Difference of Gaussian Scale-Space Pyramids for SIFT\textsuperscript{[1]} Feature Detection


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Two images of a Coral Reef near Puerto Rico.
How do we align, or register, them?
We have to figure out which points in one image, or *features* match which *features* in the other image.
Then, we can calculate the best coordinate transform from one image to the other image, and blend them.
How do we find these features?
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.
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.
High level architecture:

- Input Multiplexer
- Blur Units
- Down-sample feedback
- Difference Units
Gaussian blur is achieved through **Convolution**

### Hardware:

- Shift Register
- Multiply
- Accumulator
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
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
**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
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[1] Lowe, David G.
*Distinctive Image Features from Scale-Invariant Keypoints*,