Package 'ELMSO'

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Type Package

Title Implementation of the Efficient Large-Scale Online Display Advertising Algorithm

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Description An implementation of the algorithm described in ``Efficient Large-Scale Internet Media Selection Optimization for Online Display Advertising" by Paulson, Luo, and James (Journal of Marketing Research 2018; see URL below for journal text/citation and <http://faculty.marshall.usc.edu/gareth-james/Research/ELMSO.pdf> for a full-text version of the paper). The algorithm here is designed to allocate budget across a set of online advertising opportunities using a coordinate-descent approach, but it can be used in any resource-allocation problem with a matrix of visitation (in the case of the paper, website page-views) and channels (in the paper, websites). The package contains allocation functions both in the presence of bidding, when allocation is dependent on channel-specific cost curves, and when advertising costs are fixed at each channel.

Depends R (>= 3.4.0)

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ELMSO *Main ELMSO Function*

Description

This function allows you to allocate budget to a set of websites based on the cost curve of the websites and a matrix of pageviews for those sites.

Usage

```
ELMSO(z, CPM = NULL, a = NULL, tau = NULL, step = 0.05,
  size = 100, tol = 10^-3, iters = 200)
```

Arguments

z	An n by p matrix of pageviews
CPM	A p-dimensional vector of the average CPM values at each website. This is used to calculate the cost curve from a shifted logistic function. You may instead enter values for a p-dimensional "a" vector to define your own shifted logistic cost curve.
a	A p-dimensional vector of values controlling the steepness of the shifted logistic cost curve. You may instead enter values for a p-dimensional vector of average CPM values to have the curve calculated for you.
tau	A p-dimensional vector of total pageviews (in thousands) for each website. Defaults to the total pageviews in the matrix for each website (i.e., assumes z matrix represents all website pageviews) divided by 1000.
step	A value to control the step size of the lambda grid (distance between budget points). Default is 0.05.
size	A value to control the number of lambda values tried (number of budget points). Default is 100.
tol	A value to control the convergence tolerance of the coordinate descent procedure. Default is 10^-3.
iters	A value to control the number of iterations until algorithm should exit if convergence tolerance is not reached. Default is 200.

Value

bid: A matrix of bid values by website at each budget

spend: a matrix of total spend by website at each budget

budget: a vector of budget values

lambda: a vector of lambda values

a: a vector of a values (used to calculate shifted logistic curves and reach in reach.ELMSO function)

References

Courtney Paulson, Lan Luo, and Gareth M. James (2018) Efficient Large-Scale Internet Media Selection Optimization for Online Display Advertising. Journal of Marketing Research: August 2018, Vol. 55, No. 4, pp. 489-506.

Examples

```
z=matrix(round(abs(rnorm(5000,0,0.7))),1000,5)
CPM.avg=c(3,4,5,6,7)
tau.values=rep(1000,5) #Note tau here is in thousands of pageviews

allocation=ELMSO(z=z,CPM=CPM.avg,tau=tau.values)
allocation$bid
allocation$spend
allocation$budget
allocation$lambda
allocation$a
```

ELMSO.fixed *Fixed ELMSO Function (fixed advertising costs, no cost curve)*

Description

This function allows you to allocate budget to a set of websites when cost is fixed at each website based on a matrix of pageviews for those sites.

Usage

```
ELMSO.fixed(z, CPM, tau = NULL, step = 0.05, size = 100,
  tol = 10^-3, iters = 200)
```

Arguments

z	An n by p matrix of pageviews
CPM	A p-dimensional vector of the (fixed) CPM values at each website
tau	A p-dimensional vector of total pageviews (in thousands) for each website. Defaults to the total pageviews in the matrix for each website (i.e., assumes z matrix represents all website pageviews) divided by 1000.

step	A value to control the step size of the lambda grid (distance between budget points). Default is 0.05.
size	A value to control the number of lambda values tried (number of budget points). Default is 100.
tol	A value to control the convergence tolerance of the coordinate descent procedure. Default is 10^-3.
iters	A value to control the number of iterations until algorithm should exit if convergence tolerance is not reached. Default is 200.

Value

spend: a matrix of total spend by website at each budget

budget: a vector of budget values

lambda: a vector of lambda values

References

Courtney Paulson, Lan Luo, and Gareth M. James (2018) Efficient Large-Scale Internet Media Selection Optimization for Online Display Advertising. Journal of Marketing Research: August 2018, Vol. 55, No. 4, pp. 489-506.

Examples

```
z=matrix(round(abs(rnorm(5000,0,0.7))),1000,5)
CPM.fixed=c(3,4,5,6,7)
tau.values=rep(100,5) #Note tau here is in thousands of pageviews

allocation=ELMSO.fixed(z=z,CPM=CPM.fixed,tau=tau.values)
allocation$spend
allocation$budget
allocation$lambda
```

---

reach.ELMSO *Calculating Reach from Main ELMSO Function*

Description

This function allows you to calculate reach achieved at a given budget value from the ELMSO output.

Usage

```
reach.ELMSO(bid, a, z)
```

Arguments

bid	A p-dimensional vector of the bidded CPM at each website for a particular budget value
a	A p-dimensional vector of steepness values for the cost curves associated with each website
z	An n by p matrix of pageviews

Value

A value between 0 and 1 specifying the reach achieved with the given budget allocation.

References

Courtney Paulson, Lan Luo, and Gareth M. James (2018) Efficient Large-Scale Internet Media Selection Optimization for Online Display Advertising. Journal of Marketing Research: August 2018, Vol. 55, No. 4, pp. 489-506.

Examples

```
z=matrix(round(abs(rnorm(5000,0,0.7))),1000,5)
CPM.avg=c(3,4,5,6,7)
tau.values=rep(100,5) #Note tau here is in thousands of pageviews

allocation=ELMSO(z=z,CPM=CPM.avg,tau=tau.values)
reach.ELMSO(allocation$bid[,101],allocation$a,z)
```

---

reach.ELMSO.fixed *Calculating Reach from Fixed ELMSO Function*

Description

This function allows you to calculate reach achieved at a given budget value from the fixed ELMSO output.

Usage

```
reach.ELMSO.fixed(CPM, w, z, tau = NULL)
```

Arguments

CPM	A p-dimensional vector of the fixed CPM at each website for a particular budget value
w	A p-dimensional vector of amount spent at each website
z	An n by p matrix of pageviews
tau	A p-dimensional vector of total pageviews (in thousands) for each website. Defaults to the total pageviews in the matrix for each website (i.e., assumes z matrix represents all website pageviews) divided by 1000.

Value

A value between 0 and 1 specifying the reach achieved with the given budget allocation.

References

Courtney Paulson, Lan Luo, and Gareth M. James (2018) Efficient Large-Scale Internet Media Selection Optimization for Online Display Advertising. Journal of Marketing Research: August 2018, Vol. 55, No. 4, pp. 489-506.

Examples

```
z=matrix(round(abs(rnorm(5000,0,0.7))),1000,5)
CPM.fixed=c(3,4,5,6,7)
tau.values=rep(100,5) #Note tau here is in thousands of pageviews

allocation=ELMSO.fixed(z=z,CPM=CPM.fixed,tau=tau.values)
reach.ELMSO.fixed(CPM.fixed,allocation$spend[,101],z,tau.values)
```

Index