

Package ‘ShapDoE’

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Type Package

Title Approximation of the Shapley Values Based on Experimental Designs

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Description Estimating the Shapley values using the algorithm in the paper Liuqing Yang, Yongdao Zhou, Haoda Fu, Min-Qian Liu and Wei Zheng (2024) <doi:10.1080/01621459.2023.2257364> ``Fast Approximation of the Shapley Values Based on Order-of-Addition Experimental Designs". You provide the data and define the value function, it returns the estimated Shapley values based on sampling methods or experimental designs.

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est.sh	<i>The main algorithm for estimating the Shapley value</i>
--------	--

Description

The main algorithm for estimating the Shapley value

Usage

```
est.sh(method, d, n, val, ..., p = NA, f_d = NA)
```

Arguments

method	the method used for estimating, 'SRS' means simple random sampling, 'StrRS' means structured simple random sampling, 'LS' means Latin square and 'COA' means component orthogonal array.
d	an integer, the number of players.
n	an integer, the sample size.
val	the predefined value function.
...	other parameters used in val(sets,...).
p	a prime, the bottom number of d.
f_d	a vector represents the coefficients of primitive polynomial on GF(d). For example the primitive polynomial on GF(3 ²) is x ² +x+2, then let f_d=c(1,1,2).

Value

a vector including estimated Shapley values of all players.

Examples

```
temp_adjacent<-matrix(0,nrow=8,ncol=8)
temp_adjacent[1,6:8]<-1;temp_adjacent[2,7]<-1;temp_adjacent[c(4,6,7),8]<-1;
temp_adjacent<-temp_adjacent+t(temp_adjacent)
temp_val<-function(sets,adjacent){
  if(length(sets)==1) val<-0
  else{
    subadjacent<-adjacent[sets,sets]
    nsets<-length(sets)
    A<-diag(1,nsets); B<-matrix(0,nsets,nsets)
```

```

    for(l in 1:(nsets-1)){
      A<-A%%subadjacent
      B<-B+A
    }
    val<-ifelse(sum(B==0)>nsets,0,1)
  }
  return(val)
}
est.sh('SRS',8,112,temp_val,temp_adjacent)
est.sh('StrRS',8,112,temp_val,temp_adjacent)
est.sh('LS',8,112,temp_val,temp_adjacent)
est.sh('COA',8,112,temp_val,temp_adjacent,p=2,f_d=c(1,0,1,1))

```

est.shcoa	<i>Estimating the Shapley value based on component orthogonal array (COA) with a prime power d</i>
-----------	--

Description

Estimating the Shapley value based on component orthogonal array (COA) with a prime power d

Usage

```
est.shcoa(d, n, val, p, f_d, ...)
```

Arguments

d	a power of prime p, the number of players.
n	an integer, the sample size.
val	the predefined value function.
p	a prime, the bottom number of d.
f_d	a vector represents the coefficients of primitive polynomial on GF(d). For example the primitive polynomial on GF(3^2) is x^2+x+2 , then let $f_d=c(1,1,2)$.
...	other parameters used in val(sets,...).

Value

a vector including estimated Shapley values of all players based on COA.

Examples

```

temp_adjacent<-matrix(0,nrow=8,ncol=8)
temp_adjacent[1,6:8]<-1;temp_adjacent[2,7]<-1;temp_adjacent[c(4,6,7),8]<-1;
temp_adjacent<-temp_adjacent+t(temp_adjacent)
temp_val<-function(sets,adjacent){
  if(length(sets)==1) val<-0
  else{
    subadjacent<-adjacent[sets,sets]

```

```

nsets<-length(sets)
A<-diag(1,nsets); B<-matrix(0,nsets,nsets)
for(l in 1:(nsets-1)){
  A<-A%%subadjacent
  B<-B+A
}
val<-ifelse(sum(B==0)>nsets,0,1)
}
return(val)
}
est.shcoa(8,112,temp_val,2,c(1,0,1,1),temp_adjacent)

```

est.shcoa.prime	<i>Estimating the Shapley value based on component orthogonal array (COA) with a prime d</i>
-----------------	--

Description

Estimating the Shapley value based on component orthogonal array (COA) with a prime d

Usage

```
est.shcoa.prime(d, n, val, ...)
```

Arguments

d	a prime, the number of players.
n	an integer, the sample size.
val	the predefined value function.
...	other parameters used in val(sets,...).

Value

a vector including estimated Shapley values of all players based on COA.

Examples

```

temp_adjacent<-matrix(0,nrow=5,ncol=5)
temp_adjacent[1,c(2,3,5)]<-1;temp_adjacent[2,4]<-1;temp_adjacent[3,5]<-1;
temp_adjacent<-temp_adjacent+t(temp_adjacent)
temp_val<-function(sets,adjacent){
  if(length(sets)==1) val<-0
  else{
    subadjacent<-adjacent[sets,sets]
    nsets<-length(sets)
    A<-diag(1,nsets); B<-matrix(0,nsets,nsets)
    for(l in 1:(nsets-1)){
      A<-A%%subadjacent

```

```

        B<-B+A
      }
      val<-ifelse(sum(B==0)>nsets,0,1)
    }
    return(val)
  }
  est.shcoa.prime(5,20,temp_val,temp_adjacent)

```

est.shls

*Estimating the Shapley value based on Latin square (LS)***Description**

Estimating the Shapley value based on Latin square (LS)

Usage

```
est.shls(d, n, val, ...)
```

Arguments

d	an integer, the number of players.
n	an integer, the sample size.
val	the predefined value function.
...	other parameters used in val(sets,...).

Value

a vector including estimated Shapley values of all players based on LS.

Examples

```

temp_adjacent<-matrix(0,nrow=8,ncol=8)
temp_adjacent[1,6:8]<-1;temp_adjacent[2,7]<-1;temp_adjacent[c(4,6,7),8]<-1;
temp_adjacent<-temp_adjacent+t(temp_adjacent)
temp_val<-function(sets,adjacent){
  if(length(sets)==1) val<-0
  else{
    subadjacent<-adjacent[sets,sets]
    nsets<-length(sets)
    A<-diag(1,nsets); B<-matrix(0,nsets,nsets)
    for(l in 1:(nsets-1)){
      A<-A%%subadjacent
      B<-B+A
    }
    val<-ifelse(sum(B==0)>nsets,0,1)
  }
  return(val)
}
est.shls(8,56,temp_val,temp_adjacent)

```

est.shsrs

Estimating the Shapley value based on simple random sampling (SRS)

Description

Estimating the Shapley value based on simple random sampling (SRS)

Usage

```
est.shsrs(d, n, val, ...)
```

Arguments

d	an integer, the number of players.
n	an integer, the sample size.
val	the predefined value function.
...	other parameters used in val(sets,...).

Value

a vector including estimated Shapley values of all players based on SRS.

Examples

```
temp_adjacent<-matrix(0,nrow=8,ncol=8)
temp_adjacent[1,6:8]<-1;temp_adjacent[2,7]<-1;temp_adjacent[c(4,6,7),8]<-1;
temp_adjacent<-temp_adjacent+t(temp_adjacent)
temp_val<-function(sets,adjacent){
  if(length(sets)==1) val<-0
  else{
    subadjacent<-adjacent[sets,sets]
    nsets<-length(sets)
    A<-diag(1,nsets); B<-matrix(0,nsets,nsets)
    for(l in 1:(nsets-1)){
      A<-A%%subadjacent
      B<-B+A
    }
    val<-ifelse(sum(B==0)>nsets,0,1)
  }
  return(val)
}
est.shsrs(8,112,temp_val,temp_adjacent)
```

est.shstrrs	<i>Estimating the Shapley value based on structured simple random sampling (StrRS)</i>
-------------	--

Description

Estimating the Shapley value based on structured simple random sampling (StrRS)

Usage

```
est.shstrrs(d, n, val, ...)
```

Arguments

d	an integer, the number of players.
n	an integer, the sample size.
val	the predefined value function.
...	other parameters used in val(sets,...).

Value

a vector including estimated Shapley values of all players based on StrRS.

Examples

```
temp_adjacent<-matrix(0,nrow=8,ncol=8)
temp_adjacent[1,6:8]<-1;temp_adjacent[2,7]<-1;temp_adjacent[c(4,6,7),8]<-1;
temp_adjacent<-temp_adjacent+t(temp_adjacent)
temp_val<-function(sets,adjacent){
  if(length(sets)==1) val<-0
  else{
    subadjacent<-adjacent[sets,sets]
    nsets<-length(sets)
    A<-diag(1,nsets); B<-matrix(0,nsets,nsets)
    for(l in 1:(nsets-1)){
      A<-A%%subadjacent
      B<-B+A
    }
    val<-ifelse(sum(B==0)>nsets,0,1)
  }
  return(val)
}
est.shstrrs(8,112,temp_val,temp_adjacent)
```

gfpoly.add	<i>Polynomial additive defined on GF(s) with a prime s</i>
------------	--

Description

Polynomial additive defined on GF(s) with a prime s

Usage

```
gfpoly.add(f1, f2, s)
```

Arguments

f1	a vector represents the coefficients of the first addend polynomial. For example, if the dividend is x^5+2x^3+1 , then $f1=c(1,0,2,0,0,1)$.
f2	a vector represents the coefficients of the second addend polynomial. For example, if the divisor is x^4+2 , then $f2=c(1,0,0,0,2)$.
s	a prime, the order of the Galois field (GF).

Value

a vector represents the coefficients of the resulting polynomial. For example, the result $c(1, 1, 2, 0, 0, 0)$ represents $x^5+x^4+2x^3$.

Examples

```
gfpoly.add(c(1,0,2,0,0,1),c(1,0,0,0,2),3)
```

gfpoly.div	<i>Polynomial division defined on GF(s) with a prime s</i>
------------	--

Description

Polynomial division defined on GF(s) with a prime s

Usage

```
gfpoly.div(f1, f2, s)
```

Arguments

f1	a vector represents the coefficients of the dividend polynomial. For example, if the dividend is x^5+2x^3+1 , then $f1=c(1,0,2,0,0,1)$.
f2	a vector represents the coefficients of the divisor polynomial. For example, if the divisor is x^4+2 , then $f2=c(1,0,0,0,2)$.
s	a prime, the order of the Galois field (GF).

Value

a vector represents the coefficients of the resulting polynomial. For example, the result `c(2,0,1,1)` represents $2x^3+x+1$.

Examples

```
gfpoly.div(c(1,0,2,0,0,1),c(1,0,0,0,2),3)
```

gfpoly.multi

Polynomial multiplication defined on GF(s) with a prime s

Description

Polynomial multiplication defined on GF(s) with a prime s

Usage

```
gfpoly.multi(f1, f2, s)
```

Arguments

- | | |
|----|---|
| f1 | a vector represents the coefficients of the first multiplier polynomial. For example, if the dividend is x^5+2x^3+1 , then <code>f1=c(1,0,2,0,0,1)</code> . |
| f2 | a vector represents the coefficients of the second multiplier polynomial. For example, if the divisor is x^4+2 , then <code>f2=c(1,0,0,0,2)</code> . |
| s | a prime, the order of the Galois field (GF). |

Value

a vector represents the coefficients of the resulting polynomial. For example, the result `c(1,0,2,0,2,1,1,0,0,2)` represents $x^9+2x^7+2x^5+x^4+x^3+2$.

Examples

```
gfpoly.multi(c(1,0,2,0,0,1),c(1,0,0,0,2),3)
```

is.prime

Determine whether an integer is a prime

Description

Determine whether an integer is a prime

Usage

```
is.prime(x)
```

Arguments

x the integer to be determined.

Value

the result: TRUE (x is a prime) or FALSE (x is not a prime).

Examples

```
is.prime(7)
is.prime(8)
```

oneco

Generate a component orthogonal array (COA) with a prime power d

Description

Generate a component orthogonal array (COA) with a prime power d

Usage

```
oneco(d, p, f_d)
```

Arguments

d a power of prime p, the column of the resulting COA.
p a prime, the bottom number of d.
f_d a vector represents the coefficients of primitive polynomial on GF(d). For example the primitive polynomial on GF(3²) is x²+x+2, then let f_d=c(1,1,2).

Value

a COA with d(d-1) rows and d columns.

Examples

```
onecoa(9,3,c(1,1,2))
```

onecoa.prime	<i>Generate a component orthogonal array (COA) with a prime d</i>
--------------	---

Description

Generate a component orthogonal array (COA) with a prime d

Usage

```
onecoa.prime(d)
```

Arguments

d a prime, the column of the resulting COA.

Value

a COA with d(d-1) rows and d columns.

Examples

```
onecoa.prime(5)
```

onels	<i>Generate an Latin square (LS)</i>
-------	--------------------------------------

Description

Generate an Latin square (LS)

Usage

```
onels(d)
```

Arguments

d an integer, the run size of the resulting LS.

Value

an LS with d rows and d columns.

Examples

```
onels(5)
```

`poly.div`*Polynomial division*

Description

Polynomial division

Usage`poly.div(f1, f2)`**Arguments**

- `f1` a vector represents the coefficients of the dividend polynomial. For example, if the dividend is x^5+2x^3+1 , then `f1=c(1,0,2,0,0,1)`.
- `f2` a vector represents the coefficients of the divisor polynomial. For example, if the divisor is x^4+2 , then `f2=c(1,0,0,0,2)`.

Value

a vector represents the coefficients of the resulting polynomial. For example, the result `c(2,0,-2,1)` represents $2x^3-2x+1$.

Examples`poly.div(c(1,0,2,0,0,1),c(1,0,0,0,2))`

`structed.perm`*Generate the structured samples of simple random samples*

Description

Generate the structured samples of simple random samples

Usage`structed.perm(permatrix, jcom, d)`**Arguments**

- `permatrix` a matrix, each row is a permutation.
- `jcom` an integer, represents the target component. Hope that the component `jcom` appears the same number of at each position.
- `d` the number of components.

Value

a matrix represents the structured samples.

Examples

```
temp_samples<-matrix(nrow=10,ncol=5)
for(i in 1:10){temp_samples[i,]<-sample(1:5,5)}
structed.perm(temp_samples,3,5)
```

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