

SCIENTIFIC METHODOLOGY AND (EMPIRICAL|EXPERIMENTAL) EVALUATION

Lucas M. Schnorr



Comp. Syst. Perf. Analysis
PPGC/INF/UFRGS



OVERVIEW

ACKNOWLEDGEMENT

Thanks to these people to kindly making this material available.

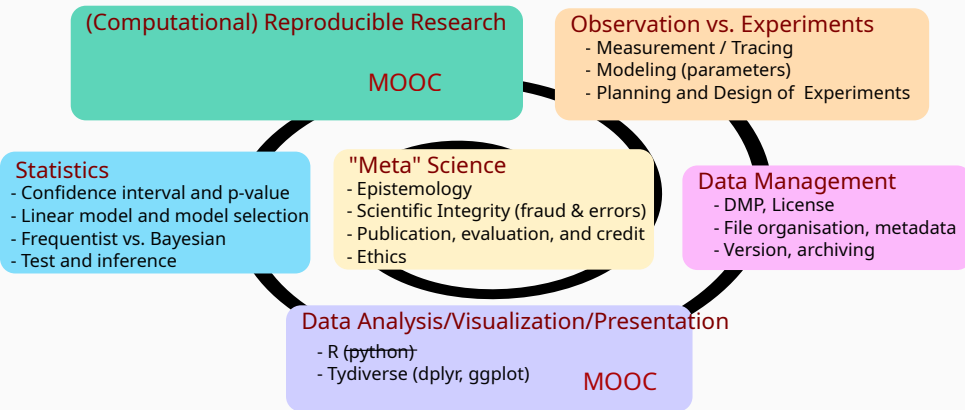


Celine, Cyril, Arnaud, and Jean-Marc

QUICK POLL

- Python
- R
- Notebooks (Rstudio, Jupyter, Org-Mode)
- Git
- Zenodo, Software Heritage
- Docker
- Guix/Nix
- Confidence Interval
- P-value, P-hacking
- Linear regression
- Model Selection
- Design of Experiments
- Reinforcement Learning

TOWARDS A RIGOROUS AND ETHICAL COMPUTER SCIENCE



REPRODUCIBLE RESEARCH

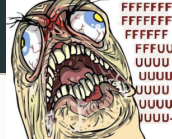
SCIENTIFIC CONSENSUS



NO TRANSPARENCY NO CONSENSUS



COMMON HORROR STORIES 1/3: *WHAT DID I DO?*



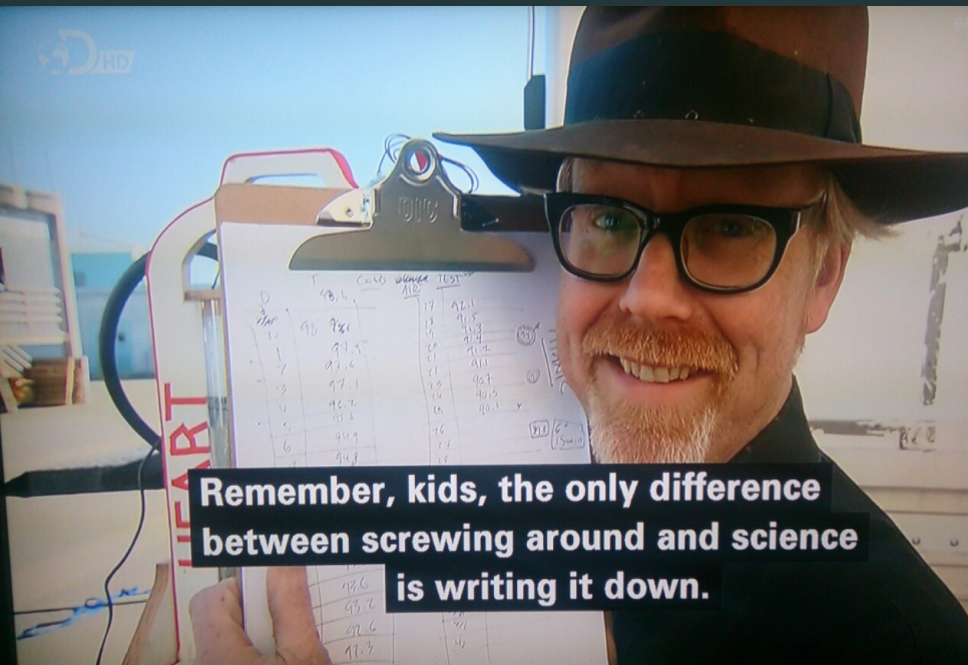
Author

- I thought I used the same parameters but I'm getting different results!
- The new student wants to compare with the method I proposed last year
- My advisor asked me whether I took care of setting this or this but I can't remember
- The damned fourth reviewer asked for a major revision and wants me to change Figure 3. Which code and which data set did I use?
- It worked yesterday! 6 months later: Why did I do that?

Reviewer

- As usual, there is no confidence interval, I wonder about the variability and whether the difference is significant or not
- That can't be true, I'm sure they removed some points
- Why is this graph in logscale? How would it look like otherwise? I'm not even sure of what this value means. If only I could access the generation script

MYTHBUSTERS: SCIENCE VS. SCREWING AROUND



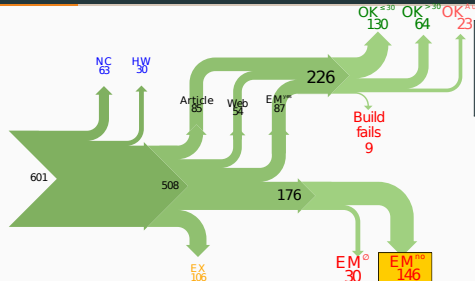
**Remember, kids, the only difference
between screwing around and science
is writing it down.**

COMMON HORROR STORIES 2/3: ARGH... DAMNED COMPUTERS

- **Alice:** I got 3.123123 **Bob:** I got segfault
- Damned! It used to work!!! Whenever I upgrade my computer, things break so I try to stay away from this 😞
- Whenever trying the code of my colleague, I had to install Foo but I broke everything and now neither his code nor mine works! 😞
- But hey! Here is my code. It's on GitHub so feel free to play with it! I'm doing open science 😊

Seriously ? It's 21st century. How come all this is so painful ?

COMMON HORROR STORIES 3/3: PLEASE HOLD ON



- Versioning Problems

Collberg, Christian et Al., *Measuring Reproducibility in Computer Systems Research*, <http://reproducibility.cs.arizona.edu/>

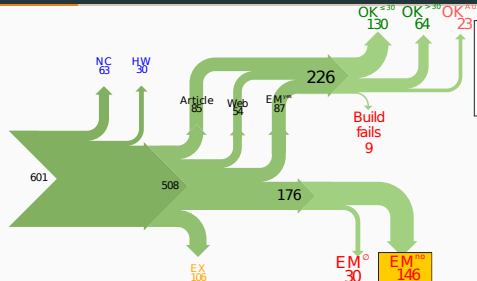
- 8 ACM conferences (ASPLOS'12, CCS'12, OOPSLA'12, OSDI'12, PLDI'12, SIGMOD'12, SOSP'11, VLDB'12) and 5 journals
- EM^{no} = the code cannot be provided

Thanks for your interest in the implementation of our paper. The good news is that I was able to find some code. I am just *hoping* that *it* is a stable working version of the code, and *matches the implementation we finally used for the paper*. Unfortunately, I have *lost some data* when *my laptop was stolen* last year. The bad news is that the code is not commented and/or clean.

8/100

Attached is the (system) source code of our algorithm. I'm *not very sure whether*

COMMON HORROR STORIES 3/3: PLEASE HOLD ON



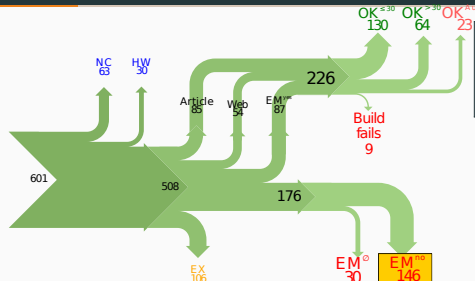
- Versioning Problems
- Bad Backup Practices

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Unfortunately, the server in which my implementation was stored had a **disk crash in April and three disks crashed simultaneously**. While the help desk made significant effort to save the data, my entire implementation for this paper was not found.

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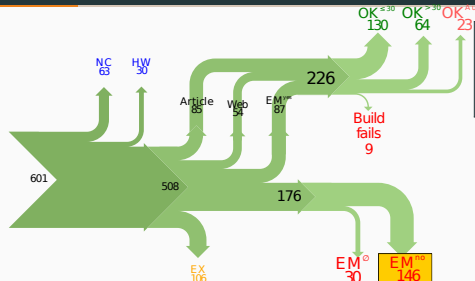


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- Versioning Problems
 - Bad Backup Practices
 - Code Will be Available Soon

Unfortunately the current system is *not mature enough at the moment*, so it's not yet publicly available. We are actively working on a number of extensions and *things are somewhat volatile*. However, once things stabilize we plan to release it to outside users. At that point, we would be happy to send you a copy.

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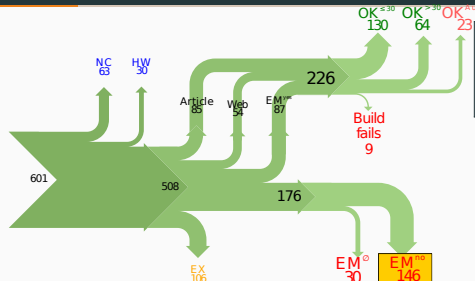


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- Code Will be Available Soon
- No Intention to Release

*I am afraid that the source code was never released. The code was **never intended to be released** so is not in any shape for general use.*

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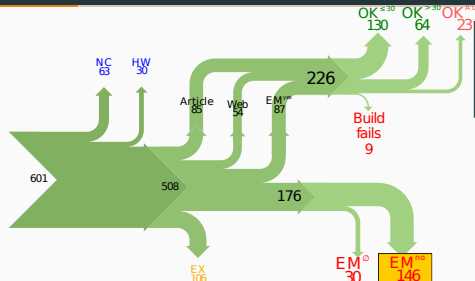
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<STUDENT> was a graduate student in our program but he left a while back so I am responding instead. For the paper we used a prototype that included many moving pieces that only <STUDENT> knew how to operate and we did not have the time to integrate them in a ready-to-share implementation before he left. Still, I hope you can build on the ideas/technique of the paper.

Unfortunately, the author who has done most of the coding for this paper has

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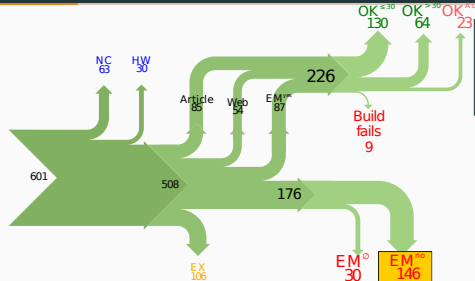
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- EM^{no} = the code cannot be provided
 - Programmer Left
 - Commercial Code
- Versioning Problems
- Bad Backup Practices
- Code Will be Available Soon
- No Intention to Release

Since this work has been done at $\langle \text{COMPANY} \rangle$ *we don't open-source code* unless there is a compelling business reason to do so. So unfortunately I don't think we'll be able to share it with you.

The code *owned by* $\langle \text{COMPANY} \rangle$, and AFAIK the code is not open-source. Your best bet is to reimplement :(Sorry.

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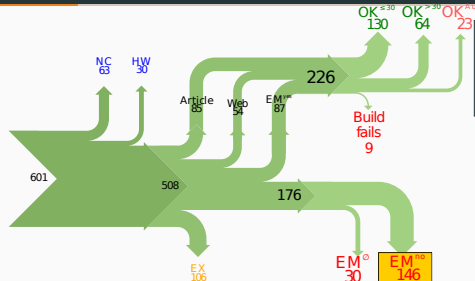
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- Programmer Left
- Commercial Code
- Proprietary Academic Code
- Versioning Problems
- Bad Backup Practices
- Code Will be Available Soon
- No Intention to Release

Unfortunately, the $\langle \text{SYSTEM} \rangle$ sources are *not meant to be opensource* (the code is partially *property of* $\langle \text{UNIVERSITY 1} \rangle$, $\langle \text{UNIVERSITY 2} \rangle$ and $\langle \text{UNIVERSITY 3} \rangle$.)

If this will change I will let you know, albeit I do not think there is an intention to make the $\langle \text{SYSTEM} \rangle$ sources opensource in the near future.

If you're interested in obtaining the code, *we only ask for a description of the re-*

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- Programmer Left
- Commercial Code
- Proprietary Academic Code
- Research vs. Sharing
- Versioning Problems
- Bad Backup Practices
- Code Will be Available Soon
- No Intention to Release

In the past when we attempted to share it, we found ourselves spending more time getting outsiders up to speed than on our own research. So I finally had to establish the policy that we will not provide the source code outside the group.

DIFFERENT REPRODUCIBILITY CONCERNS IN MODERN SCIENCE

Social Sciences, Oncology, ... methodology, statistics, pre-registration

Genomics software engineering, computational reproducibility, provenance

Computational fluid dynamics numerical issues

Artificial Intelligence most of the above

The processing steps between raw observations and findings have gotten increasingly numerous and complex

Authors



Data

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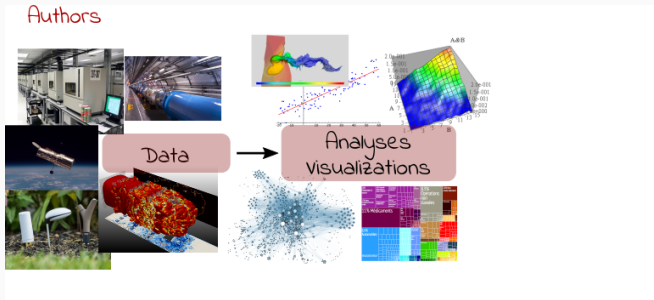
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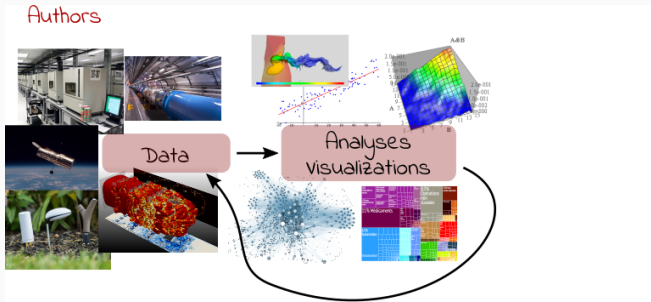
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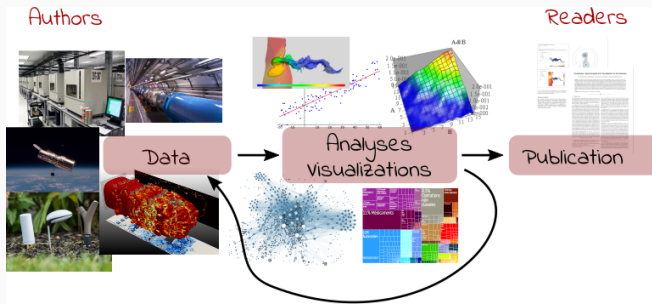
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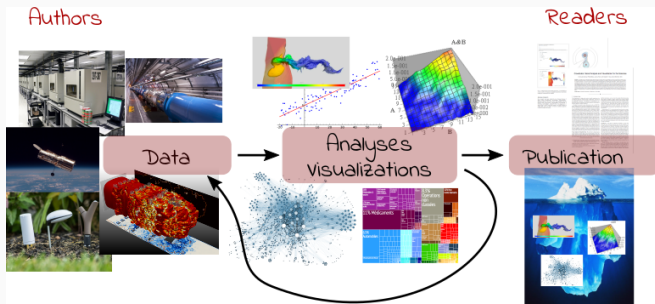
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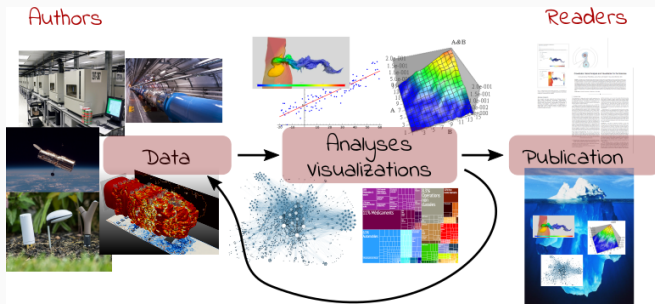
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CHANGING RESEARCH PRACTICES

Soft. Engineering, Statistics, and Reproducible Research in the **curricula**

Manifesto: *"I solemnly pledge"* (WSSSPE, Lorena Barba, FAIR)

1. I will teach my graduate students about reproducibility
2. All our research code (and writing) is under version control
3. We will always carry out verification and validation
4. We will share data, plotting script & figure under CC-BY
5. We will upload the preprint to arXiv at the time of submission of a paper
6. We will release code at the time of submission of a paper
7. We will add a "Reproducibility" declaration at the end of each paper
8. I will keep an up-to-date web presence



Learn and Teach using online resources like

- **Software Carpentry**, **The Turing Way**, ...

THE REPRODUCIBLE RESEARCH MOOC

MOOC Reproducible Research: Methodological principles for a transparent science, Learning Lab

- Konrad Hinsen, Christophe Pouzat
- **3rd Edition**: March 2020 – March 2023 (15,000+)
- In French but fully subtitled in English

Module 1 Taking notes (markdown, git)

Module 2 Computational document (Jupyter, Rstudio, Org-Mode)
Data Analysis of the Space Shuttle: Pre-Challenger Prediction of Failure

Module 3 Reproducible analysis

Data analysis : 7 possible subjects and a Peer evaluation

Module 4 Reproducibility Pitfalls (Hell)

The 2nd **MOOC "Advanced RR"** has been released in 2021 2024

- Managing data
- Software environment control
- Scientific workflow

