How to Write a CS Paper

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Overview

• A lecture on how to write CS research papers
• A systematic approach—a recipe, a formula, an algorithm
Motivation

• Writing a paper is difficult
  – Complex topic
  – New results

• Paper writing rarely taught explicitly in graduate school
  – Learned by reading papers
  – Learned through painful trial and error
Misconceptions about paper writing

• "Writing a paper takes a couple of hours"
  – No. It takes an experienced writer a week w/ sleep and 36h w/o sleep to write a paper.

• "Writing a paper takes literary talent"
  – No. Keep poetry and metaphors out of the paper.

• "Writing a paper is a mysterious, amorphous process"
  – No. There is a method for writing papers.

• "English proofreading services can fix a poorly written paper"
  – No. English proofreading fixes language problems, not exposition problems.
When to start writing

• Option 1: once you have proof of concept
  – Pro: plenty of time available for writing
  – Con: not all results available, writing has to anticipate results, writing cannot accurately emphasize strengths demonstrated in results
  – Recommended for conference submissions, and for novice writers
  – Might require a second writing pass (i.e. a major revision) to fine tune paper to final results
When to start writing

• Option 2: once all results are obtained
  – Pro: writing reflects results with high fidelity, including in abstract and in introduction
  – Con: little time available for writing, due to imminent (conference) deadline
  – Recommended for conference submissions for experienced writers, and for journal submissions (no hard deadline)
  – *Warning*: can lead to submission delays
Formatting

• Use template provided by targeted venue
  – Word
  – LaTex

• Format from the beginning
  – Accurate estimate of paper length
  – Avoids formatting nightmares close to the deadline
Tell a story

• A well written paper tells a story
• The story has to
  – flow from the “introduction” section all the way to the “conclusions and future work” section
  – be easy to read
  – be exciting
  – clearly state contributions
  – not overstate contributions
  – provide sufficient detail for reproducibility
  – not follow the work timeline proportionally
Tell a story

• The story has to
  – reiterate important points (title, abstract, introduction, method, and conclusions) without being repetitive
  – be consistent, no contradictions
  – contain no ambiguities; no “would”, “could”, “should”, “might”; everything described outside the future work section should have been actually implemented; no speculations
Figures

• Whenever something is hard to describe, use a figure (i.e. diagram, image, graph)

• Have enough figures, with detailed captions
  – Someone looking only at figures should get the main idea of the paper

• Figures should be of very high quality
  – Use professional software, e.g. Visio
  – Be prepared to invest time (multiple hours, revisions)
  – Start with canvas of final size
  – 8pt font in the final paper layout (no scaling)
Philosophy

• Your method is assumed to be bad until you prove that it is good
• Your paper is assumed to be rejected until you prove it has to be accepted
• It is not enough to not provide good reasons for the paper to be rejected
• You have to provide good reasons for the paper to be accepted
Paper components

- Title
- Authors list
- Abstract
- Keywords
- Introduction
- Prior work
- Method overview
- Method details 1
- Method details 2
- ...
Title

• Important
  – First thing a reader sees
  – Together with abstract and keywords used to decide reviewers

• Desired qualities
  – Informative
  – Accurate
  – Not too long
  – Catchy, easy to remember, impressive

• Formatting
  – Capitalize every word except for prepositions
  – “Reflected-Scene Impostors for Realistic Reflections at Interactive Rates”
Title architecture

• Most frequently
  – Nickname: New-Thing for What
    • “The WarpEngine: An Architecture for the Post-Polygonal Age”
    • “GEARS: A General and Efficient Algorithm for Rendering Shadows”
  – New-Thing for What
    • “Simplification of Node Position Data for Interactive Visualization of Dynamic Datasets”
    • “Reflected-Scene Impostors for Realistic Reflections at Interactive Rates”
  – What by (using) New-Thing
    • “CAD Visualization by Outsourcing”
Title architecture

• New-Thing
  – A new paradigm; radically new approach to solving a problem or set of problems
  – “Forward Rasterization”
  – “Camera Model Design”

• What
  – A breakthrough: finally a solution to a long standing problem
  – “Efficient Large-Scale Acquisition of Building Interiors”
Authors list

• Typically sorted on contribution
  – Rarely done alphabetically (in our field)
• First author should
  – Understand all the work reported in paper
  – Be able to present the paper
  – Know how every aspect of the method works
• Collaborators to include
  – Anyone who has contributed a significant idea
  – This leaves out those whose contribution is exclusively in the implementation, in making figures, or in collecting data (they go in acknowledgment section)
Abstract

• The longer type of abstract
  – Two paragraphs
  – First paragraph
    • Problem
    • Problem importance
    • Why problem is difficult
    • Limitations of state of the art
  – Second paragraph
    • Brief description of method contributed by paper
    • Method scope (i.e. input for which it works, assumptions)
    • Brief description of method evaluation
    • Results highlights
Abstract

• The shorter type of abstract
  – Just the second paragraph of the longer type
    • Brief description of method contributed by paper
    • Method scope (i.e. input for which it works, assumptions)
    • Brief description of method evaluation
    • Results highlights
Abstract

• Length of abstract is usually regulated
• Abstracts are expected to be dense
  – Start from something twice as long and condense
  – Tip: you could write the introduction first and then condense that into an abstract
Keywords

• Used to determine reviewers
• Used for readers to find your paper in future
• Some conferences / organizations (e.g. ACM) provide list to choose from
  – Choose carefully
  – Add your own if at all possible
• Sort based on generality
  – Usually ascending order
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Introduction

- The **most important** part of the paper
  - Often the only part of the paper a reader/reviewer will read closely from beginning to end
  - Many reviewers decide on acceptance by the end of the introduction and use the other sections as a source of evidence for their decision
  - Be prepared to spend a long time writing it (one day) and revising the introduction (throughout the writing process)
Introduction formula

• Five plus two paragraphs
• Together with title, teaser figure, author list, keywords, abstract should cover at most the first two pages of paper.
• Paragraph 1
  – Problem
  – Problem importance
Introduction formula

• Paragraph 2
  – Why is problem hard?
  – Summary of prior work approaches and of their shortcomings
    • OK to have references
    • I prefer not to have references
      – Ask reader/reviewer to extend their trust until prior work section where all prior work claims are backed up with references
      – This allows reader/reviewer to focus on story
Introduction formula

• Paragraph 3
  – Details on shortcomings of prior art that take similar approach as taken by present paper
  – What are the problems that need to be solved, for the approach to succeed?
  – This should lead to insight that created method described in current paper. Clearly understanding the problem, in detail, leads to inspiration, to good idea.
Introduction formula

• Paragraph 4
  – Introduce method presented by paper
  – Start with “insight”, “inspiration”, “key observation”
  – No implementation details, just high level ideas and concepts used
Introduction formula

• Paragraph 5
  – Summary of examples where method was tested
  – Summary of results
  – If you have an accompanying video, mention it explicitly—otherwise reviewers might miss the video!
Introduction formula

• Paragraph 6 (optional)
  – List of contributions
  – At least two, at most three, bullets recommended
  – Simplifies reviewer’s job finding the contributions (they are asked by the review form to list contributions)
  – Well written paragraphs 4 and 5 could make this paragraph unnecessary
  – Reviewers could be annoyed by the list of contributions
    • contributions of a well written strong paper are self-evident
    • explicit list of contributions can be interpreted as an attempt to manipulate reviewers
Introduction formula

• Paragraph 7 (optional)
  – Paper organization (list section titles and what each section does)
  – More useful when there are multiple “method details” section (i.e. longer papers)
  – Usually omitted for shorter papers
Prior work

• One of the most boring sections to a reader
  – Typically very poorly written

• Prior work section should be
  – Well organized
  – Comprehensive
  – Relevant to paper at hand
  – Fair
Prior work

• Convince reviewers that are expert in the area that you too are an expert in the area
• Help reviewers outside the area catch up on the state of the art
• Nothing worse than a poorly written prior work section
  – No knowledge of prior work
  – No understanding of prior work
  – No good delimitation of the contributions of the current paper
Annotated bibliography

• You write a little bit of the prior work section every time you read a paper
  – Collect an annotated bibliography
  – For every paper you read
    • Collect the citation
    • Write a summary paragraph
    • Write a strengths paragraph
    • Write a weaknesses/limitations paragraph
  – The annotated bibliography will be an invaluable help when writing prior work sections, your thesis, etc.
• Start from recent major conferences and venues
• Take one step back (i.e. look at their references)
• Take several steps back for the most relevant work
Prior work

• Organize prior work section on approaches
  – Define each approach
  – Cite early, recent, and best known paper for each approach
  – For each paper cited write a sentence
    • On what it does
    • Another one on what it excels at
    • And another one on its shortcomings

• End approach discussion with summary of strengths and weaknesses
  – If your paper takes different approach, contrast approaches
  – If your paper takes same approach, contrast your method with other methods in the approach
  – Devote more space to the approach to which your method belongs
Prior work

• Do not reuse prior work from other papers
  – Prior work section should be designed and detailed for the present paper

• Prior work section should be about one page
  – You never lose points for too many references
  – You can lose points if references are not enough
  – However, the total length of the paper has to be commensurate to contribution
  – Prior work can be condensed
  – Do not use a reference as a noun
    • “[2] describes a method”, “same approach as in [2]” are incorrect
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- Conclusions and future work
- Acknowledgments
- References
- Appendices
- Video
Overview

• Gives a high-level view of your entire method
• Use a diagram
  – Blocks for the various stages of your method
  – Arrows indicating the data flow
  – Label arrows with the type of data
• Use a pseudocode description of the main steps of your algorithm
• Each stage or step is later described in a section
  – Refer to the future section
Overview

• Gives reviewers essential help
  – Reviewers volunteer their time
  – You are responsible for making their job as easy as possible
  – Do not expect reviewers to spend hours and hours trying to make sense of your poorly written paper
  – Reviewers will simply say in the review: “I tried but I could not understand the paper, and I am an expert in the area; what chances does a regular reader have?”
Method details k

• These sections are the easiest ones to write
  – It’s your work, it’s what you did, you know it all too well
  – You love what you did, and you can’t wait to tell people about it

• Level of detail
  – Sufficient for a skilled graduate student to reproduce your work
  – Not overly verbose—concise and to the point
  – No innovation should be left unexplained
  – No simple implementation details should be provided
Method details k

• Use references when you use an existing tool
  – Make sure you explain what the algorithm/tool does
  – OK to summarize (in one sentence) how the tool does it to make paper self contained

• Use figures

• Use present tense
Method details k

• Remember, do not use “can, could, should, would”
  – Nothing worse than giving the reviewer an uneasy feeling that some of the work described is only proposed and that it was not actually done

• Do not overuse “very”, “highly”, they end up weakening what is claimed
  – E.g. “very accurate” is less accurate than “accurate”
Method details k

• Double-blind review
  – You cannot disclose your identity
  – OK to reference your prior work
  – Use third person
    • “they did this and that” not “we did this and that”
  – Do not include 10 references to your work
    • It will amount to a blatant disclosure of your identity
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Results and discussion

• You talked the talk, now you walk the walk

• Everything you promised has to be substantiated by results
  – High quality should be supported by high quality
  – Interactive rates should be supported by interactive rates
  – Overcoming shortcomings of prior art should be supported by a favorable comparison to prior art
  – Any discrepancy substantially weakens the paper
Results

• First paragraphs
  – Describe applications and scenes where you tested your method
  – Describe machines on which you collected timing information

• Subsection 1: quality
• Subsection 2: performance
• Subsection 3: comparison to prior art
• Subsection 4: limitations
Results and discussion: quality

• Provide evidence as to how well your method works
• If your method resorts to approximation, resort to truth
Results and discussion: performance

• Measure performance accurately
  – Relevant data sets

• Measure performance thoroughly
  – Identify parameters affecting performance and measure performance for various values
  – Discuss numbers obtained; discuss best and worst cases
  – When appropriate derive asymptotic cost of your method

• Show performance with graphs and tables
Results and discussion: performance

• Give some information on implementation
  – High level, do not give boring details
  – Get into details only if you did something very clever that brought a lot of performance gain

• Remember
  – Paper does not cover linearly the work you put in
  – Things that took months to implement might not even be mentioned
Results and discussion: comparison to prior art

• Try to find implementations of most prominent prior art methods
  – It saves you having to implement them
  – It brings more credibility to the comparison
  – Ask authors if they are willing to share their code

• Show quality and performance differences
  – Conduct a thorough analysis
  – Do not avoid cases where your method doesn’t do so well
  – Performance analysis for same quality
  – Quality analysis for same performance

• Discuss the comparison
  – Explain the differences
  – Explain the tradeoffs—e.g. more speed, less quality
Results and discussion: limitations

• Reviewers have to list the limitations of your method
• A strong paper is expected to self-report its limitations
• Fundamental limitations, which you might inherit from the general “approach” taken, and say so
• Limitations specific to your method, explain what you gain for those limitations, i.e. the tradeoff
• Be unapologetic—your method works for some types of input, and it’s OK that for some it does not
• Explain how some limitations might be removed through future work
Conclusions and future work

- Closing arguments in defense of your paper
  - Closing statement. The last time you talk to reviewers
  - Remind them how good your paper is
- State one more time very succinctly what the method does
  - Emphasize the strengths
  - Emphasize the difference to prior art
- Summarize the comparison to prior art one more time
Conclusions and future work

• Sketch directions for future work
  – Short term fixes and extensions were already mentioned in the limitations subsection
  – Do not make it sound like “paper is incomplete, but accept the paper please, and we promise we will do all these things”
  – Think big and think far into the future
    • Big improvements
    • Applications of method to new contexts
Acknowledgments

• Withheld for double-blind reviews
• Acknowledge all who helped, in decreasing order of contribution
• Acknowledge your group
• Acknowledge your sponsors
References

• Format well
• Do not include references not used in paper
• Include all references used in paper
• Sort according to instructions (appearance, alphabetically)
Appendices

• Put in an appendix text that is not essential to the exposition
  – Proofs
  – Additional results tables
  – Comments from users
  – Questionnaire used in user study

• Do not put in an appendix anything that you want to make sure a reviewer reads
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Video

- Typical but not unique to graphics papers
- A lot of additional work
- It can take as long as writing the paper
- Video and paper need to be consistent
  - Emphasis
  - Method description
  - Result illustration
- Title, introduction, and results of paper on one hand and video on the other hand are strongly interdependent
Video

• Length
  – At most five minutes
  – Some conferences have limits, usually 5min
  – Reviewers lose patience
  – 5min are enough to make your point
Short video

• Video components
  – Best results
Medium video

• Video components
  – Split-screen two-way comparison between method and prior art
  – Or, split-screen two-way comparison between method and truth
  – Additional examples of method
Long video

• Video components
  – Limitations of prior art
  – Preview of best results
  – Illustration of proposed method
  – Split-screen two-way comparison between method and prior art
  – Split-screen two-way comparison between method and truth
  – Or Split-screen three-way comparison between prior art, method, and truth
  – Additional examples
  – Conclusion
Video

• It’s not an action movie!
  – Camera should move very slowly, and even slower in the case of split screens
  – The sequences should be as long as possible
  – Go back and forth several times to make important points
  – Put a red box around an important detail you want to make sure the viewer sees

• For real-time methods include a real-time sequence
  – Side by side comparisons should be done from stills for perfect synch
Video

• Audio voice over is essential
  – Video is difficult to understand without audio
  – Use audio to guide the viewer’s attention to the most important qualities of your method
  – Audio has to be well synchronized to video
    • Mentioning a concept should slightly precede the visual illustration of the concept
  – Audio script should be well aligned with paper introduction, results, and conclusions
Thank you

• Good luck with paper writing
• If this lecture was helpful, acknowledge me in your paper!