

Package ‘evprof’

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Title Electric Vehicle Charging Sessions Profiling and Modelling

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Description Tools for modelling electric vehicle charging sessions into generic groups with similar connection patterns called “user profiles”, using Gaussian Mixture Models clustering. The clustering and profiling methodology is described in Cañigueral and Meléndez (2021, ISBN:0142-0615) <[doi:10.1016/j.ijepes.2021.107195](https://doi.org/10.1016/j.ijepes.2021.107195)>.

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URL <https://github.com/mcanigueral/evprof/>,
<https://mcanigueral.github.io/evprof/>

BugReports <https://github.com/mcanigueral/evprof/issues>

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choose_k_GMM

Visualize BIC indicator to choose the number of clusters

Description

The Bayesian Information Criterion (BIC) is the value of the maximized loglikelihood with a penalty on the number of parameters in the model, and allows comparison of models with differing parameterizations and/or differing numbers of clusters. In general the larger the value of the BIC, the stronger the evidence for the model and number of clusters (see, e.g. Fraley and Raftery 2002a).

Usage

```
choose_k_GMM(
  sessions,
  k,
  mclust_tol = 1e-08,
  mclust_itmax = 10000,
  log = FALSE,
  start = getOption("evprof.start.hour")
)
```

Arguments

sessions	tibble, sessions data set in evprof standard format .
k	sequence with the number of clusters, for example 1:10, for 1 to 10 clusters.
mclust_tol	tolerance parameter for clustering
mclust_itmax	maximum number of iterations
log	logical, whether to transform ConnectionStartDateTime and ConnectionHours variables to natural logarithmic scale (base = exp(1)).
start	integer, start hour in the x axis of the plot.

Value

BIC plot

Examples

```
choose_k_GMM(california_ev_sessions, k = 1:4, start = 3)
```

cluster_sessions

Cluster sessions with mclust package

Description

Cluster sessions with mclust package

Usage

```
cluster_sessions(
  sessions,
  k,
  seed,
  mclust_tol = 1e-08,
  mclust_itmax = 10000,
```

```

    log = FALSE,
    start = getOption("evprof.start.hour")
  )

```

Arguments

sessions	tibble, sessions data set in evprof standard format .
k	number of clusters
seed	random seed
mclust_tol	tolerance parameter for clustering
mclust_itmax	maximum number of iterations
log	logical, whether to transform ConnectionStartDateTime and ConnectionHours variables to natural logarithmic scale (base = exp(1)).
start	integer, start hour in the x axis of the plot.

Value

list with two attributes: sessions and models

Examples

```

library(dplyr)

# Select working day sessions (`Timecycle == 1`) that
# disconnect the same day (`Disconnection == 1`)
sessions_day <- california_ev_sessions %>%
  divide_by_timecycle(
    months_cycles = list(1:12), # Not differentiation between months
    wdays_cycles = list(1:5, 6:7) # Differentiation between workdays/weekends
  ) %>%
  divide_by_disconnection(
    division_hour = 10, start = 3
  ) %>%
  filter(
    Disconnection == 1, Timecycle == 1
  ) %>%
  sample_frac(0.05)
plot_points(sessions_day, start = 3)

# Identify two clusters
sessions_clusters <- cluster_sessions(
  sessions_day, k=2, seed = 1234, log = TRUE
)

# The column `Cluster` has been added
names(sessions_clusters$sessions)
plot_points(sessions_clusters$sessions) +
  ggplot2::aes(color = Cluster)

```

cut_sessions	<i>Cut outliers based on minimum and maximum limits of ConnectionHours and ConnectionStartTime variables</i>
--------------	--

Description

Cut outliers based on minimum and maximum limits of ConnectionHours and ConnectionStartTime variables

Usage

```
cut_sessions(
  sessions,
  connection_hours_min = NA,
  connection_hours_max = NA,
  connection_start_min = NA,
  connection_start_max = NA,
  log = FALSE,
  start = getOption("evprof.start.hour")
)
```

Arguments

sessions	tibble, sessions data set in evprof standard format .
connection_hours_min	numeric, minimum of connection hours (duration). If NA the minimum value is considered.
connection_hours_max	numeric, maximum of connection hours (duration). If NA the maximum value is considered.
connection_start_min	numeric, minimum hour of connection start (hour as numeric). If NA the minimum value is considered.
connection_start_max	numeric, maximum hour of connection start (hour as numeric). If NA the maximum value is considered.
log	logical, whether to transform ConnectionStartTime and ConnectionHours variables to natural logarithmic scale (base = $\exp(1)$).
start	integer, start hour in the x axis of the plot.

Value

session dataframe

Examples

```

library(dplyr)
# Localize the outlying sessions above a certain threshold
california_ev_sessions %>%
  sample_frac(0.05) %>%
  plot_points(start = 3)

# For example sessions that start before 5 AM or that are
# longer than 20 hours are considered outliers
sessions_clean <- california_ev_sessions %>%
  sample_frac(0.05) %>%
  cut_sessions(
    start = 3,
    connection_hours_max = 20,
    connection_start_min = 5
  )
plot_points(sessions_clean, start = 3)

```

define_clusters	<i>Define each cluster with a user profile interpretation</i>
-----------------	---

Description

Every cluster has a centroid (i.e. average start time and duration) that can be related to a daily human behaviour or connection pattern (e.g. Worktime, Dinner, etc.). In this function, a user profile name is assigned to every cluster.

Usage

```

define_clusters(
  models,
  interpretations = NULL,
  profile_names = NULL,
  log = FALSE
)

```

Arguments

models	tibble, parameters of the clusters' GMM models obtained with function <code>cluster_sessions()</code> (object models of the returned list)
interpretations	character vector with interpretation sentences of each cluster (arranged by cluster number)
profile_names	character vector with user profile assigned to each cluster (arranged by cluster number)
log	logical, whether to transform <code>ConnectionStartDateTime</code> and <code>ConnectionHours</code> variables to natural logarithmic scale (base = <code>exp(1)</code>).

Value

tibble object

Examples

```
library(dplyr)

# Select working day sessions (`Timecycle == 1`) that
# disconnect the same day (`Disconnection == 1`)
sessions_day <- california_ev_sessions %>%
  divide_by_timecycle(
    months_cycles = list(1:12), # Not differentiation between months
    wdays_cycles = list(1:5, 6:7) # Differentiation between workdays/weekends
  ) %>%
  divide_by_disconnection(
    division_hour = 10, start = 3
  ) %>%
  filter(
    Disconnection == 1, Timecycle == 1
  ) %>%
  sample_frac(0.05)
plot_points(sessions_day, start = 3)

# Identify two clusters
sessions_clusters <- cluster_sessions(
  sessions_day, k=2, seed = 1234, log = TRUE
)

# Plot the clusters found
plot_bivarGMM(
  sessions = sessions_clusters$sessions,
  models = sessions_clusters$models,
  log = TRUE, start = 3
)

# Define the clusters with user profile interpretations
define_clusters(
  models = sessions_clusters$models,
  interpretations = c(
    "Connections during working hours",
    "Connections during all day (high variability)"
  ),
  profile_names = c("Workers", "Visitors"),
  log = TRUE
)
```

Description

Detect outliers

Usage

```
detect_outliers(
  sessions,
  MinPts = NULL,
  eps = NULL,
  noise_th = 2,
  log = FALSE,
  start = getOption("evprof.start.hour")
)
```

Arguments

sessions	tibble, sessions data set in evprof standard format .
MinPts	MinPts parameter for DBSCAN clustering
eps	eps parameter for DBSCAN clustering
noise_th	noise threshold
log	logical, whether to transform ConnectionStartDateTime and ConnectionHours variables to natural logarithmic scale (base = exp(1)).
start	integer, start hour in the x axis of the plot.

Value

sessions tibble with extra boolean column `Outlier`

Examples

```
library(dplyr)
sessions_outliers <- california_ev_sessions %>%
  sample_frac(0.05) %>%
  detect_outliers(start = 3, noise_th = 5, eps = 2.5)
```

divide_by_disconnection

Divide sessions by disconnection day

Description

Divide sessions by disconnection day

Usage

```
divide_by_disconnection(  
  sessions,  
  division_hour,  
  start = getOption("evprof.start.hour")  
)
```

Arguments

`sessions` tibble, sessions data set in evprof **standard format**.

`division_hour` Hour to divide the groups according to disconnection time

`start` integer, start hour in the x axis of the plot.

Value

same sessions data set with extra column "Disconnection"

Examples

```
library(dplyr)  
sessions_disconnection <- california_ev_sessions %>%  
  sample_frac(0.05) %>%  
  divide_by_disconnection(  
    start = 2, division_hour = 5  
  )  
  
# The column `Disconnection` has been added  
names(sessions_disconnection)  
  
library(ggplot2)  
sessions_disconnection %>%  
  tidyr::drop_na() %>%  
  plot_points() +  
  facet_wrap(vars(Disconnection))
```

divide_by_timecycle *Divide sessions by time-cycle*

Description

Divide sessions by time-cycle

Usage

```
divide_by_timecycle(
  sessions,
  months_cycles = list(1:12),
  wdays_cycles = list(1:5, 6:7),
  start = getOption("evprof.start.hour")
)
```

Arguments

`sessions` tibble, sessions data set in evprof **standard format**.
`months_cycles` list containing Monthly cycles
`wdays_cycles` list containing Weekdays cycles
`start` integer, start hour in the x axis of the plot.

Value

same sessions data set with extra column "Timecycle"

Examples

```
library(dplyr)
sessions_timecycles <- california_ev_sessions %>%
  sample_frac(0.05) %>%
  divide_by_timecycle(
    months_cycles = list(1:12),
    wdays_cycles = list(1:5, 6:7)
  )

# The column `Timecycle` has been added
names(sessions_timecycles)

library(ggplot2)
plot_points(sessions_timecycles) +
  facet_wrap(vars(Timecycle))
```

drop_outliers

Drop outliers

Description

Drop outliers

Usage

```
drop_outliers(sessions)
```

Arguments

sessions tibble, sessions data set in evprof **standard format**.

Value

sessions without outliers nor column `Outlier`

Examples

```
library(dplyr)
sessions_outliers <- california_ev_sessions %>%
  sample_frac(0.05) %>%
  detect_outliers(start = 3, noise_th = 5, eps = 2.5)

plot_outliers(sessions_outliers, start = 3)

sessions_clean <- drop_outliers(sessions_outliers)

plot_points(sessions_clean, start = 3)
```

`get_charging_rates_distribution`

Get charging rates distribution in percentages

Description

Get charging rates distribution in percentages

Usage

```
get_charging_rates_distribution(sessions, unit = "year")
```

Arguments

sessions tibble, sessions data set in evprof **standard format**.
unit character, lubridate floor_date unit parameter

Value

tibble

Examples

```
get_charging_rates_distribution(california_ev_sessions, unit="month")
get_charging_rates_distribution(california_ev_sessions, unit="month")
```

get_connection_models *Get a tibble of connection GMM for every user profile*

Description

Get a tibble of connection GMM for every user profile

Usage

```
get_connection_models(
  subsets_clustering = list(),
  clusters_definition = list()
)
```

Arguments

`subsets_clustering`
list with clustering results of each subset (direct output from function `cluster_sessions()`)

`clusters_definition`
list of tibbles with clusters definitions (direct output from function `define_clusters()`) of each sub-set

Value

tibble

Examples

```
library(dplyr)

# Select working day sessions (`Timecycle == 1`) that
# disconnect the same day (`Disconnection == 1`)
sessions_day <- california_ev_sessions %>%
  divide_by_timecycle(
    months_cycles = list(1:12), # Not differentiation between months
    wdays_cycles = list(1:5, 6:7) # Differentiation between workdays/weekends
  ) %>%
  divide_by_disconnection(
    division_hour = 10, start = 3
  ) %>%
  filter(
    Disconnection == 1, Timecycle == 1
  ) %>%
  sample_frac(0.05)
plot_points(sessions_day, start = 3)

# Identify two clusters
sessions_clusters <- cluster_sessions(
  sessions_day, k=2, seed = 1234, log = TRUE
```

```

)

# Plot the clusters found
plot_bivarGMM(
  sessions = sessions_clusters$sessions,
  models = sessions_clusters$models,
  log = TRUE, start = 3
)

# Define the clusters with user profile interpretations
clusters_definitions <- define_clusters(
  models = sessions_clusters$models,
  interpretations = c(
    "Connections during working hours",
    "Connections during all day (high variability)"
  ),
  profile_names = c("Workers", "Visitors"),
  log = TRUE
)

# Create a table with the connection GMM parameters
get_connection_models(
  subsets_clustering = list(sessions_clusters),
  clusters_definition = list(clusters_definitions)
)

```

```
get_daily_avg_n_sessions
```

Get the daily average number of sessions given a range of years, months and weekdays

Description

Get the daily average number of sessions given a range of years, months and weekdays

Usage

```
get_daily_avg_n_sessions(sessions, years, months, wdays)
```

Arguments

sessions	tibble, sessions data set in evprof standard format .
years	vector of integers, range of years to consider
months	vector of integers, range of months to consider
wdays	vector of integers, range of weekdays to consider

Value

tibble with the number of sessions of each date in the given time period

Examples

```
get_daily_avg_n_sessions(  
  california_ev_sessions,  
  year = 2018, months = c(5, 6), wdays = 1  
)
```

get_daily_n_sessions *Get daily number of sessions given a range of years, months and weekdays*

Description

Get daily number of sessions given a range of years, months and weekdays

Usage

```
get_daily_n_sessions(sessions, years, months, wdays)
```

Arguments

sessions	tibble, sessions data set in evprof standard format .
years	vector of integers, range of years to consider
months	vector of integers, range of months to consider
wdays	vector of integers, range of weekdays to consider

Value

tibble with the number of sessions of each date in the given time period

Examples

```
get_daily_n_sessions(  
  california_ev_sessions,  
  year = 2018, months = c(5, 6), wdays = 1  
)
```

get_dbscan_params	<i>Get the minPts and eps values for DBSCAN to label only a specific percentage as noise</i>
-------------------	--

Description

Get the minPts and eps values for DBSCAN to label only a specific percentage as noise

Usage

```
get_dbscan_params(
  sessions,
  MinPts,
  eps0,
  noise_th = 2,
  eps_offset_pct = 0.9,
  eps_inc_pct = 0.02,
  log = FALSE,
  start = getOption("evprof.start.hour")
)
```

Arguments

sessions	tibble, sessions data set in evprof standard format .
MinPts	DBSCAN MinPts parameter
eps0	DBSCAN eps parameter corresponding to the elbow of kNN dist plot
noise_th	noise threshold
eps_offset_pct	eps_offset_pct
eps_inc_pct	eps_inc_pct
log	logical, whether to transform ConnectionStartDateTime and ConnectionHours variables to natural logarithmic scale (base = exp(1)).
start	integer, start hour in the x axis of the plot.

Value

tibble with minPts and eps parameters, and the corresponding noise

get_energy_models	<i>Get a tibble of energy GMM for every user profile</i>
-------------------	--

Description

This function simulates random energy values, makes the density curve and overlaps the simulated density curve with the real density curve of the user profile's energy values. This is useful to appreciate how the modeled values fit the real ones and increase or decrease the number of Gaussian components.

Usage

```
get_energy_models(sessions_profiles, log = TRUE, by_power = FALSE)
```

Arguments

sessions_profiles	tibble, sessions data set in evprof standard format with user profile attribute Profile
log	logical, whether to transform ConnectionStartDateTime and ConnectionHours variables to natural logarithmic scale (base = exp(1)).
by_power	Logical, true to fit the energy models for every charging rate separately

Value

tibble

Examples

```
library(dplyr)

# Classify each session to the corresponding user profile
sessions_profiles <- california_ev_sessions_profiles %>%
  dplyr::sample_frac(0.05)

# Get a table with the energy GMM parameters
get_energy_models(sessions_profiles, log = TRUE)

# If there is a `Power` variable in the data set
# you can create an energy model per power rate and user profile
# First it is convenient to round the `Power` values for more generic models
sessions_profiles <- sessions_profiles %>%
  mutate(Power = round_to_interval(Power, 3.7)) %>%
  filter(Power < 11)
sessions_profiles$Power[sessions_profiles$Power == 0] <- 3.7
get_energy_models(sessions_profiles, log = TRUE, by_power = TRUE)
```

get_ev_model *Get the EV model object of class evmodel*

Description

Get the EV model object of class evmodel

Usage

```
get_ev_model(  
  names,  
  months_lst = list(1:12, 1:12),  
  wdays_lst = list(1:5, 6:7),  
  connection_GMM,  
  energy_GMM,  
  connection_log,  
  energy_log,  
  data_tz  
)
```

Arguments

names	character vector with the given names of each time-cycle model
months_lst	list of integer vectors with the corresponding months of the year for each time-cycle model
wdays_lst	list of integer vectors with the corresponding days of the week for each model (week start = 1)
connection_GMM	list of different connection bivariate GMM obtained from get_connection_models
energy_GMM	list of different energy univariate GMM obtained from get_energy_models
connection_log	logical, true if connection models have logarithmic transformations
energy_log	logical, true if energy models have logarithmic transformations
data_tz	character, time zone of the original data (necessary to properly simulate new sessions)

Value

object of class evmodel

Examples

```

# The package evprof provides example objects of connection and energy
# Gaussian Mixture Models obtained from California's open data set
# (see California article in package website) created with functions
# `get_connection_models` and `get_energy_models`.

# For workdays sessions
workdays_connection_models <- evprof::california_GMM$workdays$connection_models
workdays_energy_models <- evprof::california_GMM$workdays$energy_models

# For weekends sessions
weekends_connection_models <- evprof::california_GMM$weekends$connection_models
weekends_energy_models <- evprof::california_GMM$weekends$energy_models

# Get the whole model
ev_model <- get_ev_model(
  names = c("Workdays", "Weekends"),
  months_lst = list(1:12, 1:12),
  wdays_lst = list(1:5, 6:7),
  connection_GMM = list(workdays_connection_models, weekends_connection_models),
  energy_GMM = list(workdays_energy_models, weekends_energy_models),
  connection_log = TRUE,
  energy_log = TRUE,
  data_tz = "America/Los_Angeles"
)

```

plot_bivarGMM

Plot Bivariate Gaussian Mixture Models

Description

Plot Bivariate Gaussian Mixture Models

Usage

```

plot_bivarGMM(
  sessions,
  models,
  profiles_names = seq(1, nrow(models)),
  points_size = 0.25,
  lines_size = 1,
  legend_nrow = 2,
  log = FALSE,
  start = getOption("evprof.start.hour")
)

```

Arguments

sessions	tibble, sessions data set in evprof standard format .
models	tibble, parameters of the clusters' GMM models obtained with function cluster_sessions (object models of the returned list)
profiles_names	names of profiles
points_size	size of scatter points in the plot
lines_size	size of lines in the plot
legend_nrow	number of rows in legend
log	logical, whether to transform ConnectionStartDateTime and ConnectionHours variables to natural logarithmic scale (base = exp(1)).
start	integer, start hour in the x axis of the plot.

Value

ggplot2 plot

Examples

```
library(dplyr)

# Select working day sessions (`Timecycle == 1`) that
# disconnect the same day (`Disconnection == 1`)
sessions_day <- california_ev_sessions %>%
  divide_by_timecycle(
    months_cycles = list(1:12), # Not differentiation between months
    wdays_cycles = list(1:5, 6:7) # Differentiation between workdays/weekends
  ) %>%
  divide_by_disconnection(
    division_hour = 10, start = 3
  ) %>%
  filter(
    Disconnection == 1, Timecycle == 1
  ) %>%
  sample_frac(0.05)
plot_points(sessions_day, start = 3)

# Identify two clusters
sessions_clusters <- cluster_sessions(
  sessions_day, k=2, seed = 1234, log = TRUE
)

# Plot the clusters found
plot_bivarGMM(
  sessions = sessions_clusters$sessions,
  models = sessions_clusters$models,
  log = TRUE, start = 3
)
```

plot_density_2D	<i>Density plot in 2D, considering Start time and Connection duration as variables</i>
-----------------	--

Description

Density plot in 2D, considering Start time and Connection duration as variables

Usage

```
plot_density_2D(  
  sessions,  
  bins = 15,  
  by = c("wday", "month", "year"),  
  start = getOption("evprof.start.hour"),  
  log = FALSE  
)
```

Arguments

sessions	tibble, sessions data set in evprof standard format .
bins	integer, parameter to pass to <code>ggplot2::stat_density_2d</code>
by	variable to facet the plot. Character being "wday", "month" or "year", considering the week to start at wday=1.
start	integer, start hour in the x axis of the plot.
log	logical, whether to transform <code>ConnectionStartDateTime</code> and <code>ConnectionHours</code> variables to natural logarithmic scale (base = $\exp(1)$).

Value

ggplot2 plot

Examples

```
library(dplyr)  
  
california_ev_sessions %>%  
  sample_frac(0.05) %>%  
  plot_density_2D(by = "wday", start = 3, bins = 15, log = FALSE)
```

plot_density_3D	<i>Density plot in 3D, considering Start time and Connection duration as variables</i>
-----------------	--

Description

Density plot in 3D, considering Start time and Connection duration as variables

Usage

```
plot_density_3D(  
  sessions,  
  start = getOption("evprof.start.hour"),  
  eye = list(x = -1.5, y = -1.5, z = 1.5),  
  log = FALSE  
)
```

Arguments

sessions	tibble, sessions data set in evprof standard format .
start	integer, start hour in the x axis of the plot.
eye	list containing x, y and z points of view. Example: <code>list(x = -1.5, y = -1.5, z = 1.5)</code>
log	logical, whether to transform <code>ConnectionStartDateTime</code> and <code>ConnectionHours</code> variables to natural logarithmic scale (base = $\exp(1)$).

Value

plotly plot (html)

Examples

```
library(dplyr)  
california_ev_sessions %>%  
  sample_frac(0.05) %>%  
  plot_density_3D(start = 3)
```

plot_division_lines *Iteration over evprof::plot_division_line function to plot multiple lines*

Description

Iteration over evprof::plot_division_line function to plot multiple lines

Usage

```
plot_division_lines(ggplot_points, n_lines, division_hour)
```

Arguments

ggplot_points ggplot2 returned by evprof::plot_points function
n_lines number of lines to plot
division_hour Hour to divide the groups according to disconnection time

Value

ggplot2 function

Examples

```
library(dplyr)
california_ev_sessions %>%
  sample_frac(0.05) %>%
  plot_points(start = 3) %>%
  plot_division_lines(n_lines = 1, division_hour = 5)
```

plot_energy_models *Compare density of estimated energy with density of real energy vector*

Description

Compare density of estimated energy with density of real energy vector

Usage

```
plot_energy_models(energy_models, nrow = 2)
```

Arguments

energy_models energy models returned by function get_energy_models
nrow integer, number of rows in the plot grid (passed to cowplot::plot_grid)

Value

ggplot

Examples

```
# The package evprof provides example objects of connection and energy
# Gaussian Mixture Models obtained from California's open data set
# (see California article in package website) created with functions
# `get_connection_models` and `get_energy_models`.

# Get the working days energy models
energy_models <- evprof::california_GMM$workdays$energy_models

# Plot energy models
plot_energy_models(energy_models)
```

plot_histogram	<i>Histogram of a variable from sessions data set</i>
----------------	---

Description

Histogram of a variable from sessions data set

Usage

```
plot_histogram(sessions, var, binwidth = 1)
```

Arguments

sessions	tibble, sessions data set in evprof standard format .
var	character, column name to compute the histogram for
binwidth	integer, width of histogram bins

Value

ggplot plot

Examples

```
plot_histogram(california_ev_sessions, "Power", binwidth = 2)
plot_histogram(california_ev_sessions, "Power", binwidth = 0.1)
```

plot_histogram_grid *Grid of multiple variable histograms*

Description

Grid of multiple variable histograms

Usage

```
plot_histogram_grid(
  sessions,
  vars = evprof::sessions_summary_feature_names,
  binwidths = rep(1, length(vars)),
  nrow = NULL,
  ncol = NULL
)
```

Arguments

sessions	tibble, sessions data set in evprof standard format .
vars	vector of characters, variables to plot
binwidths	vector of integers, binwidths of each variable histogram. The length of the vector must correspond to the length of the vars parameter.
nrow	integer, number of rows of the plot grid
ncol	integer, number of columns of the plot grid

Value

grid plot

Examples

```
plot_histogram_grid(california_ev_sessions)
plot_histogram_grid(california_ev_sessions, vars = c("Energy", "Power"))
```

plot_kNNdist *Plot kNNdist*

Description

Plot the kNN (k-nearest neighbors) distance plot to visually detect the "elbow" and define an appropriate value for eps DBSCAN parameter.

Usage

```
plot_kNNdist(
  sessions,
  MinPts = NULL,
  log = FALSE,
  start = getOption("evprof.start.hour")
)
```

Arguments

sessions	tibble, sessions data set in evprof standard format .
MinPts	integer, DBSCAN MinPts parameter. If null, a value of 200 will be considered.
log	logical, whether to transform ConnectionStartDateTime and ConnectionHours variables to natural logarithmic scale (base = exp(1)).
start	integer, start hour in the x axis of the plot.

Details

The kNN (k-nearest neighbors) distance plot can provide insights into setting the eps parameter in DBSCAN. The "elbow" in the kNN distance plot is the point where the distances start to increase significantly. At the same time, for DBSCAN, the eps parameter defines the radius within which a specified number of points must exist for a data point to be considered a core point. Therefore, the "elbow" of the kNN distance plot can provide a sense of the scale of the data and help you choose a reasonable range for the eps parameter in DBSCAN.

Value

plot

Examples

```
library(dplyr)
california_ev_sessions %>%
  sample_frac(0.05) %>%
  plot_kNNdist(start = 3, log = TRUE)
```

plot_model_clusters	<i>Plot all bi-variable GMM (clusters) with the colors corresponding to the assigned user profile. This shows which clusters correspond to which user profile, and the proportion of every user profile.</i>
---------------------	--

Description

Plot all bi-variable GMM (clusters) with the colors corresponding to the assigned user profile. This shows which clusters correspond to which user profile, and the proportion of every user profile.

Usage

```
plot_model_clusters(
  subsets_clustering = list(),
  clusters_definition = list(),
  profiles_ratios,
  log = TRUE
)
```

Arguments

```
subsets_clustering      list with clustering results of each subset (direct output from function cluser_sessions())
clusters_definition     list of tibbles with clusters definitions (direct output from function define_clusters())
                        of each sub-set
profiles_ratios         tibble with columns profile and ratio
log                     logical, whether to transform ConnectionStartDateTime and ConnectionHours
                        variables to natural logarithmic scale (base = exp(1)).
```

Value

```
ggplot2
```

Examples

```
library(dplyr)

# Select working day sessions (~Timecycle == 1~) that
# disconnect the same day (~Disconnection == 1~)
sessions_day <- evprof::california_ev_sessions_profiles %>%
  filter(Timecycle == "Workday") %>%
  sample_frac(0.05)
plot_points(sessions_day, start = 3)

# Identify two clusters
sessions_clusters <- cluster_sessions(
  sessions_day, k=2, seed = 1234, log = TRUE
)

# Plot the clusters found
plot_bivarGMM(
  sessions = sessions_clusters$sessions,
  models = sessions_clusters$models,
  log = TRUE, start = 3
)

# Define the clusters with user profile interpretations
clusters_definitions <- define_clusters(
  models = sessions_clusters$models,
```

```

    interpretations = c(
      "Connections during all day (high variability)",
      "Connections during working hours"##'
    ),
    profile_names = c("Visitors", "Workers"),
    log = TRUE
  )

# Create a table with the connection GMM parameters
connection_models <- get_connection_models(
  subsets_clustering = list(sessions_clusters),
  clusters_definition = list(clusters_definitions)
)

# Plot all bi-variable GMM (clusters) with the colors corresponding
# to their assigned user profile
plot_model_clusters(
  subsets_clustering = list(sessions_clusters),
  clusters_definition = list(clusters_definitions),
  profiles_ratios = connection_models[c("profile", "ratio")]
)

```

plot_outliers

Plot outlying sessions

Description

Plot outlying sessions

Usage

```

plot_outliers(
  sessions,
  start = getOption("evprof.start.hour"),
  log = FALSE,
  ...
)

```

Arguments

sessions	tibble, sessions data set in evprof standard format .
start	integer, start hour in the x axis of the plot.
log	logical, whether to transform ConnectionStartDateTime and ConnectionHours variables to natural logarithmic scale (base = exp(1)).
...	arguments to pass to function ggplot2::plot_point

Value

ggplot2 plot

Examples

```
library(dplyr)
sessions_outliers <- california_ev_sessions %>%
  sample_frac(0.05) %>%
  detect_outliers(start = 3, noise_th = 5, eps = 2.5)
plot_outliers(sessions_outliers, start = 3)
plot_outliers(sessions_outliers, start = 3, log = TRUE)
```

plot_points

Scatter plot of sessions

Description

Scatter plot of sessions

Usage

```
plot_points(sessions, start = getOption("evprof.start.hour"), log = FALSE, ...)
```

Arguments

sessions	tibble, sessions data set in evprof standard format .
start	integer, start hour in the x axis of the plot.
log	logical, whether to transform ConnectionStartDateTime and ConnectionHours variables to natural logarithmic scale (base = exp(1)).
...	arguments to ggplot2::geom_point function

Value

ggplot scatter plot

Examples

```
library(dplyr)
california_ev_sessions %>%
  sample_frac(0.05) %>%
  plot_points()
california_ev_sessions %>%
  sample_frac(0.05) %>%
  plot_points(start = 3)
california_ev_sessions %>%
  sample_frac(0.05) %>%
  plot_points(log = TRUE)
```

read_ev_model	<i>Read an EV model JSON file and convert it to object of class evmodel</i>
---------------	---

Description

Read an EV model JSON file and convert it to object of class evmodel

Usage

```
read_ev_model(file)
```

Arguments

file path to the JSON file

Value

object of class evmodel

Examples

```
ev_model <- california_ev_model # Model of example  
save_ev_model(ev_model, file = file.path(tempdir(), "evmodel.json"))  
read_ev_model(file = file.path(tempdir(), "evmodel.json"))
```

round_to_interval	<i>Round to nearest interval</i>
-------------------	----------------------------------

Description

Round to nearest interval

Usage

```
round_to_interval(dbl, interval)
```

Arguments

dbl number to round
interval rounding interval

Value

numeric value

Examples

```
set.seed(1)
random_vct <- rnorm(10, 5, 5)
round_to_interval(random_vct, 2.5)
```

```
save_clustering_iterations
```

Save iteration plots in PDF file

Description

Save iteration plots in PDF file

Usage

```
save_clustering_iterations(
  sessions,
  k,
  filename,
  it = 12,
  seeds = round(runif(it, min = 1, max = 1000)),
  plot_scale = 2,
  points_size = 0.25,
  mclust_tol = 1e-08,
  mclust_itmax = 10000,
  log = FALSE,
  start = getOption("evprof.start.hour")
)
```

Arguments

sessions	tibble, sessions data set in evprof standard format .
k	number of clusters
filename	string defining the PDF output file path (with extension .pdf)
it	number of iterations
seeds	seed for each iteration
plot_scale	scale of each iteration plot for a good visualization in pdf file
points_size	integer, size of points in the scatter plot
mclust_tol	tolerance parameter for clustering
mclust_itmax	maximum number of iterations
log	logical, whether to transform ConnectionStartDateTime and ConnectionHours variables to natural logarithmic scale (base = exp(1)).
start	integer, start hour in the x axis of the plot.

Value

nothing, but a PDF file is saved in the path specified by parameter filename

Examples

```
temp_file <- file.path(tempdir(), "iteration.pdf")
save_clustering_iterations(california_ev_sessions, k = 2, it = 4, filename = temp_file)
```

save_ev_model	<i>Save the EV model object of class evmodel to a JSON file</i>
---------------	---

Description

Save the EV model object of class evmodel to a JSON file

Usage

```
save_ev_model(evmodel, file)
```

Arguments

evmodel	object of class evmodel (see this link for more information)
file	character string with the path or name of the file

Value

nothing but saves the evmodel object in a JSON file

Examples

```
ev_model <- california_ev_model # Model of example
save_ev_model(ev_model, file = file.path(tempdir(), "evmodel.json"))
```

set_profiles	<i>Classify sessions into user profiles</i>
--------------	---

Description

Joins all sub-sets from the list, adding a new column Profile

Usage

```
set_profiles(sessions_clustered = list(), clusters_definition = list())
```

Arguments

`sessions_clustered`
list of tibbles with sessions clustered (sessionsobject of the output from function `cluster_sessions()`) from each sub-set

`clusters_definition`
list of tibbles with clusters definitions (direct output from function `define_clusters()`) of each sub-set

Value

tibble

Examples

```
library(dplyr)

# Select working day sessions (`Timecycle == 1`) that
# disconnect the same day (`Disconnection == 1`)
sessions_day <- california_ev_sessions %>%
  divide_by_timecycle(
    months_cycles = list(1:12), # Not differentiation between months
    wdays_cycles = list(1:5, 6:7) # Differentiation between workdays/weekends
  ) %>%
  divide_by_disconnection(
    division_hour = 10, start = 3
  ) %>%
  filter(
    Disconnection == 1, Timecycle == 1
  ) %>%
  sample_frac(0.05)

# Identify two clusters
sessions_clusters <- cluster_sessions(
  sessions_day, k=2, seed = 1234, log = TRUE
)

# Plot the clusters found
```



```

plot_bivarGMM(
  sessions = sessions_clusters$sessions,
  models = sessions_clusters$models,
  log = TRUE, start = 3
)

# Define the clusters with user profile interpretations
clusters_definitions <- define_clusters(
  models = sessions_clusters$models,
  interpretations = c(
    "Connections during working hours",
    "Connections during all day (high variability)"
  ),
  profile_names = c("Workers", "Visitors"),
  log = TRUE
)

# Classify each session to the corresponding user profile
sessions_profiles <- set_profiles(
  sessions_clustered = list(sessions_clusters$sessions),
  clusters_definition = list(clusters_definitions)
)

```

summarise_sessions	<i>Statistic summary of sessions features</i>
--------------------	---

Description

Statistic summary of sessions features

Usage

```

summarise_sessions(
  sessions,
  .funs,
  vars = evprof::sessions_summary_feature_names
)

```

Arguments

sessions	tibble, sessions data set in evprof standard format . standard format .
.funs	A function to compute, e.g. mean, max, etc.
vars	character vector, variables to compute the histogram for

Value

Summary table

Examples

```
summarise_sessions(california_ev_sessions, mean)
```

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