Online Companion to "A User's Guide to the Brave New World of Designing Simulation Experiments"

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OC 1. Introduction

This is the online companion to "A User's Guide to the Brave New World of Simulation Experiments" (hereafter referred to as "A User's Guide") by the same authors. Here we provide sample design matrices for several experimental designs used in the case study. These include orthogonal and nearly-orthogonal Latin Hypercube (LH) designs, as well as a crossed design useful when seeking to identify robust strategies.

For a complete description of the case study, as well as the resulting analysis, see Section 6 of "A User's Guide". Briefly, the case study explores an agent-based simulation model of a humanitarian assistance operation in an urban environment. The primary performance measure is the number of civilians fed.

OC 2. Designs for Initial Experiment

The initial experiment involved exploring how 40 factors impacted the performance. With this many factors, Latin Hypercubes were efficient designs for examining the impact of simultaneously changing the specified factor values. Since nearly-orthogonal LHS designs are currently available for at most 22 factors, we chose to construct square (40-run) Latin hypercubes as the basic designs and append 16 of these in order to arrive at a final design that had good orthogonality properties.

In general, let $[L_i, U_i]$ denote the range of interest for factor i during the experiment, and c_{ij} denote the coded level for factor i in run j. Then the natural level f_{ij} is found by a simple rescaling:

$$f_{ij} = L_i + \frac{(U_i - L_i)(c_{ij} - 1)}{n - 1} \tag{1}$$

Within each of our basic designs, the low and high values are coded as 1 and 40, respectively. Note that the software platform we used required integer-valued settings for all many factors, so (if necessary) we rounded the factor level to the nearest integer. Appending 16 40-run LH designs, rather than constructing a single 640-run LH

design, meant that less rounding occurred when the design was converted from coded levels to natural levels. A portion of a single base LH design (in coded levels) is provided in Table OC.1.

Table OC.1: Base LH Design for 40 Factors (Coded Levels)

Design Pt ID	Factor					
	F1	**F2**	**F3**	**F4**	**…**	**F40**
1	14	30	1	5	…	38
2	6	5	32	7	…	34
3	20	12	4	26	…	7
4	18	8	40	22	…	14
5	3	13	33	15	…	32
6	16	21	10	36	…	9
7	26	26	11	16	…	10
…	…	…	…	…	…	…
40	8	36	31	38	…	31

OC 2. Designs for Second Experiment

We now describe the designs used for the second experiment (robust design) in the HA case study. The 40 original factors were classified as four decision factors and 34 noise factors (2 were discarded from further experiments). With only four decision factors, it is possible to vary these using the orthogonal LH design shown in Table OC.1. This design requires only n=17 runs, and the low and high values are coded as 1 and 17, respectively.

Table OC.1: Orthogonal LH Design for 4 Decision Factors (Coded Levels)

Design Pt ID	Factor			
	DF1	**DF2**	**DF3**	**DF4**
1	7	6	17	14
2	10	2	5	15
3	5	3	8	2
4	17	4	11	6
5	3	13	16	8
6	14	17	6	7
7	6	11	4	17
8	16	10	15	13
9	9	9	9	9
10	11	12	1	4
11	8	16	13	3
12	13	15	10	16
13	1	14	7	12
14	15	5	2	10
15	4	1	12	11
16	12	7	14	1
17	2	8	3	5

The basic design used for the noise factor space was a nearly-orthogonal LH design for eight factors (requiring 33 runs). This design (in coded levels) is shown in the first 8 columns of Table OC.2. We replicated the last column 26 additional times in order to embed a group screening design for 27 factors that did not appear important in the initial experiment. Once again, these coded levels must be converted to natural levels spanning the factor ranges of interest in order to run the simulations.

Table OC.2: Nearly-Orthogonal LH 8-Factor Design with 27 Embedded Factors (Coded Levels)

Design Pt	8 Factor Design								Embedded Factors		
ID	NF1	NF2	NF3	NF4	NF5	NF6	NF7	NF8	NF9	…	NF34
1	15	16	7	29	23	21	33	23	23	…	23
2	5	11	13	16	15	7	30	25	25	…	25
3	30	2	6	2	32	20	11	24	24	…	24
4	33	3	14	31	4	6	15	27	27	…	27
5	16	19	8	23	5	24	3	14	14	…	14
6	11	29	10	15	18	8	2	6	6	…	6
7	32	30	9	1	1	22	29	13	13	…	13
8	31	33	12	30	31	9	18	8	8	…	8
9	8	7	18	24	20	11	20	1	1	…	1
10	10	13	23	8	7	18	28	4	4	…	4
11	25	6	32	12	21	3	13	5	5	…	5
12	22	14	31	25	6	32	8	16	16	…	16
13	7	26	19	20	10	5	12	32	32	…	32
14	13	24	29	6	26	19	9	31	31	…	31
15	28	25	30	13	12	1	24	22	22	…	22
16	20	22	33	27	25	30	27	19	19	…	19
17	17	17	17	17	17	17	17	17	17	…	17
18	19	18	27	5	11	13	1	11	11	…	11
19	29	23	21	18	19	27	4	9	9	…	9
20	4	32	28	32	2	14	23	10	10	…	10
21	1	31	20	3	30	28	19	7	7	…	7
22	18	15	26	11	29	10	31	20	20	…	20
23	23	5	24	19	16	26	32	28	28	…	28
24	2	4	25	33	33	12	5	21	21	…	21
25	3	1	22	4	3	25	16	26	26	…	26
26	26	27	16	10	14	23	14	33	33	…	33
27	24	21	11	26	27	16	6	30	30	…	30
28	9	28	2	22	13	31	21	29	29	…	29
29	12	20	3	9	28	2	26	18	18	…	18
30	27	8	15	14	24	29	22	2	2	…	2
31	21	10	5	28	8	15	25	3	3	…	3
32	6	9	4	21	22	33	10	12	12	…	12
33	14	12	1	7	9	4	7	15	15	…	15

To run the experiments, we crossed these two designs. This means that for each combination of decision factors (i.e., each row of Table OC.1), we made a total of 8 design points: one for each combination of noise factor settings (i.e., each row of Table OC.2). The crossed design approach is shown in Table OC.3. 50 independently seeded replications were made for each row of this crossed design matrix. We refer the reader to "A User's Guide" for the results of our experiments on the humanitarian assistance simulation. Further details on robust design for simulation experiments can be found in Ramberg et al. (1991) or Sanchez et al. (1996).

Table OC.3. Crossed Design (Coded Levels) for the Second Experiment

Decision Factor	**Coded Factor Levels**							**Noise Factor**
Design Pt ID	**DF1**	**DF2**	**DF3**	**DF4**	**NF1**	**…**	**NF34**	**Design Pt ID**
1	7	6	17	14	15	…	23	1
1	7	6	17	14	5	…	25	2
…	…	…	…	…	…	…	…	…
1	7	6	17	14	14	…	15	33
2	10	2	5	15	15	…	23	1
2	10	2	5	15	5	…	25	2
…	…	…	…	…	…	…	…	…
2	10	2	5	15	14	…	15	33
…	…	…	…	…	…	…	…	…
17	2	8	3	5	15	…	23	1
17	2	8	3	5	5	…	25	2
…	…	…	…	…	…	…	…	…
17	2	8	3	5	14	…	15	33

OC 4. Sources for Designs

Tables of orthogonal LH designs for seven or fewer factors, and nearly-orthogonal LH designs for up to 22 factors, are available in Cioppa (2003). Alternatively, an interactive spreadsheet that asks for up to 22 factor names, low levels, and high levels, and returns orthogonal or nearly-orthogonal designs in natural levels, can be downloaded from http://diana.gl.nps.navy.mil/~susan/NOLHdesigns.xls. Generating random LH designs is a straightforward process that is built into many standard statistical packages.

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