

Package ‘broadcast’

January 26, 2025

Title Simple Broadcasted Binding and Binary Operations for Atomic and Recursive Arrays with Minimal Dependencies

Version 0.0.0.9

Description Implements simple broadcasted binding and binary operations, for atomic and recursive arrays.

Besides linking to 'Rcpp',

'broadcast' does not depend on, vendor, link to, or otherwise use any external libraries;

'broadcast' was essentially made from scratch and can be installed out-of-the-box.

The broadcasted implementations include, but are not limited to, the following.

1) Relational operations (like ``==``, ``!=``, ``<``, ``>``, ``<=``, ``>=``; can also take into account Machine precision);

2) Arithmetic operations (like ``+``, ``-``, ``*``, ``/``, ``^``, ``pmin()``, ``pmax()``, integer modulo);

3) Boolean combiner operations (like ``&``, ``|``, ``xor()``, ``nand``);

4) String distance, (in)equality, and concatenation operations;

5) A Broadcasted implementation of ``ifelse()``;

6) A Broadcasted apply-like function;

7) Binding arrays along any arbitrary axis, with broadcast support.

The broadcasted implementations strive to minimize computation time and memory usage (which is not just good for computer efficiency, but also for the environment).

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Encoding UTF-8

LinkingTo Rcpp

Roxygen list(markdown = TRUE)

RoxygenNote 7.3.1

Depends R (>= 4.2.0)

Imports Rcpp (>= 1.0.11),
data.table

Suggests tinytest, roxygen2, altdoc, kableExtra

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aaa00_broadcast_help	<i>broadcast: Simple Broadcasted Binding and Binary Operations for Atomic and Recursive Arrays with Minimal Dependencies</i>
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Description

`broadcast`:

Simple Broadcasted Binding and Binary Operations for Atomic and Recursive Arrays with Minimal Dependencies.

Implements simple broadcasted binding and binary operations, for atomic and recursive arrays.

Besides linking to 'Rcpp', 'broadcast' does not depend on, vendor, link to, or otherwise use any external libraries; 'broadcast' was essentially made from scratch and can be installed out-of-the-box.

The broadcasted implementations include, but are not limited to, the following:

1. Relational operations (like `==`, `!=`, `<`, `>`, `<=`, `>=`; can also take into account Machine precision);
2. Arithmetic operations (like `+`, `-`, `*`, `/`, `^`, `pmin()`, `pmax()`, integer modulo);
3. Boolean combiner operations (like `&`, `|`, `xor()`, "nand");
4. String distance, (in)equality, and concatenation operations;
5. A Broadcasted implementation of `ifelse()`;
6. A Broadcasted apply-like function;
7. Binding arrays along any arbitrary axis, with broadcast support.

The broadcasted implementations strive to minimize computation time and memory usage (which is not just good for computer efficiency, but also for the environment).

Getting Started

An introduction and overview of the package can be found on the website.

Methods and Functions

Type Specific Binary Operations

'broadcast' provides a set of functions for type-specific binary operations for broadcasted operations.

These functions use an API similar to the [outer](#) and [sweep](#) functions.

The following functions for type-specific binary operations are available:

- [bc.num](#): numeric arithmetic and relational operations;
- [bc.b](#): Boolean combiner operations;
- [bc.cplx](#): complex arithmetic and equality operations;
- [bc.str](#): string equality, concatenation, and distance operations;
- [bc.list](#): apply any 'R' function to 2 recursive arrays with broadcasting.

General functions

'broadcast' also comes with 2 general broadcasted functions:

- [bc.ifelse](#): Broadcasted version of [ifelse](#).
- [bcapply](#): Broadcasted apply-like function.

Binding Implementations

...

Other functions

'broadcast' also provides [type-casting](#) functions, which preserve names and dimensions - convenient for arrays.

Author(s)

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References

The badges shown in the documentation of this R-package were made using the services of: <https://shields.io/>

array_recycle	<i>Recycle Array Dimensions</i>
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Description

The `array_recycle()` function recycles array dimensions until the specified dimension sizes are reached, and returns the array.

The various broadcasting functions "recycle" an array virtually, meaning little to no additional memory is needed.

The `array_recycle()` function, however, physically recycles an array (and thus actually occupies memory space).

Usage

```
array_recycle(x, tdim)
```

Arguments

`x` an atomic or recursive array or matrix.

`tdim` an integer vector, giving the target dimension to reach.

Value

Returns the recycled array.

Examples

```
x <- matrix(1:9, 3,3)
colnames(x) <- LETTERS[1:3]
rownames(x) <- letters[1:3]
names(x) <- month.abb[1:9]
print(x)

array_recycle(x, c(3,3,2)) # recycle to larger size
```

bc.b

Broadcasted Operations for Logical Arrays

Description

The `bc.b()` function performs broadcasted operations on 2 logical arrays.

Usage

```
bc.b(x, y, op)
```

Arguments

`x, y` conformable atomic arrays of types `logical`, `integer`, or `double`.

`op` a single string, giving the operator.
Supported Boolean combiner operators: `&`, `|`, `xor`, `nand`.
Supported relational operators: `==`, `!=`, `<`, `>`, `<=`, `>=`.

Value

For the boolean combiner operators:
A logical array as a result of the broadcasted arithmetic operation.

For relational operators:
A logical array as a result of the broadcasted relational comparison.

Examples

```

x.dim <- c(10:8)
x.len <- prod(x.dim)
x.data <- sample(c(TRUE, FALSE, NA), x.len, TRUE)
x <- array(x.data, x.dim)
y <- array(1:50, c(10,1,1))

bc.b(x, y, "&")
bc.b(x, y, "|")
bc.b(x, y, "xor")
bc.b(x, y, "nand")

bc.b(x, y, "==")
bc.b(x, y, "!=")
bc.b(x, y, "<")
bc.b(x, y, ">")
bc.b(x, y, "<=")
bc.b(x, y, ">=")

```

bc.cplx

*Broadcasted Operations for Character/String Arrays***Description**

The `bc.cplx()` function performs broadcasted operations on 2 complex arrays.

Note that `bc.cplx()` uses more strict NA checks than base 'R':

If for an element of either `x` or `y`, either the real or imaginary part is NA or NaN, then the result of the operation for that element is necessarily NA.

Usage

```
bc.cplx(x, y, op)
```

Arguments

<code>x, y</code>	conformable atomic arrays of type <code>complex</code> .
<code>op</code>	a single string, giving the operator. Supported arithmetic operators: <code>+</code> , <code>-</code> , <code>*</code> , <code>/</code> . Supported relational operators: <code>==</code> , <code>!=</code> .

Value

For arithmetic operators:

A complex array as a result of the broadcasted arithmetic operation.

For relational operators:

A logical array as a result of the broadcasted relational comparison.

Examples

```
x.dim <- c(10:8)
x.len <- prod(x.dim)
gen <- function() sample(c(rnorm(10), NA, NA, NaN, NaN, Inf, Inf, -Inf, -Inf))
x <- array(gen() + gen() * -1i, x.dim)
y <- array(gen() + gen() * -1i, c(10,1,1))

bc.cplx(x, y, "==")
bc.cplx(x, y, "!=")

bc.cplx(x, y, "+")

bc.cplx(array(gen() + gen() * -1i), array(gen() + gen() * -1i), "==")
bc.cplx(array(gen() + gen() * -1i), array(gen() + gen() * -1i), "!=")

x <- gen() + gen() * -1i
y <- gen() + gen() * -1i
out <- bc.cplx(array(x), array(y), "*")
cbind(x, y, x*y, out)
```

bc.list

Broadcasted Operations for Recursive Arrays

Description

The `bc.list()` function performs broadcasted operations on 2 Recursive arrays.

Usage

```
bc.list(x, y, f)
```

Arguments

<code>x, y</code>	conformable Recursive arrays (i.e. arrays of type <code>list</code>).
<code>f</code>	a function that takes in exactly 2 arguments, and returns a result that can be stored in a single element of a list.

Value

A recursive array.

Examples

```
x.dim <- c(c(10, 2,2))
x.len <- prod(x.dim)

gen <- function(n) sample(list(letters, month.abb, 1:10), n, TRUE)

x <- array(gen(10), x.dim)
y <- array(gen(10), c(10,1,1))
```

```
bc.list(
  x, y,
  \ (x, y) c(length(x) == length(y), typeof(x) == typeof(y))
)
```

bc.num

*Broadcasted Operations for Numeric Arrays***Description**

The `bc.num()` function performs broadcasted operations on 2 numeric arrays.

Usage

```
bc.num(x, y, op, prec = sqrt(.Machine$double.eps))
```

Arguments

<code>x, y</code>	conformable atomic arrays of types <code>logical</code> , <code>integer</code> , or <code>double</code> .
<code>op</code>	a single string, giving the operator. Supported arithmetic operators: <code>+</code> , <code>-</code> , <code>*</code> , <code>/</code> , <code>^</code> , <code>pmin</code> , <code>pmax</code> . Supported relational operators: <code>==</code> , <code>!=</code> , <code><</code> , <code>></code> , <code><=</code> , <code>>=</code> , <code>d==</code> , <code>d!=</code> , <code>d<</code> , <code>d></code> , <code>d<=</code> , <code>d>=</code> .
<code>prec</code>	a single number between 0 and 0.1, giving the machine precision to use. Only relevant for the following operators: <code>d==</code> , <code>d!=</code> , <code>d<</code> , <code>d></code> , <code>d<=</code> , <code>d>=</code> See the <code>d==</code> , <code>d!=</code> , <code>d<</code> , <code>d></code> , <code>d<=</code> , <code>d>=</code> operators from the 'tinycodet' package for details.

Value

For arithmetic operators:

A numeric array as a result of the broadcasted arithmetic operation.

For relational operators:

A logical array as a result of the broadcasted relational comparison.

Examples

```
x.dim <- c(10:8)
x.len <- prod(x.dim)
x.data <- sample(c(NA, 1.1:1000.1), x.len, TRUE)
x <- array(x.data, x.dim)
y <- array(1:50, c(10,1,1))

bc.num(x, y, "+")
bc.num(x, y, "-")
```

```

bc.num(x, y, "*")
bc.num(x, y, "/" )
bc.num(x, y, "^")

bc.num(x, y, "==")
bc.num(x, y, "!=")
bc.num(x, y, "<")
bc.num(x, y, ">")
bc.num(x, y, "<=")
bc.num(x, y, ">=")

```

bc.str

Broadcasted Operations for Character/String Arrays

Description

The `bc.str()` function performs broadcasted operations on 2 character/string arrays.
`bc.chr()` is an alias for `bc.str()`.

Usage

```
bc.str(x, y, op)
```

```
bc.chr(x, y, op)
```

Arguments

<code>x, y</code>	conformable atomic arrays of type <code>character</code> .
<code>op</code>	a single string, giving the operator. Supported concatenation operators: <code>+</code> . Supported relational operators: <code>==</code> , <code>!=</code> . Supported distance operators: <code>levenshtein</code> .

Value

For concatenation operation:
A character array as a result of the broadcasted concatenation operation.

For relational operation:
A logical array as a result of the broadcasted relational comparison.

For distance operation:
An integer array as a result of the broadcasted relational comparison.

Examples

```
# string concatenation:
x <- array(letters, c(10, 2, 1))
y <- array(letters, c(10,1,1))
bc.str(x, y, "+")

# string (in)equality:
bc.str(array(letters), array(letters), "==")
bc.str(array(letters), array(letters), "!=")

# string distance (Levenshtein):
x <- array(month.name, c(12, 1))
y <- array(month.abb, c(1, 12))
out <- bc.str(x, y, "levenshtein")
dimnames(out) <- list(month.name, month.abb)
print(out)
```

bcapply

Apply a Function to 2 Broadcasted Arrays

Description

The `bcapply()` function applies a function to 2 arrays with broadcasting.

Usage

```
bcapply(x, y, f, v = "list")
```

Arguments

- | | |
|-------------------|---|
| <code>x, y</code> | conformable atomic or recursive arrays. |
| <code>f</code> | a function that takes in exactly 2 arguments, and returns a result that can be stored in a single element of a recursive or atomic array. |
| <code>v</code> | <p>a single string, giving the scalar type for a single iteration.</p> <p>If NULL or "list" (default), the result will be a recursive array.</p> <p>If it is certain that, for every iteration, <code>f()</code> always results in a single atomic scalar, the user can specify the type in <code>v</code> to pre-allocate the result.</p> <p>Pre-allocating the results leads to slightly faster and more memory efficient code.</p> <p>NOTE: Incorrectly specifying <code>v</code> leads to undefined behaviour.</p> |

Value

An atomic or recursive array with dimensions `bc_dim(x, y)`.

Examples

```

x.dim <- c(c(10, 2,2))
x.len <- prod(x.dim)

gen <- function(n) sample(list(letters, month.abb, 1:10), n, TRUE)

x <- array(gen(10), x.dim)
y <- array(gen(10), c(10,1,1))

f <- function(x, y) list(x, y)
bcapply(x, y, f)

```

bc_dim

Predict Broadcasted dimensions

Description

bc_dim(x, y) gives the dimensions an array would have, as the result of an broadcasted binary element-wise operation between 2 arrays x and y.

Usage

```
bc_dim(x, y)
```

Arguments

x, y an atomic array or matrix.

Value

Returns the recycled array.

Examples

```

x.dim <- c(10:8)
x.len <- prod(x.dim)
x.data <- sample(c(TRUE, FALSE, NA), x.len, TRUE)
x <- array(x.data, x.dim)
y <- array(1:50, c(10,1,1))

dim(bc.b(x, y, "&")) == bc_dim(x, y)
dim(bc.b(x, y, "|")) == bc_dim(x, y)

```

bc_ifelse	<i>Broadcasted Ifelse</i>
-----------	---------------------------

Description

The `bc_ifelse()` S4 generic method performs a broadcasted form of [ifelse](#).

Usage

```
bc_ifelse(cond, yes, no)
```

Arguments

<code>cond</code>	logical vector or array with the length equal to <code>prod(bc_dim(yes, no))</code> .
<code>yes, no</code>	conformable arrays of the same type. All atomic types (see atomic) are supported. Recursive arrays of type <code>list</code> are also supported. since <code>bc_ifelse()</code> is an S4 generic, it can be extended to support special array classes.

Value

The output, here referred to as `out`, will be an array of the same type as `yes` and `no`.
After broadcasting `yes` against `no`, given any element index `i`, the following will hold for the output:

- when `cond[i] == TRUE`, `out[i]` is `yes[i]`;
- when `cond[i] == FALSE`, `out[i]` is `no[i]`;
- when `cond[i]` is `NA`, `out[i]` is `NA` when `yes` and `no` are atomic, and `out[i]` is `list(NULL)` when `yes` and `no` are recursive.

Examples

```
x.dim <- c(c(10, 2,2))
x.len <- prod(x.dim)

gen <- function(n) sample(list(letters, month.abb, 1:10), n, TRUE)

x <- array(gen(10), x.dim)
y <- array(gen(10), c(10,1,1))

cond <- bc.list(
  x, y,
  \(x, y) c(length(x) == length(y) && typeof(x) == typeof(y))
) |> as_bool()

bc_ifelse(cond, yes = x, no = y)
```

bind

*Dimensional Binding of Objects***Description**

The `bind_`implementations provide dimensional binding functionalities.

The following implementations are available:

- `bind_mat()` binds dimensionless (atomic/recursive) vectors and (atomic/recursive) matrices row- or column-wise.
Allows for recycling.
- `bind_array()` binds (atomic/recursive) arrays and (atomic/recursive) matrices.
Allows for broadcasting.
- `bind_dt()` binds `data.tables` and other `data.frame`-like objects.
This function is only available if the 'data.table' package is installed.
Returns a `data.table`.
Faster than `do.call(cbind, ...)` or `do.call(rbind, ...)` for regular `data.frame` objects.

Note that the naming convention of the binding implementations here is "bind_" followed by the **resulting class** (abbreviated).

I.e. `bind_mat` **returns** a matrix, but can bind both matrices and vectors.

And `bind_array` **returns** an array, but can bind both arrays and matrices.

And `bind_dt` **returns** a `data.table`, but can bind not only `data.tables`, but also most other `data.frame`-like objects.

Usage

```
bind_mat(input, along, name_deparse = TRUE, comnames_from = 1L)
```

```
bind_array(
  input,
  along,
  max_bc = 1L,
  name_along = TRUE,
  comnames_from = 1L,
  name_flat = FALSE
)
```

```
bind_dt(input, along, ...)
```

Arguments

`input` a list of only the appropriate objects.
If `input` is named, its names will be used for the names of dimension along of the output, as far as possible.

along	<p>a single integer, indicating the dimension along which to bind the dimensions. I.e. use <code>along = 1</code> for row-binding, <code>along = 2</code> for column-binding, etc. For arrays, additional flexibility is available:</p> <ul style="list-style-type: none"> • Specifying <code>along = 0</code> will bind the arrays on a new dimension before the first, making <code>along</code> the new first dimension. • Specifying <code>along = n+1</code>, with <code>n</code> being the last available dimension, will create an additional dimension (<code>n+1</code>) and bind the arrays along that new dimension.
name_deparse	<p>Boolean, for <code>bind_mat()</code>. Indicates if dimension <code>along</code> should be named. Uses the naming method from rbind/cbind itself.</p>
comnames_from	<p>either integer scalar or <code>NULL</code>, for <code>bind_mat()</code> and <code>bind_array()</code>. Indicates which object in <code>input</code> should be used for naming the shared dimension. If <code>NULL</code>, no communal names will be given. For example: When binding columns of matrices, the matrices will share the same rownames. Using <code>comnames_from = 10</code> will then result in <code>bind_array()</code> using <code>rownames(input[[10]])</code> for the rownames of the output.</p>
max_bc	<p>integer, for <code>bind_array</code>. Specify here the number of dimensions that are allowed to be broadcasted when binding arrays. If <code>max_bc = 0L</code>, no broadcasting will be allowed at all.</p>
name_along	<p>Boolean, for <code>bind_array()</code>. Indicates if dimension <code>along</code> should be named.</p>
name_flat	<p>Boolean, for <code>bind_array()</code>. Indicates if flat indices should be named. Note that setting this to <code>TRUE</code> will reduce performance considerably. for performance: set to FALSE</p>
...	arguments to be passed to rbindlist .

Details

The API of `bind_array()` is inspired by the fantastic `abind::abind` function by Tony Plare & Richard Heiberger (2016).

But `bind_array()` differs considerably from `abind::abind` in the following ways:

- `bind_array()` differs from `abind::abind` in that it can handle recursive arrays properly (the `abind::abind` function would unlist everything to atomic arrays, ruining the structure).
- `bind_array()` allows for broadcasting, while `abind::abind` does not support broadcasting.
- `bind_array()` is generally faster than `abind::abind`, as `bind_array()` relies heavily on 'C' and 'C++' code.
- unlike `abind::abind`, `bind_array()` only binds (atomic/recursive) arrays and matrices. `bind_array()` does not attempt to convert things to arrays when they are not arrays, but will give an error instead. This saves computation time and prevents unexpected results.
- `bind_array()` has more streamlined naming options, compared to `abind::abind`.

`bind_mat()` is a modified version of [rbind/cbind](#).

The primary difference is that `bind_mat()` gives an error when fractional recycling is attempted (like binding `1:3` with `1:10`).

Value

The bound object.

References

Plate T, Heiberger R (2016). *abind: Combine Multidimensional Arrays*. R package version 1.4-5, <https://CRAN.R-project.org/package=abind>.

Examples

```
# bind_array ====

# here, atomic and recursive arrays are mixed,
# resulting in recursive arrays

# creating the arrays
x <- c(
  lapply(1:3, \(x)sample(c(TRUE, FALSE, NA))),
  lapply(1:3, \(x)sample(1:10)),
  lapply(1:3, \(x)rnorm(10)),
  lapply(1:3, \(x)sample(letters))
)
x <- matrix(x, 4, 3, byrow = TRUE)
dimnames(x) <- list(letters[1:4], LETTERS[1:3])
print(x)

y <- matrix(1:12, 4, 3)
print(y)

# binding the arrays
input <- list(x = x, y = y)
bind_array(input, along = 0L) # binds on new dimension before first
bind_array(input, along = 1L) # binds on first dimension
bind_array(input, along = 2L)
bind_array(input, along = 3L) # bind on new dimension after last

#####

# bind_mat ====

# here, atomic and recursive matrices are mixed,
# resulting in a recursive matrix

x <- c(
  lapply(1:3, \(x)sample(c(TRUE, FALSE, NA))),
  lapply(1:3, \(x)sample(1:10)),
  lapply(1:3, \(x)rnorm(10)),
```

```

    lapply(1:3, \(x)sample(letters))
  )
  x <- matrix(x, 4, 3, byrow = TRUE)
  dimnames(x) <- list(letters[1:4], LETTERS[1:3])
  print(x)

  y <- matrix(1:12, 4, 3)
  print(y)

  bind_mat(list(x = x, y = y), 2L)

#####

# bind_dt ====

x <- data.frame(a = 1:12, b = month.abb) # data.frame
y <- data.table::data.table(a = 1:12, b = month.abb) # data.table

bind_dt(list(x = x, y = y), 2L) # column bind

bind_dt(list(x = x, y = y), 1L) # row bind

```

typecast

Atomic and List Type Casting With Names and Dimensions Preserved

Description

Type casting usually strips away attributes of objects. The functions provided here preserve dimensions, dimnames, and names, which may be more convenient for arrays and array-like objects.

The functions are as follows:

- `as_bool()`: converts object to atomic type logical (TRUE, FALSE, NA).
- `as_int()`: converts object to atomic type integer.
- `as_dbl()`: converts object to atomic type double (AKA numeric).
- `as_chr()`: converts object to atomic type character.
- `as_cplx()`: converts object to atomic type complex.
- `as_raw()`: converts object to atomic type raw.
- `as_list()`: converts object to recursive type list.

`as_num()` is an alias for `as_dbl()`.

`as_str()` is an alias for `as_chr()`.

See also [typeof](#).

Usage

```
as_bool(x, ...)  
  
as_int(x, ...)  
  
as_dbl(x, ...)  
  
as_num(x, ...)  
  
as_chr(x, ...)  
  
as_str(x, ...)  
  
as_cplx(x, ...)  
  
as_raw(x, ...)  
  
as_list(x, ...)
```

Arguments

x	an R object.
...	further arguments passed to or from other methods.

Value

The converted object.

Examples

```
# matrix example ====  
x <- matrix(sample(-1:28), ncol = 5)  
colnames(x) <- month.name[1:5]  
rownames(x) <- month.abb[1:6]  
names(x) <- c(letters[1:20], LETTERS[1:10])  
print(x)  
  
as_bool(x)  
as_int(x)  
as_dbl(x)  
as_chr(x)  
as_cplx(x)  
as_raw(x)  
  
#####  
  
# factor example ====  
x <- factor(month.abb, levels = month.abb)  
names(x) <- month.name  
print(x)
```



```
as_bool(as_int(x) > 6)
as_int(x)
as_dbl(x)
as_chr(x)
as_cplx(x)
as_raw(x)
```

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