Understanding image processing in brains and deep neural networks

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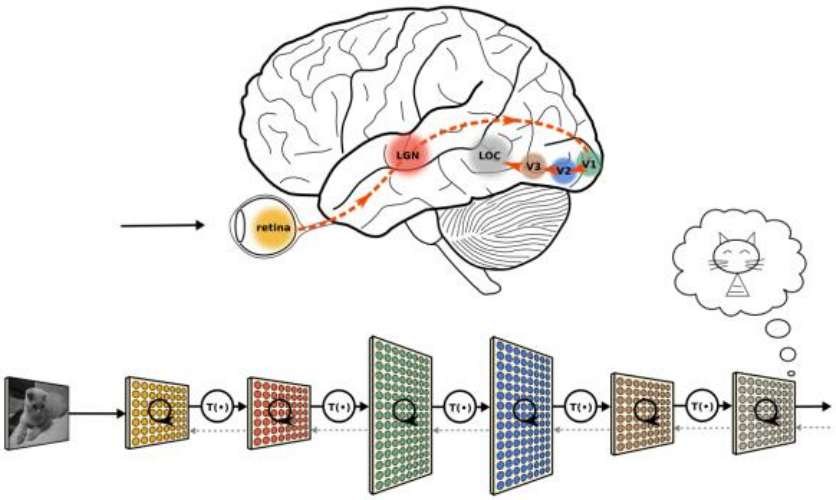

Summary

Convolutional neural networks (CNNs) have seen spectacular success in tasks like object recognition in recent years. Their internal representations have been found to match coarsely with the visual pathways in the brain. Yet, deep networks still show a performance gap compared to humans and are very susceptible to small perturbations. How can we bridge this gap? One approach is to understand how visual processing in the brain, extract interesting principles and then investigate whether these principles can be applied to improve deep networks. Conversely, interesting principles observed from deep networks can be used to understand why there are distinct brain regions with specific response properties and connectivity. Another important difference between brains and deep networks is that there are massive feedback connections between visual areas in the brain. The role played by the feedback connections in biological visual information processing is not well understood though there have been many hypotheses and studies over the last two decades.

This project seeks to investigate these issues in two ways. First, we will investigate visual image processing in the brain, identify general principles that can be used to improve deep networks. Second, we will study some general mechanisms of feedback models for CNNs, study their biological plausibility and investigate whether incorporating feedback into deep networks can improve their performance, and also gain some understanding of feedback in the mammalian visual system. In both cases the goal is to establish a two-way dialogue between deep networks and brains in the realm of visual image processing.

Eligibility

The ideal candidate should be highly motivated to study and work at the intersection of neuroscience and artificial intelligence. Basic experience in one or more of the following areas is desirable but not mandatory: image processing /computer vision/signal processing/machine learning/basic programming/analysis of brain signals (EEG/MRI data)/psychology/physiology.

Further reading

1. Jacob G, Pramod RT, Katti H & Arun SP (2021) Qualitative similarities and differences in visual object representations between brains and deep networks. *Nature Communications*, 12, 1872
2. Y Huang et al. (2020) Neural networks with recurrent Generative Feedback, *Advances in Neural Information Processing Systems (NeurIPS)*, 33:535-545

More Information

Webpage of Prof SP Arun | Webpage of Prof PS Sastry