The art of Programming Evolutionary Algorithms

Juan-Julián Merelo.

@jjmerelo

U. Granada (Spain)


Get out and
smell the air

New is always better

Programming paradigms are changing on a daily basis

GPGPU

Cloud computing

NoSQL

Map/reduce

Internet of Things

Form should fit function

Tui


And we
should
adapt to the
new


We should be a
rite
publishable papers
artifacts painlessly
through efficient,
maintainable, scientific
programming


Mind your
environment

Open source your code **and data**

Aw, maaaan!

- Open source first, then program
  - Scientific code should be born free.
- Science must be reproductible.
- Easier for others to compare with your approach
  - Increased H
    - Scientist heaven!
- Manifest *hidden* assumptions.

If you don't share, you don't care!

Minimize bugs
via
test-driven
programming

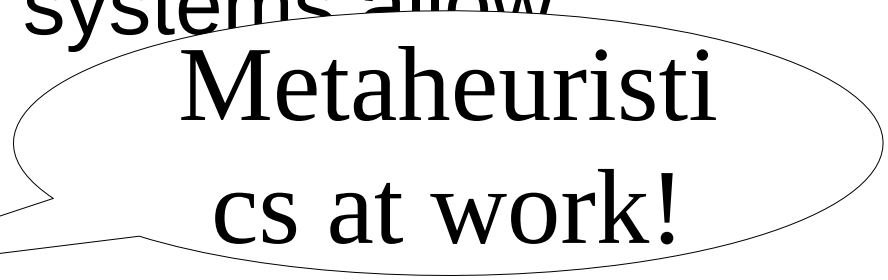
Tests before code

- What do you want your code to do?
  - Mutate a bit string, for instance.
- Write the test
  - Is the result from mutation different from the original?
    - Of course!
    - But will it be even if you change an upstream function? Or the representation?
  - Does it change all bits in the same proportion (including first and last → corner cases)?


Control the source of your power

Source control systems save the day

- Source code management systems allow
  - Checkpoints
  - *Stygmergic* interaction
  - Individual responsability over code changes
  - Branches
- Distributed are *in*: git, mercurial, bazaar
- Centralized are *out*: subversion, cvs.
- Instant backup!



Code complete

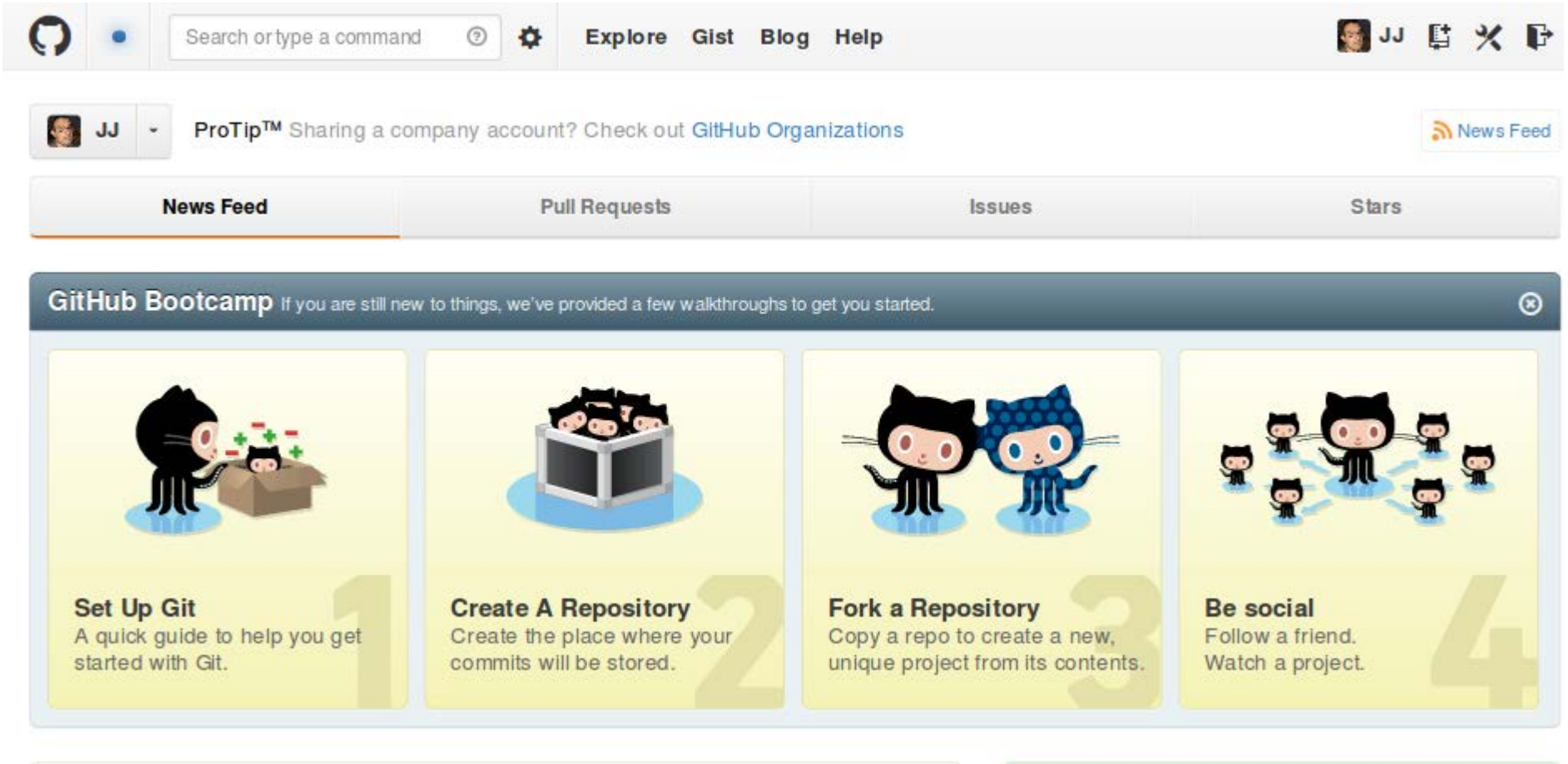
1) Check out code/Update code

2) Make changes

3) Commit changes (and push to *central* repository)

Go with the Joneses

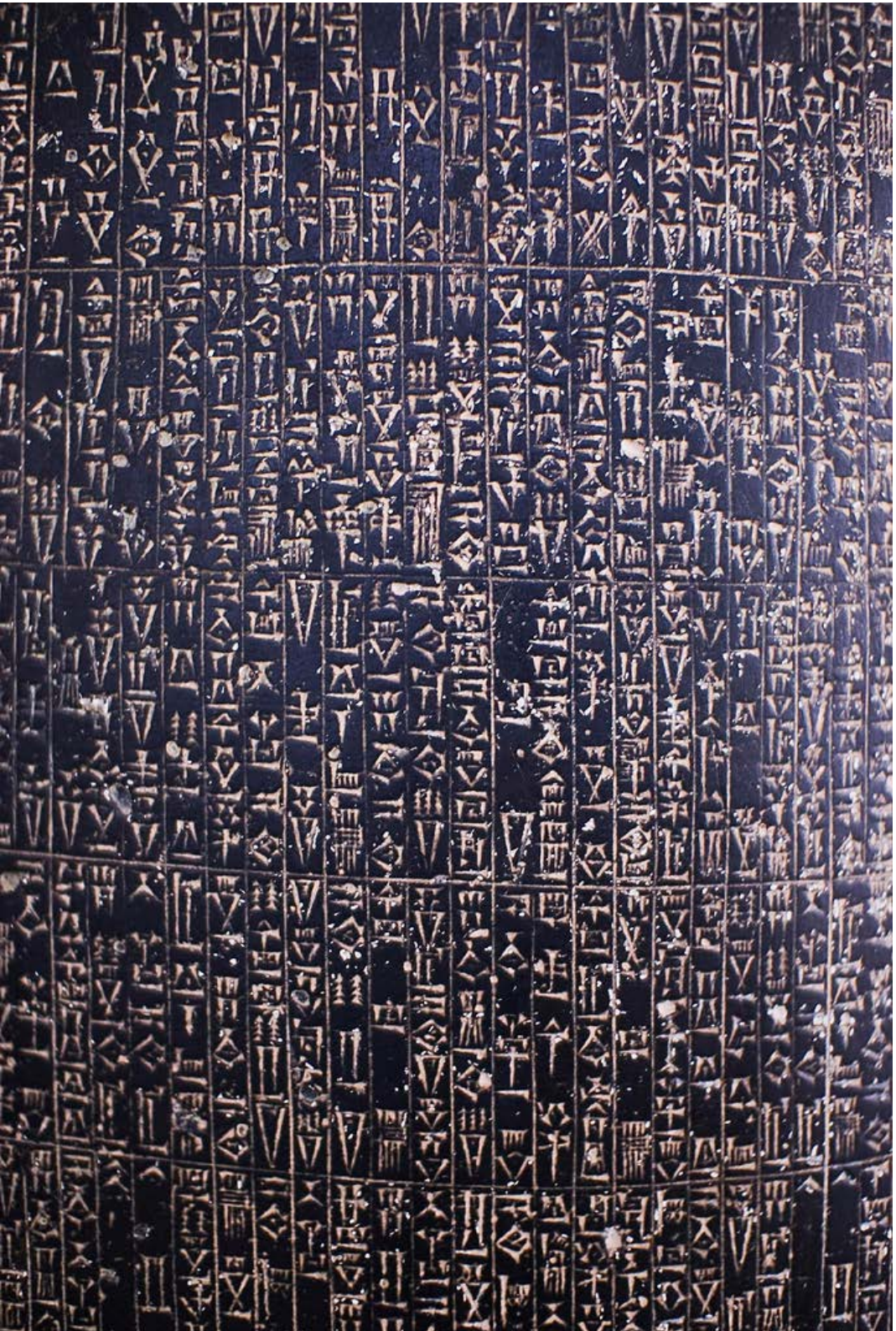
Use GitHub: http://github.com



Integrate

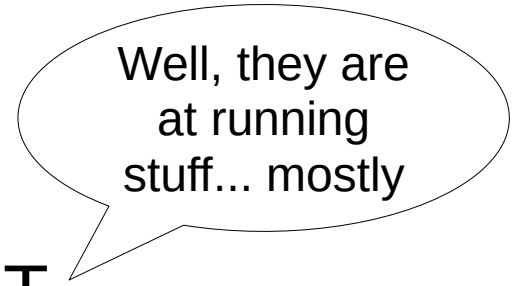
Pushing is not the end of the story

- Tests must be run, compilations made, checks and balances checked and balanced.
- Use Travis or Jenkins
  - If it's good enough for software developers, it's good enough for scientists!
- All this is free if you open source your code
  - Back to #2



Be language agnostic

Language shapes thought

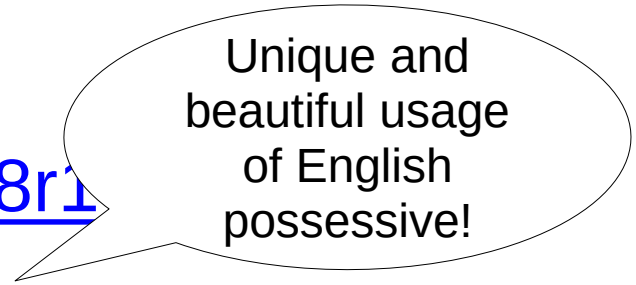


- Don't believe the hype:
  - Compiled languages are faster... NOT
  - There is no free lunch.
- Avoid programming in C in every language you use
- Consider scripting languages: Python, Perl, Lua, Ruby, Clojure, Javascript... interpreted languages *are* faster.

Language agnoticism at its best

Evolving Regular Expressions for GeneChip Probe Performance Prediction

http://www.springerlink.com/content/j3x8r1



The regular expresions are coded in AWK scripts:

Although this may seem complex, gawk (Unix' free interpreted pattern scanning and processing


Programming speed >
program speed

Scientists, not software engineers

- Our deadlines are for papers – not for software releases (but we have those, too).
- What should be optimized is speed-to-publish.
- Makes no sense to spend 90% time programming – 5% writing the paper.
- Scripting languages rock
  - and minimize time-to-publish.

Perl faster than Java?

Algorithm::Evolutionary, a flexible Perl module for evolutionary computation

http://www.springerlink.com/content/8h025g83j0q68270/

- Class-by-class, Perl library much more compact
  - Less code to write.
    - More time to write the paper, perform experiments....
- In pure EC code, Algorithm::Evolutionary was faster than ECJ.

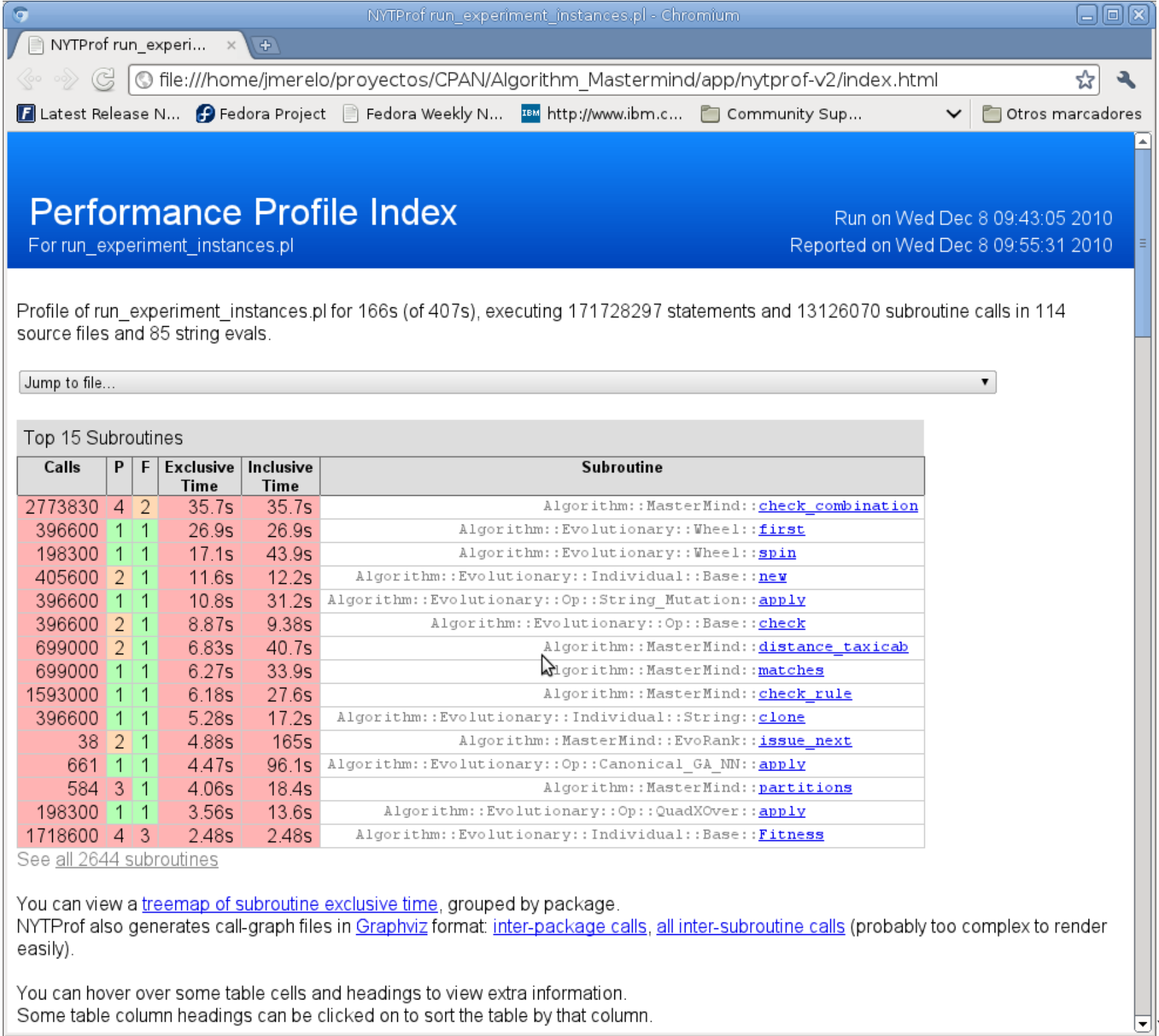
Don't assume:

measure

Performance matters

- Basic measure: CPU time as measured by `time`

```
jmerelo@penny:~/proyectos/CPAN/Algorithm-Evolutionary/benchmarks$ time perl onemax.pl

0; time: 0.003274

1; time: 0.005438

[...]

498; time: 1.006539

499; time: 1.00884
```



Going a bit deeper: profilers

There's always
a better
algorithm/
data structure

And differences are huge

- Sort algorithms are an example
  - Plus, do you need to sort the population?
- Cache fitness evaluations
  - Cache them permanently in a database?
    - Measure how much fitness evaluation takes
- Thousand ways of computing fitness
  - How do you compute the MAXONES?
    - `$fitness_of{$chromosome} = ($copy_of =~ tr/1/0/);`
- Algorithms and data structures interact.

Case Study: EAs as software programs

Time analysis of standard evolutionary algorithms as software programs

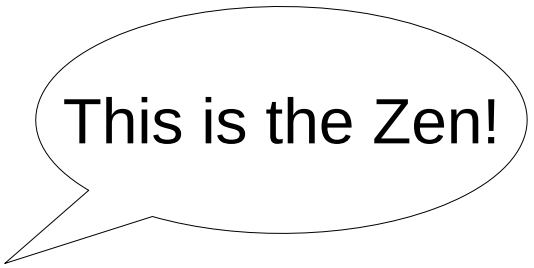
http://dx.doi.org/10.1109/ISDA.2011.6121667

Programs implementing EAs are analyzed; huge improvements can be achieved by changing random number generators or memory usage patterns

Implementation matters!


Learn the tricks of the trade

Two trades



- Evolutionary algorithms
  - Become one with your algorithm.
    - It does not work, but for a different reason that what you think it does
- Programming languages.
  - What function is better implemented?
  - Is there yet another library to do sorting?
  - Where should you go if there's a problem?
- Even a third trade: programming itself.

Case study: sort

- Sorting is routinely used in evolutinary algorithms
  - Roulette wheel, rank-based algorithms
- Faster sorts (in Perl): http://raleigh.pm.org/sorting.html
  - Sorting implies comparing
  - *Orcish* Manoeuver, *Schwartzian* transform
  - Sort::Key, fastest ever http://search.cpan.org/dist/Sort-Key/

Make experiment processing easy

Avoid drowning in data

- Every experiment produces megabytes of data
  - Timestamps, vectors, arrays, hashes.
  - Difficult to understand after some time.
- Use serialization languages for storing data
  - YAML: Yet another markup language.
  - JSON: Javascript Object Notation.
  - XML: eXtensible Markup language.
  - [Name your own].

Case study: Mastermind

Entropy-Driven Evolutionary Approaches to the Mastermind Problem

Carlos Cotta et al., http://www.springerlink.com/content/d8414476w2044g2m/

- Output uses YAML.
- Includes:
  - Experiment parameters.
  - Per-run and per-generation data.
  - Final population and run time.

Open source! (Follow #2!)

When everything fails

visualize

backup

your data

Better safe than unpublished

- Get an old computer, and backup everything there.
  - If you do open science, you get that for free!
- In some cases, create virtual machines to reproduce one paper's environment
  - Do you think gcc 3.2.3 will compile your old code?
- Use rsync, bacula or simply cp.
- It's not if your hard disk will fail, it's when.
- Cloud solutions are OK but backup that too

Keep stuff together

Where did I left my keys?

- Paper: program + data + graphics + experiment logs + text + revisions + referee reports + presentations.
- Experiments have to be rerun, graphics replotted, papers rewritten.
- Use logs to know which parameters produced which data that produced which graph.
- And put them all in the same directory tree, or use sensible naming conventions.

Consider *literate* programming

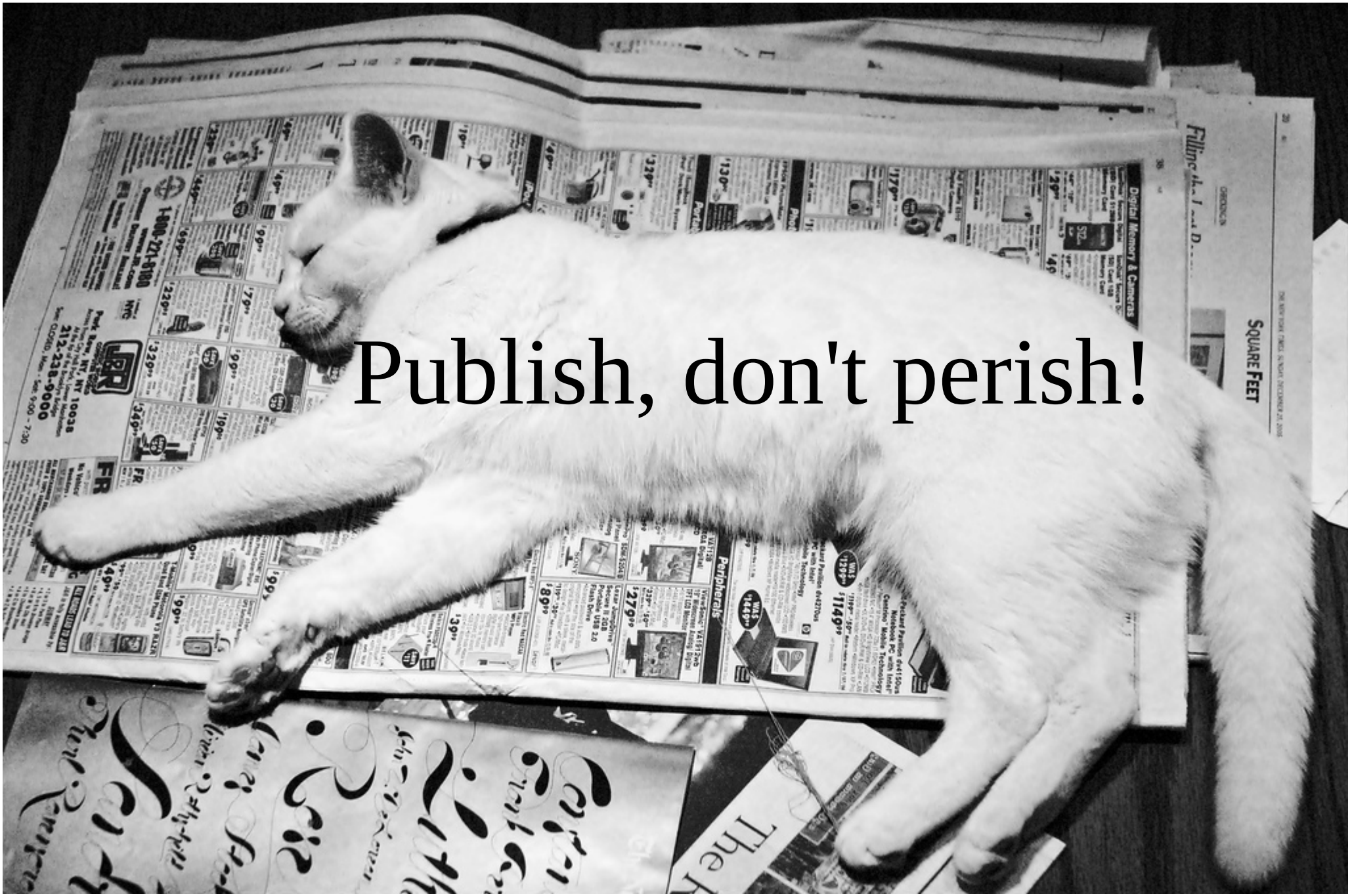
- *Literate programming* means keeping program and document describing it and results in the same place.
- SWeave and Knitr integrate LaTeX and R in the same document.
  - Check availability for your favorite platform.
- Not the most popular way of writing papers.
- But check also http://www.executablepapers.com/

Keep a balance between fashions and efficiency


Nurture your
code

A moment of joy, a lifetime of grief

- Run tests periodically, or when there is a major upgrade of interpreter, upstream library or OS.
  - Can be automated.
    - See #6.
- Maintain a roadmap of releases
  - Remember this is *free* software, **engage the community.**
- Your research is intended for the whole wide world.


Publish, don't perish!

(no cats were harmed preparing this presentation)

Check me out at:

http://twitter.com/jjmerelo

http://goo.gl/OFou1

Any (more) questions?

See you in Evostar 2014, Baeza: http://evostar.org!