A Scientific Library for Smalltalk

Serge Stinckwich

Institut de recherche pour le développement

UMMISCO Unite Mixte Internationale

UPMC Sorbonne Universités

I’m not a mathematician !

SciSmalltalk

- Building a pure Smalltalk library
- MIT Licence
- https://github.com/SergeStinckwich/SciSmalltalk
- Last stable version 0.28
- Pharo 3.0 (discontinued), Pharo 4.0, Pharo 5.0, Squeak 4.5 (v0.12)

Competitors

SciRuby

R

julia

SciPy.org

Sponsored By ENTHOUGHT

Main contributors

- Didier H. Besset (DHB packages)
- Nicolas Cellier (arbitrary floating point arithmetics)
- Stéphane Ducasse (Refactorings, packaging, documentation)
- Werner Kassens (KDETree)
- Serge Stinckwich (documentation, integration)
- Natalia Tymchuck (ODE)
- Hernán Morales Durand (Random Number Generator)
- Daniel Uber (first version)

How to install ?

```
Gofer new
    url: 'http://www.smalltalkhub.com/mc/SergeStinckwich/SciSmalltalk/main';
    configurationOf:'SciSmalltalk';
    loadVersion:'0.28'.
```

Also available in the Pharo Catalog

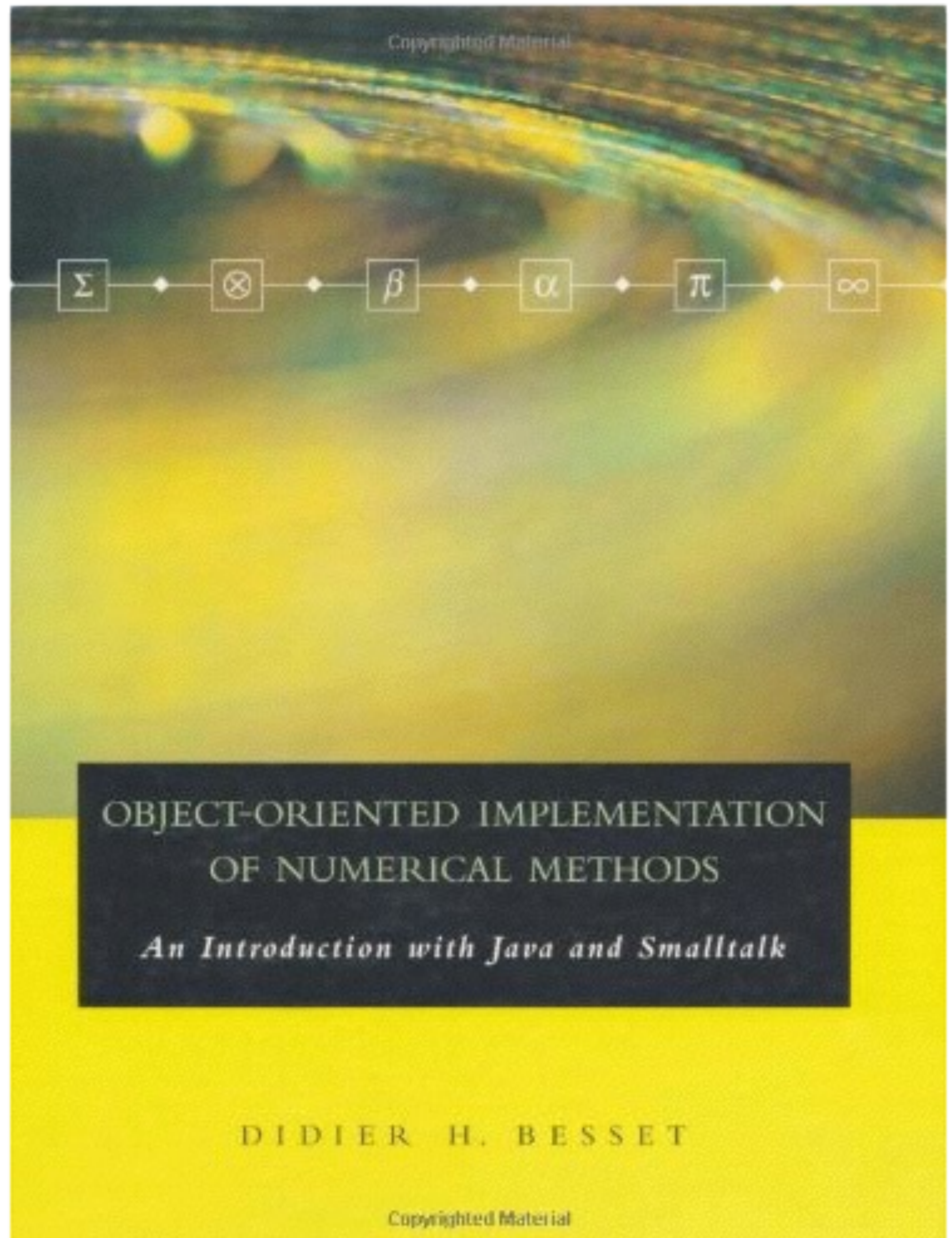
Sponsors

Metrics

- Development start in April 2012
- 632 green tests (77 classes)
- Classes (without tests): 188

Main packages

- Matrix, Statistics moments, Polynomials, Interpolations, Integration, Series, Linear Algebra (DHB)
- Ordinary Differential Equations Solver (RK4, AB2, …)
- Complex numbers, Quaternions
- Random Number Generators
- KD-Trees
- Arbitrary Floating-point arithmetics


Copyrighted Material
Σ
⊗
β
α
π
∞
OBJECT-ORIENTED IMPLEMENTATION
OF NUMERICAL METHODS
An Introduction with Java and Smalltalk
DIDIER H. BESSET
Copyrighted Material

Object-Oriented Implementation of Numerical Methods - An Introduction with Smalltalk

- Original Book from Didier Besset in 2000
- New book (remove all Java part of the book) in 2015
- Creative Commons Licence
- 410 pages
- Available freely **now** on: https://github.com/SquareBracketAssociates/NumericalMethods
- Thank you Didier !

$$\pi$$

Brent-Salamin Algorithm

- Initial value setting: $a_0 = 1 \qquad b_0 = \frac{1}{\sqrt{2}} \qquad t_0 = \frac{1}{4} \qquad p_0 = 1.$

- Repeat until the diff between an and bn is within the desired accuracy:

$$
\begin{aligned}
a_{n+1} &= \frac{a_n + b_n}{2}, \\
b_{n+1} &= \sqrt{a_n b_n}, \\
t_{n+1} &= t_n - p_n(a_n - a_{n+1})^2, \\
p_{n+1} &= 2p_n.
\end{aligned}
$$

- pi is the approximated value of:

$$\pi \approx \frac{(a_{n+1} + b_{n+1})^2}{4t_{n+1}}.$$

ArbitraryPrecisionFloat>>pi

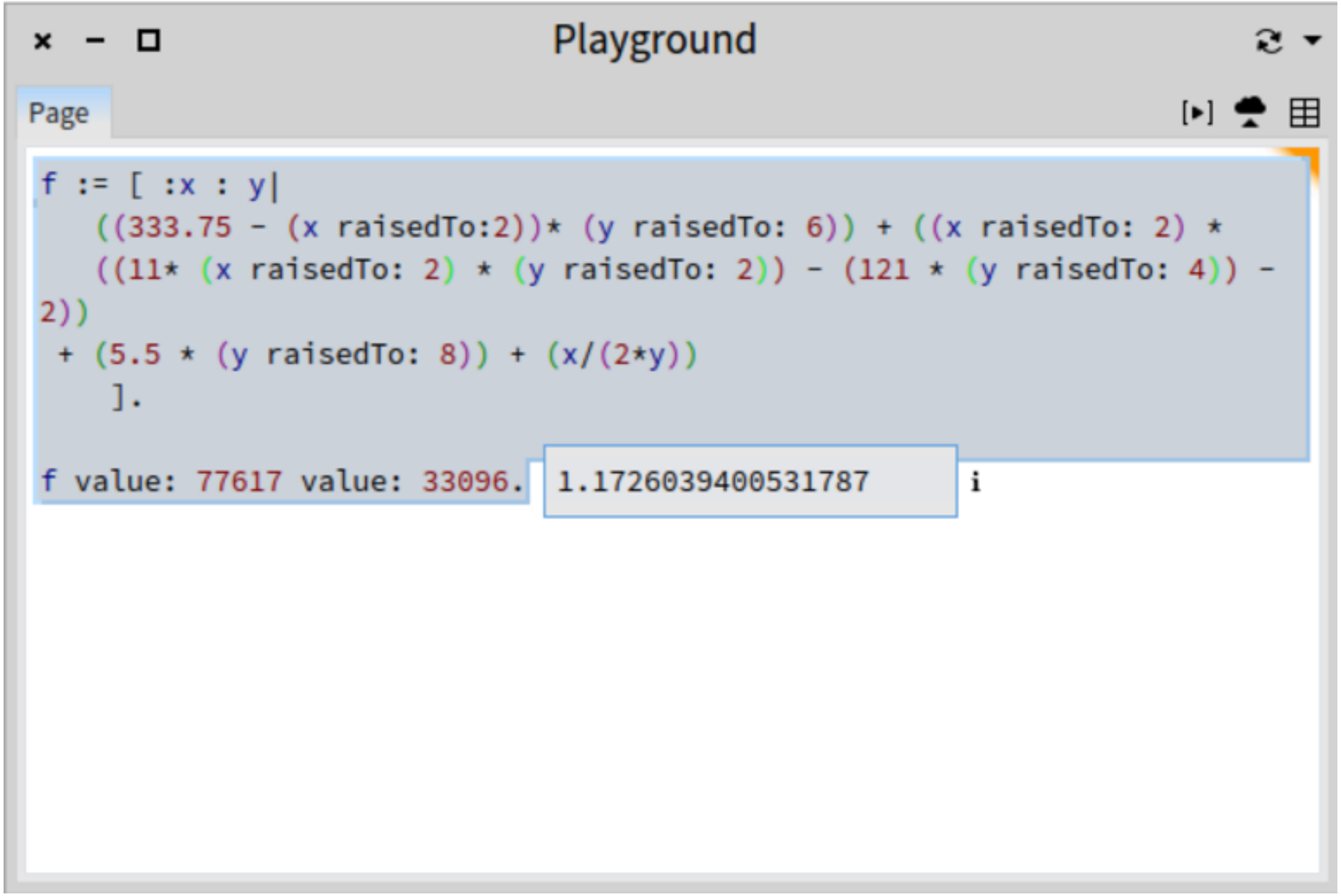
```
| a b c k pi oldpi oldExpo expo |
a := self one asArbitraryPrecisionFloatNumBits: nBits + 16.
b := (a timesTwoPower: 1) sqrt reciprocal.
c := a timesTwoPower: -1.
k := 1.
oldpi := Float pi.
oldExpo := 2.

[| am gm a2 |
am := a + b timesTwoPower: -1.
gm := (a * b) sqrt.
a := am.
b := gm.
a2 := a squared.
c inPlaceSubtract: (a2 - b squared timesTwoPower: k).
pi := (a2 timesTwoPower: 1) / c.
expo := (oldpi - pi) exponent.
expo isZero or: [expo > oldExpo or: [expo < (-1 - nBits)]]]
        whileFalse:
            [oldpi := pi.
            oldExpo := expo.
            k := k + 1].
^pi asArbitraryPrecisionFloatNumBits: nBits
```

Arbitrary Precision Arithmetics

$$y = 333.75b^6 + a^2(11a^2b^2 - b^6 - 121b^4 - 2) + 5.5b^8 + a/(2b)$$

with a = 77617 and b = 33096

Demo


Playground
Page
f := [:x : y|
((333.75 - (x raisedTo:2))* (y raisedTo: 6)) + ((x raisedTo: 2) *
((11* (x raisedTo: 2) * (y raisedTo: 2)) - (121 * (y raisedTo: 4)) -
2))
+ (5.5 * (y raisedTo: 8)) + (x/(2*y))
].
f value: 77617 value: 33096.
1.1726039400531787

Floating-point arithmetics traps

- Rump's Example
- The exact result is −0.827396059946821 35 ± 5 × 10−17
- You need to know the precision needed in order to have the good answer
- Solution: Interval arithmetics (soon in SciSmalltalk !)

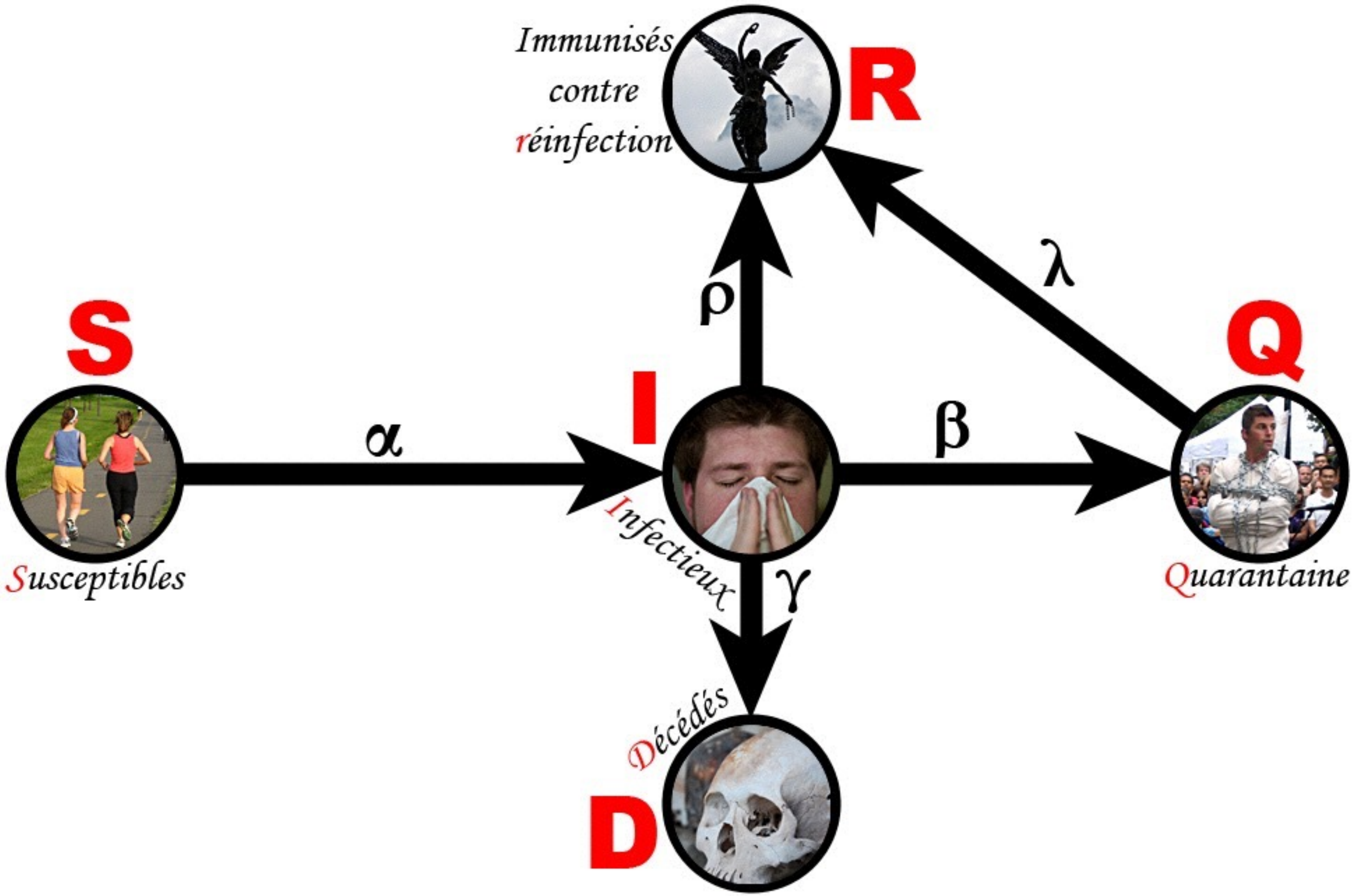
Ordinary Differential Equations (ODE)

Solving ODEs

$$\frac{dS}{dt} = -\beta * S * I \tag{2.1}$$

$$\frac{dI}{dt} = \beta * S * I - \gamma * I \tag{2.2}$$

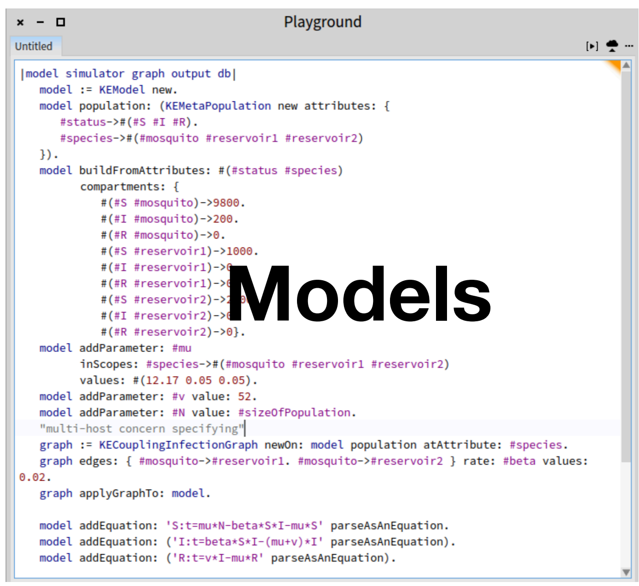
$$\frac{dR}{dt} = \gamma * I \tag{2.3}$$

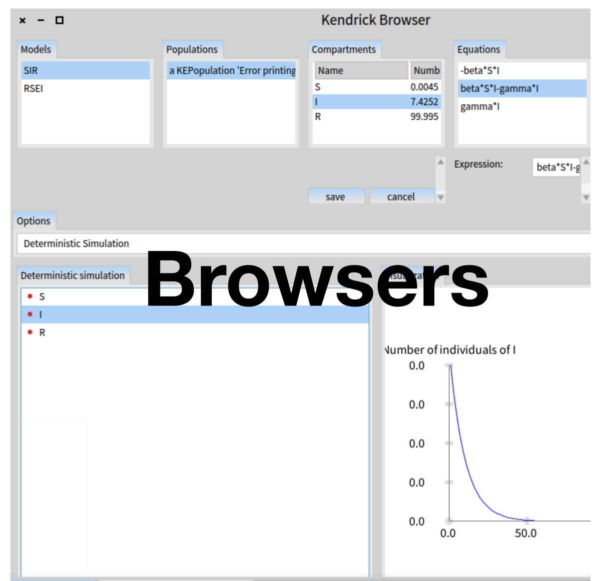

Immunisés
contre
réinfection
R
S
I
Q
α
β
ρ
λ
γ
Infectieux
Susceptibles
Quarantaine
Décédés
D

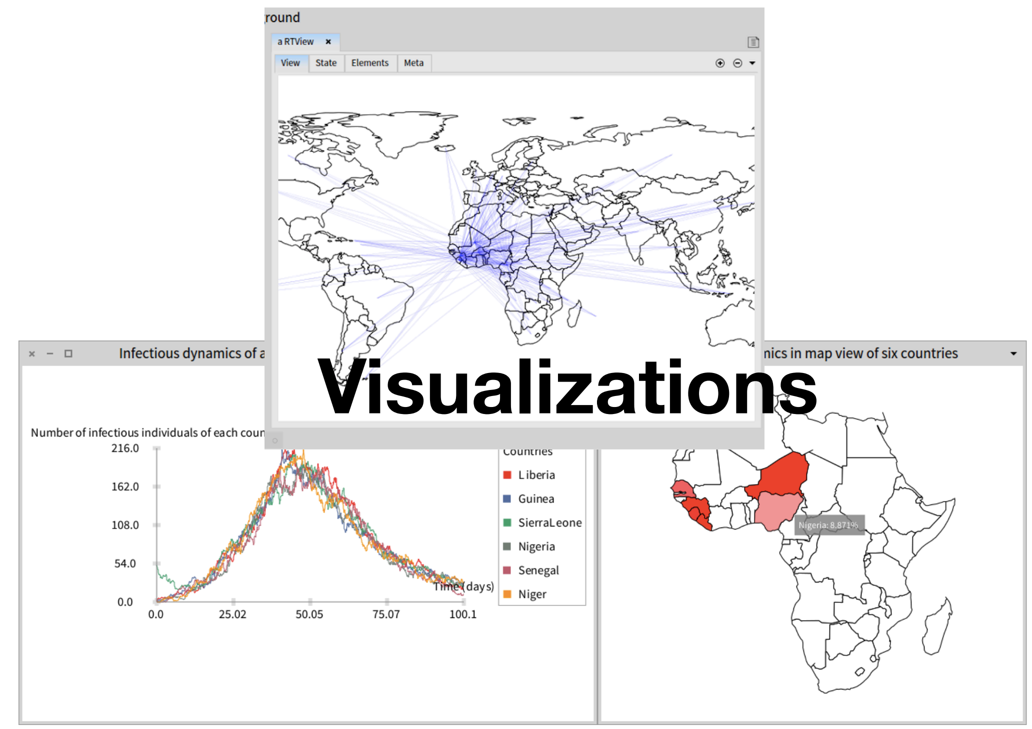
DEMO

Kendrick is a platform for epidemiological modeling and analysis.

It helps epidemiologists craft
custom analyses cheaply.







http://ummisco.github.io/kendrick/

UMMISCO Unite Mixte Internationale · LIP6 · IRD Institut de recherche pour le développement · Object Profile · ESUG European Smalltalk User Group www.esug.org

Lorentz Attractor demo

$$\frac{\mathrm{d}x}{\mathrm{d}t} = \sigma(y - x),$$
$$\frac{\mathrm{d}y}{\mathrm{d}t} = x(\rho - z) - y,$$
$$\frac{\mathrm{d}z}{\mathrm{d}t} = xy - \beta z.$$

Roadmap

- We are looking for a better name !
- Modular packaging in order to load parts of SciSmalltalk (thanks Stéphane)
- Ongoing work of Pierre Chanson (ObjectProfile) to reproduce R example in Roassal+SciSmalltalk
- We are welcoming contributions in all mathematics area (especially statistics)