Package 'droptest'

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Title Simulates LOX Drop Testing

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Author Chad Ross [aut, cre]

Maintainer Chad Ross <chad.ross@gmail.com>

Description Generates simulated data representing the LOX drop testing process (also known as impact testing). A simulated process allows for accelerated study of test behavior. Functions are provided to simulate trials, test series, and groups of test series. Functions for creating plots specific to this process are also included. Test attributes and criteria can be set arbitrarily. This work is not endorsed by or affiliated with NASA. See ``ASTM G86-17, Standard Test Method for Determining Ignition Sensitivity of Materials to Mechanical Impact in Ambient Liquid Oxygen and Pressurized Liquid and Gaseous Oxygen Environments'' <doi:10.1520/G0086-17>.

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Contents

`D7905` *Historical Data*

Description

Historical drop test data where testers did not immediately terminate testing. Useful for comparing modern test methods and simulation output.

Usage

```
data("D7905")
```

Format

A data frame with 10 observations on the following 2 variables.

`P` a numeric vector

`SD` a numeric vector

Source

NASA Technical Note NASA-TN D-7905. (1970) Written by J. B. Gayle. https://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/19750014413.pdf

Examples

```
data(D7905)
```

`dgroups` *Generates groups of simulated test series.*

Description

`dgroups` returns a collection test series organized into groups. Each batch of test series are identified with a group number. Test parameters will be uniform within each group.

Usage

```
dgroups(num.groups = NULL, probs = NULL, ...)
```

Arguments

num.groups	Integer. Specifies how many groups of drop tests to simulate.
probs	Vector. Specifies probabilities of q used for each group. Vector length must equal value of num.groups.
...	Passes values to dseries.

Value

Data table of groups where each group consists of multiple drop tests. Consisting of the following elements:

- **F_CRITERIA** The failure criteria specified.
- **REACT** The total number of simulated reactions (failures).
- **NON_REACT** The total number of simulated non-reactions (successes).
- **TRIALS** The number of simulated trials performed until failure condition met.
- **MAX_TRIALS** The maximum number of simulated trials to perform as specified.
- **PCT_REACT** The percent of simulated trials that yielded a reaction (failure).
- **Q** The probability of failure (reaction) as specified.
- **P** The probability of success (non-reaction).
- **RESULT** Whether the simulated test series as a whole failed or passed based on the failure criteria specified.
- **GROUP** Denotes the group of simulated test series.

Author(s)

Chad Ross <chad.ross@gmail.com>

See Also

dseries dtrials droptest

Examples

```
dgroups(num.groups = 2, probs = c(0.01, 0.2), num.series = 5)
dgroups(num.groups = 2, probs = c(0.01, 0.2), num.series = 5, max.trials = 60)
dgroups(num.groups = 2, probs = c(0.01, 0.2), num.series = 5, fail.criteria = 2)
dgroups(num.groups = 5, probs = seq(0.01, 0.05, by = 0.01), num.series = 2)
```

`droptest` *droptest: Simulates LOX drop testing.*

Description

Generates simulated data representing the LOX drop testing process (also known as impact testing). Drop testing is expensive, time consuming, and notoriously difficult to analyze. A simulated process allows for accelerated study of test behavior.

Details

Functions are provided to simulate trials, test series, and groups of test series. Functions for creating plots specific to this process are also included. Test attributes and criteria can be set arbitrarily. This work is not endorsed by or affiliated with NASA.

Drop testing – sometimes called impact testing – is used to evaluate if a material will interact with liquid oxygen (LOX). The material is exposed to the LOX and an impactor is dropped onto the sample. Each drop is a bernoulli trial where a reaction is a failure and a non-reaction is a success. The specified number of trials – until failure – completes one test.

While fundamentally a binomial process, drop testing – performed by the military and NASA – yields results that are difficult to analyze. Numerous tech briefs and standards have attempted to address the problem (see below for more information). Testing stops immediately once the failure condition is reached. If the failure condition occurs on drop one or two – depending on the failure criteria – then the test returns only one or two result values. Alternatively, if a material passes, or if the failure condition occurs on the last trial, then the test returns as many result values as trials.

Simulation can be used to examine the behavior of this test procedure.

Inspired by NASA Technical Note "Computer Simulation of Threshold Sensitivity Determinations" (NASA-TN-D-7663). Gayle (1974). https://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/19750004618.pdf

Definitions

- **Trial:** A simulated bernoulli trial that represents one drop of the impactor onto a material sample. Hence a trial is also referred to as a drop. Where q is the probability of failure. A reaction is recorded as a failure. Where p is the probability of success. A non-reaction is recorded as a success. Where $p = 1 - q$. See https://en.wikipedia.org/wiki/Bernoulli_trial
- **Drop Test:** A collection of simulated trials (drops) generated with equal parameters (q, number of trials, failure criteria, etc). When the failure criteria is reached the test is immediately terminated and no more trials are completed. The sooner a test reaches the failure criteria the less total trials for that particular test. A test with no failures will always contain the maximum number of trials as defined in the function parameters.
- **Test Series:** A collection of simulated drop tests. A group number can be attached to the drop tests in a test series (optional).
- **Groups:** A collection of multiple simulated test series. Each batch of test series are identified with a group number. Within each group test parameters will be identical.
- **Trial Deviation:** The average distance from q for the total percent of reactions (failures).

Author(s)

Chad Ross <chad.ross@gmail.com>

References

Pass/Fail criteria and number of observations required have been defined in the following standards:

- NASA-STD-6001B https://spaceflightsystems.grc.nasa.gov/SpaceDOC_II/Standards/documents/NASA-STD-6001B-1.pdf
- ASTM D2512 https://www.astm.org/Standards/D2512.htm
- ASTM G86-17 https://www.astm.org/Standards/G86.htm

Note: This package is not constrained by any standard. Arbitrary test criteria and observations can be specified for maximum flexibility.

For more information on drop testing:

- "An Instrument for Determination of Impact Sensitivity of Materials in Contact with Liquid Oxygen" (AB6002-EB). Lucas (1960). https://www.astm.org/DIGITAL_LIBRARY/STP/MMR/PAGES/AB6002-EB.htm
- "Reproducibility of Liquid Oxygen Impact Test Results" (NASA-TN-D-7905). Gayle (1970). https://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/19750014413.pdf
- "Lox/Gox Mechanical Impact Tester Assessment" (TM-74106). Bransford, Bryan, Frye, Stohler (1980). https://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/19800006920.pdf

Note: This work is not endorsed by or affiliated with NASA. Released under MIT license.

See Also

dtrials dseries dgroups trialdev gayleplot ratioplot D7905 PREGENTD

`dseries` *Completes multiple series of simulated drop tests.*

Description

`dseries` returns a series of simulated drop tests. Where each test consists of trials (drops).

Usage

```
dseries(num.series, tag.group = FALSE, group = 0, ...)
```

Arguments

num.series	Integer. Specifies how many series of drop tests to simulate.
tag.group	Logical. If TRUE, group number is included in output data table. Default is FALSE.
group	Integer. Assigns a group number to each simulated drop test within the same series. Only if tag.group is TRUE. Default is 0.
...	Passes q, max.trials, fail.criteria, and fail.criteria to dtrials. All are optional except q.

Value

Data table of multiple simulated drop tests. Each row of the data.table represents one simulated drop test. Containing the following elements:

- **F_CRITERIA** The failure criteria specified.
- **REACT** The total number of simulated reactions (failures).
- **NON_REACT** The total number of simulated non-reactions (successes).
- **TRIALS** The number of simulated trials performed until failure condition met.
- **MAX_TRIALS** The maximum number of simulated trials to perform as specified.
- **PCT_REACT** The the percent of simulated trials that yielded a reaction (failure).
- **Q** The probability of failure (reaction) as specified.
- **P** The probability of success (non-reaction).
- **RESULT** Whether the simulated test series as a whole failed or passed based on the failure criteria specified.

Author(s)

Chad Ross <chad.ross@gmail.com>

See Also

dtrials droptest

Examples

```
dseries(num.series = 5, q = 0.05)
dseries(num.series = 5, q = 0.05, max.trials = 60)
dseries(num.series = 5, q = 0.05, max.trials = 60, fail.criteria = 2)
```

`dtrials` *Completes a simulated drop test.*

Description

`dtrials` returns simulated bernoulli trials (drops) that compose one drop test.

Usage

```
dtrials(q, max.trials = 20, fail.criteria = 1,
  data.structure = "data.table")
```

Arguments

`q`	Integer. Specifies the probability that a reaction occurs. A reaction is interpreted as a failure therfore q is the probability of failure for the bernoulli trials. Probability of success would be $p = 1 - q$. See https://en.wikipedia.org/wiki/Bernoulli_trial
`max.trials`	Integer. The maximum number of bernoulli trials to perform. where each trial represents one drop of the impactor onto a sample. Trials performed will always be less than or equal to `max.trials`. Default is 20.
`fail.criteria`	Integer. Specifies number of reactions (failures) that can occur before an entire test is considered a failure. Must be less than or equal to `max.trials`. Default is 1.
`data.structure`	Instructs function to return result as a data.table or list. Default is data.table. **Note:** Other functions in this package only work with data.tables. List is an option strictly for future flexibility.

Value

A data table or list. Containing the following elements:

- **F_CRITERIA** The failure criteria specified.
- **REACT** The total number of simulated reactions (failures).
- **NON_REACT** The total number of simulated non-reactions (successes).
- **TRIALS** The number of simulated trials performed until the failure condition was met.
- **MAX_TRIALS** The maximum number of simulated trials specified.
- **PCT_REACT** The percent of simulated trials that yielded a reaction (failure).
- **Q** The probability of failure (reaction) as specified.
- **P** The probability of success (non-reaction).
- **RESULT** Whether the simulated test series as a whole failed or passed based on the failure criteria specified.

Author(s)

Chad Ross <chad.ross@gmail.com>

See Also

droptest

Examples

```
dtrials(0.05)
dtrials(0.05, max.trials = 60)
dtrials(0.05, fail.criteria = 2)
dtrials(0.05, max.trials = 60, fail.criteria = 2)
dtrials(0.05, data.structure = "list")
```

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gayleplot *Plot of std deviation percent, vs probability of reaction percent.*

Description

gayleplot Creates plot similar to the one seen in NASA Technical Note **NASA-TN-D-7905**. (1970) Written by J. B. Gayle. The namesake of this function. https://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/19750014413.pdf

Usage

```
gayleplot(simq = seq(0.01, 0.5, by = 0.05), ...)
```

Arguments

simq	Vector. Probabilities of failure (q) to use for simulated trials. Defaults to range of q = 0.01 to q = 0.5 in 0.05 steps.
...	Passes values to dgroups.

Details

Plots historical standard deviations (mid-test – against binomial process. Also plots standard deviations (from simulation using modern procedure.

Shows how historical data follows a binomial process, but simulated data produced using modern procedure does not.

Value

none

Author(s)

Chad Ross <chad.ross@gmail.com>

See Also

dgroups dseries dtrials droptest

Examples

```
# recommended to use num.series value greater than or equal to 1000.
gayleplot(num.series = 100)
gayleplot(num.series = 100, simq = seq(0.01, 0.05, by = 0.01))
```

PREGENTD *Trial Deviation for Pre-Generated Data*

Description

Output of `trialdev()` on a large pre-generated dataset.

Original dataset represents fifty levels of q where each level has 100,000 simulated test series. For a total of 5,000,000 simulated tests.

Usage

```
data("PREGENTD")
```

Format

A data frame with 50 observations of 4 variables.

See Also

dseries dgroups

Examples

```
data(PREGENTD)
```

`ratioplot` *Creates plot of pass/fail ratio for repeated test series.*

Description

`ratioplot` Creates plot of pass/fail ratio for repeated test series. By simulated probability of reaction.

Usage

```
ratioplot(simq = seq(0.01, 0.2, by = 0.01), colors = c("RED", "GREEN"), ...)
```

Arguments

`simq`	Vector. Probabilities of failure (q) to use for simulated trials. Defaults to range of q = 0.01 to q = 0.5 in 0.05 steps.
`colors`	Vector. Passes color options to `barplot`. Defaults to red and green.
`...`	Passes values to `dgroups`.

Value

none

Author(s)

Chad Ross <chad.ross@gmail.com>

See Also

`dgroups` `dseries` `dtrials` `droptest`

Examples

```
# recommended to use num.series value greater than or equal to 1000.
ratioplot(simq = seq(0.01, 0.20, by = 0.01), num.series = 100)
ratioplot(simq = seq(0.01, 0.20, by = 0.01), num.series = 100,
          colors = c("BLUE", "BLACK"))
```

`trialdev` *Calculates trial deviation for simulated trials (drops).*

Description

`trialdev` creates a data.table with the average distances from q for the total percent of reactions (failures).

Usage

```
trialdev(sim.values)
```

Arguments

`sim.values`	Data table. Data table produced by droptest::dtrials, droptest::dseries, or droptest::dgroups.

Value

Data table of q, p, trial deviation, and average total trials per test. Aggregated by q.

- **Q** The probability of failure (reaction) as specified.
- **P** The probability of success (non-reaction).
- **TRIAL_DEV** The average distance from q for the total percent of reactions (failures).
- **AVG_TRIALS** The average number of simulated trials reached for each q.

Author(s)

Chad Ross <chad.ross@gmail.com>

See Also

`dtrials` `dseries` `dgroups` `droptest`

Examples

```
trialdev(dtrials(q = 0.05, max.trials = 60, fail.criteria = 2))
```

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