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# Interactive Stepwise Discriminant Analysis \*

Dimitar Vandev

## ABSTRACT

ldagui.m is an interactive tool for linear and quadratic discriminant analysis. The reason for developing such a tool is the unconsistency of conventional statistical programs in following aspects:

- treating missing data;
- interaction with the user;
- testing the quality of obtained model.

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<sup>\*</sup>Supported by contracts:PRO-ENBIS: GTC1-2001-43031 and WINE DB: G6RD-CT-2001-00646



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The program Ldagui.m is developed in the frame of MAT-LAB. It is used with the help of menus, shortcuts, listboxes and a slider.

- First we will shortly outline the mathematics behind DA.
- Then we will describe menus and shortcuts of the program.
- Finally a small demonstration will be done to illustrate other features of the program.

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$$\mathbf{P}(\eta = g) = p(g)$$

• Conditional distribution of  $\xi \in R^p$  given  $\eta = g$  is described by the density f(x, m(g), C(g)).

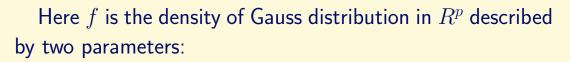
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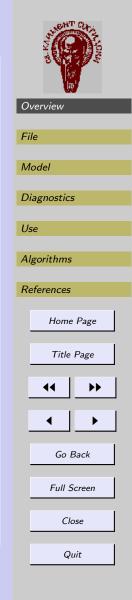


- mean m(g);
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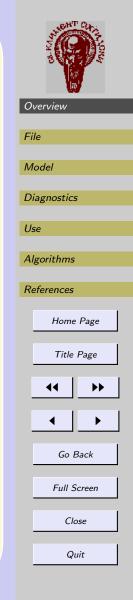
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or (what is the same) to:

$$b(\widehat{g})'x + a(\widehat{g}) \ge b(h)'x + a(h), \quad (h = 1, 2, \dots, G), \quad (5)$$

We decide that the observation x belongs to the group g, if for each h the inequality (5) holds:

$$L_g(x) \ge L_h(x), \quad (h = 1, 2, \dots, G),$$
 (6)

The functions L are called discriminant functions.

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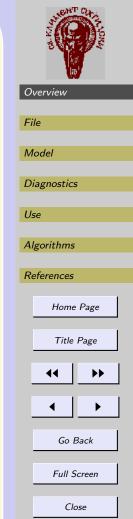
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The vector b(g) and the number a(g) in this case are calculated explicitly:

$$b(h) = m(h)'C^{-1}, \qquad a(h) = \log p(h) - m(h)'C^{-1}m(h).$$

This is why DA takes the name Linear - the discriminant functions are linear functions.



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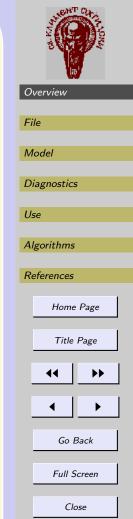
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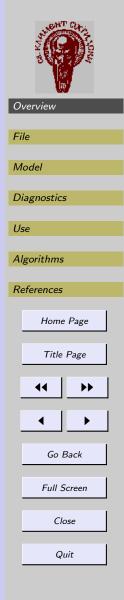
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When the assumption (3):C(g) = C is not appropriate, the corresponding functions become quadratic.



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If one has equal prior probabilities p(h) = 1/G, the solution of the classification problem (2) is equivalent to the minimization of so called Mahalanobis distances of the observation to the group means:

$$h(x,g) = (x - m(g))'C_g^{-1}(x - m(g))$$

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One uses Mahalanobis distances (8) to classify the observation to the closest group:

$$\widehat{g} = \mathop{argmin}_{h} h(x,h).$$

In general however, the Bayes rule (1) is better.



#### 1.4. Estimation

Let the training sample consists of vectors  $(g_i, x_i), i = 1.2..., n$ . Denote by I(g) the set  $\{i : g_i = g\}$  and let n(g) = |I(g)|. First the standard calculations - averages:

$$m(g) = \frac{1}{n(g)} \sum_{i \in I(g)} x_i.$$



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Cross products:

$$SS(g) = \sum_{i \in I(g)} (x_i - m(g))(x_i - m(g))', \quad SS_{in} = \sum_{g \in G} SS(g)$$



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Standard maximum likelihood estimates are:

$$C(g) = \frac{1}{n(g) - 1} SS(g), \quad C = \frac{1}{n - G} SS_{in}.$$
 (11)

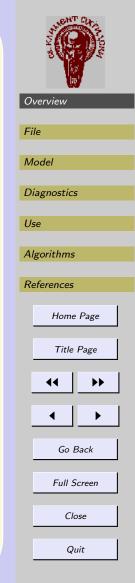


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We propose to correct the within group covariance estimate considering instead the mixture:

$$C_g := (1 - \alpha) * C + \alpha * C_g. \tag{12}$$

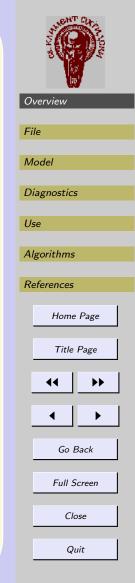
The parameter  $0 \le \alpha \le 1$  is to be chosen in interactive way via slider. Such corrections are not new (see for example (Lauter, 159-168) in (Fedorov, 1992)).



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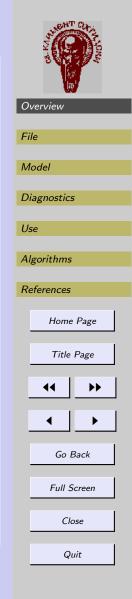
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#### 1.5. Selecting variables

The standard Fisher approach was to maximize the between group variance or (what is the same) to minimize common within group variance:

$$SS = \sum_{g \in G} \sum_{i \in I(g)} (x_i - m(g))(x_i - m(g))'.$$



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It is easy to calculate (see (Jennrich, 1977)) and convenient to update when new variable is to be chosen.



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Now we will go trough the menus of the program.



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### **2. File**

Now we will go trough the menus of the program. The File drop down menu may be used separately in order to fill the missing data with within group means.



### 2.1. Open Data

The program loads a data (.csv) file.

The program will ask you to supply one variable to be used for classification. You should decide. Otherwise the use of Ldagui.m is impossible.



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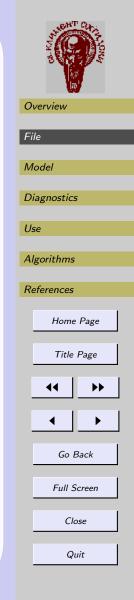
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Ldagui.m assumes that:

- the first row contains strings for variable names;
- the first column contains strings for case names. All other fields should contain numbers (or be empty for missing values).



Categorical variables

The categorical variables should have consecutive positive integer values. When exporting from Statistica you should say integers instead of text values.

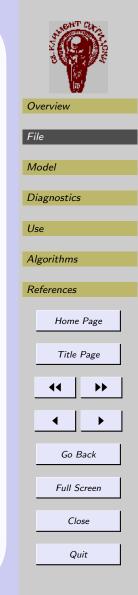


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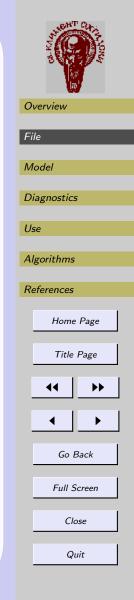
Any information about text values they may have in Statistica is loss and moreover their values in Ldagui.m are changed to first natural numbers: 1,2,3...



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Filling Missing Data is done automatically by LDAgui upon reading of .csv data. They are replaced by within group means. These means are formed by each combination of values of classification and selection variables.



#### 2.3. Save Data

Saves the data file in a form of comma separated file for later import in Excel or Statistica.

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Saves the MATLAB workspace in tempmodel.mat for later examination and use.

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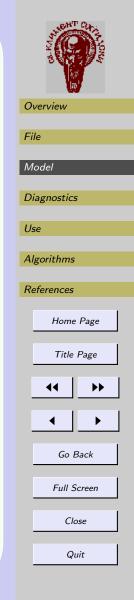
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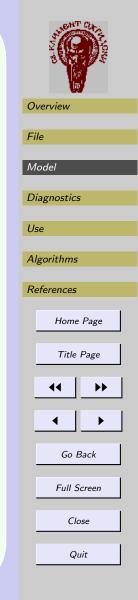
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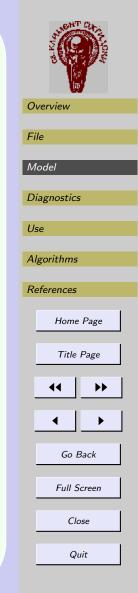
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- 5. the estimated parameters of DA model.



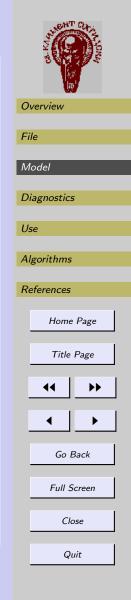
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### 3.1. Build Model

Performs all preliminary calculations for an empty model with no selection variable taken into account. To activate this option click on the Selection Listbox.



### 3.2. Load Model

# Loads previously saved model (or workspace).



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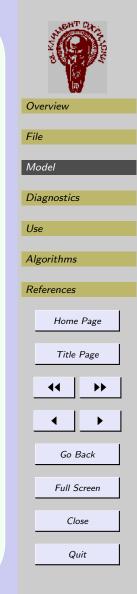
#### 3.3. Save Model

Save the current model with data, names, selected groups, predictors, etc. for later use. In fact the current workspace of MATLAB is saved.



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- File name the name of file (data or model) you have loaded recently;
- Model name the name of corresponding value of selection variable if any;
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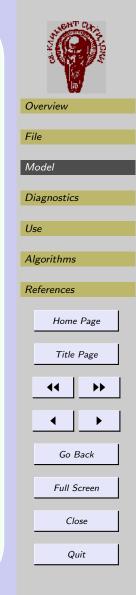


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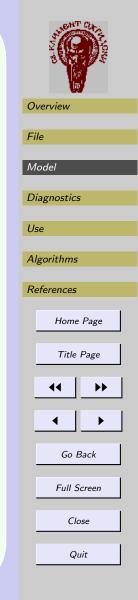
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- Results of the classification of the training sample number of errors;



The following results are printed in the MATLAB command window:

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- Cases classified with probability below .8;



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- Estimated power of the model by groups.



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- Results of the classification of the training sample number of errors;
- Cases classified with probability below .8;
- Estimated power of the model by groups.



Finally, a huge sample with 6000 observations per group is produced according estimated within group means and covariance matrices. The sample is classified and results reported on the MATLAB command window. This may be considered as an estimate of the theoretical power of the model.

3.5. Clear Model

Sozopol 22-28.06.03

Clears any information for the model. You should start with Build model step.



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Sozopol 22-28.06.03

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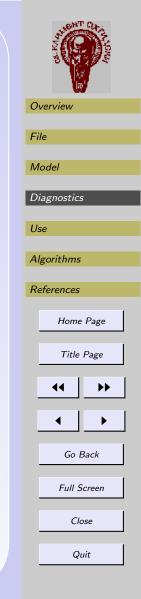
The tools proposed for making adequate decision are:

• Test - (Ctrl-t) - produces a test random sample;



The tools proposed for making adequate decision are:

- Test (Ctrl-t) produces a test random sample;
- Leave-One-Out checks the model against deleting each of observations;



The tools proposed for making adequate decision are:

- Test (Ctrl-t) produces a test random sample;
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- Plot (Ctrl-g) makes two plots over canonical variables.

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- Test (Ctrl-t) produces a test random sample;
- Leave-One-Out checks the model against deleting each of observations;
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#### 4.1. Test

A small sample with 100 observations per group is produced according estimated within group means and covariance matrices. The sample is classified and results reported on the MATLAB command window. This may be considered as an estimate of the power of the model. One may repeat this step in order to be sure or use print menu with larger sample 3.4.

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### 4.2. Leave-One-Out

A standard procedure is performed:

- 1. For each observation in the training sample a model with the same variables is build but without this particular observation.
- 2. The training sample is classified with this new model and classification errors counted.
- 3. The errors for all observations are summarized and reported.

#### 4.3. Plot

Second (upper plot) and third canonical variables are plotted against the first (on horizontal axes). The training sample is plotted with different colors for the groups



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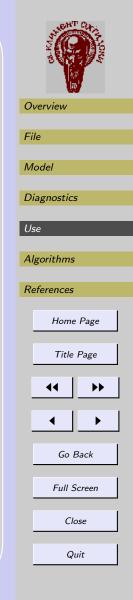
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**5.** Use

#### 5.1. Load sample

A standard data (.csv) file is loaded which should not contain missing values in the columns used for recognition. Columns to use should have the same variable names.



**5. Use** 

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5.2. Print results

Results of classification are printed.

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D. Vandev

**5. Use** 

### 5.1. Load sample

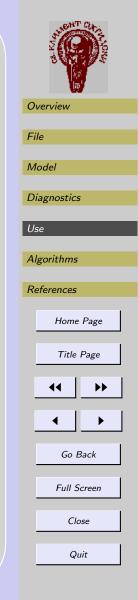
A standard data (.csv) file is loaded which should not contain missing values in the columns used for recognition. Columns to use should have the same variable names.

5.2. Print results

Results of classification are printed.

5.3. Save sample

The sample is saved in a data (.csv) file with resulting classification in the first column.



D. Vandev

# 6. Algorithms

The calculations are based on the paper of (Jennrich, 1977) in the classical collection of (Einslein, Ralston et al., 1977) being in the foundations of the package BMDP(see (Dixon, 1981)).



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### References

- DIXON, J. (ed.) (1981). *BMDP Statistical Software -81*. University of California, Los Angeles.
- EINSLEIN, K., RALSTON, A., ET AL. (eds.) (1977). Statistical Methods for Digital Computers. John Wiley & Sons, New York.
- FEDOROV, V. (ed.) (1992). *Model oriented data analysis: a survey of recent methods*. Physica-Verlag, Heidelberg.
- JENNRICH, R. I. (1977). Stepwise discriminant analysis. In: (Einslein, Ralston et al., 1977), pp. 76–95.LAUTER, H. (159-168). Bootstrap and estimation of
- nonlinear parameters. In: (Fedorov, 1992).

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- EINSLEIN, K., RALSTON, A., ET AL. (eds.) (1977). Statistical Methods for Digital Computers. John Wiley & Sons, New York.
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- JENNRICH, R. I. (1977). Stepwise discriminant analysis. In: (Einslein, Ralston et al., 1977), pp. 76–95.LAUTER, H. (159-168). Bootstrap and estimation of
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