

How to Write Research Papers

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Feb 14, 2006

Typical Paper Structure

- Title
- Abstract
- Introduction
- Optional: Background
- Related Work (alternatively put before conclusion)
- Example
- Approach/Framework
- Implementation
- Evaluation
 - Experiment/Case Studies/Experiences/Examples
- Discussion
- Conclusions (and Future work)

Title and Abstract

- Title writing pitfall:
 - Don't put uncommon buzzwords there
 - Otherwise, bad for paper search engines or readers who would like to understand what the paper is about by reading the title
 - Be specific enough but not too specific (related to the previous bullet)
- Abstract structure:
 - Short motivation (problem); Proposed solution; Evaluation; Evaluation results
- Abstract writing pitfall:
 - Don't put unexplained or undefined terms whose meanings are not well known
 - Solutions: explain them; rephrase them using plain words; not get into too much detail (without mentioning them).

Introduction Structure

- Long motivation, problem to be solved, why existing solutions are not sufficient
- Proposed solution and brief summary
- Optional: brief mention of related work if it is very related and explain differences
- Evaluation and evaluation results
- Optional: “The paper makes the following main contributions: + bulleted items”
 - Easy for reviewers to spot out major contributions
- Structure layout of the paper (you want to give readers high level ideas how different parts are related to each other)
 - Similar principle applied throughout the paper for subsections

Introduction –cont.

- Don't overclaim (even throughout the paper)!
 - But it is good to put your work in a bigger picture and a larger background
- If you want to claim some unjustified points, it is better to put them in conclusion or discussion section
- Even if so, be careful on wording
 - “Our approach provides a foundation for this new field.”
 - “*We believe* our approach *can* provide a foundation...”
 - “*We believe* our approach *has a good potential* for providing a foundation ...”
- Similarly don't over-criticize other's work (even throughout the paper)!

Background and Related Work

- Differences between background and related work (c.f. my ASE journal 06 paper)
- You can organize related work with subsections or group them in several categories
- Don't simply list related work without RELATING to your own work!
 - keywords to use: whereas, in contrast, but, however, ...
 - “excuses” to use: “does not require specs”, “focus on different problems”, “complement with each other”, ...
 - you can describe several similar related approaches together and compare them at once with yours

Background and Related Work cont.

- Don't make unjustified unobvious criticisms on related work if you don't have experimental results to back you up.
 - But you can cite others' experiments to back you up.
- Don't overclaim your work without justification
- Don't intentionally leave out your own very related previous papers (reviewers can find them out easily)
 - maybe even need to mention them in Introduction section and explain why the new work is different
 - reviewers often try to identify a marginal/incremental paper or a “least publishable unit (LPU)” (Google this term!)
- Put in PC members' work if relevant

Example

- A simple example
 - Include: where it comes from; a figure listing source code; brief description
 - Throughout the paper, it is important to have illustrating examples for those places that contain “dry” descriptions of your approach
 - If you use several examples throughout the paper, you may not need a separate Example section.
- Optional part of the section: high level description of applying your approach on the example
 - describe inputs/outputs of your approach without getting into too much detail
 - very important if the later approach description involves heavy hard-to-understand formalisms
 - see my ASE 04 Rostra and TACAS 05 Symstra papers

Approach or Framework

- Generalize your work in an abstraction level, e.g., positioning it as a framework rather than a tool
 - What you develop should be beyond your own implementation
 - Then you are in a better position when you discuss limitations of your work
 - Inherent limitation of the framework?
 - Or limitation of your current particular implementation of the framework?
[See my ASE journal 06 paper]
 - A workflow diagram is useful for explaining your framework
- Try to separate the ideas from (a particular) concrete implementation
 - But sometimes you have to mention it a bit and refer the readers to the implementation section.
- Explain some details with examples (even if you have illustrated your high level ideas in the example section)

Implementation

- What libraries you used in your tool
 - e.g., BCEL, Daikon frontend, Soot
- Detailed implementations of each step in your framework
- List complications of implementing a certain idea and how you get around them
 - if some complications are important and general, you may move them to the framework section.

Evaluation

- (Controlled) Experiment: good for tools that don't involve human interactions within the approach
experiment writing structure:
 - Hypotheses/Questions to be answered
 - Measures you use to answer these questions (higher better?)
 - Experiment setup: a good number of subjects, some scripts, some third-party tools or reimplemented tools for comparison
 - Independent variables+dependent variables -> metrics
 - Experimental results
 - Illustrate how to read your table/diagrams (columns, x/y axis, etc.)
 - Explain what does the curve or data mean, e.g., “We observed that ...”, “The experimental results show ...”
 - Summarize your findings, remember to get back to answer the hypotheses and questions; it is ok to have an undecisive or negative answer based on the experimental results
 - Optional: discussion subsection; or you can put it as a separate section
 - Sometimes you may not include cost (time/memory) in your experimental results but you need to at least discuss the analysis cost
 - Threats to validity: internal, external, and construct (see my TSE 05 paper)

Evaluation cont.

- Case studies, experiences, and examples are often good for
 - approaches with human involvements [experiments can also involve humans though]
 - approaches whose results are hard to quantify with numbers (see my ICFEM 05 paper)
 - approaches you don't have a good enough number of subjects for controlled experiments
- Case Studies
 - usually involve human subjects
 - often require careful preparation (tasks, questionnaires, interviews, etc.)
 - uncontrolled but just observe
 - lessons learned
- Experiences/Examples
 - anecdotes; maybe just you are the one who are involved
 - You may use some wordings such as “Developers can click ... to look for ...”

Evaluation cont.

- Some guidelines on doing/writing experiments
 - <http://www.acm.org/crossroads/xrds7-4/empirical.html>
 - <http://www-static.cc.gatech.edu/~harrold/8803/Classnotes/>
 - Notes of Weeks 18, 19, 20, and 21
- Some relevant papers/examples of doing/writing various types of evaluation
 - <http://www.cs.washington.edu/education/courses/590n/04sp/>
- Experiments vs. Case Studies
 - “Evaluating emerging software development technologies: lessons learned from assessing aspect-oriented programming” by Murphy et al. <http://ieeexplore.ieee.org/search/wrapper.jsp?arnumber=799936>
- A good book on case study research in general
 - “Case Study Research : Design and Methods” by Robert K. Yin
 - <http://www.amazon.com/gp/product/0761925538/104-9365607-2004707?v=glance&n=283155>

Discussion

- Limitations and issues your approach/implementation currently cannot address
 - Optional: how are you going to address them in future work
- Other caveats (scope of your approach)
- It is often a good idea to list (obvious) limitations and discuss possible solutions for them rather than hiding them
 - Reviewers can often identify obvious limitations even if you don't state them; then they will criticize your work on these limitations (you often don't have a rebuttal against these criticisms in conference reviews).
 - If your paper discusses these obvious limitations as well as their potential solutions, the situation can be alleviated (it is like you have a rebuttal in your paper already before being criticized!).
- Possible applications of your approach that you haven't validated but are convincingly feasible or effective.
- See my TACAS 05 Symstra paper

Conclusions (and Future Work)

- Often easy to write conclusions
 - nothing here should surprise readers; simply summarize your contributions and findings
 - In the introduction, “We propose a new approach ...”
vs. In the conclusions, “We have proposed a new approach ...”
- You can state the broader impacts of your approach
- You can optionally describe limitations here if you don’t have a discussion section for them and propose future work

More Readings

- <http://spoke.compose.cs.cmu.edu/ser04/course-info.htm>
- <http://www.cs.cmu.edu/~Compose/shaw-icse03.pdf>
- <http://www1.cs.columbia.edu/~kaiser/relatedwork.htm>
- <http://pag.csail.mit.edu/~mernst/advice/write-technical-paper.html>
- http://www-bsac.eecs.berkeley.edu/~muller/jmems.web/sds_editorial_june_2003.pdf
- <http://www.cs.berkeley.edu/%7Epatrsn/talks/writingtips.html>
- <http://www.csc.ncsu.edu/faculty/xie/advice.htm#writing>
- <http://www.csc.ncsu.edu/faculty/xie/adviceonresearch.html>
- <http://www.csc.ncsu.edu/faculty/xie/seconferences.htm>
- <http://www.csc.ncsu.edu/faculty/xie/publications/writingtools.html>

URL of the slides of this talk:

<http://www.csc.ncsu.edu/faculty/xie/publications/writepapers.pdf>