Software Testing - Special Session

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Introduction Write-Up [1]

[1]Based on (and using parts of) Ch. 2, 3, and 5 of **Writing for Computer Science** (Third Edition) by **Justin Zobel**

Introduction to Research

Introduction to Research

Definitions

"Scientific research is a systematic way of gathering data and harnessing curiosity. This research provides scientific information and theories for the explanation of the nature and the properties of the world. It makes practical applications possible."

Wikipedia[2]

"In the broadest sense of the word, research includes any formal gathering of data, information and facts for the advancement of knowledge. [...] The strict definition of scientific research (i.e. the scientific method) is performing a methodical study in order to prove or disprove a hypothesis, or answer a specific question."

Explorable[3]

"Science is a system for accumulating reliable knowledge. Broadly speaking, the process of science begins with speculation, observation, and a growing understanding of some idea or phenomenon. This understanding is used to shape research questions, which in turn are used to develop hypotheses that can be tested by proof or experimentation. The results are described in a paper, which is then submitted for independent review before (hopefully) being published [...]"

Writing for Computer Science[4]

[2] https://en.wikipedia.org/wiki/Research#Scientific_research
[3] https://explorable.com/definition-of-research
[4] https://link.springer.com/book/10.1007/978-1-4471-6639-9

Introduction to Research

Getting Started (1/2)

- Is your proposed topic clearly a research activity? Is it consistent with the aims and purposes of research?
- How is your project different from, say, software development, essay writing, or data analysis?
- In the context of your project, what are the area, topic, and research question? (How are these concepts distinct from each other?)
- Is the project of appropriate scale, with challenges that are a match to your skills and interests? Is the question narrow enough to give you confidence that the project is achievable?
- Is the project distinct from other active projects in your research group? Is it clear that the anticipated outcomes are interesting enough to justify the work?

Introduction to Research

Getting Started (2/2)

- Is it clear what skills and contributions you bring to the project, and what will be contributed by your advisor? What skills do you need to develop?
- What resources are required and how will you obtain them?
- What are the likely obstacles to completion, or the greatest difficulties? Do you know how these will be addressed?
- Can you write down a road map, with milestones, that provides a clear path to the anticipated research outcomes?
- Do you and your advisor have an agreed method for working together, with a defined schedule of meetings?

Introduction to Research

Reading Papers (1/2)

- Is there a contribution? Is it significant?
- Is the contribution of interest?
- Are the results correct?
- Is the appropriate literature discussed?
- Does the methodology actually answer the initial question?

Introduction to Research

Reading Papers (2/2)

- Are the proposals and results critically analyzed?
- Are appropriate conclusions drawn from the results, or are there other possible interpretations?
- Are all the technical details correct? Are they sensible?
- Could the results be verified?
- Are there any serious ambiguities or inconsistencies?

Introduction to Research

Evaluate Papers

- Is the contribution timely or only of historical interest?
- Is the topic relevant to the venue's typical readership?
- What is missing? What would complete the presentation? Is any of the material unnecessary?
- How broad is the likely readership?
- Can the paper be understood? Is it clearly written? Is the presentation at an adequate standard?
- Does the content justify the length?

Writing Introductions

Introduction to "Introduction"

Definitions

"The introduction should define the problem clearly and give sufficient background information for the following chapters. However, no details, yet! [...] Introductions can be divided into sections, if it is easier to write, but it is not necessary."

Scientific Writing for Computer Science Students - Wilhelmiina Hämäläinen[5]

"There are two basic things that should be included in the introduction: the area of computer science the project is involved with and the actual topic/name of the research project [...] Once a student identifies the field they are working in, they should then go on to briefly summarize what it is their project topic is and/or what their hypothesis for their project was."

Blog Post on The Crazy Programmer - Neeraj Mishra[6]

"An introduction can be regarded as an expanded version of the abstract. It should describe the paper's topic, the problem being studied, references to key papers, the approach to the solution, the scope and limitations of the solution, and the outcomes."

Writing for Computer Science[7]

[5] http://www.cs.joensuu.fi/pages/whamalai/sciwri/sciwri.pdf
[6] https://www.thecrazyprogrammer.com/2020/12/tips-for-writing-a-computer-science-research-project.html
[7] https://link.springer.com/book/10.1007/978-1-4471-6639-9

Writing Introductions

What to describe and provide? (1/2)

- An introduction can be regarded as an expanded version of the abstract
- It should describe
  - the paper's topic
  - the problem being studied
  - references to key papers
  - the approach to the solution
  - the scope and limitations of the solution
  - the outcomes

Writing Introductions

What to describe and provide? (2/2)

- It should provide
  - enough detail to allow readers to decide whether or not they need to read further
  - sufficient motivation
    - Why is the problem interesting?
    - What are the relevant scientific issues?
    - Why is the approach taken a good one?
    - Why are the outcomes significant?

  $\Rightarrow$ Should show that the paper is worth reading

  $\Rightarrow$ Should create a basis of common understanding and perspective for the author and readers

Writing Introductions

What to keep short?

- The introduction can discuss the importance of the conclusions, but:
  - Should include only a brief summary of the supporting evidence
    - → detailed concepts and evidence are presented in more depth in *Concept* and *Experiments* sections
  - Should introduce only the most important terminology
    - → the full terminology is usually presented in a *Preliminaries* sections
  - Should cite only the most relevant literature
    - → an in-depth discussion of the literature is presented in a *Related Work* section

Writing Introductions

How to present the contents?

- A paper is **NOT** a story in which results are kept secret until a surprise ending
  - clearly tell the reader what in the paper is new and what the outcomes are
  - Otherwise, the reader might assume there are no results and discard the paper as worthless
- However, some *suspense* is still possible
  - Only reveal what the results are, not necessarily how they were achieved in detail

Writing Introductions

What to convey?

- By the end of the introduction, the reader should
  - understand the **scope** of the work, and of the problem
  - the contribution, i.e., what the **discovery** of the work is
- The reader should appreciate
  - what the properties of this contribution are
  - what makes it interesting and plausible
  - what method was used to investigate it
  - why the method is appropriate

Writing Introductions

What to avoid?

- Irrelevance
  ("the reader cannot figure out what the paper is about")
- Inconsistency, Inadequacy, and Incompleteness
  ("information and claims are disconnected, exaggerated, or missing")
- Incomprehensibility
  ("the reader immediately feels that the work cannot be of value")
- Ugliness
  ("if something looks terrible, then the author doesn't care about the content; and if the author doesn't care, then the reader certainly shouldn't")
- Ignorance
  ("explaining only elementary concepts and irrelevant literature")

Writing Introductions - Examples

Abstract Example

- Given the topic “mechanisms for collaborative authoring”
- The introduction needs to explain
  - who is doing the authoring?
  - what abilities and experience are assumed to have?
  - what kind of tasks do collaborative authors try to complete?
  - how sophisticated do the mechanisms need to be?

Writing Introductions - Examples

Concrete Example

An Experimental Evaluation of Data Flow and Mutation Testing (A. Offutt, J. Pan, K. Tewary, T. Zhang)
Mutation testing and data flow testing are two unit-testing techniques that have recently matured enough to be used by industrial software developers. Both techniques are thought to provide a higher level of testing than older techniques such as statement and branch coverage (for example, mutation and data flow subsume statement and branch coverage), but are also more costly to apply, and require automation. Many engineering advances have been made in the past few years to support mutation and data flow, and commercial tools are now available (PiSCES for mutation and ATAC for data flow), which are currently being used in practical situations. Unfortunately, the relative merits of these techniques are still not well understood. Test engineers and test managers need objective, factual studies such as this to make well-informed decisions about testing. We will try to establish some idea of the practical cost to benefit tradeoffs between mutation and data flow testing, based on experience with the techniques.
Both techniques are white box in nature[1] and require large amounts of computational and human resources (although recent engineering advances are reducing both types of cost). Although experience has led us to believe there is significant overlap between the two techniques, they have not been successfully compared on either an analytical or experimental basis. We attempt the comparison using two experiments. First, we compare mutation and the all-uses data flow criterion to see whether either method covers the other in the sense of how close test data sets that satisfy one technique come to satisfying the other. Second, we compare mutation and all-uses by executing faulty versions of programs and comparing how many faults are found by test data sets that satisfy each technique.
Our results lead us to believe that while mutation offers more stringent testing than data flow does, both techniques provide benefits the other lacks. Our eventual goal is to find a way to test software that provides the advantages of both techniques, either by combining the two techniques or by deriving a new technique that offers the power of both mutation and data flow testing.
The remainder of this section includes a short discussion on the notion of test adequacy criteria, provides overviews of mutation and data flow testing and reviews related research. Subsequent sections present our analytical results and a discussion of our experimental procedures and results. Details about the programs and faults we used can be found in a technical report.[2]

Writing Introductions - Hands-on

Group work

Hands-on session