An Introduction to Research and Research Papers

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Why?

Writing (and research) will be a big part of your professional life

- Most people in your field will know you from your writing (and presentations)
- Papers are one of your ‘products’
  - Research papers, White papers, Internal reports, Product ideas, Grants

Good ideas can be lost if poorly presented

Research and Writing can be easier/faster/more effective if done well
What is a research paper?

A clear, concise description of an experiment (or project):

- What you did
- Why you did it
- What it means
- Why it's important
Basic Questions

Who can submit a research paper?
- Anyone (subject to your major professor’s approval)

How hard is it?
- Very and not all
Publication Process
(Subject to your Major Professor!)

- Journals and conferences have (fairly) clearly defined styles and guidelines
- Submit the paper – usually electronically
- Editor assigns 3-5 reviewers
  - Wait
- Based on the reviews editor decides: accept, reject, revise
- You get to see the reviews
- Plan to revise and resubmit
Process

- Read lots of papers
- Get an idea
- Read more papers to see if it’s a “good” idea
- Formulate a hypothesis
- Design an experiment
- Conduct the experiment
- Write up the experiment
- Submit – revise – resubmit - repeat
Reading Papers

- Title – what’s the paper about?
- Authors – do I know them?
- Keywords – what’s the paper really about?
- Abstract – what’s the paper really about?
- Introduction or results or conclusions (in some order)
- Methods or background (in some order)

Read critically
Write on the paper
Ideas and Hypotheses

Ideas can be vague – “Hey, a divide and conquer approach should work better on this problem.”

Hypotheses are precise and testable – “This specific divide and conquer algorithm should find a solution for this particular (class of) problem and will never take more time than the currently used approach.”

A clear, well defined hypothesis makes everything else easier.

(A clear, well defined problem makes everything else easier.)
Hypothesis and Experiments

“We study various properties of this graph [linked internet sites] including its diameter, degree distributions, connected components, and macroscopic structure.”

Testable?

“We hypothesize that the power law relationship will hold for considerably larger web crawls, thereby confirming it as a basic web property.”

Testable?
A useful experiment is based on a defined hypothesis.

Algorithm A will find a solution at least twice as fast as Algorithm B for problems with these well defined characteristics.

Be careful about definitions and assumptions

- Speed is measured by ...
- Memory use is the same
- The computer is running Windows 7

...
Hypotheses and Experiments

How do you create an experiment to test your hypothesis?

Know what positive results and negative results will look like in advance.
Hypothesis and Experiments

Our approach: linear, but worse initially

Expected results 1

Avg. Measure

Problem Size

Control

Our approach: linear, but worse initially
Hypothesis and Experiments

Expected results 2

Control

Our approach: Same curve, but lower constant

Avg. Measure

Problem Size
What is a research paper?

A clear, concise description of an experiment (or project):
- What you did
- Why you did it
- What it means
- Why it's important

If the hypothesis and experiment are both well defined the paper should be “easy” to write.
Parts of a Paper

- Abstract
- Introduction
- (Background)
- Methods
- Results
- (Discussion)
- Conclusion
Abstract

Abstract (Summary)
- Broad topic/impact
- Practical impact and narrower topic
- What was done
- Results
- (Impact)
Abstract

Work and results should be precise, refutable

- Avoid
  - “We study ...”
  - “We examine ...”
  - “We tried X and it works.” Works?

- Use
  - “We show ...”
  - “We implemented X under the following conditions ... The results show that X has 10% fewer errors...”
Introduction (and Background)

Context

- Broad context – why is this research important
- Narrow context – what has already been done, what is already known
- Why is this research necessary / What is the open question or open problem
  (Hint: this is what you are answering/solving)
Introduction/Background

What others have done

What hasn’t been done

What should be done ("Thus, although X has been shown, Y has not been shown.") “Robots ... could then be used to [do Y]”

What we did (show Y) “... study that makes the first steps towards [doing Y]”
Methods

- Provide clear overview
- Provide replicable details
Results

- Mostly in the figures (or tables)
- Long captions – figures almost stand alone
- Present relevant results
- Present the results that you promised in the methods section
- Tell the reader what they should learn.
  - What does the data show – be exact
  - What does the data mean
Results

Present relevant results.

Present the results that you promised in the methods section.

Tell the reader what they should learn.

What does the data show – be exact

What does it mean
Discussion/Conclusion

- **Summary:** “These results show ...”
- **Emphasize contribution:** “... we introduced ...”
- **Future work:** “This work could be extended to ...”
- **Inspiring last words:** I.e. Impact
Conclusions

What you found/what it means
- Emphasize key results

Should match abstract and introduction
- Same conclusions as in abstract and introduction

Should match goals
- E.g. should address the hypothesis(es) or questions
General Writing

Explain everything to the reader

- Why the topic is interesting
- What has been done
- What hasn’t been done
- What you did
- What you found
- Why its important
General Writing - Clarity

Language - Be **precise**
- Avoid jargon (as appropriate)
- Use definitions where necessary – avoid too many *new* definitions
- Be careful with abbreviations

English – Be **concise**
- Active sentences
- Simple Sentences
The algorithm is slow. *How slow?*

This algorithm has a high computational complexity. *How high?*

Large instances of the problem are computationally infeasible. *What is large? What is infeasible?*

The results show that algorithm A is better than algorithm B. *Better meaning what? Faster? Uses less memory? More accurate? Easier to understand? Easier to use?*

First, the objects are sorted. *Sorted by what? Size?*
General Writing - Structure

Broad and general to narrow and specific

- In the whole paper
- In sections
- In paragraphs

Autonomous cars can’t handle winter driving conditions

The LIDAR used by autonomous cars can’t identify black ice on highways
General Writing - Flow

The reader should usually know what’s coming next – the paper should flow

- Sentence to sentence
- Paragraph to paragraph
- Section to section

Flow

- Topics – the reader should know when and why you are changing topics
- Ideas – the reader should know when and why you are introducing a new idea
“Currently the leading theory regarding the cause of code growth in GP is that inviable code protects against the destructive effects of crossover.”

What’s the rest of the paragraph?

“However, the support for the protective hypothesis does not mean that protection from destructive operations is the only cause of code growth.”

What’s the rest of the paragraph? What was in the previous paragraph?
Summary

Reading
- Read a lot
- Doesn’t have to be beginning to end
- Be critical!

Research
- Have a well defined hypothesis or problem

Writing
- Be precise and concise
- Broad to narrow and flow
- Remember that you are explaining your research to the readers (and reviewers)
Thank You

Questions?
Summary

Research

- Have a hypothesis/goal
  - Clear significance
  - Well defined
  - Clear assumptions
  - Clear limits
- Are your tests the right tests?
- What are the results?
Summary

Writing

- Precise and concise
  - Every sentence, figure, table, and reference should have a specific role in explaining your research
- Think about the readers and reviewers
  - Tell the what they need to know
  - Use structure, headings, etc. to help reader

Clarity

- Good flow from idea to idea