FPGA Accelerated Seam Carving for Video

A Design Overview

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Application Area

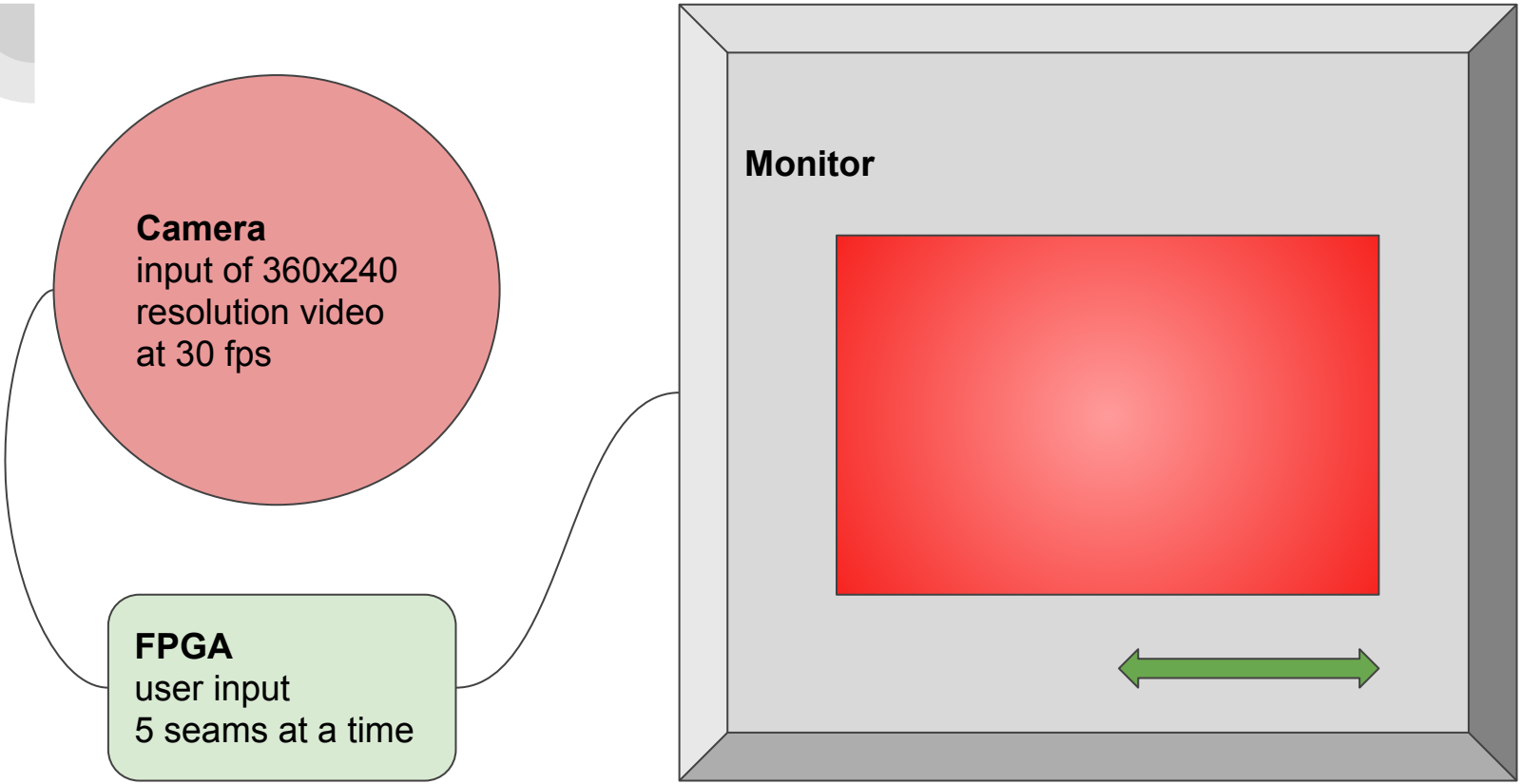
Content-aware re-scaling intelligently targets parts of the frame to remove.

- Reduced video size (users often run out of space)
  - Carve out unwanted pixels and save what's important
- Draw attention to important aspects of video
  - Highlight important aspects by removing unwanted seams
- Video processing is often slow
  - FPGA for Acceleration

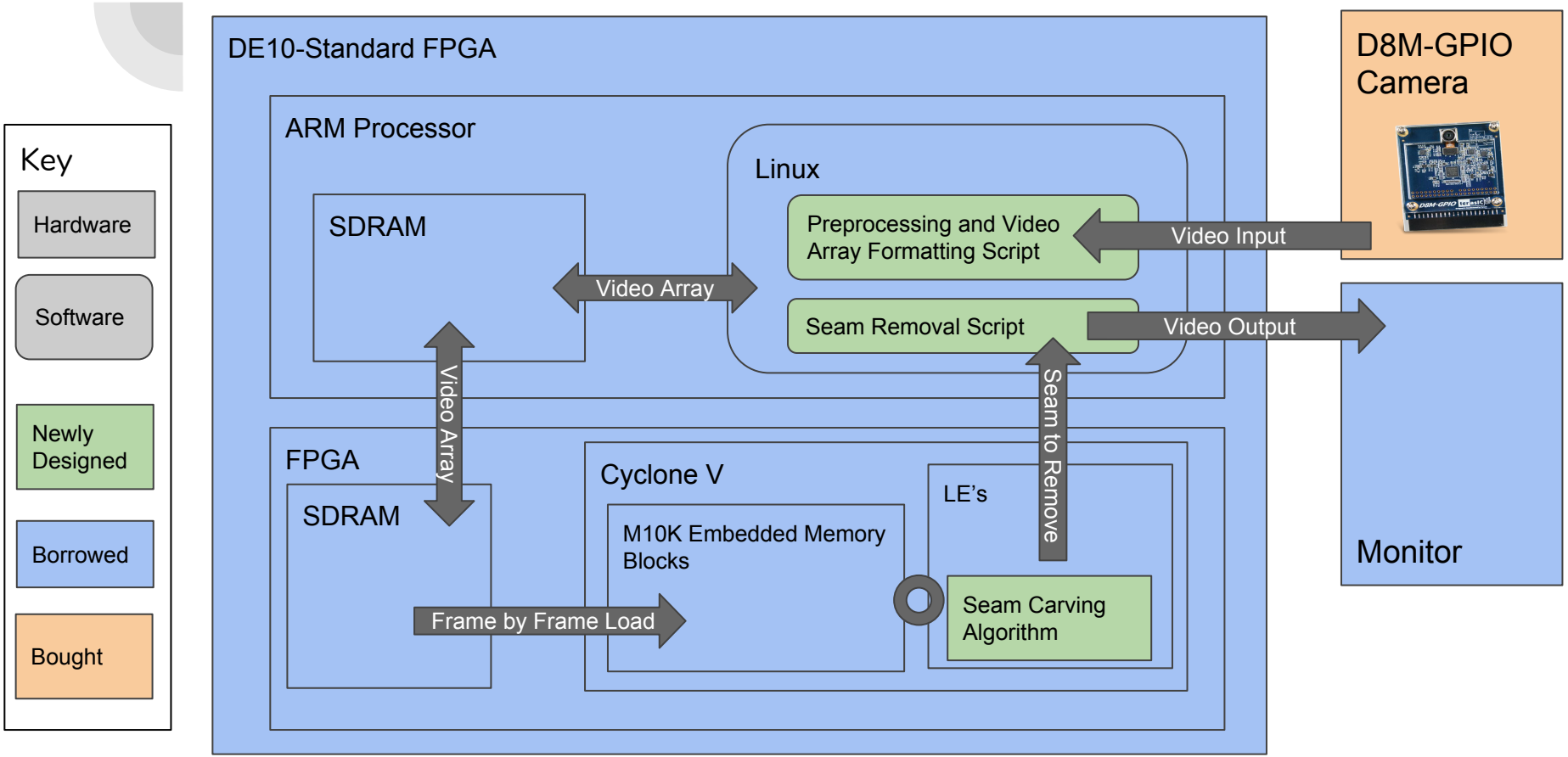
Application Area

Naive implementation of restitching of seam-carved images shown on left (spatial only). Static seam carving on right uses temporal and spatial so less distortion. Computational complexity becomes the *bottleneck* of the implementation of the algorithm. A hardware-oriented seam carving algorithm using FPGA is proposed to improve performance.

Overview of MVP



Block Diagram: Data Transfer through Hardware



Algorithm Overview

Stage 1 | Stage 2 | Stage 3

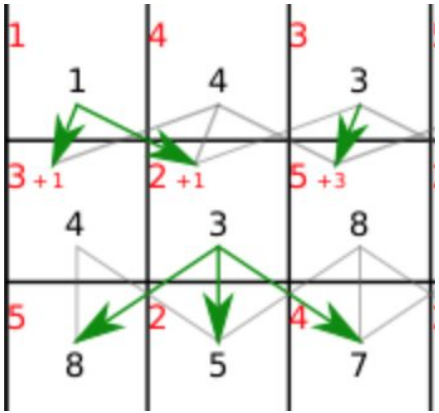
-1	0	+1
-2	0	+2
-1	0	+1

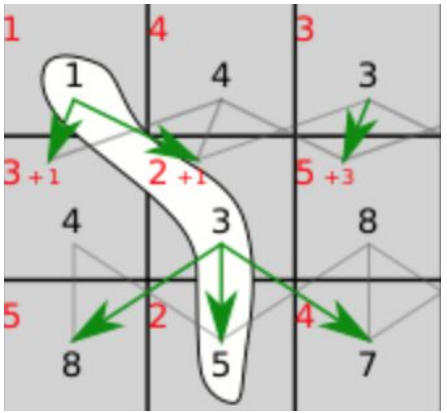
x filter

+1	+2	+1
0	0	0
-1	-2	-1

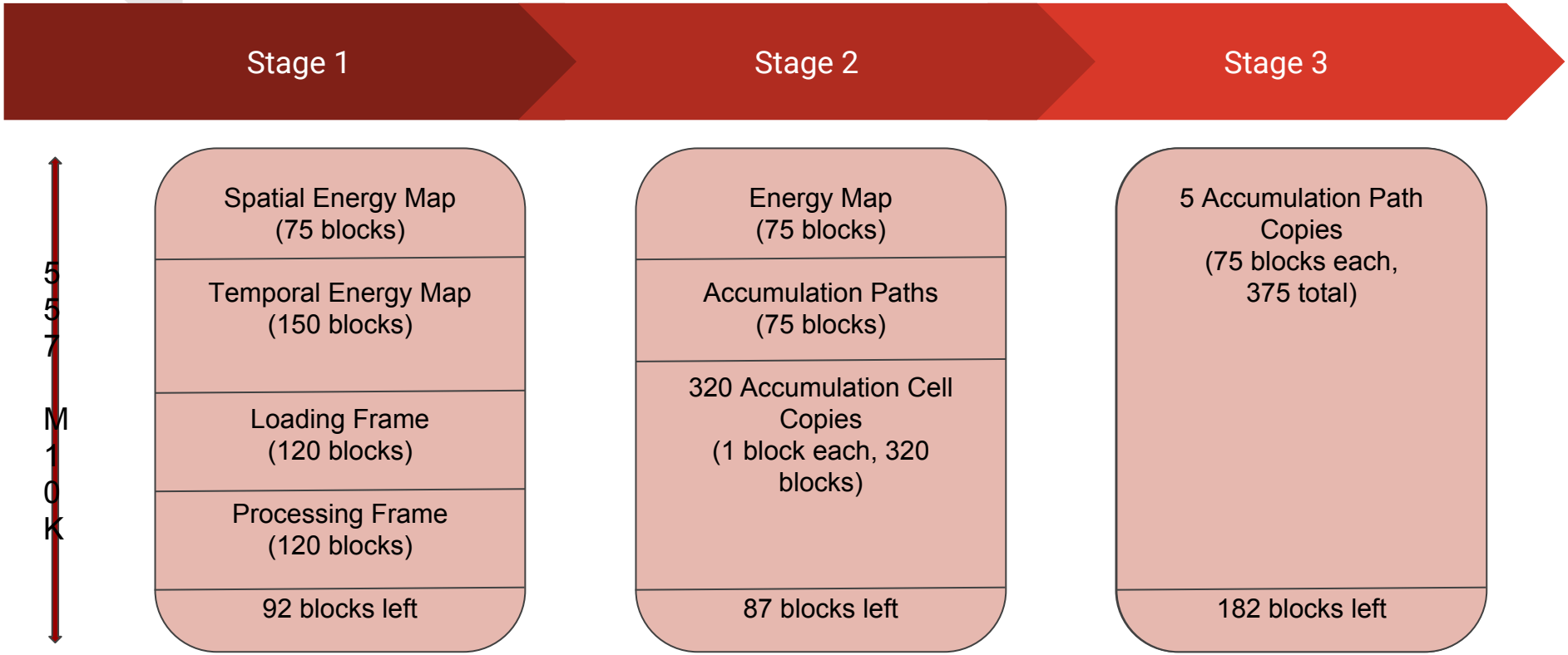
y filter

$$E_{\text{temporal}}(i,j) = \max_{t=1}^{N}\{|\frac{\partial}{\partial t} I_t(i,j)|\}$$





Memory Allocation in FPGA



Algorithm Implementation

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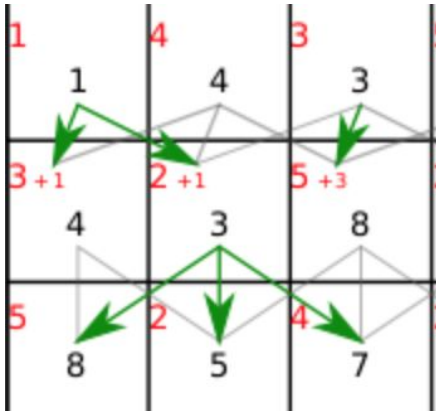
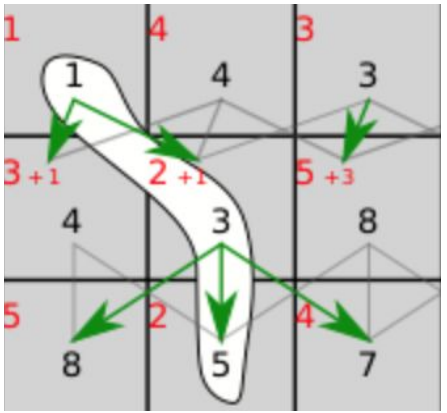




Metrics and Validation

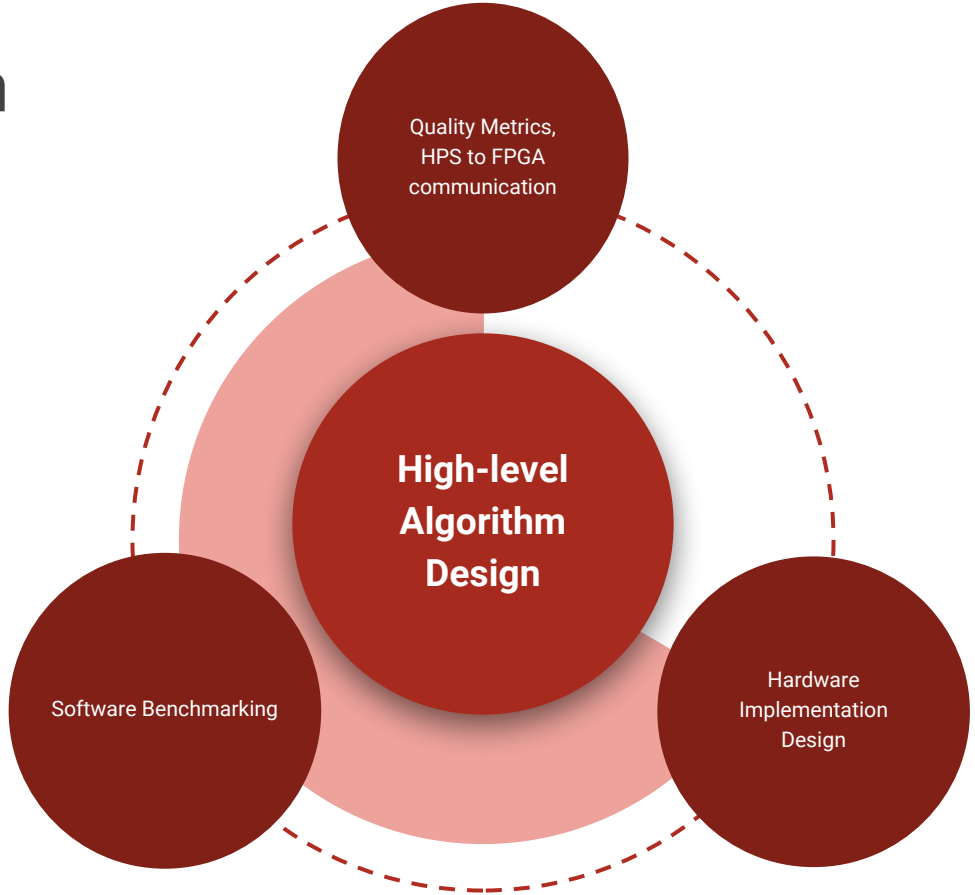
01	**Timing**	• Compare against benchmark C++ implementation of seam carving • Goal: 5x speedup
02	**Video Quality**	• PSNR, Spatio-temporal SSIM • User testing • Goal: <10% error compared to results from C++ implementation
03	**Risk Factors/Unknowns**	• Remove less seams at a time (<5) • Change blocking to optimize parallelization • Memory consumption + timing analysis for test matrices using Quartus

Benchmark Analysis (360x240 at 30 fps with 1.4 GHz Intel Core i5)

Seams	Time	Cycles
↓	↓	↓
• 30 vertical seams	• 10.646925 seconds	• 132360837 cycles

Work Distribution

Eshani



Kimberly

Shruti

Schedule

Ongoing and future tasks up until spring break.

(Post spring break for slack time as well as adding planned extension steps)