

# Package ‘RESTK’

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**Title** An Implementation of the RESTK Algorithm

**Version** 1.0.2

**Description** Implementation of the RESTK algorithm based on Markov's Inequality from Vilardell, Sergi, Serra, Isabel, Mezzetti, Enrico, Abella, Jaume, Cazorla, Francisco J. and Del Castillo, J. (2022). "Using Markov's Inequality with Power-Of-k Function for Probabilistic WCET Estimation". In 34th Euromicro Conference on Real-Time Systems (ECRTS 2022). Leibniz International Proceedings in Informatics (LIPIcs) 231 20:1-20:24. <[doi:10.4230/LIPIcs.ECRTS.2022.20](https://doi.org/10.4230/LIPIcs.ECRTS.2022.20)>. This work has been supported by the European Research Council (ERC) under the European Union's Horizon 2020 research and innovation programme (grant agreement No. 772773).

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compute_maxk	<i>Compute the maximum k for a given sample</i>
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**Description**

compute\_maxk returns the estimated quantiles for the chosen probabilities from the input sample. This method uses the sample quantile method number 8 from the default quantile function.

**Usage**

```
compute_maxk(samp = NULL, probs = NULL, quants = NULL, k_range = c(1, 120))
```

**Arguments**

samp	Sample of data to model
probs	Probabilities of interest to generate the max_k line
quants	Estimated quantiles of interest to generate the max_k line
k_range	Range of k values for the optimization function

**Value**

Returns estimated maxk for the sample and quantiles given.

**Examples**

```
samp <- rnorm(1e3, mean = 100, sd = 10)
probs <- c(1-1e-1, 1-0.5e-1, 1-1e-2)
quants <- c(100, 125, 150)
estimated_max_k <- compute_maxk(samp = samp, probs = probs, quants = quants, k_range = c(1,100))
```

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estimate_quantiles_maxk
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*Estimate Quantiles with Maxk*

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**Description**

estimate\_quantiles\_maxk use the maxk line obtained to estimate quantiles with MIK

**Usage**

```
estimate_quantiles_maxk(samp = NULL, maxk_line = NULL, probs_interest = NULL)
```

**Arguments**

samp                    sample  
 maxk\_line            maxk line obtained for the probabilities of interest  
 probs\_interest    Probabilities of interest to estimate

**Value**

Returns the estimation of the quantiles using the maxk line

**Examples**

```
linear_adjust(min_maxk = c(10, 15, 20),
              probs = c(1-1e-1, 1-1e-2, 1-1e-3),
              probs_interest = c(1-1e-6, 1-1e-7, 1-1e-8))
```

---

get_min_maxk	<i>Get the minimum maxk</i>
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**Description**

get\_min\_maxk get the minimum maxk from a set of maxks and tightness

**Usage**

```
get_min_maxk(samp_tightness = NULL, k_seq = NULL)
```

**Arguments**

samp\_tightness    tightness from a given sample and maxk  
 k\_seq             sequence of maxk to evaluate

**Value**

Returns the minimum maxk

**Examples**

```
get_min_maxk(samp_tightness = c(1.5, 1.2, 0.98),
              k_seq = c(20, 30 , 40))
```

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linear_adjust	<i>Linear adjust</i>
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**Description**

linear\_adjust function used to project the max\_k line into the probabilities of interest

**Usage**

```
linear_adjust(min_maxk = NULL, probs = NULL, probs_interest)
```

**Arguments**

min_maxk	minimum maxk found for each probability of interest
probs	Probabilities where maxk was evaluated
probs_interest	Probabilities of interest to estimate

**Value**

Returns the maxk line for the probabilities of interest

**Examples**

```
linear_adjust(min_maxk = c(10, 15, 20),
              probs = c(1-1e-1, 1-1e-2, 1-1e-3),
              probs_interest = c(1-1e-6, 1-1e-7, 1-1e-8))
```

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RESTK	<i>RESTK</i>
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**Description**

RESTK function used to project the maxk line into the probabilities of interest

**Usage**

```
RESTK(
  training_data = NULL,
  validation_data = NULL,
  probs = NULL,
  probs_interest = NULL,
  bootstrap_size = NULL,
  bootstrap_training_sims = NULL,
  bootstrap_validation_sims = NULL
)
```

**Arguments**

training\_data training data  
validation\_data validation data  
probs Probabilities where maxk was evaluated  
probs\_interest Probabilities of interest to estimate  
bootstrap\_size size of bootstrap simulations on the training data  
bootstrap\_training\_sims number of bootstrap simulations on the training data  
bootstrap\_validation\_sims number of bootstrap simulations on the validation data

**Value**

Returns the maxk line for the probabilities of interest

**Examples**

```
training_data <- rnorm(1e3, mean = 100, sd = 10)
validation_data <- rnorm(1e3, mean = 100, sd = 10)
bootstrap_size <- 1000
bootstrap_training_sims <- 10
bootstrap_validation_sims <- 10
probs <- c(1-1e-1, 1-0.5e-1, 1-1e-2)
probs_interest <- c(1-1e-6, 1-1e-7)

estimated_quants <- RESTK(training_data = training_data,
                          validation_data = validation_data,
                          probs = probs,
                          probs_interest = probs_interest,
                          bootstrap_size = bootstrap_size,
                          bootstrap_training_sims = bootstrap_training_sims,
                          bootstrap_validation_sims = bootstrap_validation_sims)
```

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RESTK\_training

*RESTK Training*

---

**Description**

RESTK\_training function used to project the maxk line into the probabilities of interest

**Usage**

```
RESTK_training(  
  training_data = NULL,  
  probs = NULL,  
  probs_interest = NULL,  
  bootstrap_size = NULL,  
  bootstrap_training_sims = NULL  
)
```

**Arguments**

training\_data training data

probs Probabilities where maxk was evaluated

probs\_interest Probabilities of interest to estimate

bootstrap\_size size of bootstrap simulations on the training data

bootstrap\_training\_sims  
number of bootstrap simulations on the training data

**Value**

Returns the estimated maxk line from the probabilities of interest

**Examples**

```
training_data <- rnorm(1e3, mean = 100, sd = 10)  
probs <- c(1-1e-1, 1-0.5e-1, 1-1e-2)  
probs_interest <- c(1-1e-6, 1-1e-7)  
bootstrap_size <- 1000  
bootstrap_training_sims <- 100  
  
maxk_line_params <- RESTK_training(training_data = training_data,  
  probs = probs,  
  probs_interest = probs_interest,  
  bootstrap_size = bootstrap_size,  
  bootstrap_training_sims = bootstrap_training_sims)
```

---

RESTK\_validation      *RESTK Validation*

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**Description**

RESTK\_validation main function for the validation of the RESTK methodology by using the maxk line

**Usage**

```
RESTK_validation(  
  validation_data = NULL,  
  maxk_line_params = NULL,  
  probs_interest = NULL,  
  bootstrap_size = NULL,  
  bootstrap_validation_sims = NULL  
)
```

**Arguments**

`validation_data` validation data

`maxk_line_params` maxk line obtained from `RESTK_training`

`probs_interest` Probabilities of interest to estimate

`bootstrap_size` size of bootstrap simulations on the validation data

`bootstrap_validation_sims` number of bootstrap simulations on the validation data

**Value**

Returns the median of the estimated quantiles from the probabilities of interest

**Examples**

```
validation_data <- rnorm(1e3, mean = 100, sd = 10)  
probs_interest <- c(1-1e-6, 1-1e-7)  
bootstrap_size <- 1000  
bootstrap_validation_sims <- 100  
maxk_line_params <- list(maxk_line = c(100, 125), min_maxk = c(10, 15))  
estimated_quants <- RESTK_validation(validation_data = validation_data,  
                                     maxk_line_params = maxk_line_params,  
                                     probs_interest = probs_interest,  
                                     bootstrap_size = bootstrap_size,  
                                     bootstrap_validation_sims = bootstrap_validation_sims)
```

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sample\_quantile\_estimation

*Estimate Quantiles within the Sample*

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**Description**

`sample_quantile_estimation` returns the estimated quantiles for the chosen probabilities from the input sample. This method uses the sample quantile method number 8 from the default quantile function.

**Usage**

```
sample_quantile_estimation(samp = NULL, probs = NULL, bootstrap_sims = NULL)
```

**Arguments**

samp                    Sample of data to model  
 probs                    Probabilities of interest to generate the max\_k line  
 bootstrap\_sims        Number of bootstrap simulations to estimate the quantiles

**Value**

Returns estimated quantiles for the chosen probabilities.

**Examples**

```
samp <- rnorm(1e3, mean = 100, sd = 10)
probs <- c(1-1e-1, 1-0.5e-1, 1-1e-2)
bootstrap_training_sims <- 100
estimated_quantiles <- sample_quantile_estimation(samp = samp,
                                                  probs = probs,
                                                  bootstrap_sims = bootstrap_training_sims)
```

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tightness	<i>Tightness function</i>
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**Description**

tightness function used to minimized the tightness as a function of the value of k

**Usage**

```
tightness(samp = NULL, prob = NULL, quant = NULL, k = NULL)
```

**Arguments**

samp                    Sample of data to model  
 prob                    Probability of interest  
 quant                    Quantile of interest  
 k                        value of k to check tightness

**Value**

Returns the squared difference between the tightness and 1

**Examples**

```
samp <- rnorm(1e3, mean = 100, sd = 10)
prob <- c(1-1e-2)
k <- 1:100
quant <- qnorm(p = prob, mean = 100, sd = 10)
tightness(samp = samp, prob = prob, quant = quant, k = k)
```

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