Package ‘LatticeDesign’

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Version 1.0-1

Title Lattice-Based Space-Filling Designs

Description Lattice-based space-
filling designs with fill or separation distance properties, including interleaved lattice-
based maximin distance designs proposed in Xu He (2018) <arXiv:1807.02289v1>,
(sliced) rotated sphere packing designs pro-
posed in Xu He (2017) <doi:10.1080/01621459.2016.1222289>
and Xu He (2018) <doi:10.1080/00401706.2018.1458655>, and densest packing-
based maximum projections designs proposed in Xu He (2018) <arXiv:1709.02062v2>.

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LatticeDesign-package *LatticeDesign package*

Description

Generate lattice-based space-filling designs with fill or separation distance properties, including interleaved lattice-based maximin distance designs, (sliced) rotated sphere packing designs and densest packing-based maximum projections designs.

Details

Package:	LatticeDesign
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Important functions in this package are: `InterleavedMaximinD` generates an interleaved lattice-based maximin distance design. `DPMPD` generates a densest packing-based maximum projection design. `RSPD` generates a rotated sphere packing design. `SlicedRSPD` generates a sliced rotated sphere packing design by partitioning one rotated sphere packing design. `AdaptiveRSPD` generates a sliced rotated sphere packing design by enlarging one rotated sphere packing design.

All those functions generate space-filling designs with fill or separation distance properties. Such designs are useful for accurate emulation of computer experiments, fitting nonparametric models and resource allocation. They are constructed from lattices, i.e., sets of points with group structures.

`RSPD` and `DPMPD` generate designs in two to eight dimensions with both unprojected and projective distance properties. Such designs are desirable when possibly the output value is insensitive to some variables. `DPMPD` can be seen as an upgrade of `RSPD` using new magic rotation matrices. Another distinction is that `RSPD` generates designs with better unprojected fill distance for nonboundary regions while `DPMPD` generates designs with better unprojected separation distance. `RSPD` and `DPMPD` construct designs by rescaling, rotating, translating and extracting the points of the lattice with asymptotically optimal fill and separation distance, respectively.

`SlicedRSPD` and `AdaptiveRSPD` generate sliced rotated sphere packing designs, i.e., a rotated sphere packing design that can be partitioned into several smaller rotated sphere packing designs. `SlicedRSPD` partitions one rotated sphere packing design. The generated designs are useful for computer experiments with a categorical variable, computer experiments from multiply resources and model validation. Alternatively, `AdaptiveRSPD` enlarges a smaller rotated sphere packing design, which is useful for adaptive design of computer experiments.

`InterleavedMaximinD` generates designs with so far the best separation distance. Such designs are useful for accurate emulation of computer experiments when the variables are almost equally important in predicting the output value or relatively accurate a priori guess on the variable importance is available. `InterleavedMaximinD` allows users to specify the relative importance of variables and is applicable to problems with any number of variables, provided that important variables are not many. On the other hand, such designs are poor in projective distance properties and are thus not recommended when the output value is insensitive to more than one unknown variables.

Author(s)

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References

He, Xu (2017). "Rotated sphere packing designs", *Journal of the American Statistical Association*, 112(520): 1612-1622.

He, Xu (2018). "Sliced rotated sphere packing designs", *Technometrics*, accepted, DOI: 10.1080/00401706.2018.1458655.

He, Xu (2018). "Interleaved lattice-based maximin distance designs", *Biometrika*, accepted, arXiv:1807.02289v1.

He, Xu (2018). "Lattice-based designs with quasi-uniform projections", arXiv:1709.02062v2.

`AdaptiveRSPD` *Sliced rotated sphere packing designs by enlarging a design*

Description

Generates a sliced rotated sphere packing design by enlarging one rotated sphere packing design.

Usage

```
AdaptiveRSPD(p=2,n,w=100)
```

Arguments

`p`	Number of dimensions, must be an integer greater than one.
`n`	Number of points of the small design, must be a positive integer.
`w`	Number of rotation matrices to try.

Details

This function generates a small rotated sphere packing design and the candidate points for enlarging it.

Value

The value returned from the function is a list containing the following components:

`Design`	The generated design.
`candidates`	The candidate points to add.
`generator`	The generator matrix.
`rotation`	The rotation matrix.

`delta`	The value of parameter delta.
`Theta`	The value of parameter Theta.
`l`	The value of parameter l.
`FillDistance`	The fill distance of the design for the nonboundary region.

References

He, Xu (2018). "Sliced rotated sphere packing designs", *Technometrics*, accepted,
DOI: 10.1080/00401706.2018.1458655.

Examples

```
AdaptiveRSPD(p=2,n=50,w=100)
```

`DPMPD` *Densest packing-based maximum projection designs*

Description

Generates a densest packing-based maximum projection design.

Usage

```
DPMPD(p,n,rotation="magic",w=100)
```

Arguments

`p`	Number of dimensions, must be an integer greater than one and no higher than eight.
`n`	Number of points, must be an integer greater than one.
`rotation`	Optional, whether to use magic rotation matrices (for p=2,3,4,6,8, recommended) or random rotation matrices.
`w`	Number of rotation matrices to try.

Details

This function generates a densest packing-based maximum projection design.

Value

The value returned from the function is a list containing the following components:

`Design`	The generated design.
`ProjectiveSeparationDistance`	The projective separation distance of the generated design, from one-dimensional projections to the unprojected design.

References

He, Xu (2018). "Lattice-based designs with quasi-uniform projections", arXiv:1709.02062v2.

Examples

```
DPMPD(p=4,n=200,w=100)
```

`GeneratorMatrices` *Generator matrices of standard interleaved lattices*

Description

These data sets give the generator matrices of standard interleaved lattices, treating dimension prumeted lattices as different lattices. Data sets GeneratorMatrices2, GeneratorMatrices3, GeneratorMatrices4, and GeneratorMatrices5 give the matrices in 2, 3, 4, and 5, dimensions, respectively.

Usage

```
data(GeneratorMatrices2);
data(GeneratorMatrices3);
data(GeneratorMatrices4);
data(GeneratorMatrices5);
```

Format

Matrices containing generator matrices.

References

He, Xu (2018). "Interleaved lattice-based maximin distance designs", *Biometrika*, accepted, arXiv:1807.02289v1.

`InterleavedMaximinD` *Interleaved lattice-based maximin distance designs*

Description

Generates an interleaved lattice-based maximin distance design.

Usage

```
InterleavedMaximinD(p,n,weight=rep(1,p));
InterleavedMaximinDAlg1(p,n,weight=rep(1,p));
InterleavedMaximinDAlg2(p,n,weight=rep(1,p));
InterleavedMaximinDAlg3(p,n,weight=rep(1,p));
```

Arguments

`p`	Number of dimensions, must be an integer greater than one.
`n`	Targeted number of points, must be an integer greater than one.
`weight`	Optional, the weights used in the distance measure, higher for more important variable.

Details

These functions generate an interleaved lattice-based maximin distance design in p dimensions and at least n points, following the algorithms provided in the paper "Interleaved lattice-based maximin distance designs". Function InterleavedMaximinD uses the recommended algorithm provided in the paper. Functions InterleavedMaximinDAlg1, InterleavedMaximinDAlg2, and InterleavedMaximinDAlg3 use Algorithm 1, 2, and 3, respectively. For InterleavedMaximinDAlg1, p must be no greater than 5. For InterleavedMaximinDAlg3, p must be greater than 8.

Value

The value returned from the function is a list containing the following components:

`Design`	The generated design.
`SeparationDistance`	The separation distance of the generated design.
`m`	The actual number of points of the generated design.
`DesignTransformed`	The generated design that is transformed to the rectangular design space given the weights.
`weight`	The weight used in the distance measure, higher for more important variable.
`s_vector`	The numbers of distinct levels of the generated design.
`L01`	The base design.

References

He, Xu (2018). "Interleaved lattice-based maximin distance designs", *Biometrika*, accepted, arXiv:1807.02289v1.

Examples

```
InterleavedMaximinD(p=3,n=10,weight=rep(1,3));
InterleavedMaximinDAlg1(p=3,n=10);
InterleavedMaximinDAlg2(p=6,n=10);
InterleavedMaximinDAlg3(p=9,n=120);
```

ProjSepD *Projective separation distance of a design*

Description

Computes the projective separation distance of a design.

Usage

```
ProjSepD(design);
```

Arguments

design	The experimental design, must be a matrix whose rows indicate experimental runs.

Details

This function computes the squared projective separation distance of a design.

Value

The value returned from the function gives the squared one-dimensional, two-dimensional, ..., (p-1)-dimensional projective separation distances, and the unprojected separation distance, where p is the number of dimensions of the design.

References

He, Xu (2018). "Lattice-based designs with quasi-uniform projections", arXiv:1709.02062v2.

Examples

```
design = rbind(1:3,c(41,1.2,1.3),c(5.4,5.48,5.7),c(4.3,2.3,2));
ProjSepD(design);
```

RSPD *Rotated sphere packing designs*

Description

Generates a rotated sphere packing design.

Usage

```
RSPD(p=2,n,rotation="magic",w=100)
```

Arguments

`p`	Number of dimensions, must be an integer greater than one.
`n`	Number of points, must be a positive integer.
`rotation`	Optional, whether to use the magic rotation matrix (for p=2, recommended) or random rotation matrices.
`w`	Number of rotation matrices to try, fixed to 1 when p=2 and rotation="magic".

Details

This function generates a rotated sphere packing design.

Value

The value returned from the function is a list containing the following components:

`Design`	The generated design.
`generator`	The generator matrix.
`rotation`	The rotation matrix.
`delta`	The value of parameter delta.
`Theta`	The value of parameter Theta.
`l`	The value of parameter l.
`FillDistance`	The fill distance of the design for the nonboundary region.

References

He, Xu (2017). "Rotated sphere packing designs", *Journal of the American Statistical Association*, 112(520): 1612-1622.

Examples

```
RSPD(p=2,n=50,rotation="magic",w=100)
```

`SlicedRSPD` *Sliced rotated sphere packing designs by partitioning a design*

Description

Generates a sliced rotated sphere packing design by partitioning one rotated sphere packing design.

Usage

```
SlicedRSPD(p=2,n,rotation="magic",w=100)
```

Arguments

`p`	Number of dimensions, must be an integer greater than one.
`n`	Number of points, must be a positive integer.
`rotation`	Optional, whether to use magic rotation matrices (for p=2, recommended) or random rotation matrices.
`w`	Number of rotation matrices to try.

Details

This function generates a rotated sphere packing design and the slice indexes of points.

Value

The value returned from the function is a list containing the following components:

`Design`	The generated design.
`slices`	The slice indexes of design points.
`generator`	The generator matrix.
`rotation`	The rotation matrix.
`delta`	The value of parameter delta.
`Theta`	The value of parameter Theta.
`l`	The value of parameter l.
`FillDistance`	The fill distance of the design for the nonboundary region.

References

He, Xu (2018). "Sliced rotated sphere packing designs", *Technometrics*, accepted,
DOI: 10.1080/00401706.2018.1458655.

Examples

```
SlicedRSPD(p=2,n=50,rotation="magic",w=100)
```

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