Research Skills:

From Area Selection to Paper Presentation

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Declaration

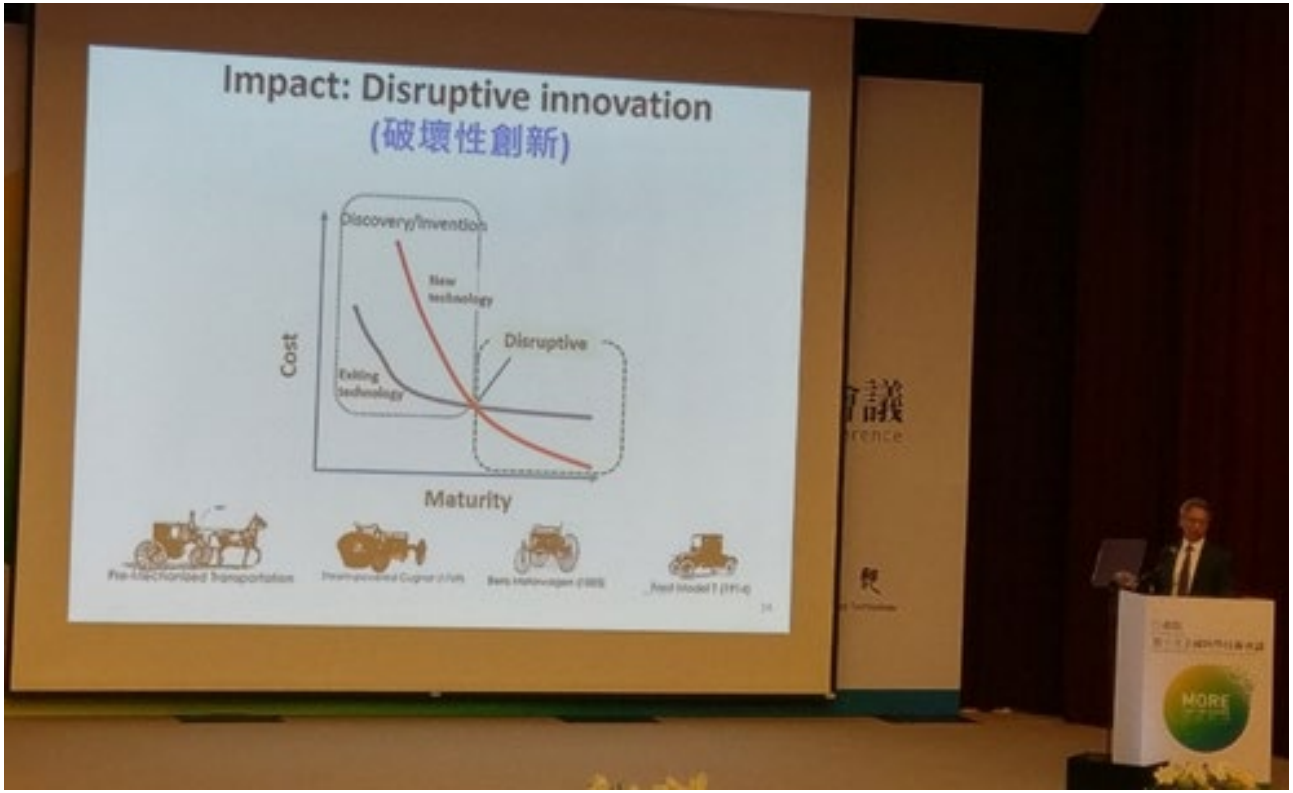
- 以下言論均來至世界知名學者，不代表本人立場。
- 以下言論的轉述，可能因本人的理解力而有所失真。

Outline

- What is research?
- Research skills
  - Pick a research area
  - Identify a research problem
  - Solve the problem
  - Write a paper
  - Submit to a conference
  - Give a presentation
- Conclusion

Why Research?

- 普 (ㄆㄨㄢˇ) 世 (ㄕˋ) 價 (ㄐㄧㄚˋ) 值 (ㄓˊ)
  - To improve human civilization



  - Why papers? Share findings with the community

What is Research?

- Research is a **re**peat **search** process to know unknown.

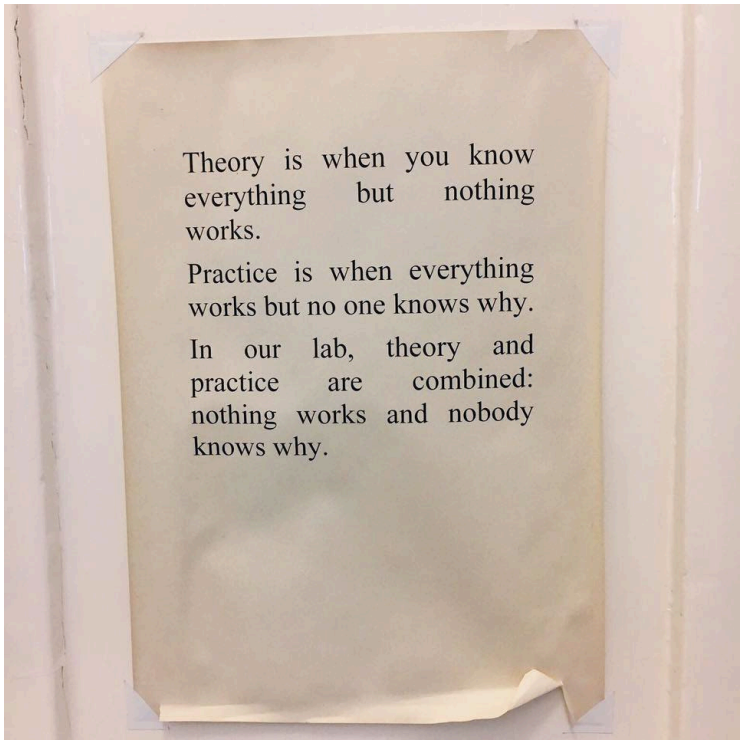
– Lui Sha

Quest for fundamental understanding? \ Considerations of use?	No	Yes
Yes	Pure basic research (Bohr)	Use-inspired basic research (Pasteur)
No		Pure applied research (Edison)

Research Types: Practice vs. Theory

- The best theory is inspired by practice, and the best practice is inspired by theory.

  - Donald E. Knuth



Researcher Styles

– Tarek Abdelzaher

- Biographer
  - What has been done in the past decades? Archive it!
- Salesman
  - I have an idea to sell. What's the market segment where it can make the most impact?
- Consultant
  - Focus on problem P from company X. How do I solve P?
- Matchmaker
  - Idea A in field X is a really good match to problem B in field Y. Apply A to B.
- Journalist
  - Is this an interesting topic today? Create a new direction.

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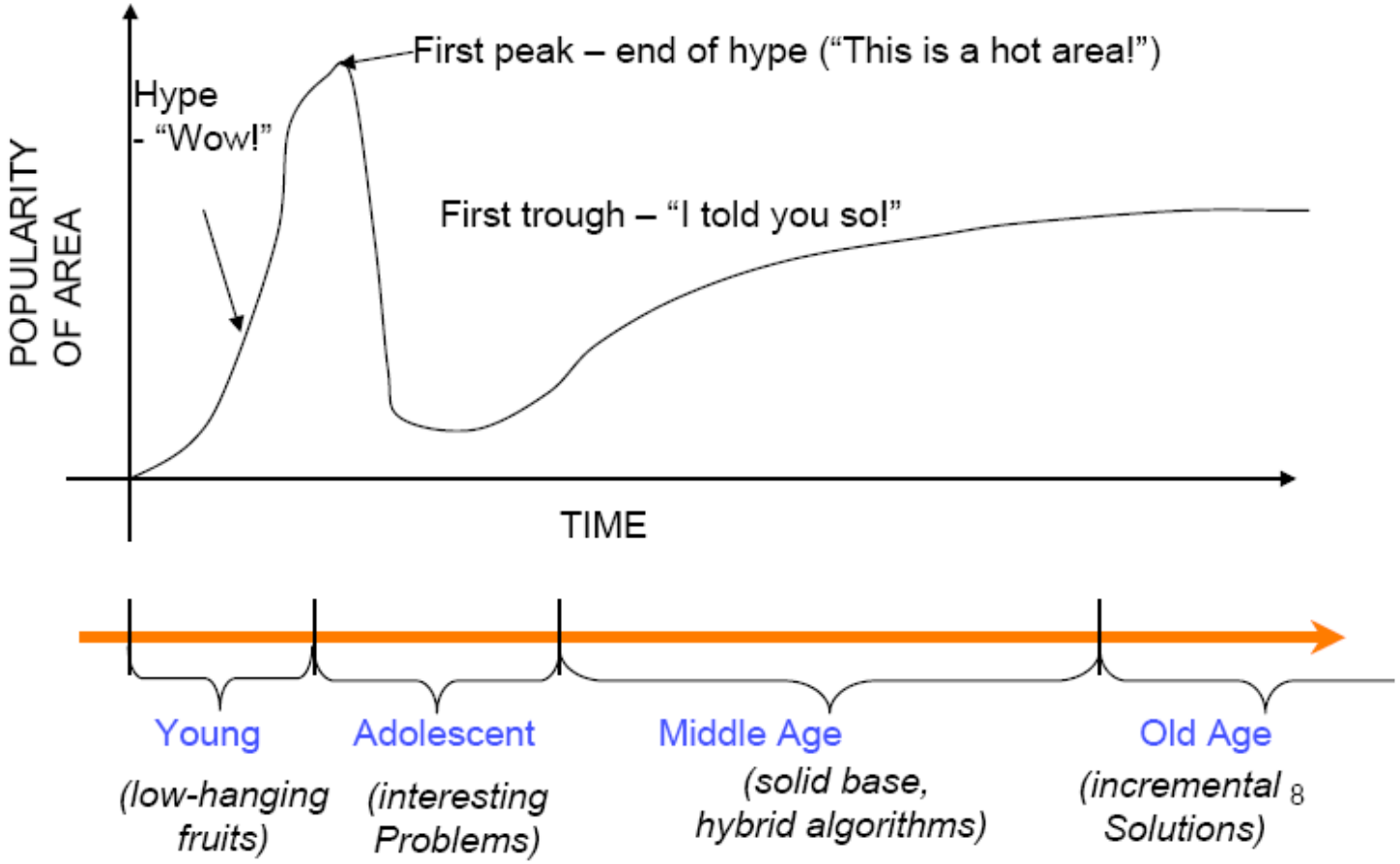
Life of Ra (a Research Area)

– Indranil Gupta



Key to Finding Your Research Area

- Match your interest/passion (theory vs. system)
  - But don't limit yourself within your comfortable zone
- Talk with other people and get feedback
  - But have you own insights
- Read best papers on top conferences
  - But do not always be a follower
- Study broadly
  - But be sure you know what the field is really about

國家實驗室 vs. 另一所大學

- YN Huang

- Bell Labs: Unix, 電晶體, 行動通訊, 衛星, 雷射

- 什麼研究是適合中研院做的?
  - Philosophy: 論文很重要, 但篇數不重要!

(1) High Risk, High Impact 的題目 (e.g., 黑洞計畫)
  - 一個團隊共同完成, 產生一篇論文, 因為沒有學位問題

(2) 團隊成員的組成 (e.g, 後量子密碼NIST標準)
  - 人數不用多, 但具研究經驗, 吸引外籍專家

(3) 經費來源支持前瞻基礎研究 (e.g., 固碳技術)
  - 關鍵突破/主題/深耕/前瞻計畫, 不要求短期商用化

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The Tough Part in Research

- Finding a problem is 90% of the problem.

- P. R. Kumar

  - Open problems (e.g., P = NP?)
    - What is solvable?
  - Mature areas
    - What is unknown?
  - Emerging areas
    - What is promising?

Don’t Work on The Problems Nobody Cares

- Problem! Problem! Problem!

- Philip S. Yu

- The most important problem of a problem is the problem itself.

Most prolific dblp authors

> Home > Statistics

- 2631 publications: H. Vincent Poor
- 1942 publications: Yang Liu
- 1890 publications: Mohamed-Slim Alouini
- 1845 publications: Philip S. Yu
- 1809 publications: Wei Wang
- 1664 publications: Yu Zhang
- 1654 publications: Wei Zhang
- 1629 publications: Lajos Hanzo
- 1557 publications: Zhu Han
- 1552 publications: Dacheng Tao

The h Index for Computer Science

200 Anil K. Jain (Michigan State U), ACM Fellow, IEEE Fellow, IEEE Technical Achiev
187 Michael I. Jordan (Berkeley), ACM Fellow, IEEE Fellow, AAAS Fellow, AAAI Fell
187 Herbert A. Simon (CMU), Nobel Laureate, Turing Award, ACM Fellow
185 Jiawei Han (UIUC), ACM Fellow, IEEE Technical Achievement Award
175 Philip S. Yu (UIC), ACM Fellow, IEEE Fellow, IEEE Technical Achievement Award
171 Andrew Zisserman (University of Oxford), Fellow of the Royal Society
169 Terrence Sejnowski (UCSD), IEEE Fellow, Member of the National Academy of Eng
168 Thomas S. Huang (UIUC), IEEE Fellow, Member of the National Academy of Engin
163 Wil van der Aalst (RWTH Aachen University), ACM Fellow, IEEE Fellow, IFIP Fell
157 Sebastian Thrun (Stanford), Member of the National Academy of Engineering

題目決定 Impact !

您如何找題目？

-- 用熟練的數學找題目

or -- 用腦袋找題目

題目決定研究的高度

- Mark Liao

Identifying the Problem

- Identifying problems is more important than finding solutions

– Y. Y. Zhou

- Define the boundaries of your problem carefully
  - Nobody will be impressed if you set the bar too low and jump over it.
  - Nobody will be impressed if you set the bar too high and don't jump over it. (Dave Redell)

How to Find a Problem? - Andrej Karpathy

- A fast but negative way
  - Read papers published at top conferences this year and propose incremental solutions
  - Very productive but little impact on the field
  - Sensible for practice (Master thesis or your first research)

- The correct way
  - Vision the trend and do things others did't do but should
  - What problems are worth and ripe for solving?
  - Cultivate taste (during PhD study) - capability of evaluating a problem's importance, difficulty, sexiness, historical context

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Sharpen Your Tools to Solve Your Problem

- Take a solid set of foundational courses
  - Math courses
    - Graph Theory, Combinatorics, Algebra, Probability Theory, Stochastic Process, Algorithm, Computational Complexity, etc.
  - Computer Science courses
    - Programming Language, Operating System, Computer Architecture, Computer Network, Compiler, etc.
- Technical English Writing

The Cone of Learning

– Edgar Dale

- After 2 weeks, we tend to remember:
  - 10% of what we read
  - 20% of what we hear
  - 30% of what we see (pictures)
  - 50% of what we hear and see
  - 70% of what we say
  - 90% of what we say and do
- The more energy that I put into a subject, the more I can remember.

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Rule of Thumb

- The reviewer would like to learn something new, not verify every detail for you!

- P.-C. Hsiu

Paper Position

- Before writing

  - Identify the paper position (as high as possible) where your paper stands in the field.
    - Create an area > Identify a problem > Propose a solution > Improve an approach
  - Sell a single core contribution that was not obvious or present before. (不要像聖誕樹!)

- During writing

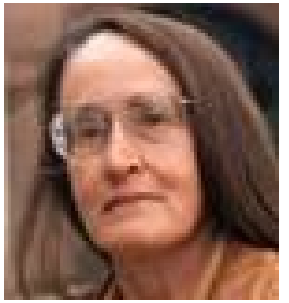
  - Argue that the thing is important and hasn't been done; then support its merit in controlled experiments.
  - Organize the entire paper around this core contribution with surgical precision. (不要畫蛇添足!)

- Andrej Karpathy

Paper Types

- Find a model paper
  - Theory: FOCS, SODA, Crypto, etc.
    - Theoretical solutions to system problems: RTSS, ICML, CVPR, VLDB, etc.
  - System: OSDI, ISCA, MobiCom, MM, etc.
    - System solutions to theoretical problems: ?
  - Measurement: SIGMETRICS, IMC, etc.
  - Survey: ACM Computing Surveys, etc.

Core Document



- Mary Shaw, *Writing Good Software Engineering Research Papers*. In Proc. of the 25th International Conference on Software Engineering (ICSE 2003), p726-736.
- Answer Mary Shaw's questions first to help you refine ideas, communicate results, organize paper writing
  - What question did you answer?
  - Why should the reader care?
  - What larger question does this address?
  - How is your result different from and better than prior work?
  - What concrete evidence shows that your result satisfies your claim?
  - Etc.

A Typical Presentation Flow

- Motivation (or trend)
- Problem
  - What are the Challenges?
- Existing Solutions
  - Why don't they work?
  - Show respect for peer-reviewed results
- Proposed Approach
  - Main idea (i.e., novel concept, design philosophy, argument, etc.)
  - Contributions to realize the idea (i.e., models, algorithms, properties, experiments, etc.)

Paper Organization (BFS, not DFS!)

- Title: brief, descriptive.
- Abstract: clear indication of objective, idea and results.
- Body of paper:
  - Background (if and only if needed)
  - Motivation (observations and inspiration)
  - Objective (well-defined problem)
  - Means of solution (technical contributions)
  - Experiment results (backup your claims)
  - Related work (not a summary but to highlight your novelty)

不能見樹不見林!

- Conclusion and future work
  - Insights, limitations, those remain to be done, etc.

Difference Between Papers and Reports

- Technical reports
  - Here is the problem. To solve it, first we do A, then we do B, next we do C, and finally we do D, and here is what we get.
- User manuals
  - We develop a system that contains module A to do X, module B to do Y, and module C to do Z, and it works well.
- Research papers
  - Readers learn much more from "why" than "what" &"how" - justify your approach, not just describe what & how you did it.

Key to Writing

– Tanya L. Crenshaw

- Follow the three B's
  - Brevity
    - Say it simply.
  - Balance
    - Balance the formal with the informal.
  - Benefit
    - Write for the benefit of your audience.

A Recipe

- P.-C. Hsiu

- How you program a big project?
  - Never put everything in the main function!
- Hierarchy
  - Paper: Project
  - Section: Module (.c file)
  - Paragraph (its own focus): Function
  - Sentence (relation in between): Line of code

- Why a movie compiled with various scenes interesting?
  - 環環相扣、前後呼應!

Tips

- Avoid jargon
  - Define before using unless well known
- Follow common terms
  - Don't use a common term for your own definition
  - Don't use your own term for a common definition
- Balance formal and informal
  - $\tilde{A}_x(A(x)) > \tilde{A}_y(A(y))$ vs. "x is *better* than y"
- Prefer simple to complicated
  - "now" versus "at this point in time"
- Obscure and pretentious use of language
  - Don't show off. Clarity is most important.

A Good Way to Learn Technical Writing

- You could write a good paper even with research that is just ok. You can also write a bad paper despite good research.

  – A. Bhatele, P. Jetley, and A. Becker in UIUC

- Review papers and learn what you think good and remember what you think bad.

  – P.-C. Hsiu

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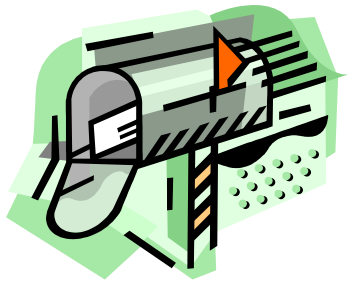
Where to Submit?

- A conference whose audience would be interested in your work (higher probability of making impact).
  - Good ones top ones, but reasonable ones.
  - Don't submit just for kicks. Spoils your reputation.



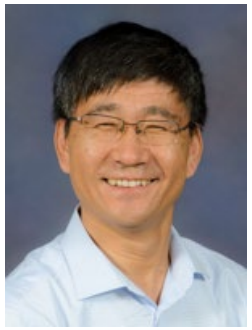
- How to judge how good a conference is?
  - Go to conferences, make friends and contacts, and ask your friends about "reputation" of a conference.
  - What is the acceptance rate, who are the TPCs, where are the papers from, Etc.
- Submit to journals! Takes a long time, but important!
  - Conference: Novelty
  - Journal: Completeness

Prior Review (writers' workshop)

- Designed for students to get early feedback from their peers
- Send the draft to the other members
- Meet to discuss
  - Members discuss what they didn't understand and didn't like.
  - The author is present but remains silent.

How to Evaluate a Paper?

- Key Point
  - What is the knowledge advancement in the paper?
- Evaluation Metrics
  - Originality: a new problem, concept, approach, or application
  - Significance: why was this work done?
  - Correctness: a rational idea realized by an unflawed approach
  - Completeness: a continuity of and an interdependence between different parts
  - Presentation: the idea is effectively communicated with a carefully planned and logical structure



- Michael Fang

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The Goal of Paper Presentation

- Not to tell your audience about what you did in your paper (寫作和口頭報告的目的是不同的!)
- But attract them to read your paper
  - Get them really excited about your problem (otherwise, won't care about your solution)
  - Give them some idea about your solution

    (not rigorous but easy to follow)
  - Show them evidences to back up your idea
- Try your best to make the audience remember your work (knowledge advancement) forever!

Understand "Understanding"

- Understanding is an act that builds a bridge between what your audience already know to what they need to know.
- Focus on key ideas and key results, go from *specific to general* and from *concrete to abstract.*
  - Get the intuitions across first
  - Most people learn inductively
  - Ask questions to keep their attention

善用人類的舉一反三!

- Lui Sha

Sha's I^3 Model

- An ideal presentation is one that is
  - Informative
  - Interesting
  - Insightful

Being Informative

- Give new knowledge **(audience-oriented)**
- "New" is relatively to your audience.
  - What they already know?
  - What they should know after your presentation?
  - What are the steps in-between?

Being Interesting

- Unexpected, counter intuitive, and difficult to believe
  - Seemingly unimportant fact that actually holds the key.
  - Seemingly true but it is in fact false.
  - A “difficult” problem is solved with ease and elegance.

Being Insightful

- Impart a deeper understanding
  - Explain a seemingly complex and confusing problem in a way that is easy to understand.
  - Unearth hidden/unstated assumptions and quickly put an argument to rest.
  - Show things in new angles, new lights and new forms and gain new understandings.
  - Demonstrate subtle but important connections/inter-dependencies between seemingly unrelated subjects.

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Undergraduate vs. Graduate

- The entrance to graduate school marks a critical phase of transition for most graduate students from absorbing knowledge to creating knowledge.

– Lui Sha

- Basically, a PhD degree means you are equipped to do all the following.

1. Pick an arbitrary area (not necessarily in CS)
2. Understand it yourself
3. Identify problems in it
4. Solve these problems in an innovative manner

– Indranil Gupta

Three stages to a CS PhD

- First, you look at a related paper's reference section and haven't read most of the papers.
- Second, you recognize all the papers.
- Third, you've shared a beer with all the first authors of all the papers.
  - Top Conferences

- Andrej Karpathy

Concrete vs. Abstract

- M.-S. Chen

- 具體的問題抽象回答
  - 助升副的標準?
  - 副升正的標準?
  - 你有問過你老闆什麼時後可以畢業嗎?
- 抽象的問題具體回答
  - 如何評價研究做得好不好?
  - GREAT: Goal, Receiver, Elite, Article, Teaming
- 教授獨特的能力?

Different Criteria at Different Stages

- T.-W. Kuo

- PhD Student/Postdoc
- Assistant Professor
- Associate Professor
- Professor
- IEEE/ACM Fellow
- Academician
- Nobel Prize/Turing Award

Potential

Independence

Leadership

Visibility (Peer Recognition)

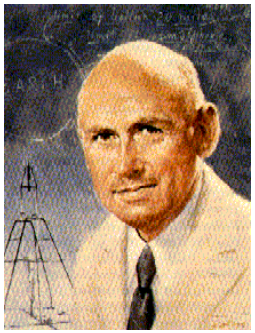
Impact

命 (Impact sufficient to change the world)

Idealism vs. Pragmatism

- It is difficult to say what is impossible, for the dream of yesterday is the hope of today and the reality of tomorrow.
  - 想深遠一點，把夢做大一點。

    – Robert H. Goddard



- Don't try to "solve the world" or "boil the ocean".
  - 做一個務實的理想主義者。

Are You Looking for an Interesting Research Area?

Welcome to Join EMCLAB@SINICA!