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WIDE-ANGLE DISPLAY DEVELOPMENTS BY COMPUTER GRAPHICS

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SUMMARY

Computer graphics can now expand its new subset, wide-angle projection, to be as significant a generic capability as computer graphics itself. My purpose is to present you with some prior work in computer graphics leading to an attractive further subset of wide-angle projection, called hemispheric projection, to be a major communication media. Hemispheric film systems have long been present and such computer graphics systems are in use in simulators. This is the leading edge of capabilities which should ultimately be as ubiquitous as CRTs. The credentials I have for making these assertions are not from degrees in science or only from my degree in graphic design, but in a history of computer graphics innovations, laying groundwork by demonstration. I believe it is timely to look at several development strategies, since hemispheric projection is now at a point comparable to the early stages of computer graphics, requiring similar patterns of development again.

POLARITY

Nobel Prize winner, Dr. Herbert Simon of Carnegie-Mellon University, in his book SCIENCE OF THE ARTIFICIAL, characterized the natural sciences as the pursuit of "what is," and the sciences of the artificial (which includes design), as the pursuit of "what should be." It occurs to me that NASA, more than any institution in history, has to stretch itself to the extreme ends of these polarities as well as cover the complete spectrum between. In designing vital systems, it must reach into the future, championing far-sighted objectives while using the most rigorous scientific knowledge, especially human performance. Each of these polarities has an organizational counterpart which can effect patterns of achievement. In the early stages of a new development, I believe it is fitting and effective to operate in the "what should be" mode, with attention to, and migration toward, the "what is" mode.

BACKGROUND

Computer graphics efforts have included a number of research and development paths such as simulations of cockpit visibility, human figure performance, operations analysis and wide-angle projection. Many of these paths were firsts and many of these were followed up over decades in three work environments, Boeing, SIU-C, and SIROCO. This work often stimulated others by showing "what to do," helping to spawn some of the computer graphics capabilities we see today.

The approaches taken can be usefully applied to the development of an array of hemispheric-projection display-system applications.

COMPUTER GRAPHICS

The term computer graphics was coined about my initial work at the Boeing Company in 1959. I cannot claim that I coined the term, as some have suggested, because, in reality my supervisor, Verne Hudson, both authorized my proposal to work in this area and further suggested shortening my longer project title to just the two words.

This effort began with a research letter defining a near-term effort. It also listed the ultimately sought attributes of computer graphics, which included many of the visual characteristics in the field today. This work also achieved the landmark Bernhart-Fetter patent on perspective images generated by digital computer. An organization was assembled to form a close relationship between research, demonstrations and direct applications to needed tasks.

The overall goals of more accurate, reliable, and clear images are sought in advancing hemispheric display systems.

The precursor to my computer graphics innovations at Boeing was a hand plot, which I then illustrated in the process of designing a book. During graphic design assignments at the University of Illinois Press Art Division, I designed the book SPACE MEDICINE for Werner Von Braun. I felt that an illustration of his space station concept should appear in orbit on the title page and that it should be as accurate as possible, in part, an homage to Chesely Bonestele. So that it would be precise, I plotted points by hand, using a technique that eliminated the vanishing points then taught in schools. The tiresome degree of repetition in the process and the emerging claims for computer capabilities convinced me that at some time in the future I would have a computer assist this process.

Now let us look at the efforts at the Boeing Company during the 1960s by glimpsing several lines of research and applications to aerospace requirements.

1. Eye: All of our activity was directed to more effectively reach the eye/brain complex in support of engineering design.

2. Computer Interior: The task was to utilize any existing computer system available to us at Boeing in order to carry out the production of useful images and series of images.

3. Communication Need: We developed an approach of defining our communication work within a spectrum of needs to be met.

4. Communication Media: We made every effort to relate the need to specific media and to integrate computer graphics into that flow.

5. Boeing 747: Static output was produced using computer graphics axonometrics and perspectives such as this Boeing 747. We merged our work with such related capabilities as master dimensions.

6. Carrier landing: More dynamic applications included dozens of color/sound motion pictures, on all major Boeing designs of the 1960s.

7. SST Mockup: Support to mockups included the Supersonic Transport 60-ft-wide diorama of precise views at the 100-ft decision point.

8. First Man: Human figure simulations were applied to 747 and space cockpit studies of reach and instrument vision, using 100 body sizes.

9. Hemispheric: Preliminary software was demonstrated for stimulus material to be projected on the interior surface of a hemisphere.

10. Interactive: Studies of interactive human factors computer graphics included anthropometrics, visibility, and other applications.

(Our disseminations stimulated other manufacturers' work. For example, GE, seeing our Runway Visual Range studies, was able, with their outstanding capability, to produce more advanced fog simulations.)

11. 747 Polar Plot: An early purpose for wide-angle projections, in this case a Mercator projection, was the first computer graphics polar plot to aid in meeting FAA requirements for the Boeing 747 visibility.

12. Screen Angle: Our efforts to explore wider viewing angles made it desirable to gain further human factors information such as Dreyfuss.

13. Human Factors in Design: In seeking out information we wanted to design systems not interfering with other human factors parameters.

14. Pacific Science Center: This hemispheric display facility for films designed by Boeing in Seattle was useful and convenient.

15. First Test: Some of the early tests did not yield a perfect match and the geometry of the software had to be rewritten.

16. Room Test: The next successful tests included one showing visual effects of sitting in a square room viewed inside a hemisphere.

17. 747 Cockpit: Among the test applications made was the 747 cockpit windows displayed as seen from the interior.

(We also proposed to use the hemispherics in the E series 747 aircraft for high-level decision makers to rapidly apprehend complex displays.)

18. Vulnerability: An application to vulnerability studies used the similarity of hemispheric geometry to the geometry of airburst threats.

19. NASA: A potential application with NASA Public Relations was to use telemetered displays for better public understanding of the space effort, including output to television or hemispheric facilities.

Now let us look at our hemispheric path of work at Southern Illinois University at Carbondale during the 1970s, to apply this to more comprehensive design issues.

1. Computer Graphics Research: At the SIU-C Department of Design in the 1970s, we conducted further computer graphics research under the sponsorship of the SIU-C Research and Projects Office, the National Science Foundation, and other private sector sources.

2. Association of Science/Technology Centers: As an outgrowth of the earlier NASA public relations study and the new goals at SIU to develop Buckminster Fuller's advanced concept of a World Resources Simulation Center, we again looked at the potential of existing hemispheric facilities that could convey necessary information to the public. A related project involved an SIU committee on Earth Resources and a period of time spent at NASA to determine types of satellite imagery available that might be processed through this type of facility.

3. Pacific Science Center Spacearium: During the 1970s, the modest research funding levels limited the tests to projecting glass slides. Mose of these centers have geometry which does not exactly match.

4. 70-MM Wide-Angle Film: Sample film from the Spacearium shows the identical distortions our test plots matched. Members of the Psychology Department at SIU-C found the possibilities for group interaction and decision-making in such a system to be promising. Among the more obvious advantages were the wide field of view, absence of extraneous visual elements, and the resulting complete attention by the observer. Among the more obvious disadvantages were the cost, complexity, and size of the systems then available or fundable to build.

Now let us look at the hemispheric research path at SIROCO, an independent research institute, in the 1980s.

1. Yards, Feet, Inches: At SIROCO, the perimeter folding problem was solved and special attributes of hemispheric displays were studies. One attribute was maintaining orientation within a display of a hierarchy of facts and images. A simple example here is yards, feet, and inches. While the full effect cannot be seen in a simple flat slide example, the advantages are more apparent in hemispheric images.

2. Earth: To demonstrate the value of a capacity for great changes in scale, needed for a world resources center, a long zoom was created.

3. United States: The zoom continues toward the United States.

4. Illinois: We continue, showing Illinois county boundaries.

5. Carbondale: And on to the street grid of Carbondale, Illinois.

6. Human Figures: And finally to the scale of two human figures.

7. Color: The images can be in color. The sequence outlined previously ends with our human figure, which is based on only one data base of an infinite number of accurate surface definitions of anthropometric percentiles and somatotypes. This rendering was done in a joint activity with the Lawrence Livermore National Laboratory using Frank Crow's HILITE, Steve Williams' updates.

In 1978 at SIROCO, we made a proposal to NASA on hemispheric display. This was approved for scientific merit; however, it could not be funded. In 1981, in assisting the SIGGRAPH committee which sponsored the annual meeting in Seattle, we worked successfully to reinstate the showing of Nelson Max's IMAX film demonstration of wide angle. In 1984 our original work helped stimulate SIGGRAPH's OMNIMAX film production.

Where is hemispheric going? I believe the answer is EVERYWHERE. At NASA, both hemispheric and spheric displays are already used in existing and emerging simulators. In future space flights, hemispheric projection should find its way into the crew's flight deck, work stations, and entertainment stations. In communicating with computers, there is just as large a bottleneck at the visual interface as at the internal bottlenecks that gave rise to parallel processing. Hemispheric projection can contribute solutions. Elsewhere, hemispheric technologies that emerge should benefit from economy-of-means in both computing and visual systems. Only a small proportion of a complete hemispheric image needs to be generated for many applications using head-mounted displays. With the costs for computer capacities dropping dramatically, even processing all the pixels should become practical for more applications.

CONCLUSION

There are fundamental human factors issues involved in this new tool. We should build generic systems rather than reinvent each application. We should, I believe, develop a location for multipurpose breadboard demonstrations with the balanced support and stimulus of a wide variety of relevant technological expertise. Further, we should explore whole new communication modalities such as "Orientation Graphics," "Discovery Graphics," and "Analogy Graphics." Spin-offs in miniatured, low-cost systems should find their way into offices and work stations.

I have presented my personal experiences over a period of years because there are elements of these early holistic approaches needed now. NASA may be the best institution in which to explore this since at NASA, as in hemispheric displays, we are at just the beginning of practical visions of the future that are all about us.