted with various hand positions, range of motion,

and range of vision indicators. These could easily be inserted into a CAD orthographic view to evaluate basic static and dynamic characteristics of fit, reach and vision.

These efforts were done in comparison to traditional methods. Crown has been a consistent user of traditional full scale models. They provided an excellent stage to compare the economies of computer versus traditional models. Once the 3D computer model is created the economies of use increase significantly during concept revision, testing and evaluation. In addition, the 3D computer model can be used to study many things. Simulations of operation in a warehouse, detailed human factor analysis and evaluation, animation's to be used in training, and safety analysis. Basic truths about 3D computer models were also discovered. They can play an important learning and economic role during conceptual design. They can assist with studying the physical interaction between humans and their environment. They can help focus decisions about concepts to reach the final possibilities more efficiently. Yet, human factor testing and evaluation of final possibilities needs to be done in reality and in full scale.

Materials presented:
"A Comparison of Prototyping Economies: A Case Study of Physical vs. Computer Modeling", Proceeding, Interface '93, the Eighth Symposium on Human Factors and Industrial Design in Consumer Products, 1993.

A selection of representative work from the Crown project shows some of these visualization possibilities.

The remaining selections on the videotape show three different human interactions with one of Crown's products: the SP 42 Stockpicker. The first is a 5 percentile female driving the Stockpicker. The second shows a 40 percentile female, then a 95 percentile male adjusting the forks prior to operation of the Stockpicker. Finally, the third shows a 40 percentile female picking boxes from shelves and placing them on a pallet.

Section 2: Future Directions

By necessity, much of the future work will be part of an interdisciplinary effort. A continuing interest towards improving the interaction between human factors and product design will make it necessary to work with experts in a variety of fields. The activities of product design / human factors are diverse. They require a wide variety of knowledge and talents.

Contacts are currently being established. Proposed studies will also help with making contacts with other interested experts. These experts include those in product design, graphic design, bio-mechanics, cognitive psychology, occupational psychology, business management and marketing, medicine, mathematics, interface design, computer graphics, and software design.

Preliminary meetings have been conducted for some future projects and envisioned others. They include:

- Continue studying the application of computer generated visualization to product design / human factors:

  > evaluation tools for computer model study of human / product / environment interaction. The evaluation tools would be used for evaluating the physical geometry aspects of Fit, Reach, Vision and Comfort conditions within the interaction;

  > more detailed generation of skeleton, muscles, and connective tissue within the human body to simulate study of a variety of issues from: therapy to restore human movement, repetitive motion injuries, and medical device testing and training

- Continue studying information management systems in product design / human factors:

  > a system to integrate the physical and cognitive human factors information for a product;

  > a notation system to represent the interaction between human physical and cognitive activities and performance. The notation system will allow the designer to represent for preliminary and conceptual design the interaction between humans and their environment. It will also allow them to understand the relationship between diverse bodies of information.

An early version of this notation system will be demonstrated at the Human Factors and Ergonomics Society annual conference October 1993