Seam Carving Through Time
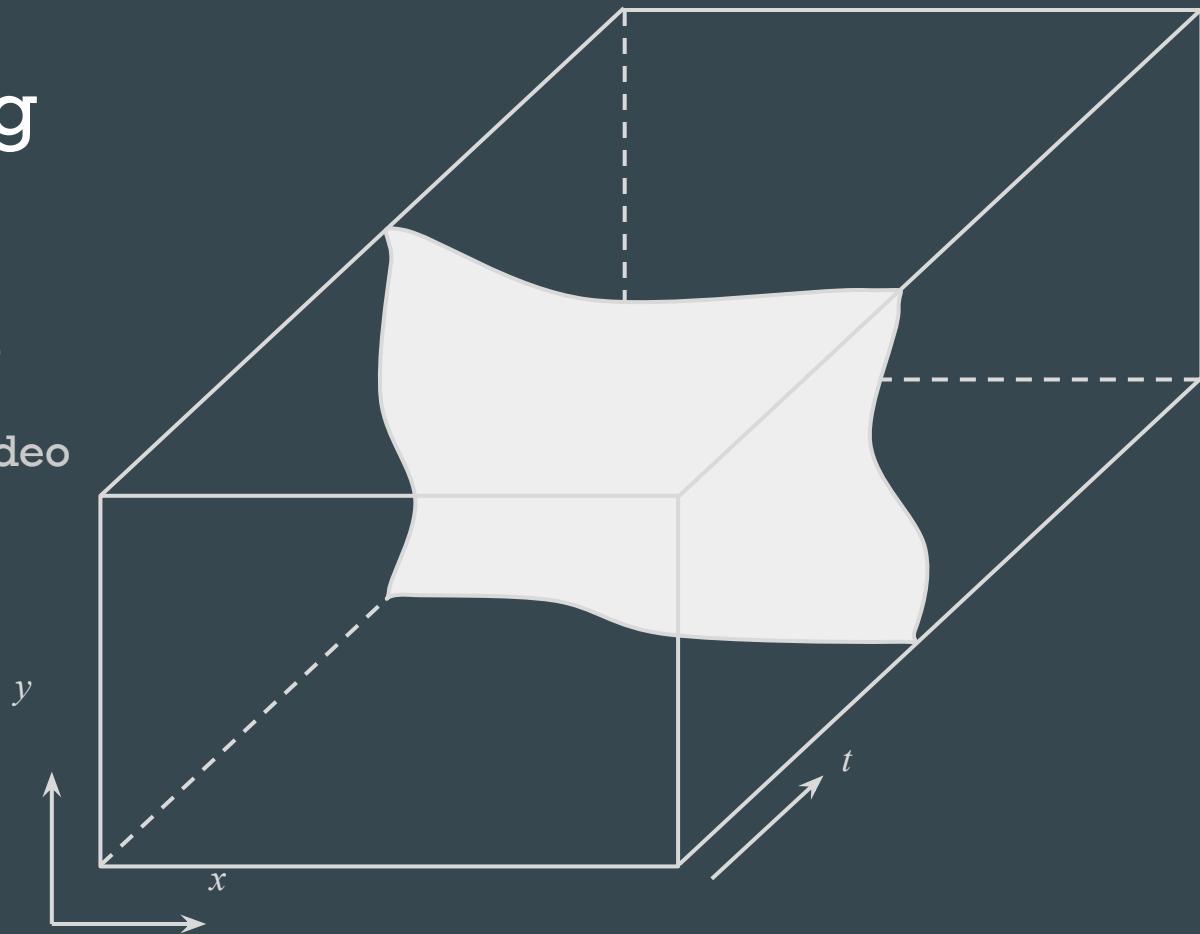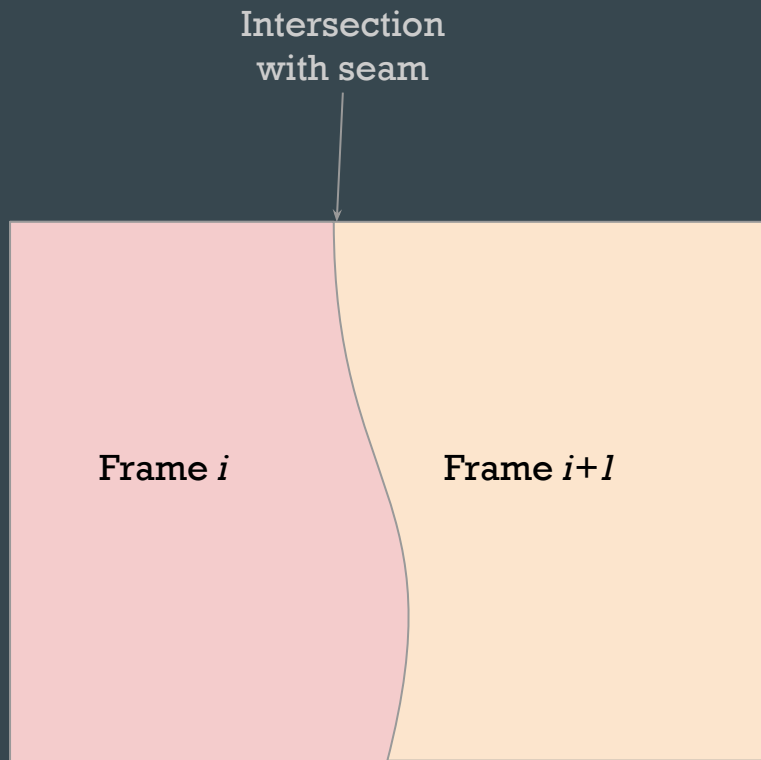
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Team BD

Maxwell Johnson - John Zhang - Riki Khorana

3D Seam Carving

- Calculate energy map

- Find 2D low energy seams

- Cut out seam to shorten video

Resulting in...

Intersection
with seam

Frame *i*

Frame *i+1*

Our Project

Apply Seam Carving
shorten video by 1.5x

Application Survey
what video works well?

Develop Heuristics
further improve output quality

Acceleration
delegate computation to FPGA

High-level Requirements: Spec

Requirement	Metric
Process a video with time length T in 3T time	Time the system from the beginning of the pre-processing to the end of the post-processing
Process a 360p and 24fps video	Input video with 360p 24fps specs, and verify that the system produces a valid output
Increase playback speed of a video by 1.5 times	Input a video of time T, and verify that the resulting video has time 2T/3
Support at least three popular video file formats as input	Input at least three videos of select file formats, and verify that the system produces a valid output

High-level Requirements: Content

Requirement	Metric
Result has smooth frame transitions	Run resulting video through energy function, and compare against standard
Result has no obvious content distortion	Conduct a user survey to have them rate 1 ~ 10. Pass if average score is > 8.5
Result has original order of events preserved	Input a synthetic video, and count how many events were misplaced in the output video

Solution Architecture Design
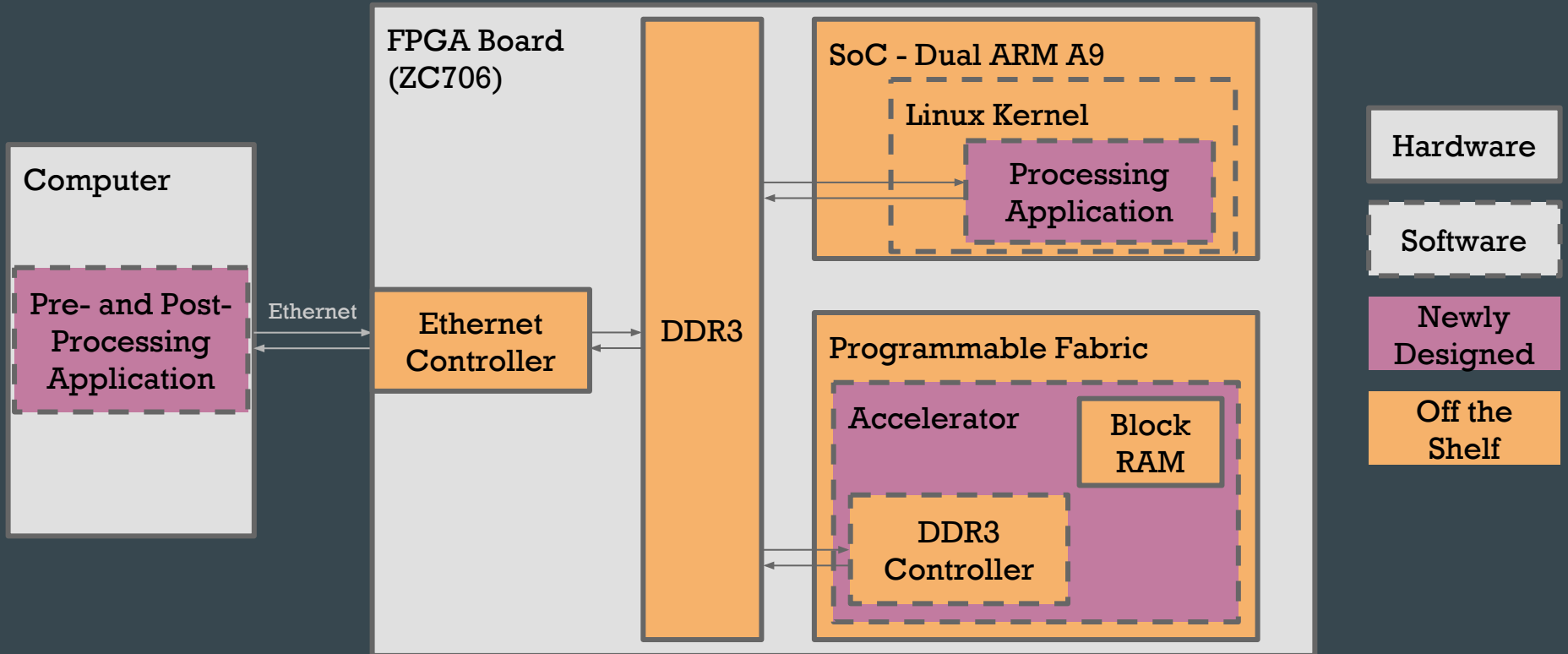
Low-Level Requirements & Metrics

- Pre- and Post Processing Application (Software)

Requirement	Metric
Convert videos to an FPGA readable format	Run the processing application and FPGA board interface to verify
Transfer videos to the FPGA through Ethernet	Run the processing application and FPGA board interface to verify

Low-Level Requirements & Metrics

- System on a Chip (SoC)

Requirement	Metric
Runs Linux Kernel as embedded operating system	Kernel set up correctly; RAM access mapped correctly;
Extracts a seam made of pixels with the lowest energy from a given energy map	Unit testing (The algorithm for searching for a low energy seam may be approximated to compensate for process speed)
Reads the video data from the RAM and performs seam carving	Unit testing for "Reading", "Modifying" and "Writing back"

Low-Level Requirements & Metrics

- Accelerator (Programmable Fabric)

Requirement	Metric
FPGA block RAM has capacity of at least 9.4Mb	Check if target met on the Vivado synthesis report
Process the energy function at 2400 fps	Use a simulation tool (VCS) to test the frame rate
Write the result of energy function to RAM at 2400 fps	Use a simulation tool (VCS) to test the frame rate

Board Capacity Utilization

	Board capacity	One test processing unit	640 test processing units (1 row of pixels)	Utilization of 640 test units
Logic cells	350000	-	-	-
Block RAMs (36Kb (kilo-bits))	545	-	-	-
Block RAM capacity (Kb (kilo-bits))	19620.0	15	9600	**48.9%**
LUTs (Look-up-tables)	218000	65	41600	**19.1%**
FFs (1-bit flip flops)	437000	80	51200	**11.7%**
DSP slices (used for multipliers)	900	1	640	**71.1%**

Division of labor

- Maxwell
  - Programmable fabric
- John
  - SoC processing application
- Riki
  - Pre- and Post Processing application
  - Implementation of seam carving algorithm
  - Development of high-level test suites

Timeline

Task Name							
Software Application				Software Application			
Research seam carving techniques		Research seam carving techniques					
Implement seam carving applications			Implement seam carving applications				
Video Processing Application			Video Processing Application				
Testing Framework						Testing Framework	
Energy Function				Energy Function			
Process existing videos				Process existing videos			
Refine metrics				Refine metrics			
Event Ordering					Event Ordering		
Set up metrics					Set up metrics		
Create testing videos					Create testing videos		
Distortions						Distortions	
Develop user test				Develop user test			
Carry out user tests					Carry out user tests		
Aggregate user test data						Aggregate user test data	
Hardware Research							
Determine hardware requiements							
Evaluate hardware options, select FPGA							
Research off-board communication options							
Toolchain and Hardware setup						Toolchain and Hardware setup	
Load Linux kernel on SoC	Load Linux kernel on SoC						
Load design on FPGA using Vivado	Load design on FPGA using Vivado						
Instantiate DDR3 controller IP		Instantiate DDR3 controller IP					
Memory transfer between fabric and SoC			Memory transfer between fabric and SoC				
Communicate between SoC and computer				Communicate between SoC and computer			
Load video into FPGA fabric				Load video into FPGA fabric			
Hardware Accelerator					Hardware Accelerator		
Design hardware to compute energy function					Design hardware to compute energy function		
Implement, debug design					Implement, debug design		
Interface with SoC						Interface with SoC	
SoC Acceleration					SoC Acceleration		
Preprocessing Application					Preprocessing Application		
Load video from computer					Load video from computer		
Dispatch tasks to FPGA						Dispatch tasks to FPGA	