

How to Be a Good AI Researcher

Tao LIN

September 24, 2024



1 Course Logistics

2 Recitation

3 How to Do Research

- The Illustrated Guide to a Ph.D.
- 10 Easy Ways to Fail a Ph.D.
- Introduction to the Research Workflow (a CV Perspective)
- How to Make Steady Progress?
- How to Keep Track With the Literature?
- How to Read Papers?
- How to Come up With Research Ideas?
- How to Do Experiments?
- How to Create More Impact

4 Concluding Remarks

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Course schedule

Week	Date	Topics
1	2024. Sep. 03	Introduction to CS & AI
2	2024. Sep. 10	How to communicate
3	2024. Sep. 14	How to do presentation
4	2024. Sep. 24	How to be a good AI researcher (I): doing research I
5	2024. Oct. 07	How to be a good AI researcher (II): productivity and career
6	2024. Oct. 15	How to be a good AI researcher (III): academic paper writing and peer reviews
7	2024. Oct. 22	Sharing the experience of writing excellent academic papers and rebuttal
8	2024. Oct. 29	Practice course

Acknowledgement

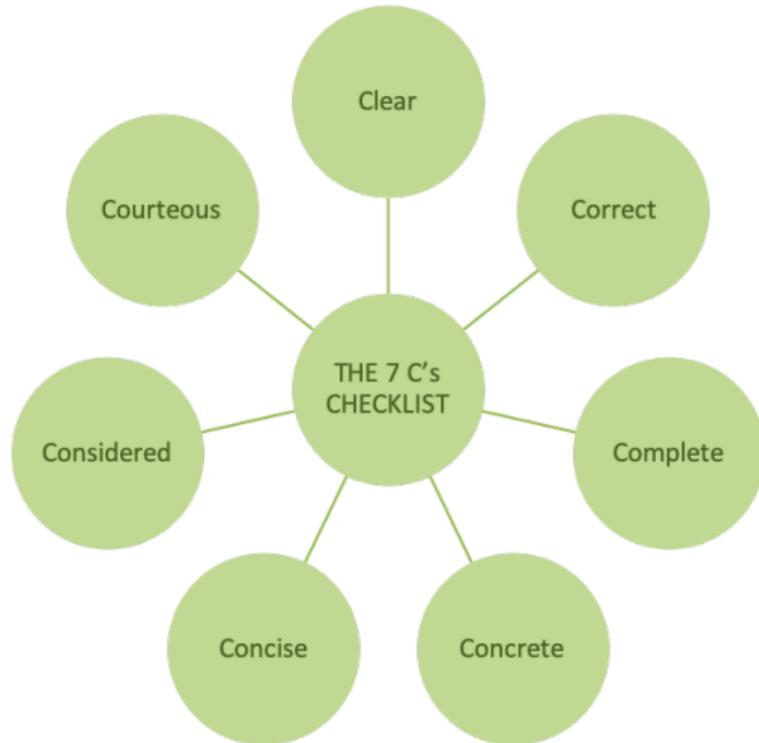
- The 7 Cs of Communication, World of Work Project
- Awesome Tips, JiaBin Huang
- The illustrated guide to a Ph.D., Matt Might
- 10 easy ways to fail a Ph.D., Matt Might

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In the previous two weeks...

We learn how to communicate: the 7 C's of communication



Please revisit our previous lecture when necessary.

We learn the principles of presentation

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- ⑤ Guide, highlight, and interpret the key results for your audience!
- ⑥ Practice almost makes perfect. Rehearse your presentation from the aspect of your audience!

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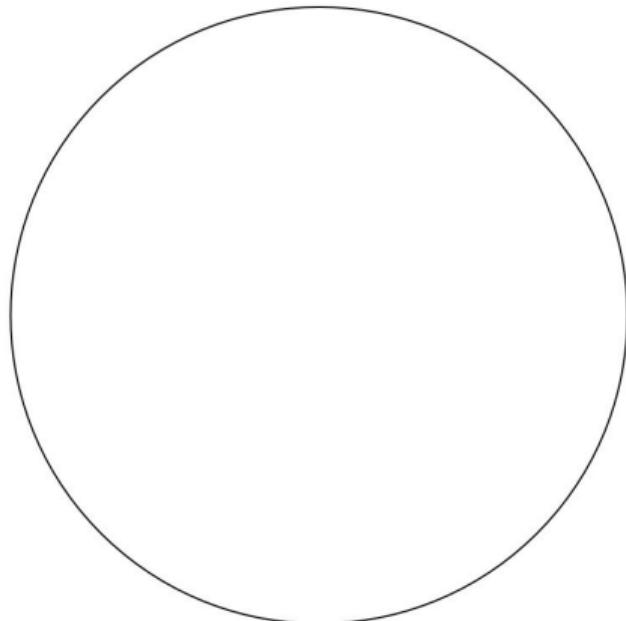
What a Ph.D. is?

¹<https://matt.might.net/articles/phd-school-in-pictures/>

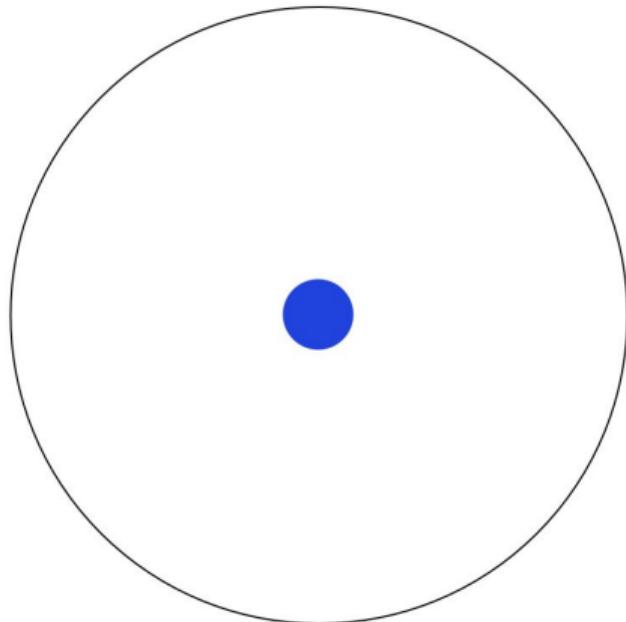
What a Ph.D. is?

Let's get started with a famous example¹

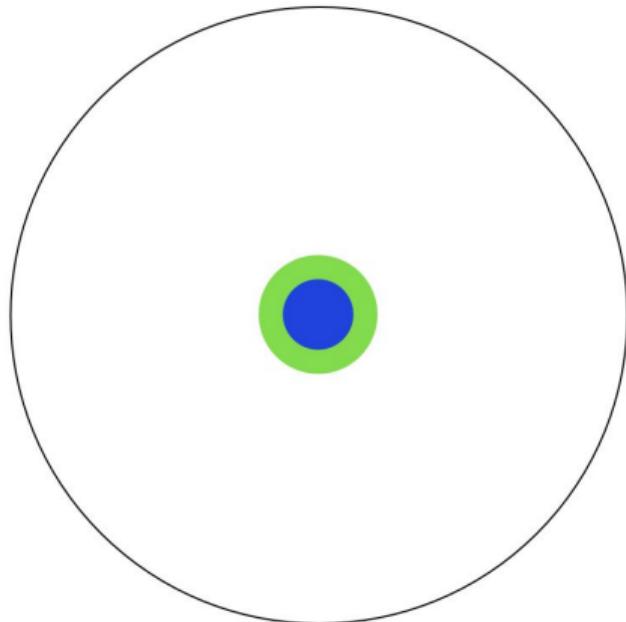
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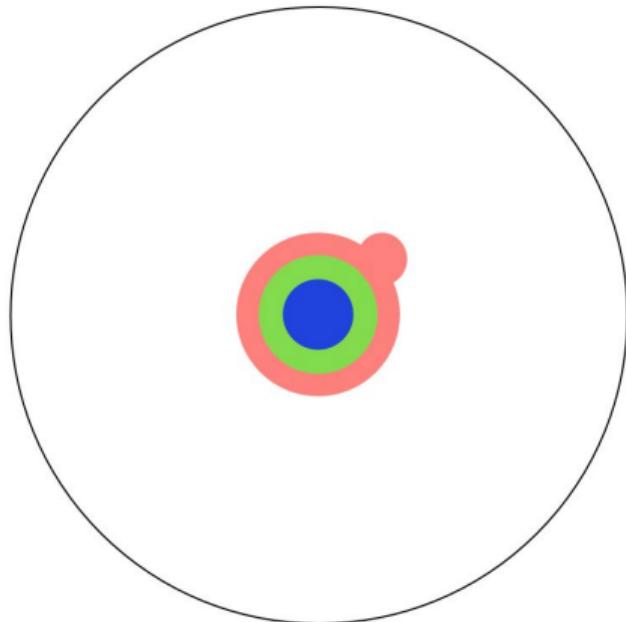
Imagine a circle that contains all of human knowledge



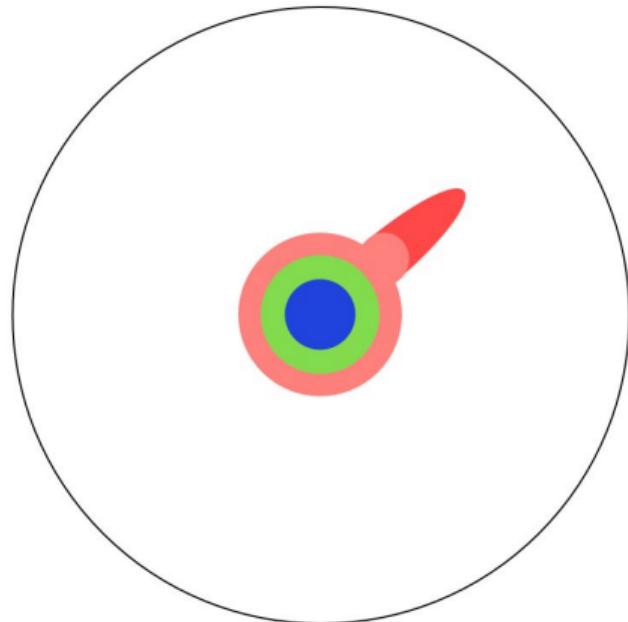
By the time you finish elementary school, you know a little



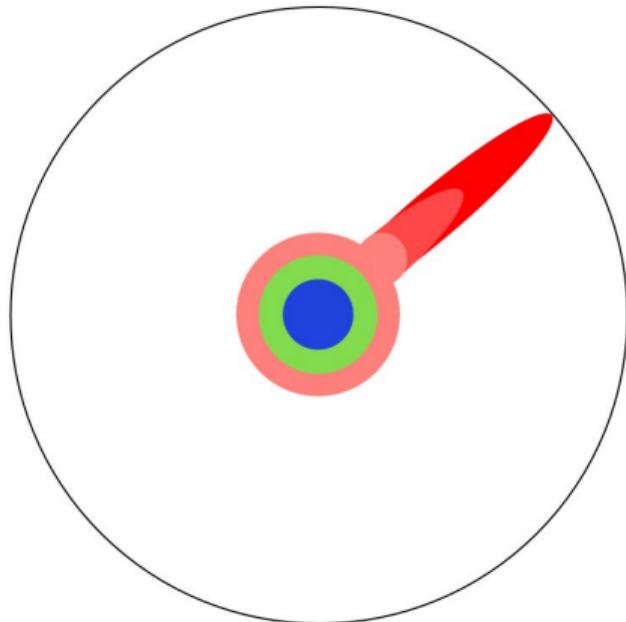
By the time you finish high school, you know a bit more



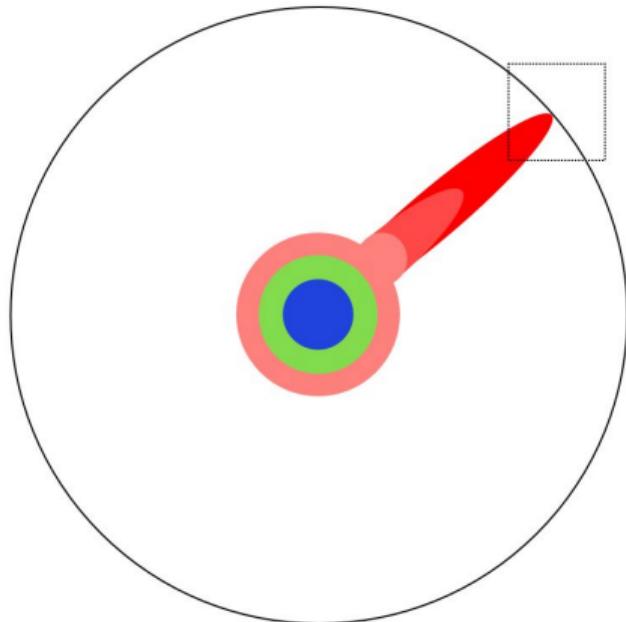
With a bachelor's degree, you gain a specialty



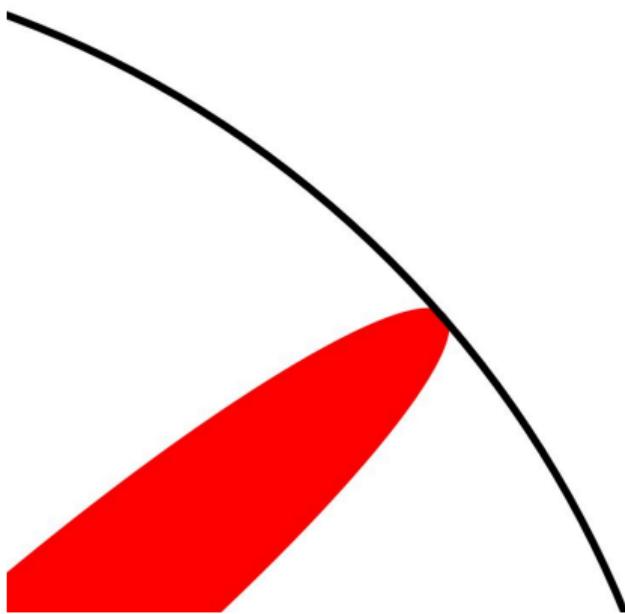
A master's degree deepens that specialty



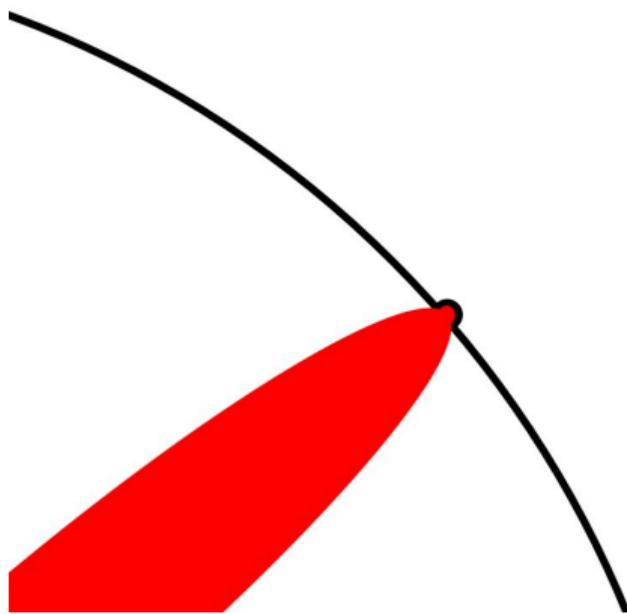
Reading research papers takes you to the edge of human knowledge



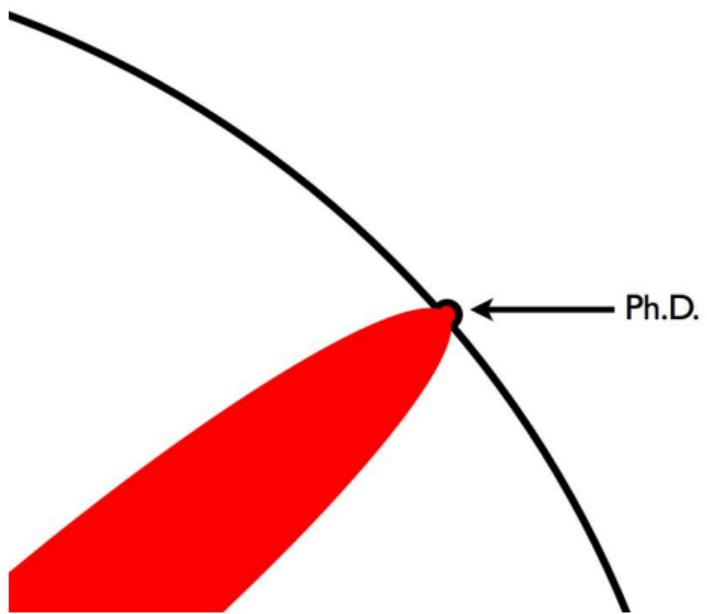
Once you're at the boundary, you focus



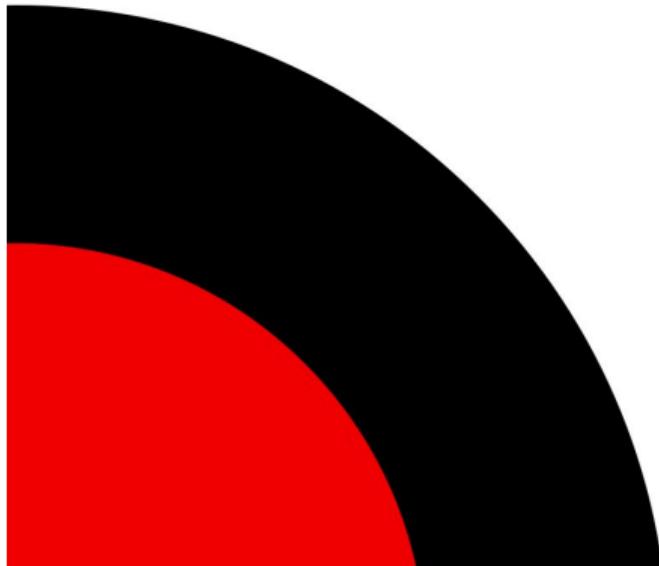
You push at the boundary for a few years



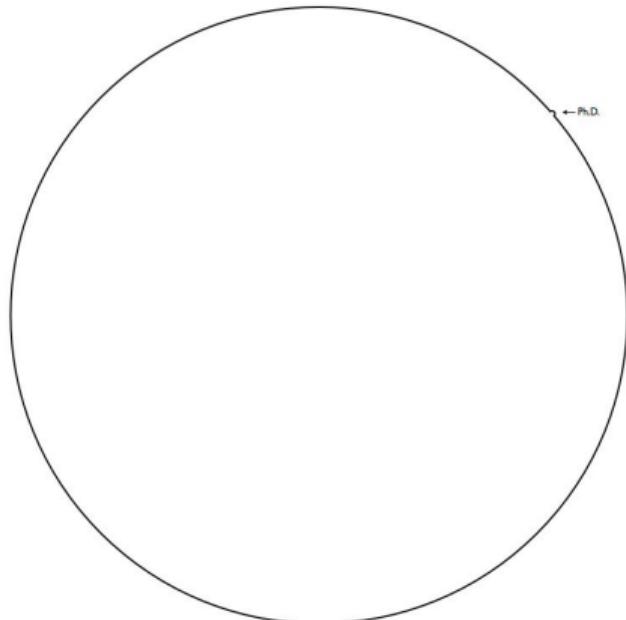
Until one day, the boundary gives way



Until one day, the boundary gives way



Of course, the world looks different to you now



Of course do not forget the bigger picture

Back to something concrete

Let's talk about 10 easy ways to fail a Ph.D.

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$$\text{Optimal GPA} = \text{Minimum Required GPA} + \epsilon$$

Learn too much

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It is important to trade off learning width and learning depth.

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- it is important to get started, and improve it through an iterative process.

Procrastinate



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We will have a separate session on tips for boosting productivity.

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- helping to craft early papers

Hands-off

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- once it happens, the student should start choosing the topics

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- You need much larger levels of independence

Aim too low

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Aiming low leaves no room for uncertainty. And research is always uncertain.

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- It is the training that counts—not the topic.

Miss the real milestones

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In practice, the real milestones are at least three good publications connected by a unified theme

- When you have a few good publications and can convince your committee → thesis proposal
- Once you can repeatedly conduct research to meet the standards of peer review → defense
- Once you can draw a unifying theme → thesis and dissertation

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- He ignored that warning.

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- He ignored that warning.
- He was lucky: it added only one more semester to his Ph.D.

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How to Make Steady Progress?



Mentor/Advisor



Research Skills

How to Make Steady Progress?



Mentor/Advisor

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Mentor/Advisor

Please check our week2 slides on
“How to work with your advisor effectively”

How to Make Steady Progress?



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Key messages:

How to Make Steady Progress?



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Key messages:

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- Show your work (what, why, how, etc)

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- Provide contexts (maintain a detailed meeting minute and start with why)

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- Set expectation (I will do XXX by YYY)

How to Make Steady Progress?



Mentor/Advisor



Research Skills

How to Make Steady Progress?



Research Skills

How to Make Steady Progress? Imagine success



How to Make Steady Progress? Work backward

- Forward: $A \rightarrow B \rightarrow C \rightarrow D \rightarrow E$
- Backward: $D \rightarrow E; C \rightarrow D; B \rightarrow C; A \rightarrow B$



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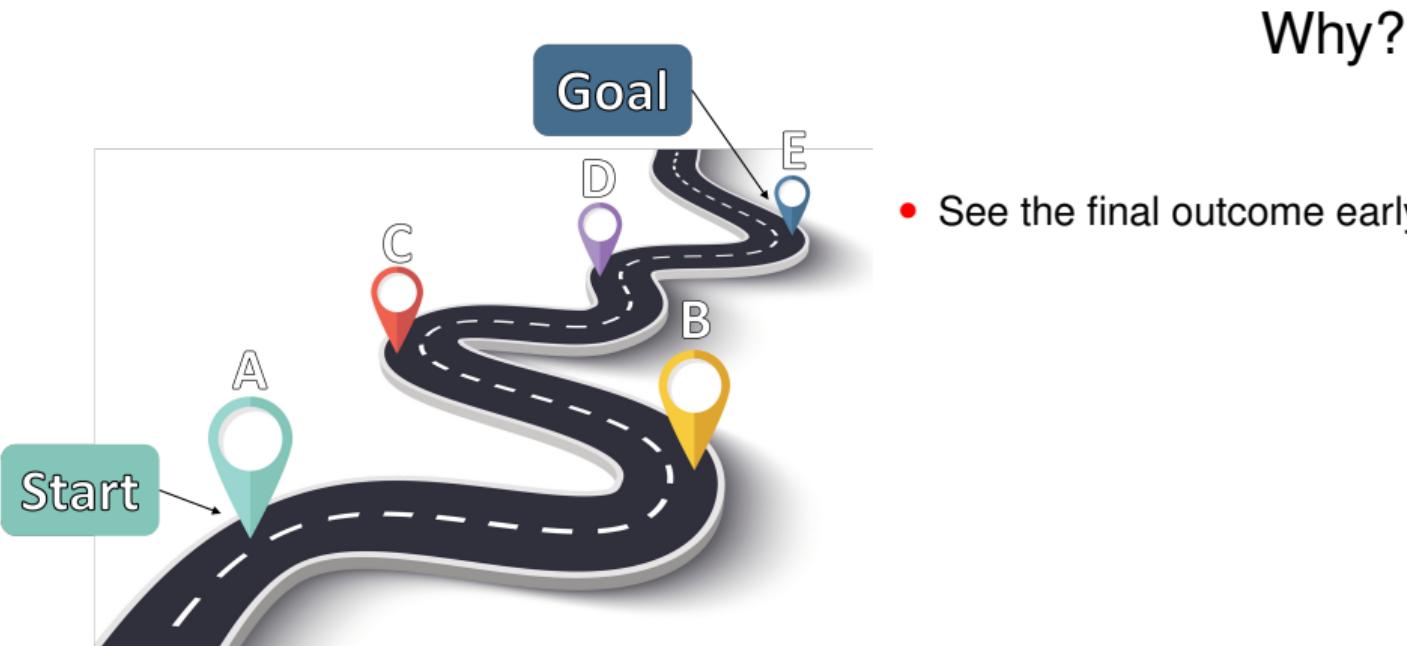
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Why?



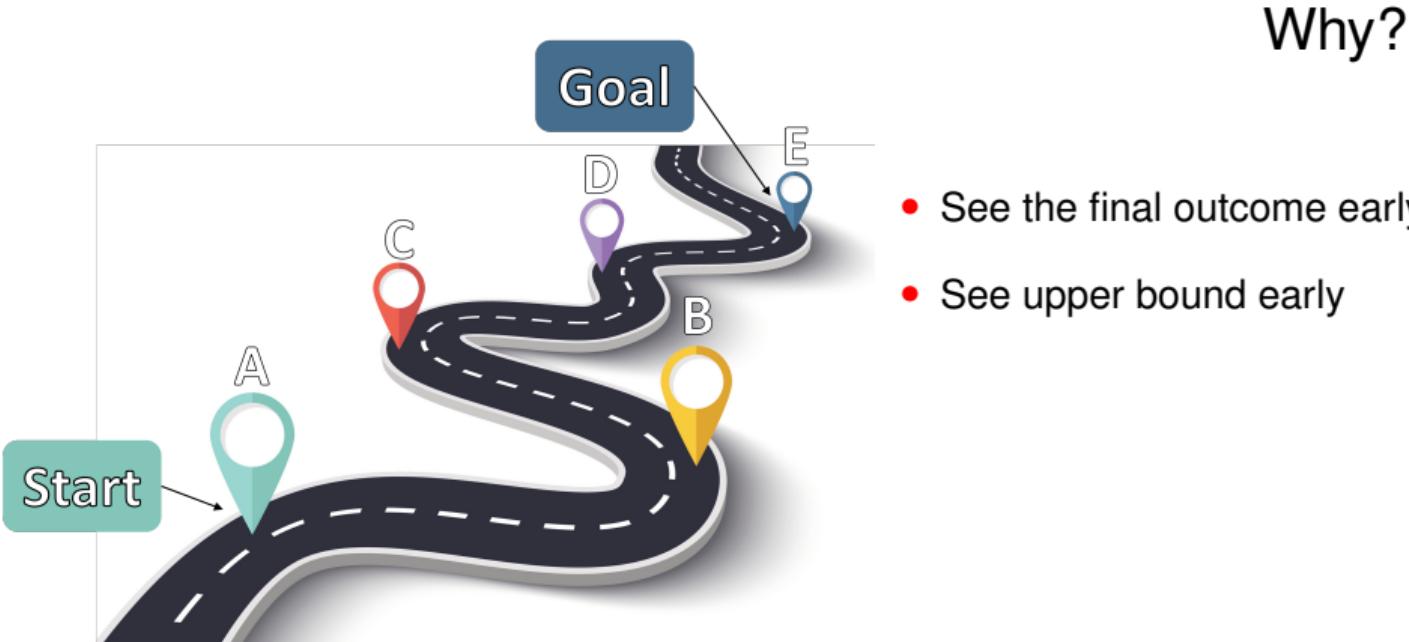
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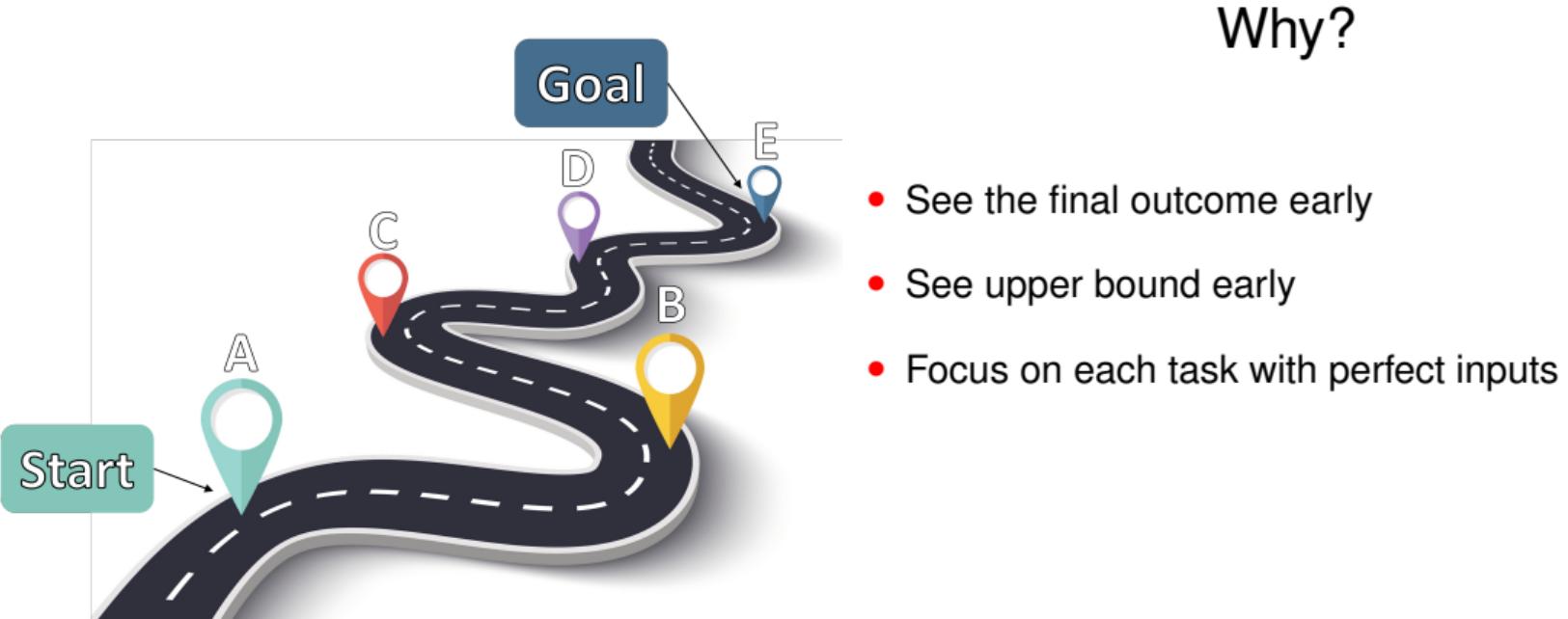
- Forward: $A \rightarrow B \rightarrow C \rightarrow D \rightarrow E$
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- See the final outcome early
- See upper bound early

How to Make Steady Progress? Work backward

- Forward: $A \rightarrow B \rightarrow C \rightarrow D \rightarrow E$
- Backward: $D \rightarrow E; C \rightarrow D; B \rightarrow C; A \rightarrow B$



How to Make Steady Progress? Work backward

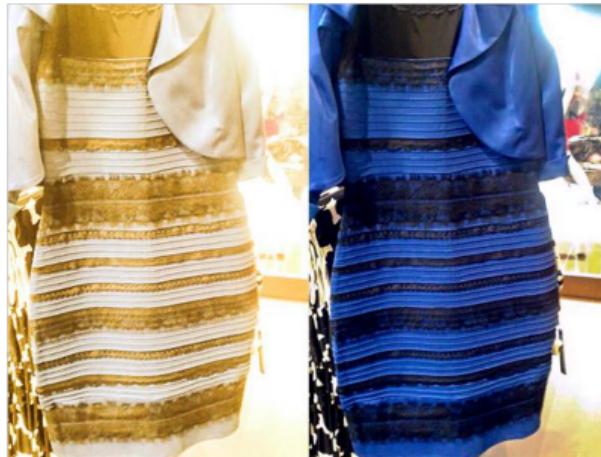
- Forward: $A \rightarrow B \rightarrow C \rightarrow D \rightarrow E$
- Backward: $D \rightarrow E; C \rightarrow D; B \rightarrow C; A \rightarrow B$



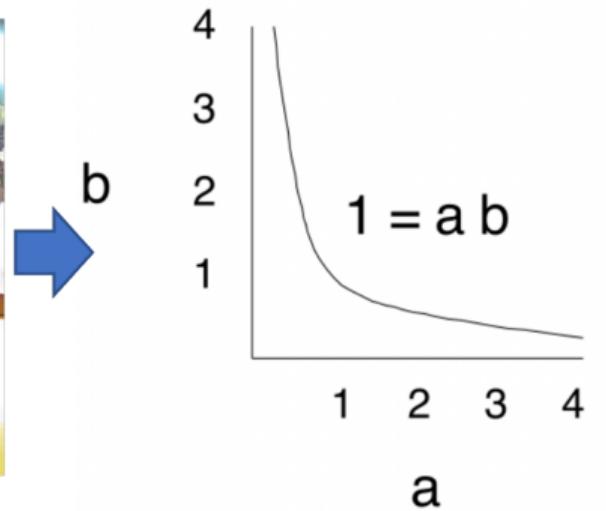
Why?

- See the final outcome early
- See upper bound early
- Focus on each task with perfect inputs
- Understand what is needed

How to Make Steady Progress? Use toy example to capture the main idea.



Color constancy problem



How to Make Steady Progress? Baselines first

Don't know where to start?



Let's build a sheep counter!

How to Make Steady Progress? Baselines first

Don't know where to start?



- Start with trying out baseline methods.

Let's build a sheep counter!

How to Make Steady Progress? Baselines first

Don't know where to start?



- Start with trying out baseline methods.
- It helps identify the limitations of STOA.

Let's build a sheep counter!

How to Make Steady Progress? Baselines first

Don't know where to start?



- Start with trying out baseline methods.
- It helps identify the limitations of STOA.
- If they work perfectly well, then??

Let's build a sheep counter!

How to Make Steady Progress? Simple case first



If your method does not work on simple/trivial cases,

How to Make Steady Progress? Simple case first



If your method does not work on simple/trivial cases,
how could you expect it to work on unconstrained, real-world cases?

How to Make Steady Progress? One thing at a time

batch_size = 4 → batch_size = 16

learning_rate = 1e-3 → learning_rate = 1e-5

use_abc_loss = False → use_abc_loss = True

When doing experiments, change exactly ONE thing at a time.

How to Make Steady Progress? One thing at a time

batch_size = 4 → batch_size = 16

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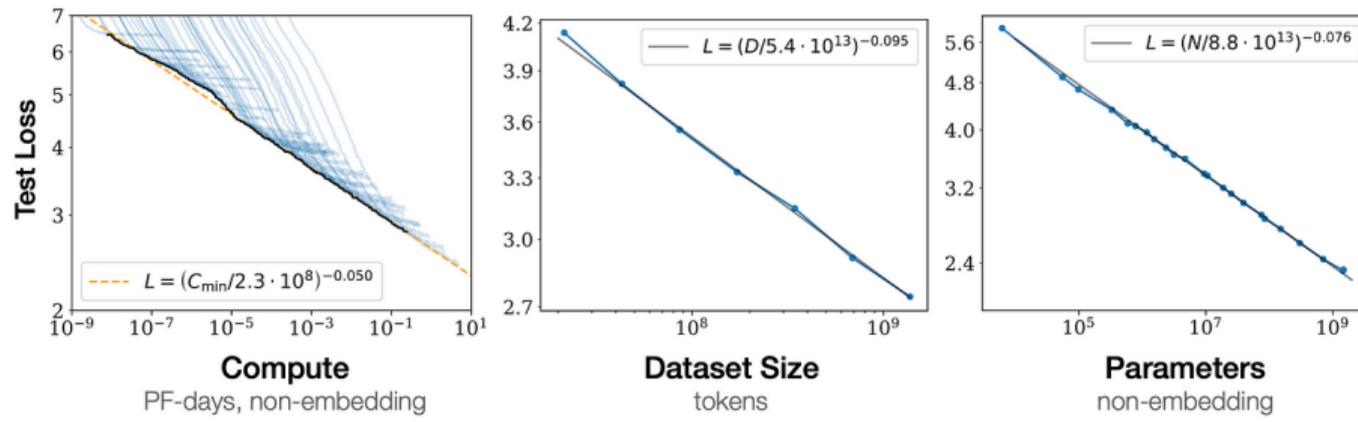
→ This helps you understand what the results mean.

How to Make Steady Progress? Identify proxy

- Do not use full-scale experiments (that may take weeks to complete) to validate your ideas

²Scaling Laws for Neural Language Models, <https://arxiv.org/abs/2001.08361>

How to Make Steady Progress? Identify proxy

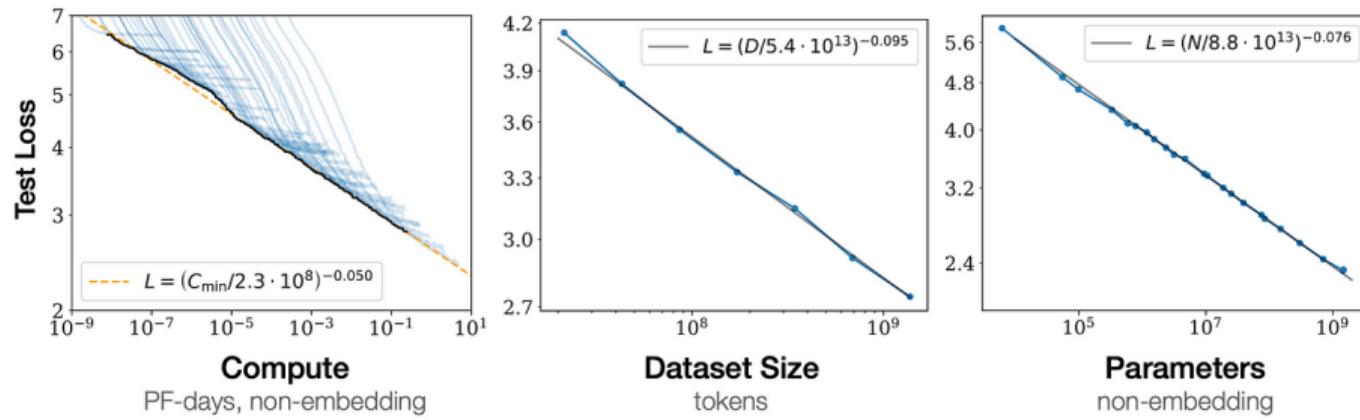


Example: *scaling rule* in Deep Learning²

- Do not use full-scale experiments (that may take weeks to complete) to validate your ideas

²Scaling Laws for Neural Language Models, <https://arxiv.org/abs/2001.08361>

How to Make Steady Progress? Identify proxy



Example: *scaling rule in Deep Learning*²

- Do not use full-scale experiments (that may take weeks to complete) to validate your ideas
- Run smaller-scale/simpler experiments with short turnaround time
→ you get to iteratively refine your ideas a lot faster.

²Scaling Laws for Neural Language Models, <https://arxiv.org/abs/2001.08361>

How to Make Steady Progress? Automate everything / make the best use of machine time

If you find that you need to do the same task twice, write a script for that.

How to Make Steady Progress? Automate everything / make the best use of machine time

If you find that you need to do the same task twice, write a script for that.

Plan your experiments → your machines work for you while you are not working.

How to Make Steady Progress? Automate everything / make the best use of machine time

If you find that you need to do the same task twice, write a script for that.

Plan your experiments → your machines work for you while you are not working.

Your future self will thank you.

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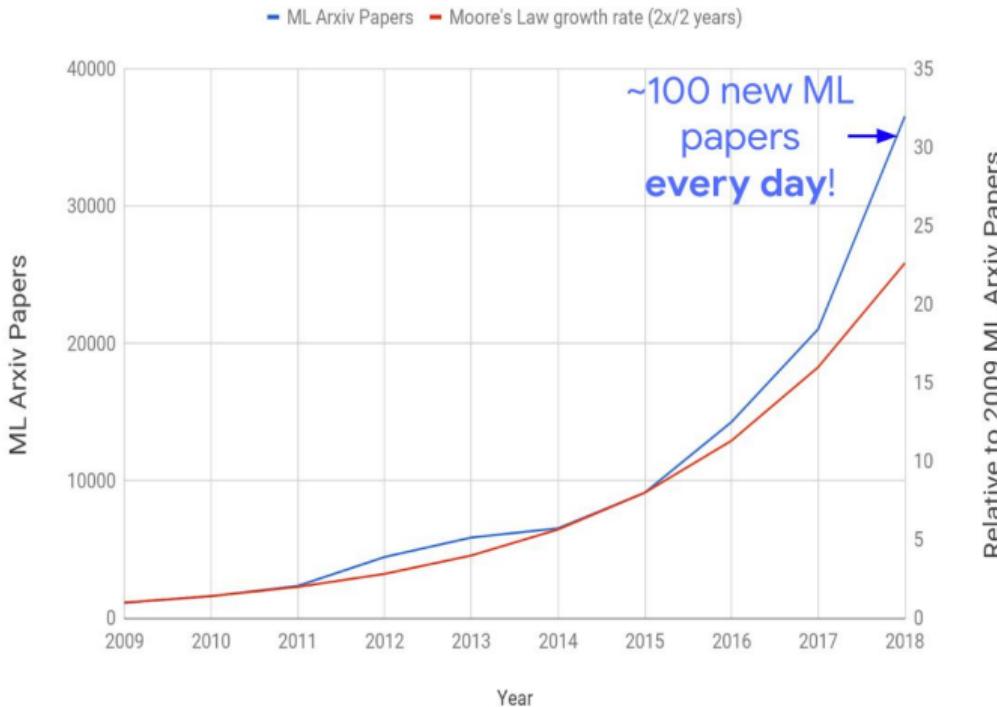
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- How to Read Papers?
- How to Come up With Research Ideas?
- How to Do Experiments?
- How to Create More Impact

4 Concluding Remarks

Machine Learning Arxiv Papers per Year



From Jeff Dean's Twitter (Year 2018).

What should we do?

Track the people, not the papers

The screenshot shows the Google Scholar Alerts interface. At the top, it says "Alerts for liamTao@gmail.com". Below that is a list of researchers with their names and the option to view "All results" or "CANCEL".

Researcher	Action
Sebastian Urban Stich - new articles	All results CANCEL
Hamed Hassani - new articles	All results CANCEL
Nicholas Carlini - new articles	All results CANCEL
Lingling Kong - new articles	All results CANCEL
Tengyu Ma - new articles	All results CANCEL
Chen Liu - new articles	All results CANCEL
Jeff Dean - new articles	All results CANCEL
Maseeh Bujwana - new articles	All results CANCEL
Martin Takáč - new articles	All results CANCEL

- There are far fewer key people who are driving the field forward than the number of papers
- Check out who the authors are when you read papers.
- Overtime you will recognize the important ones.

Read papers with good related work

A good related work section saves you so much time by providing a clear, organized view of prior work.

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Side note: please save others' time by writing a good related work.

Organize the papers

BIBTEX	EndNote™	Mendeley	Papers	zotero
BibTeX	EndNote	Mendeley	Papers	Zotero
Free license	Clarivate (commercial)	Elsevier (commercial)	Digital Science Research & Solutions Inc. (commercial)	Corporation for Digital Scholarship (non profit)
Free of charge	274,95 USD per year (149,495 USD for students)	Freemium	60 USD per year (36 USD for students)	Free of charge
Windows macOS Linux	Windows macOS	Windows macOS Linux	Windows macOS	Windows macOS Linux
Compatible with: (MS Word) Google Docs (OpenOffice) (LibreOffice) LaTeX	Compatible with: MS Word (Google Docs) OpenOffice LibreOffice (LaTeX)	Compatible with: MS Word (Google Docs) OpenOffice LibreOffice (LaTeX)	Compatible with: MS Word Google Docs OpenOffice LibreOffice (LaTeX)	Compatible with: MS Word Google Docs OpenOffice LibreOffice LaTeX
-	7k+ citation styles	9k+ citation styles	9k+ citation styles	10k+ citation styles

Updated on 17/04/2023

Consider to use a reference manager

Organize the papers

The image shows the Zotero website homepage at the top, featuring a dark background with various icons related to research and a central text area. Below the website screenshot is a screenshot of the Zotero desktop application's interface.

Zotero Website Screenshot:

- Text:** Your personal research assistant
- Text:** Zotero is a free, easy-to-use tool to help you collect, organize, annotate, cite, and share research.
- Buttons:** Download (red button), Available for Mac, Windows, Linux, and iOS.
- Text:** Just need to create a quick bibliography? Try ZoteroBib.

Zotero Desktop Application Screenshot:

- Left Sidebar:** My Library, Book Reviews, Colonial Medicine, Dissertation, Science and Empire, Teaching, Mapping, Open Access, Text Mining, Visualization.
- Central Panel:** A list of bibliographic items with columns for Title, Creator, Year, and a preview icon.
- Right Panel:** Item Type (Journal Article), Title (Circulation of Medicine in the Early Modern Atlantic World), Author (Cook, Harold J., Walker, Timothy D.), Abstract (The search for powerful drugs has caused people and commodities to move around the globe for many centuries, as it still does...), Publication (Social History of Medicine), Volume (26).

I use Zotero in my case

Avoiding reading the paper

The screenshot shows the homepage of the 'Two Minute Papers' YouTube channel. At the top, it displays the channel's name, 'Two Minute Papers', with a play button icon, 1.4M subscribers, and 815 videos. Below this, there's a brief bio: 'What a time to be alive!' followed by a link to their website: www.cs.washington.edu/~mrt/ and '3 more links'. A 'Subscribe' button is visible on the right. The main area features a grid of video thumbnails under the heading 'Created playlists'. Some visible playlist titles include 'OpenAI WRITER STUDIES', 'NVIDIA RTX AI, and more', 'VIRTUAL FINESSES', 'Virtual Reality, Alternative Reality, DeepMind explained - AlphaFold', '3D Printing / 3D Fabrication', 'Light Transport, Ray Tracing and Global Illumination (Two Minutes...)', 'Fluid, Cloth and Hair Simulations (Two Minute Papers)', 'AI and Deep Learning - Two Minute Papers', 'LuxRender', 'Two Minute Papers', and 'TU Wien Rendering / Ray Tracing Course'. Each thumbnail includes a small preview image, the title, the number of videos, and options to 'View full playlist' or 'View full project'.

The screenshot shows the homepage of the 'Paul G. Allen School' YouTube channel. It features a purple circular logo with 'PAUL G. ALLEN SCHOOL' and a white 'W'. The channel has 14.2K subscribers and 660 videos. Below the bio, there's a link to 'os.washington.edu'. The navigation bar includes HOME, VIDEOS, LIVE, PLAYLISTS (which is currently selected), COMMUNITY, CHANNELS, and ABOUT. On the right, there's a 'Sort by' dropdown set to 'Sort by'. The main content area is titled 'Created playlists' and shows a grid of video thumbnails for various lecture series and events. Examples include '2023-24 PMP Course Overviews', 'Distinguished Seminar In Optimization & Data', '2022-23 Allen School Distinguished Lecture Series', '2022-23 Allen School Colloquia', 'IFDS 2022', '2022 Northwest Robotics Symposium', '2021-22 Allen School Distinguished Lecture Series', '2021 Information-Theoretic Cryptography (ITC) Conference', 'Research Seminar: Mobile & Wireless Systems', 'UW Allen School Women's Research Day 2022', 'Research Seminar: Molecular Programming', '2020 Women's Research Day Q&A With RISHI BALASUBRAHMANYAM', '2020-21 Allen School Distinguished Lecture Series', '2020-21 Allen School Colloquia', 'Women's Research Day 2020', and 'Innovations in Theoretical Computer Science 2020'. Each thumbnail includes a small preview image, the title, the number of videos, and a 'View full playlist' link.

Instead of spending time reading the actual paper, find resources that are much easier to digest.

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- OpenAI WRITER STUDIES**: 10 videos
- NVIDIA RTX AI, and more**: 12 videos
- VIRTUAL FINESSES**: 12 videos
- Virtual Reality, Alternative Reality, DeepMind explained - AlphaFold**: 20 videos
- 3D Printing / 3D Fabrication**: 20 videos
- Light Transport, Ray Tracing and Global Illumination (Two Minutes)**: 20 videos
- Diffusion, GPT4, OpenAI, Stable Diffusion and more**: 10 videos
- Updated yesterday**
- View full playlist**
- Fluid, Cloth and Hair Simulation - Two Minute Papers**: 100+ videos
- AI and Deep Learning - Two Minute Papers**: 100+ videos
- LuxRender**: 100+ videos
- Two Minute Papers**: 100+ videos
- TU Wien Rendering / Ray Tracing Course**: 700+ videos
- View full playlist**

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- CSD 500: Computer Graphics**: 3 videos
- 2023-24 PMP Course Overviews**: 3 videos
- Distinguished Seminar in Optimization & Data**: 3 videos
- 2022-23 Allen School Distinguished Lecture Series**: 5 videos
- 2022-23 Allen School Colloquia**: 5 videos
- IFDS 2022**: 4 videos
- 2022 Northwest Robotics Symposium**: 3 videos
- 2021-22 Allen School Distinguished Lecture Series**: 8 videos
- 2021-22 Allen School Colloquia**: 8 videos
- 2021 Information-Theoretic Cryptography (ITC) Conference**: 1 video
- Research Seminar: Mobile & Wireless Systems**: 1 video
- UW Allen School Women's Research Day 2021**: 2 videos
- Research Seminar: Molecular Programming**: 3 videos
- 2020 Women's Research Day Q&A with BRENDA BALANDIER**: 10 videos
- 2020 Women's Research Day Session 1**: 10 videos
- Innovations in Theoretical Computer Science 2020**: 11 videos
- Research Seminar: Quantum Networking**: 3 videos
- Research Seminar: Internet of Robotic Things**: 5 videos
- 2020-21 Allen School Distinguished Lecture Series**: 13 videos
- 2020-21 Allen School Colloquia**: 13 videos
- Women's Research Day 2020**: 10 videos

Instead of spending time reading the actual paper, find resources that are much easier to digest.

- a talk, a YouTube video, teaser results, an introductory video, or an overview figure.

Read with a purpose

Before investing time in reading a paper, think about WHY you are reading it.

You almost never need to read a paper from top to bottom.

Read with a purpose

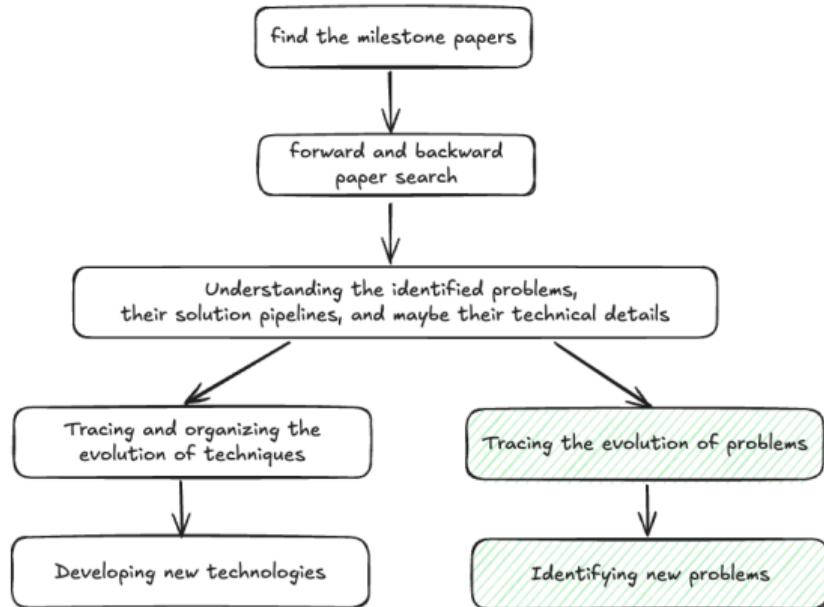
Before investing time in reading a paper, think about WHY you are reading it.

Are you reading for

- the experimental setup?
- the organization?
- the story?
- the style?
- the method?
- or the visualization?

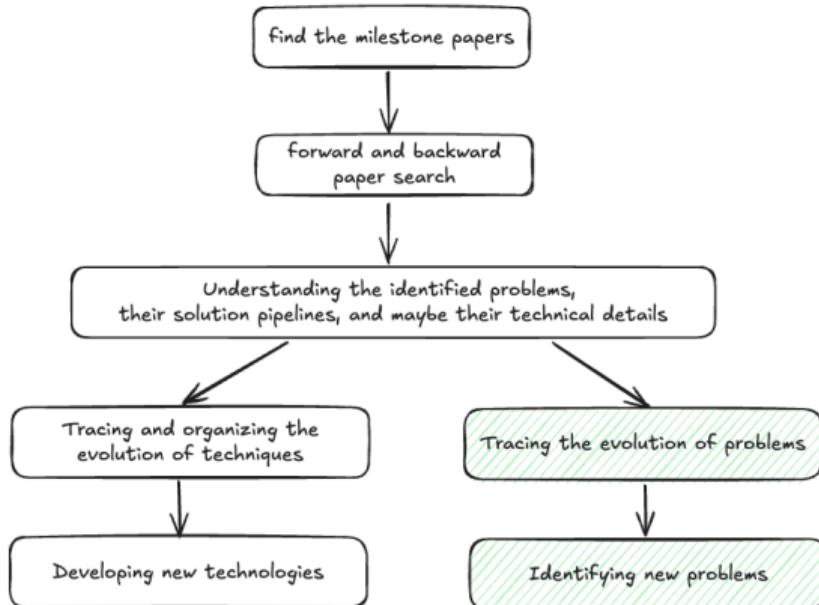
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How to be a domain expert by reading papers



How to identify milestone papers

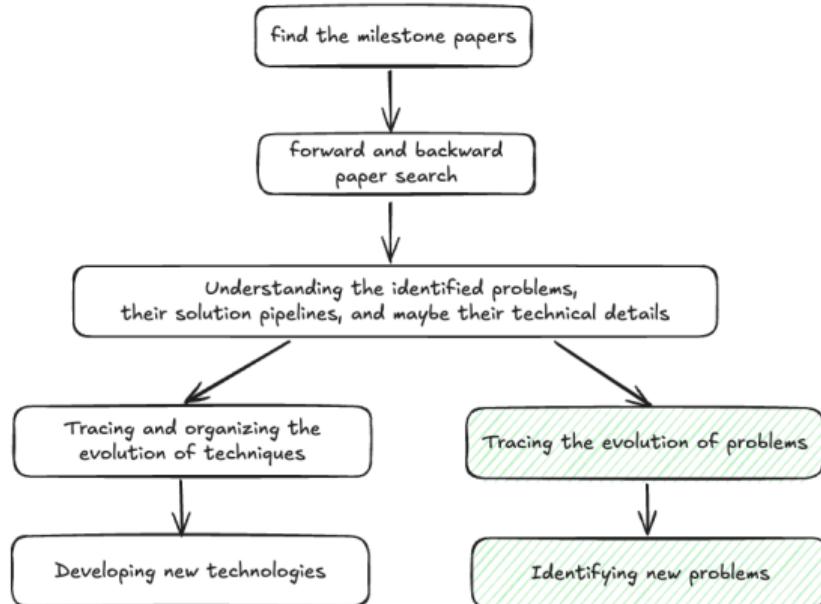
How to be a domain expert by reading papers



How to identify milestone papers

- Find the most cited papers in this field and sort them by date.

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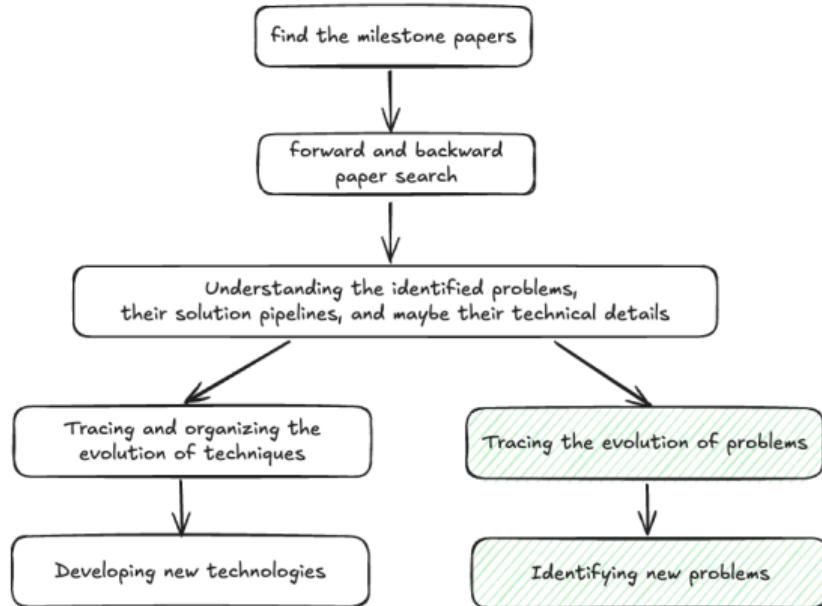


How to identify milestone papers

- Find the most cited papers in this field and sort them by date.
- Seek advice from experienced researchers.

How to be a domain expert by reading papers

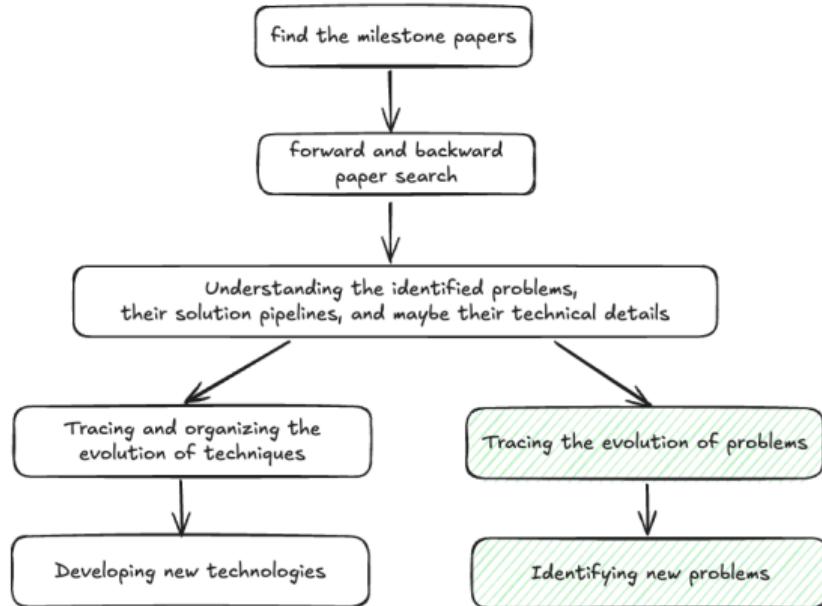
How to find papers between two milestone papers



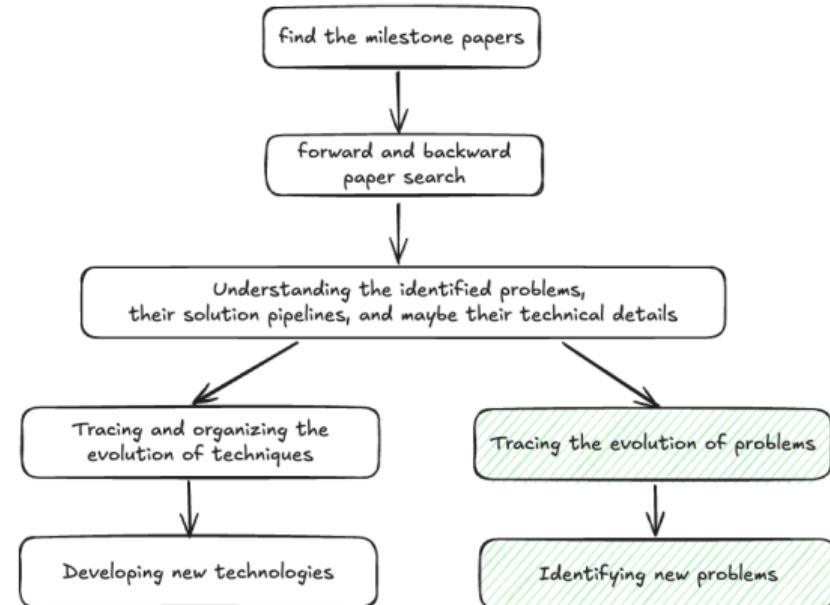
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How to find papers between two milestone papers

- Forward pass



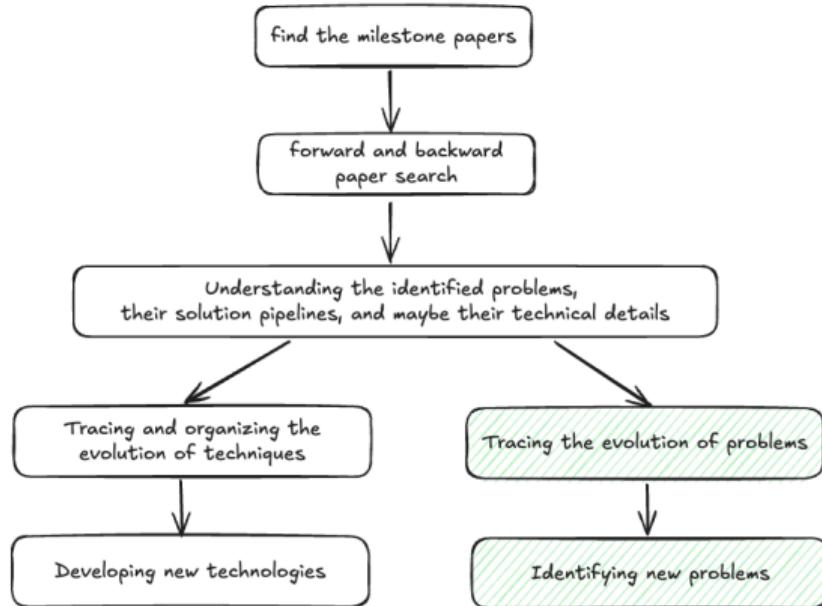
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How to find papers between two milestone papers

- Forward pass
 - papers cited by the milestone paper
 - foundation work

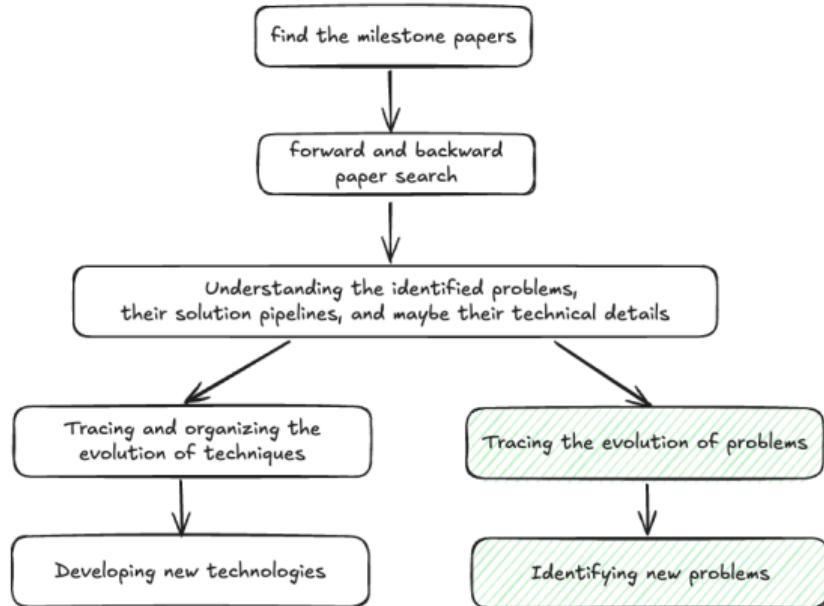
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How to find papers between two milestone papers

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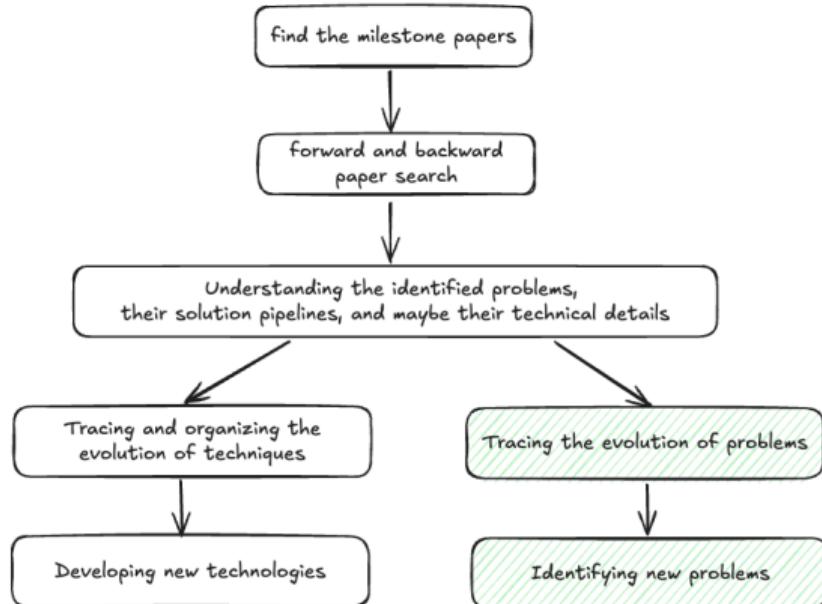
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How to find papers between two milestone papers

- Forward pass
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- Backward pass
 - papers cite the milestone paper
 - followup work

How to be a domain expert by reading papers



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Connected Papers

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1 Course Logistics

2 Recitation

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4 Concluding Remarks

Template: When reading a paper, please try to answer these questions (using 1-3 sentences).

- What is the problem? / How important is it?

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- What is the problem? / How important is it?
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- What is the problem? / How important is it?
- What are the insights?
- What is the solution? / Is it feasible?
- What is the takeaway message?
- Will this paper win the test of time award?
- Name one reason why this paper should have not appeared in NIPS, ICML, ICLR, etc?

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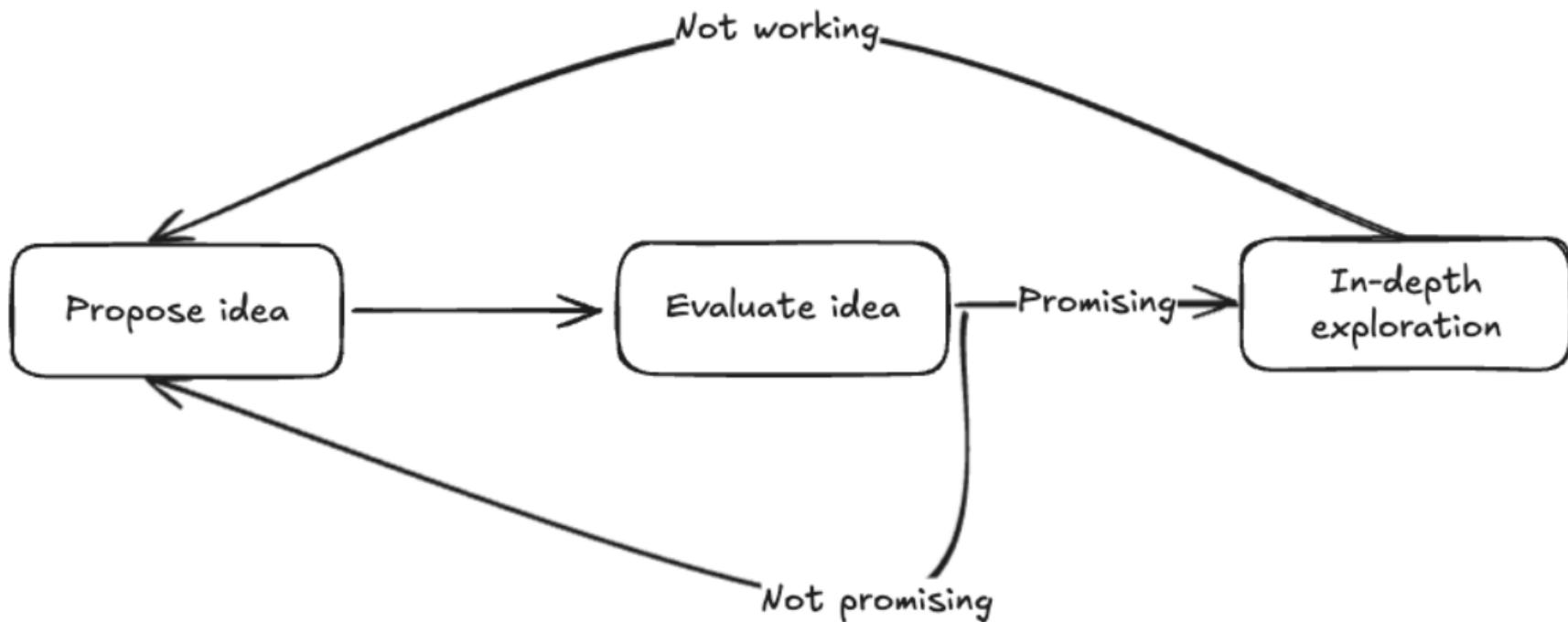
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4 Concluding Remarks

A general loop



Manipulate assumptions

- Relax assumptions

Manipulate assumptions

- Relax assumptions
- Make more assumptions

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 - Identify the underlying assumptions of existing work
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Manipulate assumptions

- Relax assumptions
 - Identify the underlying assumptions of existing work
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- Make more assumptions
 - Take a general approach and tailor it to your SPECIFIC problem.
 - Leverage all the domain knowledge (i.e., make more assumptions) to improve the method.

Combine two ideas/problems



“To steal ideas from one person is plagiarism. To steal from many is research.” — Wilson Mizner

Add an adjective

Given an existing idea X, add an adjective to make it

- slow → fast
- batch → online
- sensitive → robust
- centralized → distributed
- single-step → progressive
- single-level → hierarchical
- fixed → adaptive, sth-aware
- data-hungry → data-efficient

Stress test the state-of-the-art

Don't simply run on the fixed, boring benchmark datasets.

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→ Try it out on diverse, unconstrained examples and see how it fails.

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It's a great way to identify the limitations of existing work.

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Don't simply run on the fixed, boring benchmark datasets.

→ Try it out on diverse, unconstrained examples and see how it fails.



It's a great way to identify the limitations of existing work.



This is where your work can fill the gap.

Building and practicing your research taste

- 1 Write down a list of research ideas. Have a mentor you respect rate each idea 1-10. Discuss ideas where you disagree with them after reflection.

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- 4 Read books about the history of science. Reflect on why some researchers focused on important directions their contemporaries ignored.
- 5 Critically consider your research taste, and the community taste around you. Your taste is likely very influenced by your research cluster (your collaborators, advisor, etc)

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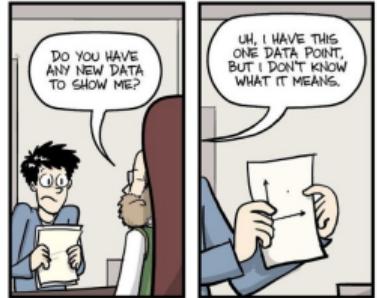
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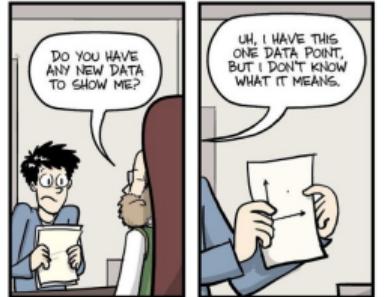
4 Concluding Remarks

Once we have the idea, we need to test them!



Junior students often feel stressed before the weekly meeting because their experiments do not go well.





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Some tips on why, what, and how to do experiments.

Why?

Your goal of experiments should be to validate/test your research questions.

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- ✗ Do an experiment to get improved performance.

Why?

Your goal of experiments should be to validate/test your research questions.

- ✗ Do an experiment to get improved performance.
- ✓ Do an experiment to test a hypothesis.

What experiments should we do?

This involves three main steps:

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- identify key research questions

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This involves three main steps:

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- break them down into baby steps

What experiments should we do?

This involves three main steps:

- identify key research questions
- break them down into baby steps
- design experiments that best answer those questions

How?

so now we know why and what, how about HOW?

How?

so now we know why and what, how about HOW?

There are no universal answers, but here are some principles I found helpful.

Some tips

- One thing at a time

Some tips

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The goal of your experiment is to test a hypothesis!

Some tips

- One thing at a time

The goal of your experiment is to test a hypothesis!

Control your variables!

Some tips

- One thing at a time

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Learn to predict the outcome **before** you do the experiments.

Some tips

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The goal of your experiment is to test a hypothesis!

Control your variables!

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Learn to predict the outcome **before** you do the experiments.

What do you expect to see if you add X / remove Y / test on Z?

Some tips

- One thing at a time

The goal of your experiment is to test a hypothesis!

Control your variables!

- Anticipate the results!

Learn to predict the outcome **before** you do the experiments.

What do you expect to see if you add X / remove Y / test on Z?

- Start with a baseline

Some tips

- One thing at a time

The goal of your experiment is to test a hypothesis!

Control your variables!

- Anticipate the results!

Learn to predict the outcome **before** you do the experiments.

What do you expect to see if you add X / remove Y / test on Z?

- Start with a baseline

Very often, you do experiments to see a "change" (either positive or negative).

Some tips

- One thing at a time

The goal of your experiment is to test a hypothesis!

Control your variables!

- Anticipate the results!

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- Ask for feedback

Your mentors/advisors are there to help you succeed.

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1 Course Logistics

2 Recitation

3 How to Do Research

- The Illustrated Guide to a Ph.D.
- 10 Easy Ways to Fail a Ph.D.
- Introduction to the Research Workflow (a CV Perspective)
- How to Make Steady Progress?
- How to Keep Track With the Literature?
- How to Read Papers?
- How to Come up With Research Ideas?
- How to Do Experiments?
- **How to Create More Impact**

4 Concluding Remarks

Pick a good name

(And Pick A Good Name!)

Reduced
Instruction
Set
Computers **R**edundant
 Array of
 Inexpensive
 Disks

Network
Of
Workstations

...

30



Make all your results available

3D Photography using Context-aware Layered Depth Inpainting

Meng-Li Shih^{1,2} Shih-Yang Su¹ Johannes Kopf³ Jia-Bin Huang¹

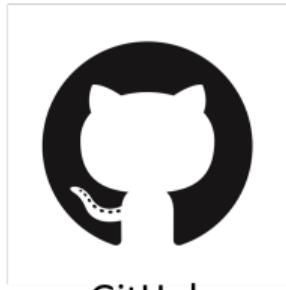
¹Virginia Tech

²National Tsing Hua University

³Facebook



Lower the barrier for others to follow



GitHub



Google colab

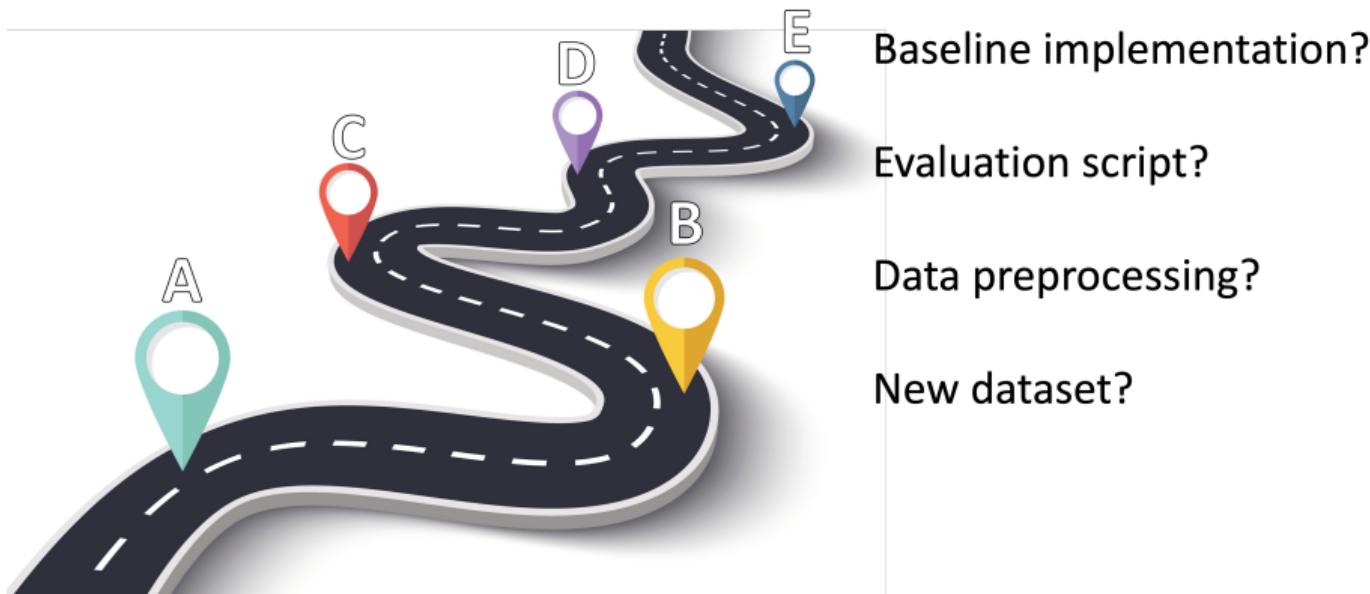


Hugging Face

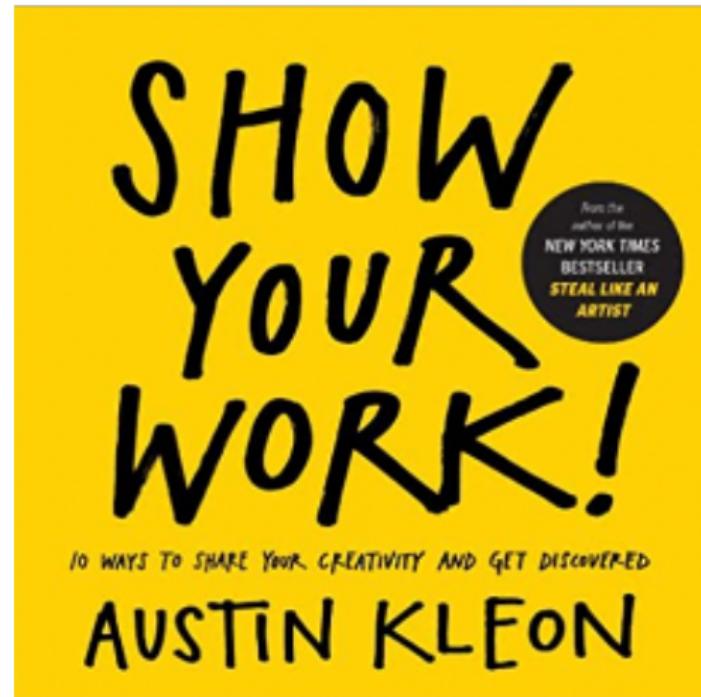


PyTorch hub

Make others' life easier



Show your work!



Your website, Zhihu, Weibo, bilibili, YouTube, Twitter, etc

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Effective communication!

Course schedule

Week	Date	Topics
1	2024. Sep. 03	Introduction to CS & AI
2	2024. Sep. 10	How to communicate
3	2024. Sep. 14	How to do presentation
4	2024. Sep. 24	How to be a good AI researcher (I): doing research I
5	2024. Oct. 07	How to be a good AI researcher (II): productivity and career
6	2024. Oct. 15	How to be a good AI researcher (III): academic paper writing and peer reviews
7	2024. Oct. 22	Sharing the experience of writing excellent academic papers and rebuttal
8	2024. Oct. 29	Practice course