Package: CRBHSF (via r-universe)

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Type Package

Title Cyber-Resilient Bayesian Healthcare Surveillance Framework

Version 0.1.0

Description Provides methods for healthcare performance surveillance using Bayesian risk estimation, latent organisational trust modelling, cyber-resilience assessment, external validation, decision-theoretic optimisation, and digital-twin deployment simulation. The package supports prospective deterioration monitoring, uncertainty-aware risk assessment, intervention prioritisation, ablation analysis, and operational evaluation for healthcare performance management and health system resilience research. The methodological framework is informed by contemporary guidance on prediction model development and validation (Efthimiou et al., 2024 <doi:10.1136/bmj-2023-078276>), transparent reporting of prediction models (Collins et al., 2024 <doi:10.1136/bmj-2023-078378>), and decision-analytic model evaluation (Vickers and Elkin, 2006 <doi:10.1177/0272989X06295361>).

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Encoding UTF-8

RoxygenNote 7.3.3

URL https://github.com/zerish12/CRBHSF

BugReports https://github.com/zerish12/CRBHSF/issues

Depends R (>= 4.1.0)

Imports dplyr, ggplot2, pROC, purrr, tibble

Suggests testthat (>= 3.0.0), knitr, rmarkdown

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NeedsCompilation no

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Contents

`clean_health_data` *Clean healthcare surveillance data*

Description

Clean healthcare surveillance data

Usage

```
clean_health_data(data, provider_col, time_col)
```

Arguments

`data`	A data frame.
`provider_col`	Character string giving the column name.
`time_col`	Character string giving the column name.

Value

A cleaned `data.frame` containing standardized health-service performance variables. The output typically includes harmonized provider identifiers, time-period variables, numeric performance measures, and derived fields required for CRBHSF risk estimation. Each row represents one provider-period observation.

`compare_ml_benchmarks` *Compare simple machine-learning benchmarks*

Description

Compare simple machine-learning benchmarks

Usage

```
compare_ml_benchmarks(data, outcome_col, predictor_cols)
```

Arguments

`data`	A data frame.
`outcome_col`	Character string giving the column name.
`predictor_cols`	Character vector of predictor column names.

Value

A `data.frame` or list containing benchmark results comparing CRBHSF with conventional machine-learning models. The output includes model names and performance metrics such as AUC, sensitivity, specificity, accuracy, and/or Brier score, depending on the supplied inputs. These results summarise relative predictive performance across competing methods.

`compute_crbhsf_risk` *Compute CRBHSF risk score*

Description

Compute CRBHSF risk score

Usage

```
compute_crbhsf_risk(
  data,
  bayes_risk_col = "risk_bayes",
  trust_col = "latent_trust",
  lambda = 0.2
)
```

Arguments

data	A data frame.
bayes_risk_col	Character string giving the column name.
trust_col	Character string giving the column name.
lambda	Numeric parameter.

Value

A data.frame containing the original observations with additional CRBHSF risk-score columns. The returned risk values represent estimated future deterioration or breach risk after incorporating performance pressure, operational pressure, and cyber/data-reliability adjustment components.

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compute_crpr *Compute Cyber-Resilience Pressure Ratio*

Description

Compute Cyber-Resilience Pressure Ratio

Usage

```
compute_crpr(data, bayes_risk_col = "risk_bayes", trust_col = "latent_trust")
```

Arguments

data	A data frame.
bayes_risk_col	Character string giving the column name.
trust_col	Character string giving the column name.

Value

A numeric vector or data.frame containing cyber-resilience pressure ratio/index values. Larger values indicate greater cyber or data-integrity pressure relative to the observed operational context and may be used as an input to CRBHSF risk scoring.

`create_deterioration_outcome` *Create future deterioration outcome*

Description

Create future deterioration outcome

Usage

```
create_deterioration_outcome(
  data,
  provider_col,
  time_col,
  value_col,
  threshold = 1
)
```

Arguments

`data`	A data frame.
`provider_col`	Character string giving the column name.
`time_col`	Character string giving the column name.
`value_col`	Character string giving the column name.
`threshold`	Numeric parameter.

Value

A `data.frame` containing the input data with an added binary deterioration outcome column. The new outcome indicates whether a provider experienced future deterioration or target breach according to the specified threshold and forecasting horizon.

`estimate_evib` *Estimate expected value of intervention benefit*

Description

Estimate expected value of intervention benefit

Usage

```
estimate_evib(
  data,
  risk_col = "risk_crbhsf",
  review_cost = 1,
  miss_cost = 10,
  threshold = 0.5
)
```

Arguments

`data`	A data frame.
`risk_col`	Character string giving the column name.
`review_cost`	Numeric parameter.
`miss_cost`	Numeric parameter.
`threshold`	Numeric parameter.

Value

A `data.frame` containing expected value of information or expected value of intervention benefit estimates for each observation or decision unit. The output typically includes baseline risk, intervention-adjusted risk, expected loss, expected benefit, and recommended action variables.

`estimate_latent_trust` *Estimate latent organisational trust*

Description

Estimate latent organisational trust

Usage

```
estimate_latent_trust(
  data,
  anomaly_col = NULL,
  corruption_col = NULL,
  cyber_col = NULL,
  missing_col = NULL,
  delay_col = NULL
)
```

Arguments

data	A data frame.
anomaly_col	Character string giving the column name.
corruption_col	Character string giving the column name.
cyber_col	Character string giving the column name.
missing_col	Character string giving the column name.
delay_col	Character string giving the column name.

Value

An object containing the function output. The exact structure depends on the inputs and analysis requested, but typically contains CRBHSF risk, performance, decision, or diagnostic summaries suitable for downstream analysis.

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fit_bayesian_surveillance

Fit lightweight Bayesian surveillance model

Description

Fit lightweight Bayesian surveillance model

Usage

```
fit_bayesian_surveillance(data, y_col, n_col, alpha0 = 2, beta0 = 2)
```

Arguments

data	A data frame.
y_col	Character string giving the column name.
n_col	Character string giving the column name.
alpha0	Numeric parameter.
beta0	Numeric parameter.

Value

An object containing the function output. The exact structure depends on the inputs and analysis requested, but typically contains CRBHSF risk, performance, decision, or diagnostic summaries suitable for downstream analysis.

`generate_surveillance_report` *Generate simple surveillance report*

Description

Generate simple surveillance report

Usage

```
generate_surveillance_report(validation_results, deployment_results = NULL)
```

Arguments

`validation_results`
: Validation results returned by validate_surveillance().

`deployment_results`
: Optional deployment results returned by simulate_digital_twin().

Value

An object containing the function output. The exact structure depends on the inputs and analysis requested, but typically contains CRBHSF risk, performance, decision, or diagnostic summaries suitable for downstream analysis.

`plot_ablation_auc` *Plot ablation AUC*

Description

Plot ablation AUC

Usage

```
plot_ablation_auc(ablation_results)
```

Arguments

`ablation_results`
: Function argument.

Value

A `ggplot` object showing the requested CRBHSF diagnostic, performance, risk, or intervention summary. The plot can be printed, modified, or saved using standard `ggplot2` functions.

plot_deployment_impact *Plot digital-twin deployment impact*

Description

Plot digital-twin deployment impact

Usage

```
plot_deployment_impact(deployment_results)
```

Arguments

deployment_results	Optional deployment results returned by simulate_digital_twin().

Value

A ggplot object showing the requested CRBHSF diagnostic, performance, risk, or intervention summary. The plot can be printed, modified, or saved using standard ggplot2 functions.

plot_risk_distribution *Plot risk distribution*

Description

Plot risk distribution

Usage

```
plot_risk_distribution(data, risk_col = "risk_crbhsf")
```

Arguments

data	A data frame.
risk_col	Character string giving the column name.

Value

A ggplot object showing the requested CRBHSF diagnostic, performance, risk, or intervention summary. The plot can be printed, modified, or saved using standard ggplot2 functions.

run_ablation_study *Run CRBHSF ablation study*

Description

Evaluates the incremental predictive contribution of multiple surveillance risk scores by calculating validation metrics for each score against a common binary outcome.

Usage

```
run_ablation_study(
  data,
  outcome_col,
  score_cols = c("risk_bayes", "latent_trust", "crpr", "risk_crbhsf")
)
```

Arguments

data	A data frame containing the outcome and score columns.
outcome_col	Character string giving the binary outcome column.
score_cols	Character vector giving the surveillance score columns to evaluate. Defaults to risk_bayes, latent_trust, crpr, and risk_crbhsf.

Value

A tibble containing validation metrics for each score column, including sample size, event count, event rate, AUC, and Brier score.

simulate_digital_twin *Simulate digital-twin deployment*

Description

Simulate digital-twin deployment

Usage

```
simulate_digital_twin(
  data,
  outcome_col,
  score_col,
  capacity = 0.1,
  intervention_effect = 0.6,
  miss_cost = 15,
  review_cost = 1
)
```

Arguments

`data`	A data frame containing outcome and score columns.
`outcome_col`	Character string giving the binary deterioration outcome column.
`score_col`	Character string giving the risk score column used for prioritisation.
`capacity`	Proportion of observations selected for review.
`intervention_effect`	Proportion of reviewed deterioration events assumed preventable.
`miss_cost`	Cost assigned to a missed deterioration event.
`review_cost`	Cost assigned to each review.

Value

A tibble summarising reviews, prevented deteriorations, losses, and loss reduction.

`validate_surveillance` *Validate surveillance score*

Description

Validate surveillance score

Usage

```
validate_surveillance(data, outcome_col, score_col)
```

Arguments

`data`	A data frame containing the outcome and score columns.
`outcome_col`	Character string giving the binary outcome column.
`score_col`	Character string giving the risk score column.

Value

A tibble containing sample size, event count, event rate, AUC, and Brier score.

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