Part 1: Research Methods
- Reflection on research methods -

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I began my PhD studies at the Department of Automatic Control in June 2013. During my first year as a PhD student, I decided upon the topic of my thesis and started to get a grip of the field by focusing on reading papers and books alongside with taking courses relevant for my topic. Thereby, the first research method I used was literature survey. I discussed the material that I had studied either in a group together with other PhD students or with my supervisor. I see these discussions as an extension of the literature survey. The topic of my thesis is on scalable control methods for large-scale and complex systems.

After my first year, I started to formulate models useful for my research question. I evaluated them by comparison with existing models and related work conducted by other researchers. Through this evaluation, I was able to formulate my first, more clearly stated, conjecture. In order to prove it, I used deductive and analytical methods. Thereafter, most of my research has been performed through deductive methods. However, I often use numerical studies in the initial stages in order to test my hypothesis, either by disproving them or by becoming more certain that they are true. It also gives me inspiration for how to construct the proofs.

I wish to become more efficient at evaluating my hypothesis. I have learned some tricks for how to quickly check if my mathematical statements are sensible or not. However, it would be valuable to become better at this and I think that this kind of knowledge comes from experience.

It is common that theoretical contributions are only presented in their most condensed form, i.e., by a theoretical statement and its proof. It is therefore not easy to understand how the author came up with the idea for the statement or even more so the proof. I think it would be helpful for the research community in general if these findings were stated a bit more clearly. For instance, one could include the numerical studies used initially to prove or disprove a statement in the presentation of the findings. This is where I think this more theoretical approach differs the most from the scientific method. It seems as if the scientific method often reveals a larger part of the conducted research.

I get the most inspiration for new research ideas when I interact and discuss research with other people. I have presented posters covering my research at two different occasions. They have both been fruitful for broadening my understanding of the topic as well as coming up with new directions for further work. Furthermore, I wish to work both individually and in collaboration with other researchers. I definitely see networking and interaction with other researchers as somewhat of a research method as it is very valuable for getting inspiration.

The main motivation behind my research is often very broad and a bit

far away from, however not unrelated to, the actual research questions that I am working on. This seems to be common praxis as I often see that it is the case in papers by other researchers as well. I want to become better at stating the actual research question when I am presenting my work, to make it more clear for the intended audience. Furthermore, I want to make sure that the reader knows my educational background. I think this might help the reader to understand why I have for instance chosen a certain methodology.

The methods I have used so far in my PhD studies are methods common in mathematics and engineering. That is, to construct theorems and proofs as well as design models and evaluate them. Considering a research topic different from these, I think it would be beneficial to work on a coherent use of notation in the topic of my thesis. Therefore, I might consider to write a review of the terminology used as well as work towards unification.

I am very much interested in applying my work in the field of biology. Therefore, I will hopefully someday use the entire framework of the scientific method. I am currently collaborating with researchers from a different field than my own. I think it would help our collaboration if we performed some sort of survey to understand how well we know each others fields. The findings from such a survey would hopefully help us to collaborate more efficiently and to formulate common research questions.

In conclusion, the research methods that I have used so far are common praxis in mathematics and engineering. I hope that I will keep an open mind and try out other research methods during my time as a PhD student. However, I think by far that the most important thing is that there keeps existing a diverse set of research methods to gather inspiration from.