COSC2148/2149/2150 Research Methods

Technical Writing

James Harland

james.harland@rmit.edu.au

(based on materials by Justin Zobel)

Overview

- What is a scientific paper?
- Why write a scientific paper?
- How to write a scientific paper?
- Bad Examples
- Tips

What is a Scientific Paper?

- Position statement in an ongoing debate about properties of the universe
- Framework for reasoned arguments and supporting evidence
- Incremental addition to scientific knowledge

The role of writing in science is to

- Define concepts, start debate
- Provide basis for common understanding
- Clearly describe elements of research: hypotheses, experiments, proofs.

Why write a scientific paper? (1)

Communicate new ideas

- State basic concepts
- Explain ideas
- Describe and justify hypotheses
- Critical history (not a catalogue) of the area
- Compare and contrast with work of others
- Broad results
- Implications

Why write a scientific paper? (2)

Present outcomes of research

- Define fundamentals
- State the hypothesis
- Describe experimental method and results structure
- Show results and proofs
- Critically analyse outcomes
- State corollaries and ramifications

(Keep but don't publish: code, output, logs, notebooks ...)

Combining these aims

- Explain and justify the idea
- Show ***enough*** results (but no more)
- Focus effort on communication
- Observe ethical constraints
- Subjective investigation, objective report
- Establish priority

Content

Clear statement of new knowledge

Reader needs to

- Understand the main result
- Know what makes it useful, new, distinct
- Reproduce experiments
- Have proof of claims and theorems

Do this and no more!

(Consider only what the reader needs, not what you feel like saying)

Reader doesn't need ...

- Opinion presented as fact, unsupported claims ("Java is clearly superior to C++")
- Essays ("The Web is a vast social experiment made possible by technological developments and economic development ... ")
- Discussion of dead ends and ideas that didn't work (unless they illustrate something)
- Jokes, amusing pictures, etc.
- Material not relevant to the topic
- Complaints ("My supervisor didn't tell me I should ... ")

Organisation

Hierarchical, not linear, for different readers:

- Not interested – discard quickly
- Curious – want main idea
- In general area – want results
- In specific area – must understand detail

Many papers written for the last class only!

Components (not necessarily headings): abstract, introduction, survey, main body, summary, bibliography, appendices

Front matter

Title, authors, maybe supervisors, affiliation, addresses, date.

Abstract:

- 50-200 words
- Concide, precise, specific
- Statement of main aim and result
- Self-contained, written in accessible language
- No references

Introduction

Include:

- Description of the area and topic
- Hypothesis
- Results and outcomes
- Ramifications

Exclude:

- Evidence
- Detail
- Jargon

Survey

Relate new work to published results

- Knowledge on which new work builds
- Knowledge that new work extends or corrects

If early in the paper:

- Sets scene, contrast with new results that come later

If late in the paper:

- Can show other results in your notation, making comparisons easier

Main Body

Sections should contain a single clear thread of ideas

Include:

- Definitions
- Algorithms
- Description of test data
- Experimental method
- Summaries of experimental results
- Theorems & proofs
- Analysis of results

Main Body

Exclude unnecessary detail:

- Too many graphs
- Uninteresting data
- Secondary or trivial proofs
- Programs and code

Project logs can be used to record information not kept in the paper

Main Body

Create a story-like flow

Discuss results as they are presented (don't separate results and discussion)

Consider how concepts will be developed:

- Chain: describe previous solutions and then new one
- Hierarchy: overview first, then details
- Example: start with a typical case to illustrate
- Complexity: start with a simple case, then a more complex one

Summary and/or conclusions

- Main results – draw themes together
- Implications of results
- Limitations of results
- Avenues for further research

Acknowledge sources of funding and sources of feedback (if not done earlier)

Back matter

Bibliography:

- List of articles referred to in the paper
- Only refer to relevant papers that **you have read**
- Provide sufficient detail for the reader to find it

Appendices:

- Details of proofs of secondary results
- Detailed experimental results
- Code (if brief and exemplary) for tricky algorithms

Most papers don't need appendices

Writing a paper

Sketch out the paper: section headings, lists of points in each section, lists of references

Carefully define the basics

Describe algorithms, experiments, results

Write survey

Fill in holes

Write conclusions.

Write introduction & abstract.

Revise, revise, revise, revise, revise, revise, revise, ...

Edit for flow, layout and style.

Writing a paper

Write uncritically. Brainstorm. Don't get frozen – keep writing, even if you have to delete it later

Don't worry about formatting until later on.

Revise **critically**

"I used to think about my sentences before writing them down; but ... I have found that it saves time to scribble ... whole pages as quickly as I possibly can... Sentences thus scribbled down are often better ones than I could have written deliberately"

- Charles Darwin

Why define carefully?

Eliminate ambiguity

A clear problem statement ensures that you have a common basis of understanding with your supervisor

Make explicit:

- What is proposed
- How it will be evaluated
- What the argument (thread of reasoning) will be

Getting started

Choose a well-written paper that presents a similar kind of idea or result, then imitate its structure

Criticise the structure first. For example

- Is the ordering reasonable (of sections and within sections)?
- Are the sections linked together?
- Where is the survey?
- Is there a non-technical introduction?

Making Progress

- Start writing early (allow at least 1/6 of project time to write up)
- Set aside blocks of time
- Carry your work with you (mentally and physically!)
- Set yourself problems, reexamine them between other tasks, keep the concepts active
- Don't expect steady progress, but do keep chipping away
- Adjust your commitments in response to progress

Writing can help research

The process of writing can show where more work is needed:

- Definition of basics: find concepts are not clear
- Abstract description of an algorithm: can see an optimisation
- Complexity analysis: difficult proof needed
- Graph of results: need more experiments or code

Write critical sections while there is ample time to do more research

Bad Example 1

From an Australian company's functional specification for a database system:

"Development of these linkages is likely to be further down the timeline than the implementation of the main system in the near future. The system should be developed with the end users clearly in view. The system must therefore run the gamut from simplicity to sophistication, robustness to flexibility, all in the context of the individual user. From the first tentative familiarisation steps, the consultation process has been used to refine the requirements by continued scrutiny and rigourous analysis until, by some alchemical process, those needs have been transmuted into specifications. The aim of these specifications is to distill the quintessence of the existing system."

Bad Example 2

From an honours report:

"Grep is no doubt simple, but inevitably slow, especially if all the documents are to be matched. Further the regular expressions used to specify the string pattern desired can be a hurdle! Worst still when just about everything that might go wrong for the day, and Alas! you are presented with a list of maybe 25 matching documents."

Bad Example 3

From a paper:

"Query languages have changed over the years. For the first database systems there were no query languages and records were retrieved with programs. Before then data was kept in filing cabinets and indexes were printed on paper. Records were retrieved by getting them from the cabinets and queries were verbal, which led to many mistakes being made. Such mistakes are impossible with new query languages like QIL."

Bad Example 4

From a paper:

"We have already seen, in our consideration of *what is,* that the usual simplified assumptions lead inexorably to a representation that is desirable, because a solution is always desirable; but repugnant, because it is false. And we have presented *what should be,* assumptions whose nature is not susceptible to easy analysis, but are the only tenable alternative to ignorance (absence of solution) or a false model (an incorrect solution). Our choice is then Hobson's choice, to make do with what material we have – viable assumptions – and to discover whether the intractable can be teased into a useful form."

Bad Example 5

"It was a dark and stormy night; the rain fell in torrents--except at occasional intervals, when it was checked by a violent gust of wind which swept up the streets (for it is in London that our scene lies), rattling along the housetops, and fiercely agitating the scanty flame of the lamps that struggled against the darkness."

--Edward George Bulwer-Lytton, Paul Clifford (1830)

http://www.bulwer-lytton.com/

Problem Areas

Economy, vigour, clarity, ambiguity.

- Unnecessary text & words, long words, waffle
- Purpose of text is not thought out, or text is obselete
- Inadequate revision
- Informality

Qualification

- Claims without qualification "users demand" -> "users may want"
- Excessive caution: "might somehow be possible"
- Double negatives: "Not necessarily unaffected"

Problem Areas

Pomposity, supposedly "scientific" writing

- "The execution of the algorithm is such that it completes in an unusually short space of time"
- "The algorithm is fast"

Lack of examples.

Background too brief

- All assumptions should be made explicit
- Many writers expect far too much of their readers

Problem Areas

Jargon, notation

- Technical terminology is needed for discussion of technical concepts
- Technical terminology excludes less informed readers
- Dense technical writing is hard to read

Lack of consistency

- Notation, mathematics, terminology
- Layout, format
- Captions, figures, tables

Problem Areas

Poor motivation, flow, organisation

- Explain the purpose, value, importance of each element (section, theorem, algorithm, definition)
- Link adjacent material so that it flows

Sloppy titles

- Choose the right keywords
- Should be short but informative

Ragged sentences

- Simple structure, single topic
- Thoroughly revised.

Hypotheses and tests

- Construct an explicit hypothesis – state clearly what you are testing
- Provide an intuitive explanation
- Propose in detail a methodology for testing the hypothesis
  - Use proof, modelling, simulation or experiment, or any of these elements in combination
  - Aim to convince the reader – use a persuasive form of test
  - A model is not equivalent to an experiment
- Interpret the results for the reader

Hypotheses and tests

Experiments should be reproducable and reliable

- Describe the data
- Describe the testbed
- Explain the parameters

Take observations: gather material to clarify your ideas

Make tests: independently verify the correctness of the ideas.

Keep records: software used, data used (or its location), experiments tried.

Conclusion

- Keep it simple
- Sketch and brainstorm first
- Outline section by section, with a list of contents
- Fill in holes and refine
- Revise, revise, revise, revise, revise, and revise some more!
- Get supervisor/s and colleagues to read drafts
- Allow plenty of time