Package 'rsurface'

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Type Package

Title Design of Rotatable Central Composite Experiments and Response Surface Analysis

Version 1.1.0

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Description Produces tables with the level of replication (number of replicates) and the experimental uncoded values of the quantitative factors to be used for rotatable Central Composite Design (CCD) experimentation and a 2-D contour plot of the corresponding variance of the predicted response according to Mead et al. (2012) <doi:10.1017/CBO9781139020879> design_ccd(), and analyzes CCD data with response surface methodology ccd_analysis(). A rotatable CCD provides values of the variance of the predicted response that are concentrically distributed around the average treatment combination used in the experimentation, which with uniform precision (implied by the use of several replicates at the average treatment combination) improves greatly the search and finding of an optimum response. These properties of a rotatable CCD represent undeniable advantages over the classical factorial design, as discussed by Panneton et al. (1999) <doi:10.13031/2013.13267> and Mead et al. (2012) <doi:10.1017/CBO9781139020879.018> among others.

Depends R (>= 3.5)

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Encoding UTF-8

LazyData true

Imports grDevices, plotly, rsm, stats

RoxygenNote 6.0.1

NeedsCompilation no

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R topics documented:

`ccd_analysis` *Response surface regression analysis of CCD data*

Description

For the simultaneous production of response surface analysis output by **rsm** used in combination with **graphics** in the second-order polynomial approach. The predictor variables must be named "Factor1", "Factor2", etc., while the response variable must be named "Response". The output includes regression model fitting and plot of the fitted response surface.

Usage

```
ccd_analysis(x)
```

Arguments

`x`	the matrix of experimental data that contains columns with the uncoded levels for each experimental factor and the observed values for the response variable in the rightmost column.

Value

The user will be prompted to enter "1" for a 3-D plot of the response surface, or "2" to plot the contour of the predicted variance of the response

"Data.For.Analysis", includes the data set and the coding coefficients for the transformation of the independent factors

"Response.Surface.Summary", includes the response surface for variable, hypothesis tests for linear, quadratic, and crossproduct terms, lack of fit test, parameter estimates, the factor ANOVA table, canonical analysis, and eigenvectors

References

Mead, R., Gilmour, S. G., and Mead, A. 2012. Statistical Principles for the Design of Experiments: Applications to Real Experiments. Cambridge University Press, Cambridge.

Panneton, B., Philion, H., Dutilleul, P., Theriault, R., and Khelifi, M. 1999. Full factorial design versus central composite design: Statistical comparison and experimental implications for spray droplet deposition. Transactions of the American Society of Agricultural Engineers 42:877-883.

Examples

```
if(interactive()){
 ccd_analysis(ExampleData)
 }
```

`design_ccd` *Defines a CCD for k quantitative factors*

Description

Defines a rotatable central composite design (CCD) for experimentation with k quantitative factors and j replicates of the central point (which corresponds to the 'average treatment combination').

Usage

```
design_ccd(j, k)
```

Arguments

`j`	the number of replicates of the central point
`k`	the number of quantitative factors used or studied in the experimentation.

Value

Three output tables containing the level of replication (number of replicates) and the experimental uncoded values of the quantitative factors to be used for experimentation and one plot showing the corresponding variance of the predicted response.

"Factorial.Points", the first table which contains the treatment combinations for a 2^*k* factorial design (which, in coded form, corresponds to the vertices of a square, a cube, or a hyper-cube when *k* = 2, 3 and more).

"Axial.Points", the second table which contains 2k axial or "star" points.

"Central.Point", the third table which contains the number of replicates for the central point, coded (0, 0, 0).

References

Mead, R., Gilmour, S. G., and Mead, A. 2012. Statistical Principles for the Design of Experiments: Applications to Real Experiments. Cambridge University Press, Cambridge.

Panneton, B., Philion, H., Dutilleul, P., Theriault, R., and Khelifi, M. 1999. Full factorial design versus central composite design: Statistical comparison and experimental implications for spray droplet deposition. Transactions of the American Society of Agricultural Engineers 42:877-883.

Examples

```
#Enter the function as shown below. The user will be prompted to input smallest
#and greatest values for each factor that will be used for experimentation.

if(interactive()){
 design_ccd(5, 3)
 }
```

ExampleData *Example data for the* **rsurface** *package*

Description

This example uses experimental data published in Czitrom and Spagon (1997), *Statistical Case Studies for Industrial Process Improvement* that describes a semiconductor wafer processing experiment. A goal of this experiment was to fit response surface models to the deposition layer stress as a function of two particular controllable factors of the chemical vapor deposition (CVD) reactor process. These factors were pressure (measured in torr) and the ratio of the gaseous reactants hydrogen gas and tungsten(VI) fluoride.

Usage

```
ExampleData
```

Format

A data frame with three columns and ten rows of values

Factor1 Pressure measured in torr

Factor2 The ratio of gaseous reactants. The smallest and greatest values for the ratios of hydrogen gas to tungsten(VI) fluoride were chosen to be 2 and 10.

Response Deposition layer stress

References

Czitrom, V., and Spagon, P. D., (1997), Statistical Case Studies for Industrial Process Improvement, Philadelphia, PA, ASA-SIAM Series on Statistics and Applied Probability.

`rsurface` *Functions for the design of CCD experiments and the analysis of CCD experimental data*

Description

A package for the planning of experiments following rotatable central composite designs (CCDs) and the analysis of CCD experimental data with response surface methodology.

Functions

`design_ccd()`, for the number of values and the experimental uncoded values for each of the k quantitative factors

`ccd_analysis()`, for response surface analysis, including the regression model fitting and plot of the fitted response surface

References

Mead, R., Gilmour, S. G., and Mead, A. 2012. Statistical Principles for the Design of Experiments: Applications to Real Experiments. Cambridge University Press, Cambridge.

Panneton, B., Philion, H., Dutilleul, P., Theriault, R., and Khelifi, M. 1999. Full factorial design versus central composite design: Statistical comparison and experimental implications for spray droplet deposition. Transactions of the American Society of Agricultural Engineers 42:877-883.

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