Software package for analysis of completely randomized block design

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Abstract

This study is to design and develop statistical software (package), OYSP1.0 which conveniently accommodates and analyzes large mass of data emanating from experimental designs, in particular, completely Randomized Block design. Visual Basic programming is used in the design. The statistical package OYSP 1.0 when implemented on a micro computer gives an encouraging result

*Keywords***:** Completely randomized, Block design, software, experiment.

1.0   Introduction

We shall consider the analysis of variance of the observations obtainable from completely randomized block design under the liner model taking the randomization into account. Scheffe' (1953), Cochran and Cox (1957), and Fisher (1926) provided the theoretical framework of the design structure.

The design structure according to Fisher (1926) consists of the grouping of the experimental units into homogenous groups so that the conditions under which the treatments are observed are as uniform as possible. If all the experimental units are very homogenous, then there need be one block of observations, and the experimental units can be assigned to the treatments completely at random, but, if more than one group of experimental units is required, the design structure is some type of a blocked design.

Under this arrangement, some packages such as SAS and Genstat have been developed to handle block designs which include completely randomized block designs.

Montgomery (1991) considered the theoretical analysis of completely randomized block design without developing a computer package to implement it. He rather chose to solve problems on completely randomized block design manually which takes much time. But, with the aid of the computer, we shall develop a software package OYSP 1.0 that will handle such problems in less time

Consider a completely randomized block design (*t, b, k, r*), where *t* is the number of treatments, b is the number of blocks, *k* is the size of each block, r is the number of replications. The necessary and sufficient condition for this structure to be complete is that *b = t*.

The statistical model for the design structure (see Montgomery (1991), Plackett (1960)) is given by

$$y_{ij} = \mu + \alpha_i + \beta_j + \in_{ij} \tag{1.1}$$

$i = 1, 2, ..., t$, $j = 1, 2, …, b$

where μ is an overall mean, $\propto_i$ is the effect of the ith treatment, β_j is the effect of the jth block, y_{ij} is the ith observation in the jth block. The random error $\in_{ij} \approx N\left(0, \sigma^2\right)$, with treatment and block effects satisfying the equations:

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$$\sum_{i=1}^{v} \propto_i = 0 \tag{1.2}$$

and
$$\sum_{j=1}^{b} \beta_j = 0 \tag{1.3}$$

respectively Furthermore, Street et a*l* (1987), Tocher (1952) introduced the incidence matrix of the design structure as

$$N = \begin{bmatrix} 1 & 1 & 111 & \cdots & 1 \\ 1 & 1 & 111 & \cdots & 1 \\ 1 & 1 & 111 & \cdots & 1 \\ 1 & 1 & 111 & \cdots & 1 \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\ 1 & 1 & 111 & \cdots & 1 \end{bmatrix} \tag{1.4}$$

such that

$$N^T N = \begin{bmatrix} r & r & r \cdots & r \\ r & r & r \cdots & r \\ \vdots & \vdots & \vdots & \vdots \\ r & r & r \cdots & r \end{bmatrix} \tag{1.5}$$

where T means transpose. The matrix $N^T N$ is called the information Matrix of the design (see James, 1957)

2.0 The sum of squares

Hence, the sum of squares for the blocks, treatments, error, and total are determined (see Montgomery, 1991)

$$SSB = \frac{\sum_{j=1}^{b} B_{.j}^2}{t} - \frac{\left(\sum_{i=1}^{t}\sum_{j=1}^{b} Y_{ij}\right)^2}{n} \ , \ SSTr = \frac{\sum_{i=1}^{t} T_{.i.}^2}{b} - \frac{\left(\sum_{i=1}^{t}\sum_{j=1}^{b} Y_{ij}\right)^2}{n} \ , \ SST = \sum_{i=1}^{t}\sum_{j=1}^{b} Y_{ij}^2 - \frac{\left(\sum_{i=1}^{t}\sum_{j=1}^{b} Y_{ij}\right)^2}{n}$$

$SSE = SST - SSB - SSTr$, with degrees of freedom (df) , df(Blocks) = $b - 1$, df(Treatments) = $t - 1$, df(Total) = $(n - 1)$, df(Error) = $(t - 1) (b - 1)$. Consequently, the mean squares for the block, Error and treatment are determined (see Cochran and Cox (1957)). $MSB = \frac{SSB}{b-1}$, $MSE = \frac{SSE}{(b-1)(t-1)}$, $MST_r = \frac{SST_r}{t-1}$ respectively.

3.0 F–test

Blocking, not only reduce the experimental error, it also provides an opportunity to see whether evidence exists to indicate a difference in the means response for the blocks. MSB provides an unbiased estimate of σ^2 based on $(b - 1)$ degrees of freedom. Where a real difference exists in the block means, MSB, will probably be inflated in comparison with MSE, and then $F_B = \frac{MSB}{MSE}$ provides a test statistic.

Consequent upon the design structure for the hypothesis of equal treatment effects, the test statistic is

$$F_{Tr} = \frac{MSTr}{MSE}$$

4.0 Software enviroment/program design
4.1 Introduction

A computer software is the set of instructions which the computer uses in processing and analyzing data to generate information. In general, software can be classified into system software and application software respectively. System software is used directly to control or manage the computer and its resources while an

application software is used in solving a problem which falls into one of the categories of life's application areas (see Kuhfeld, 1997).

In this research work, an application software named "OYSP 1.0" is developed for the analysis of Completely Randomized Block Design.

4.2   Program design

```
Option Explicit
Public Tsqr, Bsqrsum, Bsum, BBsum, sumrow As Single
Public sqrsum, sqrTD, T, Z, Y, h As Single
Public n, m, p, i, j, k As Integer
Public SST, SSB, SSE, SSTr As Single
Public MSE, MSB, MSTr, Fb, Ft As Single

Private Sub cmdenter_Click()
Dim A(), B(), C() As Single
Dim temp, temp1, temp2 As Single

pp:
n = InputBox("What is the Treatment Size")
m = InputBox("What is the Block Size")
On Error GoTo EH
ReDim A(1 To n, 1 To m)
ReDim B(1 To m)
ReDim C(1 To m)

MsgBox " Enter the Values of Each Treatment", vbInformation

temp = 0
For i = 1 To n
sumrow = 0
Y = 0

MsgBox " Enter Values of Next Treatment ", vbInformation

For j = 1 To m
A(i, j) = InputBox(" Enter Value ")
sumrow = sumrow + A(i, j)
p = A(i, j)
Y = Y + (p * p)

C(j) = C(j) + A(i, j)
Next

T = T + sumrow
temp = sumrow * sumrow
Tsqr = Tsqr + temp
sqrsum = sqrsum + Y

Next

For j = 1 To m
temp1 = C(j)
temp2 = temp1 * temp1
Bsqrsum = Bsqrsum + temp2
```

```
Next
BBsum = Bsqrsum / n
cmdenter.Enabled = False
cmdreport.Enabled = True
cmdanova.Enabled = True
EH:
If Err.Number = 13 Then GoTo pp
End Sub
Private Sub cmdexit_Click()
Unload Me
End Sub

Private Sub cmdreport_Click()
cmdreport.Enabled = True
cmdanova.Enabled = True
On Error GoTo hh
```
$k = n * m$
$h = k - m - n + 1$

$SST = sqrsum - ((T * T)/k)$
$SSB = BBsum - ((T * T)/k)$
$SSTr = (Tsqr/m) - ((T * T)/k)$
$SSE = SST - SSB - SSTr$

$MSE = SSE/(k - m - n + 1)$
$MSB = SSB/(m - 1)$
$MSTr = SSTr/(n - 1)$

$Fb = MSB / MSE$
$Ft = MSTr / MSE$

```
frmreport.lblsst = SST
frmreport.lblssb = SSB
frmreport.lblsstr = SSTr
frmreport.lblsse = SSE
frmreport.lblft = Ft
frmreport.lblfb = Fb

frmreport.Show vbModal
hh:
If Err.Number = 11 Then MsgBox "Division by Zero! Illegal Operation", vbCritical
End Sub
Private Sub cmdanova_Click()
```
frmanova.lbldfb = $m - 1$
frmanova.lbldfe = $k - m - n + 1$
frmanova.lbldfsum = k – 1
frmanova.lbldft = $n - 1$

```
frmanova.lblfb = Fb
frmanova.lblft = Ft

frmanova.lblmsb = MSB
frmanova.lblmse = MSE
frmanova.lblmst = MSTr
```

```
frmanova.lblssb = SSB
frmanova.lblsse = SSE
frmanova.lblsssum = SST
frmanova.lblsst = SSTr

frmanova.Show
End Sub

Private Sub cmdreset_Click()
cmdenter.Enabled = True
cmdreport.Enabled = False
cmdanova.Enabled = False

End Sub

Private Sub Form_Load()
cmdreport.Enabled = False
cmdanova.Enabled = False
End Sub
```

5.0   Problem

A consumer preference study involving three different package design (treatment) was laid out in a randomized block design among four supermarkets (blocks). The data below represents the number of units for each package designed within each supermarket during each of three given weeks

Package Design (Treatment)	Supermarket (Blocks)			
	1	2	3	4
1	17	15	1	6
2	34	26	23	22
3	21	21	8	16

Interest: Are there sufficient evidence indicating
   (i)   difference in the mean sales for each package design?
   (ii)   difference in the mean sales for the supermarkets?

6.0   Result
6.1   Analysis Report

Sum of Square of Total	940.666748046875
Sum of Square of Blocks	348.000081380208
Sum of Square of Treatments	547.1667
Sum of square of Error	45.4999186197915
F-Test for treatments	36.07699
F-Test for Blocks	15.2967342332272

6.2   Anova table

Source	Degree of Freedom	Sum of Square	Mean Square	F-Test
Blocks	3	348.000081380208	116.000027126736	15.2967342332272
Treatment	2	547.1667	273.583374023438	36.07699
Errors	6	45.4999186197915	7.58331976996525	
Total	11	940.666748046875		

For (*i*): since $F_{0.5,2,6} = 5.4 < F_t$ (=36.07699), we conclude that a real difference does exist in the expected sales for the three package designs.

For (*ii*): since $F_{0.5,3,6} = 4.76 < F_b$ (= 15.29673), we conclude that a real difference exists in the expected sales in the four supermarkets.

7.0   Conclusion

The package developed is efficient and reliable. It is easier to handle compared to the existing packages such as SAS and Genstat. SAS and Genstat handle all block designs while the package developed is limited to completely randomized block design structure.

The package compared favourably with SAS and Genstat respectively. Furthermore, the package is an alternative to SAS or Genstat for handling problems on completely randomized block design.

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