Research Statement

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Background

- Provides a context of your research interests. Why does it matter?

I am working on statistical machine learning for computer visions.

The field of computer vision is bifurcated. Neural networks dominate the benchmarks of most fields but are not explainable. Theoretical solutions are interpretable but perform far worse than neural networks. Our goal is to develop a mathematical framework that adds value to existing neural networks.

Why does it matter? The lack of interpretable neural-networks means they must be re-trained for each task. The result is a plethora of networks, one for each sub task. For example, there may be a dedicated network of object detection, another of classification, a third for anomaly detection and a fourth for saliency detection. Indeed, as adding just a single class to a neural network requires extensive retraining, there are often dedicated for individual categories like cats, dogs, birds, cars etc.

A practical vision system requires that the various networks be fused into a coherent whole; good mathematics would greatly facilitate this endeavor, as we show below.

Research Areas

- If you have multiple research areas, describe each area under a separate section.
- For each research area, please describe
    - what you have been doing recently and currently. What are the research problems and the proposed solutions? How does your research contributed to your field.
    - In what direction do you plan to go? What are the research problems you plan to attack? Why are these important or interesting problems to your field, or area of practice, or to society at large?

(Please take the time to describe your interests and ideas in intellectually stimulating and interesting ways. Do not just rely on a list of paper titles to convey what is interesting and exciting. Write your statement in a way that highlights interesting questions, ways of pursuing these questions, and the types of insights you are accumulating.)

We believe current statistical machine learning's poor performance is due to reliance on unrealistic assumptions. The two most problematic assumptions are:

- Assuming data can be projected to a low dimensional subspace that separates the classes of interest. This can be understood intuitively by replacing the term low dimensional with small number of attributes. Thus, the claim that low dimensional subspaces will separate classes, is equivalent to claiming a few attributes suffice to distinguish between millions of classes: cats, mountains, cars, elephants and churches, traffic lights, zebra crossings, lions, fountains, televisions, ants, etc. This is unlikely to be true.
- Assuming data arises from several generative processes, with class labels acting as symbolic names for individual generative processes. While plausible in theory, in practice, image formation is impacted by many instance specific factors such as lighting, background, white balance, etc. These may have a greater impact on the image appearance than the object of interest, making such factors impossible to ignore. However, most statistical techniques assume instance specific factors do not exist [1].

This year, we have completed our high dimensional statistical research and used it to model instance specific factors as a noise term that can be cancelled [1]. This allows us to develop statistical algorithms that use generic image features to perform a wide range of tasks. We have demonstrated this technique on classification [1], incremental learning [1] and anomaly detection [2]; we are currently the state-of-the-art for the latter two tasks.

More than just benchmark results, our work makes it possible to manipulate generic image features without the need for explicit training. This in turn allows a single neural network to perform tasks that previously required multiple networks. Further, the single network will perform these tasks exceptionally well.

Future work:

- Include more task in our statistical framework (object detection); may need grant money.
- Extend our statistical learning to neural network training; might not need grant money.
- Popularize the method; may need grant money.

Caveat: I am guilty of the incorrect assumptions listed above. We live and learn. =)

Selected Publications and Outputs

- **[1] Wen-Yan Lin**, Siying Liu, Hongdong Li, "Distance Classification: A solution to generative classification's conundrum?", *International Journal of Computer Vision, 2022.*

- **[2] Wen-Yan Lin***, Zhonghang Liu*, Siying Liu, "Locally Varying Distance Transform for Unsupervised Visual Anomaly Detection", European Conference of Computer Vision (ECCV), 202*2.*

**Denotes joint first author.*