EE 4743/6743
COMPUTER AIDED DESIGN OF DIGITAL SYSTEMS
LAB7: IMAGE PROCESSING - DITHERING

Learning Objectives: This experiment introduces dithering and using a raster memory for display.

- Image Processing – For analyzing video memory and displaying the results
- Dithering – For extending the available color range
- Strobing – Another way to extend the color range

This lab assumes that you have purchased a Basys development board. You will need to fill out the lab DATA SHEET located at the end of this lab assignment during the performance of the lab. There is NO PRELAB for this assignment.

DITHERING

With only one data bit for each color (red, green, and blue) only eight colors can be displayed. However, by exploiting the features of human perception, more colors can be made available. Newspapers found that mixing black and white together on a very fine pitch causes the two colors to blend together to form shades of gray. This is also used in television screens. On close inspection, a TV screen is only made up of red, green, and blue dots. These dots mix together to form the entire color spectrum when viewed from a distance. Since the Spartan 3 board has few colors, but a high resolution, we can also use this effect to form more colors. This effect is called dithering. See Figure 1 for a close-up example.

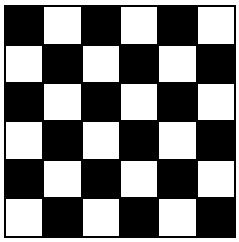

FIGURE 1: DITHERING EXAMPLE (CLOSE-UP)

STROBING

Another exploit of the features of the human eye is seen in movie projectors. The human eye has a relative slow reaction rate to changing images. When watching a movie, the image appears to be a constant brightness; however, the image is actually being turned on and off at a rate faster than the eye can perceive. This is called persistence of vision. This effect can also be used to extend the range of color in the Spartan 3 board. Flashing two different colors in the same pixel at a high rate will tend to blend those two colors together.

IMPLEMENTATION

The Basys board can display a resolution up to 640 by 480. This should be a high enough resolution to use dithering to mix colors together. You will be using a raster memory to display an image on the video monitor.

GRADE C: CREATE A PROGRAM TO DISPLAY THE RASTER IMAGE USING DITHERED COLORS

You should start from the part C which you completed in raster memory lab. This circuit should display the contents of the raster memory in four colors on the VGA monitor. You will need to modify the circuit so the colors now displayed conform to Table 1. This can be done by creating a module with the inputs from the ROM, and the row/column information. This module can be either a schematic or VHDL code.

Output Code	Color
00	Grey (White & Black)
01	Lime Green (Green & Yellow)
10	Orange (Red & Yellow)
11	Light Blue (White & Blue)

TABLE 1: COLOR ENCODING FOR THE VIDEO ROM

To create the staggered colors, look at the pattern for a 2x2 block of pixels as in Figure 2. This pattern repeats over and over, so you only need to create the logic to display this block. If this represents the upper-left most part of the screen, then the color black is displayed in pixels (0,0) and (1,1). The color white is displayed in (0,1) and (1,0). You should be able to use this information to design the circuit to dither the colors.

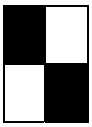

FIGURE 2: DITHERING EXAMPLE FOR 2X2 BLOCK OF PIXELS

GRADE B: CREATE A PROGRAM TO DISPLAY THE RASTER IMAGE USING STROBING

The objective of this part is to replicate the functionality of the previous part, but using strobing instead of dithering to achieve the same effect. Each pixel should alternate between two colors as dictated in Table 1. The color displayed should be the same for an entire scan of the screen. Then when the scanning beam begins to redraw a second screen, toggle the color displayed. A typical refresh rate for monitors is 60Hz, which means each color will be displayed for 1/60th of a second before changing.

You may want to use some type of register to hold which color is being displayed. You can monitor the vertical scan input to know when the screen is finished drawing and the scanning beam is returning to the top of the monitor. Use this information to toggle the contents of the register

GRADE A: CREAT A PROGRAM TO DISPLAY THE RASTER IMAGE USING BOTH METHODS

The final part of this assignment is to combine the two methods. Use dithering to display two different colors on the monitor in a staggered manner as in Figure 2. Then on each redraw of the screen, switch the colors being displayed. So for Figure 2, the first scan will draw black on pixels (0,0) and (1,1) with white on (0,1) and (1,0). Then on the second scan, it will draw black on (0,1) and (1,0) with white on (0,0) and (1,1).

MODULES

VGA_sync

Inputs:	clk	50MHz clock (converted to 25MHz clock internally)
Outputs:	h_sync	Horizontal sync for VGA port
	v_sync	Vertical sync for VGA port
	pixel_row(9:0)	10-bit value of currently drawn Y coordinate
	pixel_column(9:0)	10-bit value of currently drawn X coordinate
	video_on	High when the row and column outputs are valid
	subpixel_row(8:0)	9-bit value of lower resolution Y coordinate
	subpixel_col(8:0)	9-bit value of lower resolution X coordinate

Description: Computes pixel coordinates currently drawn and manages horizontal and vertical sync signals to VGA output. Also includes a video_on signal which should cause the RGB outputs to display black when low.

vid_rom

Inputs:	clk	50MHz clock
	addr(13:0)	Address location (0-16384)
	din(1:0)	Data input
	we	Write enable
Outputs:	dout(1:0)	Data output

Description: RAM element – stores 32kbits of data. Output is two bit word. Stores the picture to be display on the screen.

VGA_BUFFER

Inputs:	clock	50MHz clock
	red_in	red bit input
	green_in	green bit input
	blue_in	blue bit input
	video_on	High when row/col are valid
Outputs:	red_out	Red signal to VGA port
	green_out	Green signal to VGA port
	blue_out	Blue signal to VGA port

Description: If video_on is low, then pixel should be black (RGB = “000”). Otherwise it buffers the output to provide clean edges on the picture.

LAB DATA PAGE NAME:

GRADE C: CREATE A PROGRAM TO DISPLAY THE RASTER IMAGE USING DITHERED COLORS

1. Program compiles (Yes/No) _____
2. Displays the correct image with correct colors (Yes/No) _____

Total hours reported (from work log) for this lab portion: _____

TA CHECKOFF SIGNATURE: _____ (must be legible!)

GRADE B: CREATE A PROGRAM TO DISPLAY THE RASTER IMAGE USING STROBING

1. Program compiles (Yes/No) _____
2. Displays the correct image with toggling colors (Yes/No) _____

Total hours reported (from work log) for this lab portion: _____

TA CHECKOFF SIGNATURE: _____ (must be legible!)

GRADE A: CREATE A PROGRAM TO DISPLAY THE RASTER IMAGE USING BOTH METHODS

1. Program compiles (Yes/No) _____
2. Displays the correct image with correct colors (Yes/No) _____
3. 3. Displays the correct image with toggling colors (Yes/No) _____

Total hours reported (from work log) for this lab portion: _____

TA CHECKOFF SIGNATURE: _____ (must be legible!)

Student Evaluation:

Which method looked the best on the lab monitors?

What did you like most about this lab?

What would you change about this lab to make it better (not necessarily easier)?

WORK LOG PAGE NAME:

Lab portion worked on/ completed	Start Time & Date	Stop Time & Date	# Hours

Total Hours	**Grade A**	
	Grade B	
	Grade C	