Invisible Curtain

Abhijeet Nayak (an3075)
Srivatsan Raveendran (sr3859)


COLUMBIA UNIVERSITY
IN THE CITY OF NEW YORK

1 Motivation

- Implement Chroma-keying on video stream relayed through a composite camera
- A red color foreground cloth is chosen
- When held before the camera, it gets masked to display the background

Video Processing Features

Feature	SW [9:0]
Invisible Cloak	0
Video OFF (for privacy)	1
Captured Background	2
Red Filter Video	3
Green Filter Video	4
Blue Filter Video	5
Grayscale Video	6
Invert Video	7
Low Brightness Video	8
High Brightness Video	9

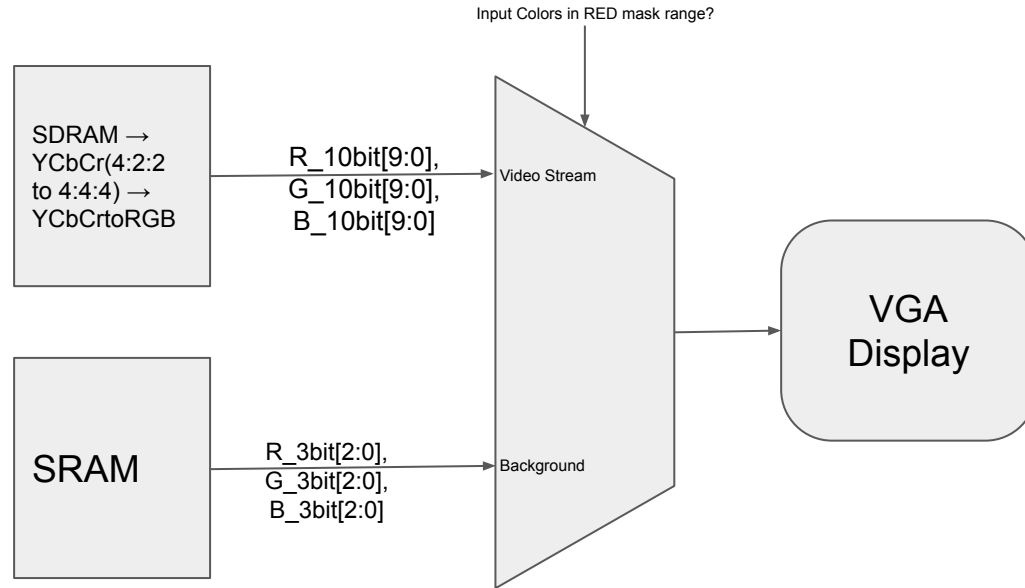KEY[0] → RST
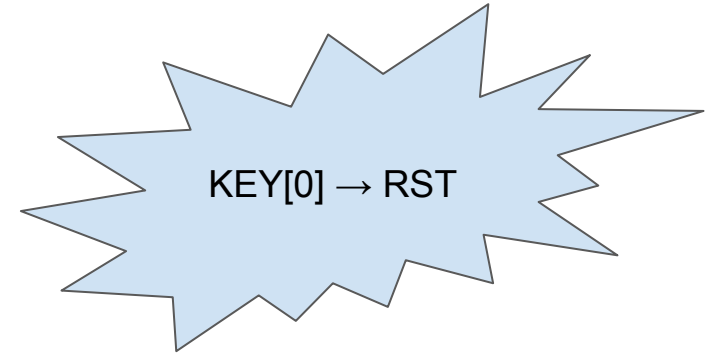
2 Systems Architecture
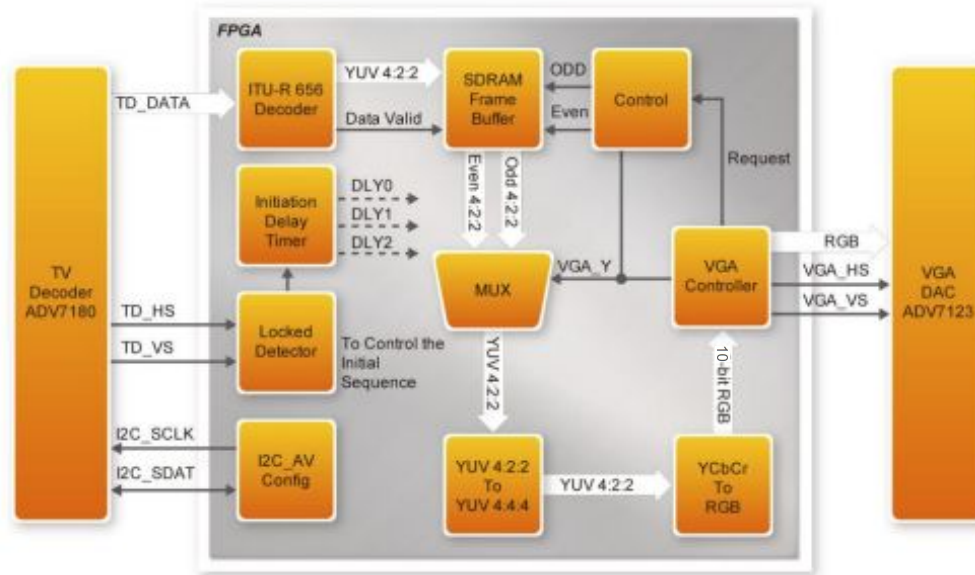
3 NTSC

- Low resolution
- Auto-gain to adjust saturation
- Output data in YCbCr format
- Access from FPGA through ADV 7180

Color Format Used

- 16 bit YCbCr 4:2:2
- 24 bit YCbCr 4:4:4
- 10 bit RGB

Chromakey

Input Colors in RED mask range?

SDRAM →
YCbCr(4:2:2
to 4:4:4) →
YCbCrtoRGB

R_10bit[9:0],
G_10bit[9:0],
B_10bit[9:0]

Video Stream

SRAM

R_3bit[2:0],
G_3bit[2:0],
B_3bit[2:0]

Background

VGA
Display

Memory Management -I

Video Stream Buffer
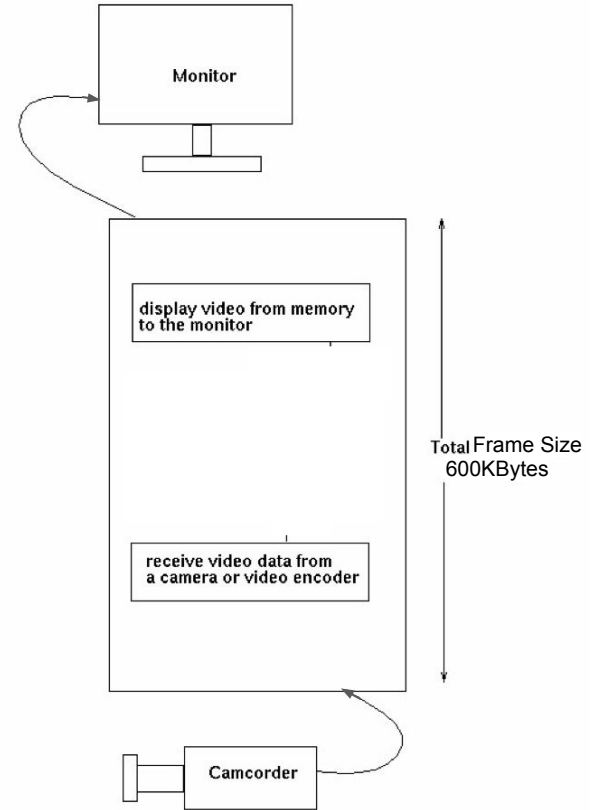
→ YCbCr - 16 bit per pixel

→ 1 Frame = 16 x 640 x 480 = 4915200 bits ⇒ 600 KB but available only 512 KB in SRAM

SDRAM (4 - port)

→ Buffered each frame

→ Interlaced Write, Deinterlaced Read

Memory Management -II

Background Image
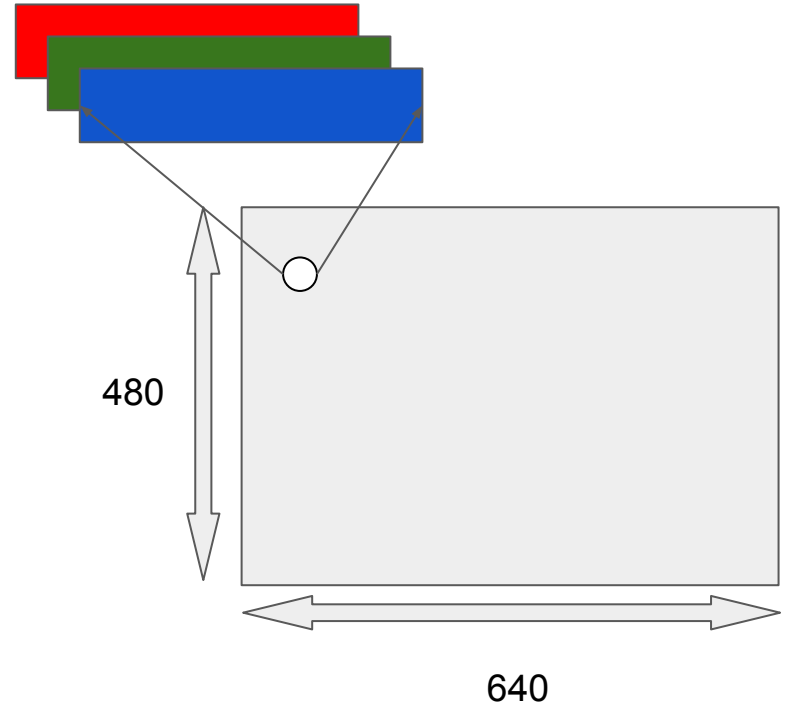
→ RGB - 3 bit per pixel, 3 channels

→ 1 Frame = 3 x 3 x 640 x 480 = 2764800 bits ⇒ 337.5 KB

→ Cannot use DRAM due to 2 port deinterlace logic ⇒ SRAM

SRAM

→ Store frame on RST

→ Read when Mask Enabled

480

640

Challenges

- Color Detection
  - Perfecting the threshold for detecting real-world red shades - varied lighting
- Memory Constraints in SRAM
  - Moved to SDRAM
- Handling aliasing artefacts
  - Accessing only Active Frame region using corrected HCount, VCount information to address pixel frame from memory
- SDRAM Synchronization
  - 3ns lead - PLL
  - Handling reads from 2 different memory areas – Background & Video Stream

Smelling rosemary increases memory

Sniff **rosemary**. The herb has been shown, in trials, to improve working **memory** because it appears to have an arousing effect on a brain

DE1

Sniff
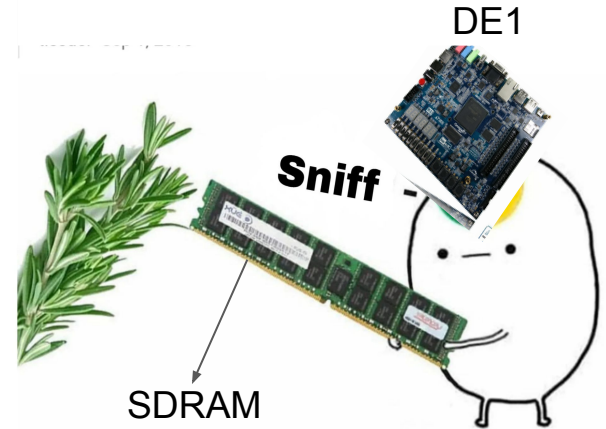
SDRAM

What Could have been better? – Future Ideas

- Wider use of SDRAM ⇒ More bits for Background
- Connect to HPS – Software image processing + 1GB SDRAM
- Send video over network - Video Call (Ethernet camera)

Testing & Debugging

- Test Cases
  - Check Color Mask with different shades of Red
    - Expanded Color Range incrementally
  - Check if system works after reset - aliasing after reset
    - Resolved VGA → SRAM addressing issue
  - Background Storage - Isolating issue between camera & memory
    - Generated image in python and copied to SRAM
  - Test all
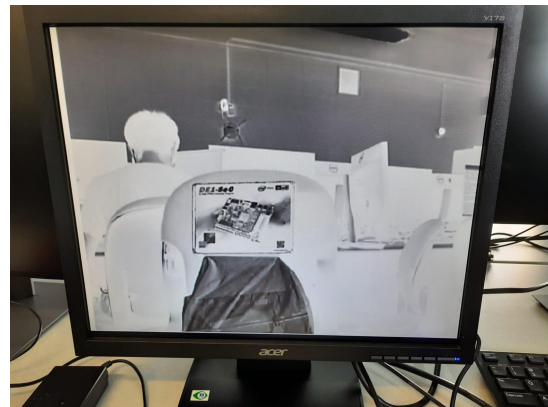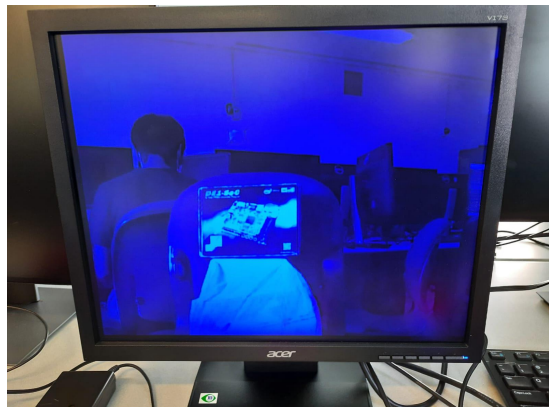   - Covered possible video processing modes toggled through HW switches

Current_X = HCont-HBlank
Current_Y = VCont-VBlank
Addr =
Current_Y*H_Active+Current_X
XBlank = XFront+XSync+Xback

Invisibility in action
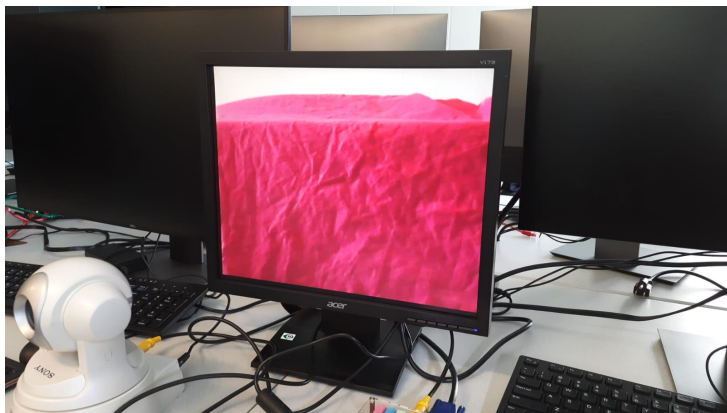
Other features

Thank you for listening!
Open to Questions & Suggestions