

Model Answer: Computer Vision, Question 1.

2001

The central issue in pattern recognition is the relation between within-class variability and between-class variability. These are determined by the degrees of freedom spanned by the pattern classes. Ideally the within-class variability should be small and the between-class variability large, so that the classes are well separated. In the case of encoding faces for identity, one would like different faces to generate face codes that are as different from each other as possible, while different images of the same face should ideally generate similar codes across conditions. Several recent investigations of how well this goal is achieved have studied the invariances in face coding schemes under changes in illumination, perspective angle or pose, and expression. Their results have tended to show that there is greater variability in the code for a given face across these three types of changes, than there is among the codes for different faces when these three factors are kept constant.

When there is variability across two or more dimensions (let us say both face identity and facial expression), then discriminability can benefit from variability *within* a class of the other dimension, but not *between* classes of the other dimension. For example, facial expressions are more reliably distinguished if there is large variation among the different expressions generated by a given face, but small variation in how a given expression is generated among different faces.

The general principle is to use the observed dimensions of variability to find clusters and create categories in such a way as to minimise the within-class variability while simultaneously maximising the between-class variability for the particular task at hand.

Advantages of wavelets for face coding include the fact that most of the major facial features (lips, eyes, etc.) are well described by just a very small number of suitably-chosen wavelets. Another advantage of wavelets over more traditional feature descriptors (edges and lines) is that major facial structure is continuous-tone and differentiable, and undergoes continuous deformation, which wavelets can well-accomodate but the more punctate feature descriptors cannot. A disadvantage of wavelet descriptors is that they do not naturally generate translation-invariant (or size or orientation invariant) codes, and they are 2D (image-based) rather than 3D (volumetric solid based) descriptors, which may be more appropriate since faces are surfaces of 3D solids (heads) and project different 2D images with rotations in 3D.