

RESEARCH INTERESTS

I work on developing **explainable 3D perception methods via inverse generation**. I am excited about leveraging priors learned in generative models for computer vision, especially for extracting 3D information from everyday 2D videos or photographs. In the long term, I hope to work towards developing a unified framework for computer vision. To this end, I am keen to continue exploring the idea of reformulating visual perception as an inverse generation problem.

EDUCATION

Princeton University, Princeton, NJ

August 2020 - May 2024

Bachelor of Science in Engineering (BSE), Computer Science.

Graduated *magna cum laude*. Received certificates in Statistics & Machine Learning, Optimization & Quantitative Decision Science.

RESEARCH EXPERIENCE

Princeton Computational Imaging Lab | Department of Computer Science, Princeton University

June 2023 - Present

Research Assistant

Advisor: Prof. Felix Heide

Princeton NLP Group | Department of Computer Science, Princeton University

May 2022 - June 2023

Research Assistant

Advisor: Prof. Karthik Narasimhan

Princeton Visual AI Lab | Department of Computer Science, Princeton University

May 2021 - August 2021

Summer Lab Assistant

Advisor: Prof. Olga Russakovsky

PUBLICATIONS & RESEARCH

Under Review at Peer-Reviewed Journals

* denotes equal contribution.

1. Towards Generalizable and Interpretable Vision with Inverse Neural Rendering

Julian Ost*, Tanushree Banerjee*, Mario Bijelic, Felix Heide

Under review at Nature Machine Intelligence, 2024

We find that inverse neural rendering offers a new perspective on predictive computer vision, investigating differentiable rendering and generative models as a prior for spatial reasoning. Paper based on the arXiv preprint, *Inverse Neural Rendering for Explainable Multi-Object Tracking*.

ArXiv Preprints

2. Inverse Neural Rendering for Explainable Multi-Object Tracking

Julian Ost*, Tanushree Banerjee*, Mario Bijelic, Felix Heide

Project Page

arXiv:2404.12359

We propose to recast 3D multi-object tracking from RGB cameras as an *Inverse Rendering* problem. Our method is not just an alternate take on tracking; it enables examining generated objects and reasoning and resolving failure cases.

1. LLMs are Superior Feedback Providers: Bootstrapping Reasoning for Lie Detection with Self-Generated Feedback

Tanushree Banerjee, Richard Zhu, Runzhe Yang, Karthik Narasimhan

arXiv:2408.13915

We investigated a bootstrapping framework that leverages LLM-generated feedback to detect deception in diplomacy games. Our approach achieved a 39% improvement over the zero-shot baseline in lying F1 without any training.

Ongoing projects

1. OD-VAE¹: Unlocking Analysis-by-Synthesis for Explainable 3D Object Detection

Tanushree Banerjee*, Julian Ost*, Maolin Mao, Mario Bijelic, Felix Heide

We propose a novel method tackling 3D object detection using an analysis-by-synthesis paradigm to leverage the strong learned priors in a Variational Auto-Encoder (VAE).

Theses

1. Inverse Neural Rendering for Explainable 3D Perception

Tanushree Banerjee. Advisor: Prof. Felix Heide

Undergraduate Senior Thesis, Princeton University, 2024

This thesis explores unlocking explainable 3D perception via Inverse Neural Rendering. *Part I* proposes and evaluates a novel take on 3D multi-object tracking, while *Part II* proposes recasting 3D object detection as an inverse generation problem.

Independent Work Reports

2. Reducing Object Hallucination in Visual Question Answering

Tanushree Banerjee. Advisor: Prof. Olga Russakovsky

Princeton University, Spring 2023

This paper proposes several approaches to identify questions not related to an image to prevent object hallucination in VQA models. The best approach achieved an improvement of 40% over the random baseline.

1. Bias in Skin Lesion Classification

Tanushree Banerjee. Advisor: Prof. Olga Russakovsky

Princeton University, Spring 2022

This paper analyzes the bias in a model against underrepresented skin tones in the training data set on skin lesion classification.

¹Object Detection-Variational Auto-Encoder

SELECTED AWARDS & ACHIEVEMENTS

- **Outstanding Computer Science Senior Thesis Prize** for my senior thesis, *Inverse Neural Rendering for Explainable 3D Perception*, advised by Prof. Felix Heide. One of 6 in 216 in the graduating class of the CS Dept. to receive the award (2024).
- **FitzRandolph Gate Award** for presentation on *Inverse Neural Rendering for Explainable Multi-Object Tracking* at Princeton Research Day (2024).
- Nominated for the **CRA Outstanding Undergraduate Research Award** by the CS Department at Princeton for my research contributions to the paper *Bootstrapping Reasoning for Lie Detection with Self-Generated Feedback*, advised by Prof. Karthik Narasimhan (2023).

TEACHING & ACADEMIC SERVICE

Undergraduate Course Assistant: Independent Work Seminar

Spring 2024

I held office hours for students in the seminar on *AI for Engineering and Physics* taught by Prof. Ryan Adams, helping them debug their code and advising them on their semester-long independent work projects.

Princeton AI4ALL Research Instructor

Summer 2022

Taught AI technology and policy to 11th grade students from underrepresented groups. Led NLP workshops and developed coding tutorials and lectures in preparation for an NLP-based capstone project. Organized guest lectures given by Princeton faculty.

CSML Undergraduate Student Ambassador

Fall 2023 - Spring 2024

Participated in CSML faculty recruitment interviews, helped organize CSML student social events.

SELECTED COURSE PROJECTS

5. **[Re] METRA: Scalable Unsupervised RL with Metric-Aware Abstraction** *Reinforcement Learning, Spring 2024*
Tanushree Banerjee*, Tao Zhong*, Tyler Benson*. Advisors: Prof. Benjamin Eysenbach, Prof. Mengdi Wang
In this reproduction study, we validate the claims of Park et al., 2024, who propose a novel unsupervised RL objective that learns diverse, useful behaviors and a compact latent space that can zero-shot solve various downstream tasks.
4. **Counterfactual Analysis for Spoken Dialogue Summarization** *Fundamentals of Deep Learning, Fall 2023*
Tanushree Banerjee*, Kiyosu Maeda*. Advisor: Prof. Sanjeev Arora
We investigate the effect of errors in speaker diarization and speech recognition on an LLM's summarization performance via counterfactual analysis, i.e. automatically injecting speaker diarization or speech recognition errors into spoken dialogue.
3. **Towards Efficient Frame Sampling Strategies for Video Action Recognition** *Computer Vision, Spring 2023*
Tanushree Banerjee*, Ameya Vaidya*, Brian Lou*. Advisor: Prof. Olga Russakovsky
We propose and evaluate two dataset and model-agnostic frame sampling strategies for computationally efficient video action recognition: one based on the norm of the optical flow of frames and the other based on the number of objects in frames.
2. **What Makes In-Context Learning Work On Generative QA Tasks?** *Understanding Large Language Models, Fall 2022*
Tanushree Banerjee*, Simon Park*, Beiqi Zou*. Advisor: Prof. Danqi Chen
We empirically analyze what aspects of the in-context demonstrations contribute to improvements in downstream task performance, extending the work of Min et al., 2022 to multiple choice and classification tasks.
1. **[Re] Double-Hard Debias: Tailoring Word Embeddings for Gender Bias Mitigation** *NLP, Spring 2022*
Tanushree Banerjee*, Jessica Ereyi*, Kevin Castro*. Advisors: Prof. Danqi Chen, Prof. Karthik Narasimhan
We reproduce the results of Wang et al., 2020 to reduce the gender bias present in pre-trained word embeddings and evaluate generalization to non-English languages by evaluating their method on Spanish GloVe word embeddings.

OTHER WORK EXPERIENCE

Software Engineering Intern | Nautilus Software Technologies

December 2020 - January 2021

Recreated the classic code-breaking game *Mastermind* in chat-bot format on Facebook Messenger using JavaScript. Collaborated in a team to present progress in the project to other student interns. Advised by Prof. Chee Wei Tan.

Circulation Desk Assistant | Princeton University

September 2021 - November 2021

Worked part-time ~15 hours per week at the Engineering Library. Managed the main floor, maker space, and engineering stacks. In charge of books that were checked in or out.

REFERENCES

1. **Prof. Felix Heide**, Assistant Professor, Princeton University fheide@cs.princeton.edu
2. **Prof. Karthik Narasimhan**, Associate Professor, Princeton University karthikn@cs.princeton.edu
3. **Prof. Olga Russakovsky**, Associate Professor, Princeton University olgarus@cs.princeton.edu