Pattern Recognition using Relative Entropy

M. Portes de Albuquerque[1], I. A. Esquef[2], A. R. Gesualdi Mello[1], Marcelo P. de Albuquerque[1]

[1]CBPF/MCT – Centro Brasileiro de Pesquisas Físicas - Rua Dr. Xavier Sigaud, 150, Urca, Rio de Janeiro, RJ, Brasil
{mpa,aline,marcelo}@cbpf.br
[2]UENF – Universidade Estadual do Norte Fluminense - Av. Alberto Lamego, 2000, Horto, Campos, RJ, Brasil
israel@uenf.br

Abstract. This paper presents a novel technique for pattern recognition using relative entropy. The entropic method was used to classify images of digits from "0" to "9". The robustness of this system was tested in order to characterize the classifier in function of its signal to noise ratio (SNR). An efficiency of 100% was obtained for noisy images with $28.8dB$ of SNR.

1 Relative entropy

The relative entropy is a measure of distance between two distributions. In statistics, it arises as an expected logarithm of the likelihood ratio. The relative entropy, also known as Cross Entropy or Kullback-Leibler distance, measures the mean change of information associated with two probability distributions p and p'. The change of information is equal to $\Delta I = -(\log p' - \log p)$ and the mean change of information is obtained by averaging over the whole distribution. The pattern recognition process consists in a search for the minimum "information gain" aiming to minimize the distance between p and p'. The probability distribution is obtained by calculating the histogram of the Euclidian distances between the object boundary pixels and its center of mass.

Suppose that p_i represents the probability distribution of all known patterns, the symmetric version of the statistic distance is defined as:

$$D_i(p:p') = \sum_j p \cdot \log(\frac{p}{p'_i}) + \sum_j p'_i \cdot \log(\frac{p'_i}{p}) \quad (1)$$

2 Entropic method application

The entropic method was used to classify digits from "0" to "9". The robustness of the system was tested by adding noise in the boundary of the objects in order to observe the classifier behavior with respect to the noise amplitude and histogram resolution, as presented in figure 1. In the natural

Figure 1: Noise degradation example.

process of digital image formation, or in image segmentation, this type of noise may appear. This analysis characterizes the classifier as function of signal to noise ratio (SNR).

3 Results

We presented to the classifier 300 variations of the object within the same noise amplitude. The efficiency of the pattern recognition process is presented in Figure 2. This graph

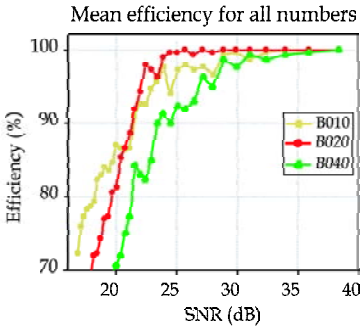

Figure 2: SNR behavior in function of histogram resolution.

shows that in order to have the best relation between noise amplitude and efficiency, it's ideal to use 20 bins of histogram resolution (B020). In addition, the limit for 100% of efficiency is obtained at $28.8dB$. In some classification cases it could be acceptable a 90% of efficiency for a SNR up to $22.6dB$.

4 Conclusion

Entropic techniques can be used in pattern recognition problems. The choice of the appropriate statistic distribution is the key to obtain high classification efficiencies.

References

[1] T. M. Cover and J. A. Thomas, Elements of Information Theory, John Wiley Sons, Inc. (1991).

[2] I. A. Esquef, Tese de Mestrado em Instrumentação Científica do CBPF/MCT(2003).