AUGMENTED DESIGN ROW-COLUMN AND TREND ANALYSES

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Abstract: To obtain estimates of augmented treatments under a mixed model.

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Title: Augmented design row-column and trend analyses.

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Purpose: To obtain estimates of augmented treatments under a mixed model.

Reference: Wolfinger, R. D. *et al.* (1997). Recovering information in augmented designs, using SAS PROC GLM and PROC MIXED. Agronomy Journal 89:856-859.

Data: The 15-row by 12 column design data set as given in Federer, W. T. (1998) Biometrics 54(2):471-481 is used here. There are two checks repeated r = 30 times each and 120 new or augmented treatments each included once. Since the row-column design was not connected in the sense that not all row, column, and treatment effects have solutions, it was necessary to use functions of row and column effects. Orthogonal polynomial regressions up to tenth degree for columns and up to 12^{th} degree for rows were computed. Those regressions with F-values less than the F-value at the 25% level were omitted from the model. Since the row-column orientation may not be in the direction of the gradients in the experiment, interactions of row and column regressions were employed to account for this type of variation. The treatments are divided into fixed effects (checks) and random effects (augmented treatments). An ordering of treatment effects from highest to lowest is useful owing to large numbers of augmented treatments usually encountered in this type of screening experiment. The following lines of the SAS program construct the orthogonal polynomial coefficients.

SAS Code

```
/* ---Create orthogonal polynomial regression coefficients.---*/
proc iml;
  opn12=orpol(1:12,10); /*---12 rows and up to tenth degree coefficients---*/
  opn12[,1] = (1:12)`;
  op12=opn12;
  create opn12 from opn12[colname={'COL' 'C1' 'C2' 'C3' 'C4' 'C5'
'C6' 'C7' 'C8' 'C9' 'C10'}]; append from opn12;
  close opn12; run;
  opn15 = orpol(1:15,12); /*---15 columns , up to 12th degree coefficients---*/
  opn15[,1]=(1:15)`;
  op15 = opn15;
  create opn15 from opn15[colname={'ROW' 'R1' 'R2' 'R3' 'R4' 'R5'
'R6' 'R7' 'R8' 'R9' 'R10' 'R11' 'R12'}];  append from opn15;
close opn15;
run;
/* The data set augmerc1.dat contained responses for grain weight and eight
other characteristics of the 122 wheat genotypes (treatments) and comes from
site number 1. */
data augsite1;
  infile 'augmerc1.dat';
  input site col row trt grainwt ca cb cc cd ra rb rc rd;
/* The following statements partition the 122 treatments into two sets, checks
(fixed) and new (treated as random). */
  if (trt>120) then new = 0; else new = 1;  if (new) then trtn= 999; else
trtn=trt;
/* The following steps create the data set augbig for analyses. */
data augbig; set augsite1;
```

```
  idx = _n_;
run;
proc sort data = augbig;
  by col; run;
data augbig;
  merge augbig opn12;
  by col;      run;
proc sort data = augbig;
  by row;  run;
data augbig;
  merge augbig opn15;
  by row;  run;
proc sort data = augbig;
  by idx;
run;
/* Exploratory model selection resulted in the following model for this
data set.  Residuals may also be obtained. */
proc glm data = augbig;
   class row col trt trtn;
   model grainwt =C1 C2 C3 C4 C6 C8 R1 R2 R4 R8 R10 R1*C1
   R1*C2 R1*C3 trt;
   output out = subres R = resid; proc print; /*---Printed in augbig---*/
run;
/* "info nobound" may be included if these solutions are desired.
The trt*new in the random statement is used when augmented treatments
are treated as random effects. */
proc mixed data = augbig info nobound;
  class row col trt trtn;
  model grainwt = trtn/solution;
  random R1 R2 R4 R8 R10 C1 C2 C3 C4 C6 C8 R1*C1 R1*C2 R1*C3
  trt*new / solution;
  lsmeans trtn;
  make 'solutionr' out = sr noprint;
run;
/* The following statements arrange the solutions in descending order. */
proc sort data = sr;
  by descending _EST_ ;
proc print;
run;
```

Using the data and program described above, an abbreviated output is given below:

```
Class    Levels    Values
ROW          15    1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
COL          12    1 2 3 4 5 6 7 8 9 10 11 12
TRT         122    1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22
                   23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41
                   42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60
                   61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79
                   80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98
                   99 100 101 102 103 104 105 106 107 108 109 110 111 112
                   113 114 115 116 117 118 119 120 121 122

TRTN          3    121 122 999  /* Checks are number 121 and 122. */

Dependent Variable: GRAINWT
```

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	135	1685564.291	12485.661	3.62	0.0001
Error	44	151761.820	3449.132		
Corrected Total	179	1837326.111			

R-Square	C.V.	Root MSE	GRAINWT Mean
0.917401	6.664109	58.72931	881.2778

Dependent Variable: GRAINWT

Source	DF	Type I SS	Mean Square	F Value	Pr > F
C1	1	7.053	7.053	0.00	0.9641
C2	1	78620.049	78620.049	22.79	0.0001
C3	1	31357.514	31357.514	9.09	0.0043
C4	1	35185.066	35185.066	10.20	0.0026
C6	1	15954.687	15954.687	4.63	0.0370
C8	1	88778.180	88778.180	25.74	0.0001
R1	1	130227.001	130227.001	37.76	0.0001
R2	1	3182.964	3182.964	0.92	0.3420
R4	1	34117.771	34117.771	9.89	0.0030
R8	1	20274.909	20274.909	5.88	0.0195
R10	1	16821.594	16821.594	4.88	0.0325
C1*R1	1	138479.979	138479.979	40.15	0.0001
C2*R1	1	61605.531	61605.531	17.86	0.0001
C3*R1	1	13248.961	13248.961	3.84	0.0564
TRT	121	1017703.032	8410.769	2.44	0.0005

Source	DF	Type III SS	Mean Square	F Value	Pr > F
C1	1	12952.986	12952.986	3.76	0.0591
C2	1	48712.489	48712.489	14.12	0.0005
C3	1	42867.475	42867.475	12.43	0.0010
C4	1	22613.228	22613.228	6.56	0.0140
C6	1	31220.232	31220.232	9.05	0.0043
C8	1	77300.177	77300.177	22.41	0.0001
R1	1	28677.708	28677.708	8.31	0.0061
R2	1	12832.205	12832.205	3.72	0.0602
R4	1	4992.843	4992.843	1.45	0.2354
R8	1	20170.221	20170.221	5.85	0.0198
R10	1	15068.496	15068.496	4.37	0.0424
C1*R1	1	52885.122	52885.122	15.33	0.0003
C2*R1	1	24976.581	24976.581	7.24	0.0100
C3*R1	1	7998.357	7998.357	2.32	0.1350
TRT	121	1017703.032	8410.769	2.44	0.0005

The MIXED Procedure

Covariance Parameter Estimates (REML)

Cov Parm	Estimate
R1	9685.7206435
R2	147.76385914
R4	2382.8694456
R8	1165.7087131
R10	1055.8582605
C1	0.00000000
C2	5739.9404029

C3	2401.8203763
C4	1702.2868779
C6	1375.7002135
C8	6678.6086902
R1*C1	125150.99858
R1*C2	62327.029930
R1*C3	7191.3342088
NEW*TRT	2880.2792533
Residual	4385.0838420

Solution for Fixed Effects

Effect	TRTN	Estimate	Std Error	DF	t	Pr > |t|
INTERCEPT		887.85653363	7.78342790	44	114.07	0.0001
TRTN	121	22.56422549	14.52418333	44	1.55	0.1275
TRTN	122	-62.03676062	14.42385015	44	-4.30	0.0001

Least Squares Means

Effect	TRTN	LSMEAN	Std Error	DF	t	Pr > |t|
TRTN	121	910.42075912	12.23674167	44	74.40	0.0001
TRTN	122	825.81977301	12.15736600	44	67.93	0.0001
TRTN	999	887.85653363	7.78342790	44	114.07	0.0001

15 highest new treatment effects

OBS	_EFFECT_	TRT	_EST_	_SEPRED_	_DF_	T	_PT_
1	R1*C1		345.50045585	76.02914755	44	4.54	0.0001
2	R1		95.98535922	21.73762881	44	4.42	0.0001
3	NEW*TRT	60	86.34108807	42.34708520	44	2.04	0.0475
4	C8		79.38460062	19.40852139	44	4.09	0.0002
5	NEW*TRT	21	62.77643482	43.26254487	44	1.45	0.1539
6	R1*C3		62.42608658	57.39674225	44	1.09	0.2827
7	NEW*TRT	11	58.69112792	43.23892480	44	1.36	0.1816
8	NEW*TRT	99	56.51372478	42.26198657	44	1.34	0.1880
9	NEW*TRT	2	54.08461760	42.75771851	44	1.26	0.2126
10	NEW*TRT	35	49.26910001	42.25202699	44	1.17	0.2499
11	NEW*TRT	118	49.05376892	42.18955585	44	1.16	0.2512
12	NEW*TRT	58	48.88460726	42.12266951	44	1.16	0.2521
13	NEW*TRT	111	46.12302563	42.56352985	44	1.08	0.2844
14	C3		45.39408465	18.47150180	44	2.46	0.0180
15	R4		44.40038633	20.28481411	44	2.19	0.0340
16	NEW*TRT	46	44.15378862	42.18922373	44	1.05	0.3010
17	NEW*TRT	120	44.13816913	42.42913604	44	1.04	0.3039
18	NEW*TRT	61	42.88822110	42.53422618	44	1.01	0.3188
19	NEW*TRT	38	39.16602034	42.24545264	44	0.93	0.3589
20	NEW*TRT	82	38.75002538	42.56505326	44	0.91	0.3676
21	NEW*TRT	90	37.87365601	42.33458245	44	0.89	0.3759

.....Random *effects 21 to 119 deleted.*

15 lowest new treatment effects.

120	NEW*TRT	5	-36.65859703	42.24564023	44	-0.87	0.3902
121	NEW*TRT	23	-36.94625121	43.22631392	44	-0.85	0.3973
122	NEW*TRT	107	-40.26108079	42.27021281	44	-0.95	0.3461
123	NEW*TRT	55	-40.71903829	42.17831063	44	-0.97	0.3396
124	NEW*TRT	42	-40.77369290	42.69072074	44	-0.96	0.3447
125	NEW*TRT	56	-41.41021039	42.21331886	44	-0.98	0.3320
126	NEW*TRT	28	-41.70085605	42.31372687	44	-0.99	0.3298
127	NEW*TRT	17	-49.15984900	42.44192942	44	-1.16	0.2530

128	NEW*TRT	6	-52.33527614	42.15283284	44	-1.24	0.2210
129	NEW*TRT	51	-57.85952344	42.47160123	44	-1.36	0.1800
130	C2		-73.26618742	19.28735943	44	-3.80	0.0004
131	NEW*TRT	52	-75.09659823	42.62419762	44	-1.76	0.0850
132	NEW*TRT	43	-80.06306299	42.56340110	44	-1.88	0.0666
133	NEW*TRT	44	-80.23408721	42.42893008	44	-1.89	0.0652
134	NEW*TRT	81	-85.99507895	42.43715136	44	-2.03	0.0488
135	NEW*TRT	50	-91.58752547	42.56624934	44	-2.15	0.0370
136	R1*C2		-238.5012759	73.78434826	44	-3.23	0.0023