Hkkjrh; df"k vu l/kku if=dk] **34¼2½** 139&141] 2019 DOI: 10.18805/BKAP170

çfro'kh çHkkok dk lfEefyr dju okyh fjLi,Ul ljQl d l;ktu gr lkf[;dh; vfHkdYiuk,¡

ftræ dekj] lhek tXxh] ,Ynk oxhl] vi.k Hkkfed* ,o fluh oxhl

Hkk—vu-i-& Hkkjrh; —f"k lkf[;dh vu l/kku lLFkku] ub fnYyh&110 012] Hkkjr

iklr% ekp 2019 Lohdr% viy 2019

lkjk'k

fjLikl lj Ql i)fr ¼vkj-,l-,e-½ ,d ;k vf/kd çfrfØ;k pjk ,o ç;kxkRed pjk ;k dkjdk d ,d lV d chp lc/k dk vueku yxkrh g A vkerkj ij] vkj-,l-,e e ;g ekuk tkrk g fd ç{k.k LorU= g rFkk çfro'kh bdkb;k dk dkb çHkko ugh g A yfdu ,lh fLFkfr e tc bdkb;k dk fcuk fdlh vUrjky d jf[kd :i l j[kk tkrk g] ogk fudVorh bdkb;k l vkojyfix ;k çfro'kh çHkkok dh mPp lEHkkouk gkrh g A blfy, ijh{k.k dh ifj'k)rk dk fu.k; yu e] e,My e bu çHkkok dk 'kkfey djuk cgr gh egRoi.k g A bld vfrfjä] ijh{k.k lpkfyr dju d fy,] lk/kuk dh miyC/krk ,o ijh{k.k dk vkdkj ,d egRoi.k dkjd g A tl&tl vkdkj c<rk g] ijh{k.k lpkfyr dju e 'kkfey ykxr e of) gkrh g] ftll ijh{k.k dh lVhdrk de gk tkrh gA bl v/;;u e çfro'kh çHkkok dk 'kkfey dju okyh fjLikl lj Ql vfHkdYiukvk ij fopkj fd;k x;k gA juk dh NkVh l[;k e fMÝfU'k;y çfro'kh çHkkok lfgr çFke vkMj jkVcy vfHkdYiuk, ¼FORDDNE½ fodflr dh x;h gA

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Statistical designs for fitting response surfaces incorporating neighbour effects

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ABSTRACT

Response Surface Methodology (RSM) approximates the relationship between one or more response variables and a set of experimental variables or factors. In RSM, it is generally assumed that the observations are independent and there is no effect of neighbouring units. But under the situation when the units are placed linearly with no gaps there is high possibility of overlapping or neighbour effects from the adjacent units. So including these effects into the model is of great importance in deciding the precision of the experiment. Further, availability of resources and size of the experiment is important factor in conducting an experiment. As the size increases, cost involved in conducting the experiment increases, thereby decreasing the precision of the experiment. In this study, response surface designs incorporating neighbour effects have been considered. Method of constructing First Order Rotatable Designs with Differential Neighbour Effects (FORDDNE) has been developed in smaller number of runs.

çLrkouk

vufØ;k lrg i)fr db 0;k[;kRed pj vkj ,d ;k ,d l vf/kd vufØ;k pj d chp lc/kk dh iMrky dju d fy, mi;kx fd;k tkrk gA ;g fof/k c,DI vkj foYlu }kjk 1951 e i'k fd;k x;k FkkA ;g mu fLFkfr;k e mi;kx fd;k tkrk g tgk db buiV pj

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Hkk—vu-i-& Hkkjrh; —f"k lkf[;dh vu l/kku lLFkku] ub fnYyh&110 012] Hkkjr

lHkkfor :i l dN çn'ku eki ;k çfØ;k dh x.koÙkk dh fo'k"krk dk çHkkfor djr gA vf/kd fooj.k d fy, fuEufyf[kr lnHkk dk v/;u fd;k tk ldrk g] [kjh ,o d,uy ¼1996½ ,o ekVxkejh ,o id ¼2006½A vufØ;k lrg i)fr dk e,My fuEu çdkj l 0;ä fd;k tkrk gA

$$y_u = f(x_{1u}, x_{2u}, x_{3u}, \ldots, x_{vu}) + e_u \qquad u = 1,2,\ldots,n$$

vufØ;k lrg i)fr e ;g ekuk tkrk g fd ç{k.k Lor= g vkj fudVorh bdkb;k dk dkb çHkko ugh gA yfdu tc bdkb;k dk fcuk fdlh vrjky d lkFk jf[kd :i e j[kk tkrk gA rk ml fLFkfr e ç;kxkRed bdkb;k dk fudVorh bdkb;k e ykx mipkj l;ktu l çfro'kh çHkko dk vuHko gk ldrk gA bl çdkj ;g ekuuk vko';d g fd vufØ;ku doy ml fo'k"k bdkb ij ykx mipkj l;ktu ij fuHkj djrh g cfYd fudVorh bdkb;k ij ykx mipkj l;ktuk ij Hkh fuHkj djrh gA bl fo"k; e T;knk fooj.k d fy, mijkä lnHkk dk v/;;u fd;k tk ldrk g] Mij ,o xVeu ¼1980 ½] tXxh] lkfjdk ,o 'kek ¼2010 ½ ,o lkfjdk] tXxh ,o 'kek ¼2013½A

;g çfro'kh çHkkok d lkFk vufØ;k lrg i)fr ij lkfgR; e n[kk x;k Fkk fd fodfl r vfHkdYiukvk dk vke rkj ij cMh l[;k e juk dh vko';drk gkrh g tk vrr% Hk[kMk dh l[;k e of) djrh gA ftl l ç;kx dju e yxu okyh ykxr e of) gk tkrh gA vr% bl y[k e juk dh NkVh l[;k e vfHkdYiukvk d cukku dh fof/k çLrr dh x;h gA

vul/kku fØ;kfof/k% rRdky ck, vkj nk, fudVorh bdkb;k l çfro'kh çHkkok dk 'kkfey dju okyk e,My bl çdkj fy[kk x;k gA

$$y_{u'} = \sum_{u=1}^{N} g_{uu'} f(x_u) + e_{u'} \qquad u' = 1,\ldots, N$$

$g_{uu'} = 1$, if $u = u'$

$= \alpha_1, |\alpha_1| < 1$, if $u - u' = 1, u' < u$

$= \alpha_2, |\alpha_2| < 1$, if $u' - u = 1, u' < u$

$$f(x_u) = \beta_0 + \sum_{i=1}^{v} \beta_i x_{iu} + e_u$$

vk0;g :i e $Y = GX\beta + e$,G çfro'kh vk0;g gA ftl dk v,Mj $N \times (N+2)$ gA rFkk **X** dk vkMj $(N+2) \times (v+1)$ gA vxj G Kkr g] $\beta = (Z'Z)^{-1}Z'Y$

tgk $Z = GX$,o $D(\beta) = \sigma^2(Z'Z)^{-1}$

$$\mathbf{X} = \begin{bmatrix} 1 & x_{11} & x_{21} & \cdots & x_{v1} \\ 1 & x_{12} & x_{22} & \cdots & x_{v2} \\ 1 & x_{13} & x_{23} & \cdots & x_{v3} \\ \vdots & \vdots & \vdots & & \vdots \\ 1 & x_{1N} & x_{2N} & \cdots & x_{vN} \end{bmatrix}$$

$$\mathbf{G}_{N\times(N+2)} = \begin{bmatrix} \alpha_1 & 1 & \alpha_2 & 0 & 0 & 0 & \cdots & 0 & 0 \\ 0 & \alpha_1 & 1 & \alpha_2 & 0 & 0 & \cdots & 0 & 0 \\ 0 & 0 & \alpha_1 & 1 & \alpha_2 & 0 & \cdots & 0 & 0 \\ 0 & 0 & 0 & \alpha_1 & 1 & \alpha_2 & \cdots & 0 & 0 \\ \vdots & & & & & & & & \vdots \\ 0 & 0 & 0 & 0 & 0 & 0 & 0\ \alpha_1 & 1\ \alpha_2 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0\ 0 & \alpha_1\ 1 & \alpha_2 \end{bmatrix}$$

FORDDNE d fuek.k dh fof/k% 2^{v-1} d mPpre Øe dk dQ,mM djd mldh vk/kh çfr–fr çklr dj] ifj.kke Lo#i juk dh l[;k ?kVdj 2^{v-2} gk tkrh gA çklr vk/kh çfr–fr ¼dh Cy,d½ dk mld uhp ,d ckj vkj fy[k] vc ,d vfrfjä dkjd d fy,] çfof"V;k -1 vkj -1 l 'k: gku okyk ,d u;k d,ye bl çdkj tkM dh igy $2^{v-2}/2$ dh çfof"V;k +1 ,o 'k"k $2^{v-2}/2$ dh çfof"V;k &1 gkA vrr% lhek ly,V bdkb;k vkj vojk/k d x.kkd 'kkfey dju d i'pkr çklr vfHkdYiuk $2^{v-2}/2$ juk e FORDDNE gA tgk v dkjdk dh l[;k dk çnf'kr djrk gA v ¾ 4 d fy, vfHkdYiuk vk0;g ,o çfro'kh vk0;g ¼G½ fuEuyf[kr :i l fy[kk tkrk gA

mijkä vfHkdYiuk $\alpha_1 = 0.1$,o $\alpha_2 = 0.3$ yu ij]

$$X_{(2^4+2)\times 5} = \begin{bmatrix} 1 & -1 & -1 & -1 & -1 \\ 1 & 1 & -1 & 1 & 1 \\ 1 & -1 & 1 & 1 & 1 \\ 1 & 1 & 1 & -1 & 1 \\ 1 & -1 & -1 & -1 & 1 \\ 1 & 1 & -1 & 1 & -1 \\ 1 & -1 & 1 & 1 & -1 \\ 1 & 1 & 1 & -1 & -1 \\ 1 & -1 & -1 & -1 & -1 \\ 1 & 1 & -1 & 1 & 1 \end{bmatrix}$$

$$\mathbf{G}_{8\times 10} = \begin{bmatrix} \alpha_1 & 1 & \alpha_2 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & \alpha_1 & 1 & \alpha_2 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & \alpha_1 & 1 & \alpha_2 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & \alpha_1 & 1 & \alpha_2 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & \alpha_1 & 1 & \alpha_2 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & \alpha_1 & 1 & \alpha_2 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & \alpha_1 & 1 & \alpha_2 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & \alpha_1 & 1 & \alpha_2 \end{bmatrix}$$

mijkä vfHkdYiuk $\alpha_1 = 0.1$,o $\alpha_2 = 0.3$ yu ij]

$$(\mathbf{Z'Z})^{-1} = \begin{bmatrix} 0.0637 & 0 & 0 & 0 & 0 \\ 0 & 0.3472 & 0 & 0 & 0 \\ 0 & 0 & 0.1201 & 0 & 0 \\ 0 & 0 & 0 & 0.1201 & 0 \\ 0 & 0 & 0 & 0 & 0.0833 \end{bmatrix}$$

vuekfur çfrfØ;k d çlkj $V(\hat{y}_0) = \sigma^2 \mathbf{x'_0}(\mathbf{Z'Z})^{-1}\mathbf{x_0}$ dk eku $0.734\sigma^2$ g , tk vfHkdYiuk d lHkh fcnvk d fy, leku gA fuEufyf[kr vfHkdYiuk doy $\frac{2^v}{2}$ e jkVVcy gA vr% mijkä fof/k }kjk jfpr vfHkdYiuk de juk e vuekfur çfrfØ;k dh lVhdrk dk cjdjkj j[krk gA ftll ç;kx e yxu okyh ykxr e dkQh gn rd cpr gkrh gA

fu"d"k

llk/kuk dh miyC/krk vkj ç;kxkRed lkexh dk vkdkj fdlh Hkh çdkj d ç;kx dju e nk egRoi.k dkjd gA tl&tl vkdkj c<rk g] ç;kx dh ifj'k)rk de gk tkrh g] blfy, çfro'kh çHkkok dk 'kkfey djr g, vufØ;k lrg vfHkdYiuk fodflr fd, x, g] tk dh igy dh ryuk e vkdkj e Hkh NkV gA fodflr dh x;h vfHkdYiuk; ç;ä pjk dh fLFkjrk lfuf'pr djrh gA

lnHk

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