CS 197 Notes

Course link - https://www.cs197.seas.harvard.edu/

A Framework for Generating Research Ideas
Lecture 10+11

How to generate research ideas?

Apply framework to:

Identify gaps in a research paper like research questions, experiment setup and findings.

Generate ideas to build on a research paper, task of interest, evaluation strategy, proposed method

Iterate on your ideas to improve quality

Identifying Gaps In A Research Paper **###**

Gaps can be in *what questions were asked*, *what experiments were setup* and the way the *paper is in with previous works*. Gaps point to future directions for research.

Identify gaps in research question

First, write the research question of the paper. Then write research hypothesis supporting that central research question. Research hypothesis is a precise testable statement of what the authors predict will be the outcome of the study. May have to infer hypothesis from experiments performed. Then, look at gaps between the research question and hypothesis, what hypothesis have not been tested?

Example Answer:

Research Question:
How well can an algorithm detect diseases without explicit annotation?

Research Hypothesis:
1. **A self-supervised model trained on chest X-ray reports (CheXzero) can perform pathology-classification tasks with accuracies comparable to those of radiologists.**
2. **CheXzero can outperform fully supervised models on pathology detection.**
3. **CheXzero can outperform previous self-supervised approaches (MoCo-CXR, MedAug, and ConVIRT) on disease classification.**

Gaps:
1. **Can CheXZero detect diseases that have never been implicitly seen in reports?**
2. **Can CheXZero maintain high-level of performance even when using a small corpus of image-text reports.**

Identify gaps in experiment setup

Pay attention to gaps. Any lack of experiments the way the method was evaluated? In the comparisons, implementation? Does the experimental setup test the research hypothesis convincingly? We are interested in the setup of experiments, not results.

Example Answer:

Research Hypothesis (with Experimental Setups):

1. ***A self-supervised model trained on chest X-ray reports (CheXzero) can perform pathology-classification tasks with accuracies comparable to those of radiologists.***
    a. **Evaluated on a test set of 500 studies from a single institution with a reference standard set by a majority vote – similar to what was used by previous studies. Comparison is performed to the average of 3 board-certified radiologists on the F1 and MCC metrics on 5 diseases. Gaps:**
2. ***CheXzero can outperform fully supervised models on pathology detection.***
    a. **Evaluated on the AUC metric on the average of 5 pathologies on the CheXpert test set (500 studies). Methods evaluated include a baseline supervised DenseNet121 model along with the DAM method with the reasoning "The DAM supervised method is included as a comparison and currently is state-of-the-art on the CheXpert dataset. An additional supervised baseline, DenseNet121, trained on the CheXpert dataset is included as a comparison since DenseNet121 is commonly used in self-supervised approaches."**
3. ***CheXzero can outperform previous self-supervised approaches (MoCo-CXR, MedAug, and ConVIRT) on disease classification.***
    a. **Setup as above.**

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Gaps:
   1. On hypothesis 1, The number of radiologists is maybe too small to
      decisively argue for being absolutely comparable to radiologists.
      Maybe the experience/training of the radiologists needs to be
      understood to qualify more precisely what constitutes radiologist
      level performance.
   2. On hypotheses 2/3, The number of pathologies evaluated for were
      limited by the number of samples in the test set. A larger set of
      pathologies evaluated would support the hypotheses more.
   3. On hypothesis 3, the number of self-supervised approaches compared to
      are limited - the choice of label-efficient approaches, ConVIRT,
      MedAug and MoCo-CXR. There are more self-supervised learning
      algorithms which can be compared to.
   4. On hypothesis 3, unclear also whether the comparisons are single
      models or ensemble models, or whether they use the same training
      source.
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Identify gaps in limitation, implicit and explicit

Now that we have identified gaps in the experimental setup, we make our way to the results and discussion. Here, we're on the lookout for expressed limitations of the work. Part of this work is easy: sometimes, there's an explicit limitation section that we can directly use, or we can infer it from statements of future work. However, sometimes the limitations of a method are expressed in the results themselves: where the methods fail

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Example Answer:

Gaps:

Explicitly Listed:
   1. “the self-supervised method still requires repeatedly querying
      performance on a labelled validation set for hyperparameter selection
      and to determine condition-specific probability thresholds when
      calculating MCC and F1 statistics.
   2. “the self-supervised method is currently limited to classifying image
      data; however, medical datasets often combine different imaging
      modalities, can incorporate non-imaging data from electronic health
      records or other sources, or can be a time series. For instance,
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      magnetic resonance imaging and computed tomography produce
      three-dimensional data that have been used to train other
      machine-learning pipelines.
   3. “On the same note, it would be of interest to apply the method to
      other tasks in which medical data are paired with some form of
      unstructured text. For instance, the self-supervised method could
      leverage the availability of pathology reports that describe
      diagnoses such as cancer present in histopathology scans”
   4. “Lastly, future work should develop approaches to scale this method
      to larger image sizes to better classify smaller pathologies.”

Implicit through results:
   1. The model’s MCC performance is lower than radiologists on atelectasis
      and pleural effusion.
   2. The model’s AUC performance on Padchest is < 0.700 on 19 findings out
      of 57 radiographic findings where n > 50.
   3. The CheXzero method severely underperforms on detection of “No
      Finding” on Padchest, with an AUC of 0.755.
```

Generating Ideas For Building on a Research Paper

1. **Change task of interest**

Apply main idea to a different modality?
Apply idea to different data type?

Apply idea to a different task? (Object detection or semantic segmentation, VQA?)
Change outcome of interest?

- Robustness properties of the model
- Data efficiency compared to other learning paradigms (fully supervised)

2. **Change the evaluation strategy?**

Evaluate on a different dataset?
Evaluate on a different metric? Give more insights.
Explain why it works/breaks?
Make different comparisons?

3. **Change the proposed method?**

Change training dataset?
Change pre-training/training strategy? (New checkpoints other than ImageNet, like LION-5B)
Change deep learning architecture?
Change problem formulation? (Multiple views as input)

Iterate on your idea

1. Search whether your idea has been tried?

Construct titles for you paper and search.

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Example: if I am interested in the application of a CheXzero-like approach
to other kinds of data, I might search for:
   -  contrastive learning histopathology text (no relevant results)
   -  contrastive learning histopathology genomic alteration (returned a
      match)
```

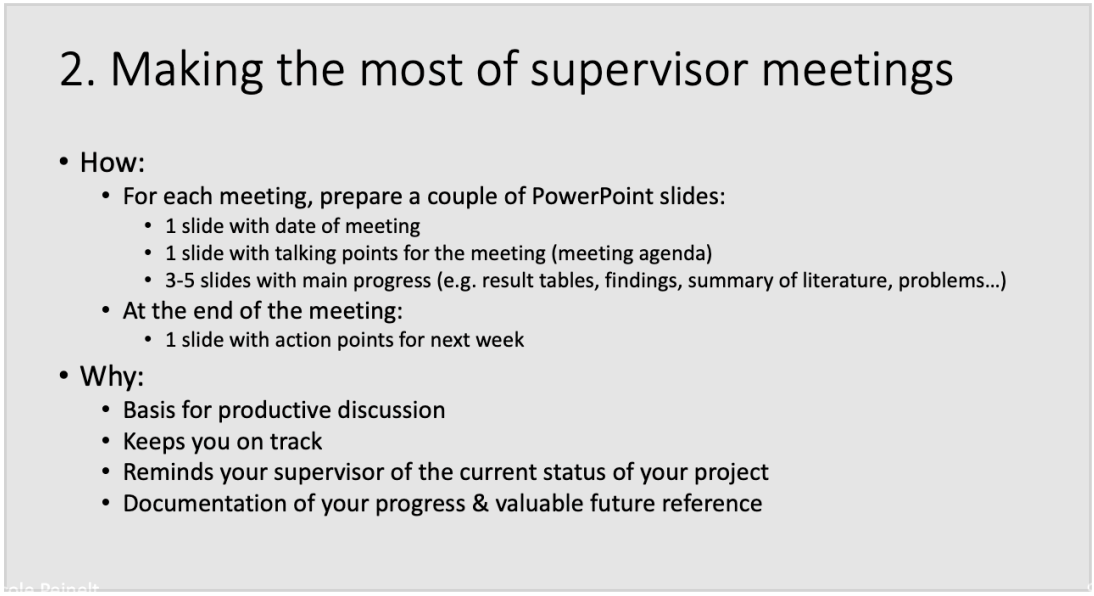
2. **Read Important Related Works and Follow Up Works**

See google scholar cited by, to find related works of the paper you are interested/building on. Arxiv, papers with code

3. Get feedback

Once draft is ready, send it to authors your building on, ask what they thing.

Tips to Manage Your Time and Efforts
Lecture 18



Think of the project tracker as your journal or diary or a log. It can remind you of the progress that you're making, and the direction you're headed. Every entry in the project tracker is marked by the date. In addition, Bullet points are organized and in sufficient detail such that a search that a future version of you project team member will be able to understand. The project tracker often links to important reference documents including a related work document, a working manuscript document, and an experimental results report (such as a google sheet or a Weights and Biases table.

Project Tracker in Google Docs Template:

Week of November 6-12

- Meeting Objective Description
- Progress Updates (per person)
    - Code
    - PRs
    - Text Descriptions
- Current Issues/Blockers
    - What has been done to address
    - What still needs to be attended to
- Next Steps (with assignments per person)

Making Progress and Impact in AI Research

Lecture 19

Mentor/Advisor Relationship

Your mentor/advisor is an input-output machine

Show your work

- what did you do

- why do it
- How you did it
- What did you find?
- Why do you think it does or does not make sense

Present failures

Provide context

Set expectations

Research skills

Imagine success
Work backward
Toy examples
Simple things first
One thing at a time “You don’t learn anything by changing multiple things at the same time.”

Create more impact

Put work out there

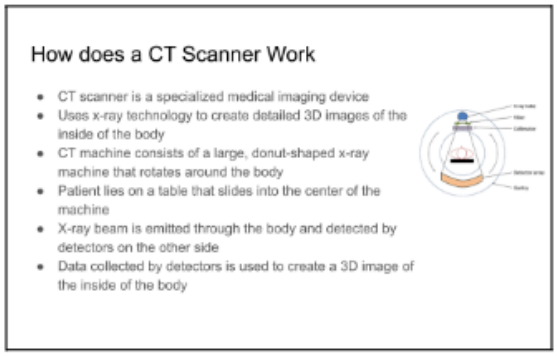
- Pick a good name
- Make results available
- Lower barrier for others to follow
- Make others’ life easier
- Show your work

Tips for Creating High-Quality Slides
Lecture 19

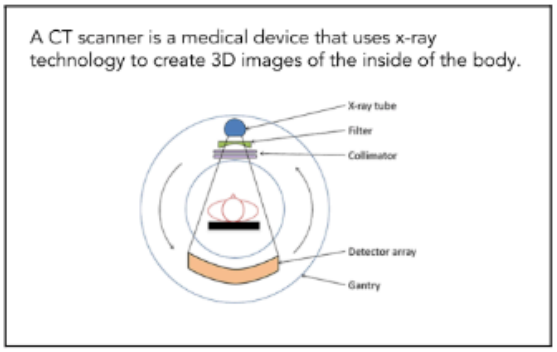
Assertion-evidence approach
1. Build talk on messages, not topics

2. Support messages with visual evidence, not long text,
3. Explain evidence by fashioning words on the spot

Script: *"A CT (computed tomography) scanner is a specialized medical imaging device that uses x-ray technology to create detailed 3D images of the inside of the body. The CT machine consists of a large, donut-shaped x-ray machine that rotates around the body while the patient lies on a table that slides into the center of the machine. As the machine rotates, it emits a beam of x-rays through the body, which is then detected by detectors on the other side of the body. The data collected by the detectors is then used to create a 3D image of the inside of the body."*

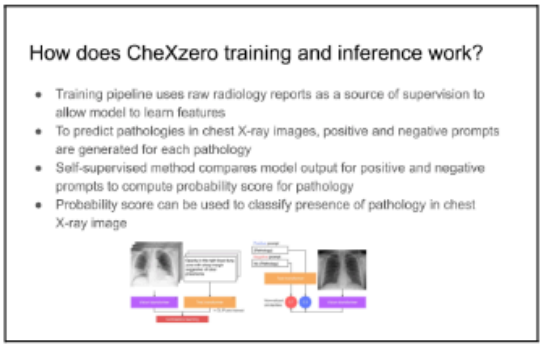


Bad ❌



Good ✓

Script: *"First, the CheXzero training pipeline involves using raw radiology reports as a natural source of supervision, allowing the model to learn features from them. Then, to predict pathologies in a chest X-ray image, we generated a positive and negative prompt for each pathology, such as 'consolidation' versus 'no consolidation'. By comparing the model output for the positive and negative prompts, the self-supervised method can compute a probability score for the pathology, which can then be used to classify its presence in the chest X-ray image."*



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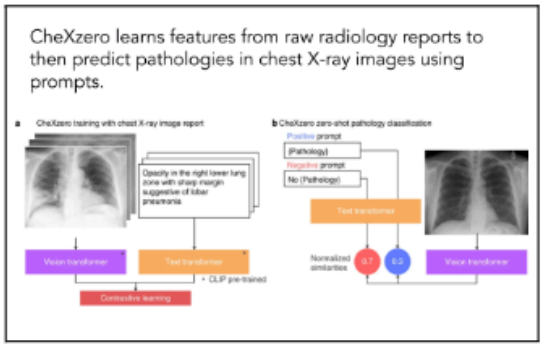

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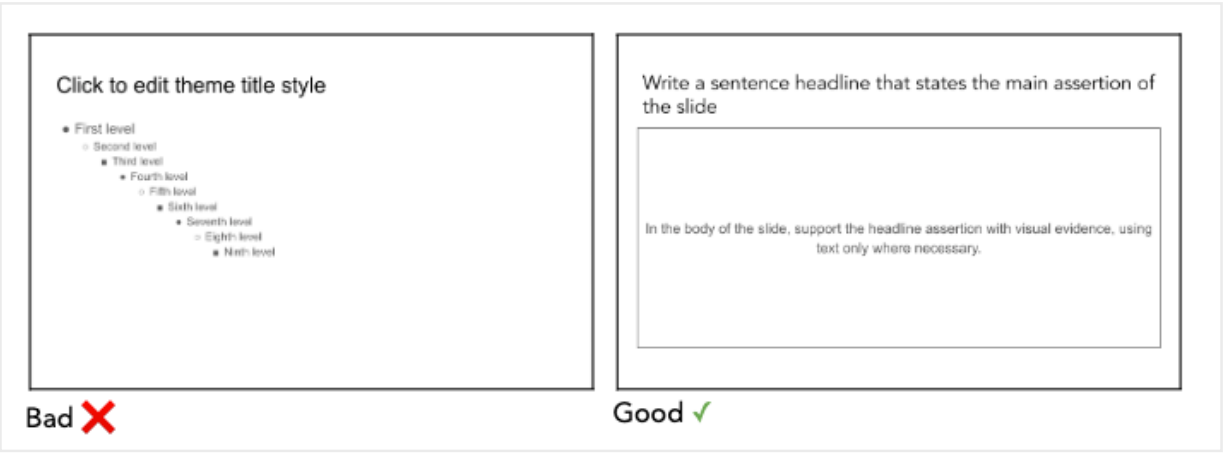


Bad ❌ Good ✓

Text telegrams

Bad ❌ Good ✓

Introduce Texts Sequentially

Second, introducing text sequentially rather than all at once. This makes reading or paraphrasing the slide to the audience more effective as the audience knows what point you are referring to. Comment fully on each line of text before moving on to the next one.

Build-up 1 Build-up 2 Build-up 3

Other tips

Use serif and sans-serif fonts together.

Serif fonts are typically used for body text because they are easier to read in large blocks of text due to the extra details on the letters. Sans-serif fonts are often used for headings and other large blocks of text because they are simpler and more modern-looking.

White background ,neutral and professional-looking

Using two colors for slide text can be effective because it can help to create a visual hierarchy and emphasize important points. For example, you could use a primary color for the main points and black for secondary points or supporting details. This can make it easier for the audience to follow the content and understand the structure of the presentation.

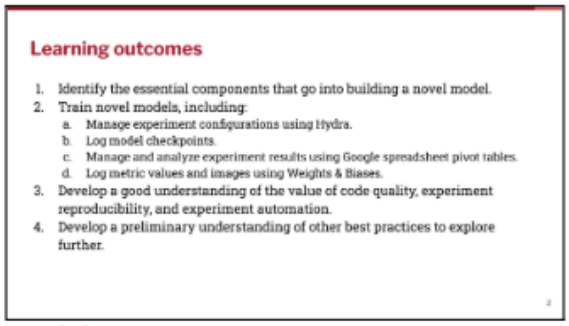
Use your slide footer for citations and page numbers

Including citations in the slide footer can be a helpful way to provide credit to the sources of your information and show that your presentation is based on credible research. To do this, you can use the slide footer feature in your presentation software to add a text box or field where you can include the citations for any sources you have used. This could include the author, title, and publication information for articles, books, or other resources.

Including the page number in the slide footer can also be useful for the audience, as it allows them to easily mark the page and ask questions about specific information during the presentation. This can be especially helpful if the audience wants to refer back to a specific slide or source later. To include the page number in the slide footer, you can use the built-in page numbering feature in your presentation software. This will automatically update the page number as you add or remove slides, so you don't have to manually update it yourself.

Overall, using the slide footer to include citations and the page number can help to make your presentation more professional and organized, and can also make it easier for the audience to follow along and ask questions.

Have an outline slide



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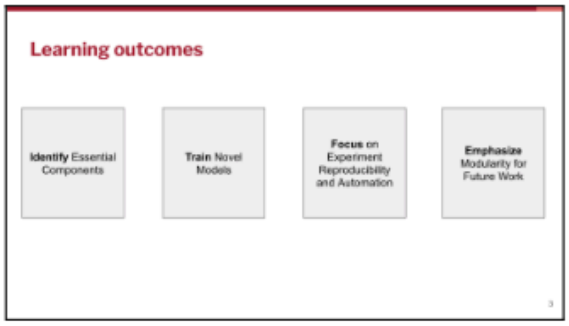
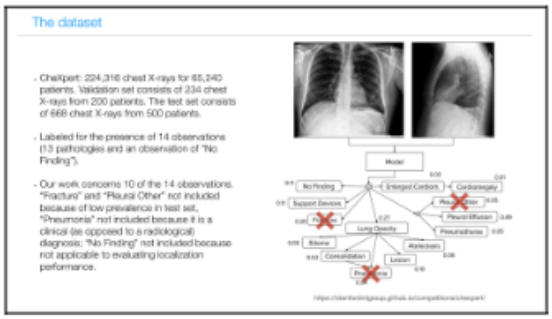


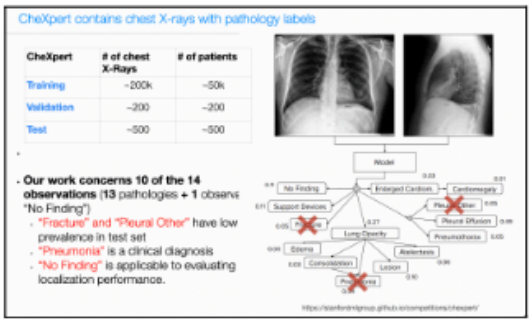
Better ✓

Reasoning:

- Eliminated unnecessary points that can be iterated on by the speaker
- Created object representations of each concept with the key word bolded with the main idea



Bad ✗



Better ✓

Reasoning:

- More descriptive title
- Less text
- Essential components extracted from figure with color
- Kept only orders of magnitude from the table