

# Package: onlineCOV (via r-universe)

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**Type** Package

**Title** Online Change Point Detection in High-Dimensional Covariance Structure

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**Description** Implement a new stopping rule to detect anomaly in the covariance structure of high-dimensional online data. The detection procedure can be applied to Gaussian or non-Gaussian data with a large number of components. Moreover, it allows both spatial and temporal dependence in data. The dependence can be estimated by a data-driven procedure. The level of threshold in the stopping rule can be determined at a pre-selected average run length. More detail can be seen in Li, L. and Li, J. (2020) ``Online Change-Point Detection in High-Dimensional Covariance Structure with Application to Dynamic Networks." <[arXiv:1911.07762](https://arxiv.org/abs/1911.07762)>.

**License** GPL (>= 2)

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nuisance.est                      *Estimate nuisance parameters in the stopping rule.*

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### Description

The function estimates the nuisance parameters required in the stopping rule, through a training sample.

### Usage

```
nuisance.est(training.sample)
```

### Arguments

training.sample  
A historical dataset without change points.

### Value

Returns a list of estimated nuisance parameters. See below for more detail.

mu.hat	The sample mean of the training sample.
M.hat	The estimated M dependence.
cor.hat	A value used to obtain the standard deviation of the test statistic in the stopping rule.

### References

Li, L. and Li, J. (2020) "Online Change-Point Detection in High-Dimensional Covariance Structure with Application to Dynamic Networks." arXiv:1911.07762.

### Examples

```
p<-200;n0<-200
M<-2

Gam1<-diag(1,p,p)

data_Mat<-matrix(0,n0,p)
L<-M+1
Z<-matrix(rnorm(p*(n0+L-1)),p*(n0+L-1),1)
vec.coef<-1/rep(c(L:1),each=p)

for(j in 1:n0){
  Gam.mat<-t(apply(Gam1,1,rep,L))*matrix(vec.coef,ncol=L*p,nrow=p,byrow=TRUE)
  data_Mat[j,]<-matrix((Gam.mat%*%Z[((j-1)*p+1):((j+L-1)*p)],1,p,byrow=FALSE)
}

training.sample<-data_Mat
```

```

nuisance.results<-nuisance.est(training.sample)
mu<-nuisance.results$mu.hat
M<-nuisance.results$M.hat
cor<-nuisance.results$cor.hat

```

---

stopping.rule                      *Online change-point detection by the stopping rule.*

---

### Description

Function to determine whether a process with continually arriving data should be terminated, based on the proposed stopping rule.

### Usage

```
stopping.rule(ARL, H, mu, M, cor, old.data, new.data)
```

### Arguments

ARL	The expected value of the stopping time when there is no change, eg. ARL = 5000.
H	The window size so that the stopping rule only considers H observations from the current time, eg. H=100.
mu	The mean vector of the observation with dimension 1 by p, can be estimated from a training sample through the function "nuisance.est".
M	M dependence, can be estimated from a training sample through the function "nuisance.est", eg. M=0 means data are temporally independent.
cor	A value used to obtain the standard deviation of the test statistic in the stopping rule, can be estimated from a training sample through the function "nuisance.est".
old.data	The observed sequence of data. The dataset has dimension H by p, where H is the window size, or the number of observed data (row), and p is the number of components (column).
new.data	A newly arrived observation with dimension 1 by p.

### Value

Returns a list with items "decision" and "old.updated". See below for more detail.

decision	returns 1 if the stopping rule detects a change point, and returns 0 otherwise.
old.updated	The updated observed dataset in this step, with dimension H by p. The Hth observation is the newly arrived observation, and the rest H-1 observations come from the previous dataset.

## References

Li, L. and Li, J. (2020) "Online Change-Point Detection in High-Dimensional Covariance Structure with Application to Dynamic Networks." arXiv:1911.07762.

## Examples

```
# The following is an example to detect covariance structure change
# in a real-time manner, in the sense that we pretend that
# the observations in the dataset continually arrive in time.
# At each time, we determine whether the process should be
# terminated through the proposed stopping rule.
# there is an immediate change point at n0=200

p<-200;n<-10000;n0<-200 #n0 is traing sample size
rho<-0.6;M<-2
H<-100;ARL<-5000

Gam1<-diag(1,p,p)
times<-1:p
d<-abs(outer(times, times, "-"))
sigma<-rho*d
Gam2<-eigen(sigma, symmetric=TRUE)$vectors%*%diag(sqrt(eigen(sigma, symmetric=TRUE)$values), p)
Gam<-cbind(Gam1, Gam2)

data_Mat<-matrix(0, n0, p)
L<-M+1
Z<-matrix(rnorm(p*(n+L-1)), p*(n+L-1), 1)
vec.coef<-1/rep(c(L:1), each=p)

for(j in 1:n0){
  Gam.m<-Gam[, 1:p]
  Gam.mat<-t(apply(Gam.m, 1, rep, L))*matrix(vec.coef, ncol=L*p, nrow=p, byrow=TRUE)
  data_Mat[j, ]<-matrix((Gam.mat%*%Z[((j-1)*p+1):((j+L-1)*p), ]), 1, p, byrow=FALSE)
}

old.data<-data_Mat
nuisance.results<-nuisance.est(old.data)
mu<-nuisance.results$mu.hat
M<-nuisance.results$M.hat
cor<-nuisance.results$cor.hat

j<-n0+1;decision = 0

while(decision==0){

  Gam.m<-Gam[, (p+1):(2*p)]
  Gam.mat<-t(apply(Gam.m, 1, rep, L))*matrix(vec.coef, ncol=L*p, nrow=p, byrow=TRUE)
  new.data<-matrix((Gam.mat%*%Z[((j-1)*p+1):((j+L-1)*p), ]), 1, p, byrow=FALSE)

  result<-stopping.rule(ARL, H, mu, M, cor, old.data, new.data)
  decision<-result$decision
}
```

```
old.data<-result$old.updated
cpt.est<-j-n0

j<-j+1
}

print(cpt.est) #The point where the detection procedure terminates.
```

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