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How to write a (hopefully good) paper

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1. Introduction
2. To write well.....
3. The structure of the paper
4. Figures
5. Conclusions and outlook

Acknowledgements

Those from whom I learned....

- teachers
- co-authors
- J.Kovacevic
- V.Goyal
- former students
- students

Antonio Ortega, USC

- “Writing a technical paper: A few random thoughts on making life easier for the reader (and your advisor!)”

To get started:

Do you want to know what knowledge is?
When you know something, recognize that you know it,
and when you don't know something,
recognize that you don't know it.
That is knowledge.

The Analects of Confucius, Book 2 Chapter 17

So:

- writing is about transmission of knowledge
- there is a ''channel'' between you and the reader
- maximize capacity!
- it is a multiuser channel (you compete for reading time...)
- the reader, by definition, is never wrong!
  (same goes for reviewers and editors...)
- there is a very slow/long feedback loop (e.g. your career..)

The basic problem in writing mathematics is the same as writing in biology, writing a novel, or writing directions for assembling a harpsicord: the problem is to communicate an idea.

To do so, and to do it clearly, you must have something to say, and you must have someone to say it to, you must organize what you want to say, and you must arrange it in order you want to say it in, you must write it, rewrite it, re-rewrite it, and re-rewrite several times, and you must be willing to think hard about and work hard on mechanical details such as diction, notation, and punctuation.

That's all there is to it.

P.Halmos, How to write mathematics.

The basic assumptions...

What are we trying to accomplish?

You have something to say

- you have some worthwhile research results
- they are solving a real problem (open problem, new problem)
- you are ahead of the crowd

You have complete results (...)

- no holes as far as you can see
- a complete picture
- a coherent picture

You are willing to communicate your results

- no killer patent killed
- you feel ready to confront the world (that is, 2.35 reviewers of some Transaction)

Full disclosure always pays....

- nothing under the carpet, please

Note:

- only latex spoken here

To write well..... read, read and read!

The classics:

- any good book is a good start (my favorite isJ.L.Borges. e.g. Fictiones)

The scientific classics

- C.E.Shannon, A Mathematical Theory of Communication, Bell Syst. Tech. Journal, 1948 (do reread this on a regular basis)
- I.Daubechies (yes, yes, the 100p. paper)

The great authors (around our topics)

- R.Gallager
- G.Strang
- S.Mallat

Note to all....

- there has to be a reading culture
- I know this is ‘’playstation generation’’ but for this job, people have to devour the Transactions when they come out
- there has to be a library culture (go find that obscure paper/book)
- there has to be a book culture (what book have you bought/read lately?)
- (do not read too much on a particular topic befopre starting research, it can be demotivating.... optimal # of papers to read!)

To write well..... write, write and write!

Writing is a painful process:

- I still write on paper, do many iterations, cut-and-paste, drafts etc
- so do many people...
- it takes a lot of time

Writing is an iterative process

- the spiral method of Halmos (1, 1&2, 1&2&3, ...)
- write, rewrite, re-rewrite (and not cut-and-paste!)
- let it sit for a while
- have other people read it (inc. boy/girlfriend!)
- read aloud
- make short sentences (many times I have seen “this phrase no verb”...)
- do get started (e.g. Camus, “The Pest”)

You should be the most critical reader

- otherwise, somebody else will....

Is the hardest paper the best paper?

- who are you trying to impress ;)
- people often spend most space on what took most time...

The tools of the trade

The books:

- E.B.White, Elements of Style
- N.J.Higham, Handbook of writing for the mathematical sciences, SIAM, 1993.
- P.Halmos, How to write mathematics, L'enseignement mathematique.

The journals:

- IEEE Tr on SP, IP, SAP
- IEEE Tr on IT, ToN, Comm, JSAC
- the IEEE magazines (SP mag etc)
- SIAM

The databases:

- http://wos.consortium.ch: The (in)famous web of science
- http://ieeexplore.org/lpdocs/epic03: all of IEEE on line
- http://citeseer.nj.nec.com: the CS DB

Size matters

The IEEE societies (IEEE 300'000)

- IEEE Computer: 125'000
- IEEE Communications: 75'000
- IEEE Circuit and Systems: 25'000
- IEEE Signal Processing: 20'000
- IEEE Information Theory: 6'000 ...

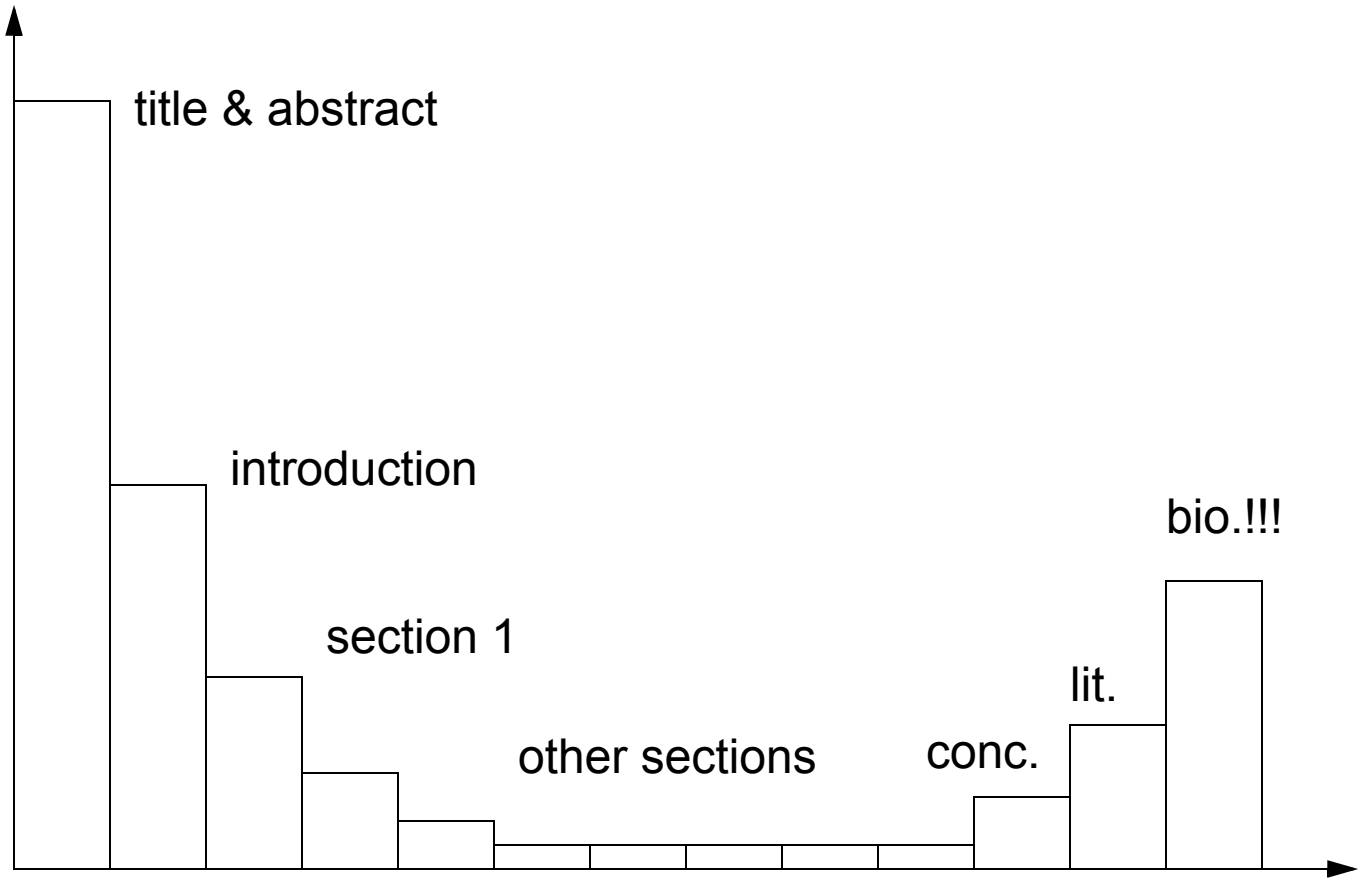
The journals (circulation):

- Signal Processing magazine: 16'000
- IEEE Tr. on SP: 5'200
- IEEE Tr. on IT: 4'500
- IEEE Tr. on IP: 2'800
- IEEE Tr. A&S: 2'400
- IEEE SP Letters: 1'500
- IEEE Tr. on Multimedia: 250!

of course, the question is who reads them

- well, impact factors for another day (but between 1.5 and 2.5...)

Statistics on what parts of a paper are read....



so do proper waterpouring!

The various reading levels of a paper

The title should be catchy, or self-explanatory

- Costa: Writing on dirty paper,
- Shannon, A Mathematical Theory of Communication
- Gallager, Variations on a theme by Huffman

The abstract is the sales pitch for the paper

- why shall I (the reader) spend N hours on this paper
- it has to pose the problem explicitely, and indicate clearly what is accomplished in the paper

The Table of Content (ToC) should allow to survey the paper

- sections have to make sense, with headings that do too
- flow, sizes

The figures should be self-contained

- browsing the paper through figures only
- caption self-contained (be able to read the figure without the text)
- text and caption complementary

Note: I do not like acronyms, but there is a certain CS culture there

The classic structure of the paper (1)

Title and abstract

- be careful with affiliations (e.g. EPFL and not swiss federal lausanne in-situte)
- be careful with acks, e.g. to funding agencies (NCCR, FN)
- the author order headache... In doubt, $\alpha\beta$tical

1. Introduction and outline

- why shall I (the reader) spend N hours on this
- motivation for the problem (why is this important...sorry, it might not be)
- it is either the proof of Fermat's last thm (no further motivation needed) or you need to properly pose the problem

2. Related work

- give credit where credit is due
- "good manners" in referencing (you know when you see it)
- make sure you set the stage for indicating why what you present is new, better, cheaper, glitzier

The classic structure of the paper (2)

3. The meat

- structure the development carefully
- make adequate sectioning/subsectioning
- decide on Lemmas, Propositions, and Theorem(s) (the "1 thm/paper" algorithm)
- put details in appendices (for ex., for each theorem, decide if it is in main text or appendix)
- theory is never made too easy
- think of examples, inc. toy examples

4. The experimental section

- describe the experimental set up precisely
- the results should be reproducible
- the presentation of the results is key (see later)

5. Conclusion(s), outlook, further work

- don't take the reader for a ride (e.g. Fermat again)

6. Appendices: can be most helpful!

7. Literature: careful please

The classic structure of the paper (3)

So write an outline first!

- structure of thoughts
- what are the main ideas you want to get accross
- make it detailed enough
- is the flow adequate (not a random juxtaposition...)
- these are not lab notes, chronological etc

The outline will change

- a manuscript is a living animal
- it will bite back
- it will give you nightmares

The skeleton of the paper is

- the motivation, problem setting
- the “main” theorem(s)
- the lemmas and propositions that allow it
- the examples that highlight how it all works
- the experiments that justify it all

Presenting an idea

The logic should be clear to anybody (not just you)

- logical progression
- idea 1 -> idea 2 etc

Be clear:

- there are 2 reasons why XYZ is not used in practice.
  (i) it is not robust in case of... (ii) it is absurdly complex for ...

Do not let the reader guess what you solved, and what not

- this is clear in the math mode, but the same is true in the experimental mode as well
- the ‘iff”. The converses. Strengthening the results.

Repeat NO, develop YES

- multiresolution approach can be best
- like in a good plot of a novel, hints can lead the reader
- wet the appetite, give a main course, highlight with dessert

How to get ideas and results accross

Be explicit

- put examples
- put tables with usable results
  (the famous “Daubechies’ filter tables)
- spell algorithms out
- put matlab code in paper or on line

Make life easy for the reader

- the reader is just as lazy as the writer
- it can be shown..show it

But don’t be boring!

- too explicit can be boring

Always ask the dual question also

- there might be new research right there

On the most misused word(s) in the literature

Optimal

- if all the optimality claimed were true... we could all retire

Complexity (computational)

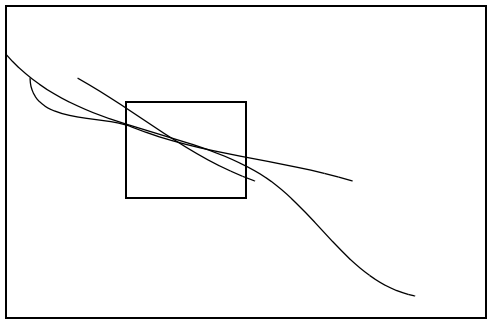
- what is complex, what measure, O(.), constants etc

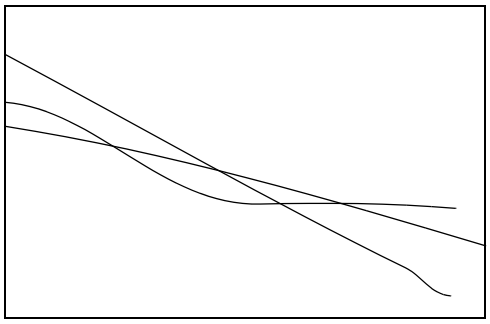
It is easy to see/verify

- probably it is not, otherwise it would be written
- it can be shown..show it (Fermat again)
- it is left as an exercise... probably you can come up with new results

As can be clearly be seen in the figure...

- by the time it is printed, most ‘’obvious’’ differences are washed out
- blow up the point





On Theorems...

Halmos' view

- present statement first
- statement should be short
- assumptions thus provided
- no "associated results" in statement
- proof follows

In engineering

- often along the way: "blabla...Thus we have proved: Thm 1"
- not so nice...

I am not ideological about it....

- what flows best is best

Presenting graphical information

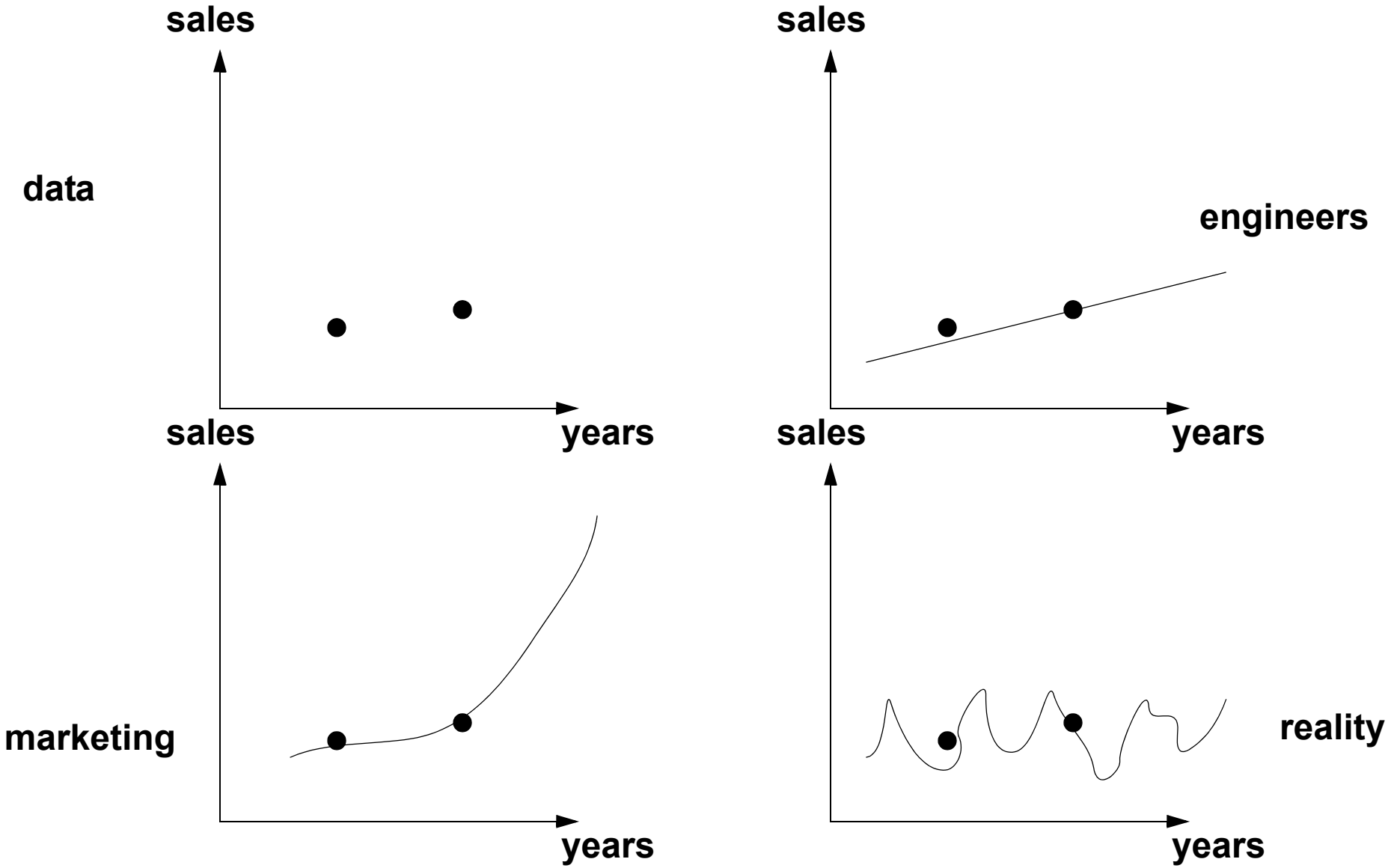
The classic books by E.R.Tufte

- The Visual Display of Quantitative Information is about pictures of numbers, how to depict data and enforce statistical honesty
- Envisioning Information is about pictures of nouns (maps, aerial photos are about nouns in space, for ex). It is also about visual strategies and colors
- Visual Explanations is about pictures of verbs, the representation of mechanism, processes, dynamics, causes and effects (there is a chapter about magi tricks!)

So, making figures is an art!

- takes a lot of effort (that is why most people skip it!)
- gets you a lot of mileage(that is what most people forget...)

Presenting results....



* from a start-up I know

Presenting experimental results (1)

Explicit experimental conditions

- one realization (the Lena syndrome)
- what method on what data set
- was there training, was the data outside the training set (no joke!)
- apples and oranges?

Often, lousy statistics...

- confidence intervals
- statistical tests
- comparisons to bounds

More data better than less...

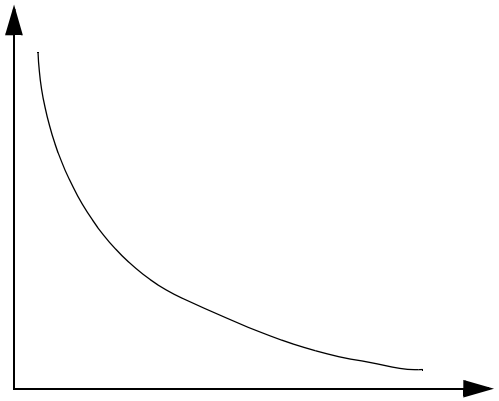
- at least if presented well
- data must be analyzed and interpreted
- avoid the boring tables

If you gained insights, so should the reader

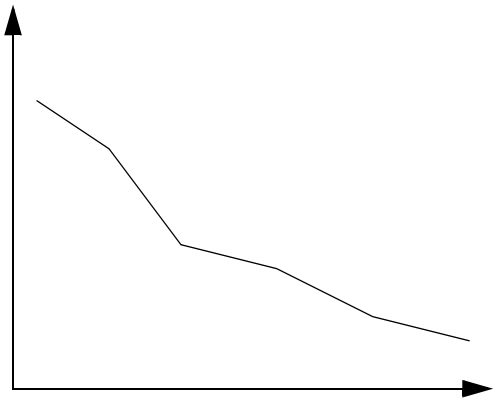
- the experiments should make a point
- make sure the point is not lost (e.g. prove/disprove a model)

Presenting experimental results (2)

Typical scenarios

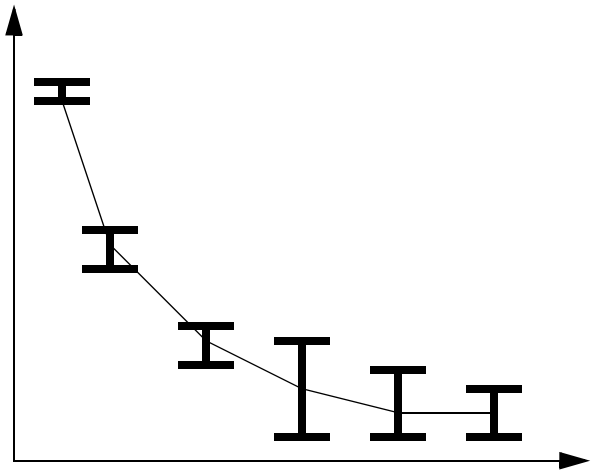


Theory says it is convex....



a few (1) experiments show this,
or simulated until answer satisfactory...

In an ideal world...



# of runs, set up, confidence intervals etc

The (nasty) details

Notations

- it is like style
- it can be a headache
- usually, conform to the norm
- think about the alphabet, but think about it first
- starting with a bad notation will bog you down, sooner or later
- simplify, simplify, but not too much
- n_k Θ_{k_ε}
- avoid pedantry, unnecessary generality etc
- be rigorous

English

- probably the easiest to fix (take courses)
- but be careful, it is the most obviously annoying thing
- punctuation: spaces ; :no spaces, : lower cases, , versus ; versus : etc
- “on the other hand”: a poor orphan?
- shorter is better:
  - we have found -> we found
  - in this paper, we have found -> we found that
  - etc

The (nasty) details (2)

Affiliation(s)

- yes, it is EPFL
  (not Universite Polytechnique Federale de Lausanne, from a famous CV)

Acknowledgements

- who paid for gets an ack
  (e.g. NCCR...)

The size problems

- our overlength page charges seems to overtake the travel budget!
- 8 page limit for Tr SP, IP etc
- hard to predict, but please be careful
- (I don't like the Part I and II slicing either...)

Checklist (A.O.)

Can a reader with the right background:

- get the basic ideas
- understand the paper
- remember what is new in this work
- follow the proofs
- replicate the experiments
- find all assumptions in the text
- be convinced that this is useful
- not fall asleep ;)

On reproducible research

Clairbout's initiative at Stanford

- geophysics
- lots of data, code, etc

Donoho's wavelab etc

- lot of mileage

Examples

- SPIHT etc

We should, collectively, make much, much more

A paper should be

- a manuscript (eventually a publication)
- a set of documented code (matlab, C, libraries etc)
- all data that was used
- a web document

Lab initiative:

- blue print for what we want to accomplish
- quality control

Conclusions

Writing well is a hard task

- we are all students of the art
- no easy short-cuts (it will show...)
- no pain no gain...

But it is a central task!

- you can prove the hardest results, if nobody reads it, it was futile a endeavour
- like teaching, one learns by writing
- writing things down leads to new insights, better ways to understand the problem, new research etc

Your papers are your thesis!

- take these 3 or 4 journal papers, and staple them ;)
- for good measure, add a good introduction and conclusion
- you are done (3 months rather than 6 or 9!)

I am looking forward to reading your next paper!