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Research Topic
Computational neuroscience

Research Problem
How does the brain process visual information?

Problem Statement
Given a set of images, construct a model of how visual signals are encoded and processed in the brain.

Operational Definitions
Visual signals: Information about visible light that is sent from the eyes to the brain that allows us to perceive our surroundings.

Encoding: The process of translating information received from sensory organs (here, specifically the eye) into electrical pulses that can be transmitted to the brain. The brain processes this information and reconstructs a three-dimensional representation of the image being viewed.

Problem Description
Human beings have a remarkable ability to process images. We can look at a two-dimensional photograph and from it construct a three-dimensional mental representation of the photo's subject. How we do this is still the subject of scientific investigation. In order to better understand how human beings process images, Lee's research explores the computational principles and neurological mechanisms that are the basis of our powers of visual perception. By extracting statistical structures from a set of two- and three-dimensional images, it is possible to predict plausible neural representations of the images based on the principle of efficient coding.

Computer Science Perspective
Using machine learning techniques, it is possible to discover structures in visual data that may not be immediately obvious from simply looking at an image. For example, shading present in a two-dimensional image can be used to predict the three-dimensional shape of the original image based on previous correlations between shape and shading. Computers are also very useful for

running simulations of neurobiological processes, allowing researchers to test different methods of encoding visual data and see which ones come closest to reproducing the original image.

Description of Disciplines Involved
Since this research is primarily about how the brain works, neuroscience plays an important role, as do related areas of biology (e.g. neurobiology) and physiology. Lee also uses mathematical and statistical models to find structures in the data and determine how neurons encode information.

Actively Involved Disciplines
Computer science, neuroscience.

Operational Definitions
Actively Involved Discipline: Any discipline from which one or more researchers made a significant contribution to the research design and interpretation of the results. Typically, the resulting research would add to the actively involved discipline's body of knowledge in some way, thus benefiting the discipline as a whole.

References
Presenter's homepage:
http://www.cnbc.cmu.edu/~tai/

Papers:
Lee, T.S., Yuille, A (2006) Efficient coding of visual scenes by grouping and segmentation: theoretical predictions and biological relevance. in Bayesian Brain, probabilistic approaches to neural coding. Ed. K. Doya, S. Ishii, R. Rao, A. Pougeti. MIT Press, 141-185.

Potetz, B., Lee, T.S. (2006) Scaling Laws in Natural Scenes and the Inference of 3D Shape. *NIPS -- Advances in Neural Information Processing Systems* 18, 1089-1096, MIT Press.

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