Kernel Optimization in Pattern Recognition Using a Genetic Algorithm

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SUMMARY

An extension of the conventional kernel-based method (Parzen density estimation method), which is one of fundamental pattern recognition methods [1], is proposed. In the conventional method, a single kernel function $K(\cdot)$ is used commonly in the superposition to make discrimination functions, or posterior probability functions $P(C_i)$. Figure 1(a) shows an example of the superposition in 1-dimensional space ($\boldsymbol{S}_i$ and d represent a sample pattern and a kernel region size, respectively).

In the extended method, each edge length of every kernel region is optimized individually. A difference in region between the conventional and the extended kernel-based methods in 2-dimensional space is shown in Fig. 1(b) (d_{jk} in Fig. 1(b)-2 represents the kth edge length of the jth kernel region).

If there are L candidates for each edge length, the number of candidates for the n-dimensional kernel region is L^n. In real applications n is more than 50 and L should be about 10 or more. Thus, we have to solve the combinatorial optimization problem for 10^{50} or more candidates and this cannot be done by using a brute-force search. We therefore apply a genetic algorithm to the combinatorial optimization problem.

In our GA operation, a chromosome represents the kernel region in an n-dimensional pattern space, and each locus corresponds to one of the candidates (genes) for an edge length of the kernel region. We have applied the extended method to a sonar spectrum recognition problem (http://www.boltz.cs.cmu.edu) and obtained a recognition accuracy of 83.9%, which is much higher than the 62.0% obtained using the conventional kernel-based method. We have also compared the recognition accuracy of the extended K-B method with those of the nearest neighbor method and a neural network (back-propagation algorithm). The results are listed in Table 1.

We have analyzed the individually optimized kernel regions and shown that in the GA process the features in the patterns are extracted automatically and embedded in the kernel regions. This feature extraction capability enables the extended kernel-based method to recognize patterns accurately.

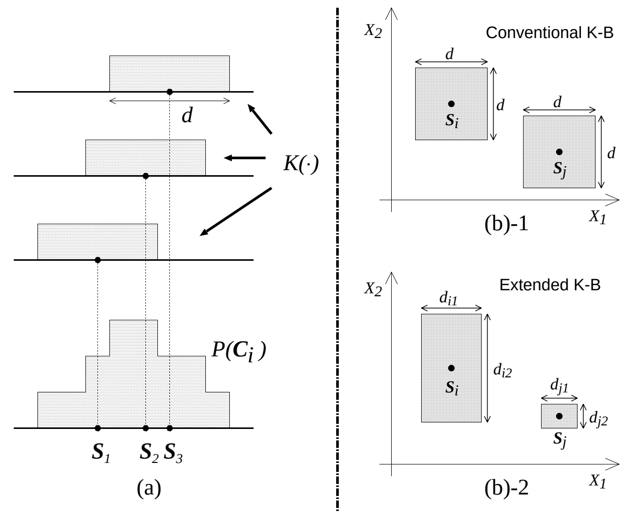

Figure 1: (a)Estimation of posterior probability by using kernel functions in the K-B method.(b)Kernel regions in the conventional K-B method and the extended K-B method.

Table 1: Recognition accuracies in the sonar spectrum recognition problem.

	Extended K-B	Nearest neighbor	Neural network
sample patterns	100.0%	100.0%	99.7%
test patterns	83.9%	82.7%	83.0%

References

[1] K. Fukunaga, "Introduction to Statistical Pattern Recognition," Academic Press, 1989.