Ultrafast display buildup with standard VGA on MS-DOS computers

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Tachistoscopic examinations, determinations of reaction times after visual stimuli, and latency measurements of visual evoked potentials require well-defined and often very fast display buildup on the monitor. Display buildup takes at least 14 msec when a VGA board is used in standard video modes. This time can be reduced to 4 msec or less by reprogramming some registers of the display adapter.

Precise presentation of visual stimuli is a prerequisite for most psychological and physiological examinations. A precision of 1 msec is required for measuring reaction times, which rarely exceed 1.5 sec (Brysbaert, Bovens, d'Ydewalle, & van Calster, 1989). High precision also appears to be important for determining latencies of visual evoked potentials (VEP), which may range between 75 msec (VEP) and 1,000 msec (event-related potentials; Stöhr, Dichgans, Diener, & Buettner, 1989).

Standard Graphic Modes on MS-DOS Computers Are Slow

The speed of display scan on the monitor is primarily determined by the display adapter of the computer and the monitor. VGA (video graphic array) has become the accepted standard on MS-DOS computers. The (preset) standard video modes of VGA allow for maximum vertical frequencies of 70 Hz, which corresponds to a scan time of approximately 14 msec. About 1 msec can be deducted from this value for the (invisible) vertical retrace of the cathode ray. Even the Super VGA (SVGA) boards now available rarely achieve vertical frequencies higher than about 90 Hz. Thus, the maximum time interval between the beginning of the time measurement and the actual start of the display scan is 14 msec at a vertical frequency of 70 Hz.

Reprogramming of the VGA Accelerates Display Buildup

The display is composed of lines, which, in the standard video modes, consist of 640 (graphic modes) or 720 (text modes) visible pixels (Michael, 1988) with invisible pixels at the left and right margin (horizontal overscan). In graphic modes with 256 colors, every pixel is visual-

ized twice (double-scanning), hence the actual horizontal resolution available is only 320 pixels (Michael, 1988).

Depending on the video mode, a screen consists of 350, 480, or 400 visible lines. At a resolution of 200 lines, each line is again displayed twice, and there are also some invisible lines at the upper and lower margins (their number depends on the video mode).

The speed at which pixels are displayed on the screen is determined by the frequency of the timing generator, which is set at 25 MHz at a 640-pixel resolution and at 28 MHz at a 720-pixel resolution. Other timing frequencies are not available for a standard VGA.

The fewer lines displayed per screen, the faster the display buildup. For example, a video mode with a resolution of 640×480 pixels is displayed at a repetition frequency of only 60 Hz, as opposed to 70 Hz for a resolution of 640×350 pixels (Spitzcok von Brisinski, 1991a). Since the standard video modes are not designed for fewer than 350 lines per screen (remember that 400 lines are displayed physically at a resolution of 200 lines), the maximum display repetition frequency is 70 Hz. Different resolutions can be achieved by reprogramming the cathode ray tube controller (CRTC) (Spitzcok von Brisinski, 1991b, 1992a, 1992b). The repetition frequency can be increased by reducing the number of physically displayed lines.

The software routines developed by the author yield repetition frequencies of up to 289 Hz, reducing the time of display buildup to less than 4 msec. The velocities were measured by using the program VTiming (Gerdes, 1991), which registers the time interval between two successive vertical cathode ray retracings by means of the PC timer component. In addition, the velocities were determined by an oscilloscope connected to the video port of the PC. The two procedures yielded identical values.

The program contains register values for 20 different vertical resolutions ranging from 363 to 101 pixels. All resolutions can be used for the 2-, 16-, and 256-color display, and it is possible to fill two different "pages" in each case. When the 256-color mode is used, horizontal resolution is only 320 rather than 640 pixels due to the required double-scanning.

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Other vertical resolutions can be achieved by assigning appropriate values to the CRTC registers 06h (vertical total register), 07h (CRT, controller overflow register), 09h (maximum scan line register), 10h (vertical retrace start register), 11h (vertical retrace end register), 12h (vertical display enable end register), 15h (start vertical blanking register), and 16h (end vertical blanking register) (Ferraro, 1990; Michael, 1988). At vertical resolutions between 101 and 255 pixels, 1 is subtracted from Ymax before the latter is assigned to registers 10h and 12h; for register 06h, a value between 6 and 12 is added (physically required overscan; the value should be as low as possible for high velocities, and distortion at the margins should be kept at a minimum). Only Bit 4 is set in register 07h (line compare). Different combinations of values can be used for vertical blanking. The following combination has proved useful: Bit 5 in register 09h (start vertical blanking), a value of 4–6 in register 16h, 136 or 231 in register 15h, and 230 in register 11h.

At vertical resolutions between 256 and 511 pixels, 257 (the sum of -256 and -1) is subtracted from Ymax before the latter is assigned to registers 10h and 12h; for register 06h, a value of 12 is added. In overflow register 07, Bits 0–4 have to be set (the individual bits represent the 8th bit, and thus a value of 256, for registers 06h, 12h, 10h, 15h, and line compare, respectively). For vertical blanking, the following values have proved useful: Bit 6 in register 09h (line compare) in combination with a value of 86–108 in register 16h and, in register 15h, a value lower by one than that in register 16h, and a value between 202 and 206 in register 11h.

Selection of a Suitable Monitor

Surprisingly, the best results have been achieved with inexpensive standard VGA fixed-frequency monitors, both monochrome and color. As indicated above, the horizontal frequency is standardized and set at approximately 31.5 kHz. As with display adapters, many VGA fixed-frequency monitors (e.g., Commodore 1403) also have a variable vertical frequency. Thus, about 100 horizontal lines can be displayed on these monitors at 289 Hz (cf. above). When using such monitors, the cathode ray scans only about one quarter of the available screen, since the distance between the horizontal lines is not changed. There are also fixed-frequency VGA monitors on the market with two fixed vertical frequencies (60 and 70 Hz; e.g., Commodore 1944). These monitors cannot be used at higher frequencies.

So-called multiscan monitors, which “automatically” adjust to the required (vertical and horizontal) frequencies, can also be used with the increased vertical frequencies of a standard VGA or a VGA-register-compatible SVGA. However, since multiscan monitors are not standardized, the results may vary widely. All multiscan monitors can be operated at a somewhat higher vertical frequency than is specified in the technical data. For instance,

the Eizo 9070s, which has a specified maximum frequency of 80 Hz, can be operated at 143 Hz with a vertical resolution of 210 instead of 400 dots. Higher vertical frequencies do not provide a correct image. This is not due to an “overload” of the monitor but simply to the fact that it is not designed to synchronize at higher values. A number of multiscan monitors also display 100 lines at 289 Hz without problems (e.g., Eizo 9400). Unlike the single-frequency monitors, all multiscan monitors space out the lines displayed—that is, they distribute the 100 lines over the entire screen.

Software Specifications

FASTVGA is a collection of routines written in C and Turbo Pascal that can be incorporated into other programs to speed up display scan. The program can be used for monochrome and color display. Hardware requirements are an IBM-compatible MS-DOS computer (XT; 286, 386, or 486 AT) operated with MS-DOS version 3.3 or higher and a VGA or register-compatible SVGA (the program does not operate with other display adapters such as CGA or EGA). Any monitor can be used subject to the above-mentioned restrictions. The software was tested extensively; none of the monitors tested was overloaded or damaged.

Availability

The source code can be obtained free of charge from the author by sending a formatted diskette (double or high density; 3.5 in. or 5.25 in.).

REFERENCES

- BRYLSBAERT, M., BOVENS, N., D'YDEWALLE, G., & VAN CALSTER, J. (1989). Turbo Pascal timing routines for the IBM microcomputer family. *Behavior Research Methods, Instruments, & Computers*, 21, 73–83.
- FERRARO, R. F. (1990). *Programmer's guide to the EGA and VGA cards*. New York: Addison-Wesley.
- GERDES, M. (1991). Messung der VGA-Bildablenkfrequenz per Software [Measurement of the VGA-display repetition frequency by software]. *Magazin für Computer Technik (ct)*, 7, 188–193.
- MICHAEL, M. (1988). *VGA-Kompedium [VGA Compendium]*. Haar: Markt & Technik Verlag.
- SPITCZOK VON BRISINSKI, I. (1991a). EGA mit 70 Hz [EGA with 70 Hz]. *Magazin für Computer Technik (ct)*, 6, 8.
- SPITCZOK VON BRISINSKI, I. (1991b). Selbstgestrickt-neue Grafik-Modi auf der Standard-VGA [Self-knitted-new graphic modes on standard VGA]. *Magazin für Computer Technik (ct)*, 12, 212–216.
- SPITCZOK VON BRISINSKI, I. (1992a). Schräge Typen-Texte auf der VGA in beliebigen Winkeln oder Kreisen ausgeben [Oblique types-text display on VGA at any angle or circle]. *Magazin für Computer Technik (ct)*, 11, 182–187.
- SPITCZOK VON BRISINSKI, I. (1992b). Zwei Seiten mit 256 KB [Two pages with 256 KB]. *CHIP*, 9, 301.
- STÖHR, M., DICHGANS, J., DIENER, H. C., & BUETTNER, U. W. (1989). *Evozierte Potentiale*. Berlin: Springer-Verlag.

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