

Intro to Sage(-Combinat)

Sage Days 49

Free and Practical Software for
(Algebraic) Combinatorics

Orsay, France



Sage

- “Creating a viable free open source alternative to Magma, Maple, Mathematica, and Matlab.”
- Free (As in Speech)
- Free (As in Beer)
- Open Source
- Active Developer Community



Sage

Combines the best open-source math software, glued together with Python:

- ATLAS
- Symmetrica
- GAP
- R
- NumPy
- NetworkX
- Maxima
- Gfan
- ... and more (80+ components in all)
- And even more functionality new to Sage itself, e.g. Crystal Bases.



Multiple Architectures

- Linux (Download, unpack, run!)
- OSX (Install Apple Developer Tools first)
- Windows (Via Virtual Box)
- ARM7
- Android?
- Raspberry Pi?



Using Sage: iPython

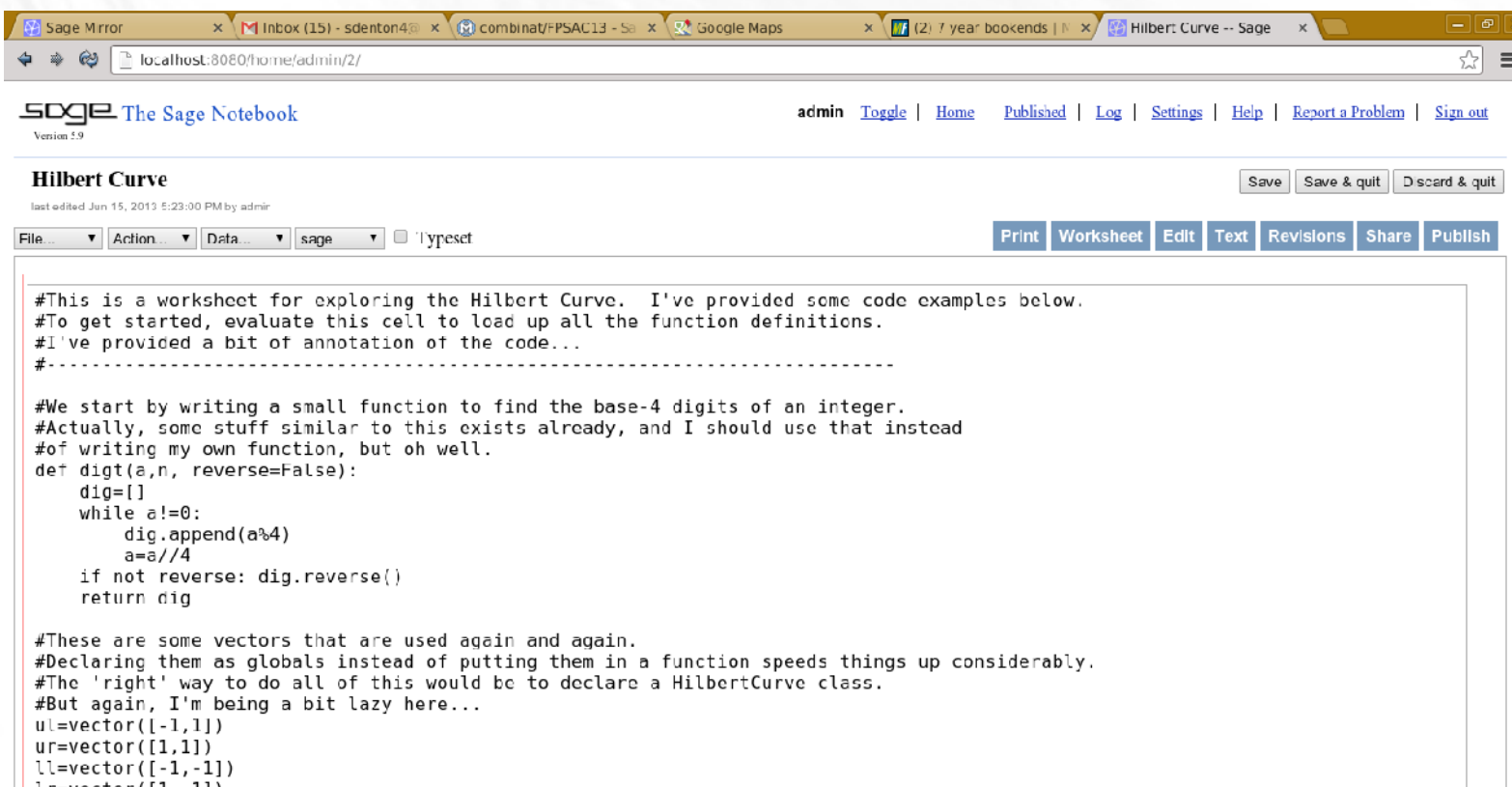
- Sage uses iPython to provide a rich interactive shell.
- 'Command line programming'
- %attach foo.sage
- Not pretty, but great for developers intending to put their code into Sage.
- Also excellent for running 'headless' computations that might take days or months to run.

```
obieroCubeRoots.sage (~/.sage/scripts) - gedit
File Edit View Search Tools Documents Help
5 def rooty(f, tmin, tmax, mesh):
6     g=f.diff()+I*t**t
7     root_list=[]
8     for j in [0..floor((tmax-tmin)*mesh)]:
9         t=tmin+j/mesh
10        h=g(t-tmin+j/mesh).polynomial(CC)
11        root_list[j]=h.roots(multiplicities=False)
12    return root_list
13
14
15 def plotRoots(R, prune=False):
16     point_list=[]
17     line_list=[]
18     col=rainbow(len(R))
19
20     for r in R:
21         pp=[r[1].real_part()]
22         color=col.pop()
23         if r[1]!=0 and prune:
24             pp=point((r[1].real_part(), r[1].imag_part()), color=col)
25             point_list.append(pp)
26     return point_list
27
28
29 def complexTo2d(p):
30     return (p.real_part(), p.imag_part())
31
32 def plottransform(f, tmin=5, tmax=5, mesh=4, prune=True):
33     g=f.diff()+I*t**t
34     R=rooty(f, tmin, tmax, mesh)
35     old_roots=None
36     line_list=[]
37     steps=floor((tmax-tmin)*mesh)
38     colors=rainbow(steps+2)

kaibutsu@sophos:~/share/perl5/Time
File Edit View Search Terminal Help
> 191 call = lamoda f, 'a', 'k', f(a, 'k')
192
193 if callable arg:
/home/kaibutsu/sage-5.8.rc0/local/lib/python2.7/site-packages/iPython-0.14.dev-py2.7.egg/iPyth
on/core/magics/execution.py in timeitself, parameter_s, local_ns)
910 else:
911     st = clock2()
--> 912     exec code in glob, local_ns
913     end = clock2()
914     out = None
<timed_exec> in <module>()
/home/kaibutsu/sage-scripts/obieroCubeRoots.sage:Ln5.py in plottransform(f, tmin, tmax, me
sh, prune)
36
37 def plottransform f, tmin=_sage_const_5, tmax=_sage_const_5, mesh=_sage_const_4,
prune=True)
--> 38     g=f.diff()+I*t**t
39     R=rooty(f, tmin, tmax, mesh)
40     old_roots=None
NameError: global name 't' is not defined
sage: t=var('t')
sage: time P:plottransform(f, tmin=-5, tmax=5, mesh=10)
CPU times: user 5.52 s, sys: 0.02 s, total: 5.54 s
Wall time: 5.58 s
sage: f
(x^5 - 8)*x
sage: f=x*(x^5 - 8)
sage: P.show(figsize=20, aspect_ratio=1, axes=False)
sage: line P:plottransform(f, tmin=20, tmax=20, mesh=10)
CPU times: user 22.32 s, sys: 0.02 s, total: 22.34 s
Wall time: 22.50 s
sage: P.show(figsize=20, aspect_ratio=1, axes=False)
sage: |
```

Using Sage: The Notebook

- Web-based notebook
- 'Cells' for code which evaluate independently, sharing variables and results
- Nice for exploration, in-line graphics
- User-friendly
- Can also be used directly as an interface for R, python, etc



The screenshot shows a web browser window with the Sage Notebook interface. The browser tabs include 'Sage Mirror', 'Inbox (15) - sdenton4@...', 'combinat/PSAC13 - Se...', 'Google Maps', '(2) 7 year bookends |', and 'Hilbert Curve -- Sage'. The address bar shows 'localhost:8080/home/admin/2/'. The page title is 'SAGE The Sage Notebook' with 'Version 5.9' below it. The user 'admin' is logged in, with links for 'Toggle', 'Home', 'Published', 'Log', 'Settings', 'Help', 'Report a Problem', and 'Sign out'. The notebook title is 'Hilbert Curve', last edited on Jun 15, 2013 at 5:23:00 PM by admin. There are buttons for 'Save', 'Save & quit', and 'Discard & quit'. Below the title is a toolbar with 'File...', 'Action...', 'Data...', 'sage', and a 'typeset' checkbox. To the right of the toolbar are buttons for 'Print', 'Worksheet', 'Edit', 'Text', 'Revisions', 'Share', and 'Publish'. The main content area contains a code cell with the following text:

```
#This is a worksheet for exploring the Hilbert Curve. I've provided some code examples below.
#To get started, evaluate this cell to load up all the function definitions.
#I've provided a bit of annotation of the code...
#-----

#We start by writing a small function to find the base-4 digits of an integer.
#Actually, some stuff similar to this exists already, and I should use that instead
#of writing my own function, but oh well.
def digt(a,n, reverse=False):
    dig=[]
    while a!=0:
        dig.append(a%4)
        a=a//4
    if not reverse: dig.reverse()
    return dig

#These are some vectors that are used again and again.
#Declaring them as globals instead of putting them in a function speeds things up considerably.
#The 'right' way to do all of this would be to declare a HilbertCurve class.
#But again, I'm being a bit lazy here...
u1=vector([-1,1])
ur=vector([1,1])
ll=vector([-1,-1])
lr=vector([1,-1])
```

Sage and Python

- Sage uses **Python** inside and out:
Can think of Sage as (i)Python with super libraries.
- Learn a useful life skill while using your computer algebra system!
- **Cython** is also available:
Dialect of Python which compiles into C. Cython code is typically many times faster than standard Python/Sage.



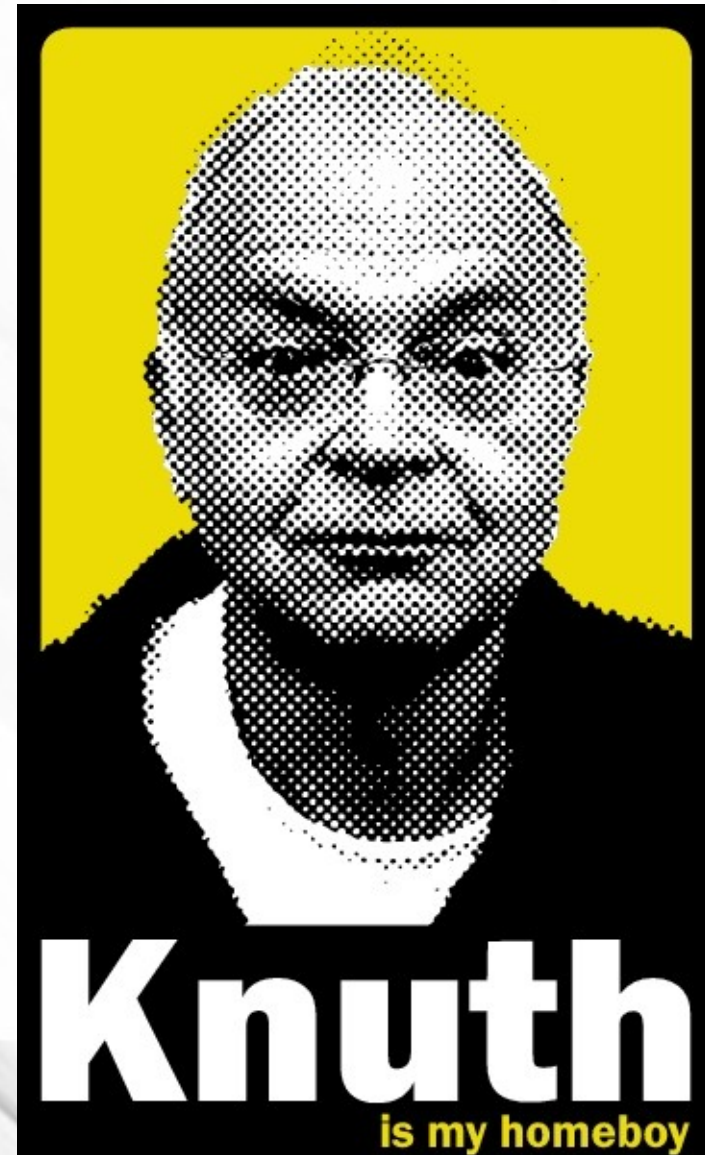
Doing the Math

- “Science is what we understand well enough to explain to a computer. Art is everything else we do.”
- Read,
- Code,
- Conjecture,
- Prove.
(I search for a proof while Sage searches for a counterexample.)



Teaching with Sage

- Sage Cell Server allows us to build interactive web notes and books.
- Remove illusion that by-hand computation is actually the objective of a class.
- Project Euler, Rosalind (bio):
Big sets of problems that require programming to solve.



*-Combinat

- Combinat was originally an open-source combinatorics extension for MuPad for sharing research code.
- MuPad itself is not open source; limits size of community.
- In 2009, MuPad-Combinat became Sage-Combinat, after much porting of code.
- Sage-Combinat now exists as a branch of Sage, with its own Mercurial-driven version control system.

Sage in Developing Countries

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FOR: AFRICAN INSTITUTE OF MATHEMATICAL SCIENCES GHANA
[AIMS GHANA]

- Shewn Edged Pink -

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REGION

CENTRAL

Sage in Developing Countries

- We live in the future!
- Research-level access for Anyone, Anywhere:
Arxiv+Sage+Latex =>
Lower barriers to research-level mathematics
- Allows us to expand the math community....
- But eventually you have to talk to people!

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Sage in Developing Countries

- AIMS model
- Workshop model (Sage Days and more)

Problems:

- Separation of disciplines
- Lack of local support – Academic, Institutional
- And and and and and and and and and and and...

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Thanks!

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