

# Package ‘EDOIF’

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**Title** Empirical Distribution Ordering Inference Framework (EDOIF)

**Version** 0.1.4

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**Description** A non-parametric framework based on estimation statistics principle. Its main purpose is to infer orders of empirical distributions from different categories based on a probability of finding a value in one distribution that is greater than an expectation of another distribution. Given a set of ordered-pair of real-category values the framework is capable of 1) inferring orders of domination of categories and representing orders in the form of a graph; 2) estimating magnitude of difference between a pair of categories in forms of mean-difference confidence intervals; and 3) visualizing domination orders and magnitudes of difference of categories. The publication of this package is at Chainarong Amornbunchornvej, Navaporn Surasvadi, Anon Plangprasopchok, and Suttipong Thajchayapong (2020) <[doi:10.1016/j.heliyon.2020.e05435](https://doi.org/10.1016/j.heliyon.2020.e05435)>.

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**URL** <https://github.com/DarkEyes/EDOIF>

**BugReports** <https://github.com/DarkEyes/EDOIF/issues>

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bootDiffmeanFunc	<i>bootDiffmeanFunc function</i>
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## Description

bootDiffmeanFunc is a support function for bootstrapping method. Its main task is to infer mean-difference confidence intervals of distributions for all categories except the first category in idx (idx[2],idx[3],...) minus a target category (idx[1]).

## Usage

```
bootDiffmeanFunc(Group, Values, idx, reps, ci, methodType)
```

## Arguments

Group	is a vector of categories of each real number in Values
Values	is a vector of real-number values
idx	is an order list of categories; idx[1] is a target category while others (idx[2],idx[3],...) are compared against idx[1] in order to compute mean-difference confidence intervals.
reps	is a number of time of sampling with replacement in a bootstrapping method.
ci	is a level of confidence interval inferred.

methodType is a type of method for inferring confidence intervals. It is a parameter of two.boot function of simpleboot package.

### Value

This function returns a list of mean-difference confidence intervals of categories idx[2],idx[3],... minus category idx[1].

result a list of objects that contains mean-difference confidence intervals of pairs of distributions. It contains mean-difference confidence intervals of categories idx[2],idx[3],... minus category idx[1].

---

checkSim3Res                    *checkSim3Res function*

---

### Description

checkSim3Res is a support function for checking whether an adjacency matrix of inferred a dominant-distribution network adjMat is corrected w.r.t. generator SimNonNormalDist().

### Usage

```
checkSim3Res(adjMat, flag = 0)
```

### Arguments

adjMat is an adjacency matrix of inferred a dominant-distribution network.  
flag is a flag of matrix. It should be set only to shift the low of matrix for comparison.

### Value

This function returns precision, recall, and F1-score of inferred adjacency matrix.

### Examples

```
# Generate simulation data with 100 samples per categories
simData<-SimNonNormalDist(nInv=100)

# Performing ordering inference from simData
resultObj<-ED0IF(simData$Values,simData$Group)

# Compare the inferred adjacency matrix with the ground truth
checkSim3Res(adjMat=resultObj$adjMat)
```

**Description**

EDOIF is a non-parametric framework based on Estimation Statistics principle. Its main purpose is to infer orders of empirical distributions from different categories base on a probability of finding a value in one distribution that greater than the expectation of another distribution.

Given a set of ordered-pair of real-category values the framework is capable of 1) inferring orders of domination of categories and representing orders in the form of a graph; 2) estimating magnitude of difference between a pair of categories in forms of confidence intervals; and 3) visualizing domination orders and magnitudes of difference of categories.

**Usage**

```
EDOIF(Values, Group, bootT, alpha, methodType)
```

**Arguments**

Values	is a vector of real-number values
Group	is a vector of categories of each real number in Values
bootT	is a number of times of sample with replacement for bootstrapping. The default is 1000. It must be above zero
alpha	is a significance level using in both confidence intervals and ordering inference it has the range [0,1]. The default is 0.05.
methodType	is an option for bootstrapping methods:either "perc" or "bca". The "perc" is the default option.

**Value**

This class constructor returns an object of EDOIF class.

obj an object of EDOIF class that contains the results of ordering inference that can be print in text mode (`print(obj)`) or graphic mode (`plot(obj)`).

The obj consists of the following variables

Values, Group	The main inputs of the framework. They are the double and character vectors respectively.
bootT, alpha, methodType	The number of bootstrapping, significance level, and bootstrapping method parameters.
sortedGroupList	A list of names of categories ascendingly ordered by their means.
sortedmeanList	A list of means of categories that are ascendingly ordered.

<code>MegDiffList[[i]]</code>	Mean difference confidence intervals and related information of all categories that have higher means than <code>sortedGroupList[i]</code> category.
<code>confInvsList[i, ]</code>	A mean confidence interval of <code>sortedGroupList[i]</code> category. <code>confInvsList[i,1]</code> is a lower bound and <code>confInvsList[i,2]</code> is an upper bound.
<code>adjMat[i, j]</code>	An element of adjacency matrix: one if <code>sortedGroupList[j]</code> category dominates <code>sortedGroupList[i]</code> using Mann-Whitney test, otherwise zero.
<code>pValMat[i, j]</code>	A p-value of Mann-Whitney test for <code>adjMat[i,j]</code> .
<code>adjDiffMat[i, j]</code>	A lower bound of confidence interval of mean difference for <code>sortedGroupList[j]</code> minus <code>sortedGroupList[i]</code> using <code>methodType</code> bootstrap.
<code>adjBootMat[i, j]</code>	One if <code>adjDiffMat[i,j]</code> is positive, otherwise, zero.
<code>netDen</code>	A network density of dominant-distribution network derived from <code>adjMat</code> .
<code>gObj</code>	An object of <code>iGraph</code> of a dominant-distribution network.

**Author(s)**

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**See Also**

Run `vignette("EDOIF_demo", package = "EDOIF")` in a terminal to learn more details about how to use our package.

**Examples**

```
# Generate simulation data
nInv<-100
initMean=10
stepMean=20
std=8
simData1<-c()
simData1$Values<-rnorm(nInv,mean=initMean,sd=std)
simData1$Group<-rep(c("C1"),times=nInv)
simData1$Values<-c(simData1$Values,rnorm(nInv,mean=initMean,sd=std) )
simData1$Group<-c(simData1$Group,rep(c("C2"),times=nInv))
simData1$Values<-c(simData1$Values,rnorm(nInv,mean=initMean+2*stepMean,sd=std) )
simData1$Group<-c(simData1$Group,rep(c("C3"),times=nInv) )
simData1$Values<-c(simData1$Values,rnorm(nInv,mean=initMean+3*stepMean,sd=std) )
simData1$Group<-c(simData1$Group, rep(c("C4"),times=nInv) )
simData1$Values<-c(simData1$Values,rnorm(nInv,mean=initMean+4*stepMean,sd=std) )
simData1$Group<-c(simData1$Group, rep(c("C5"),times=nInv) )

# Performing ordering inference from simData1

resultObj<-EDOIF(simData1$Values,simData1$Group)
```

```
# Print results in text mode
print(resultObj)

# Plot results in graphic mode
plot(resultObj)
```

---

getADJNetDen	<i>getADJNetDen function</i>
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---

### Description

getADJNetDen is a support function for calculating a network density of a dominant-distribution network.

### Usage

```
getADJNetDen(adjMat)
```

### Arguments

adjMat is an adjacency matrix of a dominant-distribution network.

### Value

This function returns a value of network density of of a dominant-distribution network for a given adjMat.

### Examples

```
# Generate simulation data with 100 samples per categories
simData<-SimNonNormalDist(nInv=100)

# Performing ordering inference from simData
resultObj<-EDOIF(simData$Values,simData$Group)

# Get a network density of an adjacency matrix
getADJNetDen(adjMat=resultObj$adjMat)
```

---

getConfInv                      *getConfInv function*

---

### Description

getConfInv is a support function for bootstrapping method. Its main purpose is to compute a mean confidence intervals of all distributions.

### Usage

```
getConfInv(Values, Group, GroupList, bootT, alpha, methodType)
```

### Arguments

Values	is a vector of real-number values
Group	is a vector of categories of each real number in Values
GroupList	is a list of names of categories ascendingly ordered by their means.
bootT	is a number of times of sample with replacement for bootstrapping. The default is 1000. It must be above zero
alpha	is a significance level using in both confidence intervals and ordering inference it has the range [0,1]. The default is 0.05.
methodType	is an option for bootstrapping methods:either "perc" or "bca". The "perc" is the default option.

### Value

This function returns a list of mean confidence intervals.

```
confInvsList[i, ]
                  The mean confidence interval of sortedGroupList[i] category. confInvsList[i,1]
                  is a lower bound and confInvsList[i,2] is an upper bound.
```

---

getDominantRADJ                      *getDominantRADJ function*

---

### Description

getDominantRADJ is a support function for inferring a dominant-distribution network using mean-difference confidence intervals.

### Usage

```
getDominantRADJ(MegDiffList, methodType)
```

**Arguments**

- `MegDiffList` is a list of objects that contains mean-difference confidence intervals inferred by `getMegDiffConfInv` function.
- `methodType` is an option for bootstrapping methods: either "perc" or "bca".

**Value**

This function returns an adjacency matrix of a dominant-distribution network `adjMat` and the corresponding lower-bound of mean difference CIs `adjDiffMat`.

- `adjDiffMat[i, j]` A lower bound of confidence interval of mean difference for `j` minus `i` using `methodType` bootstrap.
- `adjMat[i, j]` An element of adjacency matrix: One if `adjDiffMat[i,j]` is positive, otherwise, zero.

---

`getiGraphNetDen`      *getiGraphNetDen* function

---

**Description**

`getiGraphNetDen` is a support function for calculating a network density of a dominant-distribution network.

**Usage**

```
getiGraphNetDen(g)
```

**Arguments**

- `g` is an object of `iGraph` class of a dominant-distribution network.

**Value**

This function returns a value of network density of of a dominant-distribution network for a given object `g`.

**Examples**

```
# Generate simulation data with 100 samples per categories
simData<-SimNonNormalDist(nInv=100)

# Performing ordering inference from simData
resultObj<-ED0IF(simData$Values,simData$Group)

# Get a network density of an iGraph object
```



```
getiGraphNetDen(g=resultObj$gObj)
```

---

getiGraphOBJ	<i>getiGraphOBJ function</i>
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---

### Description

getiGraphOBJ is a support function for converting a dominant-distribution network adjacency matrix to an iGraph object.

### Usage

```
getiGraphOBJ(adjMat, sortedGroupList)
```

### Arguments

adjMat is an adjacency matrix of a dominant-distribution network.

sortedGroupList is a list of names of categories ascendingly ordered by their means.

### Value

This function returns an iGraph object of a dominant-distribution network for a given adjMat.

### Examples

```
# Generate simulation data with 100 samples per categories
simData<-SimNonNormalDist(nInv=100)
# Performing ordering inference from simData
resultObj<-ED0IF(simData$Values,simData$Group)
# Get an iGraph object from an adjacency matrix
igraphObj<-getiGraphOBJ(adjMat=resultObj$adjMat,sortedGroupList=resultObj$sortedGroupList)
```

---

getMegDiffConfInv      *getMegDiffConfInv function*

---

### Description

getMegDiffConfInv is a support function for bootstrapping method. Its main purpose is to compute a mean-difference confidence intervals between all pair of distributions.

### Usage

```
getMegDiffConfInv(Values, Group, GroupList, bootT, alpha, methodType)
```

### Arguments

Values	is a vector of real-number values
Group	is a vector of categories of each real number in Values
GroupList	is a list of names of categories ascendingly ordered by their means.
bootT	is a number of times of sample with replacement for bootstrapping. The default is 1000. It must be above zero
alpha	is a significance level using in both confidence intervals and ordering inference it has the range [0,1]. The default is 0.05.
methodType	is an option for bootstrapping methods:either "perc" or "bca". The "perc" is the default option.

### Value

This function returns a list of mean-difference confidence intervals.

MegDiffList a list of objects that contains mean-difference confidence intervals of all possible pairs of distributions. It contains MegDiffList[[1]],...,MegDiffList[[length(GroupList)]].

The MegDiffList consists of the following variables

MegDiffList[[i]]

Mean-difference confidence intervals and related information of all categories that have higher means than sortedGroupList[i] category.

---

getOrder                      *getOrder function*

---

**Description**

getOrder is a support function for inferring a linear order of categories ascendingly sorted by their means.

**Usage**

```
getOrder(Values, Group)
```

**Arguments**

Values                      is a vector of real-number values  
Group                        is a vector of categories of each real number in Values

**Value**

This function returns two lists: an order list of categories `sortedGroupList` and its corresponding list of means `sortedmeanList`.

`sortedGroupList`

The list of names of categories ascendingly ordered by their means.

`sortedmeanList` The list of means of categories that are ascendingly ordered.

**Examples**

```
# Generate simulation data  
  
simData<-SimNonNormalDist(nInv=100,noisePer=0.1)  
  
# Call the function to get the sorted lists  
getOrder(Values=simData$Values,Group=simData$Group)
```

---

getttestDominantRADJ    *getttestDominantRADJ function*

---

**Description**

getttestDominantRADJ is a support function for inferring a dominant-distribution network using Student's t-test.

**Usage**

```
getttestDominantRADJ(Values, Group, GroupList, alpha)
```

**Arguments**

Values	is a vector of real-number values
Group	is a vector of categories of each real number in Values
GroupList	is a list of names of categories ascendingly ordered by their means.
alpha	is a significance level using in both confidence intervals and ordering inference it has the range [0,1].

**Value**

This function returns an adjacency matrix of a dominant-distribution network `adjMat` and the corresponding p-values of all category pairs.

<code>adjMat[i, j]</code>	An element of adjacency matrix: one if <code>GroupList[j]</code> category dominates <code>GroupList[i]</code> using Student's t-test, otherwise zero.
<code>pValMat[i, j]</code>	A p-value of Student's t-test for <code>adjMat[i,j]</code> .

---

`getWilcoxDominantRADJ` *getWilcoxDominantRADJ function*

---

**Description**

`getWilcoxDominantRADJ` is a support function for inferring a dominant-distribution network using Mann-Whitney (Wilcoxon) Test.

**Usage**

```
getWilcoxDominantRADJ(Values, Group, GroupList, alpha)
```

**Arguments**

Values	is a vector of real-number values
Group	is a vector of categories of each real number in Values
GroupList	is a list of names of categories ascendingly ordered by their means.
alpha	is a significance level using in both confidence intervals and ordering inference it has the range [0,1].

**Value**

This function returns an adjacency matrix of a dominant-distribution network `adjMat`. and the corresponding p-values of all category pairs.

<code>adjMat[i, j]</code>	An element of adjacency matrix: one if <code>GroupList[j]</code> category dominates <code>GroupList[i]</code> using Mann-Whitney test, otherwise zero.
<code>pValMat[i, j]</code>	A p-value of Mann-Whitney test for <code>adjMat[i,j]</code> .

---

meanBoot	<i>meanBoot function</i>
----------	--------------------------

---

**Description**

meanBoot is a support function for bootstrapping method. Its main purpose is to compute a mean of a given samples from data selected by indices.

**Usage**

```
meanBoot(data, indices)
```

**Arguments**

data	is a vector of real-number values
indices	is a vector of TRUE/FALSE indices. It allows boot to select samples.

**Value**

This function returns a mean of values in data that have values TRUE within indices.

---

plot.EDOIF	<i>plot.EDOIF function</i>
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---

**Description**

plot.EDOIF is a support function for printing all plots of EDOIF framework: dominant-distribution network plot, mean CI plot, and mean-difference CI plot.

**Usage**

```
## S3 method for class 'EDOIF'
plot(x, ..., NList, options, fontSize)
```

**Arguments**

x	is an object of EDOIF class that contains the results of ordering inference.
...	Signature for S3 generic function.
NList	is a list of based categories users want to have in mean-difference CI plot.
options	is an option of reporting EDOIF plot(s): 0 for reporting all plots, 1 for mean-difference CI plot, 2 for mean CI plot, and 3 for dominant-distribution network plot.
fontSize	is a font size of text for all plots.

**Examples**

```
# Generate simulation data with 100 samples per categories

simData<-SimNonNormalDist(nInv=100)

# Performing ordering inference from simData

resultObj<-EDOIF(simData$Values,simData$Group)

# Plot results in graphic mode

plot(resultObj)
```

---

plotGraph

*plotGraph function*


---

**Description**

plotGraph is a support function for plotting a dominant-distribution network from an adjacency matrix.

**Usage**

```
plotGraph(obj, rankFlag = TRUE)
```

**Arguments**

obj	is an object of EDOIF class that contains the results of ordering inference.
rankFlag	is an option for including ranks of categories with in the plot: default is TRUE for including ranks.

**Value**

This function returns a list of an object of iGraph for a dominant-distribution network and its plot variable.

graphVar	An object of iGraph for a dominant-distribution network
----------	---

**Examples**

```
# Generate simulation data with 100 samples per categories

simData<-SimNonNormalDist(nInv=100)

# Performing ordering inference from simData

resultObj<-EDOIF(simData$Values,simData$Group)
```

```
# Plot a dominant-distribution network and return a list of an iGraph object
iGraphList<-plotGraph(obj=resultObj)
```

---

plotMeanCIs                      *plotMeanCIs function*

---

### Description

plotMeanCIs is a support function for plotting mean confidence intervals.

### Usage

```
plotMeanCIs(obj, fontSize = 15, rankFlag = TRUE)
```

### Arguments

obj	is an object of EDOIF class that contains the results of ordering inference.
fontSize	is a font size of text for all plots.
rankFlag	is an option for including ranks of categories with in the plot: default is TRUE for including ranks.

### Value

This function returns a list of an object of ggplot class.

pMeanCI	An object of ggplot class containing the plot of mean confidence intervals
---------	--

### Examples

```
# Generate simulation data with 100 samples per categories
simData<-SimNonNormalDist(nInv=100)

# Performing ordering inference from simData
resultObj<-EDOIF(simData$Values,simData$Group)

# Get a list of ggplot object of mean confidence intervals
ggplotList<-plotMeanCIs(obj=resultObj)

# Plot mean confidence intervals
plot(ggplotList$pMeanCI)
```

---

`plotMeanDiffCIs`      *plotMeanDiffCIs* function

---

**Description**

`plotMeanDiffCIs` is a support function for plotting difference-mean confidence intervals.

**Usage**

```
plotMeanDiffCIs(obj, NList, fontSize = 15, rankFlag = TRUE)
```

**Arguments**

<code>obj</code>	is an object of EDOIF class that contains the results of ordering inference.
<code>NList</code>	is a list of based categories users want to have in mean-difference CI plot.
<code>fontSize</code>	is a font size of text for all plots.
<code>rankFlag</code>	is an option for including ranks of categories with in the plot: default is TRUE for including ranks.

**Value**

This function returns a list of an object of ggplot class.

<code>pDiffCI</code>	An object of ggplot class containing the plot of mean-difference confidence intervals
----------------------	---

**Examples**

```
# Generate simulation data with 100 samples per categories
simData<-SimNonNormalDist(nInv=100)

# Performing ordering inference from simData
resultObj<-EDOIF(simData$Values,simData$Group)

# Get a list of ggplot object of mean-difference confidence intervals
ggplotList<-plotMeanDiffCIs(obj=resultObj)

# Plot mean-difference confidence intervals
plot(ggplotList$pDiffCI)
```



---

print.EDOIF	<i>print.EDOIF function</i>
-------------	-----------------------------

---

**Description**

print.EDOIF is a support function for printing results of ordering inference in text.

**Usage**

```
## S3 method for class 'EDOIF'  
print(x, ...)
```

**Arguments**

x is an object of EDOIF class that contains the results of ordering inference.  
... Signature for S3 generic function.

**Examples**

```
# Generate simulation data with 100 samples per categories  
  
simData<-SimNonNormalDist(nInv=100)  
  
# Performing ordering inference from simData  
  
resultObj<-EDOIF(simData$Values,simData$Group)  
  
# Print results in text mode  
  
print(resultObj)
```

---

SimMixDist	<i>SimMixDist function</i>
------------	----------------------------

---

**Description**

SimMixDist is a support function for generating samples from mixture distribution. The main purpose of this function is to generate samples from non-normal distribution.

**Usage**

```
SimMixDist(nInv, mean, std, p1, p2)
```

**Arguments**

nInv	is a number of samples the function will generate.
mean	is a mean of a normal distribution part of mixture distribution.
std	is a standard deviation of a normal distribution part of mixture distribution.
p1	is a ratio of a normal distribution within a mixture distribution.
p2	is a ratio of a Cauchy distribution within a mixture distribution.

**Value**

This function returns a list of samples  $V$  generated by a mixture distribution.

**Examples**

```
# Generate simulation data with 100 samples with a mixture distribution
# The distribution consist of the following distributions:
# 1) 10% of uniform distribution range [-400,400];
# 2) 50% of normal distribution with mean = 40 and std =8; and
# 3) 40% of Cauchy distribution with location= 45 and scale = 2.

V<-SimMixDist(nInv=100,mean=40,std=8,p1=0.1,p2=0.5)
```

---

SimNonNormalDist      *SimNonNormalDist function*

---

**Description**

SimNonNormalDist is a support function for generating samples from mixture distribution. There are five categories. Each categories has nInv samples. Categories C1,C2,C3, and C4 are dominated by C5 but none of them dominate each other.

**Usage**

```
SimNonNormalDist(nInv, noisePer)
```

**Arguments**

nInv	is a number of samples the function will generate for each category.
noisePer	is ratio of uniform distribution within a mixture distribution. It is considered as a uniform noise that make an approach to hardly distinguish whether one distribution dominates another.

**Details**

The main purpose of this function is to generate samples that contains domination relation among categories.

**Value**

This function returns a list of samples `Values` and their category `Group` generated by a mixture distribution.

`Values`            A vector of samples generated by a mixture distribution.

`Group`            A list of categories associated with `Values`.

`V1, ..., V5`      Lists of sample vectors separated by categories.

**Examples**

```
# Generate simulation data with 100 samples per categories with 10% of uniform noise  
  
simData<-SimNonNormalDist(nInv=100,noisePer=0.1)
```

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