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THE OPERATIONAL PERFORMANCE OF FOUR STATISTICAL DATA ANALYSIS PACKAGES

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Abstract

The features of statistical data analysis packages may be evaluated by examining the user interface, statistical effectiveness and operational performance. In this study some aspects of operational performance of four packages are considered. The preliminary results indicate that SAS was the slowest package while SPSS-X had among the lowest CPU usage figures an average number of I/O operations. Minitab was fastest, but could not handle all problems. BMDP was very similar to SPSS-X, but produced more printed output.

1. Introduction

The evaluation of packaged statistical software often involves subjective criteria, which vary from user tot user and from problem to problem. Several criteria to evaluate the features of statistical software have been outlined by Francis et al(1975) and can be classified in three categories: user interface, statistical effectiveness and operational performance. Procedures to compare aspects of the user interface, such as user documentation and

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control language, have been discussed by Thisted (1979a) and the statistical effectiveness and accuracy of some used algorithms have been studied by Heiberger (1981), MacCallum (1983) and Velleman, Seaman & Allen (1977), among others.

Almost all university computer installations offer various statistical data analysis packages for general use. Among those widely used by students and behavioral scientists are BMDP, SPSS-X, SAS and Minitab. Thisted (1979b) has discussed some aspects of teaching statistical computing and the use of general purpose statistical packages. While the first two categories (user interface and statistical effectiveness) can provide a basis for the selection of a package from the user's point of view, the usefulness of a package will also depend on the cost of running a job. Operational aspects, such as CPU time, I/O statements and page faults will become increasingly important when courses are set up for large numbers of students to become familiar with a statistical software package. The purpose of this study is to evaluate the operational performances of four widely used packages. We will address the user interface and appropriateness of the programs for student use in a forthcoming paper.

2. The packages

Four packages with similar capabilities for many problems, are compared: BMDP (releases 1982,1985), SPSS-X (releases 2.0,2.1) SAS (release 4.1) and Minitab(release 82.1). All test runs were done on the Tilburg university VAX 11/785 computer with a VMS 4.1 operating system.

3. Design of the study

All programs were run in batch mode, except Minitab, which was not available in batch mode on the VAX 11/785. To prevent any wait time bias and interrupt caused by other

jobs sharing the same CPU environment, the test runs were executed at night, when no other jobs were submitted to the batch queue. Additionally, test runs were also performed during daytime, when the computer was heavily loaded with interactive work.

The following measures were used: CPU time (number of seconds that a program is resident in core memory) needed to perform a statistical procedure, the number of page faults (number of times that parts of the virtual memory are placed in core memory and vice versa) during the running of a program, the frequency of I/O operations (read/write operations of the processor) and the total number of printed lines and the total number of pages used to print output by a program. The core memory requirements were not measured, because some packages use a fixed amount of memory, while others allocate storage dynamically. Moreover, the VAX 11/785 computer is a virtual memory machine, where memory requirements are not as important as the other measures.

The time needed to load a package could bias the results. Therefore the tests were performed 10 times and mean CPU time was computed and compared with the CPU time needed for a single run. The differences were at most 1.5 CPU sec.

The statistical procedures used in this evaluation were selected topics from a course in data analysis, designed to train psychology students at the Tilburg university to use data analysis techniques by means of a computer package, including: t-tests (TTEST), one- and two-way analysis of variance (ANOVA), histograms (HISTO), bivariate tables (BIVAR), regression analysis (REGRESS), principal component analysis (PCA) and factor analysis (FA). All runs were made as uniform as possible by using standard options and by controlling program options such as: the same rotation option for factor analysis was used and all runs were done with a program "system file", containing a dictionary structure for the defined variables and the actual data. Data sets used for the test runs were obtained from the data analysis course and were of orders 188 observations by 6 variables (for TTEST and ANOVA), 100 observations by 11 variables (for HISTO, BIVAR and REGRESS) and 110

observations by 9 (for FA and PCA). Minitab could not be used for ANOVA (with an unequal number of observations per cell), PCA and FA and could only be tested during daytime.

4. Results

In Table 1 the mean CPU times (sec) for each of the packages are given. Generally SAS needed more CPU time than the other packages did for all statistical procedures, except for PCA and FA, where BMDP needed the most CPU time. The performances of SPSS-X and BMDP did not differ much and Minitab was cheapest with respect to CPU time. The most striking result for BMDP was, that the 1985 release needed more CPU than the 1982 release did for all evaluated statistical procedures. There were no striking differences between the test runs during daytime and at night, except that the packages were a little faster during the night. Therefore only the results during daytime are given.

In Table 2 the mean number of page faults for each of the packages are given. SAS generally displayed the largest amount of page faults, followed by SPSS-X. BMDP and Minitab were very similar with respect to the page faults.

Table 3 presents the mean number of I/O operations for each package. The results show that SAS produced the most I/O operations. SPSS-X had about the same number of I/O operations as BMDP had, and Minitab was surely the cheapest I/O package.

Output should be complete, but not voluminous. All four packages gave the output information in a readable format, but the number of printed pages differed due to the layout and the printing of additional information. Table 4 gives the number of printed pages and lines for each procedure. BMDP produced the most pages for PCA and FA. Notice,that four out of 20-21 printed output pages given by BMDP for PCA and FA were used to print the factor scores. This option cannot be suppressed in BMDP. SPSS-X produced the most lengthly printed histograms and Minitab prints the most concise listings.

Table 1

The Mean CPU Times (sec)

Daytime	SAS	SPSS-X (2.0)	SPSS-X (2.1)	BMDP (1982)	BMDP (1985)	Minitab
TTEST	9.76	5.89	5.98	5.45	7.40	3.85
ANOVA	20.76	7.25	7.65	8.59	13.33	....
HISTO	14.28	8.56	7.70	10.90	11.39	6.34
BIVAR	15.01	6.91	7.53	10.76	14.67	5.56
REGRESS	9.24	6.47	6.30	5.40	7.77	5.05
PCA	7.26	6.68	6.78	8.37	11.28	....
FA	7.27	7.29	7.45	8.04	10.65	....

Table 2

The Mean Number of Page Faults

Daytime	SAS	SPSS-X (2.0)	SPSS-X (2.1)	BMDP (1982)	BMDP (1985)	Minitab
TTEST	2494	1195	1581	889	757	782
ANOVA	3233	1346	1649	739	825	...
HISTO	2597	1487	2038	723	733	727
BIVAR	2624	1228	1697	789	741	861
REGRESS	2168	1168	1692	713	720	746
PCA	1485	1191	1766	783	773	...
FA	1468	1180	1783	775	784	...

Table 3

The Mean Frequency of I/O Operations

Daytime	SAS	SPSS-X (2.0)	SPSS-X (2.1)	BMDP (1982)	BMDP (1985)	Minitab
TTEST	294	53	61	51	46	18
ANOVA	740	75	61	49	52	..
HISTO	358	82	63	52	55	21
BIVAR	394	81	59	49	52	21
REGRESS	317	66	59	48	64	20
PCA	116	80	73	68	55	..
FA	117	76	74	76	60	..

Table 4

The Number of Printed Output Pages and Lines

	SAS	SPSS-X	BMDP	Minitab
TTEST	1- 12	3- 68	3-112	1- 17
ANOVA	8-129	12-295	11-367	...
HISTO	10-288	20-791	14-515	6-372
BIVAR	12-316	9-200	10-422	2-138
REGRESS	2- 84	4-126	4-156	2-118
PCA	7-295	6-224	21-689	...
FA	7-298	6-226	20-631	...

5. Discussion and Conclusions

The purpose of the present study was to evaluate the operational aspects of four well-known statistical data analysis packages. Among other criteria, such as user interface and user documentation, the aspects of operational performance and cost are important to verify the usefulness of a statistical package. The used criteria, however, will not always have the same weight with respect to cost. Different computer centers may assign different weights to I/O, CPU and page faults in the used accounting algorithms. However, CPU time will generally be a very important factor when the cost of running a job is measured.

Generally, SAS was the slowest package and displayed the most number of page faults and I/O operations. SPSS-X has among the lowest CPU figures, an average number of I/O operations, but more page faults than BMDP. The 1985 release of BMDP needed more CPU than the 1982 release for all statistical procedures. This can perhaps be explained by the addition of interactive features in the 1985 release. BMDP produced the most lenthly listings. Minitab could not handle FA, PCA and ANOVA with an unequal number of scores in the cells, but was cheapest for the other

procedures. Similar results have been given by Seaman (1977), who compared some regression analysis programs on an IBM 370/168 computer.

Awaiting a comparison of the user interface of these packages for student use, it may be concluded that although SAS is the most expensive package, its interactive feature may be an advantage for student use. Minitab is the most cheapest package and also interactive, but not all problems can be handled. SPSS-X and BMDP do not differ much in operational performance and these packages share the disadvantage, that they cannot be used interactively.

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