**Extraction of information features for classification:**

***Image feature evaluation:*** An *image feature* is a distinguishing primitive characteristic or attribute of an image. Some features are natural in the sense that such features are defined by the visual appearance of an image, while other, artificial features result from specific manipulations of an image. Natural features include the luminance of a region of pixels and gray scale textural regions. Image amplitude histograms and spatial frequency spectra are examples of artificial features.

There are two quantitative approaches to the evaluation of image features: prototype performance and figure of merit. In the prototype performance approach for image classification, a prototype image with regions (segments) that have been independently categorized is classified by a classification procedure using various image features to be evaluated. The classification error is then measured for each feature set. The best set of features is, of course, that which results in the least classification error. The prototype performance approach for image segmentation is similar in nature. A prototype image with independently identified regions is segmented by a segmentation procedure using a test set of features. Then, the detected segments are compared to the known segments, and the segmentation error is evaluated. The problems associated with the prototype performance methods of feature evaluation are the integrity of the prototype data and the fact that the performance indication is dependent not only on the quality of the features but also on the classification or segmentation ability of the classifier or segmenter. The figure-of-merit approach to feature evaluation involves the establishment of some functional distance measurements between sets of image features such that a large distance implies a low classification error, and vice versa. Faugeras and Pratt (5) have utilized the *Bhattacharyya distance* (3) figure-of-merit for texture feature evaluation. The method should be extensible for other features as well. The Bhattacharyya distance (*B*-distance for simplicity) is a scalar function of the probability densities of features of a pair of classes defined as



where **x** denotes a vector containing individual image feature measurements with conditional density .

***Amplitude features:*** The most basic of all image features is some measure of image amplitude in terms of luminance, tri-stimulus value, spectral value, or other units. There are many degrees of freedom in establishing image amplitude features. Image variables such as luminance or tri-stimulus values may be utilized directly, or alternatively, some linear, nonlinear, or perhaps noninvertible transformation can be performed to generate variables in a new amplitude space. Amplitude measurements may be made at specific image points, [e.g., the amplitude F(j, k) at pixel coordinate (j, k), or over a neighborhood centered at (j, k)]. For example, the average or mean image amplitude in a WxW pixel neighborhood is given by



where *W* = 2*w* + 1. An advantage of a neighborhood, as opposed to a point measurement, is a diminishing of noise effects because of the averaging process. A disadvantage is that object edges falling within the neighborhood can lead to erroneous measurements. The median of pixels within WxW a neighborhood can be used as an alternative amplitude feature to the mean measurement of Eq. 16.2-1, or as an additional feature. The *median* is defined to be that pixel amplitude in the window for which one-half of the pixels are equal or smaller in amplitude, and one-half are equal or greater in amplitude. Another useful image amplitude feature is the neighborhood standard deviation, which can be computed as



In the literature, the standard deviation image feature is sometimes called the *image dispersion*. The mean and standard deviation of Eqs. 16.2-1 and 16.2-2 can be computed indirectly in terms of the histogram of image pixels within a neighborhood. This leads to a class of image amplitude *histogram features*. 

where rb denotes the quantized amplitude level for . The first-order histogram estimate of *P*(*b*) is simply



where *M* represents the total number of pixels in a neighborhood window centered about (j, k), and N(b) is the number of pixels of amplitude in the same window.

***Transform coefficient features:*** The coefficients of a two-dimensional transform of a luminance image specify the amplitude of the luminance patterns (two-dimensional *basis functions*) of a transform such that the weighted sum of the luminance patterns is identical to the image. By this characterization of a transform, the coefficients may be considered to indicate the degree of correspondence of a particular luminance pattern with an image field. If a basis pattern is of the same spatial form as a feature to be detected within the image, image detection can be performed simply by monitoring the value of the transform coefficient. The problem, in practice, is that objects to be detected within an image are often of complex shape and luminance distribution, and hence do not correspond closely to the more primitive luminance patterns of most image transforms. Lendaris and Stanley (8) have investigated the application of the continuous two dimensional Fourier transform of an image, obtained by a coherent optical processor, as a means of image feature extraction. The optical system produces an electric field radiation pattern proportional to

 The Fourier domain intensity pattern is normally examined in specific regions to isolate image features.

***Texture definition:*** Many portions of images of natural scenes are devoid of sharp edges over large areas. In these areas, the scene can often be characterized as exhibiting a consistent structure analogous to the texture of cloth. Image texture measurements can be used to segment an image and classify its segments.

Texture is often qualitatively described by its coarseness in the sense that a patch of wool cloth is coarser than a patch of silk cloth under the same viewing conditions. The coarseness index is related to the spatial repetition period of the local structure. A large period implies a coarse texture; a small period implies a fine texture. This perceptual coarseness index is clearly not sufficient as a quantitative texture measure, but can at least be used as a guide for the slope of texture measures; that is, small numerical texture measures should imply fine texture, and large numerical measures should indicate coarse texture. It should be recognized that texture is a neighborhood property of an image point. Therefore, texture measures are inherently dependent on the size of the observation neighborhood. Because texture is a spatial property, measurements should be restricted to regions of relative uniformity. Hence it is necessary to establish the boundary of a uniform textural region by some form of image segmentation before attempting texture measurements.

**Linear space of features:**

**Object similarity:**

**Distance between/among objects:**

**Object classes:**

**Discriminant planes and surfaces:**