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Comparison of Discriminant Analysis and Probabilistic Expert System in VCG Data Classification

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Summary

Our previous studies (Valová *et al.* 1992) have dealt with the possibilities of expert system utilization for electrocardiologic data interpretation. The results obtained in these studies provided evidence that the selected probabilistic expert system is suitable for the solution of VCG data interpretation problems. The aim of this paper was to compare the results obtained by stepwise discriminant analysis with that obtained by a probabilistic expert system. These classification methods were applied to VCG data measured by Frank's lead system. Five groups of patients were investigated: 76 healthy subjects, 36 patients with angina pectoris, 112 patients with old posterior myocardial infarction, 107 patients with old anterior myocardial infarction and 35 patients with old anteroseptal myocardial infarction. The classification was carried out by the leaving-one-out technique. Results of the classification obtained in five groups by a probabilistic expert system are evidently better than those obtained by stepwise discriminant analysis.

Key words

Probabilistic expert system – Discriminant analysis – Vectorcardiogram – Ischaemic heart disease.

Introduction

When solving various diagnostic problems, many classification methods are widely used due to the development of the computer technique. Various methods of data analysis such as factor analysis, cluster analysis, frequency analysis, discriminant analysis etc., and at present also the artificial intelligence approach, including expert systems and neural network, are more often applied for this purpose.

Methods

Stepwise discriminant analysis

The basic purpose of linear discriminant analysis is to find a discriminant function to be used for classifying cases into groups. For this solution, a set of linear discriminant functions were used in the following form:

$$g_s = a + b_1 x_1 + \ldots\ldots + b_n x_n.$$

In the case of stepwise discriminant analysis, the set of classification variables to be used in the final analysis is often not known in advance and even when it is, useful insights can be obtained by looking at analyses based on the subsets of classification variables. A stepwise discriminant analysis is a sequence of simple analyses that moves from one analysis to the next by adding or deleting a classification variable at each step according to the F-value.

We used program BMDP07M developed in Health Sciences Computing Facility, University of California, Los Angeles.

Probabilistic expert system

Expert systems are program modules simulating decision activity of an expert. An empty expert system is the algorithm, which is able to interpret investigated data using information from the knowledge base. It has to be completed with result data representation modules and user friendly utilities.

Adding the knowledge base to the empty expert system (to decision making rules procedure) the expert system is orientated on the solution of a given problem. The problem oriented expert system is thus obtained in this way. The real situation (diagnostic interpretation of the investigated subject) is solved by inserting real data into the expert system.

In our institute, the probabilistic expert system was chosen for solving the VCG signal interpretation problem because of its suitable properties (the manner of uncertainty expression, incomplete data processing possibility, etc.) (Grim 1990, Pérez and Jiroušek 1985, Valová *et al.* 1992a,b).

The probabilistic expert system is completely determined by the set of conditional probabilistic distribution, which is expressed in the form of a finite mixture of product components.

Each mixture component can be considered analogous to the rule and it can correspond to any diagnostics described by typical variable values. The probabilistic knowledge base suggestion estimates the characteristic variable histograms for each component (diagnoses) and the prior probability of its appearance (an equal prior probability was set in our study for each group).

In the case of larger variable amount, it should be useful to add background distribution common for all the components. The subject is classified in relation to the background in case that the expert system is not able to make a decision as compared to the defined classes. The background represents the probability of all components, i.e. if there is not a known histogram for a given parameter and given component, it is possible to substitute the corresponding background histogram for the missing one without influencing the resultant classification.

Data

The described classification methods were applied to VCG data processed by the KARDIO program, the result of which is an original set of VCG parameters (local characteristics described the main points on the module, velocity and curvature curves and the interval characteristics describe the spatial distribution and properties of mean QRS loops). The database of VCG records is supplied with results of complete cardiological diagnoses (obtained by both invasive and non-invasive methods) (Drška *et al.* 1974, 1986, 1990a,b).

Five groups of persons were investigated – 76 healthy subjects (H), 36 patients with angina pectoris (AP), 112 patients with posterior old myocardial infarction (MIP), 107 patients with anterior old myocardial infarction (MIA) and 35 patients with anteroseptal old myocardial infarction (MIAS).

Results

Patients were classified by the statistical jackknife method (the investigated patient was not included in the computing of the knowledge base of expert system or computing of discriminant functions). The resulting classification is shown Tables 1 and 2.

Table 1
The discriminant analysis results of investigated groups of patients

	%	H	AP	MIP	MIA	MIAS
H	59.2	45	27	2	2	0
AP	55.6	15	20	0	1	0
MIP	81.3	2	1	91	14	4
MIA	41.1	2	6	19	44	36
MIAS	57.1	1	0	0	13	20

Table 2
The probabilistic expert system results of investigated groups of patients

	%	B	H	AP	MIP	MIA	MIAS
H	90.8	0	69	4	1	2	0
AP	77.8	0	4	28	2	2	0
MIP	83.9	0	1	0	94	17	0
MIA	89.7	0	1	0	5	96	5
MIAS	82.8	0	0	0	1	5	29

The knowledge base of the background (B) is given as a mean of all knowledge bases of other groups and its weight (prior probability) was set equal to 0.001.

Table 3
A comparison of sensitivity and specificity of discriminant analysis (DA) and probalilistic expert system (PES) in investigated groups of patients

	Sensitivity		Specificity	
	PES	DA	PES	DA
H	90.8	59.2	97.6	89.7
AP	77.8	55.6	98.6	85.4
MIP	83.9	81.3	96.1	86.0
MIA	89.7	41.1	88.7	85.4
MIAS	82.8	57.1	98.3	89.3

Discussion

The classification of five groups is evidently better in case of the probabilistic expert system (Table 3).

The obtained results serve as evidence in favour of the chosen probabilistic expert system which seems suitable for the solution of VCG interpretation problem and appears to be a significant contribution to other cardiologic interpretation problems, where it is necessary to evaluate a greater number of less informative parameters.

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