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MAS 314 Design of Experiments

Practical 8 28 February–6 March 2007

This practical starts the analysis of designed experiments in row-column designs. It also shows how to construct and randomize such designs.

1 (A Latin square: fixed effects) An experiment was conducted at a cloth factory to compare the durability of four types of material. A special testing machine was used, which had four plates. Emery board is attached to the plates; a sample of cloth is held on a mechanical brush opposite each plate; and the brushes are rubbed over the plates for a certain length of time. After this time the cloth is removed and weighed: the loss in weight is a measure of its (lack of) durability.

Different runs of the machine tend to give different results, because other factors, such as temperature and humidity, vary from one run to another. So the experiment was performed in four runs. A Latin square design was used, with runs and plates as rows and columns respectively.

The data are in the file `wear.dat`. The first column is type of material; the second column is weight loss after experiment in 10^{-4} gm; each set of four data come from one run of the machine; the four plates on the machine are in the same order each time. Look at the file before loading the data into Genstat, naming the columns `material` and `wear`.

Create factors `run` and `plate`, which should start as follows.

run	plate
1	1
1	2
1	3
1	4
2	1
2	2
...	...

For the fixed-effects model, the expectation model should be $V_T + V_R + V_C$; to get this, in the anova **Dialogue Box** put

Treatment Structure: `material + run + plate`

Analyse the data.

(Strictly speaking, Genstat interprets this treatment structure as the successive extra fits in

(i) V_0,

(ii) $V_{\texttt{material}} \cap V_0^{\perp}$,

(iii) $(V_{\texttt{material}} + V_{\texttt{run}}) \cap V_{\texttt{material}}^{\perp}$ and

(iv) $\left(V_{\texttt{material}} + V_{\texttt{run}} + V_{\texttt{plate}}\right) \cap (V_{\texttt{material}} + V_{\texttt{run}})^{\perp}$.

So long as all factors are orthogonal to each other, these become the extra fits in W_0, $W_{\texttt{material}}$, $W_{\texttt{run}}$ and $W_{\texttt{plate}}$ respectively.)

2 (A Latin square: random effects) For the random-effects model we need

Treatment Structure:	`material`
Block Structure:	`run * plate`

(This means that Genstat looks for the expectation part of the model successively in V_0 and $V_{\texttt{material}} \cap V_0^{\perp}$, which are always W_0 and $W_{\texttt{material}}$, while it considers the strata (that is, the eigenspaces of the covariance matrix) to be

(i) V_0,

(ii) $V_{\texttt{run}} \cap V_0^{\perp}$,

(iii) $\left(V_{\texttt{run}} + V_{\texttt{plate}}\right) \cap V_{\texttt{run}}^{\perp}$,

(iv) $V_{\texttt{run}\wedge\texttt{plate}} \cap \left(V_{\texttt{run}} + V_{\texttt{plate}}\right)^{\perp}$,

(v) $V_{\texttt{run}\wedge\texttt{plate}}^{\perp}$.

In this case, the spaces are W_0, $W_{\texttt{run}}$, $W_{\texttt{plate}}$, $W_{\texttt{run}\wedge\texttt{plate}}$ and 0 respectively.)

Analyse the data again and compare the output for the two analyses.

3 (Constructing and randomizing a row-column design) Here we see how to construct and randomize the design for the wine-tasting experiment.

First we generate the observational units in standard order.

`Stats` → `Design` → `Generate Factors in Standard Order`

Generate factors `Judge` and `Order` with 8 and 4 levels respectively, in standard order.

Secondly, construct the systematic design. You will need to write down two Latin squares in a 4×8 array. Then create an empty column called `Wine`. Copy the levels of `Wine` from your array into this column.

Thirdly, randomize this systematic design, using

`Stats` → `Design` → `Randomize`

Fill in the boxes:

Randomize:	`Wine`
Block Structure:	`Judge * Order`

As usual, the syntax `Judge * Order` means that both `Judge` and `Order` make sense without knowing the level of the other. So Genstat randomizes whole Judges and also randomizes whole Orders.

Finally, to save the randomized version of the design, do
`Spread` → `Update` → `Refresh Sheet from Genstat`

The one part of this process that is liable to error is your own copying of the levels of Wine from your piece of paper into the spreadsheet. To check that you got this right, it is a good idea to do a dummy analysis of variance, with no data. Type the following lines into the Input Window and then submit them.

```
treatmentstructure Wine

blockstructure Judge * Order

anova
```

Look at the skeleton analysis of variance in the Output Window. Is it what you expect?

4 (A row-column design which is not square) In an experiment on feeding cows, a crossover design was used. There were 18 cows, used for three five-week periods. Three different feeds were given to the cows. For each five-week period, the total milk yield of each cow (in pounds) was measured.

The data are in the file `lact.dat` in the order:

feed for cow 1 in period 1	milk yield for cow 1 in period 1
feed for cow 2 in period 1	milk yield for cow 2 in period 1
...	...
feed for cow 18 in period 1	milk yield for cow 18 in period 1
feed for cow 1 in period 2	milk yield for cow 1 in period 2
...	...
feed for cow 18 in period 3	milk yield for cow 18 in period 3

Analyse the data.

Save the spreadsheet for use in a later practical.

5 (Factorial treatments in a Latin square) Groups of apples were stored in a shed in a 4×4 Latin square design.

C	*B*	*A*	*D*
D	*A*	*C*	*B*
B	*C*	*D*	*A*
A	*D*	*B*	*C*

There were four shelves along the side of the shed. Four groups of apples were stored on each shelf, so that 'column' represents distance from the door. The groups were labelled *A*, *B*, *C*, and *D*, where groups *A* and *B* were from one variety, groups *C* and *D* from another. Groups labelled *A* and *C* were stored for a short time, groups labelled *B* and *D* for a long time. At the end of the storage, the percentage weight loss was recorded for each group.

The data are in the file `apple.dat`. The first column gives the weight loss, the second gives the variety, the third the storage time. The order of the rows in the file is: all the groups on the top shelf, from left to right, then all the groups on the second shelf, and so on.

Analyse the data, showing the factorial treatment effects. Briefly interpret the output.