Research methodology, Essay

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1 Introduction

In this essay, I was asked to describe what kind of research methodology that I use in my daily research and to reflect over which other methodologies that I could consider using as part of my research. This is done as a part of fulfilling the requirements for the PhD course: "Introduction to Research Methodology, Ethics, and Innovation for Computing Disciplines".

2 Current methodology

My main focus of research is Numerical Optimization, in particular Large Scale Convex Optimization. the main goal of the work is to develop new optimization algorithms that scale better with problem size, so that they are able to solve very large optimization problems. This work can be divided into several possible subparts, some of which are:

1. Speculate on possible new methods and algorithms that might achieve the required performance.
2. Test the above mentioned methods on simple problems to gain insights about their performance and strengths.
3. Develop mathematical theory and proofs that guarantee some properties of the developed algorithms, for example proof of convergence, computational complexity or convergence rates.
4. Develop state-of the art implementations of the algorithm and evaluate its performance in practice compared to other algorithms.

These points do not represent a linear path of research, as my research is often going back and forth, iterating over these points, but they lay out the main focus of the research that is conducted.

If this research should be categorized into a single research methodology, I would probably argue that it is "Mathematical Conceptual Analysis". However, the research borrows ideas from other methodologies too. Going by the "Research Methods" outlined in (An Analysis of Research in Computing Disciplines) [1], my research also uses the following methods to some extent.

- Conceptional Implementation (Proof of Concept)": This method is used by me in particular in the second point above, to gain some insight of the performance and behavior of the method, but also when presenting the algorithms to other researchers.

- "Case Study": Depending on how this methodology is interpreted, it could be part of my research. It is often that we consider a specific problem and speculate (and verify) how different approaches (algorithms) work on that specific problem.
- "Mathematical Proof": Although I am not convinced that this is a research method, it is certainly an important part of my research. It is through mathematical proofs that we can be certain that our methods will achieve the minimum standards set on them, and it may also be a tool to find new generalizations of the algorithms.
- "Literature Review/analysis": This point is in some sense critical to my work, and presumably in all research, it is impossible to develop all the theory myself, and inspiration from other researchers are essential, if we are to develop new theory, it will be, as Newton said "by standing on the shoulders of Giants".

3 Possible future methodologies

I do not really think that this section makes much sense. It seems to me, that the work I have to do, to achieve that goals I set up is pretty clear cut. This may be a feature mainly of the engineering field. I think that any good researcher should try to use the most efficient methods possible, and in my case the choice seems obvious.

For example, I could try to do a survey. But to go out on the street and ask people which of my methods will converge faster, seems ludicrous. A more reasonable version would be to ask other researchers in my field what they think. This is done to some extent, especially with my advisor, but we also sometimes seek advice from other researches when we think they could have good ideas. There are however few people in the world that focus on the same specifics as us, so the value is in many cases small.

The last method I will comment on is "Data Analysis". In my case this could be interpreted as studying all the additional data generated by our algorithms, that do not directly reflect the goal. This is usually not part of my research process, but can be valuable. If properties of the additional data are found that were not expected, these could possibly be exploited for better performance or understanding. This is what led to my current research topic, but is often tedious and usually pointless. It is something I could do more of in the future, but probably won't.

Most of the other methods laid out in the article seems to fit even worse with a research area that deals only with abstract properties of mathematical constructs so I will not comment on them further.

References

[1] Iris Vessey Robert L. Glass, V. Ramesh. An analysis of research in computing disciplines.