The INCOMPLETE GUIDE to Academic Writing in Robotics Research

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Contents

1 Introduction

> "*The word robot is drawn from an old Church Slavonic word, robota, associated with labor.*" — by an initiate in academic writing in robotics, excitedly scribbling after a quick Google search.

So it seems that you must work on an academic text in the field of robotics. Being perhaps your first time or one of the first few times, you feel lost and confused, hoping to replicate the way you have been writing reports for your courses in undergraduate school. This time, however, your text will not be evaluated by the uninterested eyes of a TA who is simultaneously checking Instagram. Instead, your supervisor might, for the first time in your higher education, critique your writing style in detail. Bereft of hope and full of cognitive dissonance, your inner voice mumbles: "my supervisor is such a pain." Well, they might indeed be. Lashing out on Reddit can help relieve some stress, but is is palliative. Instead, treating the underlying cause (poor writing) is the cure that must be sought.

If anything mentioned above hit home or if your hands itched to start your academic paper in robotics with something similar to the quote above, then you are in dire need of this guide.

1.1 What is the purpose of this guide?

The purpose of this guide is to summarize relevant points specific to academic writing in robotics research that are not already thoroughly discussed in other existing guides.

We usually introduce new contents when we, the authors, need to provide academic writing advice to our students or when examining other students (e.g., Ph.D. candidates), and those guidelines are not yet present in the INCOMPLETE GUIDE.

1.2 What this guide is not

This guide is not meant to be complete. Instead, it is focused on academic texts in the robotics field, and with a strong bias towards the authors' subfields, such as medical robotics, robot kinematics and dynamics, mobile manipulators, legged robots, and robot control. Therefore, some advice might make sense only to academic roboticists, and researchers from other fields might not find the recommendations they are looking for.

This guide will not teach you academic writing from scratch: there is good literature on relevant topics, such as mathematical writing, freely available, and it is not productive to cover them here. Instead of replicating those guides, we will point them across the INCOMPLETE GUIDE should readers need more information. Besides being incomplete by design due to our focus, the guide is still a work in progress. To emphasize parts of it that will be further written or expanded, we use the classic under construction icon:

Lastly, this guide is sometimes written in light-hearted language to be more accessible to those not yet acquainted to academic writing, so it is not bound by the strict formal prose style of academia. Therefore, you should expect somewhat humorous and mildly sarcastic statements, and a more conversational style. However, whenever we present examples, they adhere to the strict rules of formal academic writing.

1.3 To whom is this guide made for?

This guide is primarily written for students doing research or technical work in robotics, and supervisors who are somewhat weary of repeating the same things over and over. Also, non-academic professionals who did not receive formal instruction on academic writing might benefit from reading this guide. More seasoned academics might also find some useful information, especially the more opinionated ones who never opened a style guide but love to trash junior researchers when reviewing their papers. (If your blood has boiled, Reviewer 2, item 4 of Section 1.4 is for you).[1]

1.4 What should I do if I disagree with some things in this guide?

Freedom of thought is a human right: you can believe the Earth is flat but cannot be persecuted for doing so. Similarly, you have the freedom to disagree with parts (or the entirety) of this guide. All of this is regardless of your affiliation, your connection, or lack thereof with the authors of this guide.

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[1] The bait was thrown. Now, let's wait for Reviewer 2 to start ranting on Twitter. Hopefully, they will reveal their identities.

Here are a few ideas in case you disagree with us (we do see the irony in advising on how to ignore/counter our advice):

1. Share those thoughts with us, politely, and we might improve this guide with your point of view. Parts of it might be made clearer as well. Oftentimes, the doubts of one are shared by many others.

2. Write your own guide. Title ideas:

   (a) A very complete guide to academic writing in robotics research.
   (b) How to hate guides: the guide.
   (c) Science is a lie: the perfect guide to pseudoscience.

3. Silently ignore the advice given in this guide and later inform us how far you got in academia.

4. Badmouth us on Twitter.

If you are a junior researcher under our responsibility, then this guide was made for you! So please do try your best to internalize all points of this guide.

Some parts of it might be subjective, and we will try our best to make that clear when presenting something that is our personal choice. Nonetheless, most of it is objective and definitions, facts, and so on care not for your disapproval. Believing the Earth is flat does not make it, indeed, flat. Forgetting about gravity does not make you impervious to falling from great heights. And that is a good thing. Finding the truth is the role of science, regardless of one's emotions. Tampering with the truth, whether purposely or not, to fit one's biases using scientific terms is pseudoscience.

Note. **On the The Appeal to (Inappropriate) Authority – *Argumentum ad Verecundiam*.** This type of fallacy is related to accepting a given claim as truth *solely* owing to one's perceived authority.[2] If Zombie Einstein were to rise from his grave and proclaim: "Actually, $1 + 1 = 3$," satellites would not suddenly start falling from the sky. In the context of this guide, we, the authors, provide relevant sources and arguments for the relevant points mentioned herein. We have also defined the scope of the guide and our areas of expertise in Section 1.2. As an individual in higher learning, the reader is expected not to use this guide as an excuse to forfeit their epistemic responsibility (e.g., the responsibility of thinking and judging by oneself). An individual that truly internalizes the concepts of this guide, instead of blindly following it, will be able to navigate the world of academic writing in robotics research beyond the topics directly covered in the INCOMPLETE GUIDE.

1.5 What is the purpose of academia?

An important aspect that should precede writing is understanding the role of academia. Academic writing is the reporting of academic work with the purpose of advancing knowledge and science. And, science, we would say, is for the good of humankind.

A lie (whether intentional or not) does not help humanity move forward. Most likely, it will put us back. Similarly to many other fields of human endeavor (like economy), academia is built upon trust. Academic texts are one of the most important deliverables of academia, which will be read and judged by others. It is expected that what is being reported was made in good faith. To keep this in check, an academic text will have to go through many gates. For instance:

1. The writer's (many times a student) conscience. Did the student make little effort to understand concepts before running the experiments? Did the student try to cut corners in the implementation? Did the student concoct their experiments in such way to only show the good and hide the bad? Did the student knowingly hide issues in their experiments from their supervisor? Did the student tamper with data to hide that one bad trial, that awkward vibration, that one weird motion? If any of the answers so far are yes, the student is being intellectually dishonest. Many times, a student might be tempted to hide what they consider bad results because they believe that this might hurt their chances of having their thesis, paper, etc. accepted. This is wrong and counterproductive. Knowing the conditions in which a technique/implementation does not work well tend to be strong pointers towards a fix or an improvement. In addition, being honest about a "bad" result shows integrity and maturity, and explaining why it does not work in those conditions is very informative. In contrast, a "bad" result will be eventually uncovered, and one's honesty being put into question is extremely taxing on everyone involved.

2. The student's supervisor. For the student, their commitment to academia might end within a few years. After that, they might feel safe and sound, untouchable by the consequences of whatever they might have done wrong or half-heartedly. Nonetheless, the student's supervisor and other collaborators might

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[2]We, the authors, hope that the title of this guide is enough to clear any doubts of any claims, even if indirect, of perfection and authority.

have much more to lose and a higher level of accountability. Proportionally to their accountability, they will know better to instruct students regarding the common pitfalls and caveats in academia and academic writing. They will know that a real system (specially a prototype) will not always work in any situation. They will question their supervisees if something looks perfect, if a graph does not match their expectations, or if there are any other indications that a student might be cutting corners (on purpose or not). Students might be tempted to see their supervisors as the enemy (oh well, maybe you did draw the short straw!), but a well-intended supervisor will be, instead, shielding you and giving the opportunity to fix mistakes that, by external eyes, could be seen as dishonesty and treated as such.

3. Examiners and reviewers. Theses and dissertations will be evaluated by members external to that specific research. This means that the contents being presented will be evaluated by expert, but unbiased, eyes. It is expected that examiners will be at least as strict as your supervisor. For these evaluations, the examiners will be made aware of how compliant the student has been with the supervisor's advice (or do you think all supervisors are robots? Certainly not _all_ of them). In other academic settings, such as submissions for conferences and journals, supervisors and collaborators might, rightfully, not be willing to be part of an academic text that does not follow their scientific standards. Convincing one's supervisor might seem daunting, but the supervisor is often the "easiest" person in the chain. Working an extra week to fix a problem pointed out by one's supervisor is much better than having a paper rejected by the reviewers after months of waiting.

4. Researchers that replicate the study. Surely the gates mentioned so far have held back countless improper examples of "scientific" work. In the prior gates, a student might be given a second chance to revise their work. Well, indeed, their are still learning. However, after the work is published and bad faith is found, the consequences are much more dire. A retracted work will be, for as long as the Internet exists, visible to everyone and anyone. The student's credibility, along with all their collaborators will be put into question. For example:

   - If one ever took a scientific ethics course in Japan, you might probably have heard of the anesthesiologist Yoshitaka Fujii,[3] who fabricated data in at least 183 papers. He was dismissed from his position as Associate Professor. Also, there was the STAP cell scandal, which involved Haruko Obokata.[4] After that incident, Obokata lost her job, was discredited, and a co-author, Yoshiki Sasai,[5] was criticized for poor supervision of Obokata.

5. Society. If the student is lucky, their contribution might make its way, directly or indirectly, to be impactful in society. It might be on the spotlight or one step towards something bigger. In any case, a properly done work can influence policy and people behavior in a positive way, whereas a lie published as truth could be catastrophic. For example:

   - One of the main sources of pseudoscience for the anti-vax movement and activism, UK's former surgeon Andrew Wakefield was responsible for the "Lancet MMR autism fraud" [3]. Despite the evidence for scientific misconduct and conflict of interest, Andrew Wakefield's pseudoscientific texts are still taken to the letter by biased groups. The influence of his work can be connected to modern outbreaks of diseases easily preventable by vaccination [2].

1.6 When should I write an academic text, and what is the purpose of it?

Good writing takes time, and people often underestimate it, especially junior researchers. Academic texts such as MSc theses, Ph.D. dissertations, and articles usually have the goal of disseminating research. If you are looking into committing yourself to a career in academia, you should need no further motivation.

> *"But, Professor, I don't want a career in academia, after I graduate I'll work in The Amazing Corporation Co.!"*

Even for students who want just to get over with their theses or dissertations to graduate, their academic outputs must still serve the purpose of disseminating knowledge, and they have the moral and ethical responsibility to do it right. That is why supervisors sometimes seem to be "picky" under the eyes of students struggling to write. (Some supervisors can actually be picky, but that is another issue!) Academic texts are expected to be authoritative, precisely because of the scientific rigor expected from them. Therefore, if they are misleading or confusing due to sloppy writing, they lose their purpose of disseminating knowledge, undermine the credibility of the scientific endeavor, and make other people waste their time. In more extreme cases, they can even lead to catastrophic results.

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[3]https://en.wikipedia.org/wiki/Yoshitaka_Fujii
[4]https://en.wikipedia.org/wiki/Haruko_Obokata
[5]https://en.wikipedia.org/wiki/Yoshiki_Sasai

2 Writing text

2.1 Software for academic writing in robotics

"Oh, there is no need for using something other than Microsoft Word to write my paper. I've been using it my whole life and it's been great!" — says the neophyte, unaware of their path toward great disappointment.

Different fields have different common practices. Maybe Microsoft Word or other WYSIWYG[6] piece of software might be perfectly fine for some disciplines that do not use many equations or advanced cross-referencing. In robotics, though, LaTeX[7] is much more widespread, and most conferences and journals make LaTeX templates available. The reason for that is because LaTeX is an advanced open-source typesetting system that generates professional-quality formatted documents, including beautiful equations and a powerful cross-referencing and citation system.

The main drawback of LaTeX, though, is the steep learning curve. Working in LaTeX seems much more like programming than writing regular text because what you write is not what you see in the final document. Instead, the user is more concerned with content and structure whereas LaTeX is responsible for formatting the document according to a well-crafted template.

There are many LaTeX editors that are user-friendly and have a much less steep learning curve. Our favorite, LyX,[8] is an open-source software that we use to write the INCOMPLETE GUIDE and all of our papers. Differently from most LaTeX editors, LyX instantly shows equations and tables, which makes the process of writing much more streamlined.

2.2 Version control

"Yes, I have the latest version of the paper here somewhere... wait a second..." — the person who does 'version control' as shown in Figure 1, with sweaty hands, in the verge of complete despair over an impending deadline.

In Figure 1, we show one example of what does **not** constitute proper version control. Does it look familiar?
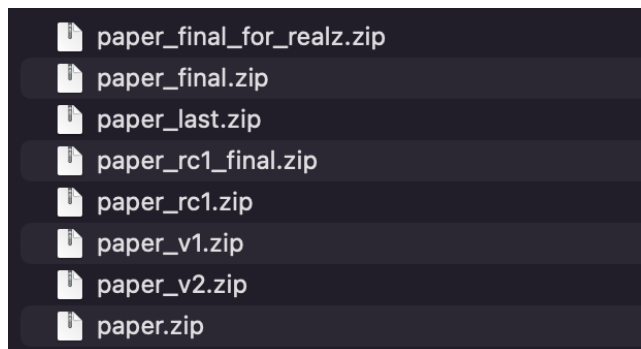

Figure 1: How **not** to do version control of your text.

Source files for academic texts (much like software source-files and other assets) quickly become an intricate composition of intertwined files. Many times an academic text needs to be worked on collaboratively by several people. With this in mind, use Git[9] to version control all files related to a given paper in a proper repository. Some desktop applications are also available, but in any case you can do enterprise-level source control of your texts by learning only some commands: `clone`, `pull`, `add, commit`, and `push`.

Websites such as Github[10] and Gitlab[11] offer generous amounts of storage for *private* repositories. Use the best one as directed by the person in charge in your group.

Note that a repository related to your academic work should **never** be made public unless you have the permission of your supervisor and other possible collaborators.

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[6]`https://en.wikipedia.org/wiki/WYSIWYG`
[7]`https://www.latex-project.org/`
[8]`www.lyx.org`
[9]https://git-scm.com
[10]https://github.com
[11]https://about.gitlab.com

2.2.1 Common pitfalls and general advice

One should always maintain a tidy repository and ensure that everything is neatly organized. To that aim, a requirement is for one to sufficiently understand what they are doing. Therefore, students should be familiar with the basic commands. One common mistake, especially for those looking for shortcuts, is to use the command

```
git add *
```

Please, don't do that! Because `git add` will add files that are meant to be versioned, the `git add *` means that all files in the current folder will be added to the repository, **including temporary ones**. Given that the temporary files in one computer will not match those in another computer, this could cause pesky merge conflicts that will take longer to fix than to learn the proper usage of `git add.`

2.3 Purpose, target audience, how much details should be included

Because academic texts are meant to disseminate knowledge, academic writers should write in a way that is as easy as possible for their audience to understand it. This does not mean that the contents will necessarily be easy or simple to understand, especially when the target audience is very advanced. However, it should not be more complicated than necessary. Different writers have different abilities, and this will be reflected in the quality of their writing. Nonetheless, writers must not be sloppy or cut corners to make their lives easier because it invariably implies in making the readers' learning process much more difficult than necessary. (Nobody denies that the learning process can sometimes be tough and frustrating, but being miserable due to someone else's poor writing is far from ideal.)

2.4 Structure of an academic text

2.5 Verbal tenses

Future tenses are good to describe future works. In an academic text that is used to describe a developed work, the present tense should be used to describe current features of the developed system and universal truths. Finished experiments that were done must be referred to using past tense.

2.6 Terminology

The terminology must be precise within the context of the target audience. Some terms that usually used colloquially in daily life might have a precise (despite of the informal use as a synonym) meaning in robotics, control, and associated fields. The precise use of those words might contrast with their use in literature or the news, where they might have a looser meaning.

Impossible Unless something is physically or mathematically impossible (e.g., traveling faster than light or dividing a number by zero), one should not use it as a synonym for impractical or unfeasible. If something is very hard, but no one has proved its impossibility, it does not mean it is impossible.

Optimal Optimality is related to an objective function that is either minimized or maximized. Therefore, there is no sense saying that something is more optimal than another thing. Also, optimal cannot be used subjectively.

Perfect Something perfect cannot, by definition, be improved. Therefore, it is impossible for something to be more perfect than another. Also, perfect is a binary concept. Either something is perfect, or it is not.

3 Mathematical writing

There are good references for mathematical writing, and everyone aspiring to write any academic texts involving mathematics should read them. One of the best ones is the book by Franco Vivaldi [8], which is very pleasant to read and informative. An earlier version of this book is still available online.[12]

   Below we summarize some of the main stylistic pitfalls and common mistakes. The list is far from comprehensive, and complying with those guidelines is the bare minimum to avoid readers from being distracted from the main points owing to bad mathematical writing. Sometimes, bad writing might even be syntactically or semantically incorrect and ambiguous.

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[12]`http://www.thinkingwriting.qmul.ac.uk/sites/default/files/shared/files/Mathematical%20Writing%20for%20undergraduates%20Vivaldi.PDF`

3.1   Grammatical rules in mathematical expressions

Mathematical expressions are part of the text and should be punctuated accordingly. For example,

> *The relationship between the hypothenuse and the perpendicular sides of a right-angled triangle is given by*
> $$c^2 = a^2 + b^2,$$
> *where c is the hypothenuse's length, and a and b are the lengths of the sides adjacent to the right angle.*

is correct, whereas

> *The relationship between the hypothenuse and the perpendicular sides of a right-angled triangle is given by*
> $$c^2 = a^2 + b^2$$
> *Where c is the hypothenuse's length, and a and b are the lengths of the sides adjacent to the right angle.*

is not.

A good rule of thumb is to see if the mathematical expression would be punctuated if it was inline. For instance, the sentence below is grammatically incorrect:

> *Newton discovered that, if m is the mass of a body and a is its acceleration, then the resulting force is given by $F = ma$ This equation is known as Newton's second law.*

Clearly, there is a period missing after the equation. Therefore, if the equation is *displayed*, that is, separated from the text, it will only make sense if it is punctuated:

> *Newton discovered that, if m is the mass of a body and a is its acceleration, then the resulting force is given by*
> $$F = ma.$$
> *This equation is known as Newton's second law.*

In other words, a displayed equation is only a stylistic feature. Therefore, it should still obey grammatical rules.

3.1.1   Avoid starting sentences with mathematical expressions

Starting sentences with mathematical expressions is not only stylistically undesirable but might be very confusing, especially if the previous sentence ends with another mathematical expression. For example, instead of

> "$\boldsymbol{x}$ *is the task-space vector that represents the end-effector pose.*"

one should write

> "*The task-space vector $\boldsymbol{x}$ represents the end-effector pose.*"

The latter avoids the problem of starting a sentence with a lower-case letter. If the mathematical expression is not a letter, it is even more awkward:

> "$\neg$ *is the symbol for the negation operator.*"

Instead, it is much better to write

> "*The negation operator is denoted by the symbol $\neg$.*"

To see how starting sentences with mathematical expressions might be confusing, consider the following sentences:

> "*The negation operator is denoted by the symbol $\neg$. $\wedge$ is the conjunction operator that represents the logical operation* AND.*"

They become clearer if rewritten as

> "*The negation operator is denoted by the symbol $\neg$, whereas $\wedge$ is the conjunction operator that represents the logical operation* AND.*"

The previous sentences are quite simple. Hence, it is unlikely that people will be overly confused by the concatenation "¬. ∧." Nonetheless, this creates an unnecessary cognitive overload that is accentuated in a mathematically-intensive text.

But even simple sentences, although mathematically correct, might sound ambiguous due to bad writing. For instance:

> *"Consider the natural number 3. 4, which is the next one, is even."*

At a first glance, it seems completely nonsensical because 3.4 is not a natural number, we do not know what its previous number should be, and a decimal number cannot be even. But then we realize that the number is not 3.4 because there is a space after the period! The same sentence, if written using words, not numerals, makes that clear:

> *"Consider the natural number three. Four, which is the next one, is even."*

The previous sentence is perfectly fine, both mathematically and grammatically! We can still use numerals, and it suffices to use our rule of never starting a sentence with a mathematical symbol:

> *"Consider the natural number 3. The next one, 4, is even."*

3.2 Multiline mathematical expressions

When using multiple mathematical expressions that must be together, such as in a multi-step derivation, a good LaTeX/LyX environment is the AMS align environment. For instance, suppose that we want to solve

$$\int_a^b a_0 x^0 + a_1 x^1 + a_2 x^2 + a_3 x^3 + a_4 x^4 \mathrm{d}x$$

while showing intermediate steps without any text between them. This often happens when subsequent steps follow immediately from previous ones without any need for further explanations. An inline derivation, such as $\int_a^b a_0 x^0 + a_1 x^1 + a_2 x^2 + a_3 x^3 + a_4 x^4 = \int_a^b a_0 x^0 \mathrm{d}x + \int_a^b a_1 x^1 \mathrm{d}x + \int_a^b a_2 x^2 \mathrm{d}x + \int_a^b a_3 x^3 \mathrm{d}x + \int_a^b a_4 x^4 \mathrm{d}x = a_0 x|_a^b + a_1 \frac{x^2}{2}|_a^b + a_2 \frac{x^3}{3}|_a^b + a_3 \frac{x^4}{4}|_a^b + a_4 \frac{x^5}{5}|_a^b = a_0(b-a) + a_1 \frac{(b^2 - a^2)}{2} + a_2 \frac{(b^3 - a^3)}{3} + a_3 \frac{(b^4 - a^4)}{4} + a_4 \frac{(b^5 - a^5)}{5} = \sum_{i=1}^5 a_{i-1} \frac{(b^i - a^i)}{i}$,$ is extremely clumsy. Putting each step of the derivation in displayed mode without aligning the equations helps in the visualization but is still awkward:

$$\int_a^b a_0 x^0 + a_1 x^1 + a_2 x^2 + a_3 x^3 + a_4 x^4 = \int_a^b a_0 x^0 \mathrm{d}x + \int_a^b a_1 x^1 \mathrm{d}x + \int_a^b a_2 x^2 \mathrm{d}x + \int_a^b a_3 x^3 \mathrm{d}x + \int_a^b a_4 x^4 \mathrm{d}x$$

$$= a_0 x|_a^b + a_1 \frac{x^2}{2}\bigg|_a^b + a_2 \frac{x^3}{3}\bigg|_a^b + a_3 \frac{x^4}{4}\bigg|_a^b + a_4 \frac{x^5}{5}\bigg|_a^b$$

$$= a_0(b-a) + a_1 \frac{(b^2 - a^2)}{2} + a_2 \frac{(b^3 - a^3)}{3} + a_3 \frac{(b^4 - a^4)}{4} + a_4 \frac{(b^5 - a^5)}{5}$$

$$= \sum_{i=1}^5 a_{i-1} \frac{(b^i - a^i)}{i}.$$

One good way of writing the previous derivation is through the AMS align environment. Namely,

$$\int_a^b a_0 x^0 + a_1 x^1 + a_2 x^2 + a_3 x^3 + a_4 x^4 = \int_a^b a_0 x^0 \mathrm{d}x + \int_a^b a_1 x^1 \mathrm{d}x + \int_a^b a_2 x^2 \mathrm{d}x + \int_a^b a_3 x^3 \mathrm{d}x + \int_a^b a_4 x^4 \mathrm{d}x$$

$$= a_0 x|_a^b + a_1 \frac{x^2}{2}\bigg|_a^b + a_2 \frac{x^3}{3}\bigg|_a^b + a_3 \frac{x^4}{4}\bigg|_a^b + a_4 \frac{x^5}{5}\bigg|_a^b$$

$$= a_0(b-a) + a_1 \frac{(b^2 - a^2)}{2} + a_2 \frac{(b^3 - a^3)}{3} + a_3 \frac{(b^4 - a^4)}{4} + a_4 \frac{(b^5 - a^5)}{5}$$

$$= \sum_{i=1}^5 a_{i-1} \frac{(b^i - a^i)}{i}.$$

Sometimes, one might want to group different mathematical expressions that do not result from a derivation. For example, suppose that we wanted to list three trigonometric identities: $\cos^2 x + \sin^2 x = 1$, $\cos(a+b) = \cos a \cos b - \sin a \sin b$, and $\sin(a+b) = \sin a \cos b + \sin b \cos a$. In the same way that we use punctuation marks while listing them inline, we need to use punctuation marks when using them in displayed mode:

$$\cos^2 x + \sin^2 x = 1,$$
$$\cos(a+b) = \cos a \cos b - \sin a \sin b,$$
$$\sin(a+b) = \sin a \cos b + \sin b \cos a.$$

However, suppose that $a = b = \pi$. In the same way that $\cos(2\pi) = \cos(\pi + \pi), = \cos\pi\cos\pi - \sin\pi\sin\pi, = 1$ is syntactically wrong because of the comma before the equal sign, so is

$$\begin{aligned} \cos(2\pi) &= \cos(\pi + \pi), \\ &= \cos\pi\cos\pi - \sin\pi\sin\pi, \\ &= 1. \end{aligned}$$

The attentive reader should have realized by now that the punctuation rules are the same for both inline and displayed equations because they are exactly the same thing.

3.3 Use of lengthy subscripts and superscripts

When using lengthy (three or more characters) subscripts and superscripts, especially when they represent text, it is a good idea to write them in upright face to increase readability. For example, although there is nothing syntactically wrong with $\mathcal{F}_{world}$, it looks much better if we write it as $\mathcal{F}_{\mathrm{world}}$. This is because letters in math mode have different typography, usually for the reason that they are meant to represent constants and variables, not text. For instance, 'abc' and 'xyz' become abc and xyz in math mode.

To write text in math mode within LaTeX/LyX, one can use either `\text` or `\mathrm`.

3.4 Variable naming

It is usually more elegant[13] and more compact to use single letters than words to denote variables. For example, the magnitude of the linear velocity v equals the product of the angular velocity ω and the radius r of the circular motion; that is,

$$v = \omega r, \tag{1}$$

which is much better than

$$\text{linear velocity} = \text{angular velocity} \times \text{radius}. \tag{2}$$

Eq. (2) often appears in more elementary texts, and are not the best choice for academic texts.

4 Graphs, figures, and illustrations

4.1 What graphs should I put in my article/report/thesis?

Graphs are used to support one's claims and help the reader understand the techniques being proposed or presented. Therefore, the first question one needs to consider is: what is needed to show to convince the reader that the proposed technique is working as designed?

For example, to show that the robot can drive the end-effector toward the desired set-point, one needs to show the time response of the error function norm. If the goal is to show that the robot respects constraints, a good way is to present a graph that illustrates that. If the objective is to show that the control signal has a particular behavior, it is a good idea to show the time evolution of the control inputs throughout the simulation, etc.

4.2 Figure annotations

Figures are used to help conveying useful information. If something can be effectively explained without figures, there is no point in using them. On the other hand, if they are confusing, they might cause more harm than good. This means that figures should be carefully thought, and sometimes it takes a **lot** of time to create them. To better connect the discussion in the text with the figures, it is useful to annotate them. This includes illustrations and graphs.

4.3 Size and disposition

It is common for papers to have a page limit, which constrains the size and number of figures one can include in the final text. Nonetheless, figures should be clear and of appropriate size, otherwise they become useless. On the other hand, some academic works such as reports do not have page limits or those are very generous, which means figures can be as large as the text width or as big as the whole page length.

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[13]This is a subjective statement but mathematicians and more mathematically-inclined engineers agree on this.
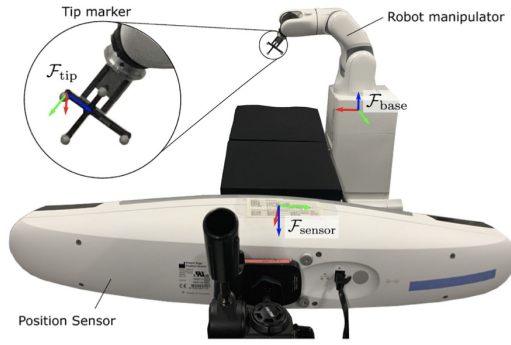
Figure 2: Example of an annotated figure with the same width as the column in a double-column paper [6].

Choosing the right size have different considerations, such as readability, aesthetics, and available space. Therefore, in double column documents, usually column figures should have the same width as the column, as illustrated in Fig. 2. Sometimes, however, the whole column width might not be sufficient, and the solution is to use a figure that spans both columns, such as in Fig. 3.

Pro tip: When defining the size of figures in LATEX/LYX, instead of using absolute values (e.g., width equal to 6 cm) or directly changing the figure scale (e.g., 70% of the original width), it is much better to define the width or length as a function of the column or text size. That way, even if the paper size or the column width changes, the figure will still maintain the same ratio with respect to the column or text width.

4.4   General recommendations

1. Figures **must** be discussed in the main text.

5   References

5.1   How many references should I put in my article/report/thesis?

The number of references depends solely on one's claims and what they want to convey. Therefore, there is no exact number or threshold that determines if a report, paper, dissertation, or thesis are good or not. Authors are expected to contextualize their work with respect to the existing literature, so the number of references should reflect their understanding of the topic. This means that those references should be directly associated with their work, and they should discuss them critically. References should help the reader to understand the technical field, and how one's work is inserted into the big picture. On the other hand, if the authors put references that are not so relevant or they do not discuss them appropriately, the reader will have the feeling that the authors don't understand their technical field and probably will be confused. Also, appropriate references should be used to support any claim that one makes that is not common knowledge (there is no need to put any reference to state that the sun is bright and hot), and for any technique that the authors haven't developed themselves. Since any technique that one might propose likely derives from previous ones, the predecessor techniques should be appropriately cited.

5.2   Tips and tricks when using author-year citations together with a numeric referencing style

Sometimes, we want to use numeric referencing citations, such as IEEETran, but also mention the authors of a given reference. For example, suppose we want to cite the INCOMPLETE GUIDE [1] but also explicitly indicate
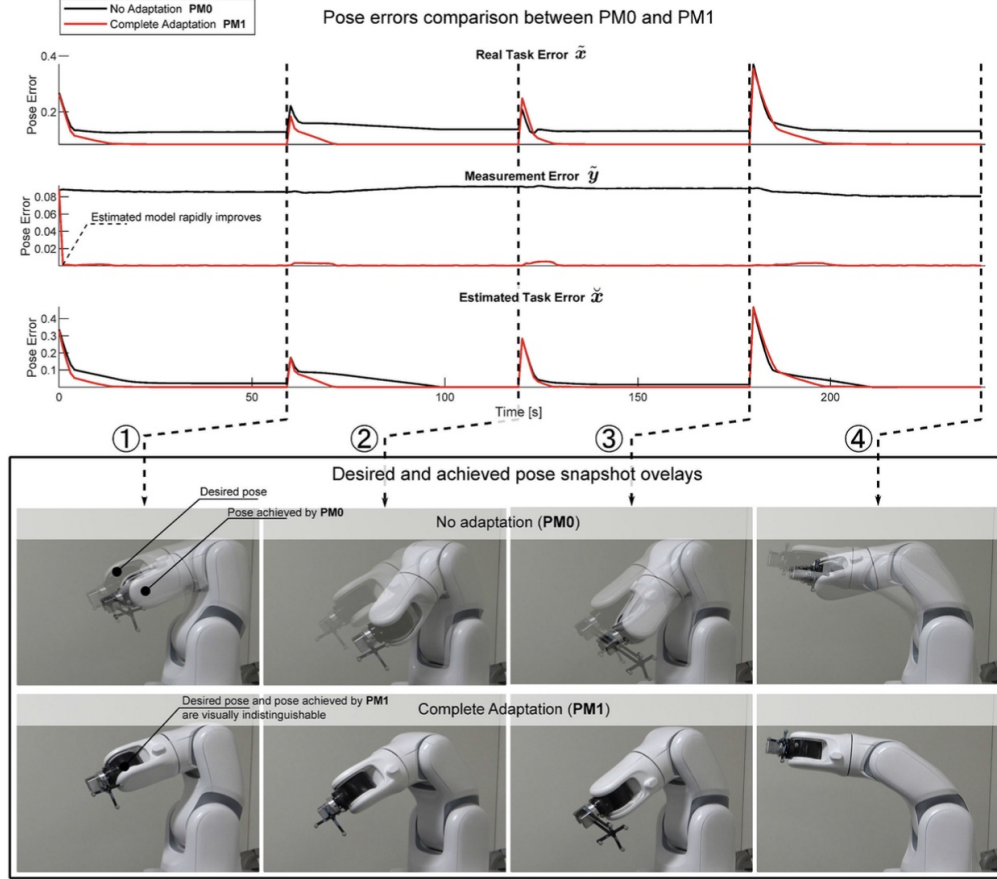
Fig. 4.   Comparison of the pose error between **PM0** and **PM1**, in terms of real task pose error $\tilde{x}$, estimated task pose error $\breve{x}$, and measurement pose error $\tilde{y}$. The proposed controller with complete measurements (**PM1**) outperforms a state-of-the-art kinematic controller [12] without adaptation (**PM0**) in all errors. The snapshots of the experiment show qualitatively the large final real task error in **PM0**, whereas the final real task error in **PM1** is indistinguishable from the real desired end-effector pose. A video of this experiment is available in the supplemental material.

current measurement y), and the estimated task error $\breve{x}$ (i.e., the error between the current estimated pose $\hat{x}$ and the desired pose x_d). Notice that when the pose error norm equals zero, the translation, rotation, and error norms also equal zero.

Regarding partial measurements, Fig. 5 shows the results of **PM0**, **PM2**, **PM3**, and **PM4** in terms of translation, rotation, and distance errors. Notice that when the translation error norm equals zero, the distance error norm also equals zero. The

1) No Adaptation: **PM0** represents the performance of a task controller without any parameter adaptation, which means that only (6) was used in the generation of control inputs. The real task error for all setpoints in Fig. 4 illustrates the errors in the initial estimation of the parameters. Because the robot parameters are all initially incorrect, no adaptation means that even if the estimated task error converges to zero, as shown by the solid-black curves in the third graph of Fig. 4 during the regulation to the set-

Figure 3: Example of an annotated figure with the same width as the column in a double-column paper [6].

the authors. Therefore, we could say that Adorno and Marinho are writing the INCOMPLETE GUIDE [1] to help not only their students but also anyone who wants to write an academic text in the robotics field.

If LaTeX/LyX is used—and we could not emphasize enough that it should!—there is no straightforward option[14] to do it automatically in the same way as when using author-year referencing styles such as the Chicago style.

Therefore, authors should follow some basic rules depending on the number of authors:

1. If there is just one author, refer to their last surname. For example, "Vivaldi [8] wrote a very good book on mathematical writing." When there are two surnames connected by a hyphen, we use both. For example, "Herculano-Houzel is a Brazilian neuroscientist who argues 'in favor of a view of cognitive abilities that is centered on absolute numbers of neurons, rather than on body size or encephalization' [4]."

2. If there are exactly two authors, refer to their last surnames. For example, "Adorno and Marinho [1] claim that LyX is more general than LaTeX in the same way C++ is more general than C."

3. For three or more authors, refer to the first author's last surname followed by *et al.*, which must be italicized. This is because *et al.* is an abbreviation of the Latin expression "*et alli,*" which means "and

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[14]At least, there is no viable option that *we* are aware of. If anyone knows how to do it automatically without having to resort to any hacking mechanism, please let us know.

others." For example, "Marinho *et al.* [7] proposed a technique, called Vector Field Inequalities, in which nonlinear constraints in the robot configuration can be transformed into linear constraints in the control inputs."

Notice that if any of the authors use a composite surname such as Herculano-Houzel, we should count it as just one surname. For example, "Herculano-Houzel and Lent [5] discovered that glial cells are not the majority in the rat brain."

6   Good practices in LaTeX and LyX

6.1   Using builtin mathematical symbols

Some mathematical symbols are builtin in LaTeX (and consequently, available in LyX) and the corresponding commands should be used. For example, for trigonometric functions, one should use $\cos\alpha$ instead of $cos\alpha$. For limits, $\lim_{t\to\infty}$ should be used instead of $lim_{t\to\infty}$, etc. Besides having a much better aesthetics, using the builtin commands enables LaTeX/LyX to handle those symbols appropriately. For example, when using displayed mathematical expressions, we obtain

$$\lim_{t\to\infty}$$

when typing `\lim_{t\to\infty}`. However, when typing `lim_{t\to\infty}`, we obtain

$$lim_{t\to\infty},$$

which is typographically incorrect.

7   General advice

7.1   Interacting with colleagues and supervisors

7.2   Asking questions

The number one rule of thumb is: "Vague questions will likely result in vague answers." Therefore, when asking questions, one should contextualize it succinctly and ask it precisely. Unnecessary details will take the focus from the relevant point, too little detail will make the question vague. Finding the right balance gets easier with time and experience. Nonetheless, sufficiently thinking about how to ask a question before meeting with one's supervisor or before writing an email will be immensely beneficial for everyone. It will help students organizing their ideas, which might even lead to the solution. Also, it will maximize the chances of their supervisors understanding the question, preventing unnecessary confusion and frustration for all parties involved. Lastly, it follows the same principle applied to writing: people's time is precious and we must respect it.

7.3   Presentations

Although there are many ways of presenting one's work through a slide presentation, some ways are better than others, so here follows a brief guideline to help in this task:

1. Slides are meant to support one's presentation and ideas. They are not meant to be standalone such as the paper, report, or thesis that one is presenting. That means slides should summarize what the presenter wants to convey and support what they are orally explaining and describing.

2. One should not use too many slides. Usually, two minutes per slide is a good rule of thumb. Therefore, a 15-min presentation should have 8 to 10 slides, but definitely no more than 15!

3. One should use legible diagrams and illustrations to help in visualizing what they are explaining. Slides should not compete with the speaker for the audience's attention. Therefore, it is paramount not to include too many texts. Instead, one should use small sentences that summarize ideas and important points.

4. A good structure for the slide presentation is the following:

   (a) First slide: Title of the presentation and the authors' names and affiliations.

   (b) Some slides to present the motivation, state-of-the-art, and main challenges.

   (c) One slide to present the main objective, which should be related to the main challenges the presenter has identified in previous slides.

(d) One slide to present the high-level solution and give the intuition without having to dive deep into the details.

(e) Some slides to present the relevant details. Not everything needs to be shown, and the presenter should be capable of summarizing their developments in a consistent, concise, and coherent way.

(f) Some slides presenting the results. Those are meant to support one's claims and provide a critical evaluation of the developed system, framework, or technique.

(g) A slide summarizing the presentation with the main take-away message.

References

[1] Bruno Vilhena Adorno and Murilo Marques Marinho. The IncompleteGuide to Academic Writing in Robotics Research, 2022.

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[4] Suzana Herculano-Houzel. The human brain in numbers: a linearly scaled-up primate brain. *Frontiers in Human Neuroscience*, 3, 2009.

[5] Suzana Herculano-Houzel and Roberto Lent. Isotropic fractionator: A simple, rapid method for the quantification of total cell and neuron numbers in the brain. *Journal of Neuroscience*, 25(10):2518–2521, 2005.

[6] Murilo Marques Marinho and Bruno Vilhena Adorno. Adaptive Constrained Kinematic Control Using Partial or Complete Task-Space Measurements. *IEEE Transactions on Robotics*, pages 1–16, 2022.

[7] Murilo Marques Marinho, Bruno Vilhena Adorno, Kanako Harada, and Mamoru Mitsuishi. Dynamic Active Constraints for Surgical Robots Using Vector-Field Inequalities. *IEEE Transactions on Robotics*, 35(5):1166–1185, oct 2019.

[8] Franco Vivaldi. *Mathematical Writing*. Springer Undergraduate Mathematics Series. Springer London, London, 2014.