Title  Hyperband for 'mlr3'

Version  0.6.0

Description  Successive Halving (Jamieson and Talwalkar (2016)  
optimization algorithm for the mlr3 ecosystem. The implementation in  
mlr3hyperband features improved scheduling and parallelizes the evaluation  
of configurations. The package includes tuners for hyperparameter  
optimization in mlr3tuning and optimizers for black-box optimization in  
bbotk.

License  LGPL-3

URL  https://mlr3hyperband.mlr-org.com,  
https://github.com/mlr-org/mlr3hyperband

BugReports  https://github.com/mlr-org/mlr3hyperband/issues

Depends  mlr3tuning (>= 1.0.0), R (>= 3.1.0)

Imports  bbotk (>= 1.0.0), checkmate (>= 1.9.4), data.table, lgr, mlr3  
(>= 0.13.1), mlr3misc (>= 0.10.0), paradox (>= 0.9.0), R6

Suggests  emoa, mlr3learners (>= 0.5.2), mlr3pipelines, rpart, testthat  
(>= 3.0.0), xgboost

Config/testthat/edition  3

Config/testthat/parallel  true

Encoding  UTF-8

NeedsCompilation  no

RoxygenNote  7.3.1

Collate  'aaa.R' 'OptimizerBatchSuccessiveHalving.R'
  'OptimizerBatchHyperband.R' 'TunerBatchHyperband.R'
  'TunerBatchSuccessiveHalving.R' 'bibentries.R' 'helper.R'
  'zzz.R'

Author  Marc Becker [aut, cre] (<https://orcid.org/0000-0002-8115-0400>),  
Sebastian Gruber [aut] (<https://orcid.org/0000-0002-8544-3470>),
mlr3hyperband-package

mlr3hyperband: Hyperband for 'mlr3'

Description


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See Also

Useful links:

- https://mlr3hyperband.mlr-org.com
- https://github.com/mlr-org/mlr3hyperband
- Report bugs at https://github.com/mlr-org/mlr3hyperband/issues

hyperband_budget  Hyperband Budget

Description

Calculates the total budget used by hyperband.

Usage

hyperband_budget(r_min, r_max, eta, integer_budget = FALSE)

Arguments

r_min  (numeric(1))
Lower bound of budget parameter.

r_max  (numeric(1))
Upper bound of budget parameter.

eta  (numeric(1))
Fraction parameter of the successive halving algorithm: With every stage the configuration budget is increased by a factor of eta and only the best 1/eta points are used for the next stage. Non-integer values are supported, but eta is not allowed to be less or equal 1.

integer_budget  (logical(1))
Determines if budget is an integer.

Value

integer(1)
### hyperband_n_configs

**Hyperband Configs**

**Description**

Calculates how many different configurations are sampled.

**Usage**

```r
hyperband_n_configs(r_min, r_max, eta)
```

**Arguments**

- `r_min` (numeric(1))
  Lower bound of budget parameter.
- `r_max` (numeric(1))
  Upper bound of budget parameter.
- `eta` (numeric(1))
  Fraction parameter of the successive halving algorithm: With every stage the configuration budget is increased by a factor of `eta` and only the best \(1/\eta\) points are used for the next stage. Non-integer values are supported, but `eta` is not allowed to be less or equal 1.

**Value**

`integer(1)`

### hyperband_schedule

**Hyperband Schedule**

**Description**

Returns hyperband schedule.

**Usage**

```r
hyperband_schedule(r_min, r_max, eta, integer_budget = FALSE)
```
### Arguments

- **r_min**
  - (numeric(1))
  - Lower bound of budget parameter.

- **r_max**
  - (numeric(1))
  - Upper bound of budget parameter.

- **eta**
  - (numeric(1))
  - Fraction parameter of the successive halving algorithm: With every stage the configuration budget is increased by a factor of eta and only the best 1/eta points are used for the next stage. Non-integer values are supported, but eta is not allowed to be less or equal 1.

- **integer_budget**
  - (logical(1))
  - Determines if budget is an integer.

### Value

```
data.table::data.table()
```

---

### Optimizer Using the Hyperband Algorithm

Optimizer using the Hyperband (HB) algorithm. HB runs the Successive Halving Algorithm (SHA) with different numbers of starting configurations. The algorithm is initialized with the same parameters as Successive Halving but without \( n \). Each run of Successive Halving is called a bracket and starts with a different budget \( r_0 \). A smaller starting budget means that more configurations can be tried out. The most explorative bracket allocated the minimum budget \( r_{\text{min}} \). The next bracket increases the starting budget by a factor of eta \( \text{eta} \). In each bracket, the starting budget increases further until the last bracket \( s = 0 \) essentially performs a random search with the full budget \( r_{\text{max}} \). The number of brackets \( s_{\text{max}} + 1 \) is calculated with \( s_{\text{max}} = \log(r_{\text{min}} / r_{\text{max}})(\text{eta}) \). Under the condition that \( r_0 \) increases by eta \( \text{eta} \) with each bracket, \( r_{\text{min}} \) sometimes has to be adjusted slightly in order not to use more than \( r_{\text{max}} \) resources in the last bracket. The number of configurations in the base stages is calculated so that each bracket uses approximately the same amount of budget.

The following table shows a full run of HB with \( \text{eta} = 2 \), \( r_{\text{min}} = 1 \) and \( r_{\text{max}} = 8 \).

<table>
<thead>
<tr>
<th>( s )</th>
<th>( i )</th>
<th>( n_i )</th>
<th>( r_i )</th>
<th>( n_i )</th>
<th>( r_i )</th>
<th>( n_i )</th>
<th>( r_i )</th>
<th>( n_i )</th>
<th>( r_i )</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>8</td>
<td>1</td>
<td>6</td>
<td>2</td>
<td>4</td>
<td>4</td>
<td>8</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>4</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>2</td>
<td>8</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>4</td>
<td>1</td>
<td>8</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>1</td>
<td>8</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\( s \) is the bracket number, \( i \) is the stage number, \( n_i \) is the number of configurations and \( r_i \) is the budget allocated to a single configuration.
The budget hyperparameter must be tagged with "budget" in the search space. The minimum budget ($r_{\min}$) which is allocated in the base stage of the most explorative bracket, is set by the lower bound of the budget parameter. The upper bound defines the maximum budget ($r_{\max}$) which is allocated to the candidates in the last stages.

Resources

The gallery features a collection of case studies and demos about optimization.

- Tune the hyperparameters of XGBoost with Hyperband.
- Use data subsampling and Hyperband to optimize a support vector machine.

Dictionary

This bbotk::Optimizer can be instantiated via the dictionary bbotk::mlr_optimizers or with the associated sugar function bbotk::opt():

```r
mlr_optimizers$get("hyperband")
opt("hyperband")
```

Parameters

- **eta** numeric(1)
  With every stage, the budget is increased by a factor of $\eta$ and only the best $1 / \eta$ points are promoted to the next stage. Non-integer values are supported, but $\eta$ is not allowed to be less or equal to 1.

- **sampler** paradox::Sampler
  Object defining how the samples of the parameter space should be drawn in the base stage of each bracket. The default is uniform sampling.

- **repetitions** integer(1)
  If 1 (default), optimization is stopped once all brackets are evaluated. Otherwise, optimization is stopped after repetitions runs of HB. The bbotk::Terminator might stop the optimization before all repetitions are executed.

Archive

The bbotk::Archive holds the following additional columns that are specific to HB:

- **bracket** (integer(1))
  The bracket index. Counts down to 0.

- **stage** (integer(1))
  The stages of each bracket. Starts counting at 0.

- **repetition** (integer(1))
  Repetition index. Start counting at 1.
Custom Sampler

Hyperband supports custom \texttt{paradox::Sampler} object for initial configurations in each bracket. A custom sampler may look like this (the full example is given in the \textit{examples} section):

\begin{verbatim}
# - beta distribution with alpha = 2 and beta = 5
# - categorical distribution with custom probabilities
sampler = SamplerJointIndep$new(list(
    Sampler1DRfun$new(params[[2]], function(n) rbeta(n, 2, 5)),
    Sampler1DCateg$new(params[[3]], prob = c(0.2, 0.3, 0.5))
))
\end{verbatim}

Progress Bars

\$optimize() supports progress bars via the package \texttt{progressr} combined with a \texttt{bbo\texttt{t}k::Terminator}. Simply wrap the function in \texttt{progressr::with\_progress()} to enable them. We recommend to use package \texttt{progress} as backend; enable with \texttt{progressr::handlers("progress")}.

Logging

Hyperband uses a logger (as implemented in \texttt{lgr}) from package \texttt{bbo\texttt{t}k}. Use \texttt{lgr::get\_logger("bbo\texttt{t}k")} to access and control the logger.

Super classes

\texttt{bbo\texttt{t}k::Optimizer \rightarrow bbo\texttt{t}k::OptimizerBatch \rightarrow OptimizerBatchHyperband}

Methods

\textbf{Public methods:}

- \texttt{OptimizerBatchHyperband$new()}
- \texttt{OptimizerBatchHyperband$clone()}  

\textbf{Method} \texttt{new()}: Creates a new instance of this \texttt{R6} class.

\textit{Usage:}

\texttt{OptimizerBatchHyperband$new()}

\textbf{Method} \texttt{clone()}: The objects of this class are cloneable with this method.

\textit{Usage:}

\texttt{OptimizerBatchHyperband$clone(deep = FALSE)}

\textit{Arguments:}

depth Whether to make a deep clone.

Source

Examples

```r
library(bbotk)
library(data.table)

# set search space
search_space = domain = ps(
  x1 = p_dbl(-5, 10),
  x2 = p_dbl(0, 15),
  fidelity = p_dbl(1e-2, 1, tags = "budget")
)

# Branin function with fidelity, see `bbotk::branin()`
fun = function(xs) branin_wu(xs[['x1']], xs[['x2']], xs[['fidelity']])

# create objective
objective = ObjectiveRFun$new(
  fun = fun,
  domain = domain,
  codomain = ps(y = p_dbl(tags = "minimize"))
)

# initialize instance and optimizer
instance = OptimInstanceSingleCrit$new(
  objective = objective,
  search_space = search_space,
  terminator = trm("evals", n_evals = 50)
)

optimizer = opt("hyperband")

# optimize branin function
optimizer$optimize(instance)

# best scoring evaluation
instance$result

# all evaluations
as.data.table(instance$archive)
```

---

**mlr_optimizers_successive_halving**

*Hyperparameter Optimization with Successive Halving*

**Description**

Optimizer using the Successive Halving Algorithm (SHA). SHA is initialized with the number of starting configurations \(n\), the proportion of configurations discarded in each stage \(\eta\), and the minimum \(r_{\text{min}}\) and maximum \(r_{\text{max}}\) budget of a single evaluation. The algorithm starts by sampling \(n\) random configurations and allocating the minimum budget \(r_{\text{min}}\) to them. The configurations are
evaluated and $1 / \eta$ of the worst-performing configurations are discarded. The remaining configurations are promoted to the next stage and evaluated on a larger budget. The following table is the stage layout for $\eta = 2$, $r_{\text{min}} = 1$ and $r_{\text{max}} = 8$.

<table>
<thead>
<tr>
<th>$i$</th>
<th>$n_i$</th>
<th>$r_i$</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>8</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>3</td>
<td>1</td>
<td>8</td>
</tr>
</tbody>
</table>

$i$ is the stage number, $n_i$ is the number of configurations and $r_i$ is the budget allocated to a single configuration.

The number of stages is calculated so that each stage consumes approximately the same budget. This sometimes results in the minimum budget having to be slightly adjusted by the algorithm.

**Resources**

The gallery features a collection of case studies and demos about optimization.

- **Tune** the hyperparameters of XGBoost with Hyperband (Hyperband can be easily swapped with SHA).
- Use data **subsampling** and Hyperband to optimize a support vector machine.

**Dictionary**

This **bbotk::Optimizer** can be instantiated via the **dictionary bbotk::mlr_optimizers** or with the associated sugar function **bbotk::opt()**:

```r
mlr_optimizers$get("successive_halving")
```
```r
opt("successive_halving")
```

**Parameters**

- **n** integer(1)
  Number of configurations in the base stage.
- **eta** numeric(1)
  With every stage, the budget is increased by a factor of $\eta$ and only the best $1 / \eta$ configurations are promoted to the next stage. Non-integer values are supported, but $\eta$ is not allowed to be less or equal to 1.
- **sampler** paradox::Sampler
  Object defining how the samples of the parameter space should be drawn. The default is uniform sampling.
- **repetitions** integer(1)
  If 1 (default), optimization is stopped once all stages are evaluated. Otherwise, optimization is stopped after repetitions runs of SHA. The **bbotk::Terminator** might stop the optimization before all repetitions are executed.
adjust_minimum_budget logical(1)

If TRUE, the minimum budget is increased so that the last stage uses the maximum budget defined in the search space.

Archive

The `bbotk::Archive` holds the following additional columns that are specific to SHA:

- `stage` (integer(1))
  Stage index. Starts counting at 0.
- `repetition` (integer(1))
  Repetition index. Starts counting at 1.

Custom Sampler

Hyperband supports custom `paradox::Sampler` object for initial configurations in each bracket. A custom sampler may look like this (the full example is given in the `examples` section):

```r
# - beta distribution with alpha = 2 and beta = 5
# - categorical distribution with custom probabilities
sampler = SamplerJointIndep$new(list(
  Sampler1DRfun$new(params[[2]], function(n) rbeta(n, 2, 5)),
  Sampler1DCateg$new(params[[3]], prob = c(0.2, 0.3, 0.5))
))
```

Progress Bars

 `$optimize()` supports progress bars via the package `progressr` combined with a `bbotk::Terminator`. Simply wrap the function in `progressr::with_progress()` to enable them. We recommend to use package `progress` as backend; enable with `progressr::handlers("progress")`.

Logging

Hyperband uses a logger (as implemented in `lgr`) from package `bbotk`. Use `lgr::get_logger("bbotk")` to access and control the logger.

Super classes

`bbotk::Optimizer` -> `bbotk::OptimizerBatch` -> `OptimizerBatchSuccessiveHalving`

Methods

Public methods:

- `OptimizerBatchSuccessiveHalving$new()`
- `OptimizerBatchSuccessiveHalving$clone()`

Method `new()`: Creates a new instance of this R6 class.

Usage:

`OptimizerBatchSuccessiveHalving$new()`
Method clone(): The objects of this class are cloneable with this method.

Usage:
OptimizerBatchSuccessiveHalving$clone(deep = FALSE)

Arguments:
depth Whether to make a deep clone.

Source

Examples

```r
library(bbotk)
library(data.table)

# set search space
search_space = domain = ps(
  x1 = p_dbl(-5, 10),
  x2 = p_dbl(0, 15),
  fidelity = p_dbl(1e-2, 1, tags = "budget")
)

# Branin function with fidelity, see `bbotk::branin()`
fun = function(xs) branin_wu(xs["x1"], xs["x2"], xs["fidelity"])

# create objective
objective = ObjectiveRFun$new(
  fun = fun,
  domain = domain,
  codomain = ps(y = p_dbl(tags = "minimize"))
)

# initialize instance and optimizer
instance = OptimInstanceSingleCrit$new(
  objective = objective,
  search_space = search_space,
  terminator = trm("evals", n_evals = 50)
)

optimizer = opt("successive_halving")

# optimize branin function
optimizer$optimize(instance)

# best scoring evaluation
instance$result

# all evaluations
```
Optimizer using the Hyperband (HB) algorithm. HB runs the Successive Halving Algorithm (SHA) with different numbers of starting configurations. The algorithm is initialized with the same parameters as Successive Halving but without \( n \). Each run of Successive Halving is called a bracket and starts with a different budget \( r_0 \). A smaller starting budget means that more configurations can be tried out. The most explorative bracket allocated the minimum budget \( r_{\text{min}} \). The next bracket increases the starting budget by a factor of \( \eta \). In each bracket, the starting budget increases further until the last bracket \( s = 0 \) essentially performs a random search with the full budget \( r_{\text{max}} \). The number of brackets \( s_{\text{max}} + 1 \) is calculated with \( s_{\text{max}} = \log(r_{\text{min}} / r_{\text{max}})(\eta) \). Under the condition that \( r_0 \) increases by \( \eta \) with each bracket, \( r_{\text{min}} \) sometimes has to be adjusted slightly in order not to use more than \( r_{\text{max}} \) resources in the last bracket. The number of configurations in the base stages is calculated so that each bracket uses approximately the same amount of budget.

The following table shows a full run of HB with \( \eta = 2 \), \( r_{\text{min}} = 1 \) and \( r_{\text{max}} = 8 \).

<table>
<thead>
<tr>
<th>( s )</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>( i )</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>( n_i )</td>
<td>8</td>
<td>4</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>( r_i )</td>
<td>1</td>
<td>6</td>
<td>3</td>
<td>2</td>
</tr>
</tbody>
</table>

\( s \) is the bracket number, \( i \) is the stage number, \( n_i \) is the number of configurations and \( r_i \) is the budget allocated to a single configuration.

The budget hyperparameter must be tagged with "budget" in the search space. The minimum budget \( (r_{\text{min}}) \) which is allocated in the base stage of the most explorative bracket, is set by the lower bound of the budget parameter. The upper bound defines the maximum budget \( (r_{\text{max}}) \) which is allocated to the candidates in the last stages.

**Dictionary**

This mlr3tuning::Tuner can be instantiated via the dictionary mlr3tuning::mlr_tuners or with the associated sugar function mlr3tuning::tnr():

```r
TunerBatchHyperband$new()
mlr_tuners$get("hyperband")
tnr("hyperband")
```
Subsample Budget

If the learner lacks a natural budget parameter, `mlr3pipelines::PipeOpSubsample` can be applied to use the subsampling rate as budget parameter. The resulting `mlr3pipelines::GraphLearner` is fitted on small proportions of the `mlr3::Task` in the first stage, and on the complete task in last stage.

Custom Sampler

Hyperband supports custom `paradox::Sampler` object for initial configurations in each bracket. A custom sampler may look like this (the full example is given in the examples section):

```r
# - beta distribution with alpha = 2 and beta = 5
# - categorical distribution with custom probabilities
sampler = SamplerJointIndep$new(list(
    Sampler1DRunfun$new(params[[2]], function(n) rbeta(n, 2, 5)),
    Sampler1DCateg$new(params[[3]], prob = c(0.2, 0.3, 0.5))
))
```

Progress Bars

$optimize() supports progress bars via the package `progressr` combined with a `bbotk::Terminator`. Simply wrap the function in `progressr::with_progress()` to enable them. We recommend to use package `progress` as backend; enable with `progressr::handlers("progress")`.

Parallelization

This hyperband implementation evaluates hyperparameter configurations of equal budget across brackets in one batch. For example, all configurations in stage 1 of bracket 3 and stage 0 of bracket 2 in one batch. To select a parallel backend, use the `plan()` function of the `future` package.

Logging

Hyperband uses a logger (as implemented in `lgr`) from package `bbotk`. Use `lgr::get_logger("bbotk")` to access and control the logger.

Resources

The gallery features a collection of case studies and demos about optimization.

- Tune the hyperparameters of XGBoost with Hyperband.
- Use data subsampling and Hyperband to optimize a support vector machine.

Parameters

- `eta numeric(1)`
  With every stage, the budget is increased by a factor of `eta` and only the best \(\frac{1}{\eta}\) points are promoted to the next stage. Non-integer values are supported, but `eta` is not allowed to be less or equal to 1.

- `sampler paradox::Sampler`
  Object defining how the samples of the parameter space should be drawn in the base stage of each bracket. The default is uniform sampling.
repetitions integer(1)
   If 1 (default), optimization is stopped once all brackets are evaluated. Otherwise, optimization is stopped after repetitions runs of HB. The `bbotk::Terminator` might stop the optimization before all repetitions are executed.

Archive

The `bbotk::Archive` holds the following additional columns that are specific to HB:

- `bracket (integer(1))`
  The bracket index. Counts down to 0.
- `stage (integer(1))`
  The stages of each bracket. Starts counting at 0.
- `repetition (integer(1))`
  Repetition index. Start counting at 1.

Super classes

`mlr3tuning::Tuner` -> `mlr3tuning::TunerBatch` -> `mlr3tuning::TunerBatchFromOptimizerBatch` -> `TunerBatchHyperband`

Methods

**Public methods:**

- `TunerBatchHyperband$new()`
- `TunerBatchHyperband$clone()`

**Method new():** Creates a new instance of this R6 class.

*Usage:*

```r
TunerBatchHyperband$new()
```

**Method clone():** The objects of this class are cloneable with this method.

*Usage:*

```r
TunerBatchHyperband$clone(deep = FALSE)
```

*Arguments:*

depth Whether to make a deep clone.

Source

Examples

```r
if(requireNamespace("xgboost")) {
  library(mlr3learners)

  # define hyperparameter and budget parameter
  search_space = ps(
    nrounds = p_int(lower = 1, upper = 16, tags = "budget"),
    eta = p_dbl(lower = 0, upper = 1),
    booster = p_fct(levels = c("gbtree", "gblinear", "dart"))
  )

  # hyperparameter tuning on the pima indians diabetes data set
  instance = tune(
    tnr("hyperband"),
    task = tsk("pima"),
    learner = lrn("classif.xgboost", eval_metric = "logloss"),
    resampling = rsmp("cv", folds = 3),
    measures = msr("classif.ce"),
    search_space = search_space,
    term_evals = 100
  )

  # best performing hyperparameter configuration
  instance$result
}
```

---

**mlr_tuners_successive_halving**

*Hyperparameter Tuning with Successive Halving*

**Description**

Optimizer using the Successive Halving Algorithm (SHA). SHA is initialized with the number of starting configurations \( n \), the proportion of configurations discarded in each stage \( \eta \), and the minimum \( r_{\text{min}} \) and maximum \( r_{\text{max}} \) budget of a single evaluation. The algorithm starts by sampling \( n \) random configurations and allocating the minimum budget \( r_{\text{min}} \) to them. The configurations are evaluated and \( 1 / \eta \) of the worst-performing configurations are discarded. The remaining configurations are promoted to the next stage and evaluated on a larger budget. The following table is the stage layout for \( \eta = 2 \), \( r_{\text{min}} = 1 \) and \( r_{\text{max}} = 8 \).

<table>
<thead>
<tr>
<th>( i )</th>
<th>( n_i )</th>
<th>( r_i )</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>8</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>3</td>
<td>1</td>
<td>8</td>
</tr>
</tbody>
</table>
i is the stage number, \( n_i \) is the number of configurations and \( r_i \) is the budget allocated to a single configuration.

The number of stages is calculated so that each stage consumes approximately the same budget. This sometimes results in the minimum budget having to be slightly adjusted by the algorithm.

**Dictionary**

This `mlr3tuning::Tuner` can be instantiated via the dictionary `mlr3tuning::mlr_tuners` or with the associated sugar function `mlr3tuning::tnr()`:

```r
TunerBatchSuccessiveHalving$new()
mlr_tuners$get("successive_halving")
tnr("successive_halving")
```

**Subsample Budget**

If the learner lacks a natural budget parameter, `mlr3pipelines::PipeOpSubsample` can be applied to use the subsampling rate as budget parameter. The resulting `mlr3pipelines::GraphLearner` is fitted on small proportions of the `mlr3::Task` in the first stage, and on the complete task in last stage.

**Custom Sampler**

Hyperband supports custom `paradox::Sampler` object for initial configurations in each bracket. A custom sampler may look like this (the full example is given in the examples section):

```r
# - beta distribution with alpha = 2 and beta = 5
# - categorical distribution with custom probabilities
sampler = SamplerJointIndep$new(list(
    Sampler1DFun$new(params[[2]], function(n) rbeta(n, 2, 5)),
    Sampler1DCateg$new(params[[3]], prob = c(0.2, 0.3, 0.5))
))
```

**Progress Bars**

`$optimize()` supports progress bars via the package `progressr` combined with a `bbotk::Terminator`. Simply wrap the function in `progressr::with_progress()` to enable them. We recommend to use package `progress` as backend; enable with `progressr::handlers("progress")`.

**Parallelization**

The hyperparameter configurations of one stage are evaluated in parallel with the `future` package. To select a parallel backend, use the `plan()` function of the `future` package.

**Logging**

Hyperband uses a logger (as implemented in `lgr`) from package `bbotk`. Use `lgr::get_logger("bbotk")` to access and control the logger.
Resources

The gallery features a collection of case studies and demos about optimization.

- Tune the hyperparameters of XGBoost with Hyperband (Hyperband can be easily swapped with SHA).
- Use data subsampling and Hyperband to optimize a support vector machine.

Parameters

n integer(1)
   Number of configurations in the base stage.

eta numeric(1)
   With every stage, the budget is increased by a factor of \( \eta \) and only the best \( \frac{1}{\eta} \) configurations are promoted to the next stage. Non-integer values are supported, but \( \eta \) is not allowed to be less or equal to 1.

sampler paradox::Sampler
   Object defining how the samples of the parameter space should be drawn. The default is uniform sampling.

repetitions integer(1)
   If 1 (default), optimization is stopped once all stages are evaluated. Otherwise, optimization is stopped after \( \text{repetitions} \) runs of SHA. The bbotk::Terminator might stop the optimization before all repetitions are executed.

adjust_minimum_budget logical(1)
   If TRUE, the minimum budget is increased so that the last stage uses the maximum budget defined in the search space.

Archive

The bbotk::Archive holds the following additional columns that are specific to SHA:

- stage (integer(1))
  Stage index. Starts counting at 0.

- repetition (integer(1))
  Repetition index. Start counting at 1.

Super classes

mlr3tuning::Tuner -> mlr3tuning::TunerBatch -> mlr3tuning::TunerBatchFromOptimizerBatch
   -> TunerBatchSuccessiveHalving

Methods

Public methods:

- TunerBatchSuccessiveHalving$new()
- TunerBatchSuccessiveHalving$clone()

Method new(): Creates a new instance of this R6 class.
**Usage:**

TunerBatchSuccessiveHalving$new()

**Method clone():** The objects of this class are cloneable with this method.

**Usage:**

TunerBatchSuccessiveHalving$clone(deep = FALSE)

**Arguments:**

depth Whether to make a deep clone.

**Source**


**Examples**

```r
if(requireNamespace("xgboost")) {
  library(mlr3learners)

  # define hyperparameter and budget parameter
  search_space = ps(
    nrounds = p_int(lower = 1, upper = 16, tags = "budget"),
    eta = p_dbl(lower = 0, upper = 1),
    booster = p_fct(levels = c("gbtree", "gblinear", "dart"))
  )

  # hyperparameter tuning on the pima indians diabetes data set
  instance = tune(
    tnr("successive_halving"),
    task = tsk("pima"),
    learner = lrn("classif.xgboost", eval_metric = "logloss"),
    resampling = rsmp("cv", folds = 3),
    measures = msr("classif.ce"),
    search_space = search_space,
    term_evals = 100
  )

  # best performing hyperparameter configuration
  instance$result
}
```
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