

Project Summary

1. Intellectual merit.

Finding statistical models for the bewildering varieties of visual patterns in natural scenes such as object patterns and texture patterns is at the core of understanding the mystery of vision. The availability of large amount of image data from free large data bases and from the internet, the richness and diversity of the structures underlying image data, and the difficulty in understanding and interpreting image data pose great challenges to conventional statistical thinking and methodologies. They also create great opportunities for statisticians to develop new ideas and methods that will greatly advance the state of the art of statistical modeling, learning and computing.

Continuing the pattern theoretical approach pioneered by Grenander and advocated by Mumford, and building on the active basis model that the PIs have recently developed, the PIs propose three research projects to further develop statistical models as well as the associated learning and inference algorithms for representing, learning and recognizing visual patterns. The proposed research will shed new lights on existing statistical models and will lead to novel statistical models and learning algorithms. In particular, it will contribute to statistics and vision in the following aspects. (1) It will lead to powerful and parsimonious statistical models for both object patterns and texture patterns. In particular, it will lead to a sparse and symbolic representation of object shapes, which can be considered a compelling next step if we are to continue the sparse coding principle underlying the design and learning of various wavelets dictionaries. (2) It will lead to a deeper and more concrete understanding of the relationship between two learning paradigms. One is the generative approach that constructs generative models where learning and inference are based on likelihoods or posterior distributions. The other is the discriminative approach where the learning is based on margin-type criteria. The generative models studied in the proposed research will make the comparison between these two approaches more concrete and realistic. (3) It will lead to a unification of the wavelet sparse coding model for object shape patterns and the spatial statistics and Markov random field models for stochastic texture patterns. These two approaches to image representation and description have been widely popular but mostly isolated from each other. Our work reveals a deep connection between them. (4) The proposed models and algorithms are inspired by theories of visual cortex, so they should also be of interest to researchers in neuroscience.

2. Broader impacts.

The proposed activities will strengthen the educational and research program in the Department of Statistics, UCLA. The PIs will develop and upgrade courses at both graduate and undergraduate levels at UCLA by incorporating topics related to the proposed research. The wealth of data and code that have been posted on the reproducibility webpages have proven useful for training both undergraduate and graduate students. Such webpages will continue to be enhanced and developed. The proposed research will support two graduate students. The proposed activities will provide innovative training by mixing students from different academic backgrounds, namely, mathematics-statistics and engineering-computer science. The PIs plan to organize summer schools and workshops to promote statistical modeling and learning in vision, and to facilitate the integration of research themes in statistics, applied mathematics, and computer science.