How ~~not~~ to write a research paper

Version 0.2

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Some of the following sections are partially based on (and sometimes shamelessly copied from): *A primer of mathematical writing* by Steven G. Krantz.

1 Typical outline of a paper

Abstract

- The abstract should answer the question why one should read the paper.
- Describe in a couple of sentences the topic and your main contribution, i.e., what is new.

Chapter 1: Introduction

- What is the problem you are solving?
- Why is it important?
- What is new in your approach, i.e., what is your main contribution?
- What are limitations of your method?
- Introduce the required notation and definitions.
- Commonly the section ends with an outline of the paper: In Section 2, we will describe ... Section 3 contains ...

Chapter 2: Background

- What other methods have been developed for this problem, if any?
- What are the differences between these methods and your approach?
- Describe the state-of-the-art methods you are using or improving on.
- Cite all *relevant* literature.

...

Chapter i: The main result

- Describe the main contribution of the paper.
- If possible, illustrate the definitions and results using simple guiding examples.

...

Chapter $n-1$: Numerical results

- Describe the setup precisely: How were the parameters chosen? Which computers were used? What methodology did you use to investigate scalability and runtimes?
- Show results for relevant instances. If possible use preexisting public available sets of tests.
- Either use the whole set of tests or give a convincing reason why you only used a selection.
- Try to avoid self-generated random instances.
- Compare your method with other available methods, if possible.

Chapter n: Conclusion

- Give a brief description of what has been accomplished and the main results.
- Are there any open questions?
- How could the obtained results be improved in the future? (Be careful: if this is too obvious, why did you not do it already?)
- Can this approach be applied to other problems?

Appendix

- Auxiliary or supplementary material that is not required when reading the paper for the first time but adds to the main picture goes here.
- If the proofs are too long for the main text, describe details in the appendix.
- If a proof is very similar to one already in the text, move the second one to the appendix.

References

- List relevant previous work.
- Whenever an idea or method has been proposed in another publication, it should be mentioned in the text and listed here.

2 General guidelines and questions

- Who will be the audience of the paper?
- Which definitions, methods, and results are assumed to be well-known? Definitions such as "Let $\mathbb{R}$ be the set of all real numbers ...", for example, are typically not required in a mathematical paper.
- Try to make the paper as self-contained as possible. Whenever something might be unclear, refer to a paper or book that addresses the problem, e.g.: For more details, see [1] and references therein. However, check it is really there. Do not copy this sentence from another paper.
- To find an appropriate journal, ask your professor.

3 Style

- Be concise. Every sentence should convey some information to the reader.
- Do not repeat yourself. In general, everything should be written exactly once in an article.
- **Do not** start every section stating what to expect in this section, and end it with a summary of the section and an outlook to the next section.
- Read the following bullets, or use `https://grammarly.com`.
- Instead of writing the same phrases like "hence" or "therefore" repeatedly, use "thus", "so", "it follows that", "as a result" etc.
- Prefer active voice over passive voice: The manifold M is acted upon by the Lie group G as follows. The Lie group G acts on the manifold M as follows.
- Avoid big words when small ones do the trick. Make some effort to write simple and straightforward English.
- Avoid unnecessarily long sentences. Long sentences should be broken up into simple sentences, if possible (for a German).
- Break up complex ideas into palatable bites. Use short and declarative sentences.
- Never use the word "very" unless you would be comfortable using "damn" instead.
- Do not use contractions such as "don't", "it's", "we'll", or "ain't".
- "We" vs. "I" vs. "One": The custom is to use the first person plural, i.e. "we". "One" sounds clumsy and "I" self-important.
- Captions of figures should be self-explanatory (without having to read the entire paper first).

- Each figure must be referenced in the main text.
- Make sure that the bibliography style is consistent.
- Capitalize names such as Theorem 1, Remark 2, Figure 3, etc.
- "That" vs. "which": The house that was built in the '50s is more expensive. The house, which was built in the '50s, is more expensive. The former sentence is *limiting* the houses to houses built in the '50s, while the latter is adding new information and *describing* the house.
- "Less" vs. "fewer": "fewer" is in general for things you can count and "less" for things you cannot count.
- "Can not" vs. "cannot": the preferred way of writing "can not" is "cannot", unless you write something like: The operator $\mathcal{L}$ can not only be used to prove uniqueness, but also to ...
- Use "a" or "an" depending on pronunciation, not spelling, e.g. a unit and an n-dimensional vector space.
- Spelling should be either British or American throughout the paper, use either behaviour or behavior, analyse or analyze, labelled or labeled, etc.
- Avoid starting sentences with a number, abbreviation, or formula: f is continuous. The function f is continuous.
- Use words like "clearly" and "obviously" with caution.
- The German phrase "Im Folgenden werden wir ..." should not be translated as "In the following, we will ...". You can write "In the following section/chapter/paragraph, we will ...", "In what follows, we will ...", or "Below, we will ...".

4 Mathematical writing

- Use the Lemma, Theorem, Remark, and Example environments in LaTeX to structure your paper. Whenever necessary, refer to previous definitions and formulas.
- Displayed math versus in-text formulas: Long formulas and important formulas are better displayed.
- In the final manuscript, use equation numbers only for formulas that will be referenced later in the text. For manuscripts still under review, it can be helpful to number most of the equations so that reviewers can easily point to formulas.
- Try to plan your notation in advance and be consistent. Use, for instance, lower-case letters such as c, d and v, w for scalars and vectors, upper-case letters such as A, B for matrices, and blackboard bold letters such as $\mathbb{N}, \mathbb{R}$ for sets.
- Use plain English for simple mathematical statements: $\forall x \in \mathbb{R}^+ \exists y \in \mathbb{R} : y^2 = x$. Every nonnegative real number has a square root.

- When you define a term (for the first time), you should italicize the word, e.g.: We call f a *weak solution* of the partial differential equation if ...
- Symbols in different formulas should be separated by words. Consider F_r, $r < s$. Consider F_r, where $r < s$.

5 Punctuation

- Use the Oxford comma consistently: The function f is continuous, nonnegative, and monotonically increasing.
- The letters within abbreviations such as e.g. or i.e. are followed by periods and have no space between them. (Make sure to use `~` or `\ ` in LaTeX after these abbreviations to produce a normal sized space.)
- Do not overuse commas. Commas should indicate logical pauses.
- When combining two sentences into one compound sentence using "and", "but", or "or", a comma is used.
- If you use words like "therefore", "however", "finally", or "thus" at the beginning of a sentence, put a comma after them, e.g.: Thus, the solution is unique.
- Words like "however" in the middle of a sentence are separated by two commas, e.g.: The solution, however, is not unique.
- Hyphen (-) vs. n-dash (–) vs. m-dash (—): a hyphen connects words, e.g. well-known, ill-advised, toll-free call; an n-dash joins ranges of numbers and also different persons, e.g. 1990–2000, March–April, Perron–Frobenius operator; an m-dash separates an inserted thought—like this one—from the rest of the text; instead of m-dashes without spaces, you can use n-dashes with surrounding spaces – like this – to insert a thought, depending on the style guide.
- Equations are part of a sentence and should be punctuated accordingly. If an equation ends a sentence, a period must be placed at its end.

6 LaTeX

- This $< f, g >$ is not a scalar product (seen in many publications), use $\langle f, g \rangle$ instead: `\langle`, `\rangle`.
- Similarly, for "much less than", type `\ll`, not `<<`: $a \ll b$ vs. $a << b$.
- Often $\varnothing$ (`\varnothing`) is preferred over $\emptyset$ (`\emptyset`).
- Commands like `\rm`, `\it`, `\bf`, etc. are obsolete, please use `\textrm`, `\textit`, `\textbf`, etc., e.g. `\textbf{some text}` instead of `{\bf some text}`.
- Use `\emph{...}` to emphasize text.

- Use `\eqref{...}` to reference equations, not `(\ref{...})`.
- Use the `amsmath` environments `\split`, `\align`, and `\multline` for typesetting long formulas.
- Use the `pmatrix` and `bmatrix` environments for matrices.
- Use `\begin{proof} ... \end{proof}` for proofs. The proof environment automatically places a QED symbol at the end of the proof.
- If the proof ends with a displayed formula, use `\qedhere` to avoid a new line containing just the QED symbol:

  Proof. Since $u \in L^2$, it follows that
  $$\mathcal{L}u = -f.$$
  □

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  $$\mathcal{L}u = -f.$$
  □

- In text math mode, commas and periods are part of the sentence, not the formula: `For $ x < 0 $, we obtain the desired result.`
- Use `\left(` and `\right)` to enclose larger expressions:
  $$(\int_0^1 f(x)\,dx)^2 \quad \text{vs.} \quad \left(\int_0^1 f(x)\,dx\right)^2.$$
- Spaces in math mode:

ab	`$ a b $`	normal spacing
$a\!b$	`$ a \! b $`	negative thin space
$a\,b$	`$ a \, b $`	thin space
$a\:b$	`$ a \: b $`	medium space
$a\;b$	`$ a \; b $`	large space
$a \quad b$	`$ a \quad b $`	1em space
$a \qquad b$	`$ a \qquad b $`	2em space
$a \hspace{3em} b$	`$ a \hspace{3em} b $`	user-defined space

- Text in displayed equations: `\text{some text}`.
- Prefer vector graphic over bitmap images.

References

[1] S. G. Krantz. *A Primer of Mathematical Writing: Being a Disquisition on Having Your Ideas Recorded, Typeset, Published, Read & Appreciated.* American Mathematical Society, 1997.