

4.9 Computer programs

The tests for multivariate normal data that are discussed in this chapter are fairly readily available in standard statistical computer packages, although many packages will be missing one or two of them. Also, the results of tests based on F-distribution approximations may vary to some extent from one program to the next because of the use of different approximations. On the other hand, for the robust tests on variances, some or all of the calculations may need to be done in a spreadsheet.

This chapter has been restricted to situations where there are two or more multivariate samples being compared to see whether they seem to come from populations with different mean vectors or from populations with different covariance matrices. In terms of mean vectors, this is the simplest case of what is sometimes called multivariate analysis of variance, or MANOVA for short. More complicated examples involve samples being classified on the basis of several factors, giving a generalization of ordinary analysis of variance (ANOVA). Many statistical packages allow the general MANOVA calculations to be performed.

4.10 Chapter summary

- The t-test is described for comparing the mean values of two samples from populations with equal variances. Welch's test is also described for situations where the population variances are not equal. Both tests assume that the data values are normally distributed.
- Hotelling's T^2 test is described as the generalization of the t-test when there is more than one variable being measured for two samples.
- The multiple testing problem (i.e., the type-one error rate becoming inflated if several univariate tests are carried out at one time) is discussed, together with the advantage of using one multivariate test instead.
- The F-test and Levene's robust test are described for comparing the variation in two samples.
- Box's M-test, a robust alternative based on the approach used in Levene's test, and Van Valen's test are described for comparing the variation in two samples.
- Four tests are described for comparing the mean vectors of several multivariate samples. These are Wilks's lambda test, Roy's largest root test, Pillai's trace statistic, and the Lawes-Hotelling trace. Approximate F-tests are described for assessing the significance of the statistics involved in each case.
- Box's M-test is described as a means for comparing the variation in several multivariate samples. This is noted to be very sensitive to the required assumption that the data are multivariate normally distributed. Robust alternatives using the principle behind Levene's test are therefore described.

1. Multivariate analysis of variance (MANOVA) is mentioned as a generalization of the methods discussed in this chapter.

Exercise

Example 1.4 concerned the comparison between prehistoric dogs from Thailand and six other related animal groups in terms of mean mandible measurements. Table 4.5 shows some further data for the comparison of these groups that are part of the more extensive data discussed in the paper by Hingham et al. (1980).

1. Test for significant differences between the five species in terms of the mean values and the variation in the nine variables. Test both for overall differences and for differences between the prehistoric Thai dogs and each of the other groups singly. What conclusion do you draw with regard to the similarity between prehistoric Thai dogs and the other groups?
2. Is there evidence of differences between the size of males and females of the same species for the first four groups?
3. Using a suitable graphical method, compare the distribution of the nine variables for the prehistoric and modern Thai dogs.

Table 4.5 Values for Nine Mandible Measurements for Samples of Five Canine Groups (mm)

	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	Sex ^a
Modern Dogs from Thailand										
1	123	10.1	23	23	19	7.8	32	33	5.6	1
2	137	9.6	19	22	19	7.8	32	40	5.8	1
3	121	10.2	18	21	21	7.9	35	38	6.2	1
4	130	10.7	24	22	20	7.9	32	37	5.9	1
5	149	12.0	25	25	21	8.4	35	43	6.6	1
6	125	9.5	23	20	20	7.8	33	37	6.3	1
7	126	9.1	20	22	19	7.5	32	35	5.5	1
8	125	9.7	19	19	19	7.5	32	37	6.2	1
9	121	9.6	22	20	18	7.6	31	35	5.3	2
10	122	8.9	20	20	19	7.6	31	35	5.7	2
11	115	9.3	19	19	20	7.8	33	34	6.5	2
12	112	9.1	19	20	19	6.6	30	33	5.1	2
13	124	9.3	21	21	18	7.1	30	36	5.5	2
14	128	9.6	22	21	19	7.5	32	38	5.8	2
15	130	8.4	23	20	19	7.3	31	40	5.8	2
16	127	10.5	25	23	20	8.7	32	35	6.1	2

(continued)