The Research Process in Computer Science

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Provides a brief introduction to finding a research topic, then selecting an appropriate methodology from which to approach the problem. This, with unique consideration to performing research in the field of computer science.

1. INTRODUCTION

All researchers should become at least generally aware of the common research methodologies in popular use. However, due to the nature of work and the unique set of tools available in the field of computer science, a researcher in this field also needs to be aware of methods specific to his field, as well as the various common pitfalls encountered when he wishes to implement them. First, however, he must choose a topic to write about – a topic that, hopefully, is original and significant enough to warrant the attention of his colleagues and peers.

2. FINDING A PROBLEM

It is often said that finding a research problem is the hardest part of writing, whether one is working on their doctoral dissertation or simply doing research in hopes of being published. Eisner suggests several ways in which to contribute to computer science, ranging from relatively small to significant [Eisner 1997]. He advises that likely the least impactful way to contribute to the field is by reproducing or implementing the work of another. Though unexciting, such work can help lend validity to nascent theories, or assist in the development of emerging systems. Other ways to find a research problem include improving upon available work by "tweaking" a well-known solution or technique (although, we're warned, doing so should result in some tangible, significant benefit to the established solution in order to be judged as worthwhile). For more ambitious ideas, a researcher may find inspiration by reviewing important papers in their research area, paying particular attention to problems (realized or otherwise) that are impeding further progress. Even without solving these problems outright, there could possibly be valuable work in formalizing them. Lastly, there is always the option of speaking to a colleague or an advisor. This could be particularly useful if your field of study is multidisciplinary (e.g., bioinformatics). Appealing to others with more experience in a related discipline might be very effective at uncovering problems worthy of further exploration.

3. RESEARCH METHODS

As a unique flavor of science, some distinct research processes have been developed within the field of computer science. Chief among these include the following:

— formal
— experimental
— build

We will briefly explore each of these research methods, along with their common pitfalls when applicable.

3.1. Formal Methodology

A "formal methodology" is the most frequently used in theoretical computer science (this subfield is credited with supporting the field of computing). The basic idea here is to abstract away as many details and extraneous variables as possible, leaving behind only the essence of the problem under consideration. This subfield is concerned with answers to theoretical

questions about computing, such as limitations of algorithms, models, and formalisms. Such theoretical approaches to computer science are based on the formal methodology since they are related to logic and mathematics. It is important to note that while we may use the formal methodology to develop a new model or theory, it is often necessary to use other methodologies (such as those that follow) to prove their efficiency [Ayash].

3.2. Experimental

Experiments can be used to test the veracity of theories. Supposedly, there is much work done in the form of experimental results in the computer science field, much of which was done hastily or without due regard to detail [Amaral 2011]. Because of this, many experimental computer science results are non-reproducible; reproducibility of both the experiment and its results is critically important when following this research method. To this end, it is suggested that good record keeping is mandatory. Similarly, test bed systems are often modified or reconfigured without regard to the impact on the experiment or the ability to reproduce its results if needed. "Annotating, filing, and documenting are essential for the future relevance of an experimental scientist's work." [Amaral 2011] When it comes to compiling a report following an experiment, it is very important to state in plain English the results of the experiment. The author should not rely on simply including the data to explain the outcome. Furthermore, one should never rely on aggregations of data to draw conclusions (e.g. putting too much weight on an average). The researcher should include raw data as necessary, however, it is incumbent upon him to draw conclusions and state them clearly and accurately.

3.3. Build

As will often happen in the computer science field, it may be necessary to write a program in order to test a theory, run a simulation, or generate a data set. When a simulation is used, it offers the ability to investigate systems too large or too complex to perform in the real world [Amaral 2011]. For example, researchers may simulate the effect a new routing protocol will have on a particular network topology. Developing a proper simulation will allow preliminary conclusions to be made about the problem without the monetary or logistical complications of a full-scale experiment.

4. CONCLUSION

While the field of computer science is very clearly a branded subfield of science, it is difficult to categorized more accurately than to say it lies somewhere between hard science such as physics and math, and soft science, such as economics or psychology. As such, it evolved a set of its own unique research methods, among which a few were discussed here. There are, however, many other methodologies being used in the field, particularly in areas whose level of specialization is highest. The methods discussed in this essay are relatively general, and broadly applicable to many research problems a computer scientist may encounter and be faced with solving.

REFERENCES

Jos Nelson Amaral. 2011. About Computing Science Research Methodology. (2011). Retrieved September 1, 2015 from http://webdocs.cs.ualberta.ca/~c603/readings/research-methods.pdf

Eng. Mohannad M. Ayash. Research Methodologies in Computer Science and Information Systems. (????).

Jason Eisner. 1997. How to Find Research Problems. (1997). Retrieved September 1, 2015 from http://www.cs.jhu.edu/~jason/advice/how-to-find-research-problems.html