

# How to do good research?

YU Haifeng

<http://www.comp.nus.edu.sg/~yuhf>

# Disclaimer

- Different people can have different views on research methodology
- Most of such differences are due to differences in research areas
- What I will describe are more applicable to my research area

# How to do good research?

- Over 800 million search results on google...
  - A lot of good suggestions
  - But these are often **corollaries** from things that are more fundamental
- Here I instead focus more on **axioms**
  - Analogy: What is the most effective way to learn mathematics?

## **15 Steps to Good Research**

<http://www.library.georgetown.edu/tutorials/research-guides/15-steps>

1. “Define and articulate a research question”...
2. “Identify possible sources of information in many types and formats”...
3. “Judge the scope of the project”...
4. “Re-evaluate the research question”...
5. ....

# Axiom #1: Research creates new knowledge

Corollary: It thus follows that you need to show

1. **What** is the new knowledge you intend to create? (articulate a research problem)
2. Why this is **new** knowledge instead of existing knowledge? (literature survey)
3. Why this has not been done before (remember it is hard to prove non-existence)?
4. Why this is new **knowledge** instead of belief/superstition/guesswork (showing the correctness)?

New knowledge  
created by your  
research



what mankind  
already knows

## Axiom #2:

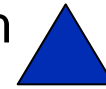
# Good research creates good new knowledge

What is good new knowledge –

**Quantity and quality**

- Large amount
  - It does not matter how much you know, it matters how much you create
- Strong results (10x improvement)
- Generality
  - Especially for algorithm problems (e.g., travelling salesman problem)
- Solves a long-standing problem

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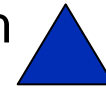
## Axiom #2:

# Good research creates good new knowledge

What is good new knowledge – **Utility**

- Useful in practice
  - Cure cancer
- Useful to help future research
  - Lower bounds
  - Unifying theory (P, NP)
  - Foundational work
- New approaches
  - Can be used to create other new knowledge (Yao's lemma for randomized algorithms)

New knowledge  
created by your  
research

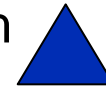


what mankind  
already knows

# Axiom #3: Research involves intellectual challenge

- Anything that can be **easily (in an intellectual sense) inferred** is not considered research
  - E.g., Mechanically applying existing approaches
  - E.g., Applying existing approaches to a different context without much modification/adaptation
  - E.g., Combining multiple existing orthogonal approaches

New knowledge  
created by your  
research



what can be easily inferred based on what mankind already knows

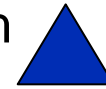
**Example: Solving a randomly generated system of linear equations**

# Axiom #3: Research involves intellectual challenge

Hence need to show

1. Why your new knowledge involves intellectual challenge (i.e., sufficient distance from existing knowledge)
2. Why you are the one overcoming this intellectual challenge
  - First one to try
  - Has unique insight
  - Rely on recent advances

New knowledge  
created by your  
research



what can be easily inferred based on what mankind already knows

**Example: Solving a randomly generated system of linear equations**



# Summary of Axioms

- Research creates **new knowledge**
- Good research creates **good new knowledge**
- Research involves **intellectual challenge**

How to do good research?

You just need to create good new knowledge that involves intellectual challenge.

# How to write a good research paper?

- Axiom: **Your paper should show that you create good new knowledge that involves intellectual challenge.**
- Corollaries:
  - Papers usually have a literature survey
  - Papers usually have either proofs or experimental results
  - Papers usually focus on the novel aspects of the design, instead of all aspects of the design
  - Papers often spend a lot of time motivating the problem – explaining why the new knowledge is useful
  - Papers often explain why the work is non-trivial (i.e., intellectual challenge)
- You want to remember the axiom and forgot all these corollaries...