

# Package ‘mmcm’

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**Version** 1.2-2

**Depends** mvtnorm

**Title** Modified Maximum Contrast Method

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**Description** This package provides an implementation of modified maximum contrast methods and the maximum contrast method. This version supports functions mmcm.mvt, mcm.mvt that gives P-value by using randomized quasi-Monte Carlo method from pmvt function of package mvtnorm, and mmcm.resamp that gives P-value by using the permutation method.

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**Collate** ‘mcm.mvt.R’ ‘mmcm.mvt.R’ ‘mmcm.resamp.R’ ‘print.mmcm.R’ ‘zzz.R’ ‘package.R’

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`mmcm-package`*The modified maximum contrast method package*

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### Description

This package provides an implementation of modified maximum contrast methods and the maximum contrast method. This version supports functions `mmcm.mvt`, `mcm.mvt` that gives P-value by using randomized quasi-Monte Carlo method from `pmvt` function of package `mvtnorm`, and `mmcm.resamp` that gives P-value by using the permutation method. In a one-way problem testing pattern of several factor level means, the maximum contrast statistics (Yoshimura, I., 1997) may be used. But under unequal sample size situations, denominator of the maximum contrast statistics is overestimated. Thus we propose a modified maximum contrast statistics for the unequal sample size situation. Denominator of the modified maximum contrast statistics is not influenced under the unequal sample size situation.

### Author(s)

Author: Kengo NAGASHIMA and Yasunori SATO

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### References

Nagashima, K., Sato, Y., Hamada, C. (2011). A modified maximum contrast method for unequal sample sizes in pharmacogenomic studies *Stat Appl Genet Mol Biol.* **10**(1): Article 41. <http://dx.doi.org/10.2202/1544-6115.1560>

Sato, Y., Laird, N.M., Nagashima, K., et al. (2009). A new statistical screening approach for finding pharmacokinetics-related genes in genome-wide studies. *Pharmacogenomics J.* **9**(2): 137–146. <http://www.ncbi.nlm.nih.gov/pubmed/19104505>

Yoshimura, I., Wakana, A., Hamada, C. (1997). A performance comparison of maximum contrast methods to detect dose dependency. *Drug Information J.* **31**: 423–432.

### See Also

[mcm.mvt](#), [mmcm.mvt](#), [mmcm.resamp](#)

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`mcm.mvt`*The maximum contrast method by using the randomized quasi-Monte Carlo method*

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### Description

This function gives *P*-value for the maximum contrast statistics by using randomized quasi-Monte Carlo method from `pmvt` function of package `mvtnorm`.

**Usage**

```
mcm.mvt(x, g, contrast, alternative = c("two.sided",
"less", "greater"), algorithm = GenzBretz())
```

**Arguments**

x	a numeric vector of data values
g	a integer vector giving the group for the corresponding elements of x
contrast	a numeric contrast coefficient matrix for the maximum contrast statistics
alternative	a character string specifying the alternative hypothesis, must be one of "two.sided" (default), "greater" or "less". You can specify just the initial letter.
algorithm	an object of class <a href="#">GenzBretz</a> defining the hyper parameters of this algorithm

**Details**

`mcm.mvt` performs the maximum contrast method that is detecting a true response pattern.

$Y_{ij}$  ( $i = 1, \dots, a; j = 1, \dots, n_i$ ) is an observed response for  $j$ th individual in  $i$ th group.

$C$  is coefficient matrix for the maximum contrast statistics ( $i \times k$  matrix,  $i$ : No. of groups,  $k$ : No. of pattern).

$$C = (c_1 \sim c_2 \sim \dots \sim c_k)^t$$

$c_k$  is coefficient vector of  $k$ th pattern.

$$c_k = (c_{k1} \sim c_{k2} \sim \dots \sim c_{ki})^t \quad (\sum_i c_{ki} = 0)$$

$T_{\max}$  is the maximum contrast statistic.

$$\bar{Y}_i = \frac{\sum_{j=1}^{n_i} Y_{ij}}{n_i}, \quad \bar{\bar{Y}} = (\bar{Y}_1 \sim \bar{Y}_2 \sim \dots \sim \bar{Y}_a)^t,$$

$$D = \text{diag}(n_1, n_2, \dots, n_i, \dots, n_a), \quad \bar{\bar{V}} = \frac{1}{\gamma} \sum_{j=1}^{n_i} \sum_{i=1}^a (Y_{ij} - \bar{Y}_i)^2,$$

$$\gamma = \sum_{i=1}^a (n_i - 1), \quad \bar{\bar{T}}_k = \frac{c_k^t \bar{\bar{Y}}}{\sqrt{V c_k^t D c_k}},$$

$$T_{\max} = \max(T_1, T_2, \dots, T_k).$$

Consider testing the overall null hypothesis  $H_0 : \mu_1 = \mu_2 = \dots = \mu_i$ , versus alternative hypotheses  $H_1$  for response patterns ( $H_1 : \mu_1 < \mu_2 < \dots < \mu_i, \sim \mu_1 = \mu_2 < \dots < \mu_i, \sim \mu_1 < \mu_2 < \dots = \mu_i$ ). The  $P$ -value for the probability distribution of  $T_{\max}$  under the overall null hypothesis is

$$P\text{-value} = \Pr(T_{\max} > t_{\max} \mid H_0)$$

$t_{\max}$  is observed value of statistics. This function gives distribution of  $T_{\max}$  by using randomized quasi-Monte Carlo method from package `mvtnorm`.

**Value**

statistic	the value of the test statistic with a name describing it.
p.value	the p-value for the test.
alternative	a character string describing the alternative hypothesis.
method	the type of test applied.
contrast	a character string giving the names of the data.
contrast.index	a suffix of coefficient vector of the $k$ th pattern that gives maximum contrast statistics (row number of the coefficient matrix).
error	estimated absolute error and,
msg	status messages.

**References**

Yoshimura, I., Wakana, A., Hamada, C. (1997). A performance comparison of maximum contrast methods to detect dose dependency. *Drug Information J.* **31**: 423–432.

**See Also**

[pmvt](#), [GenzBretz](#), [mmcm.mvt](#)

**Examples**

```
## Example 1 ##
# true response pattern: dominant model c=(1, 1, -2)
set.seed(136885)
x <- c(
  rnorm(130, mean = 1 / 6, sd = 1),
  rnorm( 90, mean = 1 / 6, sd = 1),
  rnorm( 10, mean = -2 / 6, sd = 1)
)
g <- rep(1:3, c(130, 90, 10))
boxplot(
  x ~ g,
  width = c(length(g[g==1]), length(g[g==2]), length(g[g==3])),
  main = "Dominant model (sample data)",
  xlab = "Genotype",
  ylab = "PK parameter"
)

# coefficient matrix
# c_1: additive, c_2: recessive, c_3: dominant
contrast <- rbind(
  c(-1, 0, 1), c(-2, 1, 1), c(-1, -1, 2)
)
y <- mcm.mvt(x, g, contrast)
y

## Example 2 ##
# for dataframe
```

```

# true response pattern: pos = 1 dominant model c=( 1, 1, -2)
#                               2 additive model c=(-1, 0, 1)
#                               3 recessive model c=( 2, -1, -1)
set.seed(3872435)
x <- c(
  rnorm(130, mean = 1 / 6, sd = 1),
  rnorm( 90, mean = 1 / 6, sd = 1),
  rnorm( 10, mean = -2 / 6, sd = 1),
  rnorm(130, mean = -1 / 4, sd = 1),
  rnorm( 90, mean = 0 / 4, sd = 1),
  rnorm( 10, mean = 1 / 4, sd = 1),
  rnorm(130, mean = 2 / 6, sd = 1),
  rnorm( 90, mean = -1 / 6, sd = 1),
  rnorm( 10, mean = -1 / 6, sd = 1)
)
g <- rep(rep(1:3, c(130, 90, 10)), 3)
pos <- rep(c("rsXXX", "rsYYY", "rsZZZ"), each=230)
xx <- data.frame(pos = pos, x = x, g = g)

# coefficient matrix
# c_1: additive, c_2: recessive, c_3: dominant
contrast <- rbind(
  c(-1, 0, 1), c(-2, 1, 1), c(-1, -1, 2)
)
mmcmapply <- function(r) {
  mcm.mvt(
    xx$х[xx$pos==r[1]], xx$g[xx$pos==r[1]],
    contrast
  )
}
y <- tapply(xx$pos, xx$pos, mmcmapply)
yy <- data.frame(
  Pos      = as.vector(names(y)),
  Pval     = as.vector(sapply(y, "[[", 3)),
  Pattern  = as.vector(sapply(y, "[[", 7)),
  QMC_Error = as.vector(sapply(y, "[[", 9))
)
# miss-detection!
yy

```

mmcm.mvt

*The modified maximum contrast method by using randomized quasi-Monte Carlo method*

## Description

This function gives  $P$ -value for the modified maximum contrast statistics by using randomized quasi-Monte Carlo method from `pmvt` function of package `mvtnorm`.

**Usage**

```
mmcm.mvt(x, g, contrast, alternative = c("two.sided",
"less", "greater"), algorithm = GenzBretz())
```

**Arguments**

x	a numeric vector of data values
g	a integer vector giving the group for the corresponding elements of x
contrast	a numeric contrast coefficient matrix for modified maximum contrast statistics
alternative	a character string specifying the alternative hypothesis, must be one of "two.sided" (default), "greater" or "less". You can specify just the initial letter.
algorithm	an object of class <a href="#">GenzBretz</a> defining the hyper parameters of this algorithm.

**Details**

`mmcm.mvt` performs the modified maximum contrast method that is detecting a true response pattern under the unequal sample size situation.

$Y_{ij}$  ( $i = 1, \sim 2, \sim \dots; \sim j = 1, \sim 2, \sim \dots, \sim n_i$ ) is an observed response for  $j$ th individual in  $i$ th group.

$C$  is coefficient matrix for modified maximum contrast statistics ( $i \times k$  matrix,  $i$ : No. of groups,  $k$ : No. of pattern).

$$C = (c_1 \sim c_2 \sim \dots \sim c_k)^t$$

$c_k$  is coefficient vector of  $k$ th pattern.

$$c_k = (c_{k1} \sim c_{k2} \sim \dots \sim c_{ki})^t \quad (\sum_i c_{ki} = 0)$$

$S_{\max}$  is the modified maximum contrast statistic.

$$\bar{Y}_i = \frac{\sum_{j=1}^{n_i} Y_{ij}}{n_i}, \quad \sim \sim \bar{Y} = (\bar{Y}_1 \sim \bar{Y}_2 \sim \dots \sim \bar{Y}_i \dots \sim \bar{Y}_a)^t,$$

$$V = \frac{1}{\gamma} \sum_{j=1}^{n_i} \sum_{i=1}^a (Y_{ij} - \bar{Y}_i)^2, \quad \sim \sim \gamma = \sum_{i=1}^a (n_i - 1),$$

$$S_k = \frac{c_k^t \bar{Y}}{\sqrt{V c_k^t c_k}},$$

$$S_{\max} = \max(S_1, \sim S_2, \sim \dots, \sim S_k).$$

Consider testing the overall null hypothesis  $H_0 : \mu_1 = \mu_2 = \dots = \mu_i$ , versus alternative hypotheses  $H_1$  for response patterns ( $H_1 : \mu_1 < \mu_2 < \dots < \mu_i, \sim \mu_1 = \mu_2 < \dots < \mu_i, \sim \mu_1 < \mu_2 < \dots = \mu_i$ ). The  $P$ -value for the probability distribution of  $S_{\max}$  under the overall null hypothesis is

$$P\text{-value} = \Pr(S_{\max} > s_{\max} \mid H_0)$$

$s_{\max}$  is observed value of statistics. This function gives distribution of  $S_{\max}$  by using randomized quasi-Monte Carlo method from package `mvtnorm`.

**Value**

statistic	the value of the test statistic with a name describing it.
p.value	the p-value for the test.
alternative	a character string describing the alternative hypothesis.
method	the type of test applied.
contrast	a character string giving the names of the data.
contrast.index	a suffix of coefficient vector of the $k$ th pattern that gives modified maximum contrast statistics (row number of the coefficient matrix).
error	estimated absolute error and,
msg	status messages.

**References**

Nagashima, K., Sato, Y., Hamada, C. (2011). A modified maximum contrast method for unequal sample sizes in pharmacogenomic studies *Stat Appl Genet Mol Biol.* **10**(1): Article 41. <http://dx.doi.org/10.2202/1544-6115.1560>

Sato, Y., Laird, N.M., Nagashima, K., et al. (2009). A new statistical screening approach for finding pharmacokinetics-related genes in genome-wide studies. *Pharmacogenomics J.* **9**(2): 137–146. <http://www.ncbi.nlm.nih.gov/pubmed/19104505>

**See Also**

[pmvt](#), [GenzBretz](#), [mmcm.resamp](#)

**Examples**

```
## Example 1 ##
# true response pattern: dominant model c=(1, 1, -2)
set.seed(136885)
x <- c(
  rnorm(130, mean = 1 / 6, sd = 1),
  rnorm( 90, mean = 1 / 6, sd = 1),
  rnorm( 10, mean = -2 / 6, sd = 1)
)
g <- rep(1:3, c(130, 90, 10))
boxplot(
  x ~ g,
  width = c(length(g[g==1]), length(g[g==2]), length(g[g==3])),
  main = "Dominant model (sample data)",
  xlab = "Genotype", ylab="PK parameter"
)

# coefficient matrix
# c_1: additive, c_2: recessive, c_3: dominant
contrast <- rbind(
  c(-1, 0, 1), c(-2, 1, 1), c(-1, -1, 2)
)
y <- mmcm.mvt(x, g, contrast)
```

```

y

## Example 2 ##
# for dataframe
# true response pattern: pos = 1 dominant model c=( 1, 1, -2)
#                          2 additive model c=(-1, 0, 1)
#                          3 recessive model c=( 2, -1, -1)
set.seed(3872435)
x <- c(
  rnorm(130, mean = 1 / 6, sd = 1),
  rnorm( 90, mean = 1 / 6, sd = 1),
  rnorm( 10, mean = -2 / 6, sd = 1),
  rnorm(130, mean = -1 / 4, sd = 1),
  rnorm( 90, mean = 0 / 4, sd = 1),
  rnorm( 10, mean = 1 / 4, sd = 1),
  rnorm(130, mean = 2 / 6, sd = 1),
  rnorm( 90, mean = -1 / 6, sd = 1),
  rnorm( 10, mean = -1 / 6, sd = 1)
)
g <- rep(rep(1:3, c(130, 90, 10)), 3)
pos <- rep(c("rsXXX", "rsYYY", "rsZZZ"), each=230)
xx <- data.frame(pos = pos, x = x, g = g)

# coefficient matrix
# c_1: additive, c_2: recessive, c_3: dominant
contrast <- rbind(
  c(-1, 0, 1), c(-2, 1, 1), c(-1, -1, 2)
)
mmcmapply <- function(r) {
  mmcm.mvt(
    xx$x[xx$pos=="r[1]"], xx$g[xx$pos=="r[1]"],
    contrast
  )
}
y <- tapply(xx$pos, xx$pos, mmcmapply)
yy <- data.frame(
  Pos      = as.vector(names(y)),
  Pval     = as.vector(sapply(y, "[[", 3)),
  Pattern  = as.vector(sapply(y, "[[", 7)),
  QMC_Error = as.vector(sapply(y, "[[", 9))
)
yy

```

## Description

This function gives  $P$ -value for the permuted modified maximum contrast method.

**Usage**

```
mmcm.resamp(x, g, contrast, alternative = c("two.sided",
"less", "greater"), nsample = 20000, abseps = 0.001, seed
= NULL)
```

**Arguments**

x	a numeric vector of data values
g	a integer vector giving the group for the corresponding elements of x
contrast	a numeric contrast coefficient matrix for permuted modified maximum contrast statistics
alternative	a character string specifying the alternative hypothesis, must be one of "two.sided" (default), "greater" or "less". You can specify just the initial letter.
nsample	specifies the number of resamples (default: 20000)
abseps	specifies the absolute error tolerance (default: 0.001)
seed	a single value, interpreted as an integer; see <code>set.seed()</code> function. (default: NULL)

**Details**

`mmcm.resamp` performs the permuted modified maximum contrast method that is detecting a true response pattern under the unequal sample size situation.

$Y_{ij}$  ( $i = 1, \sim 2, \sim \dots; \sim j = 1, \sim 2, \sim \dots, \sim n_i$ ) is an observed response for  $j$ th individual in  $i$ th group.

$C$  is coefficient matrix for permuted modified maximum contrast statistics ( $i \times k$  matrix,  $i$ : No. of groups,  $k$ : No. of pattern).

$$C = (c_1 \sim c_2 \sim \dots \sim c_k)^t$$

$c_k$  is coefficient vector of  $k$ th pattern.

$$c_k = (c_{k1} \sim c_{k2} \sim \dots \sim c_{ki})^t \quad (\sum_i c_{ki} = 0)$$

$M_{\max}$  is a permuted modified maximum contrast statistic.

$$\bar{Y}_i = \frac{\sum_{j=1}^{n_i} Y_{ij}}{n_i}, \sim \sim \bar{Y} = (\bar{Y}_1 \sim \bar{Y}_2 \sim \dots \sim \bar{Y}_i \sim \dots \sim \bar{Y}_a)^t, M_k = \frac{c_k^t \bar{Y}}{\sqrt{c_k^t c_k}}$$

$$M_{\max} = \max(M_1, \sim M_2, \sim \dots, \sim M_k).$$

Consider testing the overall null hypothesis  $H_0 : \mu_1 = \mu_2 = \dots = \mu_i$ , versus alternative hypotheses  $H_1$  for response patterns ( $H_1 : \mu_1 < \mu_2 < \dots < \mu_i, \sim \mu_1 = \mu_2 < \dots < \mu_i, \sim \mu_1 < \mu_2 < \dots = \mu_i$ ). The  $P$ -value for the probability distribution of  $M_{\max}$  under the overall null hypothesis is

$$P\text{-value} = \Pr(M_{\max} > m_{\max} \mid H_0)$$

$m_{\max}$  is observed value of statistics. This function gives distribution of  $M_{\max}$  by using the permutation method, follow algorithm:

1. Initialize counting variable:  $COUNT = 0$ . Input parameters:  $NRESAMPMIN$  (minimum resampling count, we set 1000),  $NRESAMPMAX$  (maximum resampling count), and  $\epsilon$  (absolute error tolerance).
2. Calculate  $m_{\max}$  that is the observed value of the test statistic.
3. Let  $y_{ij}^{(r)}$  denote data, which are sampled without replacement, and independently, form observed value  $y_{ij}$ . Where,  $(r)$  is suffix of the resampling number ( $r = 1, 2, \dots$ ).
4. Calculate  $m_{\max}^{(r)}$  from  $y_{ij}^{(r)}$ . If  $m_{\max}^{(r)} > m_{\max}$ , then increment the counting variable:  $COUNT = COUNT + 1$ . Calculate approximate P-value  $\hat{p}^{(r)} = COUNT/r$ , and the simulation standard error  $SE(\hat{p}^{(r)}) = \sqrt{\hat{p}^{(r)}(1 - \hat{p}^{(r)})/r}$ .
5. Repeat 3–4, while  $r > 1000$  and  $3.5SE(\hat{p}^{(r)}) < \epsilon$  (corresponding to 99% confidence level), or  $NRESAMPMAX$  times. Output the approximate P-value  $\hat{p}^{(r)}$ .

### Value

statistic	the value of the test statistic with a name describing it.
p.value	the p-value for the test.
alternative	a character string describing the alternative hypothesis.
method	the type of test applied.
contrast	a character string giving the names of the data.
contrast.index	a suffix of coefficient vector of the $k$ th pattern that gives permuted modified maximum contrast statistics (row number of the coefficient matrix).
error	estimated absolute error and,
msg	status messages.

### References

- Nagashima, K., Sato, Y., Hamada, C. (2011). A modified maximum contrast method for unequal sample sizes in pharmacogenomic studies *Stat Appl Genet Mol Biol.* **10**(1): Article 41. <http://dx.doi.org/10.2202/1544-6115.1560>
- Sato, Y., Laird, N.M., Nagashima, K., et al. (2009). A new statistical screening approach for finding pharmacokinetics-related genes in genome-wide studies. *Pharmacogenomics J.* **9**(2): 137–146. <http://www.ncbi.nlm.nih.gov/pubmed/19104505>

### See Also

[mmcm.mvt](#)

### Examples

```
## Example 1 ##
# true response pattern: dominant model c=(1, 1, -2)
set.seed(136885)
x <- c(
  rnorm(130, mean = 1 / 6, sd = 1),
  rnorm( 90, mean = 1 / 6, sd = 1),
  rnorm( 10, mean = -2 / 6, sd = 1)
```

```

)
g <- rep(1:3, c(130, 90, 10))
boxplot(
  x ~ g,
  width = c(length(g[g==1]), length(g[g==2]), length(g[g==3])),
  main = "Dominant model (sample data)",
  xlab = "Genotype", ylab="PK parameter"
)

# coefficient matrix
# c_1: additive, c_2: recessive, c_3: dominant
contrast <- rbind(
  c(-1, 0, 1), c(-2, 1, 1), c(-1, -1, 2)
)
y <- mmcm.resamp(x, g, contrast, nsample = 20000, abseps = 0.01, seed = 5784324)
y

## Example 2 ##
# for dataframe
# true response pattern: pos = 1 dominant model c=( 1, 1, -2)
#                          2 additive model c=(-1, 0, 1)
#                          3 recessive model c=( 2, -1, -1)
set.seed(3872435)
x <- c(
  rnorm(130, mean = 1 / 6, sd = 1),
  rnorm( 90, mean = 1 / 6, sd = 1),
  rnorm( 10, mean = -2 / 6, sd = 1),
  rnorm(130, mean = -1 / 4, sd = 1),
  rnorm( 90, mean = 0 / 4, sd = 1),
  rnorm( 10, mean = 1 / 4, sd = 1),
  rnorm(130, mean = 2 / 6, sd = 1),
  rnorm( 90, mean = -1 / 6, sd = 1),
  rnorm( 10, mean = -1 / 6, sd = 1)
)
g <- rep(rep(1:3, c(130, 90, 10)), 3)
pos <- rep(c("rsXXX", "rsYYY", "rsZZZ"), each=230)
xx <- data.frame(pos = pos, x = x, g = g)

# coefficient matrix
# c_1: additive, c_2: recessive, c_3: dominant
contrast <- rbind(
  c(-1, 0, 1), c(-2, 1, 1), c(-1, -1, 2)
)

mmcmapply <- function(r) {
  mmcm.resamp(
    xx$xx[xx$pos==r[1]], xx$g[xx$pos==r[1]],
    contrast, nsample = 10000, abseps = 0.01, seed = 5784324+as.numeric(r[1])
  )
}
y <- tapply(xx$pos, xx$pos, mmcmapply)
yy <- data.frame(
  Pos      = as.vector(names(y)),

```

```

Pval      = as.vector(sapply(y, "[[", 3)),
Pattern   = as.vector(sapply(y, "[[", 7)),
MC_Error  = as.vector(sapply(y, "[[", 9))
)
yy

```

---

print.mmcm

*Print function for mmcm object*


---

### Description

This function print result of function [mcm.mvt](#), [mmcm.mvt](#) and [mmcm.resamp](#)

### Usage

```

## S3 method for class 'mmcm'
print(x, digits = getOption("digits"),
      ...)

```

### Arguments

x	Object of class mmcm, which is result of function <a href="#">mcm.mvt</a> , <a href="#">mmcm.mvt</a> and <a href="#">mmcm.resamp</a> .
digits	a non-null value for digits specifies the minimum number of significant digits to be printed in values. The default, NULL, uses <a href="#">getOption(digits)</a> . (For the interpretation for complex numbers see <a href="#">signif</a> .) Non-integer values will be rounded down, and only values greater than or equal to 1 and no greater than 22 are accepted.
...	Further arguments passed to or from other methods.

### Details

The case where printed "More than 2 contrast coefficient vectors were selected", some contrast may be unsuitable.

### See Also

[print.default](#), [mmcm.mvt](#), [mmcm.resamp](#), [mcm.mvt](#)

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