Difference of Gaussian Scale-Space Pyramids for SIFT[1] Feature Detection

[1] Lowe, David G.
Distinctive Image Features from Scale-Invariant Keypoints,
International Journal of Computer Vision, 2004.

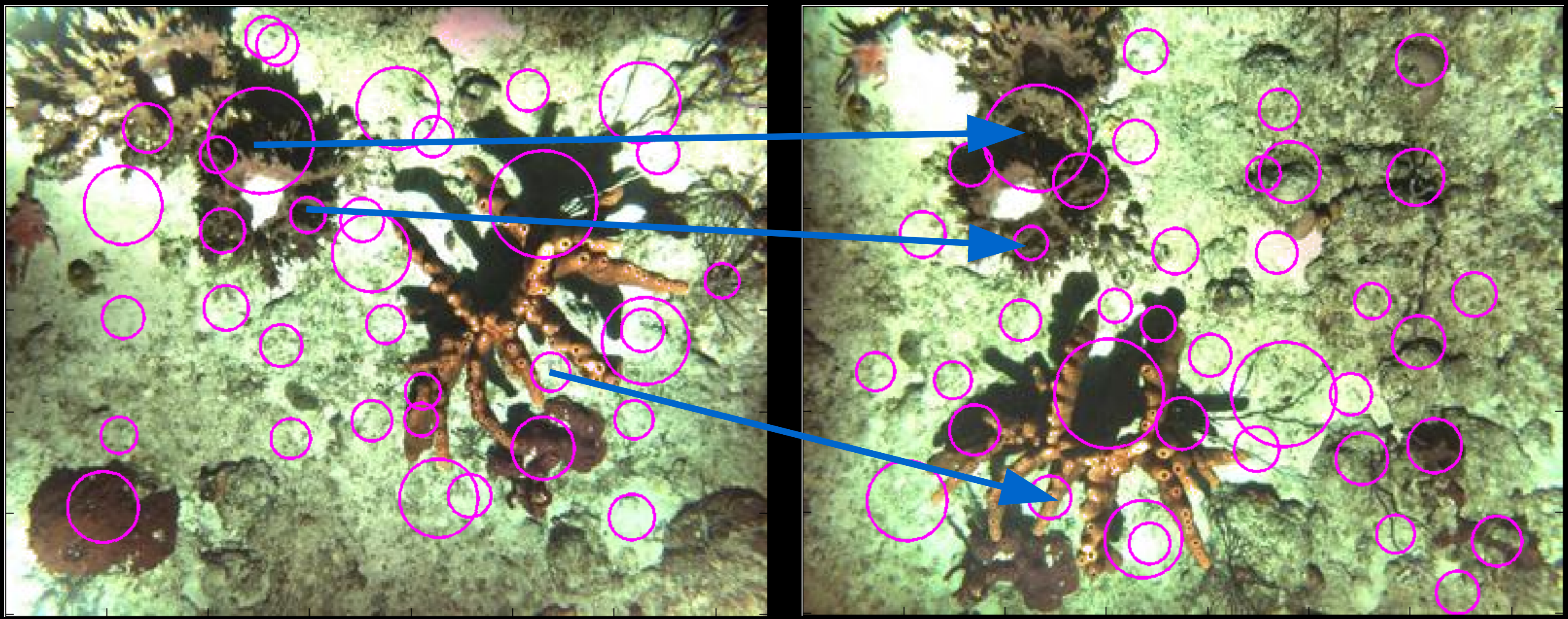
Chris Murphy
Ballard Blair

6.375

Difference of Gaussian Scale-Space Pyramids

Two images of a Coral Reef near Puerto Rico.
How do we align, or ***register***, them?

Difference of Gaussian Scale-Space Pyramids

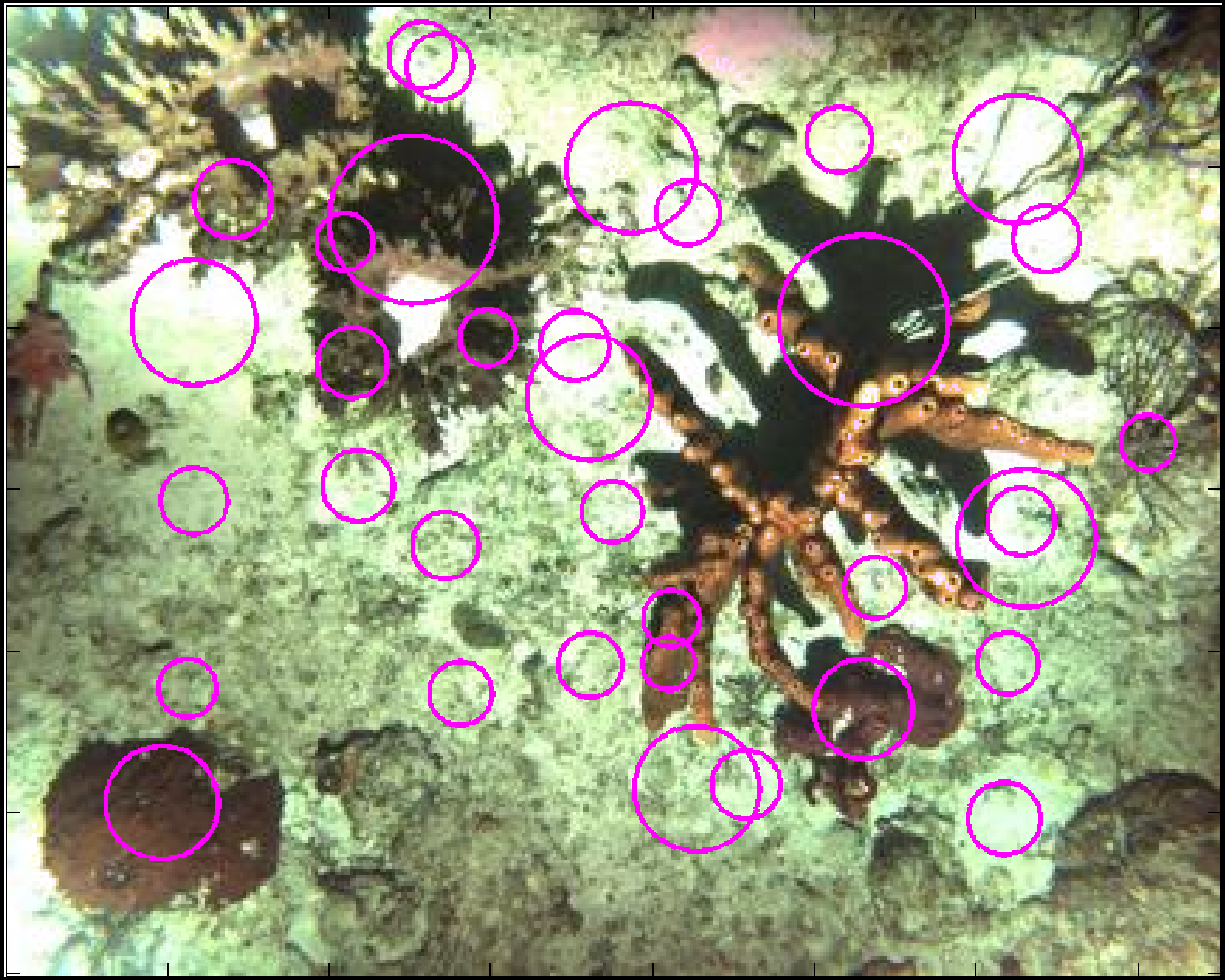


We have to figure out which points in one image, or ***features*** match which ***features*** in the other image.

Difference of Gaussian Scale-Space Pyramids

Then, we can calculate the best coordinate transform from one image to the other image, and blend them.

Difference of Gaussian Scale-Space Pyramids

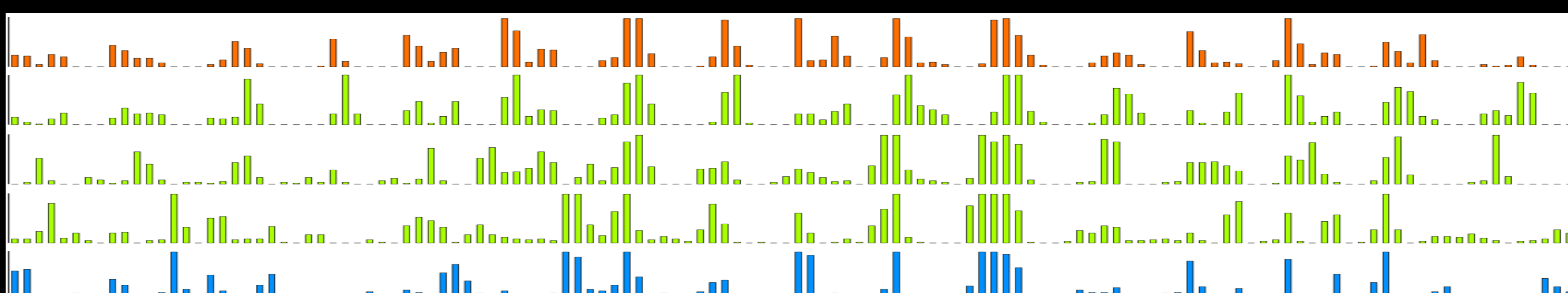


How do we find these features?

Difference of Gaussian Scale-Space Pyramids

How do we find these features automatically? SIFT!
SIFT finds good* features, consisting of:

- An X, Y location
- A scale
- An orientation
- A ***Feature vector;*** a 128 bin Histogram of gradient values used to identify and match features between images.



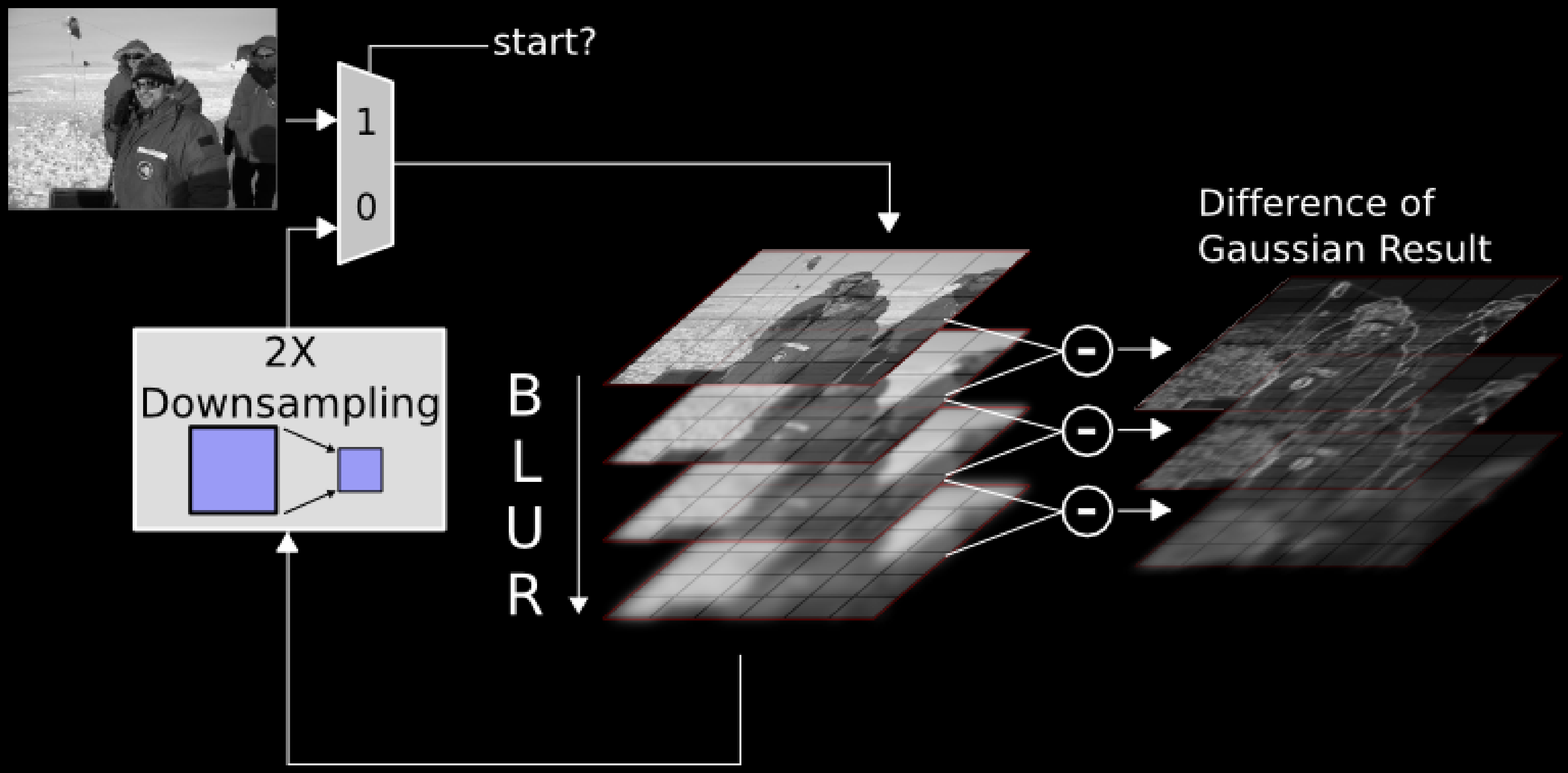
* “Good” being defined as relatively robust to change in lighting, viewpoint, or occlusions.

Difference of Gaussian Scale-Space Pyramids

SIFT looks for extrema in ***Difference of Gaussian*** filtered versions of an image. This computation is done for many image sizes, or ***Octaves***, and with a variety of different strength blurs, or ***Scales.***

Calculating these ***Difference of Gaussian*** images in hardware was the focus of our project.

Difference of Gaussian Scale-Space Pyramids

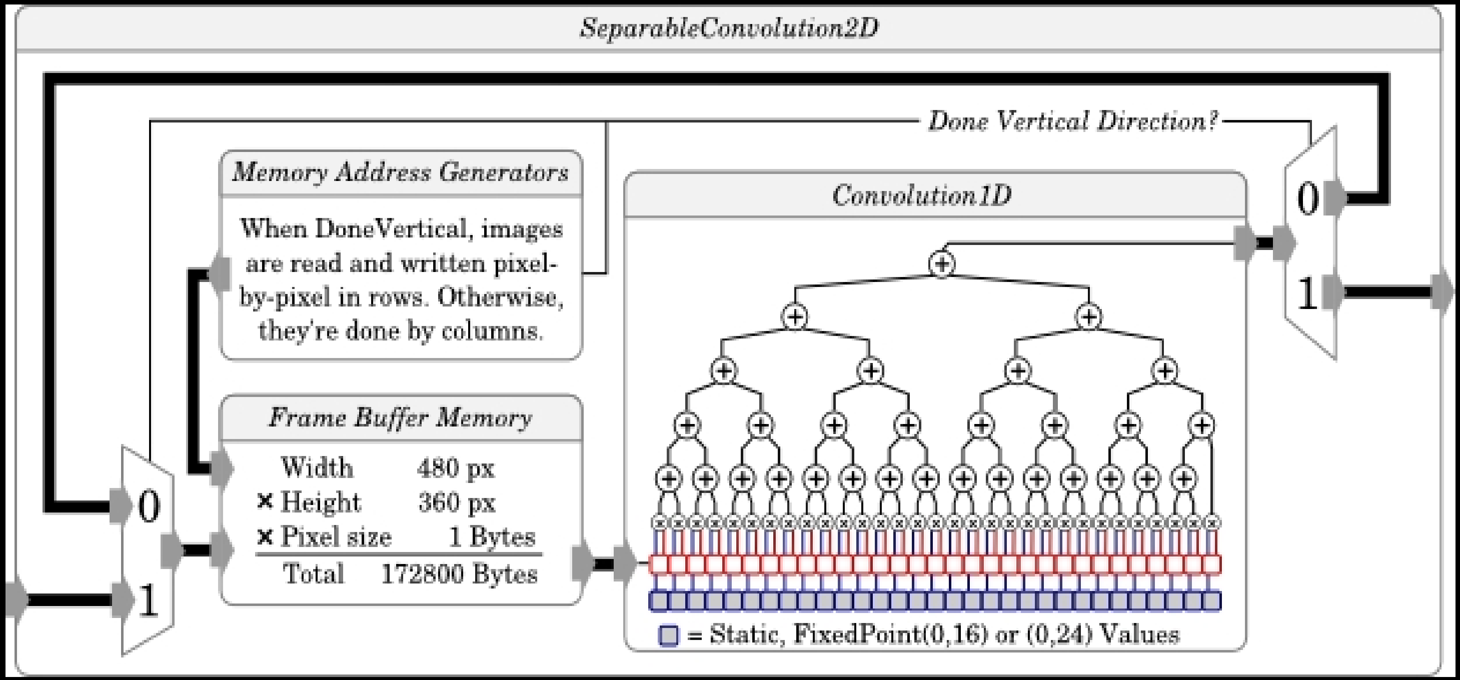


High level architecture:

- Input Multiplexer
- Blur Units
- Down-sample feedback
- Difference Units

Difference of Gaussian Scale-Space Pyramids

Gaussian blur is achieved through ***Convolution***



Hardware:

- Shift Register
- Multiply
- Accumulator

Difference of Gaussian Scale-Space Pyramids

Difference of Gaussian Scale-Space Pyramids

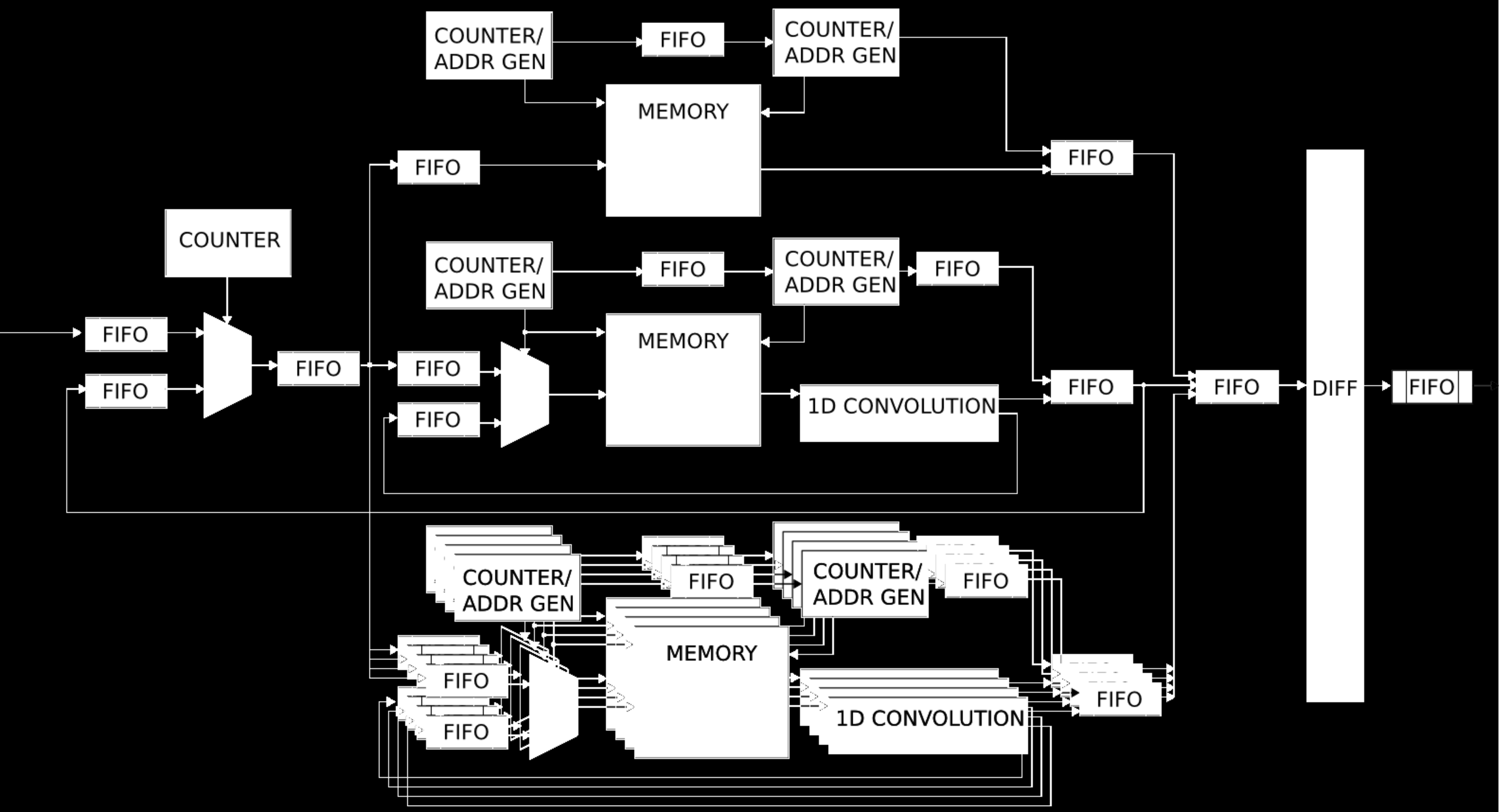
Architecture decisions:

- Self contained blur units
- Separable Convolution
- Separate Image Buffers

Implications:

- Lots of Memory (~1MB)
- Parallel execution
- Distributed control

Difference of Gaussian Scale-Space Pyramids



Difference of Gaussian Scale-Space Pyramids

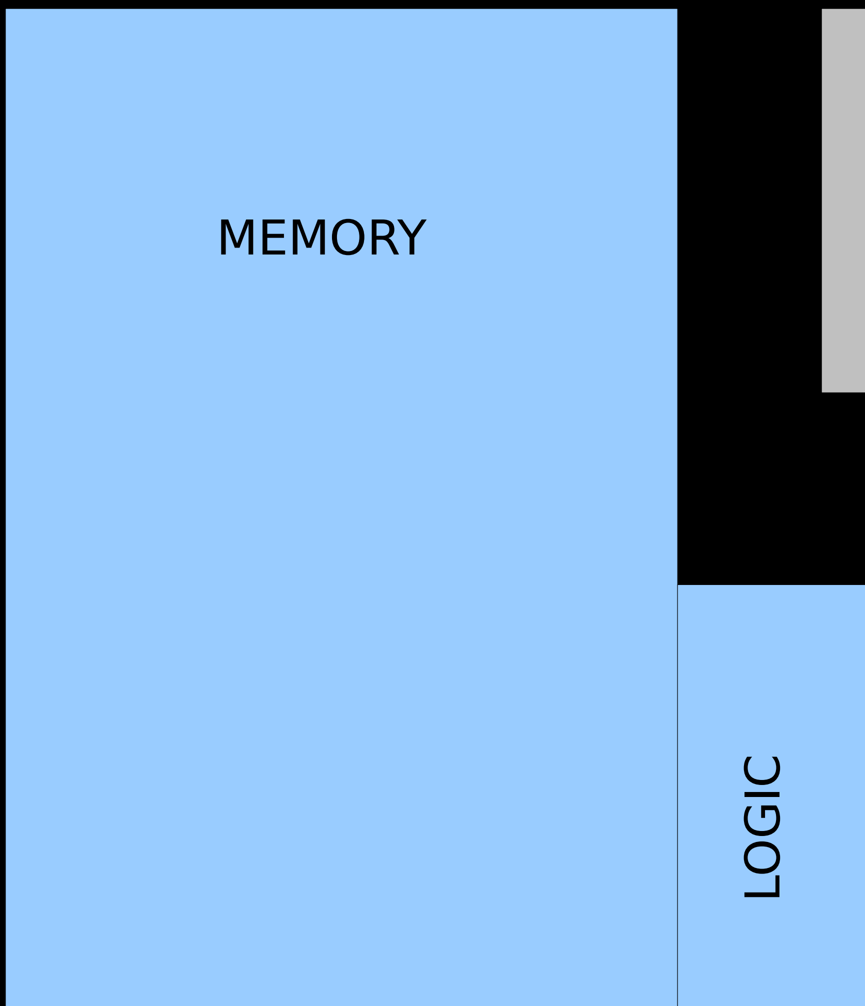
Memory Management

- 6 memory units in design
- Address Generation
- Down-sampling
- Extra pixel reads

Hardware:

- 43 generated RAMs per unit
- Write / Read timing
- RAM generator

Difference of Gaussian Scale-Space Pyramids



Size:

w/o MEM: 1058500 um^2
w/ MEM: ~10000000 um^2

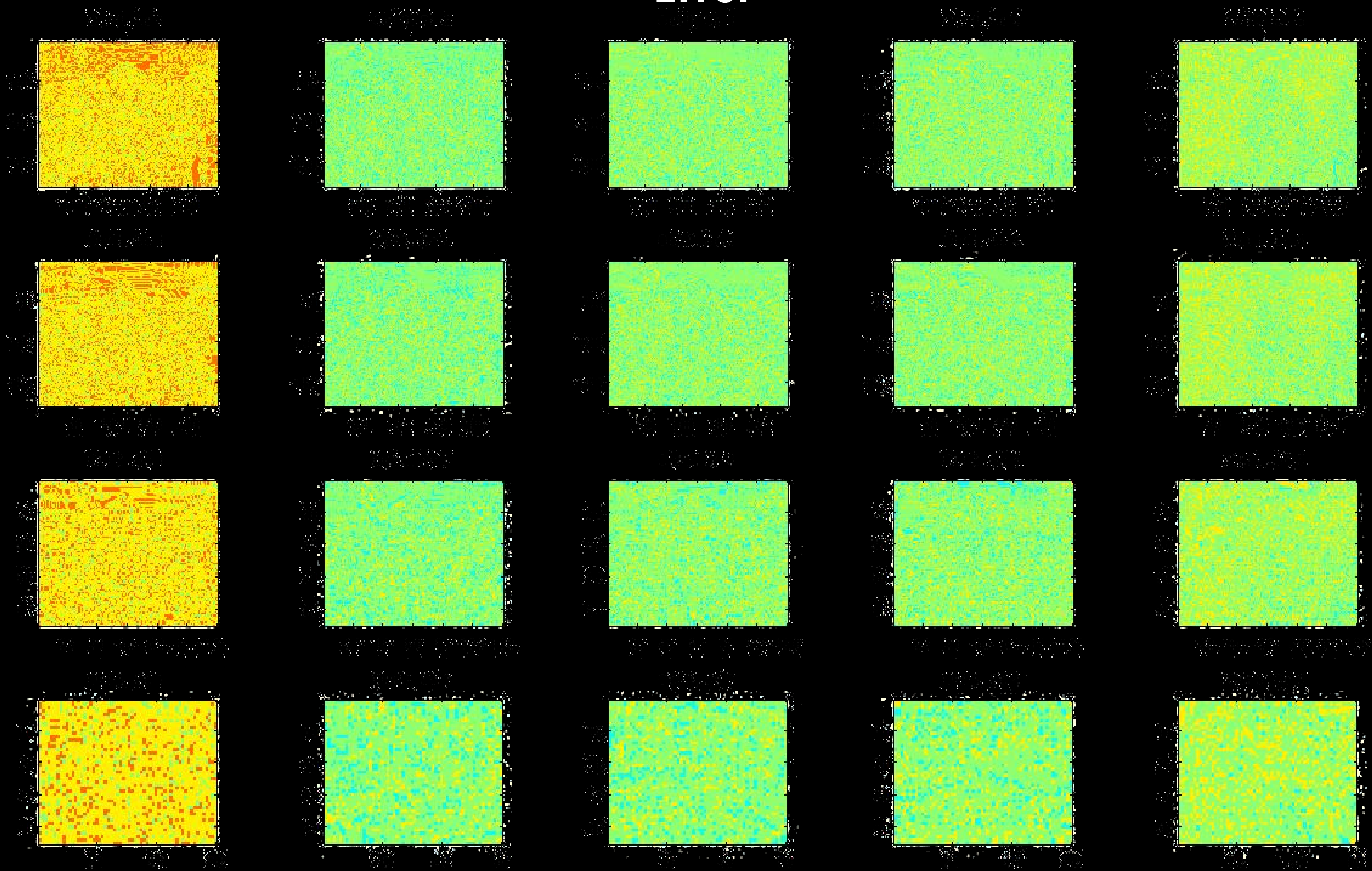
Speed (w/o MEM):

Clock:	155 MHz
Cycles per image:	750,000
Images per Sec:	200

Difference of Gaussian Scale-Space Pyramids

Difference of Gaussian Scale-Space Pyramids

Error



Difference of Gaussian Scale-Space Pyramids for SIFT[1] Feature Detection

[1] Lowe, David G.
Distinctive Image Features from Scale-Invariant Keypoints,
International Journal of Computer Vision, 2004.

Chris Murphy
Ballard Blair

6.375