Package 'confoundvis'

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Type Package

Title Visualization Tools for Sensitivity Analysis of Unmeasured Confounding

Version 0.1.0

Description Provides visualization tools for sensitivity analysis to unmeasured confounding in observational studies. Includes contour-based sensitivity plots, robustness curves, and benchmark-oriented graphics that help researchers assess how strong omitted confounding would need to be to attenuate, invalidate, or reverse estimated effects. Supports regression-based sensitivity analysis frameworks, including impact threshold approaches (Frank, 2000, <doi:10.1177/0049124100029002001>), partial R-squared methods (Cinelli and Hazlett, 2020, <doi:10.1111/rssb.12348>), and E-value style metrics (VanderWeele and Ding, 2017, <doi:10.7326/M16-2607>). Emphasizes clear, interpretable, and publication-ready graphical summaries for transparent reporting of causal sensitivity analyses across the social, behavioral, health, and educational sciences.

License GPL-3

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Contents

`as.data.frame.confoundsens` *Coerce a confoundsens object to a data frame*

Description

Coerce a confoundsens object to a data frame

Usage

```
## S3 method for class 'confoundsens'
as.data.frame(x, ...)
```

Arguments

`x`	A `confoundsens` object.
`...`	Unused; included for S3 method consistency.

Value

A data.frame with columns `lambda` and `theta`, plus optional columns `level`, `se`, and `t` when present in `x`.

Examples

```
x <- new_confoundsens(
  lambda = seq(0, 0.2, length.out = 5),
  theta  = seq(1, 0.8, length.out = 5),
  se     = rep(0.05, 5)
)
as.data.frame(x)
```

`as_confoundsens` *Convert a data frame to a confoundsens object*

Description

Converts a data frame containing sensitivity analysis results into a `confoundsens` object suitable for use with `confoundvis` plotting functions.

Usage

```
as_confoundsens(
  data,
  lambda = "lambda",
  theta = "theta",
  level = NULL,
  se = NULL,
  t = NULL
)
```

Arguments

`data`	A data.frame containing sensitivity analysis results.
`lambda`	Character string; name of the column containing lambda values. Default `"lambda"`.
`theta`	Character string; name of the column containing theta values. Default `"theta"`.
`level`	Optional character string; name of the column containing level identifiers (e.g., `"within"` / `"between"`).
`se`	Optional character string; name of the column containing standard errors for `theta`.
`t`	Optional character string; name of the column containing test statistics.

Value

A `confoundsens` object.

Examples

```
df <- data.frame(
  lambda = seq(0, 0.2, length.out = 10),
  theta  = seq(1, 0.5, length.out = 10),
  se     = rep(0.1, 10),
  level  = rep(c("within", "between"), length.out = 10)
)
x <- as_confoundsens(df)
x
```

`fit_local_quadratic` *Fit a local quadratic approximation*

Description

Fits a second-order Taylor (quadratic) approximation of an effect path $\theta(\delta)$ near $\delta = 0$ using ordinary least squares:

$$\theta(\delta) \approx a + b\delta + c\delta^2.$$

Usage

```
fit_local_quadratic(
  data = NULL,
  delta = NULL,
  theta = NULL,
  local_max_delta = 0.2,
  include_intercept = TRUE,
  tol = 1e-12
)
```

Arguments

`data`	Optional data.frame containing columns named `delta` and `theta`. If supplied, the `delta` and `theta` arguments are ignored.
`delta`	Optional numeric vector of delta values. Used only when `data = NULL`.
`theta`	Optional numeric vector of theta values. Used only when `data = NULL`.
`local_max_delta`	Positive numeric scalar giving the half-width of the local window: only observations with $\lvert\delta\rvert \leq$ `local_max_delta` are used in the fit.
`include_intercept`	Logical; if `TRUE` (default), include an intercept term.
`tol`	Non-negative numeric scalar tolerance used when selecting observations within the local window.

Details

You may supply either a data.frame containing columns `delta` and `theta`, or supply numeric vectors `delta` and `theta` directly.

Value

A named list with elements:

- `coef` — named coefficient vector from `stats::lm()`.
- `intercept`, `slope`, `quad` — individual coefficients (NA when absent).
- `model` — the fitted `lm` object.
- `local_data` — the data.frame used for fitting.
- `local_max_delta` — the window half-width used.

Examples

```
df <- data.frame(
  delta = seq(0, 0.3, length.out = 60),
  theta = 0.4 - 0.7 * seq(0, 0.3, length.out = 60) +
          0.4 * seq(0, 0.3, length.out = 60)^2
)
fit_local_quadratic(df, local_max_delta = 0.2)
```

---

new_confoundsens *Create a confoundsens object*

Description

Constructs a `confoundsens` object — a lightweight container for storing sensitivity paths (e.g., $\theta(\lambda)$) and optional uncertainty or stratification information used by `confoundvis` plotting functions.

Usage

```
new_confoundsens(lambda, theta, level = NULL, se = NULL, t = NULL)
```

Arguments

`lambda`	Numeric vector of sensitivity strength values (e.g., ITCV lambda or delta). Should be nondecreasing; a warning is issued otherwise.
`theta`	Numeric vector of effect estimates along the sensitivity path. Must be the same length as `lambda`.
`level`	Optional character (or coercible) vector of level identifiers (e.g., `"within"`, `"between"`). Must be the same length as `lambda`.
`se`	Optional numeric vector of standard errors for `theta`. Must be the same length as `lambda`.
`t`	Optional numeric vector of test statistics along the path. Must be the same length as `lambda`.

Value

A confoundsens object (a list with class "confoundsens").

Examples

```
x <- new_confoundsens(
  lambda = seq(0, 0.2, length.out = 10),
  theta  = seq(1, 0.6, length.out = 10),
  se     = rep(0.1, 10)
)
x
```

---

plot_cone_comparison *Compare reversal cones across multilevel components*

Description

Produces a two-panel plot comparing the reversal cone cross-sections for the within-cluster and between-cluster confounding components in multilevel settings. Each panel calls plot_reversal_cone() and they are displayed side by side using faceting.

Usage

```
plot_cone_comparison(
  theta0_within = 0.35,
  theta0_between = 0.5,
  delta_within = 0.2,
  delta_between = 0.3,
  ...
)
```

Arguments

theta0_within	Numeric; within-cluster baseline effect.
theta0_between	Numeric; between-cluster baseline effect.
delta_within	Numeric; within-cluster confounding magnitude (> 0).
delta_between	Numeric; between-cluster confounding magnitude (> 0).
...	Additional arguments passed to plot_reversal_cone().

Value

Invisibly, a list with ggplot objects within and between. The plots are drawn side-by-side to the current device.

Examples

```
plot_cone_comparison(
  theta0_within  = 0.35, theta0_between = 0.50,
  delta_within   = 0.20, delta_between  = 0.30
)
```

`plot_figure2_taylor_panels` *Three-panel Taylor approximation figure*

Description

Produces a three-panel figure (linear / concave-down / convex-up) showing a simulated confounding path together with its first-order (tangent) and second-order (local quadratic) approximations. The panels correspond to the three curvature regimes in the mITCV framework.

Usage

```
plot_figure2_taylor_panels(
  delta_max = 1.5,
  step = 0.02,
  theta0 = 0.4,
  slope = -0.7,
  kappa = 0.4,
  local_max_delta = 0.2
)
```

Arguments

`delta_max`	Positive numeric scalar. Upper bound of the delta grid.
`step`	Positive numeric scalar. Grid step size.
`theta0`	Numeric scalar. Baseline effect at delta = 0.
`slope`	Numeric scalar. First-order slope at delta = 0.
`kappa`	Non-negative numeric scalar. Curvature magnitude.
`local_max_delta`	Positive numeric scalar <= `delta_max`. Width of the local window used for the quadratic approximation.

Value

A named list with ggplot objects `A` (linear), `B` (concave), and `C` (convex), returned invisibly. The three panels are also printed to the active graphics device via `gridExtra::grid.arrange()` if **gridExtra** is installed, or via `graphics::layout()` otherwise.

Examples

```
plots <- plot_figure2_taylor_panels()
# Access individual panels
plots$A
```

`plot_local_taylor` *Local Taylor diagnostic plot*

Description

Plots local Taylor series components (or any multi-series decomposition) as a function of `delta` from a long-form data.frame. Lines are distinguished by colour and linetype, keyed by `series`.

Usage

```
plot_local_taylor(df, facet = FALSE)
```

Arguments

`df`	A data.frame in long form with columns: • `delta` — numeric; the confounding-strength grid. • `series` — character or factor; name of each curve (e.g., `"path"`, `"tangent"`, `"quadratic"`). • `value` — numeric; the effect value for each (delta, series) pair.
`facet`	Logical; if `TRUE`, produce a faceted plot with one panel per `series`. If `FALSE` (default), overlay all series on a single panel with colour and linetype aesthetics.

Value

A `ggplot2::ggplot()` object.

Examples

```
df <- data.frame(
  delta  = rep(seq(0, 0.2, length.out = 25), 3),
  series = rep(c("path", "tangent", "quadratic"), each = 25),
  value  = c(
    0.4 - 0.7 * seq(0, 0.2, length.out = 25) - 0.4 * seq(0, 0.2, length.out = 25)^2,
    0.4 - 0.7 * seq(0, 0.2, length.out = 25),
    0.4 - 0.7 * seq(0, 0.2, length.out = 25) + 0.2 * seq(0, 0.2, length.out = 25)^2
  )
)
plot_local_taylor(df)
plot_local_taylor(df, facet = TRUE)
```

`plot_reversal_cone` *Reversal cone geometry plot*

Description

Visualizes the two-dimensional cross-section of the reversal cone C_l at a fixed confounding effect magnitude $|\delta|$. The cone partitions the (q, p) confounding parameter space into an **attenuation zone** (where the effect shrinks but does not reverse sign) and a **reversal zone** (where the sign changes). The boundary between zones is the reversal curve derived from the multilevel mITCV framework.

Usage

```
plot_reversal_cone(
  theta0 = 0.4,
  delta = 0.2,
  q_range = c(0, 1),
  p_range = c(-1, 1),
  grid_n = 200L,
  show_boundary = TRUE,
  show_volume = TRUE
)
```

Arguments

`theta0`	Numeric; baseline estimated effect at zero confounding (must be nonzero).
`delta`	Numeric; the fixed confounding effect magnitude $\|\delta\|$ at which the cross-section is evaluated (> 0).
`q_range`	Numeric vector of length 2; range of the confounding prevalence parameter $q \in [0, 1]$ (default `c(0, 1)`).
`p_range`	Numeric vector of length 2; range of the confounding impact parameter p (default `c(-1, 1)`).
`grid_n`	Integer; grid resolution for each axis (default 200).
`show_boundary`	Logical; draw the reversal boundary curve.
`show_volume`	Logical; annotate with the cone volume proportion.

Value

A ggplot object.

Examples

```
plot_reversal_cone(theta0 = 0.40, delta = 0.20)
plot_reversal_cone(theta0 = 0.40, delta = 0.50)
```

`plot_robustness_curve` *Plot a robustness curve*

Description

Plots the sensitivity path stored in a `confoundsens` object as a function of `lambda`. By default, plots the effect path `theta(lambda)`; optionally plots the test-statistic path `t(lambda)`. Pointwise 95% confidence bands are drawn when standard errors are available.

Usage

```
plot_robustness_curve(
  x,
  what = c("theta", "t"),
  bands = TRUE,
  points = TRUE,
  facet_level = TRUE
)
```

Arguments

`x`	A `confoundsens` object created by `new_confoundsens()` or `as_confoundsens()`.
`what`	Character; which path to plot: `"theta"` (default) or `"t"`.
`bands`	Logical; if `TRUE` and `x$se` is present, draw 95% pointwise confidence bands (applies only when `what = "theta"`).
`points`	Logical; if `TRUE`, overlay points on the line.
`facet_level`	Logical; if `TRUE` and `x$level` is present, facet the plot by level.

Value

A `ggplot2::ggplot()` object.

Examples

```
x <- new_confoundsens(
  lambda = seq(0, 0.2, length.out = 25),
  theta  = 1 - 2 * seq(0, 0.2, length.out = 25),
  se     = rep(0.05, 25),
  level  = rep(c("within", "between"), length.out = 25)
)
plot_robustness_curve(x)
plot_robustness_curve(x, bands = FALSE, facet_level = FALSE)
```

plot_sensitivity_contour *Sensitivity contour plot*

Description

Draws an ITCV-style hyperbolic boundary in (r_{YU}, r_{DU}) space and optionally overlays observed covariate benchmarks as labelled points. The robust region is the interior of the hyperbola where $|r_{YU} \cdot r_{DU}| <$ `threshold`.

Usage

```
plot_sensitivity_contour(threshold, grid_n = 200, benchmarks = NULL)
```

Arguments

`threshold`	Positive numeric scalar; the ITCV-style product threshold. The boundary satisfies $\|r_{YU} \cdot r_{DU}\| =$ `threshold`.
`grid_n`	Integer >= 50; number of points used per branch of the boundary curve. Larger values give smoother curves.
`benchmarks`	Optional data.frame with columns `r_yu` and `r_du` (numeric) and an optional `label` column (character). Each row is plotted as a labelled benchmark point.

Value

A `ggplot2::ggplot()` object.

Examples

```
b <- data.frame(
  r_yu  = c(0.10, 0.15),
  r_du  = c(0.20, 0.12),
  label = c("SES", "BMI")
)
plot_sensitivity_contour(threshold = 0.02, benchmarks = b)
```

plot_sensitivity_love *Sensitivity Love plot*

Description

Benchmarks a sensitivity threshold against the empirical distribution of observed covariate impacts in a "Love plot"-style display. Each covariate appears as a point on a horizontal impact axis; the sensitivity threshold is shown as a vertical reference line. Covariates to the left of the line are weaker than the threshold; those to the right pose a credible threat.

Usage

```
plot_sensitivity_love(df, threshold, sort = TRUE, top = NULL)
```

Arguments

df	A data.frame with at least two columns: • covariate — covariate names (character or factor). • impact — numeric impact values (e.g., ITCV product $\lvert r_{YU} \cdot r_{DU} \rvert$, partial R^2, or other confounding-strength metric).
threshold	Single non-missing numeric value to draw as a vertical reference line (the sensitivity threshold).
sort	Logical; if TRUE (default), sort covariates by impact on the y-axis (ascending).
top	Optional positive integer. If supplied, only the top covariates with the largest absolute impact are displayed.

Value

A ggplot2::ggplot() object.

Examples

```
df <- data.frame(
  covariate = c("SES", "BMI", "Gender", "Race", "Age"),
  impact    = c(0.12, 0.05, 0.02, 0.08, 0.03)
)
plot_sensitivity_love(df, threshold = 0.10)
plot_sensitivity_love(df, threshold = 0.10, top = 3)
```

---

print.confoundsens *Print method for confoundsens objects*

Description

Prints a concise summary of the key fields in a confoundsens object.

Usage

```
## S3 method for class 'confoundsens'
print(x, ...)
```

Arguments

x	A confoundsens object.
...	Unused; included for S3 method consistency.

Value

x, invisibly.

Examples

```
x <- new_confoundsens(
  lambda = seq(0, 0.2, length.out = 5),
  theta  = seq(1, 0.8, length.out = 5)
)
print(x)
```

---

simulate_taylor_demo *Simulate demo confounding paths for Taylor panel figures*

Description

Generates three synthetic sensitivity paths — linear, concave-down, and convex-up — sharing the same baseline effect $\theta(0)$ and first-order slope, but differing in second-order curvature. These toy paths illustrate the difference between tangent-based (first-order) and local quadratic (second-order) sensitivity approximations.

Usage

```
simulate_taylor_demo(
  delta_max = 1.5,
  step = 0.02,
  theta0 = 0.4,
  slope = -0.7,
  kappa = 0.4
)
```

Arguments

delta_max	Single positive numeric scalar. Upper bound of the δ grid.
step	Single positive numeric scalar. Step size for the grid.
theta0	Single numeric scalar. Baseline effect at $\delta = 0$.
slope	Single numeric scalar. First-order slope at $\delta = 0$.
kappa	Single non-negative numeric scalar. Curvature magnitude.

Details

The three regimes are:

- **Linear**: $\theta(\delta) = \theta_0 + s\delta$
- **Concave-down**: $\theta(\delta) = \theta_0 + s\delta - \kappa\delta^2$
- **Convex-up**: $\theta(\delta) = \theta_0 + s\delta + \kappa\delta^2$

Value

A named list with elements `linear`, `concave`, and `convex`, each a `new_confoundsens()` object.

Examples

```
sims <- simulate_taylor_demo(
  delta_max = 1, step = 0.05, theta0 = 0.4, slope = -0.7, kappa = 0.4
)
sims$linear
plot_robustness_curve(sims$concave)
```

---

summary.confoundsens *Summary method for confoundsens objects*

Description

Produces a concise numerical summary of the sensitivity path, optionally broken down by level.

Usage

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

Arguments

`object`	A `confoundsens` object.
`...`	Unused; included for S3 method consistency.

Value

An object of class `summary.confoundsens` containing a `table` data.frame with per-level summary statistics.

Examples

```
x <- new_confoundsens(
  lambda = seq(0, 0.2, length.out = 10),
  theta  = seq(1, 0.6, length.out = 10),
  se     = rep(0.08, 10),
  level  = rep(c("within", "between"), length.out = 10)
)
summary(x)
```

Index