A title that immediately tells even a non-expert reader what the report is about and catches his/her interest

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Abstract

This guide is not for general writing but rather scientific writing as one would submit to a journal or conference. It is also specifically advising on the reports describing an implementation of the applied estimation project. Most of this also applies to a thesis although that would be much longer and there are some other differences. The abstract should state the problem and why it is important. It should describe what you have contributed / accomplished and what implications / impact this has. The abstract should be self contained. Someone that has not read the report should be able to understand it. It should not contain abbreviations and bibliographic references. It should be short. Remember that it is not a summary of the report. Think of it more as an ad for the report where the aim is to raise interest and make someone read all of it.

TOTAL LENGTH LIMIT: 10 pages
TOTAL SIZE LIMIT: 9 MB

1 Introduction (1–2 pages)

The introduction is the most important part of the paper. Depending on how you structure the introduction it is typically about 10–25% of the total paper. By the time the reader has finished it he or she will know:

- What was the problem.
- Why is the problem worth addressing.
- Something about the choices for solving the problem
- What the authors did (Be clear what parts are 'contributions').
- Why they did it.
- Hint of why they think they succeeded (why are the results good).
- And most important: the reader has formed an opinion of the author's depth and breadth of knowledge on the subject.

The last point is critical to the readers assessment of everything that comes later. You can not show the reader your code or take him to your lab to see your equipment and routines... He judges your credibility and then uses that to set how much to trust that you took care of all the small details that make the results mean something. If the readers feel you might not really have a grip on the subject then they might not trust that you did everything the right way. They will require more proof and you will not have space or possibility to provide that. I often see very nice results in tables or figures but just do not believe them based on the text that preceded them. It might not be that I think they cheated on the results but just that they did things that biased the results through ignorance. (Or they cheated.) The better the results the greater the suspicion.

The introduction should start by explaining what the problem is and why it is important. You must not copy the text from the abstract. So it is good to mention some applications that would benefit from this work. These are great if accompanied by cited quotes that someone else has said this is important.

The introduction then outlines at a very high level the parts of the problem and some approaches to solving it. Here we do not give details and avoid terminology that is not well known to the target reader.

After your have motivated why you do what you do you should provide the reader with information about your specific results and give the reader a hint

at how you got there. You cannot go into great details here since the reader does not have enough knowledge but an expert should be able to tell what you did rather precisely and a non-expert should understand at least in a sketchy way how you approached the problem. It is a strength, almost a necessity, to reference the key results that your work rests on. Very few scientific papers make huge new discoveries, disconnected from all other results. It is more about incremental contributions where researchers document their small steps towards a bigger goal. By sharing their new knowledge, the field as a whole progresses. Do not hide references that are close to what you did. Use them to show how well you know the field and how other work is aligned with yours.

If you are unable to reference any other work you will have to spend a huge amount of effort to convince the reader that there is in fact no relevant work and that you were not simply too lazy to look for it. The more well researched an area is the more focused and close to your work the references will be. When the area is not so well researched you will have to widen your scope and refer to the closest work to your work even if it may be far. Again, the aim is to make sure that the reader is convinced that you know the field and hence that you are a reliable source of new information.

In this report template we will make use of a separate section (see Section /refsec:relwork) for describing the related work in detail.

1.1 Contribution

In a scientific paper this may not be an actual section but here we want you to practice to make this concrete. You cannot leave it up to the reader to guess why what you have done is important and what you have contributed and what is novel. This should be spelled out in clear text here and repeated at least twice more in the report. Once where the actual contribution is made and once at the end of the paper. If the reader puts down the report not knowing what you accomplished you have failed miserably. I typically like to put 2 or three bullets at the end of the introduction with the main contributions listed. Followed by a short explanation of them.

1.2 Outline

Many people also like to end with an outline of what the rest of the report will contain section by section. That is helpful if it is more than just the section titles as that I can read as I go. If it explains why the order is as it is and what the big picture is it helps.

2 Related work (1–2 pages)

This section should show that you know the field well. You can reference the book, [Thrun et al., 2005], but there must other be peer reviewed articles also. Look at the book's references. If you were writing a paper for a conference you would want to make sure that you reference anyone that might review your paper. Do not make use of mass references such "In [2,3,4,5] various non-linear estimators are presented". You should explain what each paper is about (1-2 sentences) and how what you did relates to it. Give credit to the people that introduced an idea and not just the person that used it last. You want to make sure that you cover both historical references (who introduced the idea) and current references (latest results in a certain area). Make it interesting to read. It is not just a list of references. Make sure to make it clear what parts of the related work you make use of, was inspired by, build on, or improve upon. Here you have a golden opportunity to make your contribution crystal clear with respect to previous work.

The best related work sections read almost like a story. They give the origins of the ideas that became important. They explain what was holding back progress. They explain the breakthroughs that moved things forward again. Finally ending at the current state of the art. All the while the parts that end up in or contrast to the authors own method or results are highlighted.

It is scientific papers that you have found that we want you to describe here. Typically you will start by reading a few papers and then look at papers that they refer to and so on. Remember that it is not OK to reference a paper that you have not read. Just because paper X claims that that paper Y showed fact Z does not mean that you can refer to paper Y as showing Z, you should read at least the relevant parts of Y. Do not read the papers in great detail to start with. Start by getting an overview to determine if it is of interest. If it is, read it again more carefully. This process will result in a lot of papers. Not all of these should be referenced in this section. This section lists work that is related to your work and it is not an account for all of what you read.

When searching for initial papers use general search terms that seem related. Goggle scholar will typically rank them based on number of citations which generally is a good indicator of the most important works. You should also look for that little cited but very similar to your work paper. That is considerably harder to find but for the projects here you will likely be implementing something more or less from a paper so this is not a problem (cite that paper and look at what they cite and what papers cited them).

3 My method (1–4) pages

You will describe your method / approach / theory in detail in this section. In a real paper you would pick a section title that is more descriptive than the above. Depending on the work you have done this might be split into several sections. Make use of references that describe core elements of your method so that you do not have to describe everything. There is no room for that. Key results from other sources should be summarized to make the paper self contained enough for someone in your field to be able to read it without having to read ten other papers before they can understand your paper.

Make use of examples to explain things before you go into the gory details. Make good use of figures. Do not introduce mathematical symbols unless you make use of them. All symbols, tables and figures need to be explained in the body of the text. Figures should also have captions that are somewhat self contained so that someone skimming and looking at the figures can know what they show. If you present something complicated you may want to explain it in several iterations where you start with an easy to understand, possibly somewhat simplified explanation and then go into details. A reader that is only looking for a method to use may not be interested in all the details but rather enough to understand how to use it and what limitations there are. Such a reader may not be a domain expert and he/she is likely to skip to the experiments at some point in this section because it gets too complicated to understand. Your presentation should make this possible. Any new twist you add needs to be motivated in some way. In a real paper a criticism is often why did you add this twist or modification. Was the justification theoretical or just to 'make it work.' Why is it better than other choices. Hacks make papers hard to pass muster in the real world. In this project however this sort of critic is not going to come from me as it is not relevant. I want you to get it to work so that is fine as a justification. I also want you to play around and try out ideas, so that is also a good motivation.

Do not be patronizing and avoid statements like "obvious algebraic manipulations yield...". It is often better to aim too low when it comes to your expectations of what the reader knows than too high. It is much easier to skip one of your steps than to come up with that step yourself as a reader.

3.1 Implementation (0–2 pages)

The description of your method should be provided at a level of abstract where implementation details are avoided as much as possible. For conveying general knowledge it is typically uninteresting to know that you implemented

your system in C++ or .NET and that you make use of package so and so. However to assess your results it may be important to know some of these details. This section, if present, provides the implementation details. Limit the description to what is important. What language you used to implement your system is in many cases not interesting either but it might be interesting to know that you used a kd-tree to make access to certain data more efficient or that you made this run super fast using the GPU. This is particularly important if you make comparisons of speed. Comparing EKF in Matlab to PF using GPU it would be important to point out theses details but if in the end you are focused on accuracy then it does not matter at all.

Exactly what you put here varies from case to case. Instructions for how to run your system would not end up here unless it is related to the problem you deal with. Remember that it is not a software manual or a user guide.

4 Experimental results (1–4 pages)

In this project your task is to create a working implementation of some estimation method so an experimental evaluation is to be expected. Make experiments that backs up the claims you make. If you have improved / modified some other method, compare your new method with the old. If possible include other methods in the comparison.

Here you should have figures and tables that show the results. It is best if there are numerical measures such as mean square error or a histogram over errors. this is even better if the errors are normalized with the covariance. Often one plots the errors over time as bars or points and the 2 sigma bound as a curve. A figure that one can see that the estimate is following the true values is good if you can show it. All that requires ground truth so if you do not have that your job here is more difficult be creative and show something that indicates it works. For example the innovation process can still be shown.

When writing a paper in a well researched area you would be expected to compare your result to all or a significant fraction of related results and show why your method / contribution is worth publication. This does not apply here but some comparisons will help.

Make sure to provide your experimental setup carefully. You want someone else to be able to replicate what you did.

A paper where everything works flawless according to the experiments is typically looked upon with skepticism. Nothing is perfect! If you get perfect results it often means that your tests where not challenging enough. As a reader I want to know what the limitations are so push it to the limit or at

least provide solid arguments for where such limits might be.

It is essential to provide an analysis of your results. It is not the reader, but you, that should interpret the results. Do not assume that the reader is an expert so even result that to you seem obvious may be worth to point out. When you write a longer report, your thesis for example, the warning lights should go off when you end up with figures without any texts on several pages. In this case you have probably not provided enough analysis.

As already said but worth repeating, all figures that you have in the report must be referenced in the text. Provide captions that allows a reader to browse your paper and get the gist of your results. Summarize your findings at the end of each experiment if long.

If you have statement / hypotheses that you cannot really back up with the results put these at the end. Here you can speculate a bit and be less formal. But be clear that this is not a claim but speculation.

5 Summary and Conclusions (0.5–1 page)

Summarize what you have done and make sure that your highlight your contributions. You should not introduce new results in the summary. Results should be introduced in the main sections above. Here you can speculate on how these results could be extended, what would happen in other settings or how the method could be used other domains and how to continue with the research in the future. In this section you can put statements that one cannot understand unless you have read the paper which is not possible in the abstract for example. You do not need to be as formal in this section.

References

[Thrun et al., 2005] Thrun, S., Burgard, W., and Fox, D. (2005). *Probalistic robotics*. MIT Press.