SAS MACRO FOR GENERATION OF ALL POSSIBLE MINIMALLY CHANGED 2^k RUN ORDER WITH TREND FACTOR VALUE THROUGH EXHAUTIVE SEARCH ALGORITHM

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Minimally changed run sequences for a factorial design are not unique instead there may exists a number of minimally changed run orders for a specific factorial combination. However, due to execution of runs in different order among minimally changed run sequences, effect of trend may be different. Following SAS macro has been developed to perform exhaustive search procedure to generate all possible minimally changed run order for two level factorial design. The SAS macro has been developed using SAS 9.3 where user need to enter "**the number of levels each factor (it should be >=2) separated by commas**" as **s = .** The macro will then generate **all possible minimally changed run orders for the specified two level factorial design along with factor wise level changes**. Further, the macro **will also generate D, D_t and Trend Factor (TF)** value for all the generated minimally changed run order based on following model:

Let, there are k factors x_1, x_2, ...x_k. Let, **Y** is n × 1 vector of response variable. Then the model for factorial run orders in the presence of trend component can be defined as

$$\mathbf{Y} = \mathbf{F}\boldsymbol{\alpha} + \mathbf{G}\boldsymbol{\beta} + \boldsymbol{\varepsilon}$$

Where, **F** denote the design matrix of order n × p where p is the number of parameters to be estimated [here, only general mean and all the main effects have been considered]. Here, $\boldsymbol{\alpha}$ is a p × 1 vector of parameters of interest. Here, **G** of order n × q represent the orthogonal polynomial coefficient to measure trend effect [here only linear trend has been considered thus q = 1] and $\boldsymbol{\beta}$ is a q × 1 vector of trend effects. Based on the above model following can be defined [Tack and Vandebroek (2001)]:

D- optimality criterion (D): Considering the above experimental set-up, the D-optimal design is found by minimizing the generalized variance or equivalently, by maximizing the determinant of the information matrix as $D = |\mathbf{F'F}|$.

D_t-optimality criterion (D_t): Considering the above experimental set-up, the D_t-optimality criterion is found by minimizing the generalized variance or equivalently maximizes the information in presence of trend as $D_t = \left|\mathbf{F'F}\text{-}\mathbf{F'G}\left(\mathbf{G'G}\right)^{-1}\mathbf{G'F}\right|$.

Trend Factor: In order to see the effect of trend on factorial run order, Tack and Vandebroek (2001) defined the term trend factor which as

$$\text{Trend Factor(TF)} = \left[\frac{D_t}{D}\right]^{\frac{1}{p}},\ 0 \le \text{TF} \le 1.$$

For a completely trend free run order, TF will be equal to 1 and for a run order which is completely affected by trend, TF will take value 0.

The SAS macro will also generate **total number of minimally changed run order in the last**.

The programme has been implemented with single processor having the computational specification as follows:

Processor: Intel(R) Core(TM) i5-3470, CPU @ 3.20 GHz, **RAM:** 8 GB, **Hard Disk Drive:** 500 GB

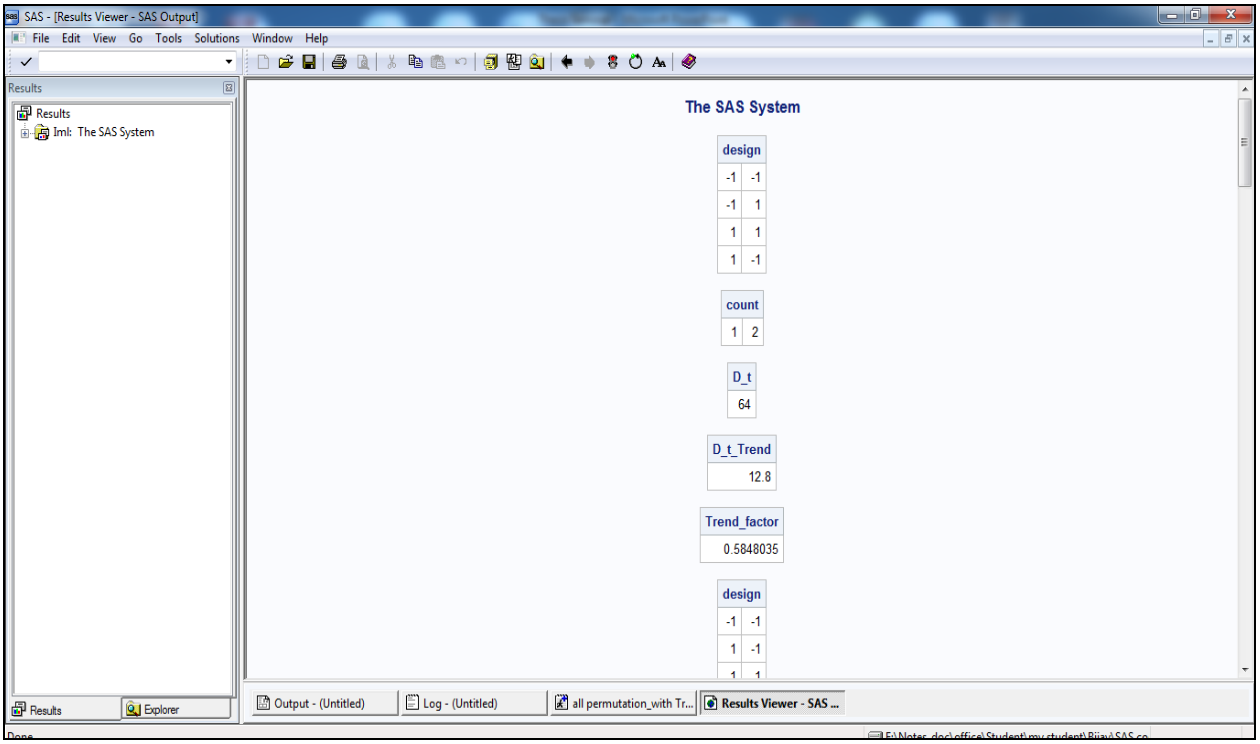
Code

```
proc iml;
ods rtf file='fact.rtf'startpage=no;
s={2,2,2};/* Enter the number of levels each factor (it should be >=2)
seperated by commas*/
a=j(max(s),nrow(s),0);
do kk=1 to nrow(s);
m=mod(s[kk, ],2);
do i=1 to s[kk, ];
do j=i to s[kk, ];
if m=1 then
            do;
            a[j,kk]=-((s[kk, ]-1)/2)+(i-1);
            end;
            else
            do;
            if -(s[kk, ]/2)+(i-1)<0 then do;
            a[j,kk]=-(s[kk, ]/2)+(i-1);
            end;
            else do;
            a[j,kk]=-(s[kk, ]/2)+i;
            end;
            end;
end;
end;
end;
*print a;
aa=j(s[1, ],1,0);
do i=1 to s[1, ];
aa[i,]=a[i,1];
end;
*print aa;
sum=1;
do j=1 to nrow(s)-1;
```

```
do i=1 to nrow(aa);
kk=repeat(aa[i,],s[j+1,],1);
if i=1 then do;
aaa=kk;
end;else do;
aaa=aaa//kk;
end;
end;
*print aaa;
sum=sum*s[j, ];
if mod(sum,2)=0 then do;
ggg=j(s[j+1, ],1,0);
do i=1 to s[j+1, ];
ggg[i,]=a[i,j+1];
end;
ggg1=ggg;
ggg2=ggg//ggg1;
hh=repeat(ggg2,sum/2,1);
aa=aaa||hh;
end;
else do;
ggg=j(s[j+1, ],1,0);
do i=1 to s[j+1, ];
ggg[i,]=a[i,j+1];
end;
ggg1=ggg;
ggg2=ggg//ggg1;
hh1=repeat(ggg2,(sum-1)/2,1);
hh=hh1//ggg;
aa=aaa||hh;
end;
end;
*print aa;
/************Normalised Linear trend component*************/
m=mod(nrow(aa),2);
ma=j(nrow(aa),1,0);
do i=1 to nrow(aa);
if m=1 then
            do;
            ma[i,1]=-((nrow(aa)-1)/2)+(i-1);
            end;
            else do;
            ma[i,1]=-(nrow(aa)-1)+(2*(i-1));
            end;
end;
mk=sqrt(ssq(ma));
ma=ma/mk;
*print ma;
/*******************************************/
```

```
total_design=0;
p=allperm(nrow(aa));
n=nrow(p);
*print p;
*print n;
design=j(nrow(aa),ncol(aa),0);
do j=1 to nrow(p);
kk=1;
do i=1 to ncol(p);
design[kk, ]=aa[p[j,i],];
kk=kk+1;
end;
count=j(1,ncol(design),0);
do k=1 to ncol(design);
do l=2 to nrow(design);
if design[l-1,k]^=design[l,k] then do;
count[1,k]=count[1,k]+1;
int=j(nrow(aa),1,1);
design_int=int||design;
D_t=det(design_int`*design_int);/*D_T without Trend*/
*D_t_Trend=(det((design`*design)-
(design`*ma*inv(ma`*ma)*ma`*design)))**(1/ncol(design));
D_t_Trend=det(((design_int`*design_int)||(design_int`*ma))//((ma`*design_int)
||(ma`*ma)));
Trend_factor=(D_t_Trend/D_t)**(1/ncol(design_int));
end;
end;
end;
if sum(count)=nrow(aa)-1 then do;
total_design=total_design+1;
print design;
print count;
print D_t;
print D_t_Trend;
print Trend_factor;
*print ma;
end;
end;
print total_design;
ods rtf close;
quit;
```

A screenshot of the output is as follows



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