Package 'massProps'

April 19, 2025

Title Calculate Mass Properties and Uncertainties of Tree Structures

Version 0.3.2

Description Recursively calculates mass properties (mass, center of mass, moments and products of inertia, and optionally, their uncertainties) for arbitrary decomposition trees. R. L. Zimmerman, J. H. Nakai. (2005) <https://www.sawe.org/product/paper-3360/>).

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Contents

add_radii_of_gyration *Add radii of gyration*

Description

add_radii_of_gyration() adds calculated radii of gyration to a data frame of rolled-up mass properties.

Radii of gyration are calculated directly from moments of inertia and mass; they are not recursively-defined, and do not require a rollup method.

Usage

```
add_radii_of_gyration(df)
```

Arguments

df	A data frame with (at least) these columns: id, mass, Cx, Cy, Cz, Ixx, Iyy, Izz, Ixy, Ixz, Iyz, POIconv, Ipoint.

Value

A data frame with the same columns as df, plus radii of gyration in columns kx, ky, and kz.‘

Examples

```
test_table_rollup <- rollup_mass_props(test_tree, test_table)
add_radii_of_gyration(test_table_rollup)
```

combine_mass_props *Combine mass properties*

Description

combine_mass_props() calculates the mass properties of an aggregate from a list of constituent mass properties.

Usage

```
combine_mass_props(mpl)
```

Arguments

`mpl`	A list of mass properties lists, each of which contains the following named elements: • `mass` Numeric mass. • `center_mass` Numeric 3-vector center of mass. • `point` Logical indicating point mass. The inertia of point masses is excluded from calculations. • `inertia` Numeric 3x3 matrix inertia tensor.

Details

See vignette("massProps", package = "massProps") for details on the algorithms employed.

Value

Combined mass properties list with the same named elements.

Examples

```
leaves <- names(igraph::neighbors(test_tree, "A.3", mode = "in"))
mpl <- Map(f = function(id) get_mass_props(test_table, id), leaves)
combine_mass_props(mpl)
```

`combine_mass_props_and_unc` *Combine mass properties and uncertainties*

Description

`combine_mass_props_and_unc()` is a convenience wrapper that concatenates the results of `combine_mass_props()` and `combine_mass_props_unc()`.

Usage

```
combine_mass_props_and_unc(mpl)
```

Arguments

`mpl`	A list of mass properties and uncertainties lists, each of which contains the following named elements: • `mass` Numeric mass. • `center_mass` Numeric 3-vector center of mass. • `point` Logical indicating point mass. The inertia of point masses is excluded from calculations. • `inertia` Numeric 3x3 matrix inertia tensor.

- sigma_mass mass uncertainty
- sigma_center_mass center of mass uncertainty (3-dimensional numeric)
- sigma_inertia Inertia tensor uncertainty (3x3 numeric matrix)

Value

Combined mass properties list with the same named elements.

Examples

```
leaves <- names(igraph::neighbors(sawe_tree, "Combined", mode = "in"))
mpl <- Map(f = function(id) get_mass_props_and_unc(sawe_table, id), leaves)
combine_mass_props_and_unc(mpl)
```

---

combine_mass_props_unc

Combine mass properties uncertainties

Description

combine_mass_prop_unc() calculates the mass properties uncertainties of an aggregate from the mass properties and uncertainties of its constituents and the mass properties of the aggregate.

Usage

```
combine_mass_props_unc(mpl, amp)
```

Arguments

mpl	A list of mass properties and uncertainties lists, each of which contains the following named elements: • mass Numeric mass. • center_mass Numeric 3-vector center of mass. • point Logical indicating point mass. The inertia of point masses is excluded from calculations. • inertia Numeric 3x3 matrix inertia tensor. • sigma_mass mass uncertainty • sigma_center_mass center of mass uncertainty (3-dimensional numeric) • sigma_inertia Inertia tensor uncertainty (3x3 numeric matrix)
amp	A named list of mass properties for the aggregate containing the following named elements: • mass Numeric mass. • center_mass Numeric 3-vector center of mass. • point Logical indicating point mass. The inertia of point masses is excluded from calculations. • inertia Numeric 3x3 matrix inertia tensor.

Details

See vignette("massProps", package = "massProps") for details on the algorithms employed.

Value

The mass properties and uncertainties of the aggregate. A list with the same elements as members of `mpl`.

Examples

```
leaves <- names(igraph::neighbors(sawe_tree, "Combined", mode = "in"))
mpl <- Map(f = function(id) get_mass_props_and_unc(sawe_table, id), leaves)
combine_mass_props_unc(mpl, amp = get_mass_props(sawe_table, "Combined"))
```

---

get_mass_props *Get mass properties for a row in a data frame*

Description

`get_mass_props()` creates a mass properties list from a selected row in a data frame.

Usage

```
get_mass_props(df, id)
```

Arguments

`df`	A data frame with (at least) these columns: `id`, `mass`, `Cx`, `Cy`, `Cz`, `Ixx`, `Iyy`, `Izz`, `Ixy`, `Ixz`, `Iyz`, `POIconv`, `Ipoint`.
`id`	The `id` value of the desired row.

Value

A list with the following named elements:

- `mass` Numeric mass.
- `center_mass` Numeric 3-vector center of mass.
- `point` Logical indicating point mass. The inertia of point masses is excluded from calculations.
- `inertia` Numeric 3x3 matrix inertia tensor. The signs of the off-diagonal elements of the inertia tensor are determined by `POIconv`. For example, the xy element of the inertia tensor is `Ixy` if `POIconv` is "-"; it is -`Ixy` if `POIconv` is "+".

Examples

```
get_mass_props(mp_table, "C.1.2.2.3.1.2.3")
```

get_mass_props_and_unc *Get mass properties and uncertainties for a row in a data frame*

Description

`get_mass_props_and_unc()` is a convenience wrapper that combines the results of `get_mass_props()` and `get_mass_props_unc()`.

Usage

```
get_mass_props_and_unc(df, id)
```

Arguments

`df`	A data frame with (at least) these columns: `id`, `mass`, `Cx`, `Cy`, `Cz`, `Ixx`, `Iyy`, `Izz`, `Ixy`, `Ixz`, `Iyz`, `POIconv`, `Ipoint`, `sigma_mass`, `sigma_Cx`, `sigma_Cy`, `sigma_Cz`,`sigma_Ixy`, `sigma_Ixz`, `sigma_Iyz`.
`id`	The `id` value of the desired row.

Value

A list with the following named elements:

- `mass` Numeric mass.
- `center_mass` Numeric 3-vector center of mass.
- `point` Logical indicating point mass. The inertia of point masses is excluded from calculations.
- `inertia` Numeric 3x3 matrix inertia tensor. The signs of the off-diagonal elements of the inertia tensor are determined by `POIconv`. For example, the xy element of the inertia tensor is `Ixy` if `POIconv` is "-"; it is `-Ixy` if `POIconv` is "+".
- `sigma_mass` Numeric mass uncertainty.
- `sigma_center_mass` Numeric 3-vector center of mass uncertainties.
- `sigma_inertia` Numeric 3x3 matrix inertia tensor uncertainties.

Examples

```
get_mass_props_and_unc(mp_table, "C.1.2.2.3.1.2.3")
```

get_mass_props_and_unc_and_radii *Get mass properties and uncertainties and radii of gyration*

Description

get_mass_props_and_unc_and_radii() creates a mass properties and uncertainties and radii of gyration list from a selected row in a data frame.

Usage

```
get_mass_props_and_unc_and_radii(df, id)
```

Arguments

df	A data frame with (at least) these columns: id, mass, Cx, Cy, Cz, Ixx, Iyy, Izz, Ixy, Ixz, Iyz, POIconv, Ipoint, sigma_mass, sigma_Cx, sigma_Cy, sigma_Cz,sigma_Ixy, sigma_Ixz, sigma_Iyz, kx, ky, kz.
id	The id value of the desired row.

Value

A list with the following named elements:

- mass Numeric mass.
- center_mass Numeric 3-vector center of mass.
- point Logical indicating point mass. The inertia of point masses is excluded from calculations.
- inertia Numeric 3x3 matrix inertia tensor. The signs of the off-diagonal elements of the inertia tensor are determined by POIconv. For example, the xy element of the inertia tensor is Ixy if POIconv is "-"; it is -Ixy if POIconv is "+".
- sigma_mass Numeric mass uncertainty.
- sigma_center_mass Numeric 3-vector center of mass uncertainties.
- sigma_inertia Numeric 3x3 matrix inertia tensor uncertainties.
- radii_gyration Numeric 3-vector radii of gyration.

Examples

```
mp_table_small_rollup <- rollup_mass_props_and_unc(mp_tree_small, mp_table_small)
radii_table_small <- add_radii_of_gyration(mp_table_small_rollup)
get_mass_props_and_unc_and_radii(radii_table_small, "C.1")
```

`get_mass_props_and_unc_and_radii_and_unc` *Get mass properties and uncertainties and radii of gyration and uncertainties*

Description

`get_mass_props_and_unc_and_radii_and_unc()` creates a mass properties and uncertainties and radii of gyration and uncertainties list from a selected row in a data frame.

Usage

```
get_mass_props_and_unc_and_radii_and_unc(df, id)
```

Arguments

`df`	A data frame with (at least) these columns: `id`, `mass`, `Cx`, `Cy`, `Cz`, `Ixx`, `Iyy`, `Izz`, `Ixy`, `Ixz`, `Iyz`, `POIconv`, `Ipoint`, `sigma_mass`, `sigma_Cx`, `sigma_Cy`, `sigma_Cz`,`sigma_Ixy`, `sigma_Ixz`, `sigma_Iyz`, `kx`, `ky`, `kz`, `sigma_kx`, `sigma_ky`, `sigma_kz`.
`id`	The `id` value of the desired row.

Value

A list with the following named elements:

- `mass` Numeric mass.
- `center_mass` Numeric 3-vector center of mass.
- `point` Logical indicating point mass. The inertia of point masses is excluded from calculations.
- `inertia` Numeric 3x3 matrix inertia tensor. The signs of the off-diagonal elements of the inertia tensor are determined by `POIconv`. For example, the xy element of the inertia tensor is `Ixy` if `POIconv` is "-"; it is `-Ixy` if `POIconv` is "+".
- `sigma_mass` Numeric mass uncertainty.
- `sigma_center_mass` Numeric 3-vector center of mass uncertainties.
- `sigma_inertia` Numeric 3x3 matrix inertia tensor uncertainties.
- `radii_gyration` Numeric 3-vector radii of gyration.
- `sigma_radii_gyration` Numeric 3-vector radii of gyration uncertainties.

Examples

```
mp_table_small_rollup <- rollup_mass_props_and_unc(mp_tree_small, mp_table_small)
radii_and_unc_table <- rollup_radii_of_gyration_unc(
                          mp_tree_small, add_radii_of_gyration(mp_table_small_rollup))
get_mass_props_and_unc_and_radii_and_unc(radii_and_unc_table, "C.1")
```

get_mass_props_unc *Get mass properties uncertainties for a row in a data frame*

Description

`get_mass_props_unc()` creates a mass properties uncertainties list from a selected row in a data frame.

Usage

```
get_mass_props_unc(df, id)
```

Arguments

`df`	A data frame with (at least) these columns: `id`, `sigma_mass`, `sigma_Cx`, `sigma_Cy`, `sigma_Cz`, `sigma_Ixx`, `sigma_Iyy`, `sigma_Izz`, `sigma_Ixy`, `sigma_Ixz`, `sigma_Iyz`.
`id`	The `id` value of the desired row.

Value

A list with the following named elements:

- `sigma_mass` Numeric mass uncertainty.
- `sigma_center_mass` Numeric 3-vector center of mass uncertainties.
- `sigma_inertia` Numeric 3x3 matrix inertia tensor uncertainties.

Examples

```
get_mass_props_unc(mp_table, "C.1.2.2.3.1.2.3")
```

mp_table *Example Mass Properties Table*

Description

Example Mass Properties Table

Usage

```
mp_table
```

Format

A data frame with columns:

id unique key

name character name

POIconv sign convention for products of inertia (one of c("+", "-"))

mass mass

Cx x-component of center of mass

Cy y-component of center of mass

Cz z-component of center of mass

Ixx I_{xx} moment of inertia

Iyy I_{yy} moment of inertia

Izz I_{zz} moment of inertia

Ixy I_{xy} product of inertia

Ixz I_{xz} product of inertia

Iyz I_{yz} product of inertia

Ipoint logical indicator to consider item a point mass, i.e., with negligible inertia

sigma_mass mass uncertainty

sigma_Cx x-component of center of mass uncertainty

sigma_Cy y-component of center of mass uncertainty

sigma_Cz z-component of center of mass uncertainty

sigma_Ixx I_{xx} moment of inertia uncertainty

sigma_Iyy I_{yy} moment of inertia uncertainty

sigma_Izz I_{zz} moment of inertia uncertainty

sigma_Ixy I_{xy} product of inertia uncertainty

sigma_Ixz I_{xz} product of inertia uncertainty

sigma_Iyz I_{yz} product of inertia uncertainty

---

mp_table_small *Example Small Mass Properties Table*

Description

Example Small Mass Properties Table

Usage

```
mp_table_small
```

Format

A data frame with columns:

id unique key
name character name
POIconv sign convention for products of inertia (one of c("+", "-"))
mass mass
Cx x-component of center of mass
Cy y-component of center of mass
Cz z-component of center of mass
Ixx I_{xx} moment of inertia
Iyy I_{yy} moment of inertia
Izz I_{zz} moment of inertia
Ixy I_{xy} product of inertia
Ixz I_{xz} product of inertia
Iyz I_{yz} product of inertia
Ipoint logical indicator to consider item a point mass, i.e., with negligible inertia
sigma_mass mass uncertainty
sigma_Cx x-component of center of mass uncertainty
sigma_Cy y-component of center of mass uncertainty
sigma_Cz z-component of center of mass uncertainty
sigma_Ixx I_{xx} moment of inertia uncertainty
sigma_Iyy I_{yy} moment of inertia uncertainty
sigma_Izz I_{zz} moment of inertia uncertainty
sigma_Ixy I_{xy} product of inertia uncertainty
sigma_Ixz I_{xz} product of inertia uncertainty
sigma_Iyz I_{yz} product of inertia uncertainty

---

mp_tree *Example Mass Properties Tree*

Description

Example Mass Properties Tree

Usage

```
mp_tree
```

Format

An 'igraph' tree whose vertices are named as the values of the `id` column of a mass properties table and whose directed edges point from child id to parent id.

mp_tree_small *Example Small Mass Properties Tree*

Description

Example Small Mass Properties Tree

Usage

```
mp_tree_small
```

Format

An 'igraph' tree whose vertices are named as the values of the `id` column of a mass properties table and whose directed edges point from child id to parent id.

rollup_mass_props *Roll up mass properties*

Description

'rollup_mass_props()' rolls up mass properties in a data frame such that the mass properties of each non-leaf vertex element is the aggregation of those of its child elements.

Usage

```
rollup_mass_props(tree, df, validate_df = validate_mass_props_table, ...)
```

Arguments

`tree`	An 'igraph' tree whose vertices are named as the values of the `id` column of `df` and whose directed edges point from child id to parent id.
`df`	A data frame with (at least) these columns: `id`, `mass`, `Cx`, `Cy`, `Cz`, `Ixx`, `Iyy`, `Izz`, `Ixy`, `Ixz`, `Iyz`, `POIconv`, `Ipoint`.
`validate_df`	A validator for the tree and table, default `validate_mass_props_table()`
`...`	Other parameters passed to `rollupTree::rollup()`

Value

The updated data frame

Examples

```
rollup_mass_props(mp_tree_small, mp_table_small)
```

`rollup_mass_props_and_unc` *Roll up mass properties and uncertainties*

Description

'rollup_mass_props_and_unc()' rolls up mass properties in a data frame with (at least) these columns: `id`, `mass`, `Cx`, `Cy`, `Cz`, `Ixx`, `Iyy`, `Izz`, `Ixy`, `Ixz`, `Iyz`, `POIconv`, `Ipoint`, `sigma_mass`, `sigma_Cx`, `sigma_Cy`, `sigma_Cz`, `sigma_Ixx`, `sigma_Iyy`, `sigma_Izz`, `sigma_Ixy`, `sigma_Ixz`, `sigma_Iyz`.

The difference between `rollup_mass_props_unc()` and `rollup_mass_props_and_unc()` is that `rollup_mass_props_unc()` expects the mass properties in its input to have been rolled up, whereas `rollup_mass_props_and_unc()` performs the mass properties rollup itself.

Usage

```
rollup_mass_props_and_unc(
  tree,
  df,
  validate_df = validate_mass_props_and_unc_table,
  ...
)
```

Arguments

`tree`	An 'igraph' tree whose vertices are named as the values of the `id` column of `df` and whose directed edges point from child id to parent id.
`df`	A data frame with (at least) these columns: `id`, `mass`, `Cx`, `Cy`, `Cz`, `Ixx`, `Iyy`, `Izz`, `Ixy`, `Ixz`, `Iyz`, `POIconv`, `Ipoint`.
`validate_df`	A validator for the tree and table, default `validate_mass_props_and_unc_table()`
`...`	Other parameters passed to `rollupTree::rollup()`

Value

The updated data frame

Examples

```
rollup_mass_props_and_unc(mp_tree_small, mp_table_small)
```

rollup_mass_props_and_unc_fast

Roll up mass properties and uncertainties without input validation

Description

`rollup_mass_props_and_unc_fast()` performs the same operation as `rollup_mass_props_and_unc()` but omits input validation. It is somewhat faster than `rollup_mass_props_and_unc()` but should be used with caution and only under circumstances in which the caller assumes responsibility for validity of input. Its behavior when passed ill-formed input is unspecified.

Usage

```
rollup_mass_props_and_unc_fast(tree, df)
```

Arguments

`tree`	An 'igraph' tree whose vertices are named as the values of the `id` column of `df` and whose directed edges point from child id to parent id.
`df`	A data frame with (at least) these columns: `id`, `mass`, `Cx`, `Cy`, `Cz`, `Ixx`, `Iyy`, `Izz`, `Ixy`, `Ixz`, `Iyz`, `POIconv`, `Ipoint`.

Value

The updated data frame

Examples

```
rollup_mass_props_and_unc_fast(sawe_tree, sawe_table)
```

rollup_mass_props_fast

Roll up mass properties without input validation

Description

`rollup_mass_props_fast()` performs the same operation as `rollup_mass_props()` but omits input validation. It is somewhat faster than `rollup_mass_props()` but should be used with caution and only under circumstances in which the caller assumes responsibility for validity of input. Its behavior when passed ill-formed input is unspecified.

Usage

```
rollup_mass_props_fast(tree, df)
```

Arguments

tree	An 'igraph' tree whose vertices are named as the values of the id column of df and whose directed edges point from child id to parent id.
df	A data frame with (at least) these columns: id, mass, Cx, Cy, Cz, Ixx, Iyy, Izz, Ixy, Ixz, Iyz, POIconv, Ipoint.

Value

The updated data frame

Examples

```
rollup_mass_props_fast(test_tree, test_table)
```

---

rollup_mass_props_unc *Roll up mass properties uncertainties*

Description

rollup_mass_props_unc() rolls up mass properties uncertainties in a data frame such that the uncertainties of each non-leaf vertex element is the aggregation of the mass properties and uncertainties of its child elements.

The difference between rollup_mass_props_unc() and rollup_mass_props_and_unc() is that rollup_mass_props_unc() expects the mass properties in its input to have been rolled up, whereas rollup_mass_props_and_unc() performs the mass properties rollup itself.

Usage

```
rollup_mass_props_unc(
  tree,
  df,
  validate_df = validate_mass_props_and_unc_table,
  ...
)
```

Arguments

tree	An 'igraph' tree whose vertices are named as the values of the id column of df and whose directed edges point from child id to parent id.
df	A data frame with (at least) these columns: id, mass, Cx, Cy, Cz, Ixx, Iyy, Izz, Ixy, Ixz, Iyz, POIconv, Ipoint.
validate_df	A validator for the tree and table, default validate_mass_props_and_unc_table()
...	Other parameters passed to rollupTree::rollup()

Value

The updated data frame

Examples

```
mp_ru <- rollup_mass_props(mp_tree_small, mp_table_small)
rollup_mass_props_unc(mp_tree_small, mp_ru)
```

---

rollup_mass_props_unc_fast

Roll up mass properties uncertainties without input validation

---

Description

`rollup_mass_props_unc_fast()` performs the same operation as `rollup_mass_props_unc()` but omits input validation. It is somewhat faster than `rollup_mass_props_unc()` but should be used with caution and only under circumstances in which the caller assumes responsibility for validity of input. Its behavior when passed ill-formed input is unspecified.

Usage

```
rollup_mass_props_unc_fast(tree, df)
```

Arguments

`tree`	An 'igraph' tree whose vertices are named as the values of the `id` column of `df` and whose directed edges point from child id to parent id.
`df`	A data frame with (at least) these columns: `id`, `mass`, `Cx`, `Cy`, `Cz`, `Ixx`, `Iyy`, `Izz`, `Ixy`, `Ixz`, `Iyz`, `POIconv`, `Ipoint`.

Value

The updated data frame

Examples

```
rollup_mass_props_unc_fast(sawe_tree, sawe_table)
```

rollup_radii_of_gyration_unc *Roll up radii of gyration uncertainties*

Description

rollup_radii_of_gyration_unc() adds calculated radii of gyration uncertainties to a data frame of rolled-up mass properties and uncertainties.

Radii of gyration uncertainties are calculated directly from moments of inertia and mass and their uncertainties; they are not recursively-defined. Radii of gyration uncertainties for composite elements depend on uncertainties of their component elements.

Usage

```
rollup_radii_of_gyration_unc(tree, df)
```

Arguments

tree	An 'igraph' tree whose vertices are named as the values of the id column of df and whose directed edges point from child id to parent id.
df	A data frame with (at least) these columns: id, mass, Cx, Cy, Cz, Ixx, Iyy, Izz, Ixy, Ixz, Iyz, POIconv, Ipoint.

Value

A data frame with the same columns as df, plus radii of gyration in columns sigma_kx, sigma_ky, and sigma_kz.‘

Examples

```
sawe_table_rollup <- rollup_mass_props(sawe_tree, sawe_table)
rollup_radii_of_gyration_unc(sawe_tree, add_radii_of_gyration(sawe_table_rollup))
```

sawe_table *Mass Properties and Uncertainties Table from SAWE Paper No. 3360*

Description

Mass Properties and Uncertainties Table from SAWE Paper No. 3360

Usage

```
sawe_table
```

Format

A data frame with columns:

id unique key

mass mass

Cx x component of center of mass

Cy y component of center of mass

Cz z component of center of mass

Ixx Ixx moment of inertia

Iyy Iyy moment of inertia

Izz Izz moment of inertia

Ixy Ixy product of inertia

Ixz Ixz product of inertia

Iyz Iyz product of inertia

sigma_mass mass uncertainty

sigma_Cx x component of center of mass uncertainty

sigma_Cy y component of center of mass uncertainty

sigma_Cz z component of center of mass uncertainty

sigma_Ixx Ixx moment of inertia uncertainty

sigma_Iyy Iyy moment of inertia uncertainty

sigma_Izz Izz moment of inertia uncertainty

sigma_Ixy Ixy product of inertia uncertainty

sigma_Ixz Ixz product of inertia uncertainty

sigma_Iyz Iyz product of inertia uncertainty

Ipoint logical indicator to consider item a point mass

POIconv sign convention for products of inertia (one of c("+", "-"))

Source

Zimmerman, Robert L., and John H. Nakai. 2005. “Are You Sure? Uncertainty in Mass Properties Engineering.” In 64th Annual International Conference on Mass Properties Engineering, 123–60. Society of Allied Weight Engineers.

Note: the results for combined mass properties and uncertainties in the published example are accurate only within approximately 0.2%.

sawe_tree *Mass Properties and Uncertainties Tree from SAWE Paper No. 3360*

Description

Mass Properties and Uncertainties Tree from SAWE Paper No. 3360

Usage

```
sawe_tree
```

Format

An igraph tree with edges from child id to parent id.

Source

Zimmerman, Robert L., and John H. Nakai. 2005. "Are You Sure? Uncertainty in Mass Properties Engineering." In 64th Annual International Conference on Mass Properties Engineering, 123–60. Society of Allied Weight Engineers.

set_mass_props *Set mass properties for a row in a data frame*

Description

`set_mass_props()` sets mass properties for a specified row in a data frame.

Usage

```
set_mass_props(df, id, mp)
```

Arguments

`df`	A data frame with an `id` column.
`id`	The `id` value of the desired row.
`mp`	A list with the following named elements: • `mass` Numeric mass. • `center_mass` Numeric 3-vector center of mass. • `point` Logical indicating point mass. The inertia of point masses is excluded from calculations. • `poi_conv` Enumeration c("+", "-") indicating sign convention for products of inertia. • `inertia` Numeric 3x3 matrix inertia tensor. The signs of the products of inertia are determined by `POIconv`. For example, `Ixy` is the xy element of the inertia tensor if `POIconv` is "-"; it is the additive inverse of that value if `POIconv` is "+".

Value

The updated data frame with columns `id`, `mass`, `Cx`, `Cy`, `Cz`, `Ixx`, `Iyy`, `Izz`, `Ixy`, `Ixz`, `Iyz`, `POIconv`, `Ipoint`.

Examples

```
df <- data.frame(id = c("C.1.2.2.3.1.2.3", "C.1.2.2.3.2.1.1"))
mp <- get_mass_props(mp_table, "C.1.2.2.3.2.1.1")
mp$poi_conv = "+"
set_mass_props(df, "C.1.2.2.3.2.1.1", mp)
```

`set_mass_props_and_unc` *Set mass properties and uncertainties for a row in a data frame*

Description

`set_mass_props_and_unc()` is a convenience wrapper that combines the results of `set_mass_props()` and `set_mass_props_unc()`.

Usage

```
set_mass_props_and_unc(df, id, mpu)
```

Arguments

`df`	A data frame with an `id` column.
`id`	The `id` value of the desired row.
`mpu`	A list containing the following named elements:

- `mass` Numeric mass.
- `center_mass` Numeric 3-vector center of mass.
- `point` Logical indicating point mass. The inertia of point masses is excluded from calculations.
- `poi_conv` Enumeration c("+", "-") indicating sign convention for products of inertia.
- `inertia` Numeric 3x3 matrix inertia tensor. The signs of the products of inertia are determined by `POIconv`. For example, `Ixy` is the xy element of the inertia tensor if `POIconv` is "-"; it is the additive inverse of that value if `POIconv` is "+".
- `sigma_mass` Numeric mass uncertainty.
- `sigma_center_mass` Numeric 3-vector center of mass uncertainties.
- `sigma_inertia` Numeric 3x3 matrix inertia tensor uncertainties.

Value

The updated data frame.

Examples

```
mpu <- c(get_mass_props_and_unc(sawe_table, "Widget"), poi_conv = "+")
set_mass_props_and_unc(sawe_table, "Combined", mpu)
```

`set_mass_props_unc` *Set mass properties uncertainties for a row in a data frame*

Description

`set_mass_props_unc()` sets mass properties uncertainties for a selected row in a data frame with an `id` column.

Usage

```
set_mass_props_unc(df, id, mpu)
```

Arguments

`df`	A data frame with an `id` column.
`id`	The `id` value of the desired row.
`mpu`	A list with the following named elements: • `sigma_mass` Numeric mass uncertainty. • `sigma_center_mass` Numeric 3-vector center of mass uncertainties. • `sigma_inertia` Numeric 3x3 matrix inertia tensor uncertainties.

Value

The updated data frame.

Examples

```
set_mass_props_unc(sawe_table, "Combined", get_mass_props_unc(sawe_table, "Widget"))
```

set_poi_conv_from_target

Set POI convention for mass properties list to match a target item

Description

`set_poi_conv_from_target()` sets the products of inertia sign convention for a mass properties list to that of a target item in a mass properties table. This convention determines how products of inertia are saved to the data frame.

The signature of `set_poi_conv_from_target()` is such that it can be passed as an `override` argument to `update_mass_props()` and `update_mass_props_and_unc()`, thus ensuring that all calculated POI values follow the negative integral convention of the target item to which they are written.

Usage

```
set_poi_conv_from_target(df, target, mp)
```

Arguments

`df`	A data frame with columns `id` and `POIconv`.
`target`	The `id` value of the target row.
`mp`	A mass properties list.

Value

The mass properties list with the named element `poi_conv` set to the `POIconv` column of the target row in the data frame.

Examples

```
set_poi_conv_from_target(mp_table, "C.1.2.2.3.2.1", get_mass_props(mp_table, "C.1.2.2.3.2.1.1"))
```

set_poi_conv_minus

Set POI sign convention for mass properties list to "-"

Description

`set_poi_conv_minus()` sets the products of inertia sign convention for a mass properties list to "-". This convention determines how products of inertia are saved to a data set.

The signature of `set_poi_conv_minus()` is such that it can be passed as an `override` argument to `update_mass_props()` and `update_mass_props_and_unc()`, thus ensuring that calculated POI values are saved using the negative integral convention.

Usage

```
set_poi_conv_minus(ds, target, mp)
```

Arguments

ds	Ignored.
target	Ignored.
mp	A mass properties list.

Value

The mass properties list with the named element poi_conv set to "-"

Examples

```
set_poi_conv_minus(NULL, NULL, get_mass_props(mp_table, "C.1.2.2.3.2.1.1"))
```

---

set_poi_conv_plus *Set POI sign convention for mass properties list to "+"*

Description

set_poi_conv_plus() sets the products of inertia sign convention for a mass properties list to "+". This convention determines how products of inertia are saved to a data set.

The signature of set_poi_conv_plus() is such that it can be passed as an override argument to update_mass_props() and update_mass_props_and_unc(), thus ensuring that calculated POI values are saved using the positive integral convention.

Usage

```
set_poi_conv_plus(ds, target, mp)
```

Arguments

ds	Ignored.
target	Ignored.
mp	A mass properties list.

Value

The input mass properties list with the named element poi_conv set to "+"

Examples

```
set_poi_conv_plus(NULL, NULL, get_mass_props(mp_table, "C.1.2.2.3.2.1.1"))
```

set_radii_of_gyration *Set radii of gyration for a row in a data frame*

Description

`set_radii_of_gyration()` sets radii of gyration for a selected row in a data frame with an `id` column.

Usage

```
set_radii_of_gyration(df, id, rg)
```

Arguments

`df`	A data frame with an `id` column.
`id`	The `id` value of the desired row.
`rg`	A list with the following named elements: • `radii_gyration` Numeric 3x3 matrix radii of gyration.

Value

The updated data frame.

Examples

```
rgl <- list(radii_gyration = c(x = 1, y = 2, z = 3))
set_radii_of_gyration(mp_table, "C.1", rgl)[1:5, ]
```

set_radii_of_gyration_unc *Set radii of gyration uncertainties for a row in a data frame*

Description

`set_radii_of_gyration_unc()` sets radii of gyration uncertainties for a selected row in a data frame with an `id` column.

Usage

```
set_radii_of_gyration_unc(df, id, rgu)
```

Arguments

df	A data frame with an id column.
id	The id value of the desired row.
rgu	A list with the following named elements: • sigma_radii_gyration Numeric 3x3 matrix radii of gyration uncertainties.

Value

The updated data frame.

Examples

```
rgul <- list(sigma_radii_gyration = c(x = 1, y = 2, z = 3))
set_radii_of_gyration_unc(mp_table, "C.1", rgul)[1:5, ]
```

---

test_table *Example Mass Properties Table*

Description

Example Mass Properties Table

Usage

```
test_table
```

Format

A data frame with columns:

id unique key
parent parent key
mass mass
Cx x component of center of mass
Cy y component of center of mass
Cz z component of center of mass
Ixx Ixx moment of inertia
Iyy Iyy moment of inertia
Izz Izz moment of inertia
Ixy Ixy product of inertia
Ixz Ixz product of inertia
Iyz Iyz product of inertia
POIconv sign convention for products of inertia (one of c("+", "-"))
Ipoint logical indicator to consider item a point mass

test_tree *Example Mass Properties Tree*

Description

Example Mass Properties Tree

Usage

```
test_tree
```

Format

An igraph tree with edges from child id to parent id.

test_unc_table *Example Mass Properties and Uncertainties Table*

Description

Example Mass Properties and Uncertainties Table

Usage

```
test_unc_table
```

Format

A data frame with columns:

id unique key

parent parent key

mass mass

Cx x component of center of mass

Cy y component of center of mass

Cz z component of center of mass

Ixx Ixx moment of inertia

Iyy Iyy moment of inertia

Izz Izz moment of inertia

Ixy Ixy product of inertia

Ixz Ixz product of inertia

Iyz Iyz product of inertia

POIconv sign convention for products of inertia (one of c("+", "-"))

Ipoint logical indicator to consider item a point mass

sigma_mass mass uncertainty

sigma_Cx x component of center of mass uncertainty

sigma_Cy y component of center of mass uncertainty

sigma_Cz z component of center of mass uncertainty

sigma_Ixx Ixx moment of inertia uncertainty

sigma_Iyy Iyy moment of inertia uncertainty

sigma_Izz Izz moment of inertia uncertainty

sigma_Ixy Ixy product of inertia uncertainty

sigma_Ixz Ixz product of inertia uncertainty

sigma_Iyz Iyz product of inertia uncertainty

`update_mass_props` *Update mass properties*

Description

`update_mass_props()` updates mass properties for a specified target row from specified source rows in a data frame.

Usage

```
update_mass_props(df, target, sources, override = set_poi_conv_from_target)
```

Arguments

`df`	A data frame with (at least) these columns: `id`, `mass`, `Cx`, `Cy`, `Cz`, `Ixx`, `Iyy`, `Izz`, `Ixy`, `Ixz`, `Iyz`, `POIconv`, `Ipoint`.
`target`	The `id` value of the target row.
`sources`	List of `id` values of the of the source rows.
`override`	An override function, called as override(df, target, value). The default override sets the POI sign convention of a computed aggregate to the `POIconv` column of the target row in the data frame.

Value

The updated data frame.

Examples

```
leaves <- names(igraph::neighbors(test_tree, "A.3", mode = "in"))
update_mass_props(test_table, "A.3", leaves)
```

update_mass_props_and_unc *Update mass properties and uncertainties*

Description

update_mass_props_and_unc() updates mass properties and uncertainties for a specified target row from specified source rows in a data frame.

Usage

```
update_mass_props_and_unc(
  df,
  target,
  sources,
  override = set_poi_conv_from_target
)
```

Arguments

df	A data frame with (at least) these columns: id, mass, Cx, Cy, Cz, Ixx, Iyy, Izz, Ixy, Ixz, Iyz, POIconv, Ipoint, sigma_mass, sigma_Cx, sigma_Cy, sigma_Cz, sigma_Ixx, sigma_Iyy, sigma_Izz, sigma_Ixy, sigma_Ixz, sigma_Iyz.
target	The id value of the target row.
sources	List of id values of the of the source rows.
override	An override function, called as override(df, target, value). The default override sets the POI sign convention of a computed aggregate to the POIconv column of the target row in the data frame.

Value

The updated data frame.

Examples

```
leaves <- list("Widget", "2nd Part")
update_mass_props_and_unc(sawe_table, "Combined", leaves)
```

update_mass_props_unc *Update mass properties uncertainties*

Description

update_mass_props_unc() updates mass properties uncertainties for a specified target row from specified source rows in a data frame with (at least) these columns: id, sigma_mass, sigma_Cx, sigma_Cy, sigma_Cz, sigma_Ixx, sigma_Iyy, sigma_Izz, sigma_Ixy, sigma_Ixz, sigma_Iyz.

Usage

```
update_mass_props_unc(df, target, sources, override = set_poi_conv_from_target)
```

Arguments

df	A data frame with (at least) these columns: id, mass, Cx, Cy, Cz, Ixx, Iyy, Izz, Ixy, Ixz, Iyz, POIconv, Ipoint, sigma_mass, sigma_Cx, sigma_Cy, sigma_Cz, sigma_Ixx, sigma_Iyy, sigma_Izz, sigma_Ixy, sigma_Ixz, sigma_Iyz.
target	The id value of the target row.
sources	List of id values of the of the source rows.
override	An override function, called as override(df, target, value). The default override sets the POI sign convention of a computed aggregate to the POIconv column of the target row in the data frame.

Value

The updated data frame.

Examples

```
leaves <- names(igraph::neighbors(sawe_tree, "Combined", mode = "in"))
update_mass_props_unc(sawe_table, "Combined", leaves)
```

validate_mass_props *Validate mass properties*

Description

validate_mass_props() ensures that a mass properties list satisfies the following constraints:

- mass is non-missing and positive
- center_mass is a 3-vector of non-missing numeric values
- point is TRUE or FALSE

- if point is FALSE:
  - inertia is positive definite
  - eigenvalues $\{\lambda_1, \lambda_2, \lambda_3\}$ of inertia satisfy the triangle inequalities:
    * $\lambda_1 < \lambda_2 + \lambda_3$
    * $\lambda_2 < \lambda_1 + \lambda_3$
    * $\lambda_3 < \lambda_1 + \lambda_2$

Usage

```
validate_mass_props(mp)
```

Arguments

mp	Mass properties list containing the following named elements • mass Numeric mass. • center_mass Numeric 3-vector center of mass. • point Logical indicating point mass. The inertia of point masses is excluded from calculations. • inertia Numeric 3x3 matrix inertia tensor.

Value

TRUE if valid, stops otherwise

Examples

```
mp <- get_mass_props(test_table, "C.1")
validate_mass_props(mp)
```

---

validate_mass_props_and_unc

Validate mass properties and uncertainties

Description

validate_mass_props_and_unc() is a convenience wrapper that calculates the logical conjunction of validate_mass_props() and validate_mass_props_unc().

Usage

```
validate_mass_props_and_unc(mpu)
```

Arguments

mpu	Mass properties and uncertainties list containing the following named elements • mass mass (numeric) • center_mass center of mass (3-dimensional numeric) • inertia Inertia tensor (3x3 numeric matrix) • point Logical indicating point mass, i.e., negligible inertia • sigma_mass mass uncertainty • sigma_center_mass center of mass uncertainty (3-dimensional numeric) • sigma_inertia Inertia tensor uncertainty (3x3 numeric matrix)

Value

TRUE if valid, stops otherwise

Examples

```
mpu <- get_mass_props_and_unc(sawe_table, "Widget")
validate_mass_props_and_unc(mpu)
```

---

validate_mass_props_and_unc_table

Validate a mass properties and uncertainties table

Description

validate_mass_props_and_unc() calls validate_mass_props_table() and further applies the checks of validate_mass_props_and_unc() to every row of the data frame corresponding to a leaf vertex of the tree.

Usage

```
validate_mass_props_and_unc_table(tree, df)
```

Arguments

tree	An 'igraph' tree whose vertices are named as the values of the id column of df and whose directed edges point from child id to parent id.
df	A data frame with (at least) these columns: id, mass, Cx, Cy, Cz, Ixx, Iyy, Izz, Ixy, Ixz, Iyz, POIconv, Ipoint, sigma_mass, sigma_Cx, sigma_Cy, sigma_Cz, sigma_Ixx, sigma_Iyy, sigma_Izz, sigma_Ixy, sigma_Ixz, sigma_Iyz.

Value

TRUE if valid, stops with an error otherwise

Examples

```
validate_mass_props_and_unc_table(mp_tree_small, mp_table_small)
```

`validate_mass_props_table`
Validate a mass properties table

Description

`validate_mass_props_table()` checks that the names of vertices in a tree and the `id` values of a data frame are identical. It further applies the checks of `validate_mass_props()` to every row of the data frame corresponding to a leaf vertex of the tree.

`validate_mass_props_table()` ensures that the `id` column of the table and the vertices of the tree contain the same identifiers, and that the mass properties of every leaf element of the table are valid.

Usage

```
validate_mass_props_table(tree, df)
```

Arguments

`tree`	An 'igraph' tree whose vertices are named as the values of the `id` column of `df` and whose directed edges point from child id to parent id.
`df`	A data frame with (at least) these columns: `id`, `mass`, `Cx`, `Cy`, `Cz`, `Ixx`, `Iyy`, `Izz`, `Ixy`, `Ixz`, `Iyz`, `POIconv`, `Ipoint`.

Value

TRUE if valid, stops with an error otherwise

Examples

```
validate_mass_props_table(mp_tree_small, mp_table_small)
```

validate_mass_props_unc *Validate mass properties uncertainties*

Description

validate_mass_props_unc() ensures that a mass properties and uncertainties list satisfies the following constraints:

- sigma_mass is non-missing and non-negative
- sigma_center_mass is a 3-vector of non-missing non-negative values
- if point is FALSE, the sigma_inertia contains no missing or negative values

Usage

```
validate_mass_props_unc(mp)
```

Arguments

mp	Mass properties and uncertainties list containing the following named elements • point Logical indicating point mass, i.e., negligible inertia • sigma_mass mass uncertainty • sigma_center_mass center of mass uncertainty (3-dimensional numeric) • sigma_inertia Inertia tensor uncertainty (3x3 numeric matrix)

Value

TRUE if valid, stops otherwise

Examples

```
mp <- get_mass_props_and_unc(sawe_table, "Widget")
validate_mass_props_unc(mp)
```

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