informatics / mathematics

Advanced Tutorial on Sage

Calcul mathématique avec
SAGE

Published in June 2013
456 pages, in french
pdf: free (CC BY-SA)
`sagebook.gforge.inria.fr`
paper: $9.44 on Amazon

Plan

- A Bit of History
- Architecture of Sage
- Online Tutorial
  - First Steps
  - Calculus
  - Graphics
  - Polynomials and Systems
  - Linear Algebra
  - Numerics
  - Combinatorics and Linear Programming

Not covered by this tutorial: differential equations, recurrences, number theory, graph theory

A Bit of History

Axiom: started in 1971 at IBM (Scratchpad) by Jenks, Trager, Watt, Davenport, Sutor, Morrison. 1990: sold to NAG, renamed Axiom. 2001: Tim Daly get Axiom released under the modified BSD license. 2007: two forks (OpenAxiom and FriCAS). Last release of Axiom is from May 2012, OpenAxiom April 2013, FriCAS June 2013.

Maxima: started at MIT in 1982 (Macsyma) with funding from the US DOE. Two versions: Symbolics Macsyma (commercial) and a version developed by Bill Schelter, released up from 1998 under GPL, and called Maxima. Latest version (source) is from April 2013.

MuPAD: development started in 1989 at University of Paderborn (Germany), first official release 1.0 in August 1992, available to non-profit educational and scientific institutions free of charge until 2005 (MuPAD Light). 1997: commercial version MuPAD Pro (SciFace company). 2008: SciFace purchased by MathWorks, MuPAD withdrawn as independent software product.

May 2002, Lyon (France): Workshop on Open Source Computer Algebra. MuPAD, Linbox, GINAC, GIAC, ACE, mu-EC, mupad-combinat, Scilab, SYNAPS, GAP, TeXmacs, Magma, FOC, Axiom, PARI, Maxima.

History of Sage

Cf http://wstein.org/mathsoftbio/history.pdf

William Stein, graduate student at Berkeley, is asked by Ken Ribet:
Does a prime p exist, such that the Hecke algebra of height p is ramified in p?

W. Stein finds a paper by Hijikata giving an algorithm, but requires to compute class numbers of large quadratic fields. How to compute them?

WS heard of Pari/GP. He installs it on his Linux computer. Pari/GP can compute rapidly class numbers: *The algebraic number theory algorithms implemented [...] were amazing, deep, and very fast!*

There was a major bug [...] the function qfclassno, silently returned wrong answers

in 1999, David Kohel [...] told me about implementing algorithms related to his thesis in Magma

David had implemented code for computing with quaternion algebras, and this was the only implementation of that algorithm in the world

my algorithm fundamentally relied on exactly the computations in rational quaternion algebras that David Kohel had implemented in Magma

I had a thesis to finish

David [...] was able to give me a copy of Magma for my own computer, which had his code in it. [...] I was the first person ever to systematically compute Tamagawa numbers of general modular abelian varieties

So in 1999 David Kohel put me in a situation where I was fundamentally dependent on a closed source non-free program in order to continue my own research

Magma was not open source [...] Magma was not free. And as a language, Magma was significantly behind C++

At that moment I started designing what would eventually become Sage

I then realized that if I did this, I would have to do it myself [...] I wouldn't get to do number theory for years [...] I spent the next 5 years writing and using Magma

Since Magma didn't have any parallel capabilities, I stumbled on some language called Python (Version 2.3), which looked a lot like Magma, but was designed for general purpose scripting

I had by this point developed a large list of issues with Magma. For example the documentation and examples in the Magma reference manual aren't automatically tested [...] Python had solved the dozens of major problems I had with Magma!

2005: development of MANIN (old name of Sage)

2006 (February): Sage Days, release of Sage 1.0 during W. Stein's talk (39MB)

January 5, 2007, 00:06: release of Sage 1.5.2 (72MB)
January 5, 2007, 19:58: release of Sage 1.5.3 (74MB)
November 3, 2007: release of Sage 2.8.11 (158MB)
November 7, 2007: release of Sage 2.8.12 (163MB)
November 21, 2007: release of Sage 2.8.13 (165MB)
November 25, 2007: release of Sage 2.8.14 (165MB)
December 24, 2009: release of Sage 4.3 (260MB)
January 21, 2010: release of Sage 4.3.1 (264MB)
May 14, 2012: release of Sage 5.0 (294MB)
April 30, 2013: release of Sage 5.9 (314MB)
June 17, 2013: release of Sage 5.10 (320MB)
August 13, 2013: release of Sage 5.11 (324MB)

Sage 5.11

Released on 13 August 2013.

87 people contributed to this release

17 made their first contribution to Sage

161 tickets closed in this release

The Sage Community (see sagemath.org)

Sage Days:

- ► Sage Days 6 (Cryptography, Arithmetic Geometry): Bristol (UK), Nov 2007
- ► Sage Days 10, Nancy (France), Oct 2008
- ► Sage Days 23.5 (Singular and Sage), Kaiserslautern (Germany), Jul 2010
- ► Sage Days 52 (Arithmetics over DVR, p-adics), September 2-6, 2013, Université Rennes 1, France
- ► Sage Days 53 (Computational Number Theory, Geometry, and Physics), September 23-29, 2013, University of Oxford
- ► Sage Days 54 (Sage Developer Days), University of California Davis
- ► Sage Days 55 (Arithmetic and Complex Dynamics), November 7-10, 2013, Melbourne, Florida

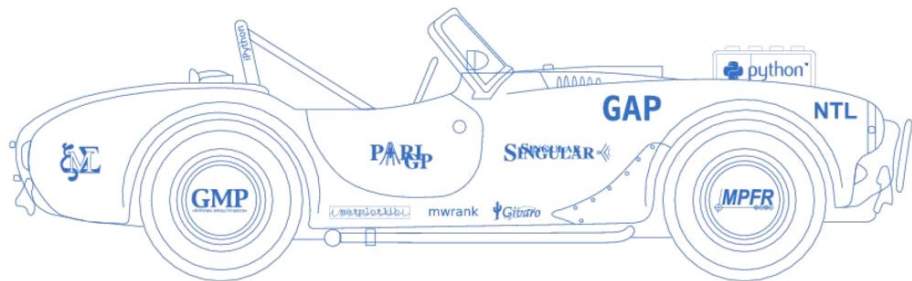Bug Days, Doc Days, Review Days, Education Days, ...

Sage Resources

Mailing lists `sage-support`, `sage-devel`

Trac server `http://trac.sagemath.org/`

Architecture of Sage

SAGE

Building »The Car«

Sage is based on Python, thus Sage is cool (cf Olivier Debeir tutorial)!

Version 5.9 includes 92 packages (Atlas, Boost, Cython, GCC 4.7.2, GSL, FPLLL, Ipython, Linbox, Matplotlib, Maxima, GNU MPFR, Numpy, Pari/GP, Python 2.7.3, R, Scipy, Singular, Sympy)

1416 Python source files with a total of 871877 lines

354 Cython files with a total of 380889 lines

Starting the Tutorial

1. Start Sage
2. type `notebook()`
3. Click on "Upload"
4. enter the URL
   `http://www.loria.fr/~zimmerma/Euroscipy2013.sws`

Coding sprint

Sunday 25, room K.3.401, 9:00-19:00

- ▶ Use Cython to boost your code
- ▶ Modify your Sage version
- ▶ Report bugs
- ▶ Fix bugs
- ▶ Review patches