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STATISTICALLY CERTIFIED UNSUPERVISED LEARNING

((Charles Chubb,' Zhong-Lin Lu[2] and George Sperling[1])) 'University of California, Irvine, CA *University of Southern California, Los Angeles CA

Purpose. To understand the process by which the visual system, without explicit training, discovers structure in the visual world. Method. We propose a novel *independence rejection procedure* (IRP) to extract characteristic structures in an arbitrary population *I* of images or other inputs. IRP is based on the assumption that sensing structure in an image is tantamount to rejecting the null hypothesis H_0 that the image is devoid of structure (i.e., consists of random noise). IRP starts with an arbitrary orthonormal set of linear filters (receptive fields). Each successive input image from ***I*** is preprocessed to insure that if H_0 were true, then the histogram of receptive field outputs would be Normal. IRP then modifies its receptive fields to increase the deviation of the current output histogram from Normality, thereby increasing IRP's power to reject H_0 for the current image. IRP then examines the next image and repeats the process. When there are structures in the *I*-images, IRP evolves receptive fields that are statistically empowered to discriminate these structures from randomness. The statistical properties of the IRP have been derived for a particular implementation. However, the basic concept is so robust that there is enormous freedom in implementations. IRP's capabilities were demonstrated in three test populations: natural images, artificial images composed of mixtures of basis functions, and faulty random number generators. **Results.** (1) IRP rejected the null hypothesis that the UNIX random number generator rand() is truly random. (2) IRP sucessfully extracted component images from random composites of a fixed set of images. (3) For a set *I* of 134,120 natural image patches, the resulting receptive fields detect structure with $p < .005$ in 89% of a (previously unpresented) test set of *I*-patches. Receptive fields derived from natural images resemble those of Vl simple cells. **Conjecture.** The visual system contains a hierarchical arrangement of IRPs whose aim is to discover increasingly abstract levels of structure in the visual world by rejecting the null hypothesis that the input to each successive level is &void of structure.

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