

# How to Write a Visualization Research Paper: A Starting Point

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### Abstract

*This paper attempts to explain the mechanics of writing a research paper in visualization. This serves as a useful starting point for those who have never written a research paper before or have very little previous experience. After all, no one is born knowing how to write one. And yet, there are certain elements, a commonality, that should be found in virtually all good visualization research papers. We give our recommendations as to each section a good research paper consists of as well as what each section contains. This paper itself follows our recommended structure.*

*We believe that paper writing should start with the abstract. The abstract can be approximately 6–12 sentences. It is a difficult starting point, but it forces the author to write down a concise description of what they are researching and what the benefits are. Chances are, if the author cannot start out by writing an abstract, then it is not clear in the author's mind what the paper should be about. Of course, the abstract will be refined and updated during the paper writing process. The abstract should concisely (1) identify the research topic, (2) describe the novelty of the presented work and (3) identify the benefits and advantages that result.*

**Keywords:** visualization research paper, writing methodology

**ACM CCS:** K.3.2 [Computer and Information Science Education]: Computer Science Education

### 1. Introduction (Motivation)

*'Give a man a fish; you have fed him for today. Teach a man to fish; and you have fed him for a lifetime.'*—Lao Tzu (Chinese proverb).

This quote summarizes the idea behind this paper. It strives to serve as a fishing rod, or at least partially, for those new to writing research papers. These brief guidelines are meant to serve as a starting point to those (most likely students) writing a research paper for the first time. The idea was inspired by some new PhD candidate students studying visual computing and preparing their first research paper(s). Writing a good visualization research paper is difficult, yet, students are given this task with little or no instruction. We felt a strong need to at least provide the student with some written guidelines to start with, which, to the best of our knowledge, do not exist.

Here, we go through section-by-section, those components that we believe a good research paper, in general, contains. We give general informal guidelines on the contents of each section as well. We describe the *Introduction* (Section 1), *Related Work* (Section 2), *Method* (Section 3), *Implementation* (Section 5), *Results* (Section 6), *Conclusions and Future Work* (Section 8) and *Acknowledgements* (Section 9), sections. We also provide recommendations on paper titles (Section 1), temporal planning (Section 1), literature searching (Section 2), collaborations (Section 2), diagrams and figures, images (Section 3.5), enhancements (Section 4), application papers (Section 7), performance analysis (Section 6.2), movies (Section 6.3), supplementary material (Section 6.3), proofreading (Section 9.1) and references (Section 9.2). Several citations to examples are provided for reference. We keep in mind that these topics are rather subjective and our discussion of each topic is driven by experience. The result

# Introduction (Motivation)

“Give a man a fish. You have fed him for today. Teach a man to fish, and you have fed him for a lifetime.”—Lao Tzu

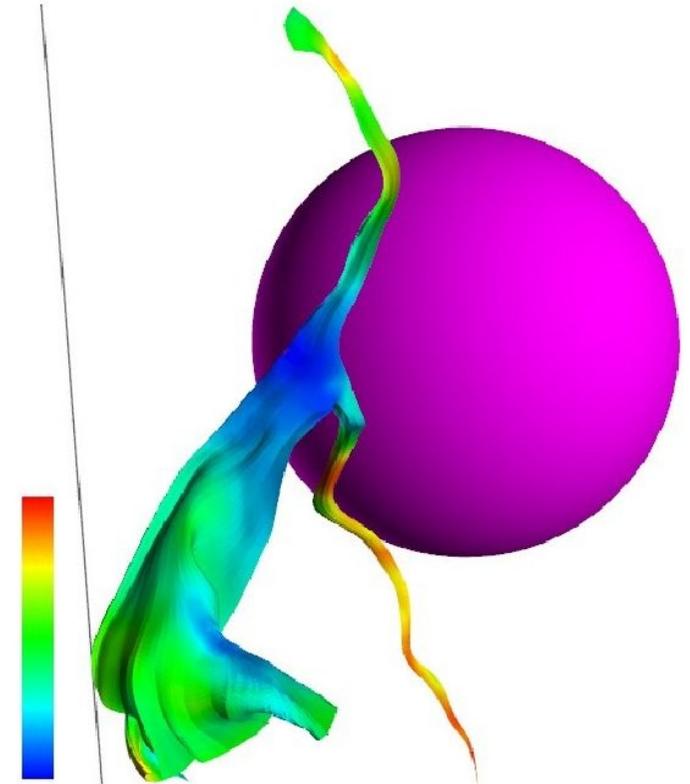
(Chinese proverb).

- Meant to serve as a **starting point** for those new to writing research papers
- Writing papers is a difficult task, but we still demand it. Guidelines and instructions are generally absent (for visualization)
- No substitute for experience or an advisor
- We go section-by-section



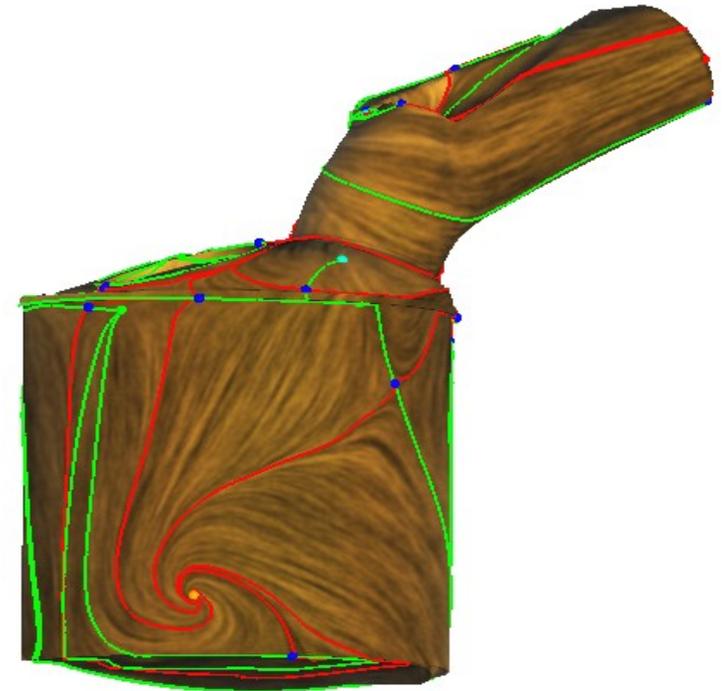
# Overview

- Abstract
- Introduction
  - Paper titles,
  - Temporal planning
  - LaTeX
- Related Work
  - Literature searching
  - Collaborations
- Method
  - Method Overview
  - Stage  $N$
  - Parameters
  - Figures and images
- Enhancements



# Overview (Continued)

- Implementation
- Results and Performance
  - Results
  - Performance Analysis
  - Movies and Supplementary Material
- Application Papers
- Conclusions and Future Work
- Acknowledgements
- On Proof Reading
- References
- Citations to examples are provided throughout



# Abstract

- Writing starts with Abstract
- 6-12 sentences (recall: rough guideline)
- ✓ Identify research topic
- ✓ Describe novelty of work
- ✓ Identify benefits and advantages
- Sample Abstract given

# Introduction (Motivation)

- Introduction Section should really be called “Motivation”
- “What is this research topic good for?”
- Novelty, benefits, and advantages of research is described.
- A bulleted list of contributions is given including words like, “novelty”, “contribute”, and “advantageous”
- Mention challenges
- Wrap up with paper summary
- Example Introduction given

# Introduction and Contributions

Each contribution and each benefit that reading paper provides is identified explicitly in a bulleted list. Possible points to mention include:

- Does presented algorithm(s) provide novel visualization of some sort? That is, images never before seen.
- Does presented work provide new interaction techniques not previously published?
- Does technique described result in faster performance times than previous algorithms and if so why?
- Does approach provide new insight in some way?
- Does work take advantage of the graphics card hardware in some way? For example, using texture-mapping hardware, or hardware-accelerated interpolation?
- What are contributions, precisely, of this paper? What does reader potentially gain from this paper?

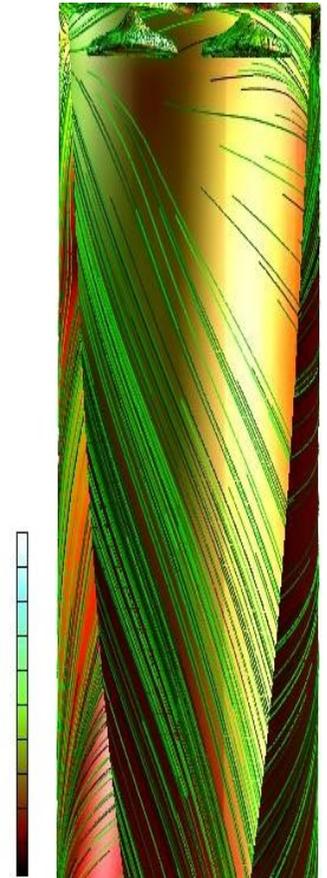
# On Paper Titles, Temporal Planning, and LaTeX

- **Titles:** Paper titles need to be both descriptive *and* concise (three words theory)
  - Can be resolved using the **title:subtitle** combination
  - **Temporal Planning:** Two months (minimum) are needed to write high quality transcript (recall: for beginners)
  - **LaTeX** produces high quality, publishable output
  - Closest software to a standard

# Related Work

- A defining characteristic of a research paper
- Choosing scope can be difficult
- Each paper described ~2-3 sentences
- Differences with current work need to be clear
- Subjectivity involved -can influence choice of reviewers
- Use names not just numbers, e.g. Jobard et al. [1]
- Sample Related Work Section provided

Most previous literature for *this* paper focuses on negative



# On the Literature Search and Collaborations

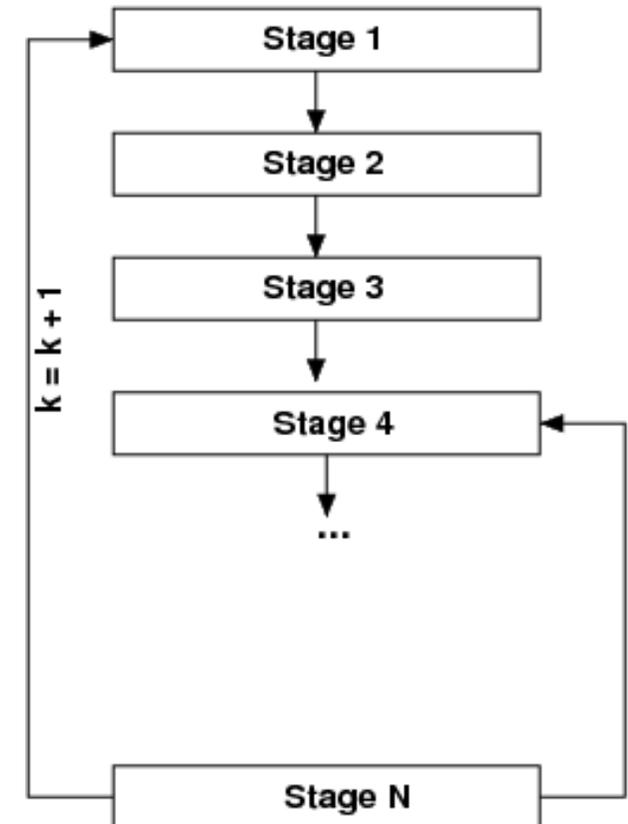
- Basic literature search consists of browsing last 10 years of the IEEE Visualization/InfoVis and EuroVis (formally VisSym) Conference Proceedings
- More papers will be found in the References section of those papers
- Don't forget to look for State-of-the-Art (STAR) reports in Eurographics and ACM Computing Surveys
- Observe the number of papers on the topic
- Collaborations can help fill gaps in knowledge

# Method (or Computational Model)

- Main focus of paper
- Presents an idealized model or process by which algorithm or system works
- Contains enough detail such that results can be reproduced
- Starts with an Overview Section
- Examples are cited

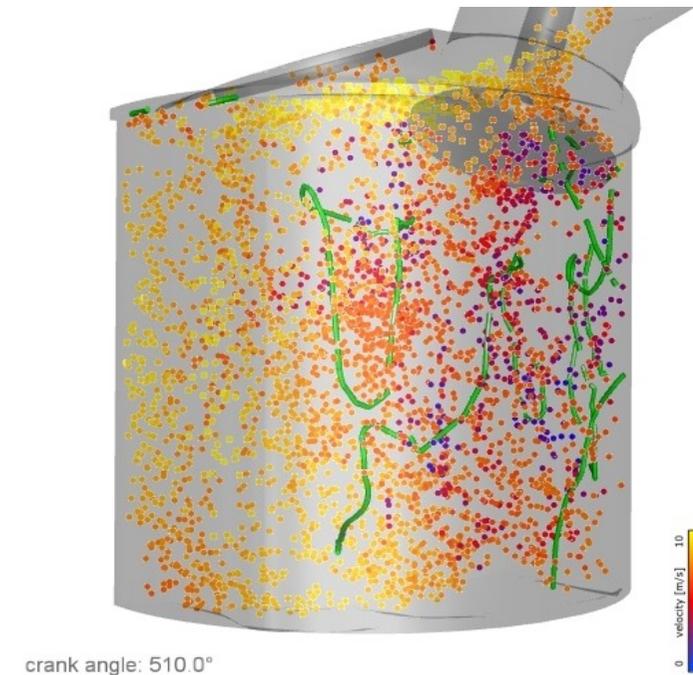
# Method: Method Overview

- Method section starts with Method Overview Subsection
- Overview contains overview diagram or illustration
- Overview diagram depicts ideal conceptual model (as opposed to implementation)
- Method Section follows a divide-and-conquer approach: one sub-section per component in the overview diagram
- References to good examples given



# Parameters, Figures, and Images

- New algorithms and systems introduce new parameters, e.g., threshold values, alpha values, special distances, min. and max. values
  - Identify and discuss these new parameters, illustrate the range a values
  - Figures + Captions are ***self-contained***
  - Readers and reviewers often *start with* figures and images
  - Images that show a *new* visualization are very good
  - Pedagogic figures are good
  - Xfig and Inkscape are two open-source packages for good figure drawing



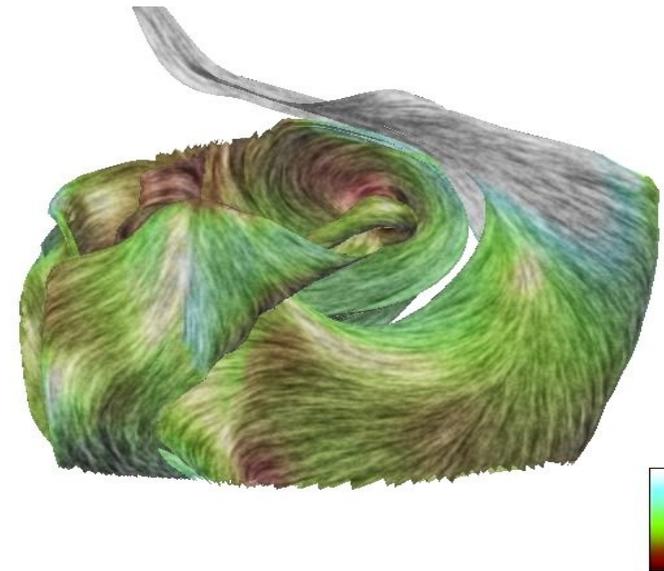
# Enhancements (or Extensions)

- An Enhancements section may follow the Method section
- Often describes things that can be done to improve or extend the output of the basic algorithm
- Usually optional, but add a polish to existing work
- **Implementation** Section is optional and describes implementation details of model
- Describes aspects of model that are *unexpected*
- Sometimes implementation details are integrated into Method sub-sections
- Pseudo-code is a nice way to describe implementation



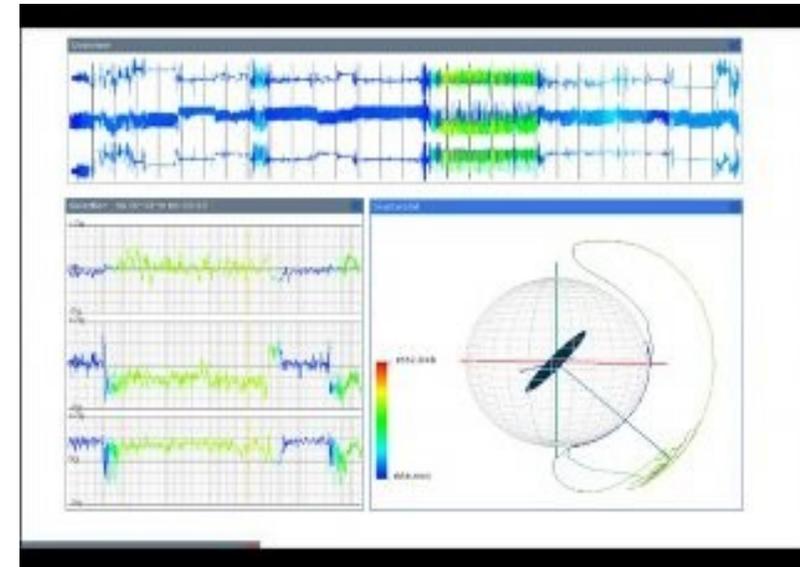
# Results and Performance

- Results and Performance Analysis can be separate or together
- Results show nicest images being applied to both synthetic and real-world data sets
- Don't forget to include a description of the data sets, e.g., size, resolution, grid, dimensionality, attributes etc.
- Performance analysis often show a trade-off between accuracy and speed or memory and speed
- A good performance analysis also shows limits of algorithm
- References given to examples



# Application Papers

- Present contribution of visualization technique(s) to understanding of application-specific data
  - Introduction Section is similar
  - Related Work Section is similar-may include domain-specific literature
  - May contain additional Background Section
  - Contains Visualizations Section rather than a Method Section
  - Compares traditional visualizations with modern ones
  - Contains Domain Expert Review Section.
  - Conclusions and Future Work are similar



# Movies and Supplementary Material

- Generally strengthen paper submission
- Communicate time-dependent aspects of work, e.g., interaction
- May give impression that work is polished
- May communicate *more results* than paper alone
- Nice way to demonstrate algorithm parameters discussed in method section
- We recommend MPEG format for platform-independence

# Movies and Supplementary Material

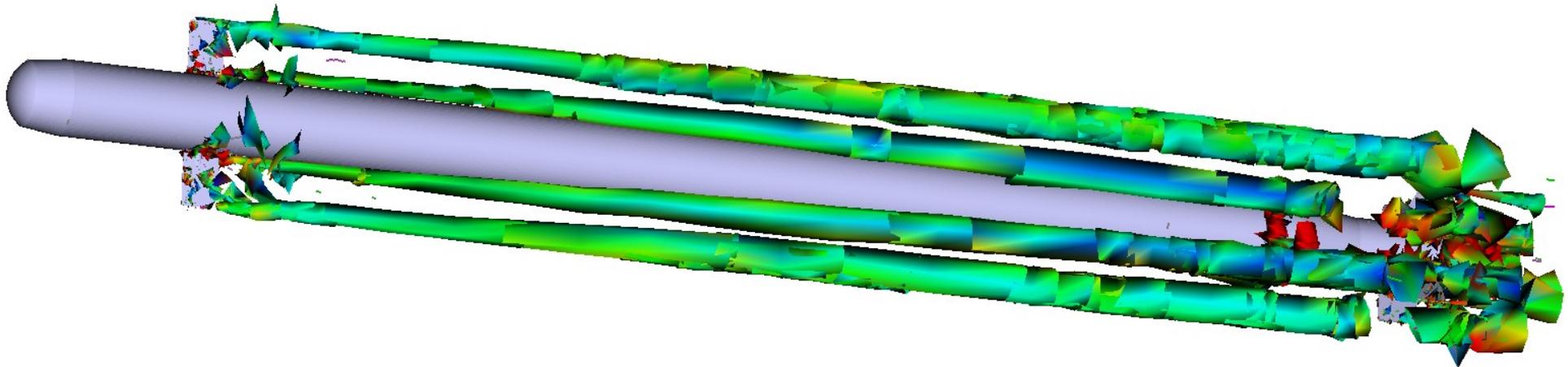
- Add user-option that automatically re-sizes screen, e.g., 512x512 resolution, and saves each frame to a JPEG file
- Still images are used as input to a movie editing program, e.g., Adobe Premiere or Video Mach
- If no supplementary material is accepted by submission system, a URL may be provided
- Don't forget to check file size limits before submission
- (Show sample movie.)

# Conclusions, Future Work, and Acknowledgements

- Conclusions summarizes paper and re-emphasize the novelty, benefits, and advantages of presented work
- Future work is usually kept short to save space
- Example Conclusion and Future Work Section given
- Acknowledgements thank funding agencies involved
- Acknowledgements can also be used to thank contributors or potential reviewers
- Sample Acknowledgements Section given

# On Proof Reading

- Ideally, paper is proof read by a new reader before submission
- References are complete and carefully proof read
- Some reviewers start with the references
- Many references ( $\sim 37$ ) are provided



# Acknowledgements

- Thank you for your attention! Any questions?

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- Benjamin Spencer, Edward Grundy, Eugene Zhang, R Daniel Bergeron, Helwig Hauser, and Colin Ware, and all other co-authors
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- Or please visit:

<http://cs.swan.ac.uk/~csbob>

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