CSEE 4840 Embedded systems Design

Light Saber generator-
Return of the Jedi

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Overview

- Motivation
- Goals
  - Real Time Video Display
  - Color detection
  - Light saber generation
- Real time video processing
  - Processing at 60 fps
Motivation

- To learn integration of hardware and software
- Real time video processing on the FPGA board
- Inspired by
  - Luke Skywalker (Star wars!!)
Objectives

- To capture video in real time of a person holding a sword
- Do real time video processing at 60 fps
- Replace the sword with a light saber on the VGA display
System Architecture

- Camera
- ADV 7181
- ITU
- Initiation Delay timer
- Locked Detector
- YCbCr to RGB
- XY Detection
- VGA Controller
- Avalon Communicator
- ADV 7123
- RAM
- VGA Display
- NIOS
- AVALON BUS
Timing diagrams
Timing diagram 1

TD_VS

VGA_VS

16 ms (60 fps)
Timing Diagram 2

Fill up 1 line buffer

Read 1 line buffer
Timing diagram 3 (Software)

1. Generation of light saber
2. Filling up a RAM for communication with hardware

Read blue/green data
Real time Video Display

- 60 fps display
  - To emulate real time video

- No frame storage
  - SRAM not dual ported
  - SDRAM is a time deterrent
  - Real item display on the fly

- Usage of 2 line buffers
  - Swap between the 2 line buffers
  - Avoids loss of information

- No interlacing
  - replicating even/odd frame
Color detection

- Conventional approach
  - Euclidean distance
  - Intense computations hence delay

- Our approaches
  - RGB vs YCrCb
    - RGB has varying threshold with varying intensity of light
    - YCrCb has greater tolerance
Light saber generation

- Find centre of mass for ends of sword
Light saber generation

- Calculate the slope of the line
Light saber generation

- Use a predefined sword width and halo width
Light saber generation

- Filling the coordinate table
Software Design

- Centre of mass calculation
- Using theta calculations find the four edge points of the light saber for a predefined width.
- Use a table to store the X1 and X2 for each line displayed by the VGA.
Design challenges

- For real time video display
  - Horizontal sync and Vertical sync w.r.t incoming video from ADV 7181
- Achieving 60 fps
- Making the system work without frame buffers
- Deal with multiple clock domains
Design challenges (contd..)

- Floating point calculations
- Line drawing algorithms
- Synchronization with the VGA module in hardware
- Hardware signals are sampled more than once
Lessons learnt

- Start early
- DE2 Terasic real time video code is all junk
- Design timing diagrams before implementation
- Conventional measuring techniques like CRO are life savers
- More time for debugging
May the force be with you!!!
Thank You