

DOE design of experiments

If possible, this is a good start

In research it is possible to reduce the experimental work by carrying the experiments using an organized plan. To start, it is necessary to find out the essential factors which have significant role in explaining the phenomenon under research.

First: Extract the essential

This can be done using a fractional factorial design. It is started by selecting the candidate variables, which may be significant in explaining the phenomenon. For each factor, two values are selected to be used in experiments. The values should be chosen with care. They must be reasonable so that the phenomenon can be experimented using just those values. If they are too close together then the differences between experimental results may remain small.

The scheme should be as follows: The high value is denoted by + and the low value by -

Each row is a permutation of variables. Each column corresponds one variable. The scheme is balanced so that every variable is as many times in the + state and in the - state. In other words each column has equal number of +:s and -:s. For seven variables the scheme should be like following:

```
+ + + - + - - f
- + + + - + - f
- - + + + - + f
+ - - + + + - f
- + - - + + + f
+ - + - - + + f
+ + - + - - + f
+ + + - + - - f
- - - - - - - f
```

For verification, there should be extra variables that are non significant in the scheme. The statistical routines that are used to analyze the experimental set demand some redundancy. Recommended number of insignificant slack variables is one third of all variables. In a balanced design the number of pluses equals number of minuses. Moreover correlation between the independent variables is zero. This method is generally known as Plackett-Burman design. There is an other popular scheme called Taguchi method. It differs a little from this.

The building rules for a balanced scheme are quite simple.

- 1) Select the first row, where the number of variables is sufficient.
- 2) Shift the row by one for next row until you have n rows.
- 3) The last (n+1)th row is only minuses.
- 4) You can change plus and minus signs
- 5) List of first rows

```
03 y + + -
07 y + + + - + - -
11 y + + - + + + - - - + -
15 y + + + + - + - + + - - + - - -
19 y + - - + + + + - + - + - - - + + -
23 y + + + + + - + - + + - - + + - - + - + - - - -
```


DOE analysis report

Dependent Variable = funct Fcrit= 1.500

Step 1 Var= 5 x5 Added Corr .786
Res Sum Of Sqrs= 9.92 Std Err Of Estim= .842

Variable	Coeff	Coefferr	Fvalue
5 x5	.2500	.5261E-01	22.577

Constant .000

Step 2 Var= 1 x1 Added Corr .980
Res Sum Of Sqrs= 1.04 Std Err Of Estim= .283

Variable	Coeff	Coefferr	Fvalue
1 x1	.1863	.1769E-01	110.877
5 x5	.2500	.1769E-01	199.769

Constant .000

Step 3 Var= 2 x2 Added Corr 1.000
Res Sum Of Sqrs= .800E-03 Std Err Of Estim= .816E-02

Variable	Coeff	Coefferr	Fvalue
1 x1	.1863	.5103E-03	9999.990
2 x2	-.6375E-01	.5103E-03	9999.990
5 x5	.2500	.5103E-03	9999.990

Constant .000

Residual analysis

x1	x2	x5	func	model	resid
1.000	1.000	1.000	1.480	1.490	-.010
1.000	1.000	-1.000	-.500	-.510	.010
1.000	-1.000	-1.000	.000	.000	.000
-1.000	1.000	1.000	.000	.000	.000
1.000	-1.000	1.000	2.000	2.000	.000
-1.000	-1.000	1.000	.520	.510	.010
-1.000	1.000	-1.000	-2.000	-2.000	.000
1.000	1.000	1.000	1.480	1.490	-.010

One more note

The residuals in ideal set of experiments should be near zero. Big residuals indicate that some extra factors are involved.

Download estlabco/DoeAnalysis.exe

In Dos Window:

Create Data.txt

run DoeaAnalysis

You get Report.txt

DOE analysis

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Constant .000

function versus model

x1	x2	x5	func	model	resid
1.000	1.000	1.000	1.480	1.490	-.010
1.000	1.000	-1.000	-.500	-.510	.010
1.000	-1.000	-1.000	.000	.000	.000
-1.000	1.000	1.000	.000	.000	.000
1.000	-1.000	1.000	2.000	2.000	.000
-1.000	-1.000	1.000	.520	.510	.010
-1.000	1.000	-1.000	-2.000	-2.000	.000
1.000	1.000	1.000	1.480	1.490	-.010
-1.000	-1.000	-1.000	-1.500	-1.490	-.010
-1.000	-1.000	1.000	.520	.510	.010
-1.000	1.000	1.000	.000	.000	.000
1.000	-1.000	-1.000	.000	.000	.000
-1.000	1.000	-1.000	-2.000	-2.000	.000

1.000	1.000	-1.000	-.500	-.510	.010
1.000	-1.000	1.000	2.000	2.000	.000
-1.000	-1.000	-1.000	-1.500	-1.490	-.010