TRENDS IN DISPLAY DEVICES

THE VISUAL INTERFACE

(Extended Abstracts)

W.E. Howard

Rapporteurs: Mr. J.P. Black
Mr. D.E. English

Trends in Display Devices

Webster E. Howard
IBM T. J. Watson Research Center
Yorktown Heights, NY, USA

The market for display terminals and display workstations, which is experiencing explosive growth, has been, and will continue to be, dominated by the cathode ray tube (CRT) in general, and by television technology in particular. This is a consequence of the extraordinary efficiency of the conventional CRT display as well as the large manufacturing volumes for TV components. This efficiency can be seen as a coincidence of efficiency of transduction in phosphors and effiency of addressing in the generation and deflection of the beam. However, the technology has important limitations, and as more and more applications which are not well served by the conventional CRT reach attractive dimensions, other technologies will be able to compete and survive. Some of the reasons for wanting to extend or to replace the CRT will be discussed, as well as the advantages and challenges of some of the emerging technologies.

There is a widely held view that general purpose workstations, managing multiple and varied tasks, will benefit from, indeed will require, highly interactive, high resolution displays. One of the limitations of conventional CRT's is resolution, which is related to the requirement for some minumum luminance. Two approaches to this problem are to introduce an active faceplate (or image intensifier), or to introduce multiple beams working in parallel.

There is also an expectation that high-definition TV, together with large area screens, would enhance the home entertainment experience and build a new market. Since the conventional CRT does not meet this requirement, there are serious efforts to produce large screen flat TV systems, which, if successful, will provide better group and teleconference displays.

Another expected development in displays is the rise in importance of flat panel displays, for use in portable terminals and computers. Some of the interesting candidates in this arena, in addition to the already established liquid crystal displays, are electroluminescent panels and a new generation of active matrix displays which offer the possibility of high content liquid crystal displays with better appearance.

The Visual Interface

Webster E. Howard
IBM T. J. Watson Research Center
Yorktown Heights, NY, USA

One of the important issues facing display developers today is the question of what constitutes a good display. Our ability to compare one display with another, one display technology with another, or a given display with print material, is very limited and lacking in generality. We would like to be able to predict both subjective preferences and task performance differences, based upon objective physical measurements of a display, but more often we are forced to do A-B comparisons with human subjects, on a particular task. We would even be pleased to explain some results, such as an observed difference in reading speed on some displays relative to good printed material. There is reason to hope that the application of visual psychophysics will carry us a good way along this path. This can be seen in the progress which has been made in recent years in developing display metrics which incorporate more and more results of basic research in visual perception.

Early measures of image quality were completely oriented toward optical imaging systems, involved only physical measurments, and had no visual or observer component. In the next stage of development, various metrics evolved which incorporated the spatial frequency dependence of observer sensitivity, treating the observer as another stage of a linear noise-free system.

Only in recent years have workers tried to deal with noise in images, especially the noise most common in displays, that associated with sampling and matrix representations. At the same time, a psychophysical model of the visual system as a system of independent spatial frequency channels with nonlinear response characteristics was being developed, and this concept is the basis of the most ambitious of image metrics, that of Carlson and Cohen. This approach comes closest to describing an imaging system in terms of what an observer can actually see.

Another important aspect of displays is their temporal behavior. For example, an undesirable aspect of many CRT displays is flicker. The perception of flicker depends upon many parameters of a display, and the present state of understanding does not allow a simple physical measurement to predict whether or not a display will flicker for more than a specified percentage of the population. Here again, one is forced to use human observers in carefully controlled tests; however, by calibrating subjects one can reduce the number of subjects required to test a particular display.

The temporal modulation of a stimulus also interacts with spatial perception; for example, higher spatial frequencies are detected with

slower response. Thus ultimately image quality metrics will be temporo-spatial, and it is anticipated that video communication bandwidths, especially for high-definition systems, will be reduced without noticeable effect.

Finally, a most difficult aspect of display quality relates to the chromatic content of the image. Trading bits of luminance for bits of chrominance may be easy in the display system, but it is by no means straightforward in the visual system. Our perception of color variations has serious spatial limitations, especially in the blue, and our naming of colors is strongly influenced by surrounding colors. As a consequence, color in critical systems must be used cautiously, i.e. with considerable testing.

Discussion

Professor Tanenbaum: You haven't mentioned the effects of interlace on perception of flicker.

Dr. Howard: Interlace should be abandoned in most cases. Interlace was fine for television, where the viewer was at some distance from the screen, but it is not appropriate for high-quality visual displays, especially for bit-mapped graphics displays where worst case patterns can flicker badly.

Professor Randell: With reference to your comment that the quality of displays is significantly worse that that of the printed page, how bad is this difference likely to remain in future?

Dr. Howard: The answer to the question depends on which part of the marketplace is being discussed. As far as expensive terminals are concerned, they will improve soon. For the low cost terminals, the question is more difficult to answer. The problem here is that in many cases, it is not the user himself who is choosing the display. Rather, the choice may be dictated by other persons such as management, or by external factors such as union regulations and environmental health guidelines. If companies are prepared to try to accommodate these demands for quality, then the displays in the mass market could improve rapidly.