

User Interface for a Decision Support System Based on Factor Analysis

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Resumo - Neste artigo descreve-se o interface de utilizador de um Sistema de Apoio à Decisão baseado em Análises Factoriais, nomeadamente: Componentes Principais, Discriminante, Correspondências e Quadros de Distâncias. O sistema foi desenvolvido para Windows usando Visual Basic™ 3.0.

Abstract- A Decision Support System based on Factor Analysis was designed to offer the user the possibility to perform easily four types of Factor Analysis: Principal Component, Discriminant, Correspondence and Distance.

We will describe the user interface of such a system, developed for Windows using Visual Basic™ 3.0.

I. INTRODUCTION

The purpose of Data Analysis is to distinguish, in large data sets, what is essential from what is accessory. It can be used whenever it is important to simplify and reduce the complexity of a problem and it is founded on the trade-off between losing information and gaining significance.

The system developed can be used to perform Factor Analysis [1] producing synthetic representations of large numerical data sets. Thus, it is possible to represent the information using a reduced set of parameters enhancing relevant features hidden in the raw data set, and offering to the user the possibility to control, along the analysis, the progression of the error (between the raw data set and its representation).

The DSSBFA (*Decision Support System Based on Factor Analysis*) offers the user an interactive decision support working environment based on four different Factor Analysis, meant for the analysis of four types of information:

- *Principal Component Analysis* -PCA, to study quantitative data sets, all of similar nature
- *Correspondence Analysis* -CrA, to study quantitative data sets, of different nature
- *Discriminant Analysis* -DcA, to study the relationships among a qualitative variable and several quantitative variables
- *Distance Analysis* -DtA, to study distance data sets.

The success of such a system depends heavily on the type of interaction and presentation of the results. That is why we have used this problem as a practical exercise of a course on Human Computer Interface during the academic

year of 93/94. The goal was to develop a user interface as friendly as possible and this should be accomplished by a group of 7 under-graduated students co-ordinated by a MSc Student, having a mathematician as consultant.

The system was developed for a Windows platform using Visual Basic™ 3.0 [2] and it has an open architecture allowing an easy integration of new methods, auxiliary procedures or new ways of displaying results.

In the next sections we will describe briefly the user's profile as well as the system architecture. We will go into further detail on the user interface.

II. USER'S PROFILE AND TASK CHARACTERISTICS

A clear idea of the user and task characteristics is fundamental for the design of a user interface [2]. The target user population of this system consists of mathematicians working mainly in enterprises, but also possibly in research environments. A simple study of this population allows us to conclude that the priority users of this system will have the following profile:

- Low to medium computer literacy;
- Low to medium motivation;
- Low to medium experience with system;
- Little or no training;
- Discretionary use;
- Low application experience;
- Moderate task experience;
- Structured task.

These characteristics of the user and task lead us to conclude that this interface should be, fundamentally, easy to learn and remember and also that the most adequate dialog techniques were menus, fill-in-forms and direct manipulation.

Our goal was to develop a system that allows the average user (with the above described profile) to perform a simple analysis and produce results using data introduced by her/himself. This should be accomplished after spending only a reasonable amount of time learning how to use the system.

As no formal training was considered necessary, the only training available will be the *User's Guide* and the *On-Line Help*.

III. THE DECISION SUPPORT SYSTEM BASED ON FACTOR ANALYSIS

According the system specification it should allow the user to:

- introduce (edit) new (existing) data;
- perform four types of factor analysis;
- display the results in numerical or graphical form;
- manage the corresponding files;
- get On-Line Help.

The DSSBFA can be viewed as having two separate blocks: the User Interface (UI) and the code corresponding to the Factor Analysis. These two blocks communicate via a set of files containing data and results in standard formats so that the system can display data and results produced by other already existing applications that implement Factor Analysis.

As stated before, the UI of the DSSBFA had to be essentially easy to learn and remember, but should also offer some attractive features to more experienced users. To meet these requirements the inexperienced user is offered the possibility of entering all the information needed to perform the intended analysis through dialogue boxes that prompt her/him to input the data set (variable names, individual names and numerical data) as well as other needed information. An On-Line Help is also supplied. To support more skilled users, that know exactly what kind of information the analysis needs, or want to use and/or modify already existing data, the system offers the possibility of entering or editing all the information using a "spread-sheet like" editor. After performing the analysis, the results are displayed in a numerical or graphical form, interactively specified by the user.

IV. USER'S INTERFACE

Implementing a user interface is a difficult task, there is no standard procedure, but several authors agree on the fact that some fundamental principles and guidelines are to be observed in the design of a user interface. This principles are: user and task compatibility, familiarity and simplicity, consistency, minimizing errors, easy error recovery [3,4].

Due to the user's profile and task characteristics identified previously, several dialogue styles were used simultaneously: direct manipulation, menus, fill-in-forms and function keys. The functionality is presented in a quasi hierarchical structure (fig.1 shows the first level of this hierarchy).

The most significant part of this functionality is presented to the user through the options Analysis, Edit and Results. Fig. 2 shows a simplified flow chart of the interface.



Fig.1.- Window corresponding to main menu

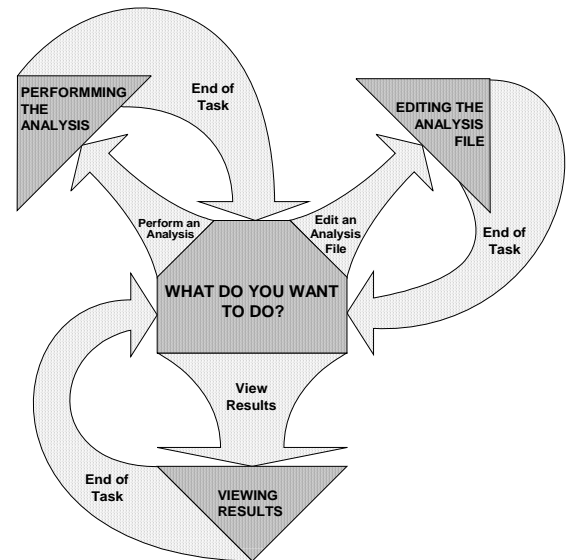


Fig.2.- Simplified Flow Chart of the User's Interface

1. Analysis

This is the first choice for the inexperienced user. It gives access to a guided (though, not flexible) process of inputting all the information needed to perform the analysis, through a set of dialog boxes. Fig. 3 shows a simplified flow chart of this option.

As three of the four types (PCA, CrA and DcA) of analysis need the same type of information, the dialogue is similar. Distance Analysis requires a simpler dialogue. Fig. 4 shows a simplified flow chart of the dialogue corresponding to PCA, CrA and DcA.

Figs 5 to 9 show the sequence of dialogue boxes as they appear to the user and illustrate, with an example, the interactive process that helps the user to input the parameters of the analysis and data set.

After the introduction of general information (identification of the analysis) regarding the data to introduce, the dialog box of the fig.6 allows the user to input specific information, namely parameters concerning the data set, type of metric to use and possible supplementary data).

After this procedure, the system will prompt the user to input the names of the variables (columns), individuals (rows) and the data matrix as shown in figs 7, 8 and 9.

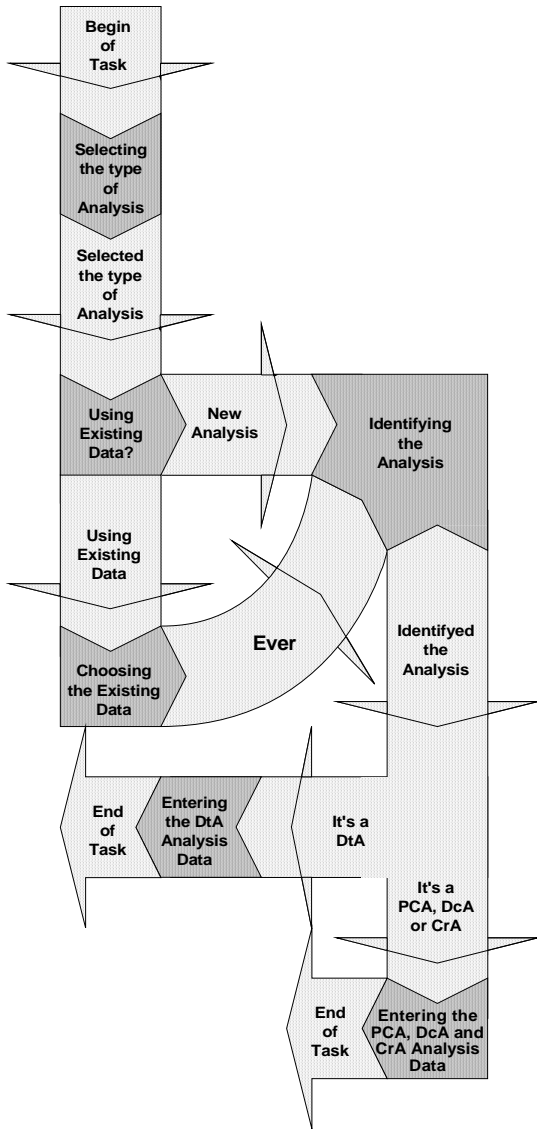


Fig.3.- Simplified flow chart of "Analysis"

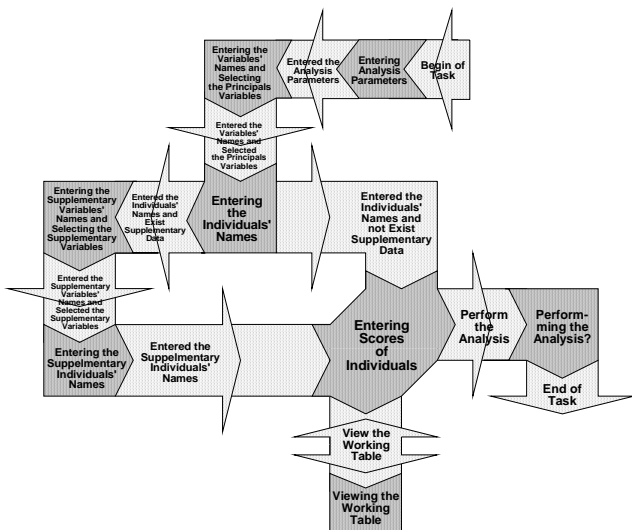


Fig.4- Simplified data flow chart of the process of entering data for PCA, CrA and DcA

Fig.5.- PCA/DcA/CrA/DtA- Analysis-ID Window.

Fig.6.- PCA/DcA/CrA- Input Parameters Window.

Var	Var1	Var2	Var3	Var4
Name	pes	alt	ida	not
Principal	x	x	x	x

Fig.7.- PCA/DcA/CrA- Input Variables' Names Window.

Ind.	Name
Ind 1	1
Ind 2	2
Ind 3	3
Ind 4	4
Ind 5	5
Ind 6	6
Ind 7	7

Fig.8- PCA/DcA/CrA- Input Individuals' Names Window.

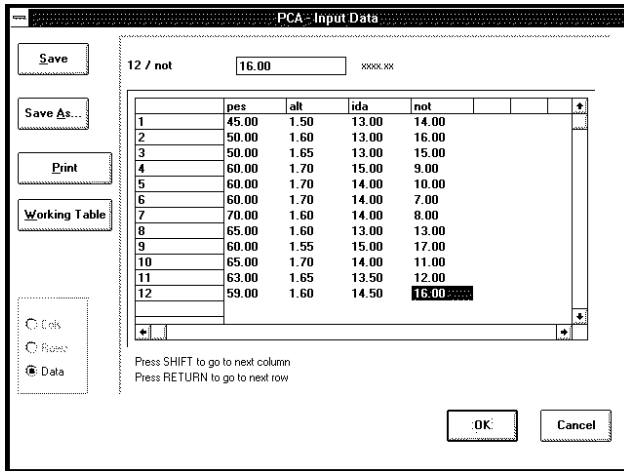


Fig.9.- PCA/DcA/CrA- Input The Data Window.

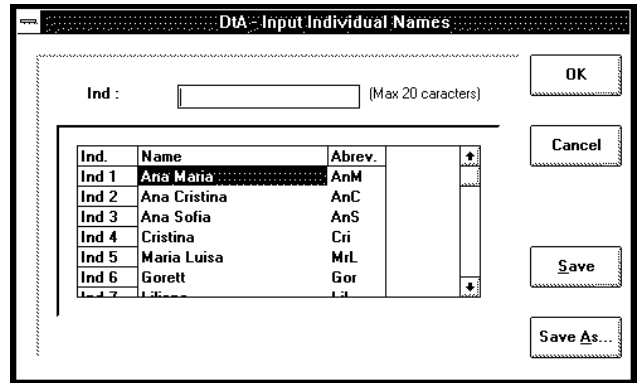


Fig.12- The PCA/DcA/CrA- Input Individuals' Names Window.

Fig. 10 shows a simplified data flow chart of the dialogue corresponding to Distance Analysis (DtA), and figs 11-13 show the sequence of dialogue boxes as they appear to the user.

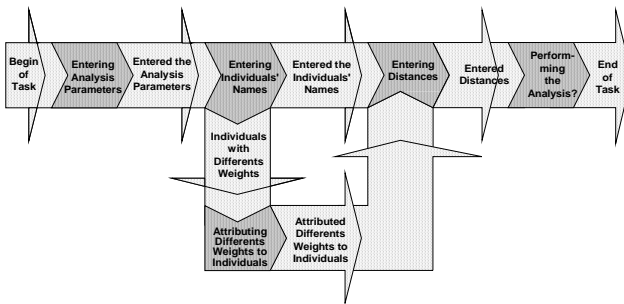


Fig.10 - The "Entering the DtA Analysis data" Architecture.

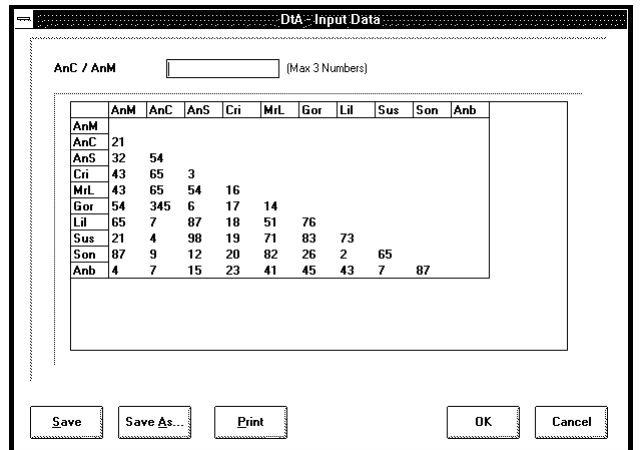


Fig.13.- DtA- Input Distances Window.

2. Edit

To input new data or edit existing data, a "spread sheet like editor" is offered. This editor may substitute dialogue boxes shown in figs 7-9 since it can input or edit information concerning the data set, variable names or individuals names. It corresponds to a more flexible way of inputting data, more adequate to an experienced user.

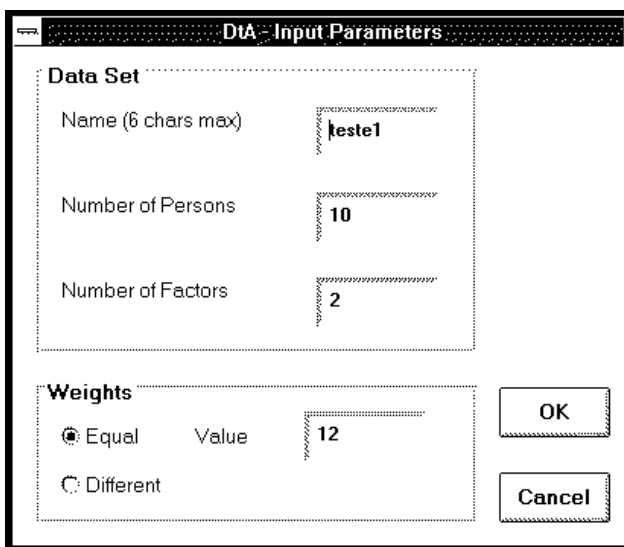


Fig.11.- DtA- Input Parameters Window.

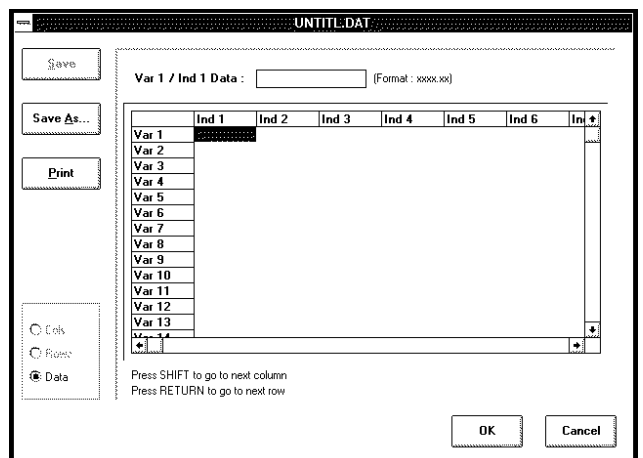


Fig.14.- Editor Window - can be used to input or edit the names of variables and individuals as well as the data set.

3. Results

Fig. 15 presents the flow chart corresponding to the Results option. This option allows the user to visualize the results in two different formats: numerically or graphically, as a projection in a 2D space which axis are chosen by the user in the Customize Window. Figs 16 to 18 show some results concerning the same example, used to illustrate the process of inputting data.

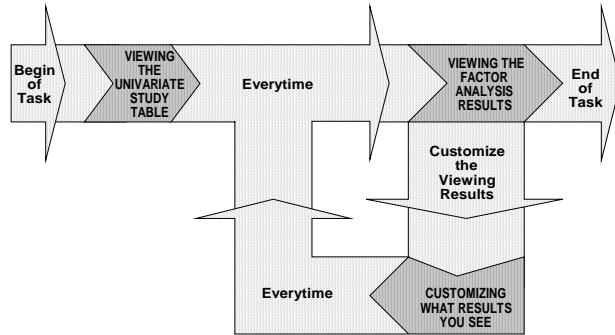


Fig.15.- The "Viewing Results" Architecture.

Univariate Study				
	media	des. padrao	variância	cont. traço [%]
pes	58.500	7.433	55.250	25
alt	1.630	.068	.005	25
ida	13.800	.748	.560	25
not	12.000	3.317	11.000	25

Fig.16.- The Univariate Study Table Window.

Customize	
Factors <input checked="" type="checkbox"/> Factor nº 1 <input checked="" type="checkbox"/> Factor nº 2 <input type="checkbox"/> Factor nº 3	Visualization <input checked="" type="checkbox"/> Chart <input checked="" type="checkbox"/> Table <input type="radio"/> Simultaneous (Ind.+Vars.)
Variables <input checked="" type="radio"/> All <input type="radio"/> Most Significant	
Ok	Cancel

Fig.17.- Customize Window

This example refers to the study of a group of students according to four characteristics: weight, height, age and mark. On reducing from four to two dimensions, only 20% of the information (variance) is lost.

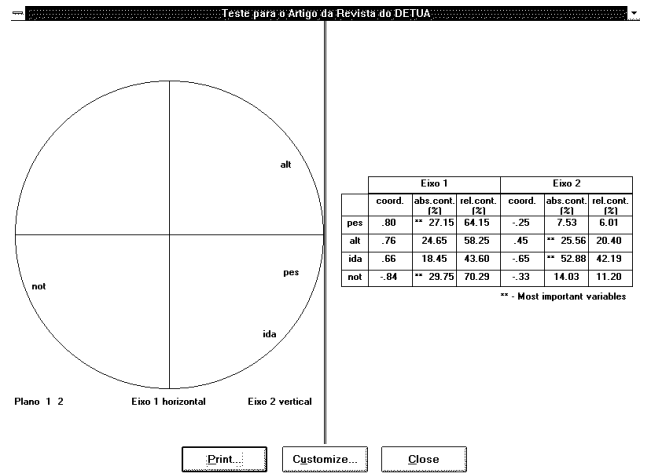


Fig.18 - Results Window.

VI. DISCUSSION

This work had two main goals: to develop an interface to a DSSBFA (Decision Support System Based on Factor Analysis) and simultaneously to illustrate the full procedure of designing, implementing and testing a user interface. A significant part of these goals, the study of the user and task characteristics, the design and the implementation of the user interface, was accomplished. A set of fundamental principles and guidelines for human-computer interface design was applied and we feel that the actual interface respects, in essence, this principles and guidelines. All this work was followed by a mathematician whose participation proved, as expected, to be indispensable.

Due to time constraints, it was not possible to perform the full test of the interface. This process should involve the design and application of tests to a set of users considered to be representative of the target population, as well as using the obtained information to improve the current interface. Since the design, implementation and test of a user interface is an iterative process, we expect to proceed this work during the courses on Human Computer Interfaces in the years to come.

ACKNOWLEDGEMENT

This work has been partially financed by JNICT - Junta Nacional de Investigação Científica e Tecnológica - grant BM1459.

REFERENCES

- [1] Foucart T. *Analyse Factorielle*, Masson, 1985
- [2] Microsoft Visual Basic - Language Reference - Programming System for Windows, 1991
- [3] Deborah Meyhew, *Principles and Guidelines in Software User Interface Design*, Prentice Hall, 1992
- [4] Foley J.D., van Dam A., Feiner S.K., Hughes J.F., *Computer Graphics-Principles and Practice*, Addison-Wesley Publishing Company, 2nd. edition, 1991