# How to Be a Good AI Researcher

**Tao LIN**

October 20, 2023

# Course schedule

| Week | Date | Topics |
|---|---|---|
| 1 | 2023. Sep. 01 | Introduction to CS & AI |
| 2 | 2023. Sep. 08 | How to communicate |
| 3 | 2023. Sep. 15 | How to present |
| 4 | 2023. Sep. 22 | How to be a good AI researcher (I): doing research |
| 5 | 2023. Oct. 13 | How to be a good AI researcher (II): productivity and career |
| 6 (this week) | **2023. Oct. 20 ← proposal submission** | How to be a good AI researcher (III): academic paper writing and peer reviews |
| 7 | 2023. Nov. 03 | Sharing the experience of writing excellent academic papers and rebuttal |
| 8 | 2023. Nov. 10 | Practice course |

# Acknowledgement


- Awesome Tips, Jiabin Huang
- How to write a rebuttal for a conference?, Jiabin Huang
- Responding to peer review, Matt Might
- How to write an author response to *ACL/EMNLP reviews
- How to Write a Great Research Paper,

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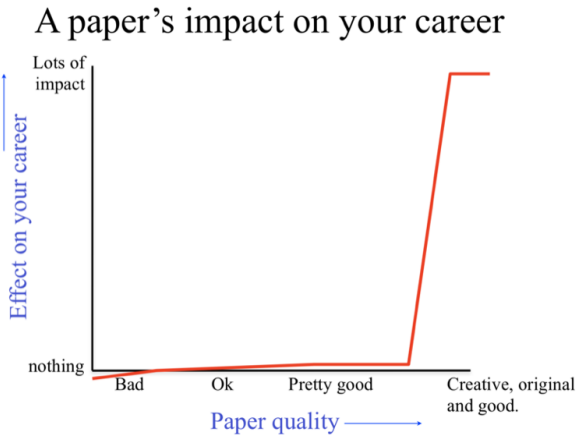
# Why we need a great paper



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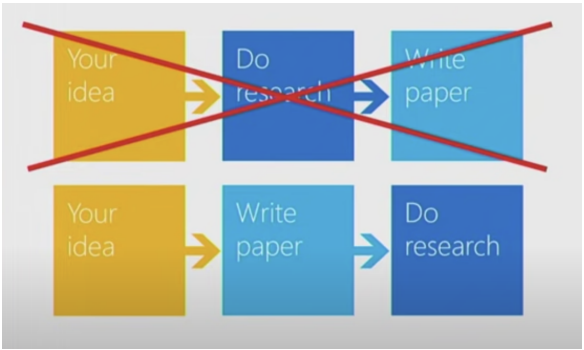

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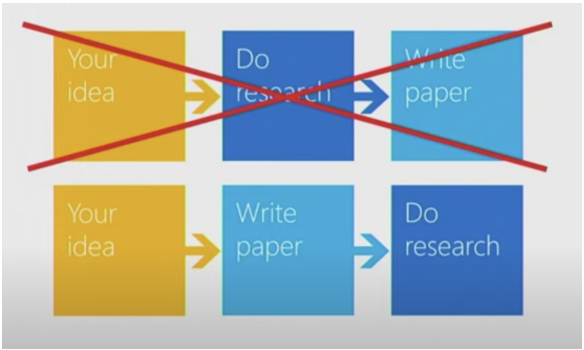


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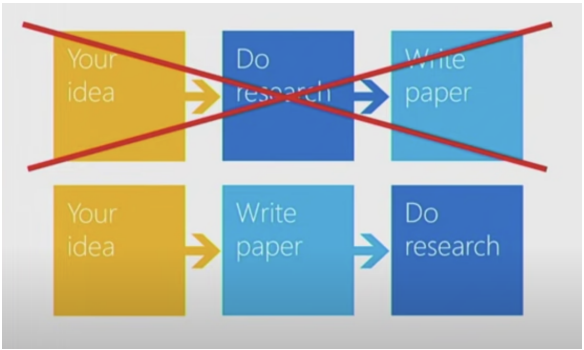


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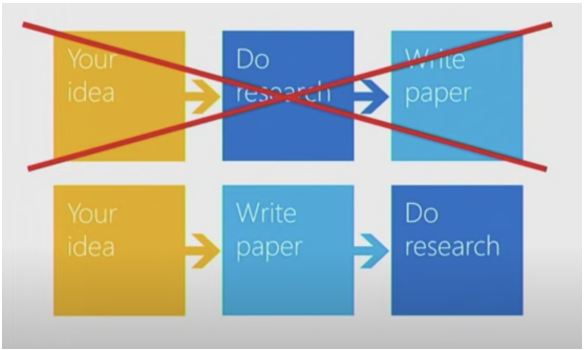


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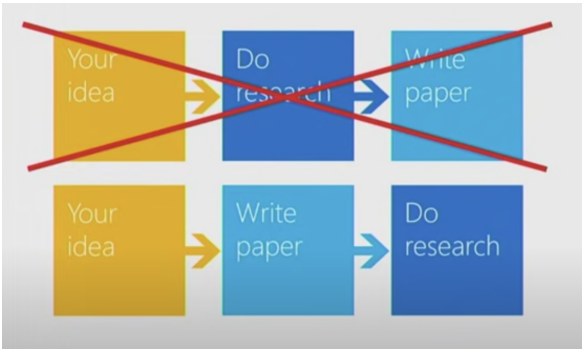


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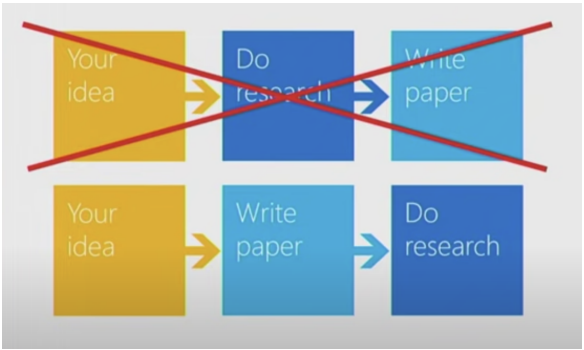


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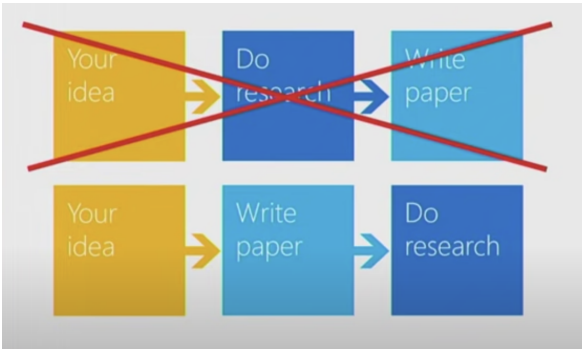


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- Be $100\%$ explicit about the idea

# General suggestions: Tell a story

Imagine you are explaining on a whiteboard

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Such flow also shapes the paper structure

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- Abstract ($4-5$ sentences, $100$ readers)
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- The problem ($1$ page, $10$ readers)
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Presenting the idea as on a whiteboard:

- Conveying the intuition is primary!
- Once your reader has the intuition, he/she can follow the details (but not vice versa)
- Even if he/she skips the details, he/she still takes away something valuable.

# Table of Contents

# Template: 3 Figures + 5 Questions

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- WHAT figure

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This helps the readers understand what your work is about.

# WHAT Example 1

Mask R-CNN showcases its key results upfront without waiting until the result section.

- Input: Single images
- Output: Instance segmentation masks


Figure 2. **Mask R-CNN** results on the COCO test set. These results are based on ResNet-101 [19], achieving a *mask* AP of 35.7 and running at 5 fps. Masks are shown in color, and bounding box, category, and confidences are also shown.

# WHAT Example 2

CycleGAN shows its ability to solve various unpaired image-to-image translation problems.

- Input: Images from domain A
- Output: Images from domain B

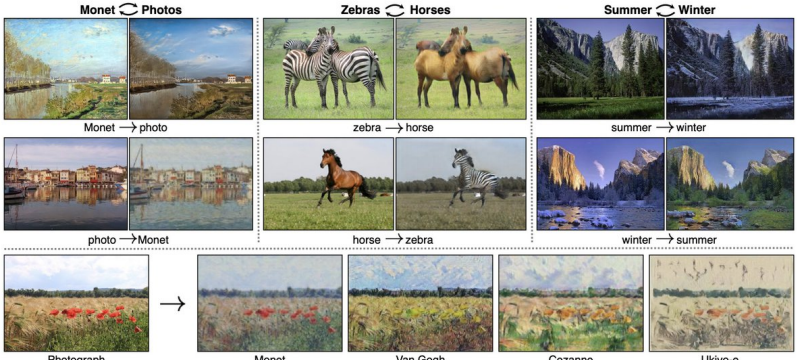


Figure 1: Given any two unordered image collections $X$ and $Y$, our algorithm learns to automatically "translate" an image from one into the other and vice versa: *(left)* Monet paintings and landscape photos from Flickr; *(center)* zebras and horses from ImageNet; *(right)* summer and winter Yosemite photos from Flickr. Example application *(bottom)*: using a collection of paintings of famous artists, our method learns to render natural photographs into the respective styles.

# WHAT Example 3

Obstruction removal paper

- Input: Obstructed images (reflection, fence, raindrop)
- Output: Clean images


(a) Reflection removal (b) Fence removal (c) Raindrop removal

Figure 1: **Seeing through obstructions.** We present a learning-based method for recovering clean images from a given short sequence of images taken by a moving camera through obstructing elements such as (a) windows, (b) fence, or (c) raindrop.

Since the images are aligned, we can use split frames to 1) save space and 2) highlight the contrast.

# WHY Figure

This figure provides the “motivation” for your work.

The best WHY figure illustrates the existing work’s core issue/problem with a concrete example:

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- SIMPLIFYING with a toy example and
- CONTEXTUALIZING with prior work

# WHY Example 1

The NEED for translation invariance with a concrete example:

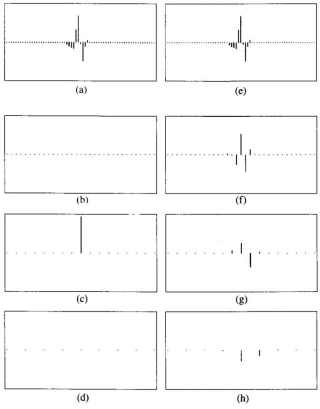


Fig. 1. Effect of translation on the wavelet representation of a signal. (a) Input signal, which is equal to one of the wavelet basis functions. (b)–(d) Decomposition of the signal into three wavelet subbands. Plotted are the coefficients of each subband. Dots correspond to zero-value coefficients. (e) Same input signal, translated one sample to to the right. (f)–(h) Decomposition of the shifted signal into three wavelet subbands. Note the drastic change in the coefficients of the transform, both within and between subbands.

- (a) Input signal
- (b-d) Coefficients of wavelet representations
- (e) Shifted the input signal by ONE sample
- (f-h) LOOK! Completely DIFFERENT coefficients

# WHY Example 2

The NEED for a more informative and intuitive description using relative attributes with concrete examples

(a) Smiling (b) **?** (c) Not smiling

(d) Natural (e) **?** (f) Manmade

Figure 1. Binary attributes are an artificially restrictive way to describe images. While it is clear that (a) is smiling, and (c) is not, the more informative and intuitive description for (b) is via *relative* attributes: he is smiling more than (a) but less than (c). Similarly, scene (e) is less natural than (d), but more so than (f). Our main idea is to model relative attributes via learned ranking functions, and then demonstrate their impact on novel forms of zero-shot learning and generating image descriptions.

# WHY Example 3

The Feature Pyramid Networks work shows multiple alternative design options (a-c) and their drawbacks. This helps motivate the NEED for their design of a fast & accurate model.

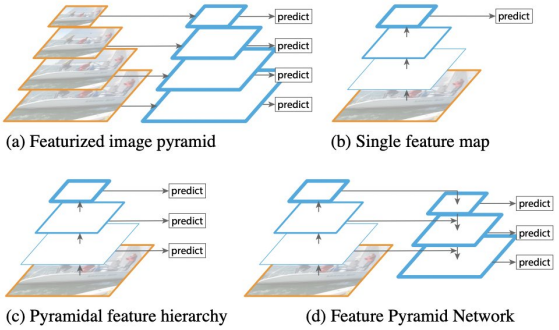


Figure 1. (a) Using an image pyramid to build a feature pyramid. Features are computed on each of the image scales independently, which is slow. (b) Recent detection systems have opted to use only single scale features for faster detection. (c) An alternative is to reuse the pyramidal feature hierarchy computed by a ConvNet as if it were a featurized image pyramid. (d) Our proposed Feature Pyramid Network (FPN) is fast like (b) and (c), but more accurate.

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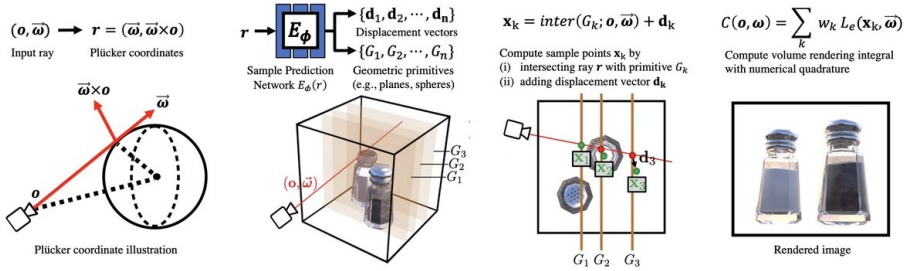
- Visualize the variables
- Cascade of small units: “Input -> some processing -> Output” (think about computational graph).

# HOW Example 1

The HyperReel paper visualizes the four main algorithmic steps.




(a) Ray parameterization (b) Sample prediction network (c) Sample generation (d) Volume rendering

Figure 2. **Overview of HyperReel for static scenes.** Given a set of images and camera poses, the training objective is to reconstruct the measured color associated with every ray. (a) Given an input ray originating at the camera origin $\mathbf{o}$ and traveling in direction $\vec{\omega}$, we first reparameterize the ray using Plücker coordinates. (b) A network $E_\phi$ takes this ray as input and outputs the parameters for a set of geometric primitives $\{G_k\}$ (such as axis-aligned planes and spheres) and displacement vectors $\{\mathbf{d}_k\}$. (c) To generate sample points $\{\mathbf{x}_k\}$ for volume rendering, we compute the intersections between the ray and the geometric primitives, and add the displacement vectors to the results. Predicting geometric primitives has the advantage of making the sample signal smooth and easy to interpolate (see Section 3.1). The displacement vectors grant additional flexibility to the sample points, enabling better capture of complex view-dependent appearance. (d) Finally, we perform volume rendering via Equation 2 to produce a pixel color and supervise training based on the corresponding observation.

Note the math notations, name, and detailed, self-contained figure caption.

# HOW Example 2

It shows the processing steps in each iteration:

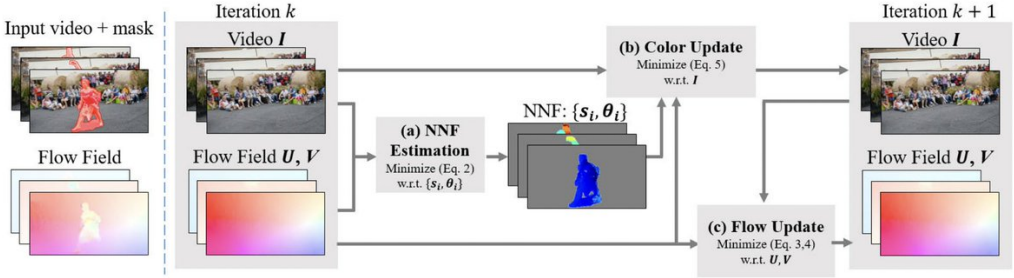



**Figure 2:** *Algorithm pipeline. Given the input video and user-selected mask, we start with computing the flow fields. After initialization at the coarsest scale (Section 4.4), in each scale our algorithm iterates through three steps (Section 4.3): (a) nearest neighbor field estimation: minimize the color spatial cost by finding dense approximate nearest neighbor source patches for all target patches; (b) color update: minimize the color spatial and color temporal cost so that the synthesized colors are both spatially and temporally coherent; and (c) flow update: refine the forward and backward flow fields. We then upsample the solution of the nearest neighbor field and flow fields to the next finer level. The color at the finer level is estimated by spatial patch voting (using the upsampled nearest neighbor field).*

# HOW Example 3

The Robust Dynamic Radiance Fields paper shows how all the math notations and variables connect with each other using this HOW figure. Note the descriptive figure caption.

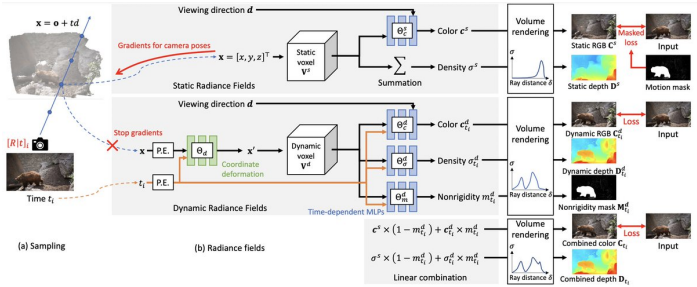



Figure 2. **Overall framework.** We model the dynamic scene with static and dynamic radiance fields. The static radiance fields take both the sampled coordinates $(x, y, z)$ and the viewing direction $\mathbf{d}$ as input and predict the density $\sigma^s$ and color $\mathbf{c}^s$. Note that the density of the static part is invariant to time and viewing direction, therefore, we use summation of the queried features as the density (instead of using an MLP). We only compute the losses over the static regions. The computed gradients backpropagate not only to the static voxel field and MLPs but also to the camera parameters. The dynamic radiance fields take the sampled coordinates and the time $t$ to obtain the *deformed coordinates* $(x', y', z')$ in the canonical space. Then we query the features using these deformed coordinates from the dynamic voxel fields and pass the features along with the time index to a time-dependent shallow MLPs to get the color $\mathbf{c}^d$, density $\sigma^d$, and nonrigidity $m^d$ of the dynamic part. Finally, after the volume rendering, we can obtain the RGB images $\mathbf{C}^{\{s,d\}}$ and the depth maps $\mathbf{D}^{\{s,d\}}$ from the static and dynamic parts along with a nonrigidity mask $\mathbf{M}^d$. Finally, we calculate the per-frame reconstruction loss. Note that here we only include per-frame losses.

With the WHAT-WHY-HOW figures, we are now ready to answer the following five questions!

- What's the problem?
- What have others done?
- What's the gap?
- What have you done?
- What do you contribute?

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Use your WHAT figure for visual references.

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- Describe what other solutions (SOTAs) are to your problem.

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- Describe what other solutions (SOTAs) are to your problem.
- Usually follows a historical trajectory, e.g., classical geometric methods did X, learning-based methods did Y, and recent hybrid methods did Z.

# Q3: What's the gap?

- Explain why all these existing solutions are NOT satisfactory (in some aspects).

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Use the example in your WHY figure to illustrate the *gap*.

# Q4: What have you done?

- Add “In this paper, ...” at the beginning of this paragraph. It helps provide a clean separation of the past/current work.

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Use your HOW figure to ground your discussions.

# Q5: What do you contribute?

- Not everything you do is “novel” e.g., a large part of your work may build upon some existing methods. Thus, it is a good practice to explicitly state your contributions.

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- Not everything you do is “novel” e.g., a large part of your work may build upon some existing methods. Thus, it is a good practice to explicitly state your contributions.
- Make a list so that lazy reviewers can use them in their reviews

In sum, the introduction section would look like this:

- What's the problem? (see WHAT figure)
- What have others done?
- What's the gap? (see WHY figure)
- What have you done? (see HOW figure)
- What do you contribute?

# Table of Contents

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Why?

- Figures/tables are much easier to understand than reading plain texts.
- Moving them to the top helps readers quickly understand your work.

# Self-contained figure/table caption and short titles

- Whatever you want to say for the figure/table, say them in the caption.

DON'Ts

DOs

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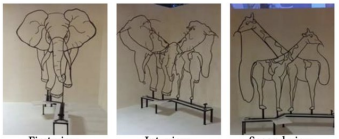

First view Int. view Second view

Fig. 2. **Example of multi-view wire sculpture art.** The anamorphose sculpture created by the French sculptor Matthieu Robert-Ortis is a classic example of *multi-view wire art*. When viewing from one specific angle, we perceive a drawing of an elephant. When viewing from another view point, the interpretation changes into two giraffes. The 2D projection in the intermediate view does not produce an interpretable image.

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  It's annoying to find and match the corresponding texts describing the figure/table in your paper.

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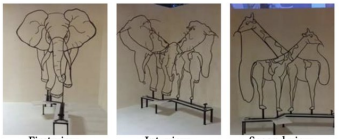

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Fig. 2. **Example of multi-view wire sculpture art.** The anamorphose sculpture created by the French sculptor Matthieu Robert-Ortis is a classic example of *multi-view wire art.* When viewing from one specific angle, we perceive a drawing of an elephant. When viewing from another view point, the interpretation changes into two giraffes. The 2D projection in the intermediate view does not produce an interpretable image.

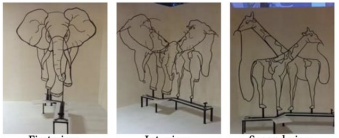
# Self-contained figure/table caption and short titles

- Whatever you want to say for the figure/table, say them in the caption.
  It's annoying to find and match the corresponding texts describing the figure/table in your paper.
- Add titles (e.g., using *paragraph*) to your figure/table captions and the main texts.

DON'Ts

Please refer to the texts for detail.

DOs



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  - They make your paper more structured and organized

DON'Ts

DOs

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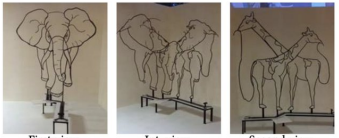

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  - They make your paper more structured and organized
  - They help your readers navigate the paper with ease.

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DOs

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# Avoid empty spaces

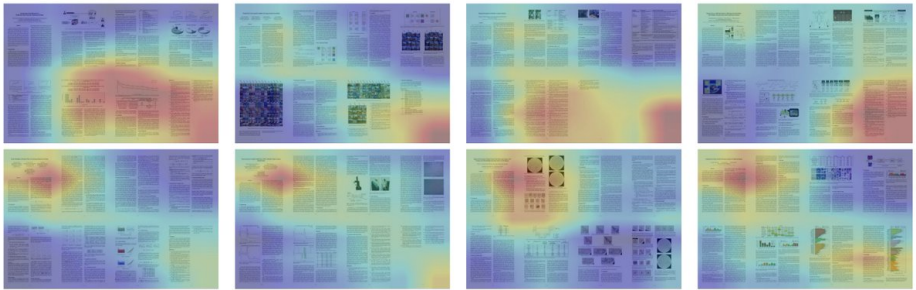


Figure 5. **Class-specific discriminative regions for *bad* papers.** (*Top*) Failing to fill the paper into a full eight-page paper is a discriminative visual cue for bad paper. (*Bottom*) The generated heatmaps focus on the top-right corner of the first page. This suggests that the *absence* of illustrative figures in the first two pages may cause the paper more difficult to understand.

Fill the paper into full page limit. It gives your readers a sense of a POLISHED and not RUSHED paper.

# Notations

DON'Ts

$$L = \lambda_1 L_1 + \lambda_2 L_2$$
$$\vdots$$
$$\lambda_1 = 0.1, \lambda_2 = 2.5$$

DOs

$$L_{total} = \lambda_{rec} L_{rec} + \lambda_{smooth} L_{smooth}$$
$$\vdots$$
$$\lambda_{rec} = 0.1, \lambda_{smooth} = 2.5$$

# Which

It is difficult to figure out what exactly “which” refers to.

DON’Ts

We present a method that addresses A, B, C, which is challenging due to X.

? ? ?

DOs

We present a method that addresses A, B, C. The problem A is challenging due to X.

# Respectively

It's hard to parse *which corresponds to which in the sentence that ends with "respectively"*

DON'Ts

We show results on three tasks. We improve the performance on the task A, task B, and task C by X%, from Y1 to Y2 mAP, and a Z point gain, respectively.

DOs

We show results on three tasks: On task A, we improve the performance by X%. On task B, we get a boost from Y1 to Y2 mAP. On task C, we achieve a Z point gain.

# Names for notations

When using notations in the sentences, mention their “names” as well.

DON’Ts

The $F_\theta$ takes $I_i, I_j$ as inputs and produce $W_{i\to j}$.

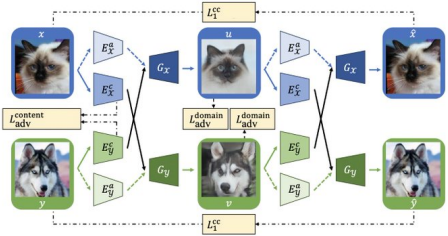
DOs

The flow estimation network $F_\theta$ takes a pair of frames $I_i, I_j$ as inputs and produces a dense flow field $W_{i\to j}$.

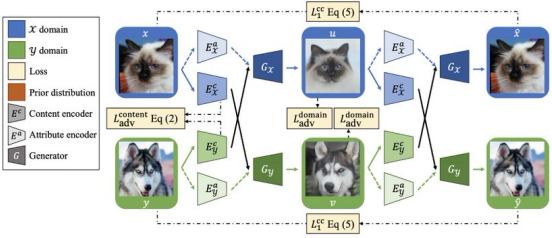
# Connect figures with equations, notations, and sections

An overview figure provides a centralized hub that connects all the important things.

DON'Ts

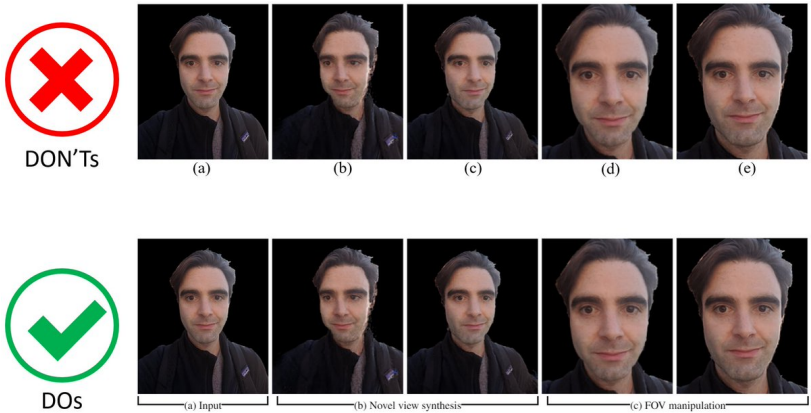



DOs



# Group subfigures

Don’t ask readers to figure out the grouping (b-c) and (d-e) in the caption.

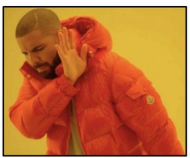


# Table of Contents

# Avoid vertical lines

Having vertical lines in a table almost always makes the table less readable.
Avoid them at all costs.

| | PSNR | SSIM | LPIPS |
|---|---|---|---|
| Method A | 23.55 | 0.872 | 0.592 |
| Method B | 24.51 | 0.853 | 0.391 |
| Method C | 25.13 | 0.834 | 0.865 |
| Ours | 25.78 | 0.895 | 0.478 |



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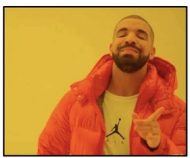
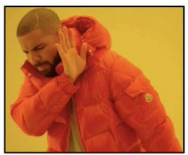


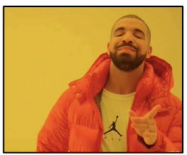
# Align everything

- Align texts to the left
- Align numbers to the center
- Align numbers at a consistent decimal point

| | PSNR ↑ | SSIM ↑ | LPIPS ↓ |
|---|---|---|---|
| Method A | 23.551 | 0.8723 | 0.59227 |
| Method B | 24.5 | 0.85 | 0.390 |
| Method C | 25.133 | 0.8344 | 0.86549 |
| Ours | 25.781 | 0.894 | 0.478 |



| | PSNR ↑ | SSIM ↑ | LPIPS ↓ |
|---|---|---|---|
| Method A | 23.55 | 0.87 | 0.592 |
| Method B | 24.51 | 0.85 | 0.391 |
| Method C | 25.13 | 0.83 | 0.865 |
| Ours | 25.78 | 0.89 | 0.478 |



# Encode rows with attributes

Factorize the variants/attributes of different methods → it becomes clear to compare one with another

DON'Ts

| Method | mAP |
|---|---|
| [Snorlax et al. 2018]* | 25.0 |
| [Bulbasaur et al. 2019]*† | 29.8 |
| [Psyduck et al. 2020] † | 32.1 |
| Ours | 35.5 |

DOs

| Method | External data? | Finetuned? | mAP |
|---|---|---|---|
| [Snorlax et al. 2018] | ✓ | - | 25.0 |
| [Bulbasaur et al. 2019] | ✓ | ✓ | 29.8 |
| [Psyduck et al. 2020] | - | ✓ | 32.1 |
| Ours | - | - | 35.5 |

# One table, one message

Decompose your big table so that each table conveys exactly one thing.

↓

This prevents people from having to compare results from distant rows.

DON'Ts

| Method | Acc (%) |
|---|---|
| Variant A1 | 75 |
| Variant A2 | 65 |
| w/o B | 77 |
| w/o C | 73 |
| Full model | 80 |

DOs

| Method | Acc (%) |
|---|---|
| Full model | 80 |
| Variant A1 | 75 |
| Variant A2 | 65 |

| Method | Acc (%) |
|---|---|
| Full model | 80 |
| Without B | 77 |

| Method | Acc (%) |
|---|---|
| Full model | 80 |
| Without C | 73 |

# Table organization

- Merge tables sharing the same structure.
- Label the metric (the larger/smaller the better) with up-arrow and down-arrow so that your readers don't need to look them up.

DON'Ts

| Method | Abs Rel | Sq Rel | RMSE | log RMSE | $\delta < 1.25$ | $\delta < 1.25^2$ | $\delta < 1.25^3$ |
|---|---|---|---|---|---|---|---|
| DeepV2D [56] | 0.526 | 3.629 | 6.493 | 0.683 | 0.487 | 0.671 | 0.761 |
| Ours - Single-scale pose (aligned MiDaS) | 0.380 | 2.617 | 5.773 | 0.533 | 0.562 | 0.736 | 0.832 |
| Ours - Single-scale pose + depth fine-tuning | 0.472 | 3.444 | 6.340 | 0.635 | 0.534 | 0.694 | 0.790 |
| Ours - Single-scale pose + depth filter | **0.375** | **2.546** | **5.763** | **0.530** | **0.569** | 0.738 | 0.835 |
| Ours - Flexible pose | 0.379 | 2.702 | 5.795 | 0.533 | 0.565 | 0.744 | 0.836 |
| Ours - Flexible pose + depth fine-tuning | 0.439 | 3.100 | 6.213 | 0.614 | 0.524 | 0.698 | 0.796 |
| **Ours - Flexible pose + depth filter** | 0.377 | 2.657 | 5.786 | 0.531 | 0.568 | **0.745** | **0.837** |

| Method | ATE (m) | RPE Trans (m) | RPE Rot (deg) |
|---|---|---|---|
| DeepV2D [56] | 0.9526 | 0.3819 | 0.1869 |
| Ours - Single-scale pose (aligned MiDaS) | 0.1883 | 0.0806 | 0.0262 |
| Ours - Single-scale pose + depth fine-tuning | 0.1686 | 0.0724 | 0.0139 |
| Ours - Single-scale pose + depth filter | 0.1882 | 0.0806 | 0.0262 |
| Ours - Flexible pose | 0.1843 | 0.0723 | 0.0095 |
| Ours - Flexible pose + depth fine-tuning | **0.1656** | **0.0651** | **0.0070** |
| **Ours - Flexible pose + depth filter** | 0.1843 | 0.0723 | 0.0095 |

DOs

| | Depth - Error metric↓ | | | | Depth - Accuracy metric↑ | | | Pose - Error metric↓ | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Method | Abs Rel | Sq Rel | RMSE | log RMSE | $\delta < 1.25$ | $\delta < 1.25^2$ | $\delta < 1.25^3$ | ATE (m)↓ | RPE Trans (m)↓ | RPE Rot (deg)↓ |
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Once the authors receive negative reviews of their submission,
they can write a response rebuttal to the reviewers' comments.

# Key facts before writing your rebuttal

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→ the reader can get back into the space quickly

→ without having to reread the paper or the original reviews

# General principles of the rebuttal

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  Don't dodge any points or refuse to answer any questions.
  If the reviewers found a flaw, admit the flaw and offer a fix (if you can find one).

# Structure of the rebuttal

- General response to all reviewers
- Responses to individual reviewers
- Confidential notes to ACs

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- It's reasonable to include a catch-all for minor stuff, something like
  - "We appreciate the reviewer's list of minor corrections and suggested references and will incorporate them in the next version."

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  - "We agree with the reviewer that X, but Y."
  - "The reviewer raises the incredibly important issue of X, and we see our paper as taking a first step to establish Y so that we can make progress on X."
- When a reviewer fails to appreciate the value of the kind of paper you've written, try to present the case in two ways:
  1. from first principles (even though it may feel like you're stating the obvious), but succinctly
  2. by pointing to similar papers accepted in the research community
- It's reasonable to include a catch-all for minor stuff, something like
  - "We appreciate the reviewer's list of minor corrections and suggested references and will incorporate them in the next version."
- If you want to make promises, make them assertively – "we will do X in the next version."

# Structure: Responses to individual reviewers

- Reflect back the things they liked about the paper.
  - For reviewers who liked your paper, this helps motivate them to fight on your behalf.
- Don't try to address everything, and don't argue. Focus on the most important issues you can respond to.
  - E.g., if there's a major misunderstanding about the paper's claims or findings, this is where you correct the record.
- Whenever you push back, start with common ground. E.g.,
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  - Don't leave them wondering by saying you "might" or "could consider" doing something.

# Structure: Confidential notes to AC

- If a reviewer didn't do their job, or clearly did not read the paper, or seems to be unprepared to review the paper properly → you can mention that here.
- Also see some reasons why not to reject papers below. If any of your reviews falls squarely into these categories, also bring it up to the ACs.

Finally, it's becoming more common for people to share reviews on social media, especially when the reviews reject the work on spurious grounds. These lead us to advise that the following are often invalid bases for rejecting a paper:

- The paper's language or writing style. Please focus on the paper's substance. We understand that there may be times when the language or writing style is so poor that reviewers can not understand the paper's content and substance. In that case, it is fine to reject the paper, however you should only do so after making a concerted effort to understand the paper.
- The paper's work is on a language other than English. We care about NLP for any language.
- The paper's results are not better than SOTA. Please look at the paper's contributions and findings, as discussed above and in this blog post.
- The paper does not use a particular method (e.g., deep learning). No one particular method is a requirement for good work. Please justify why that method is needed. Think about what the paper's contributions are, and bear in mind that having a diversity of methods used is not a bad thing.
- The paper's method is too simple. Our goal is not to design the most complex method. Again, think what the paper's contributions and findings are. Often the papers with the simplest methods are the most cited. If a simple method outperforms more complex methods from prior work, then this is often an important finding.
- The paper's topic is narrow or outdated. Please be open minded. We do not want the whole community to chase a trendy topic. Look at the paper's contributions and consider what impact it may have on our community.
- The paper's topic is completely new, such that there's no prior art or all the prior art has been done in another field. We are interested in papers that tread new ground.
- The paper is a resource paper. In a field that relies on supervised machine learning as much as NLP, development of datasets is as important as modeling work. This blog post discusses what can and cannot be grounds for dismissing a resource paper.

Please refrain from using the reasons above as primary grounds for rejection when writing your reviews. We will ensure authors are aware of these guidelines and can reference them during the author rebuttal period. ACs will be checking reviews carefully based on the above criteria, and may ask that you revise your review, or that you provide objective reasons to justify your positions.

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6. **Relax and revise**

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Remind the reviewers and AC of

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- missing baseline $\rightarrow$ baseline comparison

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3. Level 3: We tested it. It works. Here are the results. We will include them in the revised paper.

# Tips: Establish credibility for details/results already included in the paper

*R2: The baseline X is missing.*

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**Example 1**

As discussed on L512-538, we show the quantitative results in Table 3 and visual comparisons in Figure 4. We also include additional comparisons in the supp material.

# Tips: Be open and transparent

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- Do push back on mis-characterizations though.

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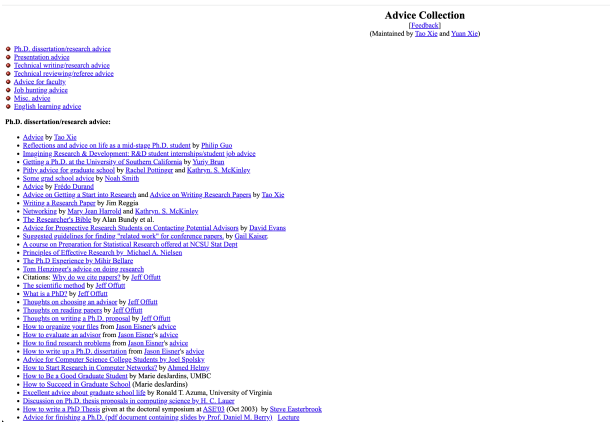
- Advice Collection



**Advice Collection**

[Feedback]

(Maintained by Tao Xie and Yuan Xie)

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- Presentation advice
- Technical writing/research advice
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- Imagining Research & Development: R&D student internships/student job advice
- Getting a Ph.D. at the University of Southern California by Yuriy Brun
- Pithy advice for graduate school by Rachel Pottinger and Kathryn. S. McKinley
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- Discussion on Ph.D. thesis proposals in computing science by H. C. Lauer
- How to write a PhD Thesis given at the doctoral symposium at ASE'03 (Oct 2003) by Steve Easterbrook
- Advice for finishing a Ph.D. (pdf document containing slides by Prof. Daniel M. Berry) Lecture