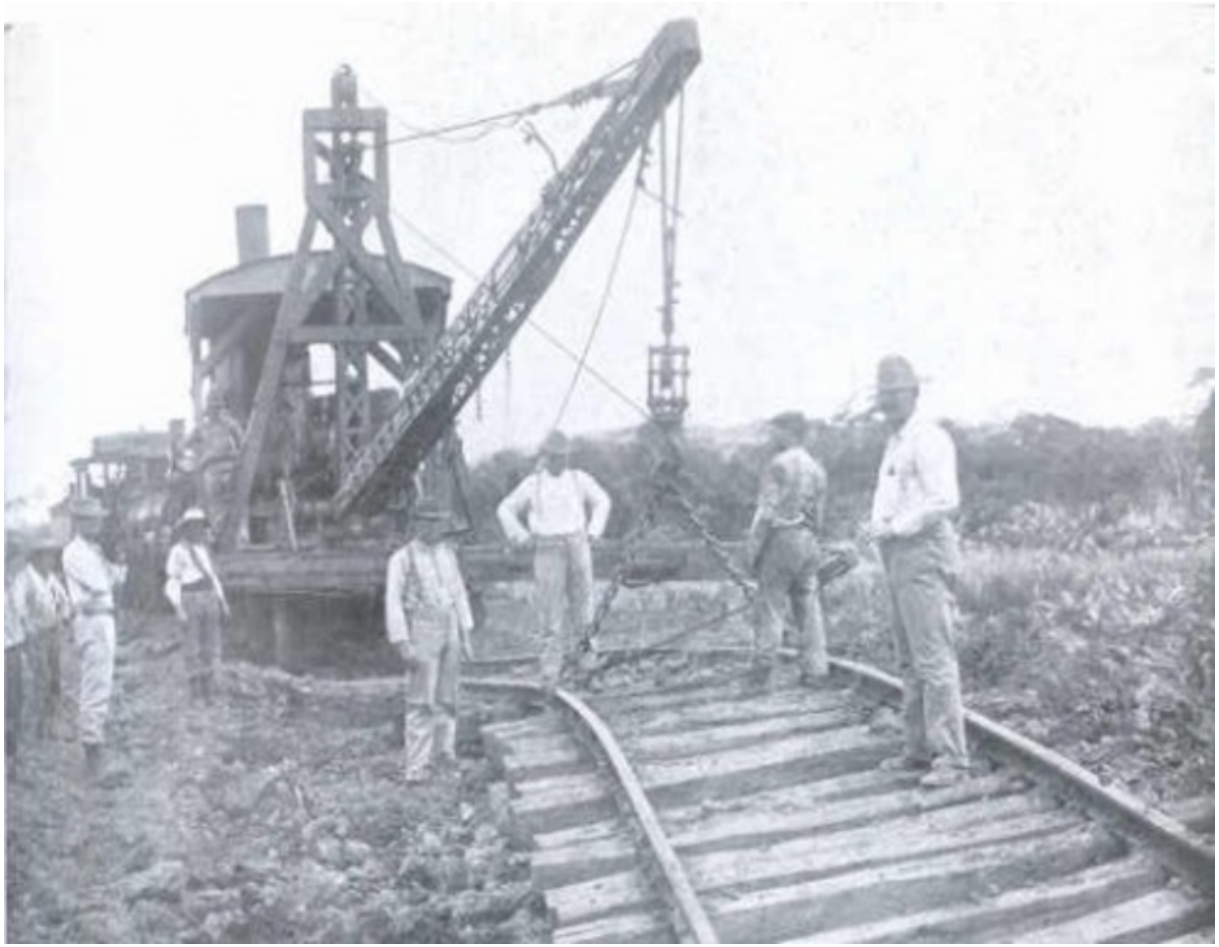
The challenge of reproducible research in the computer age

Production is not the application of tools to materials.
It is the application of logic to work.
—Peter Drucker, *The practice of management* (1954)

K. Jarrod Millman
Helen Wills Neuroscience Institute
University of California, Berkeley

Applied Mathematics Perspectives 2011
Reproducible Research: Tools and Strategies for Scientific Computing

Make the dirt fly!



Culture matters

Build quality into the process

The radical novelty of computing

The concept of radical novelties is of contemporary significance because, while we are ill-prepared to cope with them, science and technology have now shown themselves expert at inflicting them upon us.

— Edsger Dijkstra, The Cruelty of Really Teaching Computer Science (1988)

Better, faster, cheaper

- Are we doing a good (enough) job? How would we know?
- How long does it take to go from the idea as presented in (say) lab meeting to the paper being submitted?
- What proportion of measured data makes it to publication?
- Are we duplicating work that other people have done already?
- Are we doing work for other people because they don't know how to do it?
- Are there tasks that can be automated?

“truth will sooner come out of error than from confusion.”

...so when a man tries all kinds of experiments without method or order, this is mere groping in the dark; but when he proceeds with some direction and order in his experiments, it is as if he were led by the hand...
— Francis Bacon, Novum Organum (1620)

Neuroimaging

Deep magic begins here...

- Specialization
- Lack of patience
- Lack of understanding
- Confusion, frustration, and helplessness

NIPY

http://nipy.org

Neuroimaging in Python
Community Site

Community | Development | Software | Mailing list | License |

The purpose of NIPY is to make it easier to do better brain imaging research. We believe that neuroscience ideas and analysis ideas develop together. Good ideas come from understanding; understanding comes from clarity, and clarity must come from well-designed teaching materials and well-designed software. The software must be designed as a natural extension of the underlying ideas.

We aim to build software that is:

- clearly written
- clearly explained
- a good fit for the underlying ideas
- a natural home for collaboration

The process

- How many mistakes do you make?
- What do they cost?
- Could you have made mistakes you don't know about?

Data & code sharing

- Could you send someone else in the lab an email with all the information they need to rerun your analysis?
- How long would it take to write that email?

Git for everything

Python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(1994 - 1998) Computational Science & Engineering, IEEE
Early Access:
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“Literate programming”

- Sweave: LaTeX & R
- Sphinx: reStructuredText & Python

Automate, automate, automate

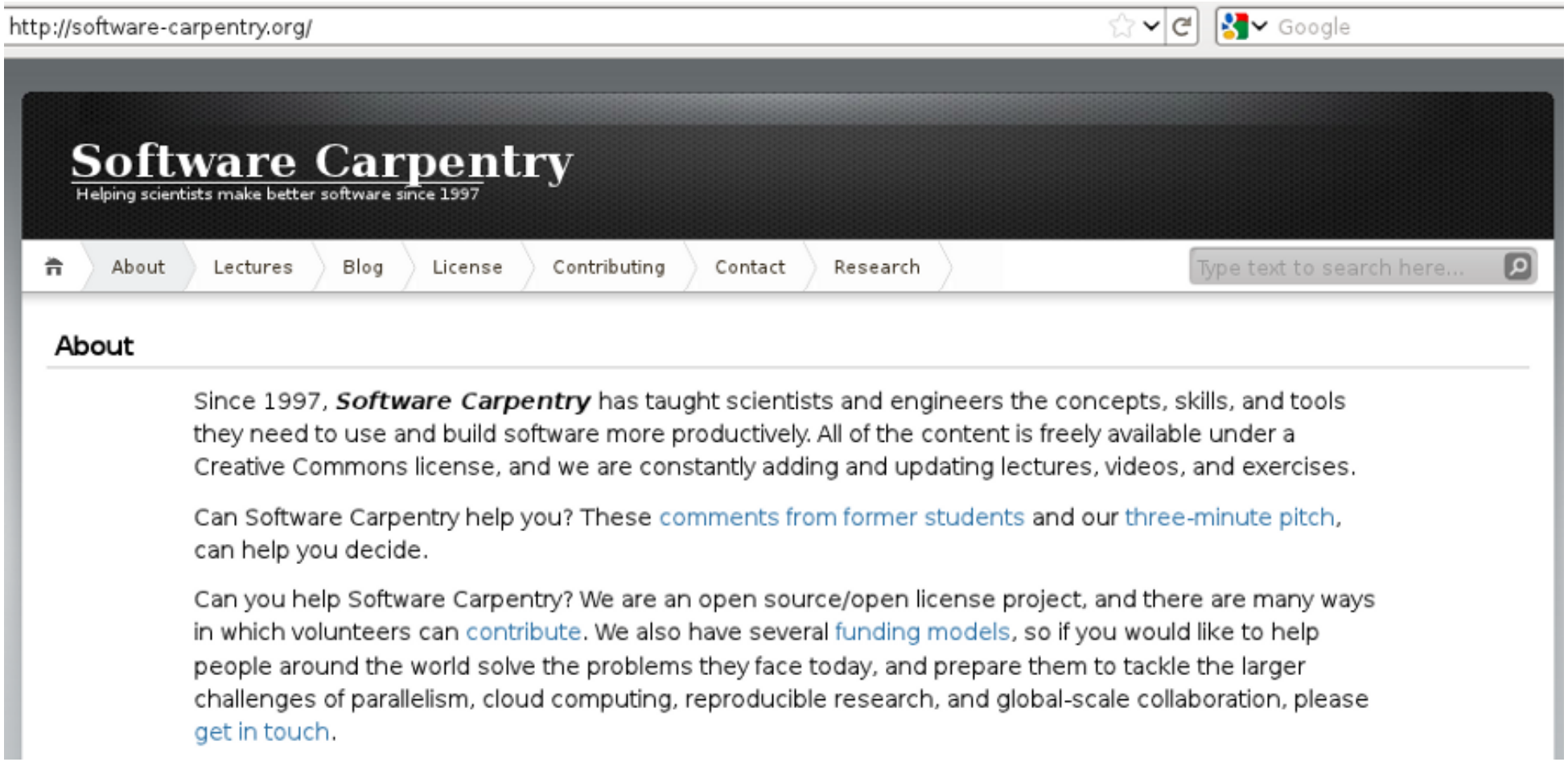
Programming as a first class citizen

- Read programming articles, books, etc.
- Learn new languagues

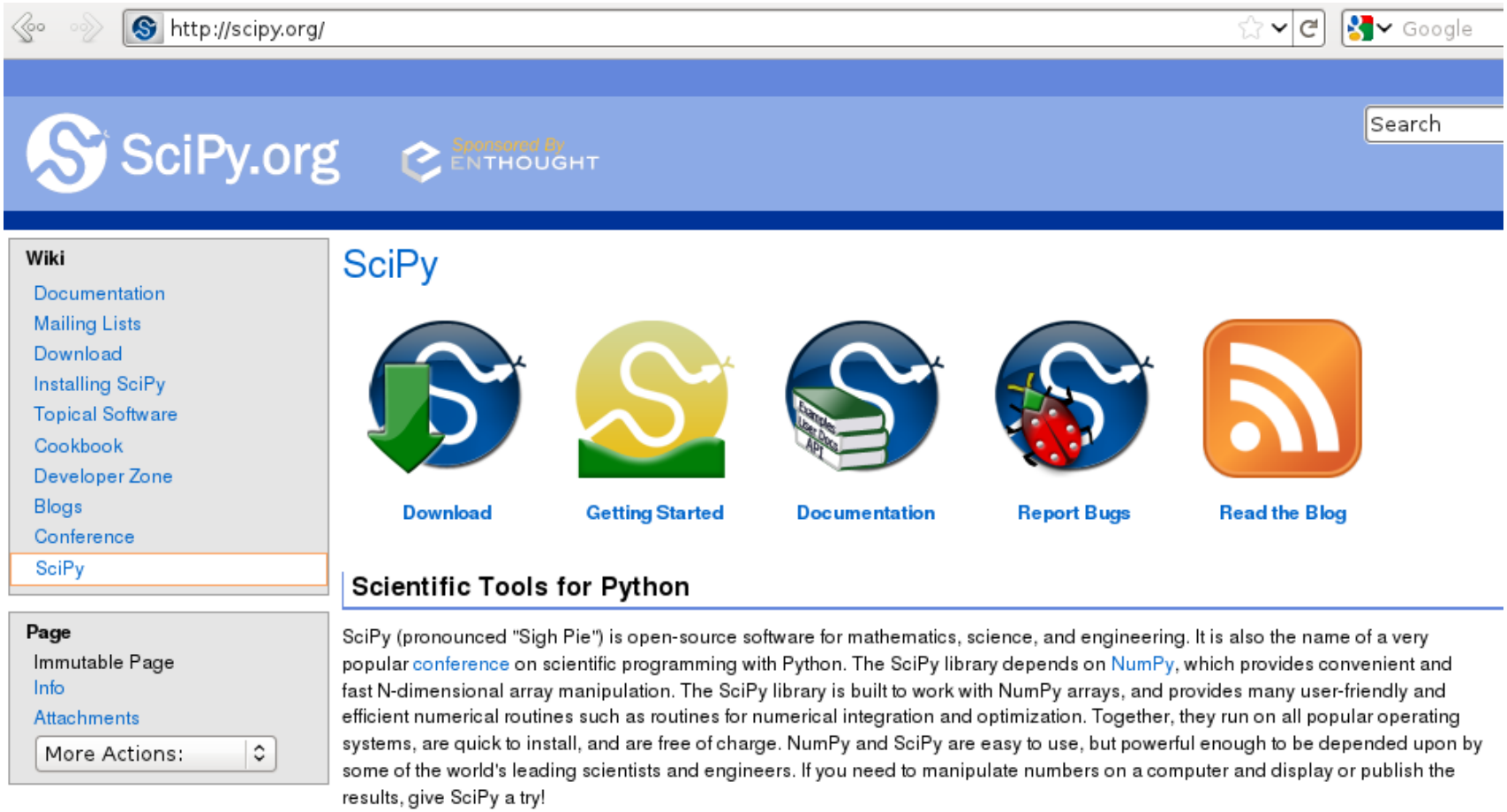
Agile methodology

- Test driven development
- Pair programming
- Metaprogramming

Programming best practices



Python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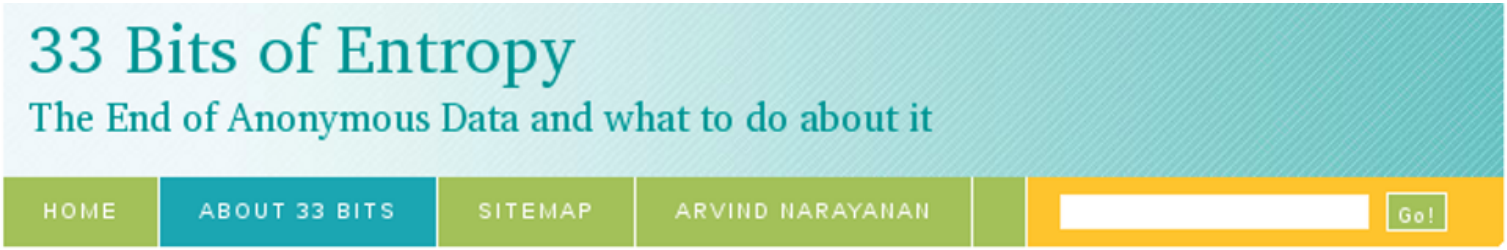
Scientific Tools for Python
SciPy (pronounced "Sigh Pie") is open-source software for mathematics, science, and engineering. It is also the name of a very popular conference on scientific programming with Python. The SciPy library depends on NumPy, which provides convenient and fast N-dimensional array manipulation. The SciPy library is built to work with NumPy arrays, and provides many user-friendly and efficient numerical routines such as routines for numerical integration and optimization. Together, they run on all popular operating systems, are quick to install, and are free of charge. NumPy and SciPy are easy to use, but powerful enough to be depended upon by some of the world's leading scientists and engineers. If you need to manipulate numbers on a computer and display or publish the results, give SciPy a try!

http://33bits.org



About 33 Bits

This is a blog about my research on privacy and anonymity. The title refers to the fact that there are only 6.6 billion people in the world, so you only need 33 bits (more precisely, 32.6 bits) of information about a person to determine who they are.

This fact has two related consequences. First, a lot of traditional thinking about anonymous data relied on the fact that you can hide in a crowd that's too big to search through. That notion completely breaks down given today's computing power: as long as the bad guy has enough information about his target, he can simply examine every possible entry in the database and select the best match.

The second consequence is that 33 bits is not really a lot. If your hometown has 100,000 people, then knowing your hometown gives me 16 bits of entropy about you, and only 17 bits remain. But the real danger is that information about a person's *behavior*, which was traditionally not considered personally identifying, can be used to cause serious privacy breaches in a variety of different contexts.

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