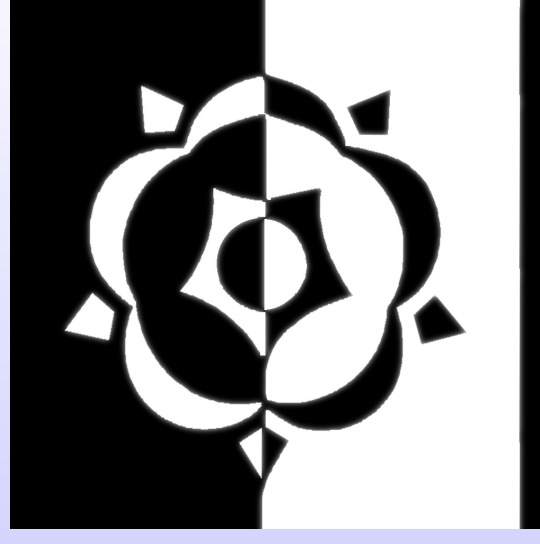




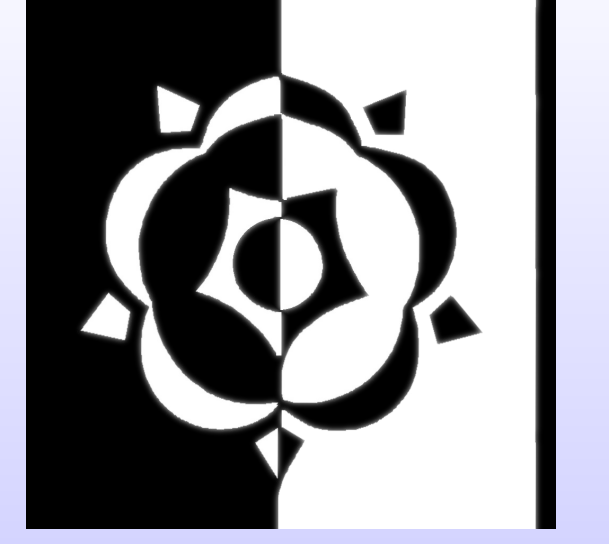
REAL-TIME COMPUTER VISION WITH RUBY AND LIBJIT

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Technologies for Simultaneous Multidimensional Imaging & Manipulation of Nanoobjects



Abstract

Many image processing algorithms can be broken down into atomic operations on arrays. There are unary operations such as additive inverse, absolute value, or square-root and binary operations such as addition or multiplication. While the arrays typically have elements of a single type, this element-type may be a signed or unsigned integer with 8, 16, 32, or more bits, a floating point number, or a complex number.

A computer vision library thus needs to implement binary operations for various combinations of element-types. Furthermore binary operations can occur as array-array-, array-scalar-, or as scalar-array-operation. This kind of requirements make it very hard to write a computer vision library in a statically typed language such as C++. On the other hand a naive implementation in a dynamically typed programming language such as Ruby will not satisfy real-time constraints.

However recently the DotGNU project has released libJIT which is a just-in-time compiler library for i386, x86-64, and other processors. The combination of Ruby, libJIT, and other free software allows interactive development of real-time algorithms in an unprecedented way.

Previous work: [WAD07], [WADB08], [HOR]

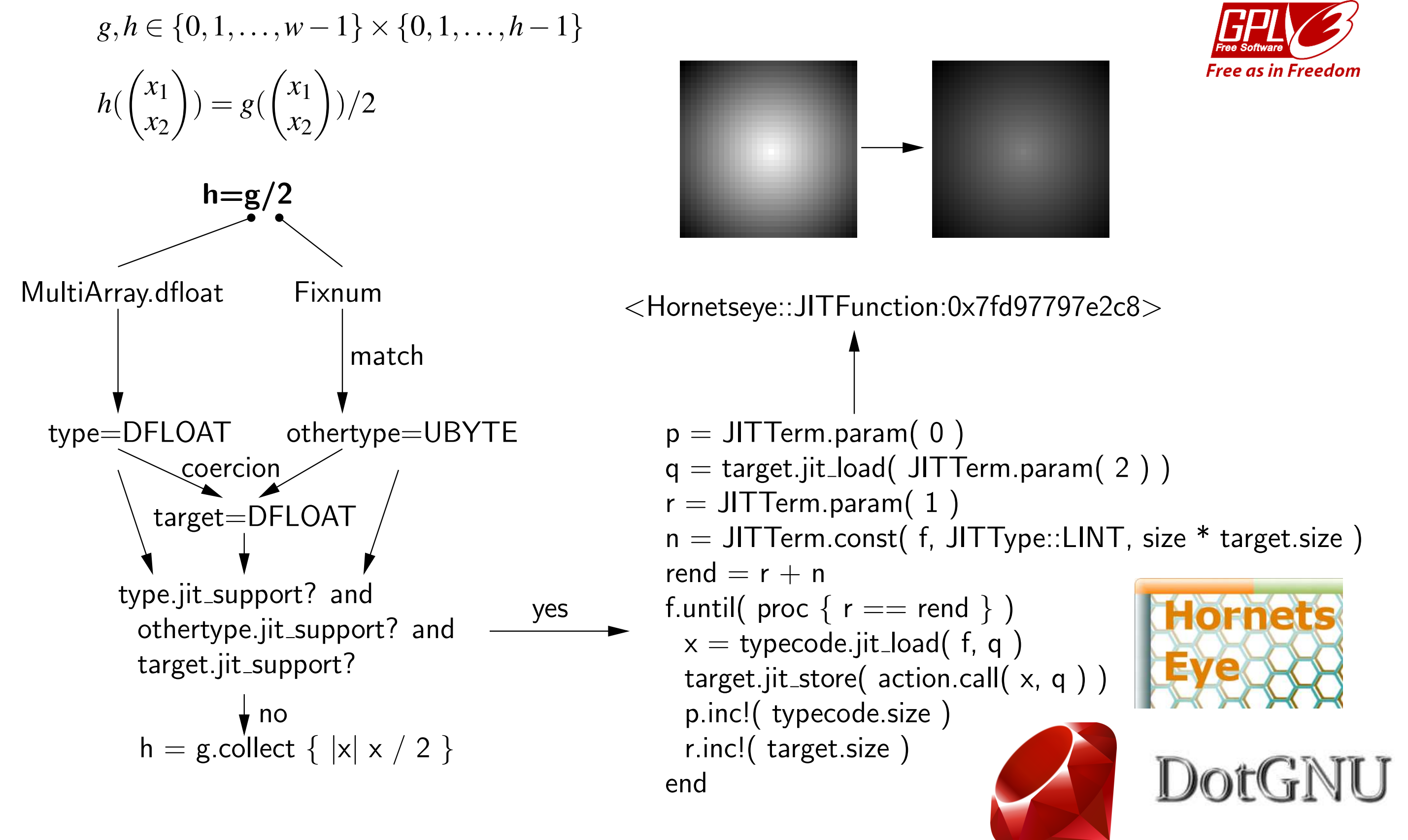
References

[HOR] Hornetseye. Web page. <http://hornetseye.rubyforge.org/>.

[WAD07] J. Wedekind, B. Amavasai, and K. Dutton. Steerable filters generated with the hypercomplex dual-tree wavelet transform. In *IEEE International Conference on Signal Processing and Communications*, pages 1291–4, 2007.

[WADB08] J. Wedekind, B. Amavasai, K. Dutton, and M. Boissenin. A machine vision extension for the Ruby programming language. pages 991–6, 2008.

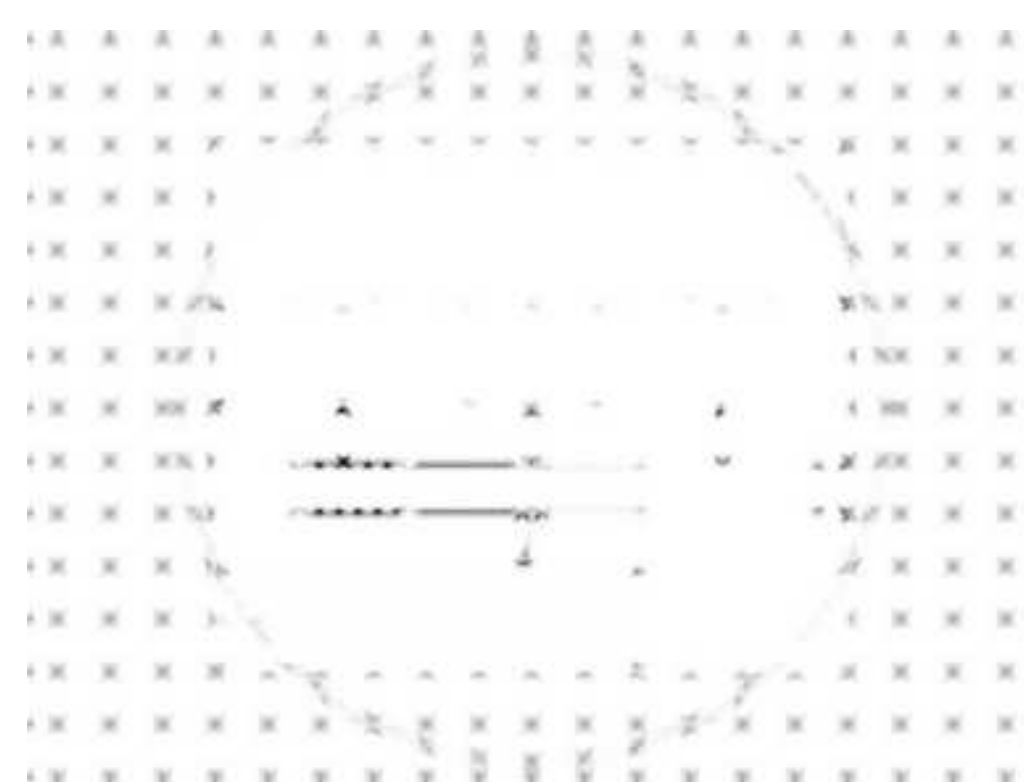
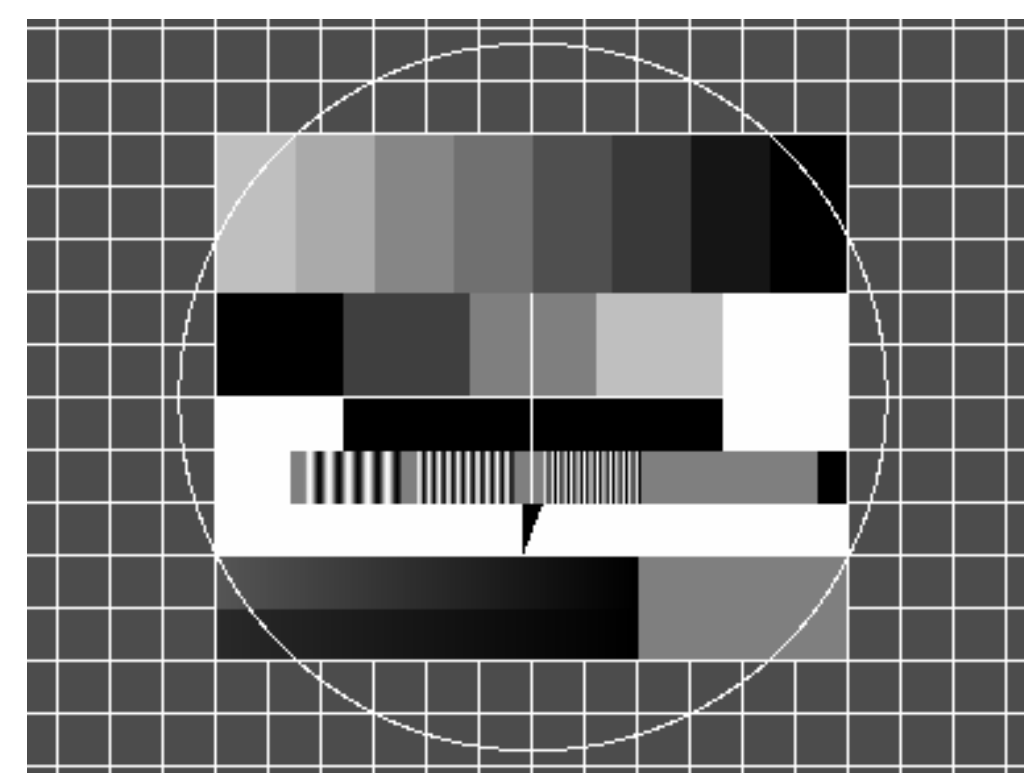
HornetsEye, libJIT, Ruby



Shi-Tomasi Corner Detector

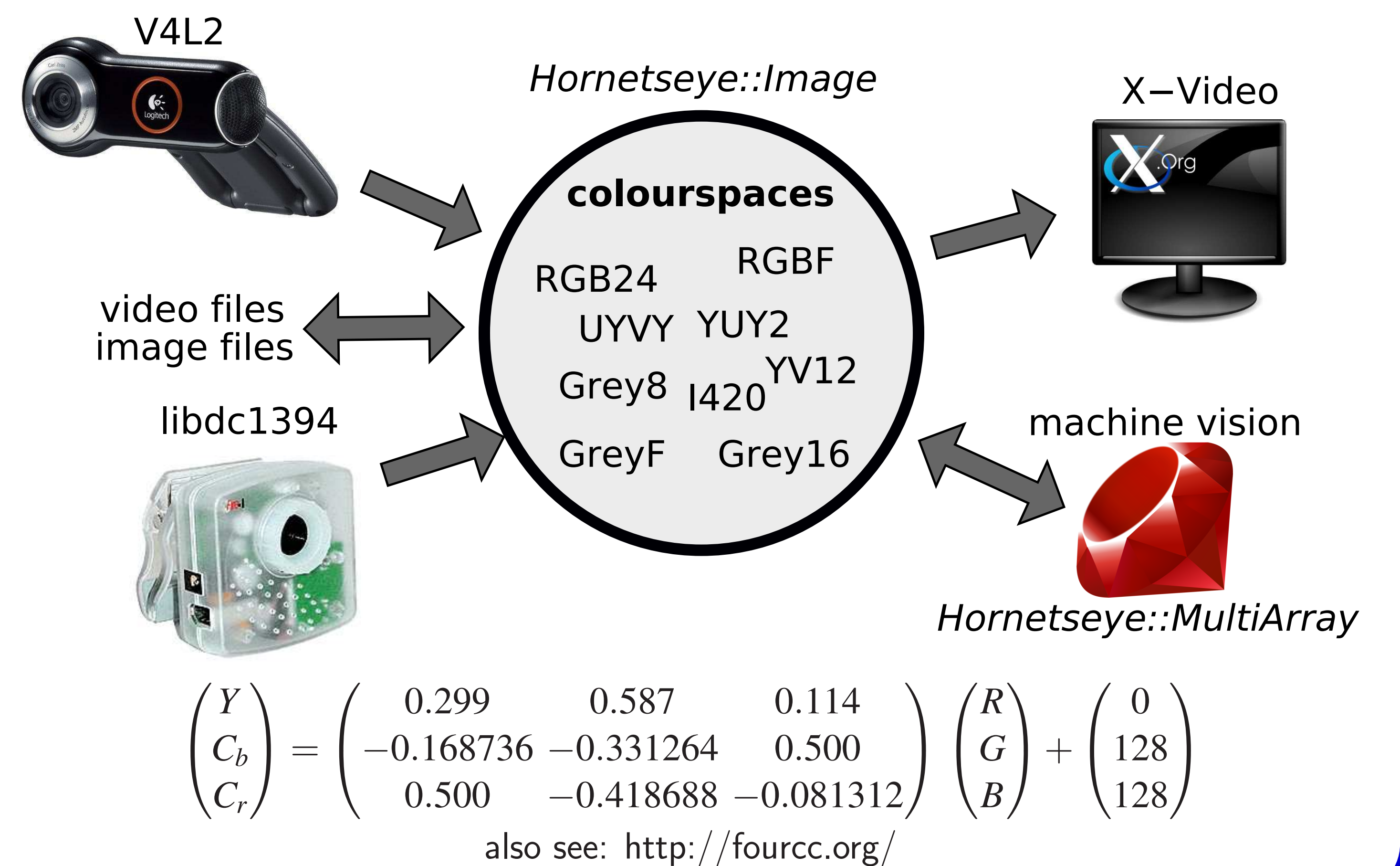
$$C := \iint_W \left(\frac{\partial g(\vec{x})}{\partial x_1} \frac{\partial g(\vec{x})}{\partial x_1} \frac{\partial g(\vec{x})}{\partial x_2} \frac{\partial g(\vec{x})}{\partial x_2} \right) d\vec{x}$$

$$C = \mathcal{A}^T \begin{pmatrix} \lambda_1 & 0 \\ 0 & \lambda_2 \end{pmatrix} \mathcal{A}, \text{ Shi-Tomasi: } \min(\lambda_1, \lambda_2) > \lambda$$

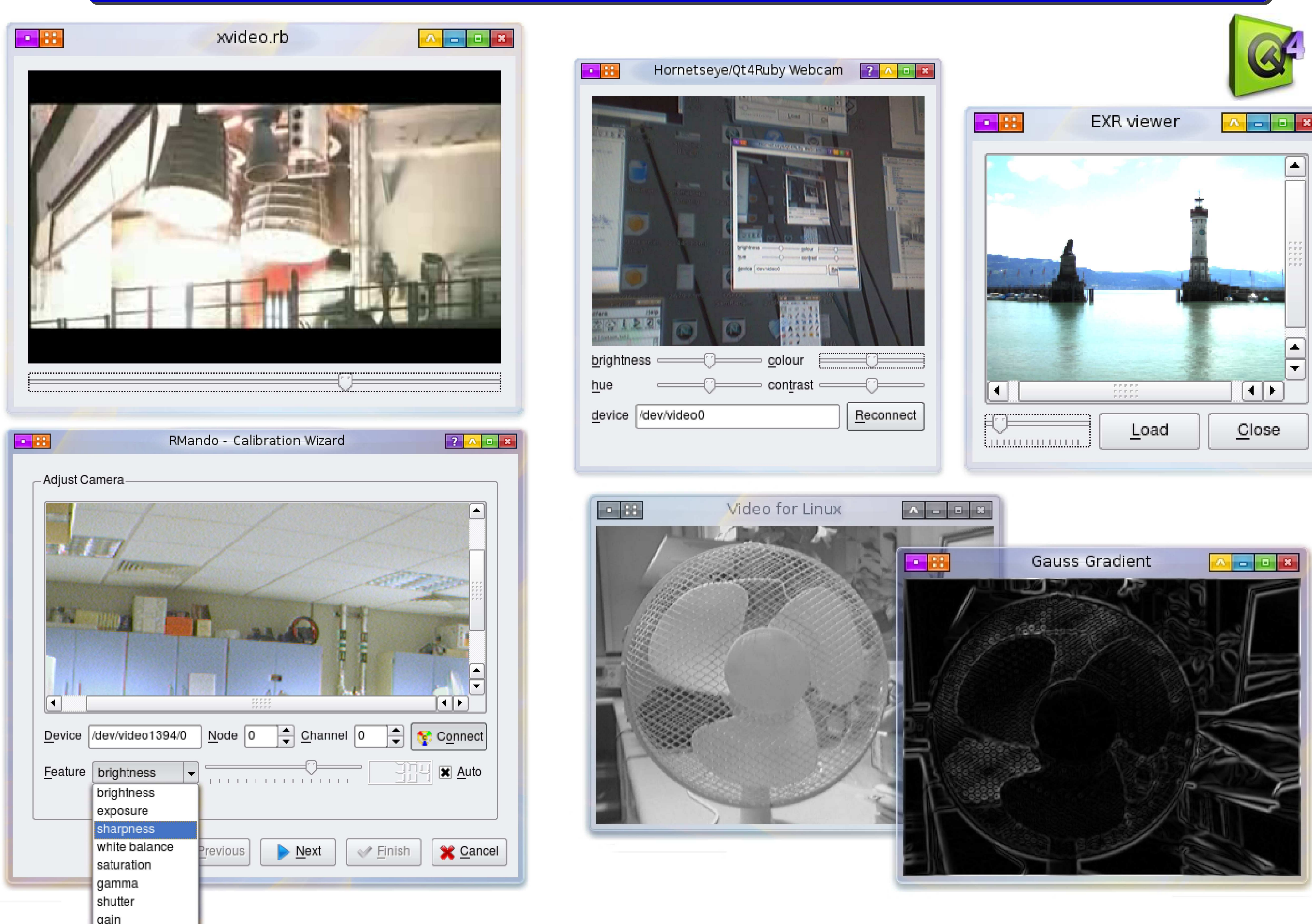


```
require 'hornetseye'
include Hornetseye
grad sigma, cov sigma = 1.0, 1.0
img = MultiArray.load grey8 'test.png'
x = img.gauss.gradient x grad sigma
y = img.gauss.gradient y grad sigma
a = ( x ** 2 ).gauss.blur cov sigma
b = ( y ** 2 ).gauss.blur cov sigma
c = ( x * y ).gauss.blur cov sigma
tr = a + b
det = a * b - c * c
dissqrt = Math.sqrt( ( tr * tr - det * 4 ) ).
major( 0.0 )
result = 0.5 * ( tr - dissqrt )
result.normalise( 255..0 ).show
```

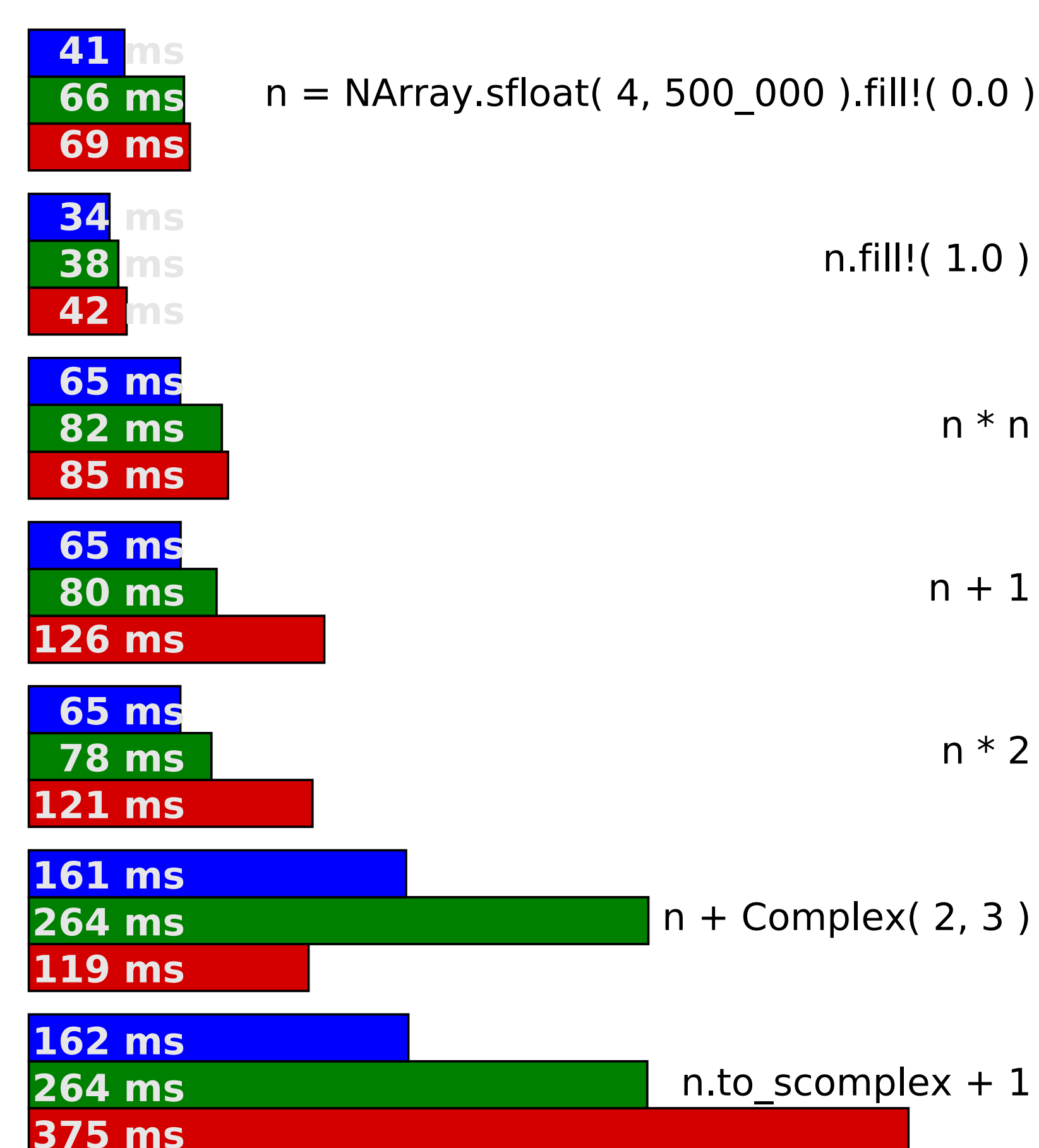
Colourspaces & I/O



GUI integration



Computing Time



Comparison

Blue bars are indicating the computing time used by a naive C++ implementation.

Green bars are indicating the computing time used by M. Tanaka's Ruby-extension *NArray*.

Red bars are indicating the computing time used by the JIT-based implementation of *HornetsEye*.

Environment

- 1.2 GHz AMD Duron™ processor
- g++ 4.1.3 compiler
- ruby 1.8.6 interpreter
- libjit-0.1.1 just-in-time compiler

Optimisation Potential

- cache for reusing compiled methods
- loop unrolling