

Essay on Research Methodology

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My Field of Research

I'm currently researching control algorithms for event-based control, a sub-field within automatic control. Whereas control algorithms traditionally are implemented with periodic sampling and actuation, event-based control instead takes the approach of sampling and actuating aperiodically and only when required (i.e. at "events"). This way, the control algorithms can be made considerably more resource efficient than their periodic counterparts.

Unlike traditional periodic control, there is currently no common design framework for event-based control, and research is therefore very much focused on adapting existing design tools to an event-based setting. This is also what my research is focused on. While prototypical case study implementations exist, there are to my knowledge no large scale implementations of event-based control in industry as of yet.

My Current Method of Research

My research (like most research in automatic control) is research in the sense of engineering and mathematics. The research questions I pose are based on engineering problems which would be interesting to solve. After a problem has been identified and I have defined a set of research questions to answer, I start by doing a literature study of papers relating to the problem. I then ask myself questions such as: "How can I represent my problem mathematically?", "Are there existing methods which can be useful for my specific problem?" and "Has someone already solved my problem?".

After the literature study, I try to formalize the problem mathematically. In some cases parts of the solution can be found simply by representing the problem

in some well-known way (e.g. solving the problem might be equivalent to solving a convex optimization problem, for which there exist many well-known solvers). After obtaining a mathematical model, I start testing different ideas. This is done both analytically and by simulation. Simulations often give clues on what properties the problem has, and what the solution should consist of.

When discovering a method which seems to solve the problem, I try to prove it also analytically. To ensure that all analytical derivations are correct, I verify the results with simulations. Since stochastic elements most often are a part of the mathematical model, I need to do many simulations and be statistically rigorous to give the results credibility. Finally, I communicate my research findings to my colleagues at the department and researchers from other universities through seminars, conferences and publishing of research papers.

Potential Future Research Methods

There are three methods I would consider including in my future research process. The first is to get earlier feedback on my simulation work through public code sharing through e.g. GitLab. It would help a lot to have other people with similar interests giving feedback on my code, and perhaps even contributing with code of their own. Of course, I have to be selective as to what I make public and when, or otherwise I might risk that someone else might publish the research findings before me.

The second method is to further verify my research findings by doing practical case studies and actually implement my solution. Building a small prototype based on the original problem and testing it would be enough. Not only would this strengthen the credibility of my theoretically derived results, but it would most probably also help inspire new directions of research as new problems arise when doing practical implementations.

The third is to go out and make some kind of "field study" in industry. I feel that a common risk in research is to find a solution and then "invent" a problem which does not really exist. By going out, meeting people from industry and identifying what they consider to be interesting problems I would ensure that the problem I'm trying to solve is actually a real problem. To make such a field study happen, a suitable starting point would be to communicate this idea to the senior members of the department, who often have a large network of connections in industry.