What is Research? (Talk II)

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Outline of Talk I

- Why research?

- What is research?

- Where do good ideas come from?

- The process of research

- Richard Hamming on research ("*You and Your Research*")

Outline of Talk II

- How to write a good research paper

- So you want to do Ph.D.?

Disclaimers

- Suggestions from an idealistic view point

- Does not provide information about the formal procedures or rules of Ph.D.

Writing A Good Research Paper

So You Want to Write A Good Paper?

- The goal of a paper is not merely to report the outcome

- Writing good papers is important for your research

  - For your understanding and shaping your ideas
  - For communicating your ideas to others
  - For getting feedback from others

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A paper you would be proud of even after a decade or so!

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  - *Private knowledge dies an untimely death*
  - *Knowledge made public lives on*

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Why Should You Care About Good Writing?

A paper is a mirror of your ideas

"You don't know something unless you know how to express it"

- Writing helps you understand your ideas better

- Writing helps you refine your ideas:
  Write, read, revise. Repeat as long as you can

- Writing is a creative process and a big source of satisfaction

Our Focus

- Significant distinction between

    ▶ How to write a good paper?

    ▶ How does a good paper look like?

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- Assumptions:

    ▶ Process is goal oriented. Once goals are clear, process is clear

    ▶ Repeat: Write, read, review, refine, revise . . .

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- Candid confession by PC members:

    "Most papers are rejected not because they do not have interesting ideas but because they are ill-structured".

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- A software?

- Design of a software?

- A piece of hardware?

- A theorem?

- A proof?

- Empirical measurements?

- . . .

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A research paper describes an idea!

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- Cannot be a complete description of work
  (process/product/modelling/reasoning/postulate/evidence)
  Must omit many details

- Should describe a logically complete idea
  Or a collection of logically complete related ideas

- Must embody a running theme that forms the essence of an idea

- This theme must be explicated in the paper

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Right choice of form and content is important

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How to read a paper?

Ingredients of Good Research

- Innovation

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- Aesthetics

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- Other important aspects :

  - Completeness
  - Rigour
  - Empirical demonstration
  - Effective communication

Ingredients of Good Survey

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    - Why are they important?

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- Have you distilled the essence of key ideas?

    ▶ Why are they important?

    ▶ Why should they be considered key ideas?

- Have you illustrated key ideas?

    ▶ New examples

    ▶ New pictures

    ▶ New applications

    ▶ Better explanations

Form Vs. Content in a Good Paper

- Good contents rides a good form

- Impossible to convey good content without using good form

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    ▶ Right structure of the paper

Form Vs. Content in a Good Paper

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  - ▸ Focus (or "the" theme) of the paper   Difficult to explain
    Too many details are as bad as too little details
    Identify the right level of abstraction to present the ideas

  - ▸ The right mix of intuition and rigour   We discuss this

  - ▸ Right structure of the paper   Our main focus

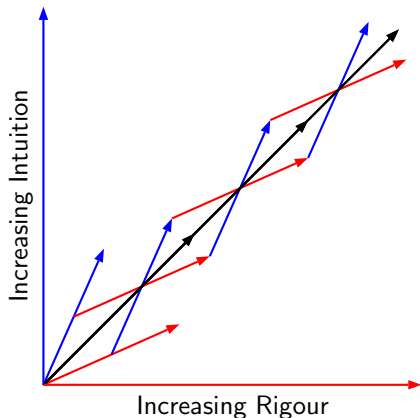## Intuition and Rigour in a Paper

- Ideas should be presented at two levels:

  ▶ Intuition
    The key idea

    - Distilling the idea to its essence
    - Emphasizing the most important aspects (ignoring some details)
    - Using representative examples (even if all aspects are not illustrated)

  ▶ Rigour
    Ensuring that there is no possibility of a different interpretation

    - Plugging all the holes through formalism or reasoning
      (Corner cases, boundary conditions, exceptions)
    - Presenting convincing empirical evidence

- Description of ideas at these two levels should be interleaved

Intuition and Rigour in a Paper

- Intuition gives hints about formalism

  Allow us to create and understand the right formalism

- Rigour establishes the correctness of the intuition

  Allows us to plug the holes and generalize the ideas

- Intuition and rigour should balance and lift each other

Credit: John Denker
(http://www.av8n.com/physics/thinking.htm#advice-paper)

Presenting Evolution of Ideas

- Evolution in discovery is different from evolution in presentation

- Evolution in presentation

    - Perspective

    - Problem Definition

    - Key Ideas

    - Key contributions

    - Development of the key ideas

    - Experiments/Measurements/Results

    - Conclusions

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    Honest analysis of work done, The Moral of the story

The Structure of a Paper

- Title

- Abstract

- Introduction, Motivation

- Background, Related work

- Main Contents

- Results, Conclusions

- Future Work

- References

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  - Wireless networks
  - Partial redundancy elimination in presence of critical edges for practical imperative programs with recursion and large number of functions and calls through function pointers

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- Possible good titles

    - A software based control system for . . .
    - On XYZ theorem
    - Reducing congestion in wireless networks
    - Partial redundancy elimination in extreme situations

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  - ▶ Reading the rest of the paper should not be necessary to get the gist
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- Must contain a statement that catches attention

Common mistakes in Abstracts

- Too verbose

- Too long

- Too short

- Omitting essential details

- No statement that interests a reader

How About this Abstract?

"We worked in Computer Science. We proved some theorems. Some were big, some were small. Big theorems had big proof, small theorems had small proofs. We tried to connect the proofs to the theorems. Sometimes we succeeded, sometimes we didn't. By then, the time for submission had arrived, so we submitted the paper ..."

M. Leunen and R. Lipton. "*How to Have Your Abstract Rejected*".

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  - Significance of the outcome,
  - Intellectual challenge, other difficulties
    Why would simple approaches not work?

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- Last chance of making the reader want to read your paper in details

How to Describe Background and Related Work?

- Not just what? but also why?, why not?, how?, how else? etc.

  - Not just a list of summaries
  - Analysis, comparison, strengths, limitations

- Organized by ideas rather than by references

Main Contents

- Answer important questions
  - ▶ Questions: Problem, Theorem, . . .
  - ▶ Answers: Algorithm/Protocol/Formulation/Proof/Counter example

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- Describe experiments, measurements

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  - Revised Statement: σ_1 is a prefix of σ_2.

How to Write Conclusions?

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- Represents the moral of the story

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      Last chance to highlight importance
    - Analysis of strength and limitations
    - What the readers should remember after they have forgotten the details

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- Brings back the general level

    ▶ Abstract $\rightarrow$ Introduction $\rightarrow$ Details: Journey from general to specific
    ▶ Details $\rightarrow$ Conclusions: Return journey from specific to general

How to Write References?

- Reference or Bibliography?
    - ▶ References: List of sources that you actually cite in your paper
    - ▶ Bibliography: List of all related publications

- Each item in the list must have at least the following fields:
  Title, Author(s), Journal/Proceedings, Publisher, Year

- URLs don't have a publication date, hence say when accessed it last

- Follow the style specified by the publisher

Elements of Writing

- Be careful about the language: Grammar, sentence formations, spellings, punctuation etc.

- Each paragraph should represent a specific idea

- Smooth transition from
    - One paragraph to the next
    - One sentence to the next

Plenty of help available on Internet ☺

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  ▸ Composition balances the indirection levels of the pivot so that it can be eliminated and the remaining two nodes can be connected to create a new edge.

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Writing a Good Sentence (2)

- Avoid pronouns with multiple antecedents

  Take the books from the shelves and dust them with a clean cloth.

  Dust what? Books or shelves?

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  - multiple double arrow edges
    multiple edges with double arrows

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    We decided to approximate the values for efficiency based on the
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  - The labels a and b are associated with nodes l and r respectively, in each case, and are computed as follows.
    In each case, the labels a and b are associated with nodes l and r respectively, and are computed as follows.

Good Writing is an Art

- Rules are not absolute

- Break rules if you must, but understand why it is necessary

- How to be a good writer? Read a lot

    ▶ Best resource: "Elements of Style" by Strunk and White

    ▶ Plenty of help available on Internet ☺

A Checklist: Idea and Lessons

- Are the ideas in the paper new? How do you know?

- Can you state the new ideas concisely?

- What exactly is the problem being solved?

- Are the ideas significant enough to justify a paper?

- Is the work described significantly different from the related work?

- Are comparisons with previous work clear and explicit?

- What is the oldest paper you referenced? The newest?

- What have you learnt from the work?

- What should the reader learn from the paper?

- How generally applicable are these lessons?

Credit: Levin and Redell

A Checklist: Choices and Context

- What were the alternatives at various points? Why were particular choices made?

- Did the choices turn out to be right? Could some other choices have been better?

- What are the assumptions on which the work is based? Are they realistic?

- How sensitive is the work of minor variations in these assumptions?

- If a model is presented, does it give new insights?

Credit: Levin and Redell

A Checklist: Focus and Presentation

- Does the introductory material contain almost everything that is required to understand the paper?

- Does the introductory material contain anything extra that is not required?

- Are the ideas organized and presented in a clear and logical manner?

- Are terms defined before they are used?

- Are forward references kept to a minimum?

- Have alternative organizations been considered?

- Does the abstract convey important ideas?

- Does the conclusion contain lessons learnt?

Credit: Levin and Redell

A Checklist: Writing Style

- Is the writing style clear and concise?

- Are words spelt and used correctly?

- Are the sentences complete and grammatically correct?

- Does each paragraph represent a well identified idea?

Credit: Levin and Redell

The Final Advise

- After you have done all of the above,

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- Analyse dispassionately why reviewers could not see your view point

Part 2

So You Want to Do Ph.D.?

Outline

- Specific questions and dilemmas about Ph.D.

- Based on actual questions asked by audience in past

On the Role of Ph.D. in Teaching

Q Is Ph.D. necessary for teaching?

On the Role of Ph.D. in Teaching

Q Is Ph.D. necessary for teaching?

A Ph.D. is not a degree, Ph.D. is a state of mind

A state in which

- one does not feel threatened by the unknown
- one derives immense satisfaction in a journey from known to unknown
- one may depend on others for questions, but not necessarily for answers

A Ph.D. is attainment of a certain level of maturity of ones mental faculties

A Ph.D. enhances quick self learning abilities

A Ph.D. makes a person a much better learner

On Financial Prospects After Ph.D.

Q Why is there so much of a difference between salaries in academia and in the industry? Isn't it unfair?

On Financial Prospects After Ph.D.

Q Why is there so much of a difference between salaries in academia and in the industry? Isn't it unfair?

A The product $\mathrm{SALARY} \times \mathrm{FREEDOM}$ is constant

A If you want nearly infinite freedom, you will get nearly zero salary

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A It is for you to decide where you want to be on the spectrum

On Deciding a Research Area

Q Should I do research in the knowledge domain that I am familiar with or should I work in a "hot" area?

On Deciding a Research Area

Q Should I do research in the knowledge domain that I am familiar with or should I work in a "hot" area?

A In general it is easier to work in an area in which you have

- ► a good background and good insights
- ► personal interest

A What matters is the group with which you work. Having people with whom you can discuss your work is a very big advantage.

A Expertise of your guide is an important consideration.

On Deciding Ph.D. Topic

Q Once the research area is finalized, how should one identify specific
research problems?

On Deciding Ph.D. Topic

Q Once the research area is finalized, how should one identify specific research problems?

A Read research papers in well known journals. Be selective about conference proceedings. Try to find scope for improvement in the papers you read.

A Attend good conferences. Talk to people.

A Interact with known researchers working in that area. Visit their web pages, contact them over email. Ask them what they are working on and why.

On Deciding Ph.D. Topic

Q How should one identify and select National/International conferences? Is there any ranking of conferences?

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A CORE ranking (www.core.edu.au) is a good starting point. Ask the people who are active in that area.

A Read past proceedings. If proceedings are not published, forget about the conference.

A Find out if the conference has a reasonable review process.

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A Read past proceedings. If proceedings are not published, forget about the conference.

A Find out if the conference has a reasonable review process.

Q How to do literature survey on the finalized area of interest? Are there any thumb rules or guidelines for selecting number of papers for literature survey?

A Read research papers in relevant journals/conferences of repute.

A There is no thumb rule for number of papers.

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A Research is like finding a black cat in the night in a dark room with no lights

   And that cat doesn't meow!

   Further, there may be no cat!

On Deciding Ph.D. Topic

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A In general, it is preferable to let the problem definition evolve over time. Some times the problem may turn out to be much harder than anticipated while some times it might be too easy.

A Begin with a tentative problem. It is best to let the scope and the depth emerge naturally as one's study matures.

A Interacting with an active group, asking for sub-problems that could contribute to the research goals of the group is a big help.

On Deciding Ph.D. Topic

A common mistake:
Fixing a problem and then seeking guidance for Ph.D. on that problem.

On Deciding Ph.D. Topic

A common mistake:
Fixing a problem and then seeking guidance for Ph.D. on that problem.

Fixing a problem only shows your initiative and abilities. However:

- your perception of relevance or significance of the problem may be flawed.

- If your problem fits into a broader research agenda, there are better prospects.

- Prospective guides have their own research agendas and are busy. Your problem must be very very attractive for them to deviate from their existing commitments.

On Deciding Ph.D. Topic

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A Find out someone who is actively working in that area. Find out from others how well is she/he known in the area.

A Find out someone who can give a lot of time to you.

A Find out someone with whom you are very comfortable.

On the Process of Ph.D.

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  proof of concept? How does one create it?

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A Proof of concept refers to a demonstration of the validity, meaningfulness, or usefulness of an idea. It could be in terms of an implementation, a conceptual reasoning, or a design of a solution.

A Ph.D. begins with questions, proof of concept tries to validate possible answers. So it comes somewhere in the middle (or even at the end) of a Ph.D.

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A Requirements spring up in the course of discovery. It is very hard to specify requirements a priori. Some broad and general requirements may be easy to visualize at the start.

A Ph.D. is a game of ideas. It is not a game of technology. Even an experimental Ph.D. begins with a speculation.

What is common to all Ph.D.'s is a cycle of:

> *Speculate, design, apply/perform experiment,*
> *observe, interpret, infer and repeat.*

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On the Process of Ph.D.

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Q When can I conclude that my Ph.D. is over?

A When you find that after you give talks on your work, people feel you have done something interesting.

On the Process of Ph.D.

Q What are the common problems all Ph.D. students face?

On the Process of Ph.D.

Q What are the common problems all Ph.D. students face?

A Difficulty in dealing with uncertainty.

A Keeping up motivation.

A Dealing with disappointments.

A Realizing the importance (or unimportance) of particular
  ideas/developments.

> *Common problems across most human pursuits!*

Last But Not the Least

Thank You!

Last But Not the Least

Thank You!

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