Modèles Statistiques (MS)

ou comment réaliser une étude en incluant de l'analyse de données

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Laboratoire LIG
Équipe-Projet Inria POLARIS

Grenoble 2017

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UE MODÈLES STATISTIQUES

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ORGANISATION

Équipe pédagogique

Jean-Marc Vincent

Jean-Marc.Vincent@imag.fr

coordination de l'UE

Laboratoire d'informatique de Grenoble

Équipe Inria POLARIS

Évaluation de performances de systèmes/réseaux/infrastructures à grande échelle

Lucas Schnorr

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Laboratoire d'informatique de Grenoble

Équipe Inria POLARIS

INF, UFRGS (Porto Alegre, Brésil)

Trace d'applications, analyse de programmes parallèles, environnement d'expérimentation

COMMUNICATION AVEC L'ÉQUIPE PÉDAGOGIQUE

Mail et adresses électroniques

Adresse Mail enseignant : Prénom.Nom@imag.fr
SUJET : [MIAGE :MS] sujet explicite

envoyer votre mail avec votre adresse officielle **@etu.univ-grenoble-alpes.fr**
toute adresse de provenance différente risque d'être "grey/black-listée" et d'atterrir dans une poubelle

le mail officiel de la L3-MIAGE est la liste
etu-2016-im2ag-gbl3ie160@univ-grenoble-alpes.fr, toute annonce officielle (quicks, apnées, déplacements de créneaux horaires,. . .) passera par ce mail (que vous devez lire quotidiennement)

Destinataires

organisation/cours/examens. . . : Jean-Marc Vincent

les **Travaux Dirigés/Pratiques** : Lucas Schnorr

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OBJECTIF PÉDAGOGIQUE DE L'UE MODÈLES STATISTIQUES

Connaissances

Savoir réaliser une étude d'un objet informatique (ou autre) à partir de données observées :
(répondre à une question, formuler une hypothèse et la confirmer)

- savoir bâtir une expérimentation simple et produire des données d'observation
- savoir analyser les résultats obtenus (processus d'analyse)
- savoir restituer les résultats sous forme synthétique (processus de visualisation, commentaires, analyse et synthèse)

En pratique, savoir réaliser une étude argumentée et correctement présentée.

Savoir utiliser un/des environnement(s) adapté(s) :

- suivi des développements logiciels (historique, versionning, collaboration) : git, github
- processus d'analyse (analyse statistique, synthèse, visualisation) : R (R-studio, ggplot)
- mise en forme et présentation : LaTeX (via un markdown)

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ORGANISATION DE LA SEMAINE

Cours /TD : guidelines pour une étude rigoureuse et reproductible

Les cours/TD seront organisés à partir d'études de cas :

- une partie synthétique sur les concepts
- une partie sur des exemples illustrant les concepts
- une partie sur votre étude de cas

Forme du travail

- travail en binôme/quadrinôme
- travail public (partageable par toute la promotion (et même plus))
- synthèse en commun (production de fiches)

Travail personnel :

- prévoir 1 à 2h de travail en moyenne à la maison pour 1 séance de cours/TD ,
- exercices à la maison (pour préparer le matériel des séances suivantes)

Évaluation : une note d'UE

- mini-projet avec une présentation
- suivi des C/TD

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CONTENU INDICATIF

Environnement

1. Introduction / problème
2. Programmation Littérale / RStudio / Rmd
3. Visualisation élémentaire / ggplot2
4. Guideline / Checklist for good graphics

Traitement de données

5. Processus d'analyse /statistiques de base (rappels)
6. Données importation pré et post traitement
7. Manipulation de donnée expérimentales (dplyr)

Mini-projet

8. Mini-projet : spécification/études préliminaires
9. Mini-projet : étude et rapport

Présentation

10. Présentation orale (tous les étudiants)

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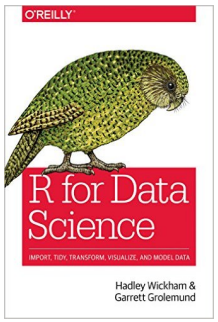
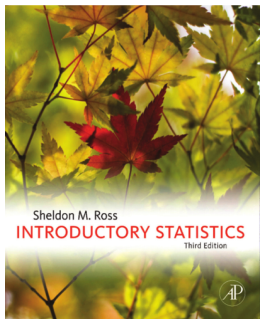
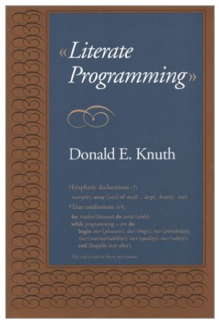
BIBLIOGRAPHIE : OUVRAGES DE RÉFÉRENCE DU COURS

- **R** *Garrett Grolemund and Hadley Wickham*, R for Data Science, O'Reilly 2015
- **Statistiques** *Sheldon Ross* Introductory Statistics. Academic Press 2010
  Également les polycopiés de Frédérique Leblanc
  http://www-ljk.imag.fr/membres/Frederique.Leblanc/
- **Historique** *Donald E. Knuth* Literate Programming. Academic Press 2010







et évidemment de nombreuses ressources sur le web ...

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UN OEIL CRITIQUE

Dernière mise à jour le dimanche 22 janvier 2017 à 00h45

	Manuel Valls	31.11% 388603 voix
	Sylvia Pinel	1.97% 24657 voix
	Vincent Peillon	6.85% 85575 voix
	François de Rugy	3.88% 48521 voix
	Arnaud Montebourg	17.52% 218885 voix
	Benoît Hamon	36.35% 454041 voix
	Jean-Luc Bennahmias	1.01% 12609 voix
	Votes blancs et nuls	1.3% 16235 voix

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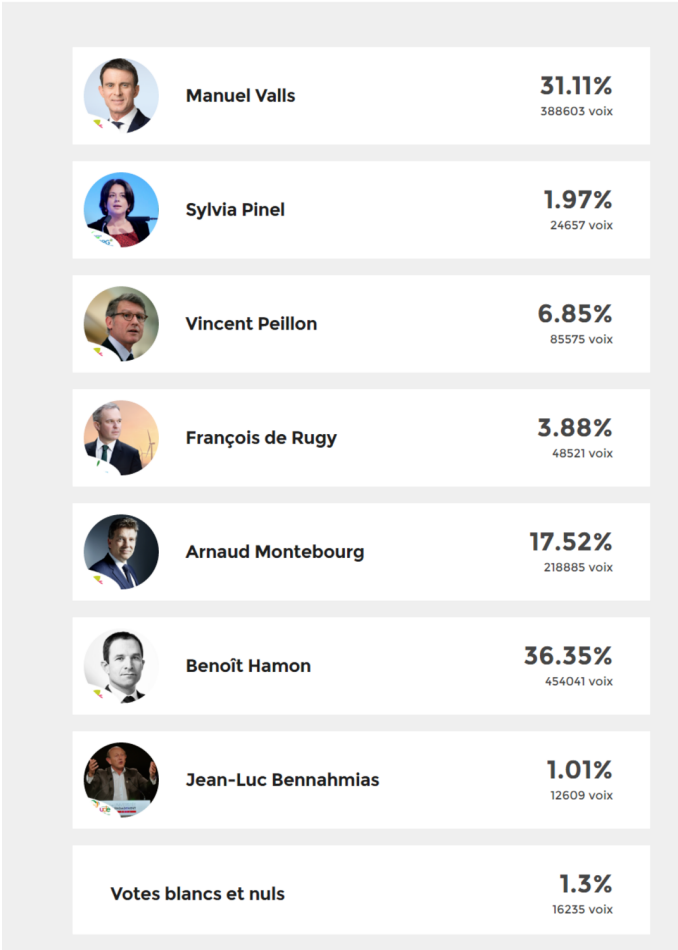
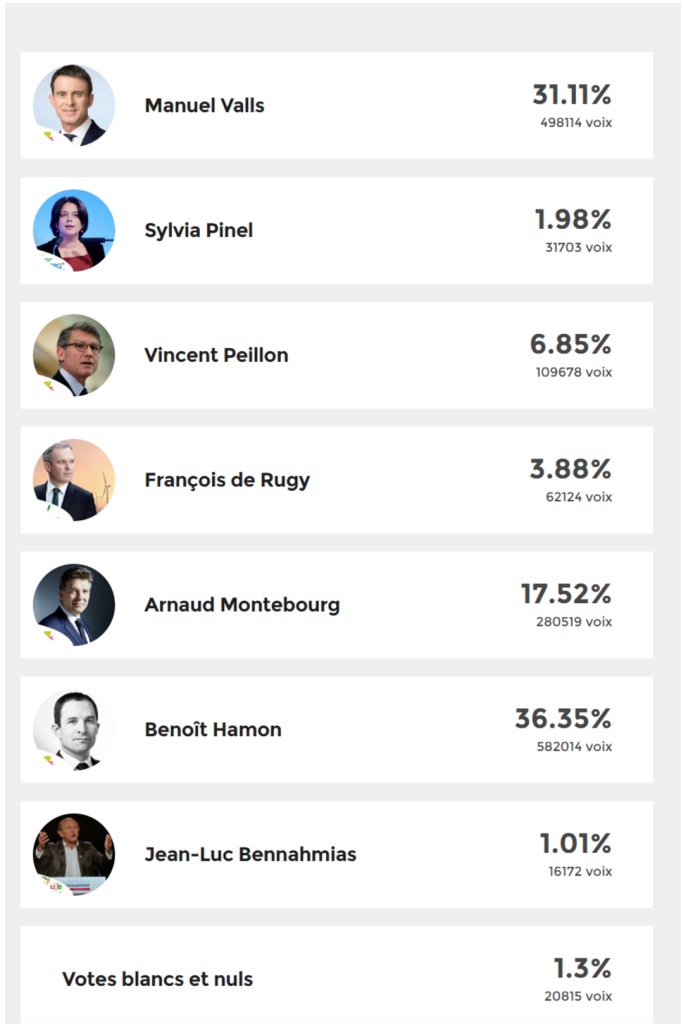
UN OEIL CRITIQUE

Dernière mise à jour le dimanche 22 janvier 2017 à 00h45





et lundi matin

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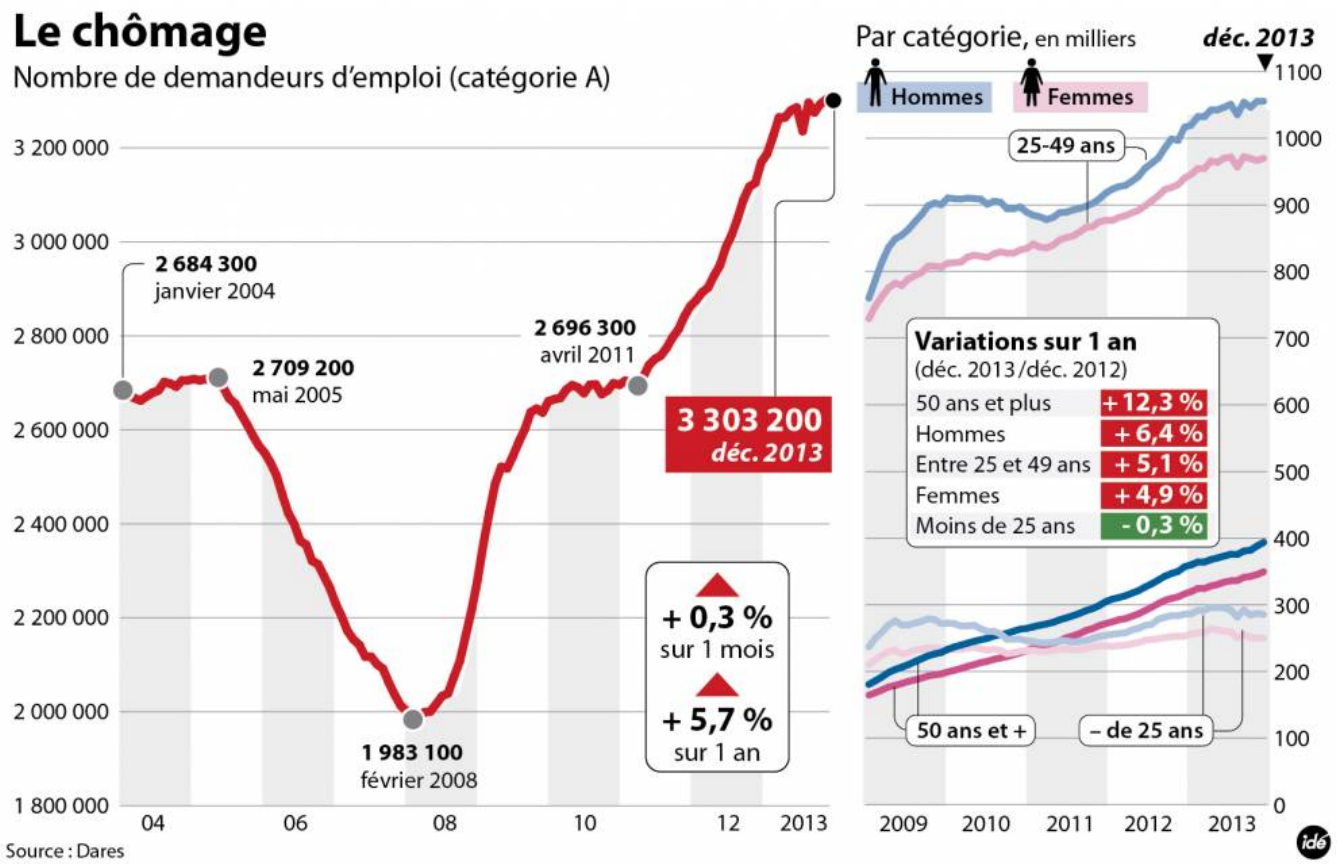
UN OEIL CRITIQUE (2)

- Performances http://www.cpubenchmark.net/index.php
- http://www.tylervigen.com/spurious-correlations
- https://www.ined.fr/fr/tout-savoir-population/
- taux de réussite au Bac

UN OEIL CRITIQUE (3)



Extrait du journal Le Point 2013

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FRUSTRATION AS AN 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 to generate this figure ?
- It worked yesterday !
- 6 months later : why did I do that ?

FRUSTRATION AS A REVIEWER

This may be an interesting contribution but :

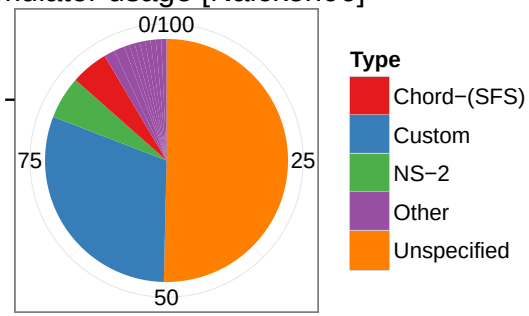
- This average value must hide something
- As usual, there is no confidence interval, I wonder about the variability and whether the difference is significant or not
- That can't be true, I'm sure they removed some points
- Why is this graph in logscale ? How would it look like otherwise ?
- The authors decided to show only a subset of the data. I wonder what the rest looks like
- There is no label/legend/... What is the meaning of this graph ? If only I could access the generation script

A FEW EDIFYING EXAMPLES

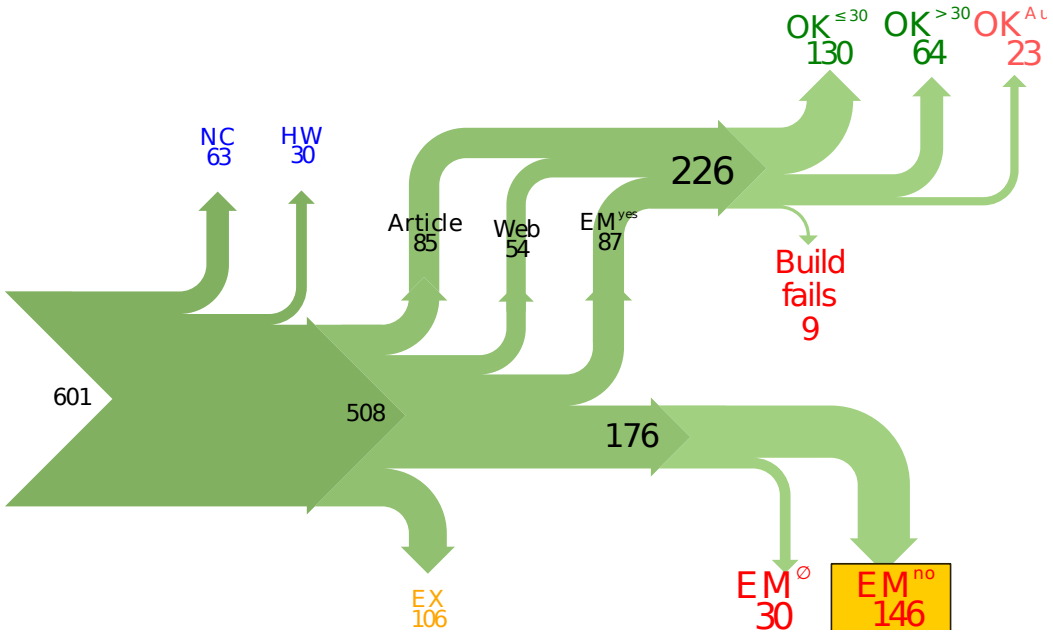
Naicken, Stephen *et Al.*, *Towards Yet Another Peer-to-Peer Simulator*, HET-NETs'06.

From 141 P2P sim.papers, 30% use a custom tool, 50% don't report used tool

Simulator usage [Naicken06]



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

THE DOG ATE MY HOMEWORK ! ! !

- Versioning Problems

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.

Attached is the ⟨system⟩ source code of our algorithm. I'm not very sure whether it is the final version of the code used in our paper, but it should be at least 99% close. Hope it will help.

THE DOG ATE MY HOMEWORK ! ! !

- Versioning Problems
- Bad Backup Practices

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.

THE DOG ATE MY HOMEWORK ! ! !

- 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.

THE DOG ATE MY HOMEWORK ! ! !

- Versioning Problems
- Bad Backup Practices
- 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.

THE DOG ATE MY HOMEWORK ! ! !

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

⟨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 passed away and the code is no longer maintained.

THE DOG ATE MY HOMEWORK ! ! !

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

Since this work has been done at ⟨COMPANY⟩ 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 ⟨COMPANY⟩, and AFAIK the code is not open-source. Your best bet is to reimplement :(Sorry.

THE DOG ATE MY HOMEWORK ! ! !

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

Unfortunately, the ⟨SYSTEM⟩ sources are not meant to be opensource (the code is partially property of ⟨UNIVERSITY 1⟩, ⟨UNIVERSITY 2⟩ and ⟨UNIVERSITY 3⟩.)
If this will change I will let you know, albeit I do not think there is an intention to make the ⟨SYSTEM⟩ sources opensource in the near future.

If you're interested in obtaining the code, we only ask for a description of the research project that the code will be used in (which may lead to some joint research), and we also have a software license agreement that the University would need to sign.

THE DOG ATE MY HOMEWORK ! ! !

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

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.

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STRUCTURE

Research articles are often structured in this basic order :

Introduction	Why was the study undertaken ? What was the research question, the tested hypothesis or the purpose of the research ?
Methods	When, where, and how was the study done ? What materials/hardware were used ? How was it configured ?
Results	What answer was found to the research question ; what did the study find ? Was the tested hypothesis true ? Present useful results in a synthetic way with a logical order.
Discussion	What might the answer imply and why does it matter ? How does it fit in with what other researchers have found ? What are the possible bias and points to improve ? What are the perspectives for future research ?

Such structure facilitates literature review and is a very effective way to convey information.
If the report is a few pages long then an abstract is required.

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STEP 0 : TAKING NOTES

Document your :

- Hypotheses : keep track of your ideas/line of thoughts
- Experiments : details on how and why an experiment was run, including failed or ambiguous attempts.
- Initial analysis or interpretation of these experiments : was the outcome conform to the expectation or not ? does it (in)validate the hypothesis ?
- Organization : keep track of things to do/fix/test/improve

Structure :

1. General information about the document and organization conventions (e.g., directory structure, notebook structure, experimental result storing mechanism, . . .)
2. Documentation of commonly used commands and of how to set up experiments (e.g., git cloning, environment deployment, connection to machines, compiling scripts)
3. Experiment results can be either structured by dates ($\rightsquigarrow$ add tags) or by experiment campaigns ($\rightsquigarrow$ add date/time)

WHICH FORMAT SHOULD I USE ?

- Wikis are encouraged to favor collaboration but I do not find them really effective
- Blogging systems are also a way of managing such notebook but they should rather be considered as an effective way to share information with others
- I recommend to use basic plain-text format and to structure it hierarchically

Here is a link to an excerpt of the journal of one of my PhD student, managed with git/org-mode. More detailed links are given in slide **??**.

Last but not least :

Provide links to Raw Data ! ! !

WHEN/HOW OFTEN SHOULD I USE IT ?

I have a very intense usage (demo to general journal and specific BOINC journal) and I tend to capture a lot of information but you do not have to be as extreme as I am. Here are a few advices :

- Spending more than an hour without at least writing what you're working on is not right. . .
  - Take a 5 minutes break and ask yourself what you're doing, what is keeping you busy and where all this is leading you
- While working on something, you will often notice/think about something you should fix/improve but you just don't want to do it now. Take 20 seconds to write a TODO entry.
- There are moments where you have to wait for something (compiling, deployment, . . .). It is generally the perfect time for improving your notes (e.g., detail the steps to accomplish a TODO entry).
- By the end of the day : daily (and weekly) review !
  - Update your lists, write what the next steps are
  - Summarize in a 2-4 lines (for your advisor) what you did, what was difficult, what you learnt.

STEP 1 : SHARING CODE AND DATA

What kinds of systems are available ?

- "Good" - The cloud (Dropbox, Google Drive, Figshare)
- Better - Version control systems (SVN, Git and Mercurial)
- "Best" - Version control systems on the cloud (GitHub, Bitbucket)

Depends on the level of privacy you expect but you probably already know these tools.
Few handle GB files...

Is this enough ?

1. Use a workflow that documents both data and process
2. Use the machine readable CSV format
3. Provide raw data and meta data, not just statistical outputs
4. Never do data manipulation and statistical tests by hand
5. Use R, Python or another free software to read and process raw data (ideally to produce complete reports with code, results and prose)

Courtesy of Adam J. Richards

STEP 2 : LITERATE PROGRAMMING

Donald Knuth : explanation of the program logic in a natural language interspersed with snippets of macros and traditional source code.

I'm way too `3l33t` to program this way but that's
exactly what we need for writing a reproducible article/analysis !

Org-mode (requires emacs)

My favorite tool.

- plain text, very smooth, works both for html, pdf, ...
- allows to combine all my favorite languages even with sessions

Ipython notebook

If you are a python user, go for it ! Web app, easy to use/setup...

KnitR (a.k.a. Sweave)

For non-emacs users and as a first step toward **reproducible papers** :

- Click and play with a modern IDE (e.g., Rstudio)

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WHY R ?

R is a great language for data analysis and statistics

- Open-source and multi-platform
- Very expressive with high-level constructs
- Excellent graphics
- Widely used in academia and business
- Very active community
  - Documentation, FAQ on http://stackoverflow.com/questions/tagged/r
- Great integration with other tools

WHY IS SUCH R A PAIN FOR COMPUTER SCIENTISTS ?

- R is not really a programming language
- Documentation is for statisticians
- Default plots are *cumbersome* (meaningful)
- Summaries are *cryptic* (precise)
- Steep learning curve even for us, computer scientists whereas we generally switch seamlessly from a language to another ! That's frustrating ! ;)

DO'S AND DONT'S

R is high level, I'll do everything myself

- CTAN comprises 4,334 TEX, LATEX, and related packages and tools. Most of you do not use plain TEX.
- Currently, the CRAN package repository features 4,030 available packages.
- How do you know which one to use ? ? ? Many of them are highly exotic (not to say useless to you).

  I learnt with http://www.r-bloggers.com/

- Lots of introductions but not necessarily what you're looking for so I'll give you a short tour.

  You should quickly realize though that you need proper training in statistics and data analysis if you do not want tell nonsense.
- Again, you should read Jain's book on The Art of Computer Systems Performance Analysis
- You may want to follow online courses :
  - https://www.coursera.org/course/compdata
  - https://www.coursera.org/course/repdata

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INSTALL AND RUN R ON DEBIAN

```
apt-cache search r
```

Err, that's not very useful :) It's the same when searching on google but once the filter bubble is set up, it gets better...

```
sudo apt-get install r-base
```

```
R
```

```
R version 3.2.0 (2015-04-16) -- "Full of Ingredients"
Copyright (C) 2015 The R Foundation for Statistical Computing
Platform: x86_64-pc-linux-gnu (64-bit)

R is free software and comes with ABSOLUTELY NO WARRANTY.
You are welcome to redistribute it under certain conditions.
Type 'license()' or 'licence()' for distribution details.

R is a collaborative project with many contributors.
Type 'contributors()' for more information and
'citation()' on how to cite R or R packages in publications.

Type 'demo()' for some demos, 'help()' for on-line help, or
'help.start()' for an HTML browser interface to help.
Type 'q()' to quit R.

>
```

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INSTALL A FEW COOL PACKAGES

R has it's own package management mechanism so just run R and type the following commands :

- `ddply`, `reshape` and `ggplot2` by Hadley Wickham (http://had.co.nz/)

```
install.packages("plyr")
  # or better: install.packages("dplyr")
install.packages("reshape")
  # or better; install.packages("tidyr")
install.packages("ggplot2")
```

- `knitR` by (Yihui Xie) http://yihui.name/knitr/

```
install.packages("knitr")
```

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IDE

Using R interactively is nice but quickly becomes painful so at some point, you'll want an IDE.

Emacs is great but you'll need **Emacs Speaks Statistics**

```
sudo apt-get install ess
```

In this tutorial, I will briefly show you rstudio (`https://www.rstudio.com/`) and later how to use `org-mode`

RStudio

File Edit Code View Project Workspace Plots Tools Help

markdown-introduction.rmd | example-r-markdown.rmd

Knit HTML | Run | Chunks

```
28
29 ```{r basicconsole}
30 x <- 1:10
31 y <- round(rnorm(10, x, 1), 2)
32 df <- data.frame(x, y)
33 df
34 ```
35
36 ## Plots
37 Images generated by `knitr` are saved in a figures folder. However,
   they also appear to be represented in the HTML output using a [data
   URI scheme]( http://en.wikipedia.org/wiki/Data_URI_scheme). This
   means that you can paste the HTML into a blog post or discussion
   forum and you don't have to worry about finding a place to store the
   images; they're embedded in the HTML.
38
39 ### Simple plot
40 Here is a basic plot using base graphics:
41
42     ```{r simpleplot}
43     plot(x)
44     ```
45
46 ```{r simpleplot}
47 plot(x)
```

47:1 Chunk 3: simpleplot R Markdown

Workspace | History

Load | Save | Import Dataset | Clear All

Data	
df	10 obs. of 2 variables
Values	
x	integer[10]
y	numeric[10]

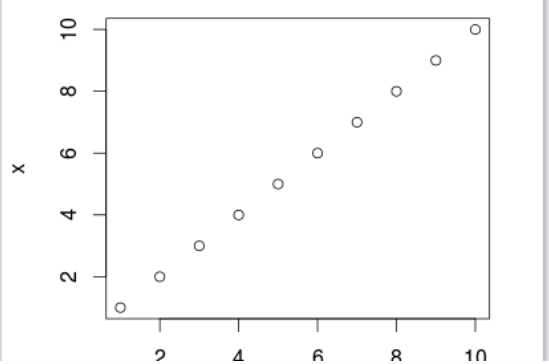
Console ~/research/statistics/rmarkdown-rmeetup-2012/

```
'help.start()' for an HTML browser interface to help.
Type 'q()' to quit R.

> set.seed(1234)
> library(ggplot2)
> library(lattice)
> x <- 1:10
> y <- round(rnorm(10, x, 1), 2)
> df <- data.frame(x, y)
> df
    x    y
1   1 1.31
2   2 2.31
3   3 3.36
4   4 3.27
5   5 5.04
6   6 6.11
7   7 8.43
8   8 8.98
9   9 8.38
```

Files | Plots | Packages | Help

Zoom | Export | Clear All



REPRODUCIBLE ANALYSIS IN MARKDOWN + R

- Create a new R Markdown document (Rmd) in rstudio
- R chunks are interspersed with ```` ```{r} ```` and ```` ``` ````
- Inline R code : `` `r sin(2+2)` ``
- You can knit the document and share it via rpubs
- R chunks can be sent to the top-level with `Alt-Ctrl-c`
- I usually work mostly with the current environment and only knit in the end
- Other engines can be used (use rstudio completion)

````
```{r engine='sh'}
ls /tmp/
```
````

- Makes reproducible analysis as simple as one click
- Great tool for quick analysis for self and colleagues, homeworks, . . .

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REPRODUCIBLE ARTICLES WITH LATEX + R

- Create a new R Sweave document (Rnw) in rstudio
- R chunks are interspersed with `<<>>=` and `@`
- You can knit the document to produce a pdf
- You'll probably quickly want to change default behavior (activate the cache, hide code, ...). In the preembule :

```
<<echo=FALSE>>=
opts_chunk$set(cache=TRUE,dpi=300,echo=FALSE,fig.width=7,
               warning=FALSE,message=FALSE)
@
```

- Great for journal articles, theses, books, ...