DuckFeed

An Embedded Take on The Classic Video Game "Duck Hunt"

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Zapper Schematic

- Open Collector Outputs
  - Easy to pull up to 3.3V (board voltage)
- Band pass filter
  - Place 390k resistor in parallel with existing one

![Zapper Schematic Diagram]
Hardware Interfacing

To Zapper

- **White**
  - 5V GPIO_1 11

- **Brown**
  - GND GPIO_1 12

- **Blue**
  - GPIO_1 0
  - 3.3V GPIO_1 29

- **Purple**
  - GPIO_1 1
  - 3.3V GPIO_1 29
  - R1 1k
  - R2 1k

White -- VDD for Zapper
Brown -- Ground for Zapper
Blue -- Light Detector Signal. Active Low
Purple -- Trigger Pull Signal. Active Low
## Timing (screen blanking) Slide

<table>
<thead>
<tr>
<th>State</th>
<th>Task</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Wait for trigger pull</td>
<td>Indefinite</td>
</tr>
<tr>
<td>2</td>
<td>Wait for trigger release</td>
<td>Indefinite</td>
</tr>
<tr>
<td>3</td>
<td>Set timer to debounce trigger release</td>
<td>200,000 cycles</td>
</tr>
<tr>
<td>4</td>
<td>Wait for raster scan to reach end of field</td>
<td>&lt; 416,000 cycles</td>
</tr>
<tr>
<td>5</td>
<td>Turn screen black for one frame. Ensure there is no light signal from the gun.</td>
<td>332,500 cycles</td>
</tr>
<tr>
<td>6</td>
<td>Keep screen black but place white targets in the place of ducks in binary search pattern. Look for light signals.</td>
<td>450,000 cycles</td>
</tr>
<tr>
<td>7</td>
<td>Return screen to background and flying ducks</td>
<td>After 5 flashes</td>
</tr>
</tbody>
</table>
Background Encoding Saves Memory!

- Background is 640 x 480 pixels, each pixel is 24 bits (rgb)
  - Almost 1MB! Definitely won't fit on chip
- Solution: Run Length Encoding with 16 Colors
  - Multiplex colors into 4 bits, length encoded in 8 bits
  - Fits in less than 10% of the memory
  - Pain to implement
Sprites

- Sprites are made out of pixel arrays stored in a rom
  - Ducks need 5 colors:
    type duck_type is array (0 to 1599) of unsigned(3 downto 0);
  - Score numbers and duck food need only 1 color:
    type score_type is array (0 to 1599) of std_logic;
    type fish_type is array (0 to 399) of std_logic;
  - Each sprite can be read simultaneously up to 2 times—need multiple constants
- Pixels are read from the rom and colors are decoded in processes in the VGA raster—1 transparent color
- Then RGB pixel values are called in the VideoOut method which draws the sprites
Sprites

Array Indexing:
- Use horizontal and vertical counters from the raster and duck position from software to calculate the index in the sprite arrays
- Ducks display differently depending on how the sprites are indexed, for example right and left facing ducks.

Flapping: alternate between up-winged duck image and down-winged duck image at every duck flap.
Software

- The cerebral cortex of the operation
  - Defines level variables (number of ducks, speed, time limit, etcetera)
- Consistently loops and:
  - Controls duck position, duck visibility, etc.
  - Keeps track of time and shots remaining
  - Decides when a level has been won or lost
Actually using Data Structures knowledge! Implemented a binary search algorithm which will determine which duck was hit, checking for cheaters, in five cycles.
Lessons Learned

- The best advice we got this semester: Fix the small problems before tackling the big problems!
  - Fixing a bug in the VGA raster helped us get the background working
- Understand the hardware
  - Dual-Ported ROMs made our life easier
Questions?