Toward a Standard Benchmark Format and Suite for Floating-Point Analysis

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Incredible progress…

Automatic Verification
Fluctuat [SAS'13]
Rosa [POPL'14]
FPTaylor [FM'15]

Optimization
STOKE [PLDI'14]

Improvement
Salsa [FMICS'15]
Herbie [PLDI'15]

Mechanized Proofs
Wave equation [ITP'10]
Rounding error [NSV'16]

Rapid improvement in hard problems!

Incredible progress…

We want our community
to keep progressing!

Next
???

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Incredible progress

We want our community to keep progressing!

Auto
Fluc
Rosa
FPTa

Salsa
Herbie

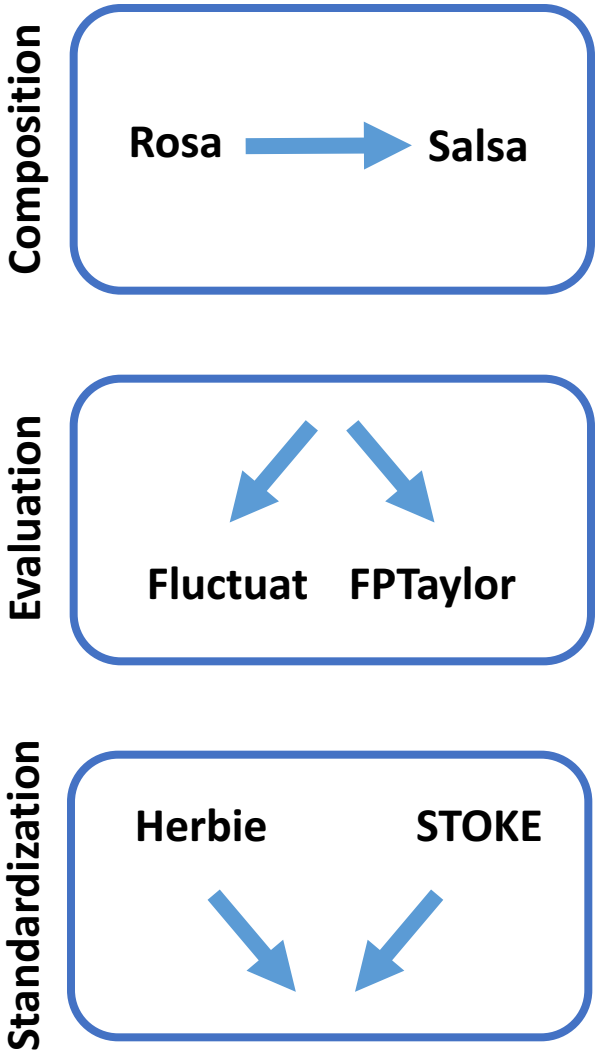
Next
???

As community grows, growing pains appear

Rapid improvement in hard problems!

Growing pains

Similar growing pains in compilers, HPC, SAT, SMT, … communities



Rosa: `def example(x: Double): Double = …`

$\sqrt{x+1}-\sqrt{x}$

Salsa: `double example(double x) { … }`

Fluctuat: `Poly, Inv, F1a, F1b, idem, …`

FPTaylor: `sine, sqrt, verhulst, …`

Herbie: `ulp(NaN, Inf) = UINT_MAX`

STOKE: `ulp(NaN, Inf) < UINT_MAX`

FPBench

FPBench is **community infrastructure** for **cooperation** and **comparison** in the FP community.

http://fpbench.org

FPBench

β

Common format

Benchmark suite

Named measures

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$$\sqrt{x+1} - \sqrt{x}$$

Arguments

```
(FPCore (x)
```

```
 (- (sqrt (+ x 1)) (sqrt x)))
```

S-expression syntax

$$\sqrt{x+1} - \sqrt{x}$$

Metadata

```
(FPCore (x)
  :name “Sqrt Difference”
  :cite (hamming-87)
  :pre (> x 0)
  (- (sqrt (+ x 1)) (sqrt x)))
```

Preconditions

```
(FPCore (x0)
  :name “Sine Newton”
  :cite (darulova-kuncak-2014)
  :pre (< (abs x0) 1)
  (while (< i 10)
    ([i 0 (+ i 1)]
     [x x0 (+ (+ (- x (/ (pow x 3) 6.0))
                 (/ (pow x 5) 120.0))
                 (/ (pow x 7) 5040.0))
              (+ (+ (- 1.0 (/ (* x x) 2.0))
                 (/ (pow x 4) 24.0))
                 (/ (pow x 6) 720.0))))])
    x))
```

Loops

Common functions

FPCore common format

Simple to use

S-expression syntax
Purely functional
No control flow analysis

Expressive

All C, Fortran functions
Loops, conditionals
Tools support parts

Extensible

Metadata properties
Tool-specific metadata
Input or output format

Generate from higher-level, imperative FPImp lang.

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Named measures

Simple to implement

Covers all existing uses

Simple to extend, specialize

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FPBench benchmark suite

72 total benchmarks

Drawn from existing papers

Annotated with source, ranges, description, citation

FPBench benchmark suite

Existing programs		Rich features		Diverse domains	
FPTaylor	29	Arith	72	Textbook	59
Herbie	28	Expt	16	Math Alg	6
Rosa	6	Trig	11	Emb Sys	4
Salsa	9	Loop	12	Sci Comp	3
		Branch	3		

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Simple to implement

Covers all existing uses

Simple to extend, specialize

From existing projects

Cover many domains

Grows over time

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FPBench measures

Formal definitions of accuracy measures

Described along 5 axes

Standard measures so tools agree

FPBench axes of measurement

Scaling vs. non-scaling

Absolute, relative, ULPs, bits, …

Forward vs. backward

Fixed input error vs fixed output error

Maximum vs. average

Sound vs. statistical

Formal guarantees vs mathematical accuracy

Improvement

FPBench

β

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Simple to implement

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Benchmark suite

From existing projects

Cover many domains

Grows over time

Named measures

Terms for measuring error

Standard across tools

Flexible but rigorous

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