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 primarly 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 opiniated 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.

[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

[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.

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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" [1]. 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 .

[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 theINCOMPLETE GUIDEand 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 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.)

2.3 Structure of an academic text

2.4 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.

2.5 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.

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[6] `https://en.wikipedia.org/wiki/WYSIWYG`
[7] `https://www.latex-project.org/`
[8] `www.lyx.org`

3 Mathematical writing

Equations 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.

3.1 Multiline equations

3.2 Use of lengthy subscripts and superscripts

3.3 Variable naming

It is usually more elegant[9] 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 your claims and help the reader understand the techniques you are using. Therefore, the first question you need to ask yourself is: what do I need to show to convince the reader that my system is working as designed? So, if you want to show that the robot can drive the end-effector towards the desired set-point, you need to show the time response of the error function norm. If you want to show that the robot respects the constraints, you need to present a graph that illustrates that. If you want to show that the control signal has a particular behavior, you then need 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. For example,

4.3 General recommendations

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

[9] This is a subjective statement but mathematicians and more mathematically-inclined engineers agree on this.

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.

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] L. Eggertson, "Lancet retracts 12-year-old article linking autism to MMR vaccines," *Canadian Medical Association Journal*, vol. 182, pp. E199–E200, mar 2010.

[2] O. Benecke and S. E. DeYoung, "Anti-Vaccine Decision-Making and Measles Resurgence in the United States," *Global Pediatric Health*, vol. 6, 2019.

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