Writing a Paper & Research Career Paths

CS 197 | Stanford University | Michael Bernstein

Today's goals

We have a bunch of things we tried, some of them worked, some of them didn't — how do we write a paper about this?

Introducing the concept of **model papers** and how to use them

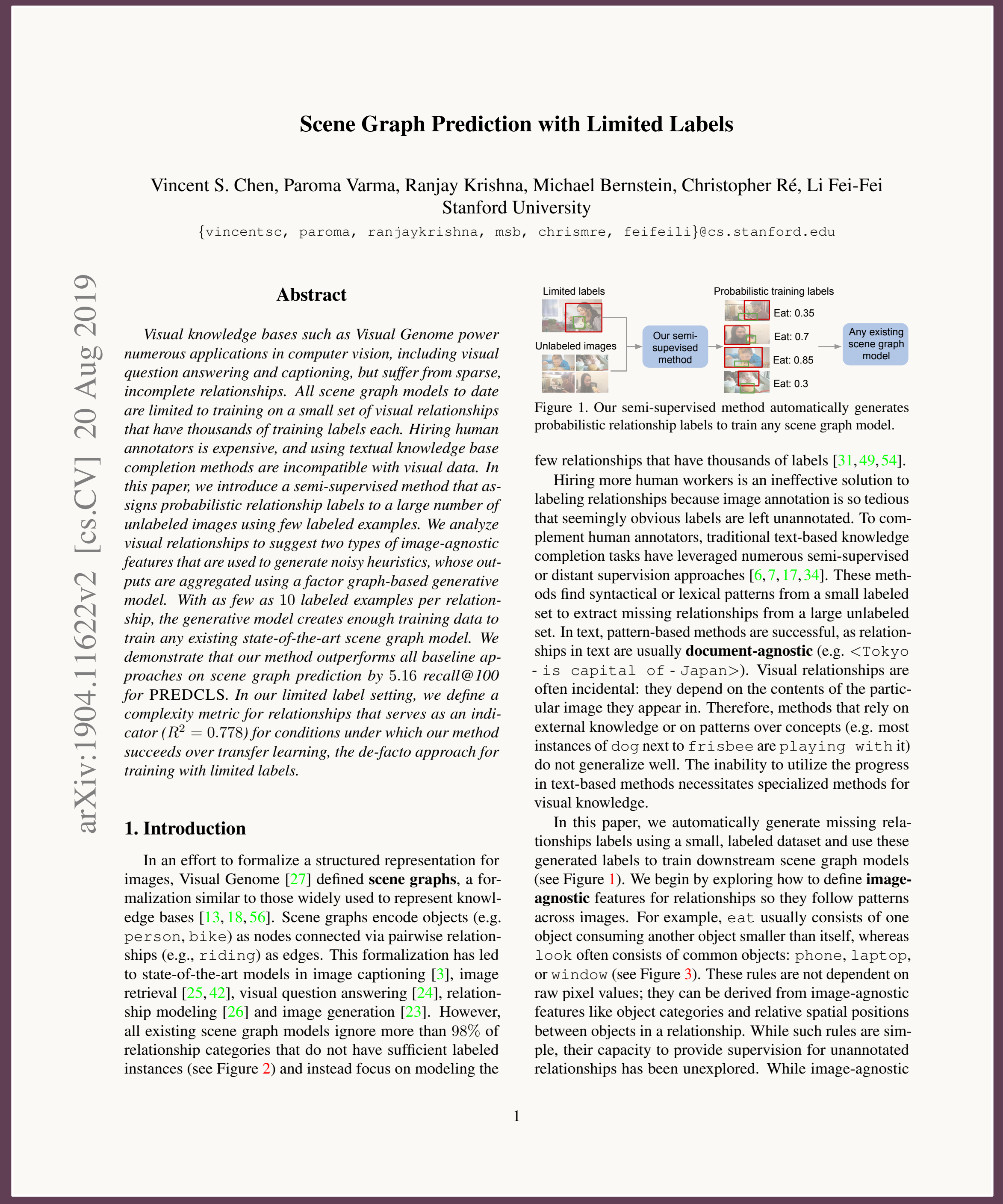
What happens if I keep doing research at Stanford? And after?

Writing A Paper


How do we get here?

The common malpractice

work
work
work
coffee
work
work
imposter syndrome
work



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Scene Graph Prediction with Limited Labels

Vincent S. Chen, Paroma Varma, Ranjay Krishna, Michael Bernstein, Christopher Ré, Li Fei-Fei
Stanford University
{vincentsc, paroma, ranjaykrishna, msb, chrismre, feifeili}@cs.stanford.edu

Abstract

Visual knowledge bases such as Visual Genome power numerous applications in computer vision, including visual question answering and captioning, but suffer from sparse, incomplete relationships. All scene graph models to date are limited to training on a small set of visual relationships that have thousands of training labels each. Hiring human annotators is expensive, and using textual knowledge base completion methods are incompatible with visual data. In this paper, we introduce a semi-supervised method that assigns probabilistic relationship labels to a large number of unlabeled images using few labeled examples. We analyze visual relationships to suggest two types of image-agnostic features that are used to generate noisy heuristics, whose outputs are aggregated using a factor graph-based generative model. With as few as 10 labeled examples per relationship, the generative model creates enough training data to train any existing state-of-the-art scene graph model. We demonstrate that our method outperforms all baseline approaches on scene graph prediction by 5.16 recall@100 for PREDCLS. In our limited label setting, we define a complexity metric for relationships that serves as an indicator ($R^2 = 0.778$) for conditions under which our method succeeds over transfer learning, the de-facto approach for training with limited labels.

1. Introduction

In an effort to formalize a structured representation for images, Visual Genome [27] defined **scene graphs**, a formalization similar to those widely used to represent knowledge bases [13, 18, 56]. Scene graphs encode objects (e.g. person, bike) as nodes connected via pairwise relationships (e.g., riding) as edges. This formalization has led to state-of-the-art models in image captioning [3], image retrieval [25, 42], visual question answering [24], relationship modeling [26] and image generation [23]. However, all existing scene graph models ignore more than 98% of relationship categories that do not have sufficient labeled instances (see Figure 2) and instead focus on modeling the few relationships that have thousands of labels [31, 49, 54].

Limited labels | Unlabeled images | Our semi-supevised method | Probabilistic training labels | Eat: 0.35 | Eat: 0.7 | Eat: 0.85 | Eat: 0.3 | Any existing scene graph model

Figure 1. Our semi-supervised method automatically generates probabilistic relationship labels to train any scene graph model.

Hiring more human workers is an ineffective solution to labeling relationships because image annotation is so tedious that seemingly obvious labels are left unannotated. To complement human annotators, traditional text-based knowledge completion tasks have leveraged numerous semi-supervised or distant supervision approaches [6, 7, 17, 34]. These methods find syntactical or lexical patterns from a small labeled set to extract missing relationships from a large unlabeled set. In text, pattern-based methods are successful, as relationships in text are usually **document-agnostic** (e.g. <Tokyo - is capital of - Japan>). Visual relationships are often incidental: they depend on the contents of the particular image they appear in. Therefore, methods that rely on external knowledge or on patterns over concepts (e.g. most instances of dog next to frisbee are playing with it) do not generalize well. The inability to utilize the progress in text-based methods necessitates specialized methods for visual knowledge.

In this paper, we automatically generate missing relationships labels using a small, labeled dataset and use these generated labels to train downstream scene graph models (see Figure 1). We begin by exploring how to define **image-agnostic** features for relationships so they follow patterns across images. For example, eat usually consists of one object consuming another object smaller than itself, whereas look often consists of common objects: phone, laptop, or window (see Figure 3). These rules are not dependent on raw pixel values; they can be derived from image-agnostic features like object categories and relative spatial positions between objects in a relationship. While such rules are simple, their capacity to provide supervision for unannotated relationships has been unexplored. While image-agnostic

1

Why is this malpractice? [1min with a partner]

Research papers are complex documents, with too many degrees of freedom to “just write”. Being strategic will save time and avoid dead ends.

…so what do we do instead?

There are many genres

Even within areas, there exist many different genres of paper. Each genre is typically built around the claim you are making, and implies a structure to the sections and to the writing. For example:

We solve a problem: articulate the problem, explain what causes that problem and what others have done to deal with it, detail your approach, and prove that you make progress on the problem

We measure an outcome: explain that nobody has bothered understanding how a phenomenon behaves, explain how to create a study that sheds light, and report the outcomes of it

We introduce a technique: articulate a problem as above, but focus the narrative on the technique you've created, since it will generalize

Genres imply structure

But, this will vary by area!

Common "We Solve A Problem" structure:

- Introduction: overview and thesis
- Related Work: situate your contribution relative to prior research
- Approach: describe your approach and important implementation details
- Evaluation: test whether your approach succeeds at its stated goals
  - Method
  - Results
- Discussion: reflect on limitations, implications, and future work
- Conclusion: summarize and restate your contribution

“Which genre is our project?”

You can often derive the appropriate genre in the same way that you derived the evaluation — what is the thesis and claim that you are supporting?

But this may be challenging until you’ve read a large number of papers. So instead…

Model papers

A model paper is a paper that you can use as a model or template for constructing your paper.

You should be able to structure your paper in the same way as your model paper

- Follow its general flow of argument in the introduction
- Use similar section and subsection heading organization
- Create figures, tables, and graphs that fulfill the same function as theirs
- Apply the same general proportions, e.g., number of pages per section

Selecting your model paper

Model paper != nearest neighbor paper

The model paper should be a paper that makes the same type of argument as yours. It should be in the same genre as you seek.

- Often the nearest neighbor paper will make a similar form of argument, but not necessarily
- Often the nearest neighbor paper will be a well-written paper, but not necessarily

Find your model paper and share it with your TA for a thumbs up before writing.

From model to paper

Start by outlining the model paper.

How does it structure its argument into sections?

What is the main expository goal of each section? What is its sub-thesis?

What role does each figure play?

From model to paper

Next, build a mapping from their outline to yours.

- Translate each section and sub-section heading into what the equivalent heading is for you
- Translate each sub-thesis into what the equivalent sub-thesis is for you
- Translate each figure into what the equivalent figure is for you

What if it doesn't quite fit?

Model papers should be templates, not straightjackets. You will probably need to adapt your mapping slightly from what your model paper does.

e.g., you require a slightly different evaluation structure or visualization than them

e.g., you're drawing on a different literature than them, and need to explain something that they didn't

You can play with the genre — just don't discard the genre. Check with your TA for any substantial changes that you want to make.

Research career paths

“OK, so I took CS 197, now what?”

What can you do after Stanford?

What can you do at Stanford?

Pathways for research

Research
is interesting

(we'll unpack this part
in a moment)

Professor

Research scientist in industry

Entrepreneur

Engineer / Engineering Lead

Professor

Work on research that you and the field find interesting.

Recruit the best rising talent in the world and mentor them.

Teach in your area of expertise.

Typical goals:

- Do research and have impact (e.g., publications, software adoption)
- Graduate amazing students
- Inspire students to learn about your area
- Room for personalization: entrepreneurship, speaking, consulting, &etc.

Research scientist

Join a company's research division and work on research from within the company. Examples: Microsoft Research, FAIR, nVidia Research, Google Brain

Typical goals:

- Do research and have impact (but more focus on translation to the company's products and less on publication)
- Create innovations that transform the company you're working for (e.g., Kinect, BERT, TPUs)

Entrepreneur

Start your own company, often based on the research you're doing, and grow it.

Typical goals:

- Scale your ideas and make them available to millions of people
- Start a new industry: your start-up is not a "me too" startup. Typically, it's pitching a dramatically new angle.
- Little focus on doing research in the short term

Engineer / Engineering Lead

Join a company and apply your skills toward the development of product

Typical goals:

- Be the company's expert in an area, and potentially grow a team to drive product in that space
- Typically, these jobs are for types of levels of expertise and experience that cannot be acquired through a BS or MS
- Little focus on doing research in the short term

What’s the distribution?

I looked into this! I scraped names of all Ph.D. graduates in Computer Science from Stanford, MIT, and UC Berkeley.

I then mapped the names onto LinkedIn pages (yes, LinkedIn availability adds bias, but we found about 75% of people)

Tag their jobs on their LinkedIn:

- Faculty: job titles including words such as "faculty" or "professor"
- Entrepreneurship: triggered by titles such as "founder" or ‘‘partner"
- Research scientist: titles such as "researcher" or "scientist" (natch)
- Engineer: titles such as "programmer" or "architect"

No statistically significant difference

No statistically significant difference

No statistically significant difference

Percentages add up to more than 100% because people can hold more than one position. Entrepreneurs and research scientists are a common mix. Faculty, likewise, can sometimes jump into industry research or start a company.

Pathways for research

Research
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(we'll unpack this part
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Research scientist in industry

Entrepreneur

Engineer / Engineering Lead

Pathways for research

Research
is interesting

Academic year
research

Summer CURIS
internship

BS with honors

Professor

Research scientist in industry

Entrepreneur

Engineer / Engineering Lead

Academic year research

Get units for doing research with a faculty member

- Generally, start with CS 195, which fulfills the CS Senior Project requirement, then go on to CS 199
- How to get started? Talk to your TA about possible faculty to approach, and we can help facilitate an introduction.
- Typically, you'll get involved in a project ongoing in the lab

Summer CURIS research

Apply your full effort toward a fun research project for the summer

- Get mentored by a faculty member and PhD student
- Get paid
- No need to balance the project against classes
- Live on campus

Typically, you join a project that's ongoing in the faculty member's lab

Apply early in winter quarter at curis.stanford.edu

BS with honors

Receive a special designation on your diploma (“BS with honors”)

Engage in a yearlong research project your senior year

- Takes the place of the senior project
- Typically, you do this with faculty who you’ve already been working with

Apply in the spring of your junior year

Pathways for research

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research

Summer CURIS
internship

BS with honors

Professor

Research scientist in industry

Entrepreneur

Engineer / Engineering Lead

Pathways for research

Research
is interesting

Academic year
research

Summer CURIS
internship

BS with honors

Ph.D.

Professor

Research scientist in industry

Entrepreneur

Engineer / Engineering Lead

All of you can succeed at a PhD!

A Ph.D. is a grown-up version of the research you do as an undergraduate or master's student. You get much more control over the projects you are working on, and become first author on the resulting publication.

It's challenging because we doubt ourselves constantly. But you also earn the ability to tackle any complex problem.

Cool side benefit: become Dr. [Lastname]

How do I get in to a Ph.D.?

The most important criteria for getting into a Ph.D. program is **demonstrated interest and ability** to do research.

"How do I demonstrate interest and ability?" **Do research!**

How do I get in to a Ph.D.?

In your statement, talk about research you did and the impact you had on the project. (You can include your CS 197 class project in it!)

You will want three recommendation letters from people with Ph.D.s to support your case.

- Typically, one is the faculty you worked most closely with on research. The other two can be supporting letters, or other research mentors. available.

What questions do you have?

Assignment 8: draft paper

Work together with your team to write a draft paper. This should be a complete draft in the template format of your research, and include reviewable drafts of every section.

“Can we include text we already wrote?” Absolutely! + tweaks

“Do we need the results of our evaluation?” Yes, but you can continue to update your results through the final presentations.

“What if our project doesn’t work out?” Still write up the report. Negative results can be valuable. Unpack in Discussion what it was about your idea or assumptions that wasn’t borne out.

Next week, we’ll be doing mock peer review of your draft papers!

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