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Full-screen ultrafast video modes overclocked by simple VESA routines and registers reprogramming under MS-DOS

ZUXIANG LIU
University of Science and Technology of China, Beijing, China
and Peking University, Beijing, China

and

BO WANG
University of Science and Technology of China, Beijing, China

Fast full-screen presentation of stimuli is necessary in psychological research. Although Spitczok von Brisinski (1994) introduced a method that achieved ultrafast display by reprogramming the registers, he could not produce an acceptable full-screen display. In this report, the author introduces a new method combining VESA routine calling with registers reprogramming that can yield a display at 640 × 480 resolution, with a refresh rate of about 150 Hz.

Fast display of stimuli is of special importance in psychological research, especially in research about visual perception and reading. Researchers have put much effort into this issue (Bokhorst, 1995; Diesch, 1994; Hutner, Duboff, Oscar-Berman, & Mueller, 1999; McKinney, MacCormac, & Welsh-Bohmer, 1999; Myors, 1998, 1999a). The key problem is the refresh cycle of the video card, which is 60 Hz under standard VGA 640 × 480 mode. Hence, no matter how fast the content of video RAM changes, each pixel flashes on the monitor about every 16.67 msec, and the total duration for presenting a full picture with size of 640 × 480 is about 16 msec (Krantz, 2000). This problem becomes extremely significant if two stimuli are desired to be displayed at the same time, one at the top part of the screen and the other at the bottom part of the screen. The gap will be above 10 msec, if the stimuli are small and near the edge of the screen (Hutner et al., 1999).

To solve this problem, Spitczok von Brisinski's (1994) method is widely used, which could yield a 4-msec refresh cycle time in the best situations. The key point was to change the CRTC registers on the video card, which controls the vertical synchronization. However, this method has its limitations, because only part of the picture would be displayed at a higher speed. With a fixed-frequency monitor, the cathode ray scans part of the monitor and shows a narrow display. With a multiscan monitor, the display size is normal, but the pixel shape is changed from square to rectangular. In studies on reading, these shortcomings are tolerable. However, they become unacceptable when the need for full-screen fast display arises in visual perception studies. For example, in McConkie and Currie's (1996) study, subjects were instructed to detect the changes in a picture, while their eye movements were monitored simultaneously and the screen changed to other, slightly different pictures, triggered by their eye movements. In this kind of experiment, full-screen display is useful, and fast display is important to finish the change before the eye movement stops. Although an ATVista display controller card was used for fast presentation in McConkie and Currie's study, screen refresh rate was still a bottleneck.

Here, the authors present a method similar to Spitczok von Brisinski's (1994). However, this method can achieve a 640 × 480 pixel display at about 150 Hz, using a normal VESA-compatible video card. Many video cards in the current market have high video clock and could be driven even to 100 Hz in Microsoft Windows at a resolution of 640 × 480. Although such a mode is not standard VGA mode, manufacturers were able to write graphics drivers for their cards to support it, because they had the capability to set their cards to higher video clock and deal with undocumented registers. Unfortunately, Microsoft Windows is not a suitable operating system for time-critical psychological studies (Myors, 1999b); researchers had to deal with this issue in DOS. One possibility was to acquire a programming manual of the video card from the manufacturer. However, researchers would have to acquire the different programming manuals for different kinds of cards in use and develop different codes for each kind of card. Fortunately, the authors have found a simpler way. Almost all the video cards in the current market support the VESA standard. Some SVGA modes could be achieved with calls to

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the VESA routine and the video BIOS provided by the manufacturers in the chips by dealing with those registers and setting the correct video clock.

The following modes were most useful: Mode 101h, 640 × 480, 256 colors; Mode 103h, 800 × 600, 256 colors; mode 105h, 1,024 × 768, 256 colors. The next question was how to get a fast full-screen 640 × 480 display with these. First, the video card should be set to a high resolution—for example, 1,024 × 768—that has higher video clock. Then, registers in charge of horizontal synchronization and vertical synchronization should be set to fit the display of standard 640 × 480 resolution. Since higher video clock has been set, the refresh rate increases.

The most difficult part was to set suitable values to registers, in order to get correct display in this overclocked configuration. The authors have developed a method to determine these parameters automatically.

The pseudocode for this method is in Listing 1.

Tests and Results

A video card, Model MX86251 of Macronix, with a Philips 2120 monitor was used. While an initial mode of 1,024 × 768 was used, a final mode of 640 × 480 correctly displayed pictures with a refresh rate of 154.4 Hz. To measure the refresh rate, the number of vertical retracing was counted for 5 sec. To verify the result from the software, a radiometer with a 0.1-msec sampling resolution was used, just as Spitczok von Brisinski (1994) had done. The radiometer gave the same result.

The authors noticed that some monitors have a viewmeter in the built-in menu. Thus, another test with three verifying methods was applied to a video card, Model Nvidia TNT2 Model 64, with a Samsung SyncMaster 753DF. The software showed a 127.5-Hz refresh rate, while the initial mode was 1,024 × 768 and the final mode was 648 × 486. The radiometer gave the same result. The built-in viewmeter of the monitor gave a 128-Hz refresh rate. It seems that the built-in viewmeter is an acceptable method to verify the refresh rate, if available.

Although this result was not as good as that of Spitczok von Brisinski's (1994), 154.4 Hz was much better than 60 Hz. Theoretically, this method could be promoted to a higher refresh rate with a higher initial mode. For example, with an initial mode of 1,280 × 1,024 and a final mode of 640 × 480, the final refresh rate would be about 256 Hz. Unfortunately, the best monitor in the authors' laboratory had a maximum vertical frequency of 160 Hz. Then, the test stopped at the best result with a correct display.

Here, an important issue that should be mentioned is that this method does not guarantee short or accurate stimulus duration. As has been pointed out by some authors (Bridgeman, 1998; Hutner et al., 1999), the persistence of the monitor's phosphor should be taken into account. Thus, if the persistence of the monitor's phosphor is longer

Listing 1

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Pseudocode:
Set Initial Standard Mode (e.g., 1024×768)
Get Video Synchronization Information
  Get Register Values
  Calculate HDisplayInitial, HSyncStartInitial, HSyncEndInitial, HTotalInitial
  Calculate VDisplayInitial, VSyncStartInitial, VSyncEndInitial, VTotalInitial
Set Final Standard Mode (e.g., 640×480)
Get Video Synchronization Information
  Get Register Values
  Calculate HDisplayFinal, HSyncStartFinal, HSyncEndFinal, HTotalFinal
  Calculate VDisplayFinal, VSyncStartFinal, VSyncEndFinal, VTotalFinal
Set Initial Standard Mode (e.g., 1024x768)
Calculate Desired Mode Synchronization Information (e.g. 680x510)
  HDisplayDesired=680;
  HSyncStartDesired=HSyncStartInital-(HSyncStartInitial-HSyncStartFinal)
    *((HDisplayInitial-HDisplayDesired)/(HDisplayInitial-HDisplayFinal));
  HSyncEndDesired=HSyncEndInital-(HSyncEndInitial-HSyncEndFinal)
    *((HDisplayInitial-HDisplayDesired)/(HDisplayInitial-HDisplayFinal));
  HTotalDesired=HTotalInital-(HTotalInitial-HTotalFinal)
    *((HDisplayInitial-HDisplayDesired)/(HDisplayInitial-HDisplayFinal));
  VDisplayDesired=680 * 3/4;
  VSyncStartDesired=VSyncStartInital-(VSyncStartInitial-VSyncStartFinal)
    *((VDisplayInitial-VDisplayDesired)/(VDisplayInitial-VDisplayFinal));
  VSyncEndDesired=VSyncEndInital-(VSyncEndInitial-VSyncEndFinal)
    *((VDisplayInitial-VDisplayDesired)/(VDisplayInitial-VDisplayFinal));
  VTotalDesired=VTotalInital-(VTotalInitial-VTotalFinal)
    *((VDisplayInitial-VDisplayDesired)/(VDisplayInitial-VDisplayFinal));
Calculate Register Values
Turn off the screen
Set Register Values
Turn on the screen with changed refresh rate
```

than the refresh interval, the shortest stimulus duration is decided by the monitor's phosphor, no matter which refresh rate is provided by this method. However, typical monitors have fast decay phosphors, and the persistence time is less than 4 msec (Bridgeman, 1998), or on the order of 0.2–0.6 msec (Hutner et al., 1999). Then, the shortest stimulus duration is decided by this method if the final refresh rate is below 250 Hz. Even in conditions in which slow decay phosphors are used, this method has its advantages. Full screen could be displayed within a shorter interval, and the time gap would be smaller if two stimuli are desired to be displayed at the same time, one at the top part of the screen and the other at the bottom part of the screen.

Software Specifications

A program named RRTST by the authors implements the aforesaid method. It was written in C and compiled with Borland C++ 3.1. In this program, 73 possible combinations of initial mode and final display size could be tested. The test contains two parts. In the first part of the test, the initial mode is 1,024 × 768, and the final mode steps from 1,024 to 624 by 8. So there are 51 combinations. In the second part of the test, the initial mode is 800 × 600, and the final mode steps from 800 to 632 by 8, which provides an additional 22 combinations. This configuration comes from the fact that the 1,024–640 combination has a refresh rate of about 154 Hz, which exceeds the acceptable range of most monitors, and the 800–640 combination has a refresh rate of about 95 Hz, which gives the same final display size but a lower frequency. Of course, the combination to be used depends on the requirements of the experiment and the limitations of the hardware (see the Hardware Limitation section below). The program writes those parameters of each combination to a file named MODESET.RRM.

Nonetheless, the authors could not get the correct display under some combinations. RRTST provides the possibility that experienced users could change the parameters in MODESET.RRM manually and test the modified mode. More information about changing those parameters manually can be found at http://www.linuxdoc.org/HOWTO/XFree86-Video-Timings-HOWTO/.

The users are allowed to use the source code and header files, provided by the authors in their own program, with the MODESET.RRM file. After adding those files to their project and copying the MODESET.RRM file created by the RRTST program to their working directory, a single call ChangeToHighRefreshRateMode() could set the desired mode combination. The users could browse the source code of the demonstration program for more details.

To simplify the programming, a free graphics library, named SVGACC.LIB, was used. This library, with SVGA support, could be used as an alternative to Borl and BGI graphics library. Programmers will be able to set the 1,024 × 768 256-color mode with one function call, res1024(). Please consult Web site http://www.zephyrsoftware.com for more details. Experienced programmers will be able to deal with VESA calls by themselves or to use other SVGA supporting libraries to implement this method.

Hardware Limitations

There are two limitations to using this method. The first one comes from the video card. Although any VESA-compatible card could be used in this method, the RAMDAC frequency in the video card limits the maximum refresh rate. Therefore, for some old video cards, undesirable displays, such as snowing dots and lines, could appear under a high refresh rate.

The second limitation comes from the monitor. In this method, a multiscan monitor should be used for full-screen display. If the refresh rate exceeds the acceptable range of the monitor, there would be a black screen or an out-of-synchronization warning message. The maximum frequency of a monitor can be found in its manual. It is possible to damage a monitor, if it is set to an unacceptable mode for a long time, according to the manual of the authors' monitor. The users should pay special attention to this possibility, although none of the monitors tested was damaged.

Availability

The source code of RRTST and documents can be obtained free of charge from the author by sending an e-mail to lzx@pku.edu.cn.

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