SAS Macro for the generation of minimally changed run sequence for Box Behnken Designs

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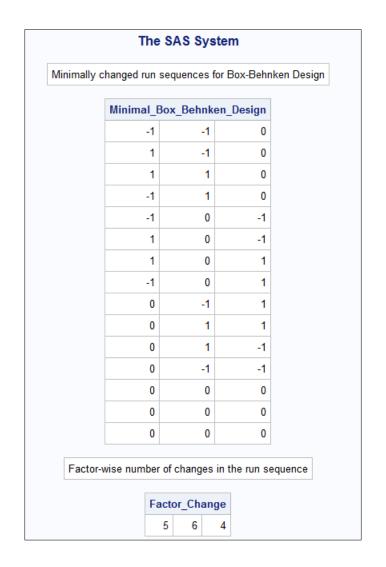Email: eldho.varghese@icar.gov.in

Second Order Response Surface Designs (SORDs) are used to explore relationship between the response variable and the input variables and to find out the optimum input combinations to achieve a desired response. Experiments where changing of input factor levels are very difficult/ costly, instead of using the standard form of run sequences, response surface design with less factor level changes in run sequences should be used. The following SAS macro has been developed to generate minimally changed run sequence for Box Behnken Designs. Here, user needs to enter the number of factors as 'k'. If the user executes the program after entering the value of k, then the SAS Macro will produce minimally changed run sequence for Box Behnken design along with the number of factor-wise level changes, total changes and the number of runs.
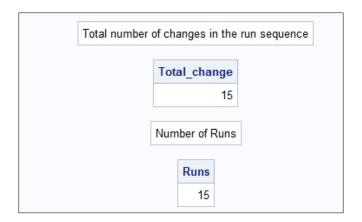
```
/*Program to generate minimally changed Box-Behnken Design*/
%let k=4; /*Enter the number of input factors*/
ods rtf  file= 'output.rtf' startpage=no;
proc iml;
v=&k;
if v<3 then do;
print 'Enter a number >=3';
end;
else do;
m=comb(v,2);
b=j(m,2,0);
k=1;
do i=1 to v-1;
do j=i+1 to v;
b[k,1]=i;
b[k,2]=j;
k=k+1;
end;
end;
*print b;
n=j(max(b),nrow(b),0);
do i=1 to nrow(b);
do j=1 to ncol(b);
n[b[i,j],i]=1;
end;
end;
*print n;
nt=t(n);
```

```
*print nt;
a={-1 -1,1 -1,1 1,-1 1};
*print a;
kk=j(nrow(a),ncol(nt),0);
kkk=j(4*nrow(nt),ncol(nt),0);
do i=1 to nrow(nt);
k=0;
do j=1 to ncol(nt);
if(nt[i,j]=1) then k=k+1;
if(nt[i,j]=1) then;
do g=1 to nrow(kk);
kk[g,j]=a[g,k];
end;
if(nt[i,j]=0) then;
do g=1 to nrow(kk);
kk[g,j]=0;
end;
end;
do j=1 to ncol(nt);
s=1;
s=s+4*(i-1);
do g=1 to nrow(kk);
kkk[s,j]=kk[g,j];
s=s+1;
end;
end;
end;
Minimal_Box_Behnken_Design=kkk;
do i=nrow(kkk)-3 to nrow(kkk);
Minimal_Box_Behnken_Design[i,ncol(kkk)]=kkk[i,ncol(kkk)]*-1;
end;
centre_points=j(v,v,0);/*To add some central points (not based
on any statistical criteria for optimun centre points)*/
Minimal_Box_Behnken_Design=Minimal_Box_Behnken_Design//centre_po
ints;
print 'Minimally changed run sequences for Box-Behnken Design';
print Minimal_Box_Behnken_Design;
Factor_Change=j(1,ncol(Minimal_Box_Behnken_Design),0);
do k=1 to ncol(Minimal_Box_Behnken_Design);
do l=2 to nrow(Minimal_Box_Behnken_Design);
if Minimal_Box_Behnken_Design[l-
1,k]^=Minimal_Box_Behnken_Design[l,k] then do;
Factor_Change[1,k]=Factor_Change[1,k]+1;
end;
end;
end;
print 'Factor-wise number of changes in the run sequence';
```

```
print Factor_Change;
Total_change=sum(Factor_Change);
Runs=nrow(Minimal_Box_Behnken_Design);
print 'Total number of changes in the run sequence';
print Total_change;
print 'Number of Runs';
print Runs;
end;
ods rtf close;
quit;
```

SAS Output

The SAS System

Minimally changed run sequences for Box-Behnken Design

Minimal_Box_Behnken_Design		
-1	-1	0
1	-1	0
1	1	0
-1	1	0
-1	0	-1
1	0	-1
1	0	1
-1	0	1
0	-1	1
0	1	1
0	1	-1
0	-1	-1
0	0	0
0	0	0
0	0	0

Factor-wise number of changes in the run sequence

Factor_Change		
5	6	4

Research Paper:

- Eldho Varghese, Arpan Bhowmik, Seema Jaggi, Cini Varghese and Shwetank Lall, (2019). On the Construction of Response Surface Designs with Minimum Level Changes. *Utilitas Mathematica*, 110, 293-303.
- Eldho Varghese*, Arpan Bhowmik, Seema Jaggi, Cini Varghese, Charanjit Kaur (2017). On the generation of cost effective response surface designs, *Computers and Electronics in Agriculture*, 133, 37-45.
- Eldho Varghese*, Arpan Bhowmik, Seema Jaggi, Cini Varghese, Charanjit Kaur (2020). Corrigendum to "On the generation of cost effective response surface designs" [Comput. Electron. Agric. 133 (2017) 37–45], *Computers and Electronics in Agriculture*, 170, 105272.