DISPLAY TECHNOLOGIES IN COMPUTER AIDED APPLICATIONS

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Introduction

The pervasiveness of the computer in the modern world is a truism. It is hard to think of an important activity such as business administration, scientific investigation, engineering design, office information flow or even home management in which the computer does not play an essential role. The reason for this state of affairs has been ascribed to the explosion of solid state technology which has made possible circuits of increasing complexity at ever diminishing sizes and costs. While this is for the most part true, there has been an accompanying explosion of display technology, which has allowed ever increasing sophistication in the manner in which computerized information can be accessed by human beings. In this paper an assessment of the state of Display Technology will be made.

Ideal Display

The ideal display would be compact, no more than book-sized, easily interfaced to digital hardware, mass producible at low cost and capable of displaying from a few tens of characters to many millions of pixels depending on the application. Resolution is the measure of the information capacity of a display. It can be measured by the number of characters in an alphanumeric display in applications such as hand-held calculators, watches and text processors. For more complex applications requiring pictures such as the

modern graphics terminal, resolution is more often measured by the total number of available display points or pixels. Resolution is perhaps the most important characteristic in choosing a display technology for an application. Another very important characteristic is the availability of different sizes and the ability to reproduce color.

Display Classification

Several classifications of displays have been proposed such as active versus passive, low versus high voltage, etc. In what follows, a different classification will be used based on addressing techniques.

CRT Addressing Techniques

In a typical refreshed CRT, the electron beam generated at the cathode, is focused into a narrow spot on the screen. There are two known techniques for generating a picture with a CRT. In raster scan systems, such as television, the beam is swept or rastered across the screen. A modulating or video signal turns the beam on at the desired points on the screen, so that the desired picture results. The second technique is known as stroke writing or calligraphic. The beam is made to trace out the desired picture, usually synthesized by a collection of vectors, directly. Any CRT can be addressed in either mode: the choice is usually determined by cost-performance considerations. Lower performance, fixed format displays generally employ raster scan. The ubiquitous 24 lines of 80 characters each data displays are a typical example. When displaying complex graphics, the quantization of the picture, inherent in the scanning technique, can produce an aliasing phenomenon known as jaggies. Essential performance comparisons between the two addressing techniques is shown in table 1.

Color

The CRT is the only technology with which a full gamut of colors is commercially available at this date. This is an important attribute, as color can represent an essential coding dimension for complex displays such as situation displays, maps, IC masks, etc. The most popular method for obtaining color in CRT's is the shadow mask in which three distinct electron beams

DISPLAYS

DIGITAL (Discrete Addressing)	ANALOG (Continuous Addressing)
L E D's	Cathode Ray Tubes (CRT's)
Plasma	
Liquid Crystal	
Electro Luminescent	
Vacuum Fluorescent	
Incandescent	

Comparisons between essential characteristics of different technologies are made in the next table.

TABLE 1

excite three arrays of phosphor dots (red, blue, and green) so as to produce the required color. Until recently, color CRT's of only moderate (TV grade) resolution were available. Higher resolution tubes, from Japan, have recently appeared, significantly increasing the quality thus obtainable.

Storage CRT's

CRT's can be designed so that the screen can continue to emit light even after the electron beam has been turned off. This feature can eliminate or strongly reduce the system memory requirements. While storage tubes have been available before, it was only in 1967 that a large (11") device with sufficient resolution for graphics became available. The device was based on an invention by R.H. Anderson. The technology, since extended to 19" and 25" screen sizes has contributed strongly to the rapid growth of computer graphics. The advantages of storage displays are (apart from the reduced memory and data rate requirements mentioned above) complete absence of flicker and an improved sense of edge sharpness (acutance) due to the bistable nature of the device. The disadvantages are lack of color, a slightly more complex device and, more importantly, reduced picture dynamics. The latter is due to the need of erasing the whole screen before a new picture can be written.

Conclusion

Only a broad overview of Display Technology has been given here. The interested reader is urged to consult the references for further details. It is always hazardous to speculate on the future, since one's crystal ball can turn into a nearsighted and distorted lens on short notice. It seems apparent however, that complex, high quality displays will be needed to keep pace with increasingly powerful computer technology. For these displays the advantages of analog addressing and the availability of color will be such to preclude a serious challenge to the CRT's dominance for another decade at the very least.

TECHNOLOGY	DISPLAY MECHANISM	RESOLUTION (N° OF CHAR)	COLOR	LIMITING FACTOR FOR LARGE SIZE/HI RESOLUTION
LIGHT EMITTING DIODES (LED's)	SOLID STATE	LESS THAN 20	1 OF 6	EFFICIENCY
PLASMA	GAS DISCHARGE	A FEW HUNDRED	POSSIBLE	EFFICIENCY, COST, NUMBER OF INTERCONNECTS
LIQUID CRYSTAL	FIELD EFFECT	LESS THAN 50	NO	ADDRESSING, COST
ELECTRO-LUMINESCENT	SOLID STATE	LIMITED	ANY SINGLE COLOR	EFFICIENCY
CRT	E-BEAM	SEVERAL THOUSAND	FULL RANGE	NONE

CRT ADDRESSING TECHNIQUES

	RASTER	STROKE WRITING
DESCRIPTION		
USAGE	TELEVISION, TEXT PROCESSING LIMITED GRAPHICS	QUALITY GRAPHICS
ADVANTAGES	LOW COST, LOW POWER	HIGH DEFINITION PICTURES
DISADVANTAGES	JAGGIES, ALIASING	HIGHER POWER
TECHNOLOGY LIMITATIONS	VIDEO, MEMORY TECHNOLOGY	DEFLECTION TECHNOLOGY

CRT's

	W/MEMORY (STORAGE)		W/O MEMORY (NON-STORAGE)	
	MESH	MESHLESS	MONOCHROME	COLOR
AVAILABLE SIZES	5-7"	5-25"	1-30"	7-26"
AVAILABLE RESOLUTION (PIXELS)	$\simeq 5.10^4$	5.10^4 TO 5.10^6	5.10^4 TO 2.10^6	5.10^4 TO 1.10^6
TYPICAL OPERATING BRIGHTNESS (FT·L)	100	8	50	40
REQUIRED DATA RATE	5.10^4	5.10^4 TO 5.10^6	3.10^6 TO BEYOND STATE OF THE ART	3.10^6 TO 30.10^6
FUTURE	NO PROGRESS	HIGHER BRIGHTNESS, CONTRAST AND LIFE	HIGHER RESOLUTION	HIGHER RESOLUTION LOWER COST