

# An algorithmic approach to constructing mixed-level orthogonal and near-orthogonal arrays

Nguyen N.-K., Liu M.-Q.

Centre for High-Performance Computing, Hanoi University of Science, 334 Nguyen Trai, Thanh Xuan, Hanoi, Viet Nam; Department of Statistics, School of Mathematical Sciences, Nankai University, Tianjin, 300071, China; LPMC, Nankai University, Tianjin, 300071, China

**Abstract:** Due to run size constraints, near-orthogonal arrays (near-OAs) and supersaturated designs, a special case of near-OA, are considered good alternatives to OAs. This paper shows (i) a combinatorial relationship between a mixed-level array and a non-resolvable incomplete block design (IBD) with varying replications (and its dual, a resolvable IBD with varying block sizes); (ii) the relationship between the criterion  $E(d^2)$  proposed by Lu and Sun [Lu, X., Sun, Y., 2001. Supersaturated designs with more than two levels. Chinese Ann. Math. B 22, 183-194] or  $E(f_{NOD})$  proposed by Fang et al. [Fang, K.T., Lin, D.K.J., Liu, M.Q., 2003b. Optimal mixed-level supersaturated design. *Metrika* 58, 279-291] used in the (near-) OA construction and the (M, S)-optimality criterion used in the IBD construction; (iii) the derivation of a tighter bound for  $E(d^2)$ ; (iv) how to modify the IBD algorithm of Nguyen [Nguyen, N.-K., 1994. Construction of optimal incomplete block designs by computer. *Technometrics* 36, 300-307] to obtain efficient (near-) OA algorithms. Some new (near-) OAs are presented and some near-OAs are compared with arrays constructed by other authors. Examples showing the use of the constructed arrays are given. © 2008 Elsevier B.V. All rights reserved.

**Index Keywords:** (n-1) criterion; Algorithmic approach; Block designs; Block sizes; Orthogonal arrays (OA); Size constraints; Supersaturated designs

Year: 2008

Source title: Computational Statistics and Data Analysis

Volume: 52

Issue: 12

Page : 5269-5276

Cited by: 3

Link: [Scopus Link](#)

Correspondence Address: Liu, M.-Q.; Department of Statistics, School of Mathematical Sciences, Nankai University, Tianjin, 300071, China; email: [mqliu@nankai.edu.cn](mailto:mqliu@nankai.edu.cn)

ISSN: 1679473

CODEN: CSDAD

DOI: 10.1016/j.csda.2008.05.004

Language of Original Document: English

Abbreviated Source Title: Computational Statistics and Data Analysis

Document Type: Article

Source: Scopus

## Authors with affiliations:

- Nguyen, N.-K., Centre for High-Performance Computing, Hanoi University of Science, 334 Nguyen Trai, Thanh Xuan, Hanoi, Viet Nam
- Liu, M.-Q., Department of Statistics, School of Mathematical Sciences, Nankai University, Tianjin, 300071, China, LPMC, Nankai University, Tianjin, 300071, China

## References:

- Booth, K.H.V., Cox, D.R., Some systematic supersaturated designs (1962) *Technometrics*, 4, pp. 489-495
- Box, G.E.P., Behnken, D.W., Some new three-level designs for the study of quantitative variables (1960) *Technometrics*, 2, pp. 455-475
- Chen, J., Liu, M.Q., Optimal mixed-level k-circulant supersaturated designs (2008) *J. Statist. Plann. Inference*, , 10.1016/j.jspi.2008.03.025 Available online 18 March 2008
- Chen, J., Liu, M.Q., Optimal mixed-level supersaturated design with general number of runs (2008) *Statist. Probab. Lett.*, , 10.1016/j.spl.2008.02.025 Available online 18 March 2008
- Fang, K.T., Ge, G.N., Liu, M.Q., Uniform supersaturated design and its construction (2002) *Sci. China Ser. A*, 45, pp. 1080-1088
- Fang, K.T., Ge, G.N., Liu, M.Q., Qin, H., Construction of minimum generalized aberration designs (2003) *Metrika*, 57, pp. 37-50
- Fang, K.T., Lin, D.K.J., Liu, M.Q., Optimal mixed-level supersaturated design (2003) *Metrika*, 58, pp. 279-291
- Fang, K.T., Ge, G.N., Liu, M.Q., Construction of optimal supersaturated designs by the packing method (2004) *Sci. China Ser. A*, 47, pp. 128-143
- Fang, K.T., Ge, G.N., Liu, M.Q., Qin, H., Combinatorial constructions for optimal supersaturated designs (2004) *Discrete Math.*, 279, pp. 191-202
- Fang, K.T., Ge, G.N., Liu, M.Q., Qin, H., Construction of uniform designs via super-simple resolvable t-designs (2004) *Util. Math.*, 66, pp. 15-32
- Fang, K.T., Li, R., Sudjianto, A., (2006) *Design and Modeling for Computer Experiments*, , Chapman & Hall, Boca Raton
- John, J.A., Williams, E.R., (1995) *Cyclic Designs and Computer Generated Designs*, , Chapman and Hall, New York
- Kuhfeld, W.F., Tobias, R.D., Large factorial designs for product engineering and market research applications (2005) *Technometrics*, 47, pp. 122-132
- Lin, D.K.J., A new class of supersaturated designs (1993) *Technometrics*, 35, pp. 28-31
- Liu, M.Q., Fang, K.T., Some results on resolvable incomplete block designs (2005) *Sci. China Ser. A*, 48, pp. 503-512
- Liu, M.Q., Lin, D.K.J., 2008. Construction of optimal mixed-level supersaturated designs. *Statist. Sinica* (in press)Liu, M.Q., Zhang, R.C., Construction of E (s<sub>2</sub>)-optimal supersaturated designs using cyclic BIBDs (2000) *J. Statist. Plann. Inference*, 91, pp. 139-150
- Lu, X., Hu, W., Zheng, Y., A systematical procedure in the construction of multi-level supersaturated designs (2003) *J. Statist. Plann. Inference*, 115, pp. 287-310
- Lu, X., Li, W., Xie, M., A class of nearly orthogonal arrays (2006) *J. Quality Technol.*, 38, pp. 148-161
- Lu, X., Sun, Y., Supersaturated designs with more than two levels (2001) *Chinese Ann. Math. B*, 22, pp. 183-194
- Ma, C.X., Fang, K.T., Liski, E., A new approach in constructing orthogonal and nearly orthogonal arrays (2000) *Metrika*, 50, pp. 255-268
- Nguyen, N.-K., Construction of optimal incomplete block designs by computer (1994) *Technometrics*, 36, pp. 300-307
- Nguyen, N.-K., An algorithmic approach to constructing supersaturated designs (1996) *Technometrics*, 38, pp. 205-209

- Nguyen, N.-K., A note on the construction of near-orthogonal arrays with mixed levels and economic run size (1996) *Technometrics*, 38, pp. 279-283
- Nguyen, N.-K., Borkowski, J.J., New 3-level response surface designs constructed from incomplete block designs (2008) *J. Statist. Plann. Inference*, 138, pp. 294-305
- Nguyen, N.-K., Cheng, C.S., New E (s<sub>2</sub>)-optimal supersaturated designs constructed from incomplete block designs (2008) *Technometrics*, 50, pp. 26-31
- Nguyen, N.-K., Miller, A.J., A review of exchange algorithms for constructing discrete D-optimal designs (1992) *Comput. Statist. Data Anal.*, 14, pp. 489-498
- Rao, C.R., Fractional experiments derivable from combinatorial arrangements of arrays (1947) *J. Roy. Statist. Soc. Suppl.*, 9, pp. 128-139
- Taguchi, G., 1959. Linear graphs for orthogonal arrays and their applications to experimental designs, with the aid of various techniques. Report of Statistical Applications Research, Japanese Union of Scientists and Engineers 6, pp. 1-43
- Wang, J.C., Wu, C.F.J., Nearly orthogonal arrays with mixed levels and small runs (1992) *Technometrics*, 34, pp. 409-422
- Wu, C.F.J., Construction of supersaturated designs through partially aliased interactions (1993) *Biometrika*, 80 (3), pp. 661-669
- Xu, H., An algorithm for constructing orthogonal and nearly-orthogonal arrays with mixed levels and small runs (2002) *Technometrics*, 44, pp. 356-368