Package: AccSamplingDesign (via r-universe)

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Title Acceptance Sampling Plans Design

Version 0.1.0

Description Provides tools for designing and analyzing Acceptance Sampling plans. Supports both Attributes Sampling (Binomial and Poisson distributions) and Variables Sampling (Normal and Beta distributions), enabling quality control for fractional and compositional data. Uses nonlinear programming for sampling plan optimization, minimizing sample size while controlling producer's and consumer's risks. Operating Characteristic curves are available for plan visualization.

License GPL-3

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`accProb` *Acceptance Probability*

Description

Calculate the probability of acceptance for a given quality level.

Usage

```
accProb(plan, p)
```

Arguments

`plan`	Acceptance plan object (`AttrPlan`/`VarPlan`).
`p`	True quality level (proportion of nonconforming).

Details

For Beta plans with unknown theta, the calculation follows the `method` stored in the plan: analytical Delta–MLE, analytical Delta–MoM, or the Govindaraju–Kissling sample-size adjustment.

Value

Numeric probability between 0 and 1.

Author(s)

Ha Truong

Examples

```
# Example for attribute plan
attr_plan <- optAttrPlan(PRQ = 0.01, CRQ = 0.1)
accProb(attr_plan, 0.05)

# Example for variable plan (normal distribution)
var_plan <- optVarPlan(
  PRQ = 0.025,        # Acceptable quality level (% nonconforming)
  CRQ = 0.1,         # Rejectable quality level (% nonconforming)
  alpha = 0.05,      # Producer's risk
  beta = 0.1,        # Consumer's risk
  distribution = "normal"
)
accProb(var_plan, 0.05)
```

`manualPlan` *Create manual acceptance sampling (AS) plan from User Inputs*

Description

Constructs an `AttrPlan` or `VarPlan` object from the given parameters.

Usage

```
manualPlan(distribution = c("binomial", "poisson", "normal", "beta"),
           n = NULL, c = NULL, k = NULL,
           USL = NULL, LSL = NULL, sigma = NULL, theta = NULL,
           sigma_type = c("known", "unknown"),
           theta_type = c("known", "unknown"),
           method = c("delta_mle", "delta_mom", "gk_adjustment"))
```

Arguments

`distribution`	One of `"binomial"`, `"poisson"`, `"normal"`, or `"beta"`.
`n`	Sample size.
`c`	Acceptance number (for attribute sampling).
`k`	Acceptability constant (for variable sampling).
`USL`	Upper specification limit.
`LSL`	Lower specification limit.
`sigma`	Standard deviation (for normal plans).
`theta`	Precision parameter (for beta plans).
`sigma_type`	Either `"known"` or `"unknown"` (for normal).
`theta_type`	Either `"known"` or `"unknown"` (for beta).
`method`	Method used by an unknown-theta Beta plan. Delta–MLE is the default; alternatives are `"delta_mom"` and `"gk_adjustment"`.

Details

This function provides a user-friendly wrapper to construct AS plan directly from parameters. Internally, it constructs the appropriate `AttrPlan` or `VarPlan`, from given paramenters.

Value

An object of class `"AttrPlan"` or `VarPlan`.

Author(s)

Ha Truong

See Also

`optPlan`, `OCdata`

Examples

```
# Attribute sampling with user-defined parameters
plan1 <- manualPlan(n = 100, c = 2, distribution = "binomial")

# Variable sampling (normal)
plan2 <- manualPlan(n = 30, k = 1.5, distribution = "normal", USL = 10, sigma = 1)

# Unknown-theta Beta plan using analytical Delta--MoM
plan3 <- manualPlan(n = 45, k = 2.2, distribution = "beta",
                    theta = 300, theta_type = "unknown", method = "delta_mom",
                    USL = 0.05)
```

`muEst` *Estimate Mean μ Based on Specification Limits and Probability*

Description

Computes the estimated mean μ for a given level of quality and specification limit under either a normal or beta distribution.

Usage

```
muEst(p, USL = NULL, LSL = NULL,
       sigma = NULL, theta = NULL,
       dist = c("normal", "beta"))
```

Arguments

p	Level of quality (numeric, between 0 and 1).
USL	Upper specification limit (numeric). Only one of USL or LSL should be provided.
LSL	Lower specification limit (numeric). Only one of USL or LSL should be provided.
sigma	Standard deviation (numeric) for the normal distribution. Must be provided if dist = "normal".
theta	Theta parameter (numeric) for the beta distribution. Must be provided if dist = "beta".
dist	Distribution type. Either "normal" or "beta".

Details

The function estimates the mean μ corresponding to a given tail probability p, assuming that the process output follows either a normal or beta distribution, and that the probability of being beyond the provided specification limit equals 1 - p.

- For the normal distribution, the mean is calculated using the inverse cumulative distribution function (quantile function) of the normal distribution.
- For the beta distribution, the mean is solved numerically such that the CDF at the specified limit equals p, given the shape determined by theta.

Exactly one of USL or LSL must be provided to define whether the probability refers to the upper or lower tail.

Value

Returns the estimated mean μ as a numeric value.

Author(s)

Ha Truong

Examples

```
# Example for normal distribution with lower specification limit (LSL)
muEst(p = 0.95, LSL = 10, sigma = 2, dist = "normal")

# Example for beta distribution with upper specification limit (USL)
muEst(p = 0.95, USL = 0.7, theta = 500, dist = "beta")
```

OCdata *Generic function for OC Curve Generation*

Description

Generic function to compute Operating Characteristic (OC) curve data from an acceptance sampling plan.

Usage

```
OCdata(plan, pd = NULL)
```

Arguments

plan	An object of class AttrPlan or VarPlan.
pd	Vector of quality levels (proportions of nonconforming items).

Details

This is a generic function. Methods are defined for objects of class AttrPlan and VarPlan, which compute the probability of acceptance across a range of quality levels (proportions of nonconforming).

See OCdata.AttrPlan and OCdata.VarPlan for details.

Value

An object of class "OCdata", a list containing:

- pd — quality levels (e.g. proportion defective)
- paccept — probability of acceptance at each level
- process_means — process means, if applicable
- dist, n, k, c — plan parameters

Author(s)

Ha Truong

See Also

optPlan, manualPlan

optAttrPlan *Attributes Acceptance Sampling Plan*

Description

Designs Attributes Acceptance Sampling plans using producer/consumer risk criteria.

Usage

```
optAttrPlan(PRQ, CRQ, alpha = 0.05, beta = 0.10,
            distribution = c("binomial", "poisson"))
```

Arguments

PRQ	Producer Risk Quality (0 < PRQ < 1)
CRQ	Consumer Risk Quality (PRQ < CRQ < 1)
alpha	Producer's risk (0.05 default)
beta	Consumer's risk (0.10 default)
distribution	Support binomial and poisson distribution

Value

AttrPlan object containing:

n	Sample size
c	Acceptance number
PRQ	Input PRQ value
CRQ	Input CRQ value
distribution	Selected distribution

Author(s)

Ha Truong

References

ISO 2859-1:1999 - Sampling procedures for inspection by attributes

Schilling, E.G., & Neubauer, D.V. (2017). Acceptance Sampling in Quality Control (3rd ed.). Chapman and Hall/CRC. https://doi.org/10.4324/9781315120744

Examples

```
plan <- optAttrPlan(PRQ = 0.01, CRQ = 0.1, alpha = 0.05, beta = 0.1,
                    distribution = "binomial")
```

optPlan *Optimal Acceptance Sampling Plan*

Description

Design optimal variable acceptance sampling plans based on specified parameters. Supports different distributions (binomial, poisson, normal, beta) and accommodates known or unknown standard deviation and process parameters.

Usage

```
optPlan(PRQ, CRQ, alpha = 0.05, beta = 0.10, USL = NULL, LSL = NULL,
        distribution = c("binomial", "poisson", "normal", "beta"),
        sigma_type = c("known", "unknown"),
        theta_type = c("known", "unknown"),
        sigma = NULL, theta = NULL,
        method = c("delta_mle", "delta_mom", "gk_adjustment"))
```

Arguments

PRQ	Producer's risk quality level (e.g., acceptable quality level).
CRQ	Consumer's risk quality level (e.g., rejectable quality level).
alpha	Producer's risk (Type I error), default is 0.05.
beta	Consumer's risk (Type II error), default is 0.10.
USL	Upper Specification Limit. Required for variable sampling plans.
LSL	Lower Specification Limit. Required for variable sampling plans.
distribution	Distribution type used in the plan. Can be "binomial", "poisson", "normal", or "beta".
sigma_type	Indicates if the standard deviation (sigma) is known or unknown.
theta_type	Indicates if the process parameter (theta) is known or unknown.
sigma	Known standard deviation of the process, if applicable.
theta	Precision (dispersion) parameter for the beta distribution. If unknown, it can be estimated from historical data using functions such as betaff.
method	Method for a Beta plan with theta_type = "unknown": "delta_mle" (default), "delta_mom", or "gk_adjustment". It must not be supplied in other cases.

Details

This function designs optimal acceptance sampling plans by balancing producer's and consumer's risks under specified quality levels. It supports plans for attributes (binomial) and variables (normal or beta distributions), including cases with unknown standard deviation or distributional parameters.

For the "normal" model, the plan can be computed assuming the standard deviation (sigma) is either known or estimated from data. Optimization for unknown sigma is performed using the derivative-free Nelder-Mead method (Nelder and Mead, 1965) via optim in base R.

For the "beta" model, the dispersion (precision) parameter theta determines how concentrated the distribution is around the mean. Users must either:

- provide a known value for theta, typically obtained from prior process studies or historical data; or
- estimate it from sample data using a fitting function such as betaff in the **VGAM** package.

Optimization for Beta plans is performed using optim with the "L-BFGS-B" method (Byrd et al., 1995) to handle bounds on sample size and acceptance numbers.

For unknown theta, the Delta methods approximate the joint uncertainty of the estimated Beta mean and precision. Delta–MLE uses inverse expected Fisher information; Delta–MoM propagates the first four Beta raw moments. The "gk_adjustment" option preserves the earlier Govindaraju–Kissling/package-style sample-size adjustment.

This approach ensures stable and efficient plan calculation while relying solely on base R functionality.

Value

Returns a list or data frame with optimal sample size(s) and critical value(s) based on the specified parameters and distribution.

distribution	Selected distribution
sample_size	Final sample size after rounding up to the next integer, for practical application.
n	Sample size (unrounded for Variables Acceptance Sampling).
k	Acceptability constant - For Variables Acceptance Sampling.
c	Acceptance number - For Attributes Acceptance Sampling.

Author(s)

Ha Truong

References

* H. Truong, V. Miranda and R. Kissling (2026). AccSamplingDesign: An R Package for Optimizing Acceptance Sampling Plans. *The R Journal*, 18(1), 368–381. doi:10.32614/RJ2026007.

* ISO 2859-1:1999 - Sampling procedures for inspection by attributes

* ISO 3951-1:2013 - Sampling procedures for inspection by variables.

* Wilrich, PT. (2004). Single Sampling Plans for Inspection by Variables under a Variance Component Situation. In: Lenz, HJ., Wilrich, PT. (eds) Frontiers in Statistical Quality Control 7. Physica, Heidelberg.

* K. Govindaraju and R. Kissling (2015). Sampling plans for Beta-distributed compositional fractions.

* J. A. Nelder and R. Mead. A simplex method for function minimization. The Computer Journal, 7(4): 308–313, 1965. DOI 10.1093/comjnl/7.4.308.

* R. H. Byrd, P. Lu, J. Nocedal and C. Zhu. A limited memory algorithm for bound constrained optimization. SIAM Journal on Scientific Computing, 16(5): 1190–1208, 1995. DOI 10.1137/0916069.

Examples

```
# Example usage (normal distribution, known sigma):
optPlan(PRQ = 0.005, CRQ = 0.03, alpha = 0.05, beta = 0.10,
        distribution = "normal", sigma_type = "known")

# Example usage (beta distribution, unknown theta):
optPlan(PRQ = 0.025, CRQ = 0.10, alpha = 0.05, beta = 0.10,
        distribution = "beta", theta = 6.6e8,
        theta_type = "unknown", method = "delta_mle", LSL = 5.65e-6)
```

`optVarPlan` *Variables Acceptance Sampling Plan*

Description

Creates Variable Acceptance Sampling plans for normal or beta distributed measurements.

Usage

```
optVarPlan(PRQ, CRQ, alpha = 0.05, beta = 0.10, USL = NULL, LSL = NULL,
         distribution = c("normal", "beta"), sigma_type = c("known", "unknown"),
           theta_type = c("known", "unknown"), sigma = NULL, theta = NULL,
           method = c("delta_mle", "delta_mom", "gk_adjustment"))
```

Arguments

`PRQ`	Producer Risk Quality (must be within valid range for the chosen distribution).
`CRQ`	Consumer Risk Quality (must be greater than PRQ and within valid range).
`alpha`	Producer's risk (numeric between 0 and 1).
`beta`	Consumer's risk (numeric between 0 and 1).
`USL`	Upper Specification Limit (numeric). Only one of `USL` or `LSL` should be provided.
`LSL`	Lower Specification Limit (numeric). Only one of `USL` or `LSL` should be provided.
`distribution`	Measurement distribution: `"normal"` or `"beta"`.
`sigma_type`	Indicates whether sigma (population standard deviation) is `"known"` or `"unknown"`.
`theta_type`	Indicates whether theta (population precision parameter for beta) is `"known"` or `"unknown"`.
`sigma`	Known standard deviation (used for normal distribution). Required if `sigma_type = "known"`.
`theta`	Precision (dispersion) parameter for the beta distribution. If unknown, it can be estimated from historical data using functions such as `betaff`.
`method`	Unknown-theta Beta method: `"delta_mle"` (default), `"delta_mom"`, or `"gk_adjustment"`. It is only applicable when `distribution = "beta"` and `theta_type = "unknown"`.

Details

The function generates variable acceptance sampling plans based on specified producer and consumer risks and either a normal or beta distribution model.

The specification limit must be defined via either `USL` (upper specification limit) or `LSL` (lower specification limit), depending on whether the one-sided quality criterion concerns the upper or lower tail. Only one limit should be provided.

For the `"normal"` model, the plan can be computed assuming the standard deviation (`sigma`) is either known or estimated from data. Optimization for unknown `sigma` is performed using the derivative-free Nelder-Mead method (Nelder and Mead, 1965) via `optim` in base R.

For the `"beta"` model, the dispersion (precision) parameter `theta` determines how concentrated the distribution is around the mean. Users must either:

- provide a known value for `theta`, typically obtained from prior process studies or historical data; or
- estimate it from sample data using a fitting function such as `betaff` in the **VGAM** package.

Optimization for Beta plans is performed using `optim` with the `"L-BFGS-B"` method (Byrd et al., 1995) to handle bounds on sample size and acceptance numbers, followed by a Nelder-Mead refinement that solves the two binding risk equations. For known-theta plans, the sample size is then rounded up from the binding solution and both risks are verified at the delivered (integer) size, so the plan meets `PR <= alpha` and `CR <= beta` as applied.

For unknown precision, Delta–MLE uses inverse expected Fisher information and Delta–MoM uses analytical covariance propagated from the first four Beta raw moments. The Govindaraju–Kissling adjustment retains the package's earlier sample-size approximation.

This approach ensures stable and efficient plan calculation while relying solely on base R functionality.

Value

A `VarPlan` object containing:

`distribution`	Distribution used ("normal" or "beta").
`sample_size`	Final sample size after rounding up to the next integer, for practical application.
`k`	Acceptability constant.
`n`	The sample size the plan is evaluated at. For known-theta Beta plans this is the delivered integer size (equal to `sample_size`); for other plans it is the unrounded value from the optimization.

Author(s)

Ha Truong

References

* H. Truong, V. Miranda and R. Kissling (2026). AccSamplingDesign: An R Package for Optimizing Acceptance Sampling Plans. *The R Journal*, 18(1), 368–381. doi:10.32614/RJ2026007.

* ISO 3951-1:2013 - Sampling procedures for inspection by variables.

* Wilrich, PT. (2004). Single Sampling Plans for Inspection by Variables under a Variance Component Situation. In: Lenz, HJ., Wilrich, PT. (eds) Frontiers in Statistical Quality Control 7. Physica, Heidelberg.

* K. Govindaraju and R. Kissling (2015). Sampling plans for Beta-distributed compositional fractions.

* J. A. Nelder and R. Mead. A simplex method for function minimization. The Computer Journal, 7(4): 308–313, 1965. DOI 10.1093/comjnl/7.4.308.

* R. H. Byrd, P. Lu, J. Nocedal and C. Zhu. A limited memory algorithm for bound constrained optimization. SIAM Journal on Scientific Computing, 16(5): 1190–1208, 1995. DOI 10.1137/0916069.

Examples

```
# Example for normal distribution plan
norm_plan <- optVarPlan(
  PRQ = 0.025,        # Acceptable quality level (% nonconforming)
  CRQ = 0.1,          # Rejectable quality level (% nonconforming)
  alpha = 0.05,       # Producer's risk
  beta = 0.1,         # Consumer's risk
  distribution = "normal",
  USL = 10
)
summary(norm_plan)

# Example for beta distribution plan
beta_plan <- optVarPlan(
  PRQ = 0.025,        # Target quality level (% nonconforming)
  CRQ = 0.1,          # Minimum quality level (% nonconforming)
  alpha = 0.05,       # Producer's risk
  beta = 0.1,         # Consumer's risk
  distribution = "beta",
  theta = 44000000,   # Beta distribution parameter
  LSL = 0.00001
)
summary(beta_plan)
```

---

plot.AttrPlan *Plot the OC Curve for Attribute Sampling Plans*

Description

Plots the Operating Characteristic (OC) curve for an attribute sampling plan object of class `AttrPlan`.

Usage

```
## S3 method for class 'AttrPlan'
plot(x, pd = NULL, ...)
```

Arguments

x	An object of class AttrPlan representing an attribute acceptance sampling plan.
pd	Optional vector of proportions of nonconforming items. If NULL (default), a range is automatically generated.
...	Additional graphical parameters passed to plot().

Details

This method computes and visualizes the probability of acceptance (P(accept)) as a function of the proportion of nonconforming items in the population, based on the attribute sampling plan.

The plot also includes reference lines at the plan's producer and consumer quality levels (PRQ, CRQ) and their corresponding acceptance probabilities.

Value

A plot showing the OC curve for the given attribute sampling plan.

Author(s)

Ha Truong

See Also

optAttrPlan, accProb, OCdata

Examples

```
# Create attribute plan
plan <- optAttrPlan(PRQ = 0.01, CRQ = 0.1)

# Plot OC curve
plot(plan)

# With custom pd
plot(plan, pd = seq(0, 0.15, by = 0.001))
```

---

plot.OCdata *Plot Method for OCdata Objects*

Description

Plots the Operating Characteristic (OC) curve from an object of class "OCdata", either by proportion nonconforming or process mean levels.

Usage

```
## S3 method for class 'OCdata'
plot(x, by = c("pd", "mean"), ...)
```

Arguments

x	An object of class "OCdata", typically generated using OCdata().
by	A character string indicating the type of OC curve to plot. Options are:
	"pd" (Default) Plot the OC curve by proportion nonconforming.
	"mean" Plot the OC curve by estimated process mean levels (only available for variable sampling plans).
...	Additional graphical parameters passed to the plot() function.

Details

This method visualizes the OC curve based on the content of the "OCdata" object.

By default, the curve is plotted against the proportion of nonconforming items (@pd). If by = "mean" is specified and the plan includes valid mean-level estimates (@process_means), the curve is plotted against mean levels.

If by = "mean" is requested but no mean estimates are available (e.g., for attribute plans), a message will be shown and no plot will be drawn.

Value

A plot showing the OC curve for the given attribute/variable sampling plan.

Author(s)

Ha Truong

See Also

OCdata, optAttrPlan, optVarPlan

Examples

```
# Attribute plan
plan_attr <- optAttrPlan(PRQ = 0.01, CRQ = 0.05)
oc_attr <- OCdata(plan_attr)
plot(oc_attr)               # OC curve by pd (default)
plot(oc_attr, by = "mean")  # Will show message if not available

# Variable plan
plan_var <- optVarPlan(PRQ = 0.025, CRQ = 0.1, USL = 0.1,
                       distribution = "normal", sigma=0.01)
oc_var <- OCdata(plan_var)
plot(oc_var)                # OC curve by pd
plot(oc_var, by = "mean")   # OC curve by mean levels
```

plot.VarPlan *Plot the OC Curve for Variable Sampling Plans*

Description

Plots the Operating Characteristic (OC) curve for an object of class `VarPlan`. Supports plotting against either the proportion of nonconforming items or the corresponding process mean levels, depending on availability.

Usage

```
## S3 method for class 'VarPlan'
plot(x, pd = NULL, by = c("pd", "mean"), ...)
```

Arguments

`x`	An object of class `VarPlan` representing a variable acceptance sampling plan.
`pd`	Optional numeric vector of proportions of nonconforming items to evaluate. If `NULL` (default), a suitable range is generated automatically.
`by`	Character string indicating which x-axis to use for plotting. Either `"pd"` for proportion nonconforming (default) or `"mean"` for process mean levels. If `"mean"` is selected but the plan lacks specification limits, an error is raised.
`...`	Additional graphical parameters passed to `plot()`.

Details

This plotting method visualizes the probability of acceptance (`P(accept)`) against the desired metric, based on the parameters of a variable sampling plan.

If `by = "pd"`, the x-axis represents the proportion of nonconforming items. If `by = "mean"` and the plan defines `limit_type` and `spec_limit`, the function estimates corresponding process means using `muEst` and plots the OC curve by those mean values.

Reference lines for the Producer's Risk Quality (PRQ) and Consumer's Risk Quality (CRQ), along with their respective acceptance probabilities, are shown when plotting by proportion.

Value

A plot showing the OC curve for the given variable sampling plan, either by nonconforming proportion or mean level.

Author(s)

Ha Truong

See Also

`optVarPlan`, `accProb`, `muEst`, `OCdata`, `plot.OCdata`

Examples

```
# Variable sampling plan with specification limits
plan <- optVarPlan(
  PRQ = 0.025, CRQ = 0.1,
  alpha = 0.05, beta = 0.1,
  distribution = "normal",
  USL = 3, sigma = 0.1
)

# Plot by proportion nonconforming
plot(plan, by = "pd")

# Plot by estimated mean level (requires spec_limit and limit_type)
plot(plan, by = "mean")

# Custom pd vector
plot(plan, pd = seq(0.01, 0.15, by = 0.001))
```

---

summary.AttrPlan *Summarize Attribute Acceptance Plan*

Description

Detailed summaries for attribute acceptance plans.

Usage

```
## S3 method for class 'AttrPlan'
summary(object, ...)
```

Arguments

object	Plan object to summarize
...	Additional parameters (ignored)

Value

No return value. This function is called for its side effect of printing a formatted summary of the attribute sampling plan to the console.

Author(s)

Ha Truong

Examples

```
attr_plan <- optAttrPlan(PRQ = 0.01, CRQ = 0.1)
summary(attr_plan)
```

summary.VarPlan *Summarize Variables Acceptance Plan*

Description

Detailed summaries for Variables Acceptance Sampling plans.

Usage

```
## S3 method for class 'VarPlan'
summary(object, ...)
```

Arguments

object	Plan object to summarize
...	Additional parameters (ignored)

Value

No return value. This function is called for its side effect of printing a formatted summary of the variable sampling plan to the console.

Author(s)

Ha Truong

Examples

```
var_plan <- optVarPlan(
  PRQ = 0.025,       # Acceptable quality level (% nonconforming)
  CRQ = 0.1,         # Rejectable quality level (% nonconforming)
  alpha = 0.05,      # Producer's risk
  beta = 0.1,        # Consumer's risk
  distribution = "normal"
)
summary(var_plan)
```

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