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SOFT TYPOGRAPHY

Christopher SCHMANDT
Architecture Machine Group, Massachusetts Institute of Technology
Cambridge, Massachusetts, USA

Improvements in digital video typography are seen as a necessary component of increased interactivity and scope of use of soft copy text display systems. A grayscaling scheme produces high quality fonts for display with standard color video equipment, reducing scintillation, smoothing curves, and improving encodability. The same concept allows a "virtual resolution" far beyond the spatial resolution of normal pixel size; this permits up to eighty characters per line of eminently readable text on color televisions.

1. INTRODUCTION

That computers are rapidly spreading into all walks of life is undeniable. The nature and quality of our interaction with machines is, however, still open to question and improvement. In fact, as the technology continues to progress, limitations of the quality of interaction with it may well define the limitation on how far computers will be accepted into everyday life.

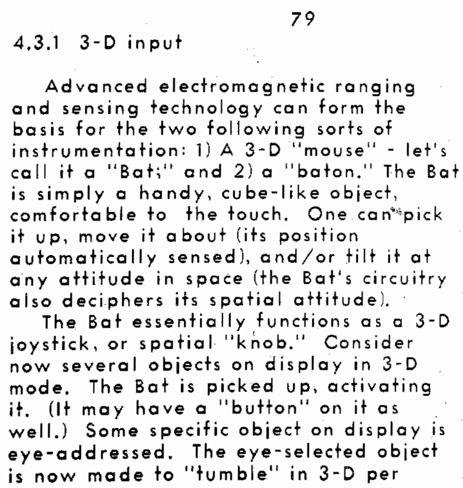
As computer interaction becomes cheaper and more sophisticated, an ever growing amount of textual data is being accessed as soft copy on video screens. But despite major improvements in hard copy technology over the last ten years, advances in soft copy quality have been few. As the cost of memory has declined, the potential and availability of raster scan computer graphics has sky-rocketed, but qualitative design improvements in digital video typography have been lacking.

Improvements in the quality of digital video text can have major impact on the usefulness of that medium by extending the scope of computer interaction. Current problems have been two-fold: inability to fit a large amount of text on a single screen, and typographically low quality, hard to read font sets. The result has been the popular (and correct!) concept of computer generated text as "ugly", a necessary but fatiguing medium of communication.

Advances in "soft typography" will have the greatest impact on computer usage when developed in the context of existing resolution color video technology. In part because low cost conventional video monitors are readily available and in widespread use, the scope of high quality text applications is vast. We can envision a range of applications, including large scale executive level "office of the future" systems, electronic communication networks, and local interactive cable television networks, as well as word-processing and computer typesetting applications.

2. GRAYSCALE FONTS

A solution addressing both font quality and character density developed at the Architecture Machine Group of MIT makes use of grayscale principles to produce typographically high quality video fonts (see fig. 1).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4.3.1 3-D input

Advanced electromagnetic ranging and sensing technology can form the basis for the two following sorts of instrumentation: 1) A 3-D "mouse" - let's call it a "Bat;" and 2) a "baton." The Bat is simply a handy, cube-like object, comfortable to the touch. One can pick it up, move it about (its position automatically sensed), and/or tilt it at any attitude in space (the Bat's circuitry also deciphers its spatial attitude).

The Bat essentially functions as a 3-D joystick, or spatial "knob." Consider now several objects on display in 3-D mode. The Bat is picked up, activating it. (It may have a "button" on it as well.) Some specific object on display is eye-addressed. The eye-selected object is now made to "tumble" in 3-D per

Fig. 1. A specimen of a Futura font. Photographed from a video screen.

Currently, digital fonts are stored in some matrix from, whether in PROM in a character generator or pixel memory in a frame buffer. The character format has been one bit per point deep, i.e. each matrix point or pixel is either on or off, black or white. Grayscale fonts use two (or more) bits per element, i.e. black, white, or one of two intermediate light and dark grays. So a character is actually a combination of an ink color, a background color, and two color levels of selected intermediate values, as shown in figure 2.

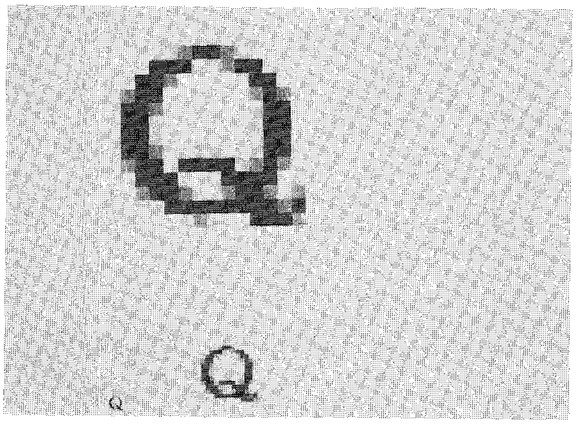

Figure 2. A grayscale character, at actual size and two blow-up scales.

This storage technique, combined with design work by skilled typographers, has produced highly readable, esthetically pleasing video fonts, which can be displayed in color as well as black and white. Full pages of text, with up to 65 characters per line NTSC encoded, or 85 characters unencoded, by 25 to 30 lines per screen, can be read comfortably on 525 line, 30 Hertz, interlaced video, as demonstrated in figure 3.

At these sizes, characters retain typographic details: variations in line thickness, fine serifs, and properly rounded edges. Visitors familiar with hard copy typography easily recognize the font styles displayed on the television monitor screen.

3. OVERCOMING DIGITAL VIDEO LIMITATIONS

Display of quality type fonts at higher densities in a raster scan digital video medium has traditionally been plagued by three problems: scintillation or flicker, bandwidth limitations in the horizontal direction, and overall jagged image edges. Most of these can be traced to the digital, discrete point nature of the computer generated video signal; this leads to sharp, high contrast boundaries in the image.

When high contrast edges lie in the horizontal direction, i.e. along raster lines, video interlace produces scintillation, which severely degrades the image and heightens eye strain considerably. This problem is particularly acute with character display, which requires many narrow horizontal lines. Adding transitional gray values, i.e. low-pass filtering in the vertical direction, lowers the contrast of the

This is a specimen of the Clarendon font developed at the Architecture Machine Group for raster scan video display. This font utilizes four color levels (background, foreground, and two intermediate colors) to obtain curve smoothing. This low pass filtering lowers the band width of the video signal, allowing the display of characters in a smaller size.

This particular font requires a maximum field size of 17 by 17 picture elements. Because the characters are proportionally spaced, typical letters occupy somewhat less space, and we are able to display approximately 70 characters per line of text.

The process whereby this font was created allows for production of Clarendon in several sizes or number of bits per pixel. Original hard copy fonts were digitized by a video camera interface, and stored as large (256 square) images at one bit per point. An interactive character editor was then used to scale the font down to an arbitrary size by the following algorithm. A grid of the dimensions of the desired reduction is overlayed on the large master character. Each grid element maps into one pixel; the grey value of that pixel is a function of the area within the grid square filled by the master image.

For best results, it is necessary to move the origin of the grid with respect to the master underneath it. The resulting reduction is then touched up by hand. Other fonts produced in a similar manner in the Laboratory include Futura and Courier.

The font is stored in a format which allows dynamic text processing from ASCII charcter strings. Multiple fonts may be displayed on the same video page. Text and background can be written in any colors with the intermediate values being obtained by

Fig. 3. A screen of text in a Clarendon font. Photographed from a video monitor

horizontal edges, reducing scintillation by spreading a line over several rasters.

Similar problems arise with high frequency changes in the horizontal direction, due to bandwidth limitations in many video monitors and the nature of the NTSC encoding technique. Particularly when discussing large-scale applications of video graphics in everyday life, we must be reminded that the graphic product will be as high quality only as the monitor which displays the signal. Many low cost color monitors have difficulty displaying high frequency signals, producing unwanted side effects along sharp vertical edges, usually interpreting the high frequency luminance signal as chroma information, i.e. inserting spurious color noise. Intermediate gray values along the vertical edges lower the frequency of the luminance signal, cutting down chrominance noise and thereby allowing more tightly packed text as well as clean colored text displays.

The other area in which the low pass filtering implied by the addition of intermediate color values aids image quality is that of resolution and detail. The most commonly noted problem of digital video graphics is that of "jaggies". A sloped line cannot be represented smoothly by discrete points, and appears rather as an annoying "stair step" pattern. The insertion of intermediate points, half way between the line and background colors, along the stair steps, smooths the line edges; the visual effect is a continuous, solid line. In font work, the flexibility added by the two extra shades of a two bit image allows significant improvements in producing smooth, stable characters. Curved edges become manageable, clearly a necessity for quality text, and sloped character elements appear as continuous lines, not jagged series of discrete points.

For designers familiar with principles of hard copy typography and printing, with their strong emphasis on crisp edges, it seems contradictory that "blurring" text by adding grays results in higher visual quality. The answer links grayscale with increase in effective resolution of digital video display. Spatial position of an edge on the video screen can be considered as integration of luminance over area. This implies that changing the brightness of a black/white boundary by changing boundary points to gray values can effectively move that boundary a fraction of a pixel. This results in a "virtual resolution" much higher than the pixel-size resolution of the display system. In fact, our work supports this theory; fine detail can be achieved by manipulating luminance, as well as position, of critically spaced pixels.

4. THE CHARACTER EDITOR

Small two bit character sets were generated in a hardware configuration of an Interdata 7/32 processor, Ramtek 9300 frame buffer, and a digitizing video camera interface.

The first stage consists of digitizing hard copy characters to create large "master" characters for future reduction. Note that in this process, hard copy characters are scanned into video memory; the character is consistently regarded as a shape, not as a series of lines.

Careful attention must be paid to the placement of the character, both vertically with respect to the baseline, and horizontally by the amount of white space at the left edge of the character, during the video digitizing process. The character is then scanned in, its width set interactively by the designer (the reduced fonts will be proportionally spaced), and stored away on disk as a packed 256 square by one bit per point image.

The full printing ASCII character set is digitized in this manner. Special symbols may be drawn freehand at the same large scale with a digitizing tablet. This large size (see fig. 4) is too large for display purposes, but ensures enough information for a good reduction.

Fig. 4. The large character masters.

A second stage of character editing produces a complete two bit font at a particular smaller size, typically 12 to 30 pixels square for the widest characters. For each character, the following procedure is applied. See also figure 5 for a view of the work station.

The large, one bit master is recalled from disk, and displayed on the designer's video monitor. A grid of

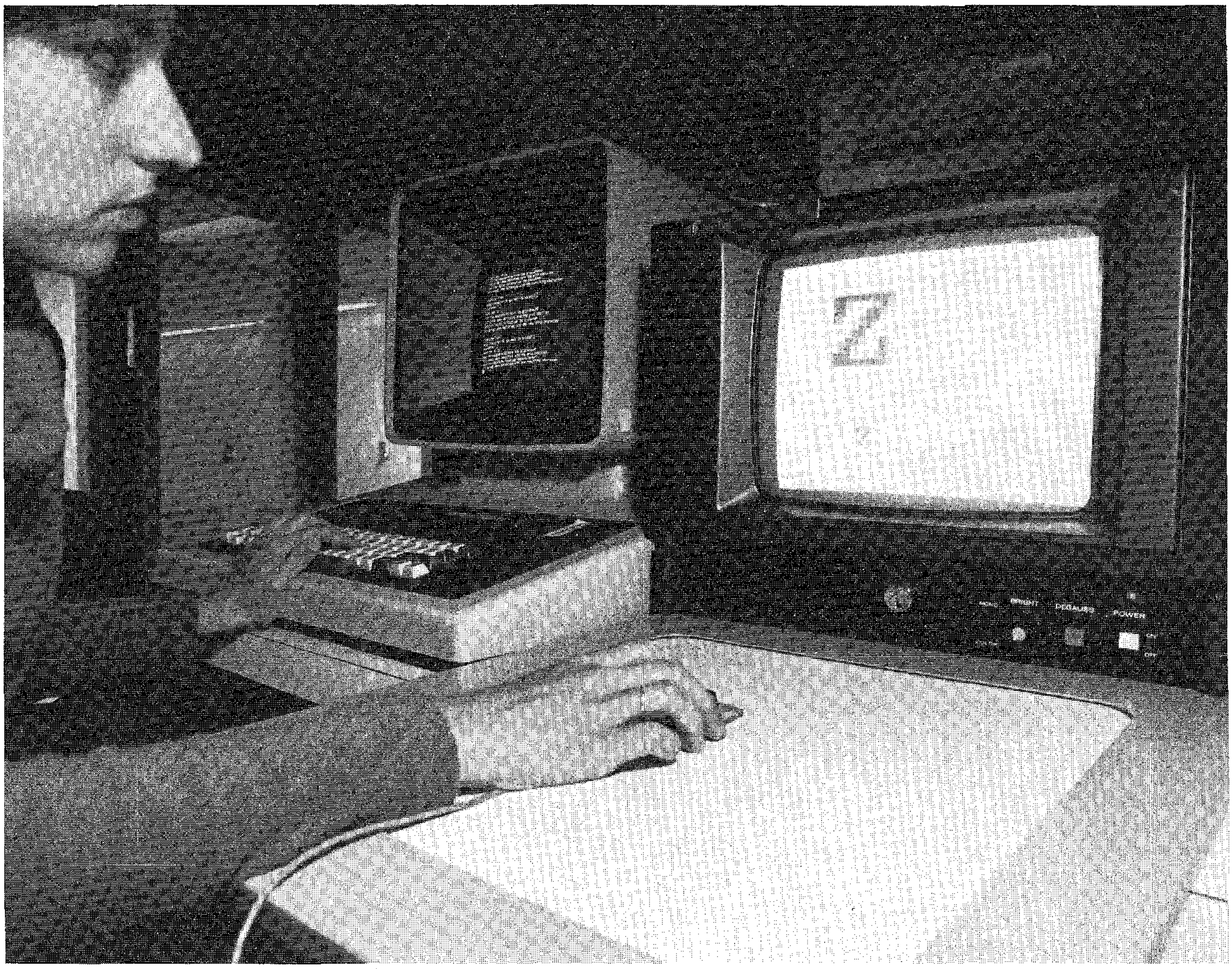

Fig. 5. The font editing work station in use.

the same dimensions as that of the desired reduction is drawn over the master; each square of the grid corresponds to one pixel of the ultimate reduction. Within each grid element, the area of the portion of the master character which lies within that element is computed, and divided by an appropriate scale factor to obtain a value between 0 and 3, i.e. between white and black. The more of a grid square filled by the master, the darker the resulting reduced pixel will be. The reduction is shown on the monitor at actual size and scale four as well (see figure 6). In addition, each character so far edited is shown in the upper right portion of the screen; this is highly useful for maintaining consistent character density throughout the font.

It must be noted that the actual reduction obtained is a function of the position of the grid overlay with respect to the master character underneath. Shifting a grid element at the edge of the master may well change the area summation of the piece of the master enclosed by that element, with corresponding changes in the reduced gray value. One grid position will produce a visibly better reduction than another. So, at this stage, the designer shifts the grid in two dimensions until the best results are

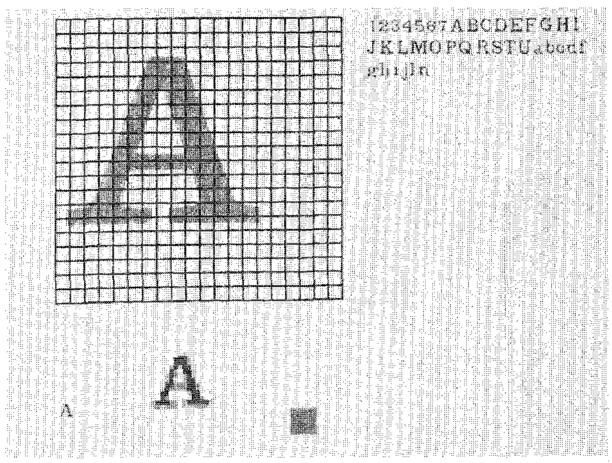

Fig. 6. Character reduction.

obtained. That is, characters are fractionally moved to line up with the raster array to avoid undue truncation error. This process is particularly useful for refining large area edges, to obtain the proper mix of black "core" to the character with the gray edging which is desired in the reduction.

When the designer is satisfied with this stage, the grid region is replaced by a scaled up version of the latest reduction (see figure 7). Now, using a tablet, the designer may touch up the corresponding pixels of the reduced character. The currently active gray value appears in a box to the left. This technique is most suited to detailed touch up, e.g. refining thick and thin character variations, serifs, etc.

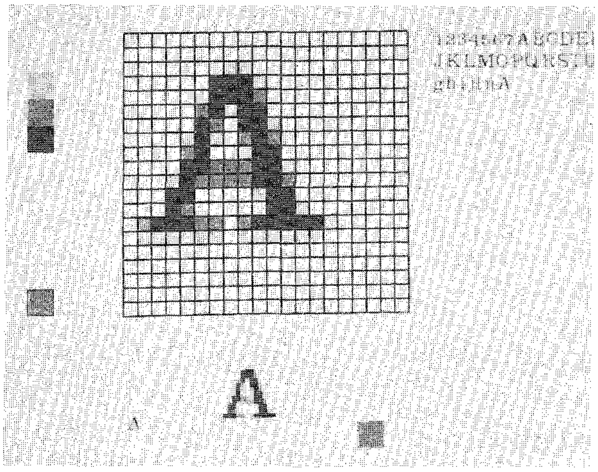

Figure 7. Touch-up in the character editor.

The final stage of editing consists of adjusting character spacing; since the fonts are single dimensionally proportionally spaced, each character has its own width. A first pass width table is computed by a scaling algorithm from the pre-set widths of the master characters. This width table may be touched up by hand, adding or subtracting white space at the right of any character.

The flexibility of the reduction process allows many of the features obtained by modern CRT typesetting equipment. A form of italics may be produced by slanting the master character while it is recalled from disk, to be overlaid with the same rectangular grid. A condensed font can be derived from the same master by using a grid with less horizontal elements than vertical elements; the area summation accomplishes a horizontal squeezing.

5. CONCLUSIONS

The combination of algorithmic and hand editing processes described above has been used to create several fonts, both serif and sans-serif, at various sizes, to test grayscale principles, with dramatic results. Characters small enough to display a full page of text remain eminently readable and stable on the screen. The same characters can be easily displayed in color, on either a white or colored background, by mapping the grays into an appropriate color wash.

Particular applications may take this process in one of two directions. The first is to store the font master, and with an appropriately tuned algorithm and fast hardware generate any desired reduction on the fly. The other is to devote time to producing the best possible reductions, and dedicating some form of storage to the final two bit matrices for each font set.

The design purpose of the font editor currently in use is not to demonstrate the ultimate in two bit reduction algorithms for characters. Rather, it has been an exploration into the intersection of typography, computer graphics, and video engineering, in an attempt to synthesize a set of principles optimizing the product produced by that intersection, digital video text. It is hoped that attention to such principles may shortly enable video display of information, both textual and other, to live up to the expectations of communities of users accustomed to demanding hard copy quality.

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