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# Bins

Calculates the optimal binning split points for rasc . The optimal split points calculated by Bins are mathematically proven global optimal analytical solutions. For categorical variables, including ordered and unordered categories, mathematically proven global optimal analytical solutions can also be calculated. Its main functions are:

1. Find the global optimal solution with or without constraints. Supported constraints: monotonic constraints (automatically determine increasing or decreasing), monotonically decreasing constraints, monotonically increasing constraints, U-shaped constraints (automatically determine convex or concave), and automatically determined constraints (monotonically increasing, monotonically decreasing, convex U-shaped, concave U-shaped).
2. Find the global optimal solution for ordered categorical variables under unconstrained and constrained conditions.
3. Use "Minimum Difference in Event Rates Between Adjacent Bins" instead of "Information Gain" or "Chi-Square Value" to prevent the formation of bins with too small differences. This allows users to intuitively understand the size of the differences between bins. This feature is also supported for categorical variables.
4. Do not replace the minimum value of the first bin with negative infinity, nor the maximum value of the last bin with positive infinity. This ensures that outliers are not masked by extending extreme values to infinity. RiskActuarialScoreCard also provides a comprehensive mechanism to handle online values exceeding modeling boundaries. This resolves the common conflict between the need to detect outliers as early as possible during data analysis and the need to mask them in online applications (to ensure that the process is not interrupted but to issue timely alerts).
5. Introduce the concept of wildcards to solve the problem that the online values of categorical variables exceed the modeling value range.
6. Support multi-process parallel computing.
7. Support binning of weighted samples.
8. Support special value merging.

In most cases, users do not need to interact directly with the Bins module. The ScoreCard module automatically calls the Bins module based on the configuration file. However, because RiskActuarialScoreCard

is a pluggable component, advanced users can use the Bins module independently, just like any other Python module.

## Functions

### `_x1OptBin`

```
_x1OptBin(x_dats,y_dats,y_label=None,weight_dats=None,train_name=None,
mono='N',sgst_mono=None,distr_min=0.02,rate_gain_min=0.001,bin_cnt_max=None,
spec_value=[],spec_distr_min=None,default_spec_distr_min=None,
spec_comb_policy={},default_spec_comb_policy='N',
is_cate=False,is_order=False,no_wild_treat='M',
order_list=None,unorder_combine_thv=None,
cust_bin=None,optBin_prcs=2)
```

Performs global optimal binning on a variable. Supports multiple features, please refer to the introduction of [Bins](#) module

Parameters

-----

`x_dats` : Series or dict<dat\_name, Series>. Required

A column of variables or the same column of variables belonging to different data sets

There are a few points to note:

1. When `mono='A'`, rasc automatically selects a monotonicity constraint from L+, L-, Uu, and Un. When automatically selecting a constraint, it verifies the correctness of the constraint using different data sets.
2. If the user has already calculated the monotonicity of the suggestion elsewhere, the result can be passed directly to the `_x1OptBin` function via the parameter `sgst_mono`. When `mono='A'` is set, the calculation will not be repeated, wasting the user's waiting time.

According to the above description: If `mono='A'` and `sgst_mono` is None, the type of `x_dats` must be dict for calculating and verifying the monotonic trend. In other cases, the type of `x_dats` can be Series or dict

`y_dats` : Series or dict<dat\_name, Series>. Required

The actual target. For details on when to pass in a Series or dict, see `x_dats`. Its type must be consistent with `x_dats`.

`y_label` : dict

Define which value in `y` means the event has occurred, and which value means the event has not occurred.

The value of keys can only be `unevent` or `event`

The value of values should be filled in according to the value of `y`

Example: `{'unevent': 'good', 'event': 'bad'}`

Generally, defining the things users care about most as events is easier to explain. For example, if you want to emphasize the incidence of lung cancer, you can say that smokers have a 50% higher incidence of lung cancer than non-smokers. In this case, you can write `{'unevent': 'No lung cancer', 'event': 'Lung cancer'}`. If you write `{'unevent': 'Lung cancer', 'event': 'No lung cancer'}`, although it does not affect the use of the model, the explanation will become that smokers have a 50% lower incidence of lung cancer than non-smokers. Obviously, the first expression is easier to understand.

Default: `None`

The meaning of `None` is equivalent to `{'unevent': 0, 'event': 1}`.

`weight_dats` : Series or dict<dat\_name, Series>

The weight of the sample. Samples with weights can also solve the global optimal binning point.

`None`: All weights are 1

When it is not `None`, you can refer to `x_dats` to see when to pass in Series or dict. Its type must be consistent with

`x_dats`

Default: `None`

`train_name` : str or `None`

When `mono='A'` and `sgst_mono=None`, this parameter specifies which dataset in `x_dats` is used to calculate the monotonicity trend. All datasets except the one corresponding to `train_name` are used to verify the calculated monotonicity trend.

Default: `None`

If `x_dats` is a dict, `train_name` cannot be `None`.

`mono` : str

Monotonicity constraints for globally optimal binning.

Value range:

N: IV value is the highest globally, no constraints

A: Automatically select a constraint from L+, L-, Uu, Un. Under this constraint, the IV value is the highest globally.

L: The highest IV value globally under linear monotonic constraints (automatically determines L+, L-)

L+: The IV value is globally the highest under the linear monotonically increasing constraint

L-: The IV value is globally the highest under the linear monotonically decreasing constraint

U: The highest IV value globally under U-type constraints (automatically determines Uu, Un)

Default: 'N'.

`sgst_mono:tuple(str,**)`

Tuple (monotonicity constraint, some backward compatibility information). The first element of the tuple is the recommended constraint: possible values are L+, L-, Uu, and Un. The remaining elements are some built-in extended information.

Recommended constraint: if mono is set to 'A' and `sgst_mono` is not None, rasc automatically sets mono to the first element of `sgst_mono` to avoid repeated calculations.

When using rasc automation, this parameter can be used to avoid repeated calculations through internal mechanisms. When using the Bins module alone, `sgst_mono` can directly use the default value.

Default: None

`distr_min : float`

Minimum distribution ratio for each bin

None: Do not set a minimum distribution ratio for each box of the variable

Note: Setting the minimum distribution ratio for a bin is not necessary to find the global optimal split point, but is determined by the user's confidence in the stability of the bin. If there are very few sample points in a bin, the random fluctuation of its event rate may be relatively large, resulting in relatively large model fluctuations.

Default: 0.02.

`rate_gain_min : float`

The event rate between any two adjacent bins cannot be less than `rate_gain_min`. Some software packages often

use information gain or chi-square value to suppress the formation of bins with too small differences. However, these parameters do not have a specific and intuitive concept for users, and it is impossible to infer how small the difference is. Therefore, the event rate is used here as an intuitive indicator to suppress the formation of bins with too small differences.

Default: 0.001.

`bin_cnt_max` : float

The maximum number of bins for a variable. Bins for special values are not counted. If a special value is merged into a bin for a normal value due to a merging rule, the merged bin is a normal bin.

Because you can specify parameters such as the monotonicity of the variable, the minimum bin ratio, and the minimum difference in event rates, these parameters can automatically adjust the number of bins (usually the better the variable effect and the more evenly distributed it is, the more bins there are, and vice versa), so usually this parameter can be set to None.

If the variables are evenly distributed and well-ordered, the number of bins may be large. Although this is in line with the actual situation, users can also specify the maximum number of bins allowed for certain business considerations.

None: Do not set the maximum number of bins for the variable

Default: None.

`spec_value` : list

Special value range

Example. [{"-9997"},"{-9999,-9998}"]

"{... , ...}" will not be parsed into a set, but will be processed as a string. {} in special values represents a discrete value space symbol.

Let's take an example to explain the meaning of the expression:

"{-9997}": When the variable value is -9997, a special meaning is assigned. For example, for the number of court executions, -9997 might mean that the ID card is not in the citizen database, rather than that it has been executed -9997 times. Through this example, users can clearly see the difference in meaning between -9997 and values like 0, 1, and 2.

"{-9998,-9999}": When a variable takes on the value -9998 or -9999, it has a special meaning. Although these two

meanings are different, for the business being modeled, they can be treated as the same and handled according to the same business logic. For example, when collecting data, data not collected due to Party A's fault is marked as -9998, while data not collected due to Party B's fault is marked as -9999. However, for the business, both values indicate randomly missing data, so they are handled according to the logic of randomly missing data. This preserves the original data's value conventions for retrospective use and saves users from the additional code required to process data.

"{None}" is a special value that means it's a null value. {None} is used instead of words like {miss} because the mechanisms for generating null values and missing values are sometimes different. Missing values represent missing data due to reasons beyond human control during the sampling process, such as a network outage or equipment failure during data transmission. This is a form of missing at random. Null values can also be caused by non-information missingness, such as a lack of loan history, a health checkup not required, or temperatures too low for equipment to collect. Null values themselves contain information. Avoid combining informative null values with missing at random null values into a single special value.

If a variable is not configured with an empty special value, but contains an empty value, a {None} group is automatically generated to contain the empty value of the variable.

default:[].

spec\_distr\_min : dict

Specify a minimum percentage for each special value of the variable. If the distribution percentage of a special value bin is less than the value specified by `spec_distr_min`, the special value bin will be merged with other bins. For specific merging rules, see the `spec_comb_policy` setting. For special values that are not covered, `default_spec_distr_min` is used.

None: Do not set a minimum distribution percentage for any special value of the variable. If `default_spec_distr_min` is also set to None, no limit is imposed on the minimum distribution percentage of special value bins.

Default: None.

default\_spec\_distr\_min : float

If the special value of a variable is not configured in `spec_distr_min`, the default minimum distribution ratio of the special value

None: Do not set the default value for the minimum proportion of special value distribution.

Default: None.

spec\_comb\_policy : dict

When the proportion of special values of a variable is less than the threshold specified by  $\text{\$}\{\text{spec\_distr\_min}\}$ , the merging strategy to be adopted can be:

A:auto finds the closest eventProb among all values

a:auto only finds the closest eventProb among non-special values

F:first merges with the first bin of non-special values

L:last merges with the last bin of non-special values

M:median merges with the middle bin of non-special values (if there are an even number of bins, merge with the bin with the high event rate)

m:median merges with the middle bin of non-special values (if there are an even number of bins, merge with the bin with the lowest event rate)

B: max Probability is merged with the bin with the largest eventProb

S:min Probability merges with the bin with the smallest eventProb

N: Do not merge

If there is a special value that is not covered,  $\text{\$}\{\text{default\_spec\_comb\_policy}\}$  is used.

ex.  $\{\text{"{-9997}":L, \text{"{-9998,-9999}":N}\}$

Note: The following example explains the meaning of special value writing:  $\{\text{"{-9997}":L, \text{"{-9998,-9999}":N}\}$  means: there are three special values -9997, -9998, and -9999 in the variable. According to the business meaning, they are divided into two business groups  $\{\text{"{-9997}"}\}$  and  $\{\text{"{-9998,-9999}"}\}$ . -9997 itself becomes a business group, and -9998 and -9999 form a business group. Since the two business groups  $\{\text{"{-9997}"}\}$  and  $\{\text{"{-9998,-9999}"}\}$  meet the special value merging rules set during binning, they are forcibly merged together at the data level to form a bin  $\{\text{"{-9997}":L, \text{"{-9998,-9999}":N}\}$ . This type of consolidation differs from consolidating -9998 and -9999 into a single business group. The consolidation described in the business group context is at the business level, determined based on business understanding. The consolidation of  $\{\text{"{-9997}":L, \text{"{-9998,-9999}":N}\}$  is at the data level, determined solely by calculating event rates. It's important to understand the process and underlying meaning behind how the three special values -9997, -9998, and -9999 become the two special value business groups  $\{\text{"{-9997}"}\}$ ,  $\{\text{"{-9998,-9999}"}\}$ , and finally become the single special value consolidation bin  $\{\text{"{-9997}":L, \text{"{-9998,-9999}":N}\}$ .

[{"-9997"},"{-9998,-9999}"]. This approach to handling special values adheres to statistical principles.

default:{}.

default\_spec\_comb\_policy : str

When  $\text{\$}\{\text{spec\_comb\_policy}\}$  does not contain a special value, the default merge policy of the special value

For the value range, see  $\text{\$}\{\text{spec\_comb\_policy}\}$

Default: 'N'.

is\_cate : bool

Indicates whether the variable is categorical.

True: Categorical variable

False: continuous variable

Default: False.

is\_order : bool

Indicates whether the variable is an ordered categorical variable.

If  $\text{is\_order}=\text{True}$ ,  $\text{is\_cate}$  will be automatically set to True

True: ordered categories

False: When  $\text{is\_cate}=\text{True}$ , it is an unordered category, and the unordered category will be globally optimally binned according to the order of event incidence.

Default: False.

no\_wild\_treat : str

When a categorical variable does not have a wildcard and uncovered categories appear, the following processing methods are used:

L: Considered equal to the lowest category in the order

H: Considered equal to the highest order category

M: Considered equal to the middle category of the sequence (the larger value is taken when the number is even)

m: Considered equal to the middle category of the sequence (smaller value if even)

None: No processing is performed on uncovered categories that appear in the variable

Default: 'M'

order\_list : tuple

Sets the order of each value in the ordered categorical variable. The order of the tuple is the nominal order. If is\_order=True and order\_list=None, the lexicographic order of the characters is used as the order.

For ordered variables, adjacent nominal sequences can only appear within the same bin or at the beginning and end of adjacent bins.

If the nominal order is inconsistent with the event rate order, you can decide for yourself whether to configure the variable as an ordered variable or an unordered variable based on the business situation.

Supports globally optimal binning for ordered variables.

All categories that do not appear in the configuration (excluding special values) are collectively called wildcard categories, denoted by \*\*. Values not covered in the training set may be seen in other datasets, and these categories are also included in the wildcard category.

When lexicographic order is used as the order, there is no wildcard category

Example: ("v1", "\*\*", "v2")

Default: None.

unorder\_combine\_thv : float

Set a threshold for unordered categorical variables and merge categories with distribution proportions less than the threshold into wildcard categories. If is\_cate=True and unorder\_combine\_thv=None, categories with too low frequency of the variable will not be wildcarded.

In other data sets, it is possible to see values that are not covered in the training set, and these categories are also put into the wildcard category.

Default: None.

cust\_bin : list

User-defined binning.

Example: [['1.0,3.0'],[6.0,9.0],[3.0,6.0],[-999,-888],[-997],[9.0,10.0],[-1000,None]]. The values do not need to be written in the order they appear.

Default: None.

optBin\_prcs:int

For certain long-tail distribution variables, if you need to calculate the global optimal binning (highest IV), it will take a long time, which may not be worth spending too much time compared to a slightly improved IV.

rascpy provides users with three usage scenarios:

Scenario 1: The bin IV is the highest, but the wait time is long. This scenario is suitable for high-performance CPUs, a large number of cores, a small number of variables, or when you need to achieve the best bin IV or use unattended modeling.

Scenario 2: It is possible to reduce IV by a small amount, but it will reduce the running time.

Scenario 3: Further reduce IV to further reduce runtime. This is suitable for users who need to see binning results quickly or have a low CPU configuration or a large number of variables.

Note: There is no difference in IV between the three scenarios for most variables, and there are only slight differences for variables with certain specific distributions.

Note: There is no significant difference in running time between the three scenarios for most variables, and there are only large differences for variables with certain specific distributions.

Default: 2

Returns

-----

optBin : list<str>

Returns the globally optimal bin split point.

Example: ['[1.0,3.0)', '[3.0,6.0)', '[6.0,10.0)', '[10.0,10.0]', '{-997}', '{-999,-888}', '{-1000,None}']

## OptBin

OptBin(X\_dats, y\_dats, y\_label=None, weight\_dats=None, train\_name=None, mono={}, default\_mono='N', sg  
st\_monos={}, distr\_min={}, default\_distr\_min=0.02, rate\_gain\_min={}, default\_rate\_gain\_min=0.001, bin\_cnt\_  
max={}, default\_bin\_cnt\_max=None, spec\_value={}, default\_spec\_value=[], spec\_distr\_min={}, default\_spec\_di  
str\_min=None, spec\_comb\_policy={}, default\_spec\_comb\_policy='N', order\_cate\_vars={}, unordered\_cate\_vars={},  
no\_wild\_treat=None, default\_no\_wild\_treat=None, cust\_bins={}, optBin\_prcs=2)

\_x1OptBin calculates the global optimal binning for a single variable, while OptBin calculates the global

optimal binning for multiple variables. OptBin is accomplished by calling `_x1OptBin`.

## Parameters

-----

`X_dats` : DataFrame or dict<dat\_name,DataFrame>. Required

Multi-column variables or multiple identical variables belonging to different datasets

There are two points to note:

1. When `mono['one var name'] = 'A'`, rasc automatically selects a constraint for 'one var name' from L+, L-, Uu, and Un. When automatically selecting a constraint, it uses different data sets to verify whether the constraint selection is correct.
2. If the user has already calculated the monotonicity of the suggestion elsewhere, the result can be passed directly to the OptBin function through the parameter `sgst_monos`. When setting `mono['one var name'] = 'A'`, the calculation will not be repeated, wasting the user's waiting time.

According to the above two principles: if `mono['one var name']='A'` and `sgst_monos['one var name']` is None, then the type of `X_dats` must be dict. In other cases, the type of `X_dats` can be Series or dict

`y_dats` : Series or dict<dat\_name,Series>. Required

The actual target. For details on when to pass a Series or a dict, see `X_dats`.

`y_label` : dict

Define which value in y means the event has occurred, and which value means the event has not occurred.

The value of keys can only be `unevent` or `event`

The value of values should be filled in according to the value of y

Example: `{'unevent':'good','event':'bad'}`

Generally, defining the things users care about most as events is easier to explain. For example, if you want to emphasize the incidence of lung cancer, you can say that smokers have a 50% higher incidence of lung cancer than non-smokers. In this case, you can write `{'unevent':'No lung cancer','event':'Lung cancer'}`. If you write `{'unevent':'Lung cancer','event':'No lung cancer'}`, although it does not affect the use of the model, the explanation will become that smokers have a 50% lower incidence of lung cancer than

n non-smokers. Obviously, the first expression is easier to understand.

Default: None

The meaning of None is equivalent to {'unevent': 0, 'event': 1}.

weight\_dats : Series or dict<dat\_name, Series> or None

The weight of the sample. Samples with weights can also solve the global optimal binning.

None: All weights are 1

When it is not None, see X\_dats for when to pass in Series or dict.

Default: None

train\_name : str or None

When mono['one var name']='A' and sgst\_mono['one var name']=None, this parameter specifies which dataset in X\_dats is used to calculate the monotonic trend suggestion for one var name. All datasets except the one corresponding to train\_name are used to verify the calculated monotonic trend.

Default: None

If X\_dats is a dict, train\_name cannot be None.

mono : dict

Configure monotonicity constraints for globally optimal binning for each variable.

Example: {"x1": "L", "x2": "N"}

Value range:

N: IV value is the highest globally, no constraints

A: Automatically select a constraint from L+, L-, Uu, Un. Under this constraint, the IV value is the highest globally.

L: The highest IV value globally under linear monotonic constraints (automatically determines L+, L-)

L+: The IV value is globally the highest under the linear monotonically increasing constraint

L-: The IV value is globally the highest under the linear monotonically decreasing constraint

U: The highest IV value globally under U-type constraints (automatically determines Uu, Un)

default: {}.

default\_mono : str

Variables not listed in mono are assumed to be monotonic.

Default: 'N'.

sgst\_monos:tuple

The recommended monotonic trend is: if mono['one var name']='A' and sgst\_monos['one var name'] is not None, rasc will automatically set mono['one var name'] to the first element of sgst\_monos['one var name']. Avoid repeated operations

When using rasc automation, this parameter can be used to avoid repeated calculations through internal mechanisms. When using the Bins module alone, sgst\_monos can be ignored.

The first element of the tuple is the recommended monotonic trend: possible values are L+, L-, Uu, Un

The remaining elements are some built-in extended information

Default: None

distr\_min : dict

Configure the minimum distribution ratio for each variable

ex. {"x1":0.05,"x2":0.01}

Note: Setting the minimum distribution ratio for a bin is not necessary to find the global optimal split point, but is determined by the user's confidence in the stability of the bin. If there are very few sample points in a bin, the random fluctuation of its event rate may be relatively large, resulting in larger fluctuations in Woe and the final model.

default:{}.

default\_distr\_min : float

Variables not appearing in distr\_min have a default minimum distribution share.

Default: 0.02.

rate\_gain\_min : dict

The event rate between any two adjacent bins cannot be less than rate\_gain\_min['one var name']

Some software packages often use information gain or chi-square value to suppress the formation of bin

s with too small differences.

However, these parameters do not provide a concrete and intuitive concept for users, and it is impossible to calculate how small the difference is.

Bins uses the intuitive indicator of event rate to suppress the formation of bins with too small differences

ex. {"x1":0.005,"x2":0.001}.

default:{}.

default\_rate\_gain\_min : float

If a variable does not appear in rate\_gain\_min, it defaults to the minimum difference in event rates between any two adjacent bins.

Default: 0.001.

bin\_cnt\_max : dict

The maximum number of bins for each variable. The bins for special values are not counted. If the special value is merged into the bin of the normal value due to the merging rule, the merged bin is the normal bin.

Example: {"x1":5,"x2":8}

Because Bins can specify parameters such as the monotonicity of the variable, the minimum bin ratio, and the minimum difference in event rates, these parameters can automatically adjust the number of bins (usually, the better the variable effect and the more evenly distributed it is, the more bins there are, and vice versa), so this parameter can usually be set to None.

If a variable is evenly distributed and has a strong order, the number of bins may be very large. Although this is in line with the actual situation, users can also specify the maximum number of bins allowed for certain business considerations.

default:{}.

default\_bin\_cnt\_max : int

If a variable does not appear in bin\_cnt\_max, the default maximum number of bins is used.

Default: None.

spec\_value : dict

The range of special values for each variable

ex. {"x1":["{-9997}","{-9999,-9998}"],"x2":["{None}"]}

"{... , ...}" will not be parsed into a set, but will be processed as a string. {} in special values represents a discrete value space symbol.

Let's take an example to explain the meaning of the expression:

"{-9997}": When the variable value is -9997, a special meaning is assigned. For example, for the number of court executions, -9997 might mean that the ID card is not in the citizen database, rather than that it has been executed -9997 times. Through this example, users can clearly see the difference in meaning between -9997 and values like 0, 1, and 2.

"{-9998,-9999}": When a variable takes on the value -9998 or -9999, it has a special meaning. Although these two meanings are different, for the business being modeled, they can be treated as the same and handled according to the same business logic. For example, when collecting data, data not collected due to Party A's fault is marked as -9998, while data not collected due to Party B's fault is marked as -9999. However, for the business, both values indicate randomly missing data, so they are handled according to the logic of randomly missing data. This preserves the original data's value conventions for retrospective use and saves users from the additional code required to process data.

"{None}" is a special value that means it's a null value. {None} is used instead of words like {miss} because the mechanisms for generating null values and missing values are sometimes different. Missing values represent missing data due to reasons beyond human control during the sampling process, such as a network outage or equipment failure during data transmission. This is a form of missing at random. Null values can also be caused by non-information missingness, such as a lack of loan history, a health checkup not required, or temperatures too low for equipment to collect. Null values themselves contain information. Avoid combining informative null values with missing at random null values into a single special value.

ex. {"x1":["{None,-9997}"]} This means that after analyzing the business, null values and -9997 can be handled the same way for this modeling.

If a variable is not configured with an empty special value, but contains an empty value, a {None} group is automatically generated to contain the empty value of the variable.

default:{}.

default\_spec\_value : list

If the variable is not configured in spec\_value, its default special value

This configuration is usually convenient when the data has global public special values.

ex. [{"{-9997}"},{None}","{-9998,-9996}"].

default:[].

spec\_distr\_min : dict

If the distribution ratio of a special value bin is less than the value specified by spec\_distr\_min, the special value bin will be merged with other bins. For specific merging rules, see the spec\_comb\_policy setting.

If it is a nested dict, the minimum percentage is specified separately for each special value of each variable.

If a dict, use the same minimum distribution weight for all unique values of each variable.

ex. {"x1":{"{-9997}":0.01,"{-9999,-9998}":0.05},"x2":0.01}.

default:{}.

default\_spec\_distr\_min : dict or float

If the special value of a variable is not configured in spec\_distr\_min, the default minimum distribution ratio of the special value

If it is a dict, a default minimum distribution ratio is specified for each special value.

If it is float, the default minimum distribution ratio of all special values is this value.

ex1. {"-9999":0.02,"-9998":0.01}

ex2. 0.05.

Default: None.

spec\_comb\_policy : dict

When the proportion of special values of a variable is less than the threshold specified by \${spec\_distr\_min}, the merging strategy to be adopted can be:

A:auto finds the closest eventProb among all values

a:auto only finds the closest eventProb among non-special values

F:first merges with the first bin of non-special values

L:last merges with the last bin of non-special values

M:median merges with the middle bin of non-special values (if there are an even number of bins, merge with the bin with the high event rate)

m:median merges with the middle bin of non-special values (if there are an even number of bins, merge with the bin with the lowest event rate)

B: max Probability is merged with the bin with the largest eventProb

S:min Probability merges with the bin with the smallest eventProb

N: Do not merge

If it is a nested dict, a separate merge strategy is specified for each special value of the variable. If there is a special value that is not covered, `default_spec_comb_policy` is used.

If a dict, all special values of the variable are merged using the strategy corresponding to that character.

ex. `spec_comb_policy={"x1":{"-9997":"F","-9998,None":"L"},"x2":"N"}`

If None, all special values of all variables are equivalent to "N" (except variables that can be overwritten by `default_spec_comb_policy`)

Note: This example explains the meaning of special value notation. `["{-9997}","{-9998,-9999}"]` means: There are three special values in the variable -9997, -9998, and -9999. Based on the business meaning, they are divided into two business groups `{-9997}` and `{-9998,-9999}`. -9997 itself becomes a business group, and -9998 and -9999 form a business group. Because the two business groups `{-9997}` and `{-9998,-9999}` meet the special value merging rules set during binning, they are forcibly merged together at the data level to form a bin `["{-9997}","{-9998,-9999}"]`. This type of consolidation differs from consolidating -9998 and -9999 into a single business group. The consolidation described in the business group context is at the business level, determined based on business understanding. The consolidation of `["{-9997}","{-9998,-9999}"]` is at the data level, determined solely by calculating event rates. It's important to understand the process and underlying meaning behind how the three special values -9997, -9998, and -9999 become the two special value business groups `{-9997}`, `{-9998,-9999}`, and finally become the single special value consolidation bin `["{-9997}","{-9998,-9999}"]`. This approach to handling special values a

dhers to statistical principles.

default:{}.

default\_spec\_comb\_policy : dict or str

When `_${spec_comb_policy}` does not contain a variable or a special value of a variable, the default special value merging strategy

If a dict, a default strategy is specified for each special value.

If it is str, all special values default to this strategy

ex1. `{"-9999":"A","-9998":"B"}`

ex2. M

For the value range, see `_${spec_comb_policy}`.

Default: 'N'.

order\_cate\_vars : dict

List the ordered categorical variables here and give the order of each category in the variable. If the value order is set to None, the lexicographic order of the characters is used as the order.

For ordered variables, adjacent nominal orders can only appear in the same bin or at the beginning and end of adjacent bins.

If the nominal order is inconsistent with the event rate order, you can decide whether to configure the variable as an ordered variable based on the business situation.

Bins supports global optimal binning for ordered variables

For example: `{"x1":("v1","v2"),"x2":("v3","**","v4"),"x3":None}`

All categories that do not appear in the configuration (excluding special values) are collectively called wildcard categories and are represented by `**`. When the lexicographical order is used as the order, there are no wildcard categories.

None or {}: variables with no ordered categories in them.

default:{}.

unorder\_cate\_vars : dict

List unordered categorical variables here, where the categories are ordered based on the event rates.

Each variable is configured with a threshold, and the categories with a distribution ratio less than the threshold are merged into the wildcard category. If the threshold of a variable is None, the category with a frequency of too small for the variable will not be wildcarded.

ex1. {'x1':0.01,'x2':None}

Bins supports global optimal binning for unordered variables

In other data sets, it is possible to see values that are not covered in the training set, and these categories are also put into the wildcard category.

None or {}: There are no unordered categorical variables in the variable.

default:{}.

no\_wild\_treat : dict

When a categorical variable does not have a wildcard and uncovered categories appear, the specified processing methods include:

L: Considered equal to the lowest category in the order

H: Considered equal to the highest order category

M: Considered equal to the middle category of the sequence (the larger value is taken when the number is even)

m: Considered equal to the middle category of the sequence (smaller value if even)

ex. {'x1':'H','x2':'m'}

None: No processing is performed on uncovered categories that appear in the variable

Default: None.

default\_no\_wild\_treat : str

When a variable has no wildcards and is not configured in no\_wild\_treat, the default treatment for uncovered categories.

Default: None.

cust\_bins : dict

User-defined binning takes precedence over other binning settings.

ex. {"x1": ["[1.0,4.0)","[4.0,9.0)","[9.0,9.0)","{-997}","{-999,-888}","{-1000,None}"]}

optBin\_prcs:int

For certain long-tail distribution variables, if you need to calculate the global optimal binning (highest IV), it will take a long time, which may not be worth spending too much time compared to a slightly improved IV.

rascpy provides users with three usage scenarios:

Scenario 1: The given bin IV is the highest, but requires a long wait. Suitable for high CPU performance, a large number of cores, or a small number of variables, or for pursuing the ultimate bin IV, or for unattended modeling.

Scenario 2: It is possible to reduce IV by a small amount, but it will reduce the running time.

Scenario 3: Further reduce IV to further reduce runtime. This is suitable for users who need to see binning results quickly or have a low CPU configuration or a large number of variables.

Note: There is no difference in IV between the three scenarios for most variables, and there are only slight differences for variables with certain specific distributions.

Note: There is no significant difference in running time between the three scenarios for most variables, and there are only large differences for variables with certain specific distributions.

Default: 2

Returns

-----

optBins : dict<str,list<str>>

The globally optimal split point for each variable.

ex. {"x1": ["[1.0,4.0)","[4.0,9.0)","[9.0,9.0)","{-997)","{-999,-888)","{-1000,None)"]}

## OptBin\_mp

OptBin\_mp(X\_dats, y\_dats, y\_label=None, weight\_dats=None, train\_name=None, mono={}, default\_mono='N', sgst\_mono={}, distr\_min={}, default\_distr\_min=0.02, rate\_gain\_min={}, default\_rate\_gain\_min=0.001, bin\_cnt\_max={}, default\_bin\_cnt\_max=None, spec\_value={}, default\_spec\_value=[], spec\_distr\_min={}, default\_spec\_distr\_min=None, spec\_comb\_policy={}, default\_spec\_comb\_policy='N', order\_cate\_vars={}, unordered\_cate\_vars

= {}, no\_wild\_treat= {}, default\_no\_wild\_treat=None, cust\_bins= {}, cores=None, optBin\_prcs=2)

Multi-process version of OptBin

#### Parameters

-----

cores : int

The number of CPU cores used.

None: Use all cores

Default: None.

Other parameters: See [Bins. OptBin](#)

#### Returns

-----

optBins : dict<str,list<str>>

Same return value as [Bins. OptBin](#)

### **\_x1FreqBin**

\_x1FreqBin(x, weight=None, freqBin\_cnt=20, spec\_value= [], is\_cate=False, is\_order=False, no\_wild\_treat='M', order\_list=None, y=None, y\_label=None, unordered\_combine\_thv=None)

Performs equal-frequency binning on the series. With the support of the Cutter component, it produces more uniform segmentation points than existing equal-frequency binning software libraries.

Can handle special values. Special values set by users can be grouped separately

Supports multiple features, please refer to the introduction of [Bins](#) module

#### Parameters

-----

x : Series

A list of variables

weight : Series

Sample weight

None: All weights are 1

Default: None

freqBin\_cnt : int

Equal frequency binning groups

Default: 20

spec\_value : list

Special value

Example. [{"-9997}","{-9999,-9998}"]

default:[]

is\_cate : bool

Mark whether the variable is a categorical variable

True: Categorical variable

False: continuous variable

Default: False

is\_order : bool

Mark whether the variable is an ordered categorical variable

If is\_order=True, is\_cate will be automatically set to True

True: ordered categories

False: When is\_cate=True, it is an unordered category.

Default: False.

no\_wild\_treat : str

When a categorical variable does not have a wildcard and uncovered categories appear, the following processing methods are used:

L: Considered equal to the lowest category in the order

H: Considered equal to the highest order category

M: Considered equal to the middle category of the sequence (the larger value is taken when the number is even)

m: Considered equal to the middle category of the sequence (smaller value if even)

None: No processing is performed on uncovered categories that appear in the variable

Default: 'M'

order\_list : tuple

Sets the order of each value in the ordered categorical variable. The order of the tuple is the nominal order. If is\_order=True and order\_list=None, the lexicographic order of the characters is used as the order.

For ordered variables, adjacent nominal sequences can only appear within the same bin or at the beginning and end of adjacent bins.

If the nominal order is inconsistent with the event rate order, you can decide for yourself whether to configure the variable as an ordered variable or an unordered variable based on the business situation.

Supports globally optimal binning for ordered variables.

All categories that do not appear in the configuration (excluding special values) are collectively called wildcard categories, denoted by \*\*. Values not covered in the training set may be seen in other datasets, and these categories are also included in the wildcard category.

When lexicographic order is used as the order, there is no wildcard category

Example: ("v1","\*\*","v2")

Default: None.

y : Series

The actual target. Because the order of unordered categorical variables is calculated by event rates, the target is needed when calculating equal frequency bins of unordered categorical variables.

Default: None.

y\_label : dict

Define which value in y means the event has occurred, and which value means the event has not occurred

rred.

The value of keys can only be unevent or event

The value of values should be filled in according to the value of y

Example: {'unevent':'good','event':'bad'}.

Default: None

The meaning of None is equivalent to {'unevent': 0, 'event': 1}.

unorder\_combine\_thv : float

Set a threshold for unordered categorical variables and merge categories with distribution proportions less than the threshold into wildcard categories. If is\_cate=True and unorder\_combine\_thv=None, categories with too low frequency of the variable will not be wildcarded.

In other data sets, it is possible to see values that are not covered in the training set, and these categories are also put into the wildcard category.

Default: None.

Returns

-----

freqbin : list<str>

Returns the equal-frequency binning split points.

Example: ['[1.0,3.0)', '[3.0,6.0)', '[6.0,10.0)', '[10.0,10.0]', '{-997}', '{-999,-888}', '{-1000,None}']

## FreqBin

FreqBin(X, y=None, y\_label=None, weight=None, freqBin\_cnt=20, spec\_value={}, default\_spec\_value=[], order\_cate\_vars={}, unorder\_cate\_vars={}, no\_wild\_treat=None, default\_no\_wild\_treat=None)

\_x1FreqBin calculates the equal-frequency binning of a variable, while FreqBin calculates the equal-frequency binning of multiple variables. FreqBin is accomplished by calling \_x1FreqBin.

Supports multiple features, please refer to the introduction of [Bins](#) module

Parameters

-----

X : DataFrame

Dataset, multiple columns of variables

y : Series

The actual target. Because the order of unordered categorical variables is calculated by event rates, the target is needed when calculating equal frequency bins of unordered categorical variables.

Default: None.

y\_label : dict

Define which value in y means the event has occurred, and which value means the event has not occurred.

The value of keys can only be unevent or event

The value of values should be filled in according to the value of y

Default: None

The meaning of None is equivalent to {'unevent': 0, 'event': 1}.

weight : Series

The weight of the sample. Samples with weights can also solve the global optimal binning.

None: All weights are 1

Default: None.

freqBin\_cnt : int

Equal frequency binning groups

Default: 20.

spec\_value : dict

The value of each variable's special value

ex. {"x1":["{-9997}","{-9999,-9998}"],"x2":["{None}"]}

default:{}.

default\_spec\_value : list

If the variable is not configured in spec\_value, its default special value

This configuration is usually convenient when the data has global public special values.

ex. [{"-9997"},"{None}","{-9998,-9996}"].

default:[].

order\_cate\_vars : dict

List the ordered categorical variables here and give the order of each category in the variable. If the value order is set to None, the lexicographic order of the characters is used as the order.

For ordered variables, adjacent nominal orders can only appear in the same bin or at the beginning and end of adjacent bins.

If the nominal order is inconsistent with the event rate order, you can decide whether to configure the variable as an ordered variable based on the business situation.

Example: {"x1":("v1","v2"),"x2":("v3","\*\*","v4"),"x3":None}

All categories that do not appear in the configuration (excluding special values) are collectively called wildcard categories and are represented by \*\*. When the lexicographical order is used as the order, there are no wildcard categories.

None or {}: variables with no ordered categories in them.

default:{}.

unorder\_cate\_vars : dict

List unordered categorical variables here, where the categories are ordered based on the event rates.

Each variable is configured with a threshold, and the categories with a distribution ratio less than the threshold are merged into the wildcard category. If the threshold of a variable is None, the category with a frequency of too small for the variable will not be wildcarded.

ex1. {'x1':0.01,'x2':None}

Bins supports global optimal binning for unordered variables

In other data sets, it is possible to see values that are not covered in the training set, and these categories are also put into the wildcard category.

None or {}: There are no unordered categorical variables in the variable.

default:{}.

no\_wild\_treat : dict

When a categorical variable does not have a wildcard and uncovered categories appear, the specified processing methods include:

L: Considered equal to the lowest category in the order

H: Considered equal to the highest order category

M: Considered equal to the middle category of the sequence (the larger value is taken when the number is even)

m: Considered equal to the middle category of the sequence (smaller value if even)

ex. {'x1':'H','x2':'m'}

None: No processing is performed on uncovered categories that appear in the variable

Default: None.

default\_no\_wild\_treat : str

When a variable has no wildcards and is not configured in no\_wild\_treat, the default treatment for uncovered categories.

Default: None.

Returns

-----

freqbins: dict<str,list<str>>

The equal-frequency cutoff points for each variable.

ex. {"x1": "[1.0,4.0)","[4.0,9.0)","[9.0,9.0)","{-997}","{-999,-888}","{-1000,None}"]}

## FreqBin\_mp

FreqBin\_mp(X, y=None, y\_label=None, weight=None, freqBin\_cnt=20, spec\_value={}, default\_spec\_value=[], order\_cate\_vars={}, unordered\_cate\_vars={}, no\_wild\_treat=None, default\_no\_wild\_treat=None, cores=None)

Multi-process version of FreqBin

## Parameters

-----

cores : int

The number of CPU cores used.

None: Use all cores

Default: None.

Other parameters: see [Bins.FreqBin](#)

## Returns

-----

freqbins: dict<str,list<str>>

The equal-frequency cutoff points for each variable.

ex. {"x1": ["[1.0,4.0)","[4.0,9.0)","[9.0,9.0)","{-997}","{-999,-888}","{-1000,None}"]}

## get\_bins\_stats

get\_bins\_stats(X, y=None, bins={}, weight=None, sync\_bins=True, y\_label=None)

Given the split point of each variable, transform X according to the split point and then count the information of each interval.

Information includes: the number of samples in the interval, the sample ratio. If y is not None, the event rate, event non-occurrence rate, woe, IV in the interval will also be counted.

## Parameters

-----

X : DataFrame

Datasets containing multiple variables

y : Series

The actual target. Can be set to None

Default: None

bins : dict<str,list<str>>

The split point for each variable.

ex. {"x1": ["[1.0,4.0)","[4.0,9.0)","[9.0,9.0)","{-997}","{-999,-888}","{-1000,None}"]}

default:{}

weight : Series

Sample weight

None: All weights are 1

Default: None

sync\_bins : bool

True: Update bins when the extreme value of X exceeds the extreme value of the cut point

False: When the extreme value of X exceeds the extreme value of the cut point, the bins are not updated

Default: True

y\_label : dict

Define which value in y means the event has occurred, and which value means the event has not occurred.

The value of keys can only be unevent or event

The value of values should be filled in according to the value of y

Default: None

The meaning of None is equivalent to {'unevent': 0, 'event': 1}.

Returns

-----

bins\_stats: dict<str,DataFrame>

Segment-wise statistics for each variable.

Example: {'x1':DataFrame,'x2':DataFrame}

## **`_x1trans_woe_value`**

`_x1trans_woe_value(x, bins_stat)`

Convert a column of values to woe

Support for categorical variables

When bins\_stat fails to cover the extreme value of x, then update bins\_stat

Parameters

-----

x : Series

A list of variables

bins\_stat : DataFrame

The return value of get\_bins\_stats corresponds to the bins\_stat of the variable.

Returns

-----

Series

woe value

DataFrame

Updated bins\_stat. When bins\_stat fails to cover the extreme value of x, bins\_stat is updated

## **`trans_woe_value`**

`trans_woe_value(X, bins_stats, sync_bins=True)`

[of](#) multiple variables, which is done by calling [Bins. x1trans\\_woe\\_value](#)

Support for categorical variables

When bins\_stat fails to cover the extreme value of the variable, bins\_stat can be updated

Parameters

-----

X : DataFrame

Dataset, containing multiple variables

bins\_stats: dict<str,DataFrame>

The return value of get\_bins\_stats.

sync\_bins : bool

Whether to update bins\_stats when bins\_stat fails to cover the extreme value of the variable

True: Update

False: Do not update

Default: True

Returns

-----

DataFrame

Converted WOE value

## **trans\_woe\_value\_mp**

trans\_woe\_value\_mp(X, bins\_stats, sync\_bins=True, cores=None)

[Bins.](#) Multi-process version of [trans\\_woe\\_value](#)

Parameters

-----

cores : int

The number of CPU cores used.

None: Use all cores

Default: None.

Other parameters: see [Bins.trans\\_woe\\_value](#)

Returns

-----

DataFrame

Converted WOE value

## **is\_cate\_bins**

is\_cate\_bins(bins)

Determine whether a bin is a categorical bin

Parameters

-----

bins : list

Bins to be judged.

Returns

-----

bool

True: Category bins

False: Continuous bins

## **bins\_stats\_to\_IV**

bins\_stats\_to\_IV(bins\_stats, asc=False)

By passing bins\_stats, it returns the IV of each variable.

Parameters

-----

bins\_stats: dict<str,DataFrame>

The return value of get\_bins\_stats.

asc : bool

True: Returns the IV in positive order

False: Returns the IV in reverse order

Default: False.

Returns

-----

Series

IV value for each variable

## **\_x1MonoSuggest**

`_x1MonoSuggest(x_dats,y_dats,w_dats=None,train_name='train',spec_value=[],is_cate=False,is_order=False,no_wild_treat='M',order_list=None,y_label=None)`

To give a monotonicity suggestion for a variable, the monotonicity is calculated on the specified dataset and then verified on other datasets.

Suggested values for monotonicity are:

L+: linear monotonically increasing

L-: linear monotonically decreasing

Uu: U-shaped concave type

Un: U-shaped convex

Parameters

-----

`x_dats : dict<dat_name, Series>`

The same variable in different datasets

`y_dats : dict<dat_name, Series>`

Actual target

Target in different datasets

`w_dats : dict<dat_name, Series>`

Sample weights in different datasets.

None: All weights are 1

Default: None

train\_name : str

Which dataset is used for calculating the monotonicity suggestion? The remaining datasets are used to test the calculated trend.

Default: train

spec\_value : list

Special value range

Example. [{"-9997}","{-9999,-9998}"]

If a variable is not configured with an empty special value, but contains an empty value, a {None} group will be automatically generated to contain the empty value of the variable.

When calculating monotonicity, special values are removed

default:[]

is\_cate : bool

Indicates whether the variable is categorical.

True: Categorical variable

False: continuous variable

Default: False.

is\_order : bool

Indicates whether the variable is an ordered categorical variable.

If is\_order=True, is\_cate will be automatically set to True

True: ordered categories

False: When is\_cate=True, it is an unordered category. Unordered categories will not give a suggested monotonic trend, and the first element of the return value will be marked as an unordered category.

Default: False.

no\_wild\_treat : str

When a categorical variable does not have a wildcard and uncovered categories appear, the following processing

methods are used:

L: Considered equal to the lowest category in the order

H: Considered equal to the highest order category

M: Considered equal to the middle category of the sequence (the larger value is taken when the number is even)

m: Considered equal to the middle category of the sequence (smaller value if even)

None: No processing is performed on uncovered categories that appear in the variable

Default: 'M'

When `is_cate=False`, this parameter will be ignored.

`order_list` : tuple

Sets the order of each value in the ordered categorical variable. The order of the tuple is the nominal order. If

`is_order=True` and `order_list=None`, the lexicographic order of the characters is used as the order.

If the nominal order is inconsistent with the event rate order, you can decide for yourself whether to configure the variable as an ordered variable or an unordered variable based on the business situation.

All categories that do not appear in the configuration (excluding special values) are collectively called wildcard categories, denoted by `**`. Values not covered in the training set may be seen in other datasets, and these categories are also included in the wildcard category.

When lexicographic order is used as the order, there is no wildcard category

Example: `("v1", "**", "v2")`

Default: None.

When `is_cate=False` or `is_order=False`, this parameter will be ignored.

`y_label` : dict

Define which value in `y` means the event has occurred, and which value means the event has not occurred.

The value of keys can only be `unevent` or `event`

The value of values should be filled in according to the value of `y`

Default: None

The meaning of None is equivalent to `{'unevent': 0, 'event': 1}`.

## Returns

-----

tuple(monotonicity suggestion, \*\*)

The first element is a monotonicity suggestion, followed by some additional information

Unordered categories will not give a suggested monotonic trend, and the first element of the return value will be marked as unordered.

## MonoSuggest

MonoSuggest(X\_dats, y\_dats, w\_dats=None, train\_name='train', spec\_value={}, default\_spec\_value=[], order\_cate\_vars={}, unordered\_cate\_vars={}, no\_wild\_treat=None, default\_no\_wild\_treat=None, y\_label=None)

Give monotonicity suggestions for multiple variables

This is done by [calling Bins. x1MonoSuggest](#)

## Parameters

-----

X\_dats : dict<dat\_name,DataFrame>

Multiple variables that are the same in different datasets

y\_dats : dict<dat\_name,Series>

Actual target

Target in different datasets

w\_dats : dict<dat\_name,Series>

Sample weights in different datasets.

None: All weights are 1

Default: None

train\_name : str

Which dataset is used for calculating the monotonicity suggestion? The remaining datasets are used to test the calculated trend.

Default: train

spec\_value : dict

The range of special values for each variable

ex. {"x1":["{-9997}","{-9999,-9998}"],"x2":["{None}"]}

default:{}.

default\_spec\_value : list

If the variable is not configured in spec\_value, its default special value

This configuration is usually convenient when the data has global public special values.

ex. [{"{-9997}","{None}","{-9998,-9996}"}].

default:[].

order\_cate\_vars : dict

List the ordered categorical variables here and give the order of each category in the variable. If the value order is set to None, the lexicographic order of the characters is used as the order.

If the nominal order is inconsistent with the event rate order, you can decide whether to configure the variable as an ordered variable based on the business situation.

For example: {"x1":("v1","v2"),"x2":("v3","\*\*","v4"),"x3":None}

All categories that do not appear in the configuration (excluding special values) are collectively called wildcard categories and are represented by \*\*. When the lexicographical order is used as the order, there are no wildcard categories.

None or {}: variables with no ordered categories in them.

default:{}.

unordered\_cate\_vars : list or dict

Listing unordered categorical variables here will not give a suggested monotonic trend, and the first element of the return value will be marked as an unordered category.

ex1. ['x1','x2']

ex2. {'x1':0.01,'x2':None}

None or {}: There are no unordered categorical variables in the variable.

default:{}.

no\_wild\_treat : dict

When a categorical variable does not have a wildcard and uncovered categories appear, the specified processing methods include:

L: Considered equal to the lowest category in the order

H: Considered equal to the highest order category

M: Considered equal to the middle category of the sequence (the larger value is taken when the number is even)

m: Considered equal to the middle category of the sequence (smaller value if even)

ex. {'x1':'H','x2':'m'}

None: No processing is performed on uncovered categories that appear in the variable

Default: None.

default\_no\_wild\_treat : str

When a variable has no wildcards and is not configured in no\_wild\_treat, the default treatment for uncovered categories.

Default: None.

y\_label : dict

Define which value in y means the event has occurred, and which value means the event has not occurred.

The value of keys can only be unevent or event

The value of values should be filled in according to the value of y

Default: None

The meaning of None is equivalent to {'unevent': 0, 'event': 1}.

Returns

-----

```
dict<var_name,tuple(monotonicity_suggestion,**)>
```

The first element is a monotonicity recommendation, followed by some additional information (for backward compatibility)

## MonoSuggest\_mp

```
MonoSuggest_mp(X_dats, y_dats, w_dats=None, train_name='train'  
               , spec_value={}, default_spec_value=[]  
               , order_cate_vars={}, unordered_cate_vars={}, no_wild_treat=None, default_no_wild_treat=None  
               , y_label=None, cores=None)
```

Multi-process version of MonoSuggest

### Parameters

-----

cores : int

The number of CPU cores used.

None: Use all cores

Default: None.

Other parameters: See [Bins. MonoSuggest](#)

### Returns

-----

```
dict<var_name,tuple(monotonicity_suggestion,**)>
```

The first element is a monotonicity recommendation, followed by some additional information (for backward compatibility)

## Cutter

Perform equal frequency segmentation or segmentation according to specified split points, which has the following enhancements over the built-in Python segmenter:

1. Mathematically provable analytical solution with minimum global error.

2. All split points come from the original values.
3. More user-friendly support for left-closed and right-open: a. The last group is right-closed. b. The extreme values at both ends of the minimum and maximum groups are derived from the original data, unlike Python's built-in splitter, which modifies the extreme values at both ends.
4. It can also provide the global optimal segmentation solution for extremely tilted data.
5. Support weighted series.
6. Supports user-specified special values. Special values are grouped separately, and users can also configure multiple special values to be combined into one group.
7. If the special value does not contain null values, but the sequence contains null values, the null values will be automatically processed into a group.
8. Use the specified split point to cut the sequence. When the maximum or minimum value of the sequence exceeds the split point boundary, the maximum and minimum values of the split point will be automatically expanded.

It is recommended to try replacing Python's built-in equal frequency segmentation component with Cutter.

Note: Cutter can only be used for numeric sequences. Character sequences must first be converted to numeric using `Category`.

## Functions

### `_is_ascending`

`_is_ascending(bins)`

Determine whether the bins are in ascending or descending order

Parameters

-----

bins : list

Split Point

ex1. `[["1.0,4.0"],["4.0,9.0"],["9.0,9.0"],{"-997"},{"-999,-888"},{"-1000,None"}]`

Returns

-----

bool

True: for ascending bins

Fals e: descending bins

## **`_is_spec_bin`**

`_is_spec_bin(one_bin)`

Determine whether a bin is a special value

Parameters

-----

`one_bin` : list or str

A single bin.

Supports combine bin. Combine bin means that two bins that meet the artificially set merging rules are merged together

`['[1,2)', '[2,4)', '{-1000}']`], where `['[2,4)', '{-1000}']` is a merged bin

Returns

-----

bool

True: This bin is a special value bin.

False: This bin is not a special value bin

## **`freq_cut`**

`freq_cut(data, threshold_distr, min_distr, weight=None, spec_value=[], ascending=True)`

Equal frequency segmentation tool. Supports weighted and special valued sequences. For more functions, please refer to the introduction of the [Cutter module](#).

Parameters

-----

`data` : array like

A sequence of numbers to be split

`threshold_distr` : int or float

Greater than 1: Divide into several parts

Less than 1: What is the proportion of each portion?

min\_distr : float

The minimum acceptable percentage. Due to data skew, it is not guaranteed that all bins will meet threshold\_distr. Some bins may exceed threshold\_distr, while others may fall below it. However, the minimum percentage will not fall below min\_distr.

weight : array like

The weight of the data point

None: Each data point has a weight of 1

Default: None.

spec\_value : list

Special value range

Example. [{"-9997"}, {"-9999,-9998"}]

default:[].

ascending : bool

True: binning in ascending order. Example: ['[1,4)', '[4,10)', '[10,10]']

False: Binning in descending order. Example: ['[10,9)', '[9,4)', '[4,1]']

Default: True.

Returns

-----

list

Return to bins

Example: ['[1.0,4.0)', '[4.0,6.0)', '[6.0,9.0)', '[9.0,10.0]', '{-997}', '{-1000,None}']

## cut\_by\_bins

cut\_by\_bins(data, bins)

Split the data into the specified bins and return the labels for each data point in order.

Parameters

-----

data : array like

A sequence of numbers to be split

bins : list

Specified bins

Example: ['[1.0,4.0)', '[4.0,6.0)', '[6.0,9.0)', '[9.0,10.0]', '{-997}', '{-1000,None}']

It also supports merging bins, such as ['[1.0,4.0)', '[4.0,6.0)', '[6.0,9.0)', '[9.0,10.0]', '{-997}'], '{-1000,None}']

Returns

-----

array like

Same data type as data

The bin corresponding to the data point in data

bool

Whether the extreme values of bins are updated

list

Updated extreme value bins

## freq\_cut\_data

freq\_cut\_data(data, threshold\_distr, min\_distr, weight=None, spec\_value=[], ascending=True)

First call freq\_cut, then call cut\_by\_bins with the return value

## Parameters

-----

data : array like

Sequence to be split

threshold\_distr : int or float

Greater than 1: Divide into several parts

Less than 1: What is the proportion of each portion?

min\_distr : float

The minimum acceptable percentage. Due to data skew, it's not guaranteed that all bins will meet threshold\_distr. Some bins may exceed threshold\_distr, while others may fall below it. However, the minimum percentage will not fall below min\_distr.

weight : array like

The weight of the data point

None: Each data point has a weight of 1

Default: None.

spec\_value : list

Special value range

Example. [{"-9997}","{-9999,-9998}"]

default:[].

ascending : bool

True: binning in ascending order. Example: ['[1,4)', '[4,10)', '[10,10]']

False: Binning in descending order. Example: ['[10,9)', '[9,4)', '[4,1]']

Default: True.

## Returns

-----

array like

Same data type as data

The bin corresponding to the data point in data

list

Split Point

## **cut\_array**

`cut_array(datas, threshold_distr, min_distr, cutby=0, weight=None, spec_value=[], ascending=True)`

Cut multiple sets of sequences in a unified way

Automatically expand the extreme value of cutby corresponding data

Parameters

-----

**datas:** dict, DataFrame, ndarray like

Multiple sets of sequences to be split

**threshold\_distr :** int or float

Greater than 1: Divide into several parts

Less than 1: What is the proportion of each portion?

**min\_distr :** float

The minimum acceptable percentage. Due to data skew, it's not guaranteed that all bins will meet threshold\_distr. Some bins may exceed threshold\_distr, while others may fall below it. However, the minimum percentage will not fall below min\_distr.

**cutby :** int, str, list

int: If datas is ndarray like, then cutby is grouped based on the first column.

str: If datas is a dict or DataFrame, it is grouped according to the corresponding benchmark series of c

utby

list:cutby is bins, all series are grouped according to cutby

Default: 0.

weight : array like

The weight of each data point in the base series only needs to pass the weight of the base series.

None: The weight of each data point in the benchmark series is 1

Default: None.

spec\_value : list

Special value range

Example. [{"-9997}","{-9999,-9998}"]

default:[].

ascending : bool

True: binning in ascending order. Example: ['[1,4)', '[4,10)', '[10,10]']

False: Binning in descending order. Example: ['[10,9)', '[9,4)', '[4,1]']

Default: True.

Returns

-----

dict,DataFrame,ndarray like

The same type as the array in datas

The bin corresponding to the data point in the sequence in datas

bins : list

Split Point

## sort\_label

sort\_label(one\_bin)

The lambda function used to sort the bins.

Usage: sorted(bins,key=sort\_label)

### Parameters

-----

one\_bin : str or list

str: a bin

list: a combination bin

### Returns

-----

float or str

The order of the bins.

## eq\_bin

eq\_bin(one\_bin, compare)

Are two bins equal?

### Parameters

-----

one\_bin : str or list

Original bin

compare : str or list

Comparison bin

### Returns

-----

bool

Whether two bins are equal.

## auto\_round

```
auto_round(dats,ex_cols=[],default_spec_value=[],spec_values={},default_trunc_int=True,trunc_ints={})
```

Automatically determine the precision for each column in the dataframe and convert it into a new dataframe with the calculated precision.

The premise of the precision conversion of each column is not to reduce the IV value of its bin, otherwise the original data remains unchanged.

Parameters

-----

**dats** : DataFrame

Multiple sequences to be converted

**ex\_cols**: list

Variables in ex\_cols are not converted to the same precision

**default\_spec\_value** : list

Default special value. If a special value of an array is not in spec\_values , default\_spec\_value is used.

If a special value is not in the sequence, it will be automatically ignored

Example. [{"{-9997}"}, {"{-9999,-9998}"}]

**spec\_values** : dict

Set a separate special value for the variable, and no precision conversion will be performed on the special value

Example: {'X1': [{"{-9997}"}, {"{-9999,-9998}"}], "X2": [{"{-9999}"}]}

If a special value is not in the sequence, it will be automatically ignored

**default\_trunc\_int** : bool

Whether to use the default value for integer precision conversion. If the variable is not in trunc\_ints, the default value is used

Integer conversion example: 10212 -> 10210

10212 -> 10200

The premise of automatic adjustment of integer precision is also not to reduce the IV of its binning

**trunc\_ints** : dict(str, bool )

Whether to perform precision conversion on integers.

Example: {'x1':True,'x2':False}

Integer conversion example: 10212 -> 10210

10212 -> 10200

The premise of automatic adjustment of integer precision is also not to reduce the IV of its binning

Returns

-----

dataframe

Dataframe after automatic precision conversion

## **auto\_round\_one**

auto\_round\_one(data,spec\_value,trunc\_int = True)

Automatically determine the precision of a column of data and convert each value in the column to that precision.

The principle of automatic accuracy determination is not to reduce the IV of its bins, otherwise the original data remains unchanged.

Parameters

-----

data : array like

A series of numbers

spec\_value : list

The value of a special value. Special values will not be converted to a specific value.

If a special value is not in the sequence, it will be automatically ignored

Example. [{"-9997}","{-9999,-9998}"]

trunc\_int: bool

Whether to automatically adjust integer variables

For example: 10212 -> 10210

10212 -> 10200

The premise of automatic adjustment of integer precision is also not to reduce the IV of its binning

Returns

-----

array like has the same type as data

Sequence after automatic precision reduction

# Category

The Category module is used to convert categorical variables into continuous variables

1. Can handle ordered and unordered categories
2. Ordered categories can specify the category order or convert it using lexicographic order
3. Unordered categories are transformed using event rates
4. Support sequences with special values
5. Support weighted series
6. You can set wildcards to handle categories that do not appear in the training set
7. Support merging and converting of small categories

## Functions

### cate\_to\_cateBin

`cate_to_cateBin(x, cate_bins, wild='**')`

Convert categories into category bins.

Example: 'A' -> '<A,B,C>'

Parameters

-----

`x` : str

category.

`cate_bins` : list

Category bins.

ex. ['<A,B,C>', '<a,b,c,\*\*>']

`wild` : str

Wildcard identifier

default: '\*\*'.

Returns

-----

str

The category bin corresponding to x.

ex. '<a,b,c,\*\*>'

## **cate\_to\_num**

cate\_to\_num(dat, is\_order=False, spec\_value=[], wild='\*\*', no\_wild\_treat='M', order\_list=None, letter\_asc=True, y=None, y\_label=None, weight=None, unordered\_combine\_thv=None, prob\_asc=True)

Convert categorical variables into numerical values

Parameters

-----

dat : array like

A list of categorical variables to be converted

is\_order : bool

True: The categorical variable to be converted is an ordered category

False: The categorical variable to be converted is an unordered category

Default: False

spec\_value : list

List all special values. Example: ['-999,-888','-1000']

spec\_value will not be converted to a number. In the new array, this value is still treated as a special value and handled according to the rules of special values.

default:[]

wild : str

Wildcard identifier

default:'\*\*'

no\_wild\_treat : str

When a categorical variable does not have a wildcard and uncovered categories appear, the specified processing methods include:

L: Considered equal to the lowest category in the order

H: Considered equal to the highest order category

M: Considered equal to the middle category of the sequence (the larger value is taken when the number is even)

m: Considered equal to the middle category of the sequence (smaller value if even)

Default: M

`order_list` : tuple

Sets the order of each value in the ordered categorical variable. The order of the tuple is the nominal order. If `is_order=True` and `order_list=None`, the lexicographic order of the characters is used as the order.

If the nominal order is inconsistent with the event rate order, you can decide for yourself whether to configure the variable as an ordered variable or an unordered variable based on the business situation.

Supports global optimal binning for ordered variables. The converted sequence can be directly processed by Bins.

All categories that do not appear in the configuration (excluding special values) are collectively called wildcard categories, denoted by `**`. Values not covered in the training set may be seen in other datasets, and these categories are also included in the wildcard category.

When lexicographic order is used as the order, there is no wildcard category

Example: `("v1","**","v2")`

Default: None.

`letter_asc` : bool

When ordered categories use lexicographic order:

True: The larger the lexicographic order, the larger the converted value.

False: The smaller the lexicographic order, the smaller the converted value

Default: True.

y : Series

The actual target. Because the order of unordered categorical variables is calculated by event rates, target is needed when is\_order=False.

Default: None.

y\_label : dict

Define which value in y means the event has occurred, and which value means the event has not occurred.

The value of keys can only be unevent or event

The value of values should be filled in according to the value of y

Example: {'unevent':'good','event':'bad'}.

Default: None

The meaning of None is equivalent to {'unevent': 0, 'event': 1}.

weight : array like

The weight of the sample. When is\_order=False,

None: All weights are 1

Default: None.

unorder\_combine\_thv : float

Set a threshold for unordered categorical variables and merge categories with a distribution ratio less than the threshold into wildcard categories. If is\_order=False and unorder\_combine\_thv=None, categories with too low a frequency for the variable will not be wildcarded.

Default: None.

prob\_asc : bool

When the categories are unordered:

True: The higher the event rate, the larger the converted value

False: The higher the event rate, the smaller the converted value

Default: True.

Returns

-----

trans\_data : array like

The converted numeric sequence

encoder : Series

Converted code table

The key of the encoder is the category, and the value is the corresponding value.

## numInterval\_to\_cateBin

numInterval\_to\_cateBin(encoder, numer\_interval)

Convert the numeric interval back to a category set. The expression of cateBin is '<c1,c2,...>'

Parameters

-----

encoder : Series

The code table returned by cate\_to\_num. The encoder key is the category and the value is the corresponding numeric value.

numer\_interval : str or list

A numeric range or a combined numeric range to be converted

Example: '[4,7)' or '['[4,7)', '{-999}']

Returns

-----

str

cateBin. If numer\_interval contains the number corresponding to the wildcard, the converted cateBin contains the wildcard

Example: When `numer_interval` is a numeric interval, '`<A,B,C,**>`'

When `numer_interval` is a combined numeric interval, ['`<A,B,C>`', '`<a,b,c,**>`']

# Impute

## Classes

### BCSpecValImpute

Common missing value imputation methods can only handle missing values, but cannot handle special values, especially when data contains both missing and special values. Special values cannot be simply equated with missing values. Simply treating special values as missing values without considering the business scenario will lead to information loss. Special values transform numeric data into a complex data type that mixes categorical and numerical data. Currently, no model can directly handle this data (although some models can produce results, they are inaccurate and meaningless). The Impute package provided by `rascpy` can solve this problem. The transformed data can be directly fed into any model and meet practical business requirements.

`BCSpecValImpute` can be used to handle special values and missing values in the data of binary classification problems.

It can handle special values and missing values for continuous, unordered categorical, and ordered categorical variables.

`BCSpecValImpute` not only fills empty values, but also converts special values that the model cannot handle.

It uses the special value merging method of the `Bins` module in `rascpy` (an optimal binning algorithm that uses mathematics to ensure that its IV is the highest) to merge special values with normal values, and then sets the special value to the mean of all normal values in the bin it is merged with (for continuous variables) or randomly selects a category (for categorical variables. Since all categories in the bin are considered to be the same category, they can be randomly selected)

#### `__init__`

```
__init__(self,spec_value={},default_spec_value=[],order_cate_vars={},unorder_cate_vars={},impute_None=True,cores=None)
```

Parameters

-----

`spec_value` : dict

The range of special values for each variable

ex. `{"x1":["{-9997}","{-9999,-9998}"],"x2":["{None}"]}`

"{... , ...}" will not be parsed into a set, but will be processed as a string. {} in special values represents a discrete value space symbol.

Let's take an example to explain the meaning of the expression:

"{-9997}": When the variable value is -9997, a special meaning is assigned. For example, for the number of court executions, -9997 might mean that the ID card is not in the citizen database, rather than that it has been executed -9997 times. Through this example, users can clearly see the difference in meaning between -9997 and values like 0, 1, and 2.

"{-9998,-9999}": When a variable takes on the value -9998 or -9999, it has a special meaning. Although these two meanings are different, for the business being modeled, they can be treated as the same and handled according to the same business logic. For example, when collecting data, data not collected due to Party A's fault is marked as -9998, while data not collected due to Party B's fault is marked as -9999. However, for the business, both values indicate randomly missing data, so they are handled according to the logic of randomly missing data. This preserves the original data's value conventions for retrospective use and saves users from the additional code required to process data.

"{None}" is a null special value or missing value. For the difference between the two, see the section about outliers, missing values, and special values. {None} is used instead of {miss} because the mechanisms for generating null values and missing values are sometimes different. A missing value indicates that due to reasons beyond human control during the sampling process, a sample point was not collected, resulting in missing data information. For example, a network outage or equipment failure during data transmission may have prevented data from being collected. This is a form of missing at random. Null values can also be caused by non-information missingness, such as a lack of loan records, a health check not requiring a specific medical examination, or a temperature too low for the equipment to collect data. Null values themselves contain information. Do not combine informative null values and missing at random null values into a single special value.

ex. {"x1":{"None,-9997}} This means that after analyzing the business, null values and -9997 can be handled the same way for this modeling.

If a variable is not configured with an empty special value, but contains an empty value, a {None} group is automatically generated to contain the empty value of the variable.

default:{}.

default\_spec\_value : list

If the variable is not configured in spec\_value, its default special value

This configuration is usually convenient when the data has global public special values.

ex. [{"-9997}","{None}","{-9998,-9996}"].

default:[].

order\_cate\_vars : dict

List the ordered categorical variables here and give the order of each category in the variable. If the value order is set to None, the lexicographic order of the characters is used as the order.

For ordered variables, adjacent nominal orders can only appear in the same bin or at the beginning and end of adjacent bins.

If the nominal order is inconsistent with the event rate order, you can decide whether to configure the variable as an ordered variable based on the business situation.

Bins supports global optimal binning for ordered variables

For example: {"x1":("v1","v2"),"x2":("v3","\*", "v4"),"x3":None}

All categories that do not appear in the configuration (excluding special values) are collectively called wildcard categories and are represented by \*\*. When the lexicographical order is used as the order, there are no wildcard categories.

None or {}: variables with no ordered categories in them.

default:{}.

unordered\_cate\_vars : dict

List unordered categorical variables here, where the categories are ordered based on the event rates.

Each variable is configured with a threshold, and the categories with a distribution ratio less than the threshold are merged into the wildcard category. If the threshold of a variable is None, the category with a frequency of too small for the variable will not be wildcarded.

ex1. {'x1':0.01,'x2':None}

Bins supports global optimal binning for unordered variables

In other data sets, it is possible to see values that are not covered in the training set, and these categories are also put into the wildcard category.

None or {}: There are no unordered categorical variables in the variable.

default:{}.

impute\_None : bool

Whether to fill null values, because some models can automatically handle null values. If you want to use such models later, you don't need to handle null values when filling.

If the nulls in the data are not randomly missing but business missing, representing a state and the subsequent model can automatically handle null values, it is recommended to set this parameter to False

True: fill empty values

False: Do not fill in null values and let the subsequent model handle them (if the model can handle null values)

Default: True

cores : int

The number of CPU cores used.

None: Use all cores

When it is less than 0, it reserves the number of CPU cores, i.e. `os.cpu_count() - cores`

Default: None.

Returns

-----

None.

## fit

fit(self,X,y,weight=None,y\_label=None)

Train each missing value filling method for each variable (if `impute_None=True`) and each special value conversion method

## Parameters

-----

X : DataFrame

Data that needs to be converted

If a variable is not configured with a special value, or does not contain the configured special value, the variable will be automatically ignored.

y : Series

target

weight : Series, optional

Weight

Default: None.

y\_label : dict, optional

Define which value in target means the event has occurred, and which value means the event has not occurred.

The value of keys can only be unevent or event

The value of values should be filled in according to the value of y

Default: None

The meaning of None is equivalent to {'unevent': 0, 'event': 1}.

## Returns

-----

None.

## transform

transform(self,X)

Fill missing values and convert special values. Need to be called after fit.

## Parameters

-----

X : DataFrame

Data that needs to be populated and transformed

Returns

-----

DataFrame

The padded and transformed data.

## **fit\_transform**

`fit_transform(self,X,y,weight=None,y_label=None)`

First call fit training, then call transform conversion

See fit, transform

# **Index**

## **Functions**

### **AUC**

`AUC(target, score, weight=None, y_label=None)`

Calculating the AUC metric

Support weight

Support target value customization

Parameters

-----

target : array like

The actual target.

score : array like

Predicted value

sample\_weight : array like

Sample weight

None: All weights are 1

Default: None.

y\_label : dict

Define which value in target means the event has occurred, and which value means the event has not occurred.

The value of keys can only be unevent or event

The value of values should be filled in according to the value of y

Default: None

The meaning of None is equivalent to {'unevent': 0, 'event': 1}.

Returns

-----

float

Prediction AUC value

## KS

KS(target, score, sample\_weight=None, y\_label=None)

Calculating the KS indicator

Support weight

Support target value customization

Parameters

-----

target : array like

The actual target.

score : array like

Predicted value

sample\_weight : array like

Sample weight

None: All weights are 1

Default: None.

y\_label : dict

Define which value in target means the event has occurred, and which value means the event has not occurred.

The value of keys can only be unevent or event

The value of values should be filled in according to the value of y

Default: None

The meaning of None is equivalent to {'unevent': 0, 'event': 1}.

Returns

-----

float

Predicted KS value

## LIFTn

LIFTn(target, pred, n=10, weight=None, score\_reverse=True, y\_label=None)

Calculating the LIFT metric

Support weight

Support target value customization

Parameters

-----

target : array like

The actual target.

pred : array like

Predicted value

n : int

Specify the percentile of LIFT

weight : array like

Sample weight

None: All weights are 1

Default: None.

score\_reverse : bool

True: The larger the pred, the lower the event rate

False: The smaller pred is, the lower the event rate is.

y\_label : dict

Define which value in target means the event has occurred, and which value means the event has not occurred.

The value of keys can only be unevent or event

The value of values should be filled in according to the value of y

Default: None

The meaning of None is equivalent to {'unevent': 0, 'event': 1}.

Returns

-----

float

The value of LIFTn

## PSI\_by\_dat

PSI\_by\_dat(Ddat, threshold\_distr=0.05, min\_distr=0.02, cutby=0, Dweight=None, spec\_value=[], min\_spec\_dist=0.005)

To calculate the PSI between multiple single-column datasets, first perform a binning node calculation for the specified dataset. Then, split all datasets according to that node and calculate the distribution. Finally, call the PSI\_by\_dist method to obtain the PSI values and other related information for each pair of datasets.

### Parameters

-----

Ddat : dict<str, Series>

Multiple single-column datasets

threshold\_distr : int or float

Greater than 1: Divide into several parts

Less than 1: What is the proportion of each portion?

Default: 0.05

min\_distr : float

The minimum acceptable percentage. Due to data skew, it is not guaranteed that all bins will meet threshold\_distr. Some bins may exceed threshold\_distr, while others may fall below it. However, the minimum percentage will not fall below min\_distr.

cutby : int, str, list

int: If datas is ndarray like, then cutby is grouped based on the first column.

str: If datas is a dict or DataFrame, it is grouped according to the corresponding benchmark series of cutby

list: cutby is bins, all series are grouped according to cutby

Default: 0.

Dweight : dict<str, Series>

The weight of each series

None: Each data point has a weight of 1

Default: None

spec\_value : list

Special value range

Example. [{"-9997"}, {"-9999,-9998"}]

default:[].

min\_spec\_dist : float

If the proportion of special values in each data set is less than min\_spec\_dist, the special values are not included in the calculation of PSI.

Default: 0

Returns

-----

float:

The maximum PSI between two datasets

DataFrame:

Intermediate data for calculating PSI between two datasets

DataFrame:

Summary of the results, including the maximum PSI between the two datasets

DataFrame:

PSI between two datasets.

## PSI\_by\_dist

PSI\_by\_dist(Ddist, spec\_value=[], min\_spec\_dist= 0.005 )

Given the distribution of each single column data set, calculate the PSI between the data sets

Example:

```
from Index import PSI_by_dist

import pandas as pd

label = ['[0.0,2.0)', '[2.0,3.0)', '[3.0,4.0)', '[4.0,22.0)', '{-9993,-9994}'], '{-9996,-9997,-9998,-9999}']

d1 = pd.Series(index=label, data=[0.6497, 0.0943, 0.0422, 0.0346, 0.1792])

d2 = pd.Series(index=label, data=[0.6286, 0.0960, 0.0428, 0.0410, 0.1916])

d3 = pd.Series(index=label, data=[0.6417, 0.0844, 0.0478, 0.0445, 0.1816])

dists = {'d1': d1, 'd2': d2, 'd3': d3}

psi_max, psi_df, dist_df, psi_values = PSI_by_dist(dists)
```

psi\_max:0.0044

psi\_df:

	d1	d2	PSI	SUM_PSI	d1	d3	PSI	SUM_PSI	d2	d3	PSI	SUM_PSI
[0.0,2.0)	0.6497	0.6286	0.000697	0.002651	0.6497	0.6417	0.000099	0.004418	0.6286	0.6417	0.000270	0.003139
[2.0,3.0)	0.0943	0.0960	0.000030	0.002651	0.0943	0.0844	0.001098	0.004418	0.0960	0.0844	0.001494	0.003139
[3.0,4.0)	0.0422	0.0428	0.000008	0.002651	0.0422	0.0478	0.000698	0.004418	0.0428	0.0478	0.000552	0.003139
[4.0,22.0),{-9993,-9994}]	0.0346	0.0410	0.001086	0.002651	0.0346	0.0445	0.002491	0.004418	0.0410	0.0445	0.000287	0.003139
{-9996,-9997,-9998,-9999}	0.1792	0.1916	0.000830	0.002651	0.1792	0.1816	0.000032	0.004418	0.1916	0.1816	0.000536	0.003139

dist\_df:

	d1	d2	d3	PSI_MAX	MAX_LOC
[0.0,2.0)	0.6497	0.6286	0.6417	0.0044	d1 , d3
[2.0,3.0)	0.0943	0.0960	0.0844	0.0044	d1 , d3
[3.0,4.0)	0.0422	0.0428	0.0478	0.0044	d1 , d3

```
[[4.0,22.0],{-9993,-9994}] 0.0346 0.0410 0.0445 0.0044 d1 , d3
```

```
{-9996,-9997,-9998,-9999} 0.1792 0.1916 0.1816 0.0044 d1 , d3
```

psi\_values:

```
data_name_1 data_name_2 PSI
```

```
0 d1 d2 0.002651
```

```
1 d1 d3 0.004418
```

```
2 d2 d3 0.003139
```

Parameters

-----

Ddist : dict<str,Series>

Distribution information of multiple single-column datasets. The distribution nodes between multiple data sets need to be consistent

spec\_value : list

Special value range

Example. [{"{-9997}"}, {"{-9999,-9998}"}]

min\_spec\_dist : float

If the proportion of special values in each data set is less than min\_spec\_dist, the special values are not included in the calculation of PSI.

Default: 0

Returns

-----

float:

The maximum PSI between two datasets

DataFrame:

Intermediate data for calculating PSI between two datasets

DataFrame:

Summary of the results, including the maximum PSI between the two datasets

DataFrame:

PSI between two datasets.

## VIF

VIF(df)

Calculate the VIF of a variable

Parameters

-----

df : DataFrame

Multi-column variables

Returns

-----

Series

The VIF value of each variable.

## Lan

By changing the value of lan, you can switch the language

Example: How to add German

```
from Lan_GER import GER
```

```
lan = GER
```

After the change, the language of all output results will be changed to German

# Performance

## Functions

### perf\_summary

```
perf_summary(datas,y_label=None,cut_data_name=None,wide=0.05,thin=None,thin_head=10,lift=None,score_reverse=True)
```

Calculate and summarize the model performance. Including:

1. Divide the output of the model into equal frequency, observe the number, distribution, proportion, cumulative number, cumulative distribution, cumulative proportion, ODDS, Lift and other information of each interval segment and summarize them

- 2.lift,ks,auc

#### Parameters

-----

`datas: dict{str,tuple(y_true,y_hat,weight)}`

All datasets for which model performance needs to be summarized.

The key is the name of the dataset, and the value is a tuple structure that stores `y_true`, `y_hat`, and `weight`. If `weight=None`, all samples have equal weights.

`y_label : dict, optional`

Define which value in target means the event has occurred, and which value means the event has not occurred.

The value of keys can only be `unevent` or `event`

The value of values should be filled in according to the value of `y`

Default: `None`.

`None` is equivalent to `{'unevent': 0, 'event': 1}`.

`cut_data_name : str, optional`

According to which dataset the model output is divided into equal frequency groups.

`None`: Perform equal frequency division according to the distribution of each data set

Whether to use the same dataset or separate datasets to calculate equal-frequency splits depends on the user's focus and business needs. Using the same dataset (usually the train dataset) not only reflects model performance, but also reflects the stability of the model output and the differences in model scores across different datasets. Using separate datasets to calculate equal-frequency splits reflects the model's true performance on each piece of data (usually higher than using the same dataset).

For example, if the model is used to sort applications (e.g., sorting scores and approving applications based on a certain percentage), if the user uses the same threshold for all applications, consider using the same dataset to calculate the split node. If the user customizes different thresholds for different applications, consider using the separate datasets to calculate the split node.

Using the same or different data sets to calculate split nodes requires users to make comprehensive judgments based on their own business application scenarios.

Default: None.

`wide` : float, optional

The model's output is grouped into equal frequency groups. This parameter is the user's desired proportion of each group. Thanks to the powerful Cutter module, even if the score distribution is skewed, it can still provide the grouping closest to wide.

Default: 0.05.

`thin` : float, optional

This option has the same meaning as wide, but provides a more detailed breakdown. Some businesses may not only focus on the overall situation, but also on the recognition efficiency (such as recall and precision) of the small subset of events with the highest (or lowest) occurrence rate. This can be achieved by configuring thin. If thin is not None, the function returns two model metric statistics tables for equal-frequency groups: a broader wide model metric table and a narrower thin model metric table.

Default: None.

`thin_head` : int, optional

The smaller the thin value is, the more equal-frequency groups there are. The narrower the thin model indicator statistics table will be, the longer it will be. It is not very convenient. Usually, the purpose of

using thin is just to focus on the head data. Therefore, thin\_head can be used to control the length of the thin model indicator statistics table, and only the first thin\_head groups are retained.

If thin is None, thin\_head is automatically ignored.

If thin\_head is None, all thin groups will be retained.

Default: 10.

lift : tuple(int,...), optional

Calculate the corresponding lift value

Example: (1,5,10,20) represents the calculation model lift1, lift5, lift10, lift20

None: Do not calculate the lift of the model

Default: None.

score\_reverse: bool , optional

Tell the relationship between the scoring value and the event rate so that the function can give a humanized display

True: The higher the probability of an event occurring, the lower the score

False: The higher the probability of an event, the higher the score

Default: True

Returns

-----

wide\_perfs : dict<str,pd.DataFrame>

Returns the number, distribution, proportion, cumulative number, cumulative distribution, cumulative proportion, ODDS, Lift and other information of each interval segment after each data set is equally grouped according to wide

thin\_perfs : dict<str,pd.DataFrame>

Returns the number, distribution, proportion, cumulative number, cumulative distribution, cumulative proportion, ODDS, Lift and other information of each interval segment after each data set is equally grouped according to thin model output.

lifts : dict<str,list>

Returns the lift specified by the user for each dataset

If the user-specified lift is None, this value also returns None.

ks : dict<str,float>

Returns the ks of each data set

auc : dict<str,float>

Returns the auc of each dataset

## **gen\_perf\_table\_by\_pred**

gen\_perf\_table\_by\_pred(target,pred,pect,y\_label=None,weight=None,score\_reverse=True)

According to the user-given y\_target, y\_hat, weight and the specified proportion of each equal-frequency group, the number, distribution, proportion, cumulative number, cumulative distribution, cumulative proportion, ODDS, Lift and other information of each interval segment of the model output are summarized.

Parameters

-----

target : pd.Series

y\_target

pred : pd.Series

y\_true

pect : float

The expected proportion of each group depends on the powerful function of the Cutter module. Even if

the score distribution is skewed, it can still give the group closest to the expected proportion.

`y_label` : dict, optional

Define which value in target means the event has occurred, and which value means the event has not occurred.

The value of keys can only be `unevent` or `event`

The value of values should be filled in according to the value of `y`

Default: None.

None is equivalent to `{'unevent': 0, 'event': 1}`.

`weight` : `pd.Series`

The weight of each sample

None: All samples have the same weight

Default: None.

`score_reverse`: bool , optional

Tell the relationship between the scoring value and the event rate so that the function can give a humanized display

True: The higher the probability of an event occurring, the lower the score

False: The higher the probability of an event, the higher the score

Default: True

Returns

-----

`perf` : `pd.DataFrame`

Returns the number, distribution, proportion, cumulative number, cumulative distribution, cumulative proportion, ODDS, Lift and other information of each interval segment after equal frequency grouping of model output

label\_bins : list

Returns the grouping of model outputs

## Reg\_Step\_Wise\_MP

Since Version== 2025.10.2 , Reg\_Step\_Wise\_MP has been replaced by StepwiseRegressionSKLearn. Although Reg\_Step\_Wise\_MP can still be used, it is recommended to use StepwiseRegressionSKLearn because it is more computationally efficient.

It is a linear/logistic two-way stepwise regression implemented in Python, which adds the following features to the traditional two-way stepwise regression:

1. When performing stepwise variable selection for logistic regression, AUC, KS, and LIFT metrics can be used instead of AIC and BIC. For some business scenarios, AUC and KS are more relevant. For example, in ranking tasks, a model built using the KS metric uses fewer variables while maintaining the same KS, thereby reducing data costs.
2. When performing stepwise variable selection, use other datasets to calculate model evaluation metrics rather than the modeling dataset. Especially when the data size is large and a validation set is included in addition to the training and test sets, it is recommended to use the validation set to calculate evaluation metrics to guide variable selection. This helps reduce overfitting.
3. Supports using partial data to calculate model evaluation metrics to guide variable selection. For example, if a business needs to maintain a certain pass rate of N%, then the bad event rate of the top N% of samples can be minimized, without requiring all samples to be included in the calculation. Actual testing shows that in appropriate scenarios, using partial data as evaluation metrics results in fewer variables than using full data, but the metrics of interest to users remain unchanged. Because the model focuses only on the top, more easily distinguishable sample points, business objectives can be achieved without requiring too many variables.
4. Supports setting multiple conditions. Variables must meet all conditions simultaneously to be included in the model. Built-in conditions include: P-Value, VIF, correlation coefficient, coefficient sign, number of variables in a group, etc.
5. Supports specifying variables that must be entered into the model. If the specified variables conflict with the conditions in 4, a comprehensive mechanism has been designed to resolve the problem.
6. The modeling process is exported to Excel, recording the reasons for deleting each variable and the

process information of each round of stepwise regression.

7. Support actuarial calculations, using company profits as a loss function, which simultaneously considers the model's prediction accuracy + the profit level of a single user + the data cost (in the testing phase, there will be significant changes later)

In most cases, users do not need to interact directly with the `Reg_Step_Wise_MP` component. However, `rascpy` is designed to be pluggable, so advanced users can use the `Reg_Step_Wise_MP` module independently, just like any other Python module.

## Classes

### LinearReg

#### `__init__`

```
__init__(self, X, y, user_save_cols=[], user_set_cols=[], fit_weight=None,
         measure='r2', measure_weight=None, measure_X=None, measure_y=None, kw_measure_args=None,
         pvalue_max=0.05, vif_max=3, corr_max=0.8, coef_sign={}, default_coef_sign=None,
         iter_num=20, kw_algorithm_class_args=None, n_core=None, results_save=None, exc_group=None)
```

Bidirectional stepwise linear regression

Parameters

-----

`X` : `DataFrame`

`X` dataset

`y` : `Series`

Actual target

`user_save_cols` : array like

Forced variables into the module

default:[].

user\_set\_cols : array like

Only these variables can be entered into the model, without addition or deletion.

If user\_set\_cols is not empty and has length greater than 0, stepwise regression degenerates to ordinary regression.

default:[].

fit\_weight : array like

Modeling weights

None: The weight of each modeling sample point is 1

This weight is not the sample weight, and the two have different meanings. Generally speaking, the sample weight mainly records the sampling ratio during the sampling process, while the modeling weight is set for various considerations, such as reducing heteroscedasticity, balancing positive and negative samples, and setting different loss costs.

Default: None.

measure : str

In bidirectional stepwise regression, an indicator is used to determine whether the model has improved.

Indicators include: r2, adj\_r2 (under development)

Default: 'r2'.

measure\_weight : array like

The sample weight used when calculating the measure indicator. This weight has a different meaning from fit\_weight, and its meaning is usually similar to that of the sample weight.

Default: None.

measure\_X : DataFrame

X data set used to measure model performance indicators when gradually screening variables

None: Use the same dataset as used for modeling

Default: None.

measure\_y : Series

The y data set used to measure the model performance index when gradually screening variables

None: Use the same dataset as used for modeling

Default: None.

kw\_measure\_args : dict

Additional parameters passed to the metric calculation method

Default: None.

pvalue\_max : float

The p-value of the coefficients of all model variables (excluding the intercept term) must be less than or equal to the threshold

Variables that the user requires to be entered into the model are not subject to this restriction

If a non-mandatory variable is included in the model and causes the p-value of a mandatory variable whose p-value is originally less than the threshold to exceed the threshold, the non-mandatory variable will not be included in the model. However, if the p-value of a mandatory variable originally exceeds the threshold, that is, the p-value caused by other mandatory variables exceeds the threshold, the introduction of the non-mandatory variable will not be affected.

None: No constraints are placed on the p-value of the model variable.

Default: 0.05

vif\_max : float

The vif of all model variables (excluding the intercept term) must be less than or equal to the threshold

Variables forced into the module are not affected by this constraint

If a non-mandatory variable is included in the model and causes the vif of a mandatory variable whose vif is originally less than the threshold to exceed the threshold, the non-mandatory variable will not be included in the model. However, if the vif of a mandatory variable itself exceeds the threshold, that is, the vif caused by other mandatory variables exceeds the threshold, the introduction of the non-mandatory variable will not be affected.

None: No restrictions are placed on the vif of the input variables

Default: 3

corr\_max : float

The correlation coefficients between all input variables must be less than or equal to the threshold

If the correlation coefficient of a non-forced variable with a forced variable exceeds the threshold, the non-forced variable will not be introduced into the model.

Even if the correlation coefficient between two forced variables is above this threshold, both variables will be included.

None: No restriction on the correlation coefficient of the model variables

Default: 0.8

coef\_sign : dict

Sign constraints on variable coefficients

ex. {"x1":"+","x2":-"} or file://xx/xx.json read from the file

Value Description:

+ The coefficient of this variable is positive

- The coefficient of this variable has a negative sign

None This variable does not constrain the coefficient sign

coef\_sign = None: No constraints are placed on the coefficient signs of all variables

Variables that the user forces to be entered into the model are not subject to this constraint

If the introduction of a non-mandatory variable causes a mandatory variable that originally satisfied the sign constraint to no longer satisfy the sign constraint, the non-mandatory variable cannot be included in the module. If the sign of the mandatory variable itself does not satisfy the sign constraint, the introduction of the non-mandatory variable will not be affected.

Default: None

default\_coef\_sign : str

When a variable is not in coef\_sign, the default value of the variable symbol constraint is

None: The default value of all variables is None

Default: None

iter\_num : int

Maximum number of iterations

Each iteration has two operations:

1. Find a variable from all remaining variables that meets the constraints and whose addition will improve the model index by the highest amount. Introduce this variable into the model.
2. Find a variable from all the variables in the model that meets the constraints and whose removal will improve the model index more than the current one, and the one with the highest improvement. Remove this variable from the model.

If, at the Nth round ( $N < \text{iter\_num}$ ), adding or removing variables does not improve the model's performance further, the iteration terminates early.

Default: 20

kw\_algorithm\_class\_args : dict

Additional parameters passed to the underlying regression algorithm.

Default: None.

n\_core : int or float

>1: Specifies the number of CPU cores

=1: Do not use multi-process

<1: Actual number of cores = total number of CPU cores \* n\_core rounded down

None: Actual number of cores = total number of CPU cores - 1

Default: None.

results\_save : str

The file name that records the modeling process. In addition to common information, the file also records the process of variable selection and elimination in stepwise regression, as well as the reasons for variable deletion.

None: Do not record the process

Default: None.

`exc_group : str`

Exclusive group, only one variable in the group can be entered into the model

ex1. `exc_group = _g`

ex2. `exc_group = g#`

Value Description:

The value must have exactly two characters:

A character is any character except `g`. It is a delimiter for variable names. Group names can be separated by this delimiter.

A character can only be `g`. If `g` appears in the front, it means the group name is the prefix of the variable name. If `g` appears in the back, it means the group name is the suffix of the variable name.

For example, if the variable naming format is `x1_gname1`, then this should be configured as `_g`

If the variable naming format is `gname1#x1`, then this should be configured as `g#`

If a variable does not contain a separator, it means that the variable is not restricted by the exclusive group constraint.

Default: None. No variable in the data is subject to the constraints of the exclusive group.

## **fit**

`fit(self)`

After constructing the `LinearReg` object, you need to call the `fit` method to perform linear bidirectional stepwise regression

Returns

-----  
`in_vars : list`

Model variables

`clf_final : statsmodels.regression.linear_model.RegressionResults` like

The main method of `clf_final`:

predict(X) outputs the model prediction value

The main attributes of clf\_final are:

intercept\_ intercept term

coef\_ Coefficient of each variable (excluding the intercept term)

tvalues is the t statistic of each model variable. Where const is the t statistic of the intercept term

pvalues Two-tailed P-value of each model variable

rsquared R2 goodness of fit of the model

rsquared\_adj The adjusted R2 goodness of fit of the model

aic aic

bic bic

resid residuals of the model

clf\_perf : DataFrame

Model building information: R-squared, adjusted R-squared, AIC, BIC, Log-Likelihood, F-statistic, Prob (F-statistic), etc.

clf\_coef : DataFrame

Model parameter information: Coef, Std.Err, coefficient test t statistic, t statistic Pvalue, confidence interval, Standardized Coefficients

del\_reason : Series

The reason for deletion of each deleted variable

step\_proc : DataFrame

Detailed records of each round of modeling process, including: adding or removing variables, and model performance indicators .

# LogisticReg

## `__init__`

```
__init__(self, X, y, y_label=None, user_save_cols=[], user_set_cols=[],
          , fit_weight=None, measure='aic', measure_weight=None
          , measure_frac=None, measure_X=None, measure_y=None, kw_measure_args=None
          , pvalue_max=0.05, vif_max=3, corr_max=0.8, coef_sign={}, default_coef_sign=None
          , iter_num=20, kw_algorithm_class_args=None, n_core=None, results_save=None, exc_group=None)
```

Bidirectional stepwise logistic regression. It adds functionality to existing packages that implement bidirectional stepwise logistic regression. See the introduction of the [Reg Step Wise MP module](#).

### Parameters

-----

X : DataFrame

X dataset

y : Series

Actual target

y\_label : dict

Define which value in y means the event has occurred, and which value means the event has not occurred.

The value of keys can only be unevent or event

The value of values should be filled in according to the value of y

Example: {'unevent':'good','event':'bad'}

Generally, defining the things users care about most as events is easier to explain. For example, if you want to emphasize the incidence of lung cancer, you can say that smokers have a 50% higher incidence of lung cancer than non-smokers. In this case, you can write {'unevent':'No lung cancer','event':'Lung cancer'}. If you write {'unevent':'Lung cancer','event':'No lung cancer'}, although it does not affect the use of the model, the explanation will become that smokers have a 50% lower incidence of lung cancer than

n non-smokers. Obviously, the first expression is easier to understand.

Default: None

The meaning of None is equivalent to {'unevent': 0, 'event': 1}.

user\_save\_cols : array like

Forced variables into the module

default:[]

user\_set\_cols : array like

Only these variables can be entered into the model, without addition or deletion.

If user\_set\_cols is not empty and has length greater than 0, stepwise regression degenerates to ordinary regression.

default:[]

fit\_weight : array like

Modeling weights

None: The weight of each modeling sample point is 1

This weight is not the sample weight, and the two have different meanings. Generally speaking, the sample weight mainly records the sampling ratio during the sampling process, while the modeling weight is set for various considerations, such as reducing heteroscedasticity, balancing positive and negative samples, and setting different loss costs.

Default: None

measure : str

In bidirectional stepwise regression, an indicator is used to determine whether the model has improved.

Indicators include: aic, bic, roc\_auc, ks, lift\_n (under development), ks\_price (under development)

Cannot be None

Default: 'aic'.

measure\_weight : array like

The sample weight used when calculating the measure indicator. This weight has a different meaning from `fit_weight`, and its meaning is usually similar to that of the sample weight.

If `measure` is `aic` or `bic`, the `measure_weight` configuration is ignored.

Default: `None`.

`measure_frac` : float

Sort by the probability of event occurrence from large to small or small to large, and take the first `N` sample points from the configuration file `$(MODEL_CONFIG:measure_data_name)` as the evaluation index of the model

`None`: Take all sample points from the configuration file `$(MODEL_CONFIG:measure_data_name)` to calculate the model evaluation index. Equivalent to `measure_frac=1`.

If `measure_index` is `aic` or `bic`, the `measure_frac` configuration is ignored. Only the entire modeling data can be used.

`measure_frac > 1`: Take the first `N = measure_frac` sample points from large to small

`0 < measure_frac <= 1`: Take the first `N = sample_n*measure_frac` sample points from largest to smallest (round down)

`-1 <= measure_frac < 0`: Take the first `N = sample_n*measure_frac*-1` sample points from smallest to largest (round down)

`measure_frac < -1`: Take the first `N = measure_frac*-1` sample points from small to large

Default: `None`

`measure_X` : DataFrame

`X` data set used to measure model performance indicators when gradually screening variables

`None`: Use the same dataset as used for modeling

If `measure` is `aic` or `bic`, the `measure_X` configuration is ignored. Only the same dataset as that used for modeling can be used.

Default: `None`.

`measure_y` : Series

The `y` data set used to measure the model performance index when gradually screening variables

None: Use the same dataset as used for modeling

If measure is aic or bic, the measure\_y configuration is ignored. You can only use the same dataset as the one used for modeling.

Default: None.

kw\_measure\_args : dict

Additional parameters passed to the metric calculation method

Default: None.

pvalue\_max : float

The p-value of the coefficients of all model variables (excluding the intercept term) must be less than or equal to the threshold

Variables that the user requires to be entered into the model are not subject to this restriction

If a non-mandatory variable is included in the model and causes the p-value of a mandatory variable whose p-value is originally less than the threshold to exceed the threshold, the non-mandatory variable will not be included in the model. However, if the p-value of a mandatory variable originally exceeds the threshold, that is, the p-value caused by other mandatory variables exceeds the threshold, the introduction of the non-mandatory variable will not be affected.

None: No constraints are placed on the p-value of the model variable.

Default: 0.05

vif\_max : float

The vif of all model variables (excluding the intercept term) must be less than or equal to the threshold

Variables forced into the module are not affected by this constraint

If a non-mandatory variable is included in the model and causes the vif of a mandatory variable whose vif is originally less than the threshold to exceed the threshold, the non-mandatory variable will not be included in the model. However, if the vif of a mandatory variable itself exceeds the threshold, that is, the vif caused by other mandatory variables exceeds the threshold, the introduction of the non-mandatory variable will not be affected.

None: No restrictions are placed on the vif of the input variables

Default: 3

corr\_max : float

The correlation coefficients between all input variables must be less than or equal to the threshold

If the correlation coefficient of a non-forced variable with a forced variable exceeds the threshold, the non-forced variable will not be introduced into the model.

Even if the correlation coefficient between two forced variables is above this threshold, both variables will be included.

None: No restriction on the correlation coefficient of the model variables

Default: 0.8

coef\_sign : dict

Sign constraints on variable coefficients

ex. {"x1": "+", "x2": "-"} or file://xx/xx.json read from the file

Value Description:

+ The coefficient of this variable is positive

- The coefficient of this variable has a negative sign

None This variable does not constrain the coefficient sign

coef\_sign = None: No constraints are placed on the coefficient signs of all variables

Variables that the user forces to be entered into the model are not subject to this constraint

If the introduction of a non-mandatory variable causes a mandatory variable that originally satisfied the sign constraint to no longer satisfy the sign constraint, the non-mandatory variable cannot be included in the module. If the sign of the mandatory variable itself does not satisfy the sign constraint, the introduction of the non-mandatory variable will not be affected.

Default: None

default\_coef\_sign : str

When a variable is not in coef\_sign, the default value of the variable symbol constraint is

None: The default value of all variables is None

Default: None

iter\_num : int

Maximum number of iterations

Each iteration has two operations:

1. Find a variable from all remaining variables that meets the constraints and whose addition will improve the model index by the highest amount. Introduce this variable into the model.
2. Find a variable from all the variables in the model that meets the constraints and whose removal will improve the model index more than the current one, and the one with the highest improvement. Remove this variable from the model.

If, at the Nth round ( $N < \text{iter\_num}$ ), adding or removing variables does not improve the model's performance further, the iteration terminates early.

Default: 20

kw\_algorithm\_class\_args : dict

Additional parameters passed to the underlying regression algorithm.

Default: None.

n\_core : int or float

>1: Specifies the number of CPU cores

=1: Do not use multi-process

<1: Actual number of cores = total number of CPU cores \* n\_core rounded down

None: Actual number of cores = total number of CPU cores - 1

Default: None.

results\_save : str

The file name that records the modeling process. In addition to common information, the file also records the process of variable selection and elimination in stepwise regression, as well as the reasons for variable deletion.

None: Do not record the process

Default: None.

`exc_group : str`

Exclusive group, only one variable in the group can be entered into the model

ex1. `exc_group = _g`

ex2. `exc_group = g#`

Value Description:

The value must have exactly two characters:

A character is any character except `g`. It is a delimiter for variable names. Group names can be separated by this delimiter.

A character can only be `g`. If `g` appears in the front, it means the group name is the prefix of the variable name. If `g` appears in the back, it means the group name is the suffix of the variable name.

For example, if the variable naming format is `x1_gname1`, then this should be configured as `_g`

If the variable naming format is `gname1#x1`, then this should be configured as `g#`

If a variable does not contain a separator, it means that the variable is not restricted by the exclusive group constraint.

Default: None. No variable in the data is subject to the constraints of the exclusive group.

## **fit**

`fit(self)`

After constructing the `LogisticReg` object, you need to call the `fit` method to perform a bidirectional stepwise regression.

Returns

-----

`in_vars : list`

Model variables

clf\_final : statsmodels.genmod.generalized\_linear\_model.GLMResults like

The main method of clf\_final:

predict(X) The regression value predicted by the model

The main attributes of clf\_final are:

intercept\_ intercept term

coef\_ Coefficient of each variable (excluding the intercept term)

tvalues is the t statistic of each model variable. Where const is the t statistic of the intercept term

pvalues Two-tailed P-value of each model variable

resid\_pearson Pearson residual

resid\_deviance residual deviation

clf\_perf : DataFrame

Model building information: Link Function, Df Residuals, Method (optimization algorithm), AIC, BIC, Log-Likelihood, LL-Null, Deviance, Pearson chi2, Scale, etc.

clf\_coef : DataFrame

Model parameter information summary: Coef, Std.Err, coefficient test Wald statistic, Wald statistic Pvalue, confidence interval, Standardized Coefficients

del\_reason : Series

The reason for deletion of each deleted variable

step\_proc : DataFrame

Detailed records of each round of modeling process, including: adding or removing variables, and model performance indicators .

# Report

## Functions

### write\_performance

```
write_performance(datas,y_label=None,cut_data_name=None,wide=0.05,thin=0.01,thin_head=10,lift=None,score_reverse=True,writer=None,sheet_name=lan['Performance of the model'],filePath=None)
```

Write the performance indicators of the data set into Excel. Including:

1. Divide the output of the model into equal frequency, observe the number, distribution, proportion, cumulative number, cumulative distribution, cumulative proportion, ODDS, Lift and other information of each interval segment and summarize them

- 2.lift,ks,auc

#### Parameters

-----

**datas:** dict{str,tuple(y\_true,y\_hat,weight)}

All datasets for which model performance needs to be summarized.

The key is the name of the dataset, and the value is a tuple structure that stores y\_true, y\_hat, and weight.If weight=None, all samples have equal weights.

**y\_label :** dict, optional

Defines which value in y represents the occurrence of the event and which value represents the non-occurrence of the event.

Keys can only be 'unevent' or 'event'.

Values should be set according to the actual values in y.

Default: None.

None is equivalent to {'unevent': 0, 'event': 1}.

**cut\_data\_name :** str, optional

According to which dataset the model output is divided into equal frequency groups.

None: Perform equal frequency division according to the distribution of each data set

Whether to use the same dataset or separate datasets to calculate equal-frequency splits depends on the user's focus and business needs. Using the same dataset (usually the train dataset) not only refl

ects model performance, but also reflects the stability of the model output and the differences in model scores across different datasets. Using separate datasets to calculate equal-frequency splits reflects the model's true performance on each piece of data (usually higher than using the same dataset).

For example, if the model is used to sort applications (e.g., sorting scores and approving applications based on a certain percentage), if the user uses the same threshold for all applications, consider using the same dataset to calculate the split node. If the user customizes different thresholds for different applications, consider using the separate datasets to calculate the split node.

Using the same or different data sets to calculate split nodes requires users to make comprehensive judgments based on their own business application scenarios.

Default: None.

`wide` : float, optional

The model's output is grouped into equal frequency groups. This parameter is the user's desired proportion of each group. Thanks to the powerful Cutter module, even if the score distribution is skewed, it can still provide the grouping closest to wide.

Default: 0.05.

`thin` : float, optional

This option has the same meaning as `wide`, but provides a more detailed breakdown. Some businesses may not only focus on the overall situation, but also on the recognition efficiency (such as recall and precision) of the small subset of events with the highest (or lowest) occurrence rate. This can be achieved by configuring `thin`. If `thin` is not None, the function returns two model metric statistics tables for equal-frequency groups: a broader `wide` model metric table and a narrower `thin` model metric table.

Default: None.

`thin_head` : int, optional

The smaller the `thin` value is, the more equal-frequency groups there are. The narrower the `thin` model indicator statistics table will be, the longer it will be. It is not very convenient. Usually, the purpose of using `thin` is just to focus on the head data. Therefore, `thin_head` can be used to control the length of the `thin` model indicator statistics table, and only the first `thin_head` groups are retained.

If thin is None, thin\_head is automatically ignored.

If thin\_head is None, all thin groups will be retained.

Default: 10.

lift : tuple(int,...), optional

Calculate the corresponding lift value

Example: (1,5,10,20) represents the calculation model lift1, lift5, lift10, lift20

None: Do not calculate the lift of the model

Default: None.

score\_reverse: bool , optional

Tell the relationship between the scoring value and the event rate so that the function can give a humanized display

True: The higher the probability of an event occurring, the lower the score

False: The higher the probability of an event, the higher the score

Default: True

writer : writer, optional

A writer for Excel. If you want to combine the current information with other information and output them in the same Excel file, it is more convenient to use the writer. Otherwise, it is more convenient to use filePath.

sheet\_name : str, optional

Write the performance indicators of the model to the sheet page

filePath : str, optional

Writer is used first. If writer is None, the Excel file location specified by filePath is used.

Both writer and filePath cannot be None at the same time

## Returns

-----

`wide_perfs : dict<str,pd.DataFrame>`

Returns the number, distribution, proportion, cumulative number, cumulative distribution, cumulative proportion, ODDS, Lift and other information of each interval segment after each data set is equally grouped according to wide

`thin_perfs : dict<str,pd.DataFrame>`

Returns the number, distribution, proportion, cumulative number, cumulative distribution, cumulative proportion, ODDS, Lift and other information of each interval segment after each data set is equally grouped according to thin model output.

`lifts : dict<str,list>`

Returns the lift specified by the user for each dataset

If the user-specified lift is None, this value also returns None.

`ks : dict<str,float>`

Returns the ks of each data set

`auc : dict<str,float>`

Returns the auc of each dataset

## **write\_y\_stat**

`write_y_stat(datas,y_stat_group_cols = None,weight_col=None,y_col='y',y_label=None,writer=None,sheet_name=lan['0113'],filePath=None)`

Perform statistics on the Y value distribution of all data sets. If `y_stat_group_cols` is specified, statistics are performed after grouping according to `y_stat_group_cols`.

## Parameters

-----  
datas: dict{str,dict{str,dataframe}}

datas is a two-level nested dict structure. The first str is the purpose of the dataset, and the second str is the name of the dataset.

Example: {'model\_data':{'train':df\_train,'test':df\_test},'perf\_data':{'client1':df1,'client2':df2},'oot\_data':{'time1':df\_time1,'time2':df\_time2}}

y\_stat\_group\_cols : list, optional

One or more user-specified variables for grouping statistics Y

None: No group is specified

Default: None.

weight\_col : str, optional

Sample weight column name.

None: All samples have the same weight

Default: None.

y\_col : str, optional

Column name for the sample y values

Default: 'y'.

y\_label : dict, optional

Defines which value in y represents the occurrence of the event and which value represents the non-occurrence of the event.

Keys can only be 'unevent' or 'event'.

Values should be set according to the actual values in y.

Default: None.

None is equivalent to {'unevent': 0, 'event': 1}.

writer : writer, optional

A writer for Excel. If you want to combine the current information with other information and output them in the same Excel file, it is more convenient to use the writer. Otherwise, it is more convenient

t to use filePath.

sheet\_name : str, optional

Write the y statistical results to the sheet page

filePath : str, optional

Writer is used first. If writer is None, the Excel file location specified by filePath is used.

Both writer and filePath cannot be None at the same time

Returns

-----

None.

## **write\_feature\_select**

write\_feature\_select(indices,filtered\_cols,used\_cols,filters\_middle\_data,var\_describe\_file\_path=None,writer=None, sheet\_name=lan['Selection of variables'],filePath=None)

Write the results of variable selection into Excel

Parameters

-----

indices : dict{str,Series}

Display the indicator values of each variable in the report

key is the indicator name

vaue is the value of each variable on the key indicator

filtered\_cols : dict{str,str}

The reason why each variable is filtered out. Multiple reasons are separated by carriage returns.

The reasons include not meeting the threshold of the indicator (list several indicators if they are not m

et) and logistic regression deletion

used\_cols : dict<str,str>

The reason for each variable to be included in the model includes:

Logistic regression introduction, user forced introduction, etc.

filters\_middle\_data : dict{str,dataframe}

Output the intermediate process data of the variable indicators entered by the user to Excel

str will be used as the name of the sheet

var\_describe\_file\_path : str, optional

Variable description file

The first column of the file records the name of the variable. The name must be consistent with the variable in the model data and the capitalization must be the same.

The columns of the file except the first column will be displayed in the Excel sheet page corresponding to the variable selection, which is convenient for users to view

writer : writer, optional

A writer for Excel. If you want to combine the current information with other information and output them in the same Excel file, it is more convenient to use the writer. Otherwise, it is more convenient to use filePath.

sheet\_name : str, optional

Write the results to the sheet page

filePath : str, optional

Writer is used first. If writer is None, the Excel file location specified by filePath is used.

Both writer and filePath cannot be None at the same time

## Returns

-----

None.

## write\_reg

`write_reg(reg,var_describe_file_path,writer=None,sheet_name=lan['Model Info'],filePath=None)`

Output the return result of `StepwiseRegressionSKLearn.LogisticReg/LinearReg.fit()` to Excel

## Parameters

-----

`reg`: `StepwiseRegressionSKLearn.LogisticReg/LinearReg`

Instance produced after `StepwiseRegressionSKLearn.LogisticReg/LinearReg.fit`

`var_describe_file_path` : str, optional

Variable description file

The first column of the file records the name of the variable. The name must be consistent with the variable in the model data and the capitalization must be the same.

All columns except the first column will be displayed in the Excel sheet page corresponding to the model selection, which is convenient for users to view.

`writer` : writer, optional

A writer for Excel. If you want to combine the current information with other information and output them in the same Excel file, it is more convenient to use the writer. Otherwise, it is more convenient to use `filePath`.

`sheet_name` : str, optional

Write the results to the sheet page

`filePath` : str, optional

Writer is used first. If writer is None, the Excel file location specified by filePath is used.

Both writer and filePath cannot be None at the same time

Returns

-----

None.

## write\_card

```
write_card(Dcard,base_points,base_event_rate,pdo,train_bins_stat,stand_coef,var_describe_file_path,writer,sheet_name=lan['Score card'],filePath=None)
```

Enter the scorecard into Excel, including:

The score of each variable in each bin, the parameters for calibrating the scorecard score, and the variable weights

Parameters

-----

Dcard:

ScoreCard.CardFlow.card

base\_points : float

Benchmark score

base\_event\_rate : float

Benchmark event rate corresponding to the benchmark score

pdo : float

PDO

stand\_coef : TYPE

The return value of `Reg_Step_Wise_MP.LogisticReg.fit()` is `clf_coef['Standardized Estimate']`

`writer` : writer, optional

A writer for Excel. If you want to combine the current information with other information and output them in the same Excel file, it is more convenient to use the writer. Otherwise, it is more convenient to use `filePath`.

`sheet_name` : str, optional

Write the y statistical results to the sheet page

`filePath` : str, optional

Writer is used first. If `writer` is `None`, the Excel file location specified by `filePath` is used.

Both `writer` and `filePath` cannot be `None` at the same time

Returns

-----

None.

## **bfy\_df\_like\_excel**

`bfy_df_like_excel(df_grid,writer,sheet_name='Sheet1',default_decimal=None,default_text_lum=0,default_red_max=True,row_num=0,col_num=0,row_gap=2,col_gap=2,align=True,ex_align=[],default_index=True)`

Output all DataFrame or Series into a single Excel sheet, with the output style resembling an Excel pivot table. Users can also customize partial beautification functions.

example:

```

from rascpy.Report import bfy_df_like_excel

df_grid=[]

df_rows1=[]#put a df outputted to 1 row in this list
df_rows2=[]#put a df outputted to 2 row in this list
df_rows3=[]#put a df outputted to 3 row in this list
df_rows4=[]#put a df outputted to 4 row in this list

#Note: The row here is not the concept of "row" in Excel

df_grid.append(df_rows1)

df_grid.append(df_rows2)

df_grid.append(df_rows3)

df_grid.append(df_rows4)


df1 = pd.DataFrame(np.random.randn(10, 4), columns=['A1', 'B1', 'C1', 'D1'])

df1['SCORE_BIN']=['[0,100)', '[100,200)', '[200,300)', '[300,400)', '[400,500)', '[500,600)', '[600,700)', '[700,800)', '[800,900)', '[900,1000]']

#Output df1 to the first table in the first row

df_rows1.append({'df':df1[['SCORE_BIN', 'A1', 'B1', 'C1', 'D1']], 'title': ['notAnum'], 'percent_cols':df1.columns, 'color_gradient_sep':True})


df2 = pd.DataFrame(np.random.randn(2, 4), columns=['A2', 'B2', 'C2', 'D2'])

#Output df2 to the second table in row 1

df_rows1.append({'df':df2, 'color_gradient_cols':['A2', 'C2'], 'title': ['percent for BC', 'gradient_color for AC'], 'percent_cols':['B2', 'C2']})


df3 = pd.DataFrame(np.random.randn(15, 4), columns=['A3', 'B3', 'C3', 'D3'])

#Output df3 to the first table in the second row

df_rows2.append({'df':df3, 'color_gradient_cols':['B3'], 'title': ['red_max==True'], 'red_max':True})


df4 = pd.DataFrame(np.random.randn(4, 5), columns=['A4', 'B4', 'C4', 'D4', 'E4'])

```

```
#Output df4 to the second table in the second row
```

```
df_rows2.append({'df':df4,'color_gradient_sep':False,'text_lum':0.4,'title':['text_lum=0.4']})
```

```
df5 = pd.DataFrame(np.random.randn(10, 15), columns=map(lambda x:'Col_%d'%x,range(1,16)))
```

```
#Output df5 to the first table in the third row
```

```
df_rows3.append({'df':df5,'color_gradient_sep':True,'title':['not_align']})
```

```
df6 = pd.DataFrame({'A6':[1,2,3,4,None],'B6':[0.1,1.2,100.5,7.4,1]})
```

```
#Output df6 to the first table in row 4
```

```
df_rows4.append({'df':df6,'color_gradient_sep':True,'percent_cols':['A6']})
```

```
df7 = pd.DataFrame({'A7':[1,2,3,4],'B7':[0.1,1.2,100.5,7.4]})
```

```
#Output df7 to the second table in row 4
```

```
df_rows4.append({'df':df7,'not_color_gradient_cols':df7.columns,'title':['ALL not_color_gradient']})
```

```
#Two output methods, choose one according to actual needs
```

```
r,c = bfy_df_like_excel(df_grid,'pivot.xlsx',sheet_name='demo',red_max=False,row_num=4,col_num=4,row_
gap=2,col_gap=2,align=True,ex_align=[2])
```

```
# or
```

```
with pd.ExcelWriter('pivot.xlsx') as writer:
```

```
    r,c = bfy_df_like_excel(df_grid,writer,sheet_name='demo',red_max=False,row_num=4,col_num=4,row
_gap=2,col_gap=2)
```

```
    print(r,c)
```

Parameters

-----

df\_grid: a 2-dimensional list

[

[dict,dict,...], #line 1

[dict,dict,...],#Line 2

...

]

Each dict represents the settings of a DataFrame or Series

The key meaning of dict:

df: DataFrame or Series to be output

title: See bfy\_df\_like\_excel\_one.df

percent\_cols: see bfy\_df\_like\_excel\_one.percent\_cols

color\_gradient\_cols: see bfy\_df\_like\_excel\_one.color\_gradient\_cols

not\_color\_gradient\_cols: see bfy\_df\_like\_excel\_one.not\_color\_gradient\_cols

color\_gradient\_sep: see bfy\_df\_like\_excel\_one.color\_gradient\_sep

decimal: See bfy\_df\_like\_excel\_one.decimal If decimal is not set for the df, default\_decimal is used by default

text\_lum: See bfy\_df\_like\_excel\_one.text\_lum If text\_lum is not set for the df, default\_text\_lum is used by default

red\_max: See bfy\_df\_like\_excel\_one.red\_max If red\_max is not set for the df, default\_red\_max is used by default

index: See bfy\_df\_like\_excel\_one.index If index is not set for the df, default\_index is used by default

writer : str or pandas.ExcelWriter

Specify the excel path, or an already constructed ExcelWriter.

sheet\_name : str, optional

The specified Excel sheet.

Default 'Sheet1'

default\_decimal: int, optional

The default number of decimal places. If decimal is not set for one df, default\_decimal is used by default.

Default: None

default\_text\_lum : float, optional

A value between [0,1] that controls the color difference between the text and the color scale. A larger value for text\_lum increases the color difference.

When text\_lum=0, the text is always black

If text\_lum is not set for one df, default\_text\_lum is used by default.

Default 0

default\_red\_max : bool , optional

True: The larger the value, the redder the color, and the smaller the value, the greener the color.

False: The larger the value, the greener the color, and the smaller the value, the redder the color.

If red\_max is not set for one df, default\_red\_max is used by default.

Defaults is True when the language environment is Chinese, False for other languages environment.

row\_num : int, optional

The starting row number of the table

Default is 0.

col\_num : int, optional

The starting column number of the table

Default is 0.

row\_gap : int, optional

The spacing between rows.

Default is 2.

col\_gap : int, optional

The spacing between columns.

Default is 2.

`align : bool, optional`

If the columns in DataFrame from different rows in need to be aligned

Default is True

`ex_align : list, optional`

All DataFrames in the specified row do not need to have their columns aligned with DataFrames of the same columns in other rows.

Default is []

`default_index: boolean, optional`

True: Export the index to Excel

False: Do not export the index to Excel

If one df do not set index ,using default\_index

Default is True

Returns

-----

int

The last row after all tables are output.

int

The last column after all tables are output. (Not the largest column in the last row)

For example, if there are two rows, the maximum column of the first row is 5, and the maximum column of the second row is 4, then 5 is returned.

## **bfy\_df\_like\_excel\_one**

`bfy_df_like_excel_one(df,writer, sheet_name='Sheet1', title=[], decimal=None, percent_cols=[], color_gradient_cols=None, not_color_gradient_cols=[], color_gradient_sep=True, text_lum=0.5, red_max=True, row_num=0, column=0, index=True)`

Beautify a dataframe or Series into an Excel pivot table-style chart and output it to the specified Excel.

You can do Excel color scale filling and percentage display (not formatted as percentage, but displayed as percentage, the actual value and value type remain unchanged).

example:

```
df1 = pd.DataFrame(np.random.randn(10, 4), columns=['A1', 'B1', 'C1', 'D1'])
df1['SCORE_BIN']=['[0,100)', '[100,200)', '[200,300)', '[300,400)', '[400,500)', '[500,600)', '[600,700)', '[700,800)', '[800,900)', '[900,1000)']
r,c = bfy_df_like_excel_one(df1,'df1.xlsx',title=['DF1','any'],percent_cols=df1.columns,color_gradient_sep=True,text_lum=0,row_num=2,col_num=2)
print(r,c)
```

#### Parameters

-----

**df** : DataFrame or Series

Dataframe or Series that needs to be beautified

**writer** : str or pandas.ExcelWriter

Specify the excel path, or an already constructed ExcelWriter.

**sheet\_name** : str, optional

The specified Excel sheet.

Default 'Sheet1'

**title** : list, optional

Each text in the title will be output above the table, and each element will occupy a cell

The default is [].

**decimal** : int , optional

The number of decimal places retained. Automatically exclude int type columns and non-numeric col

umns in df

The original data stored in Excel will not be changed, only the display of Excel will be changed. The function is the same as "Format Cells - Keep Decimals" in Excel.

None: Do not adjust the number of decimal places

Default: None

percent\_cols: list, optional

Columns that need to be displayed as percentages automatically retain 2 decimal places of percentages

For example: 0.23456 -> 23.46%

The original data stored in Excel will not be changed, only the display of Excel will be changed. The function is the same as "Format Cells - Percentage" in Excel.

Int type columns and non-numeric columns will be automatically excluded

default[]

color\_gradient\_cols : list, optional

Columns that need to display color scale

None: All numeric columns in df need to display color scales

Non-numeric columns will be automatically excluded

Default is None.

not\_color\_gradient\_cols : list, optional

Columns that do not need to display color levels. not\_color\_gradient\_cols has a higher priority than color\_gradient\_cols

Non-numeric columns are automatically excluded, so there is no need to mark them here.

default[].

color\_gradient\_sep: bool , optional

True: The color of each cell is determined by the maximum and minimum values in its column

False: The color of each cell will be determined by the maximum and minimum values of all partici

pating color scale columns.

Default True

text\_lum : float, optional

A value between [0,1] that controls the color difference between the text and the color scale. A larger value for text\_lum increases the color difference.

When text\_lum=0, the text is always black

Default 0.5

red\_max : bool , optional

True: The larger the value, the redder the color, and the smaller the value, the greener the color.

False: The larger the value, the greener the color, and the smaller the value, the redder the color.

Defaults is True when the language environment is Chinese, False for other languages environment.

row\_num : int, optional

The starting row number of the table

Default is 0.

col\_num : int, optional

The starting column number of the table

Default is 0.

index : boolean, optional

True: Export the index to Excel

False: Do not export the index to Excel

Defaults is True

Returns

-----

int

The row\_num at the end (the row number in the lower right corner of the table)

int

col\_num at the end (the column number in the lower right corner of the table)

# Sampling

## Functions

### split\_cls

```
split_cls(dat,y='y',test_size=0.3,w=None,groups=[],random_state=0,y_label=None)
```

High-precision high-dimensional stratified sampling. The stratified sampling built into machine learning is overly simplistic. When stratified sampling is performed solely on the Y label, a phenomenon may occur: after the variables in the training and test sets are segmented with equal frequency according to the same nodes, the event rates of Y differ significantly, making it difficult to narrow the indicator differences between the training and validation sets during modeling. Without high-precision high-dimensional stratified sampling, this problem can only be addressed by reducing model performance to increase model generalization. Another phenomenon is that after binning, the binning effects of the training and validation sets differ significantly, reflected in significantly different IV values. Without high-precision high-dimensional stratified sampling, the only way to increase generalization is to increase the bin width. The stratified sampling method provided by rascpy has been tested and found to significantly alleviate this phenomenon, reducing the difference between the training and validation sets without reducing model performance or binning IV. (Excessive differences between datasets are often caused by inconsistent high-dimensional joint distributions, but due to sampling accuracy limitations, they can only be treated as overfitting.)

One of the most important evaluation criteria for the effectiveness of a high-dimensional stratified sampling algorithm is whether the joint distribution of each x variable and y can remain consistent in each data set after sampling.

If the data itself can be divided into multiple groups from different dimensions, then it is also required that the joint distribution of each x variable and y can be consistent in each group in each data set after sampling.

rascpy provides the rascpy.Sampling.split\_cls algorithm, which is designed for high-precision sampling of binary classification problems. Compared with multiple sampling algorithms, it shows good consistency in joint distribution, regardless of whether the data contains groups. This is especially true for x variables, which have good predictive power.

#### Parameters

-----

dat : DataFrame

Data to be sampled

y : str, optional

target, performs stratified sampling based on the column names specified by y. After sampling, the event rates of y remain roughly consistent across all datasets. The joint distribution of each x and y is also kept roughly consistent across all datasets.

Default: 'y'.

test\_size : float, optional

The scale of the dataset

Default: 0.3.

w : str, optional

The column name corresponding to the sample weights. If w is not empty, stratified sampling is performed according to the column corresponding to y, so that the weighted event rate of y remains roughly consistent across all datasets. The weighted joint distribution of each x and y is also kept roughly consistent across all datasets.

Default: None, meaning all samples have equal weights.

groups : list, optional

The elements in groups are the column names corresponding to the data groups. If the number of elements in groups is 2 or more, a cross-group is formed. Each sample point belongs to a group (only 1 group) or a cross-group (2 or more groups). When the number of elements in groups is greater than 0, stricter requirements are imposed on stratified sampling, that is, the following requirements must still be met within each group or cross-group:

1. Meet the test\_size ratio requirements
2. The event rate or weighted event rate that satisfies y should be roughly consistent
3. The joint distribution of each x and y should be kept roughly consistent across all datasets.

default:[].

random\_state: float, optional

Random Seed

Default: 0.

y\_label : dict, optional

Defines which value in y represents the occurrence of the event and which value represents the non-occurrence of the event.

Keys can only be 'unevent' or 'event'.

Values should be set according to the actual values in y.

Default: None.

None is equivalent to {'unevent': 0, 'event': 1}.

Returns

-----

DataFrame

train dataset.

DataFrame  
test dataset.

# ScoreCard

## Classes

### CardFlow

It divides the scorecard development process into 10 phases: data reading, equal-frequency binning, feature pre-screening, monotonic and U-shaped recommendations, rasc optimal binning, Word of Equinox conversion, feature screening, model building, scorecard creation, and report generation. Results are automatically saved after each phase, allowing you to resume work from any breakpoint, and restarting the computer will not lose the results of completed steps.

For example, `cardflow.start(start_step=1,end_step=10)` executes all steps. After execution, if the user changes the configuration file, such as changing the feature filtering conditions, which affects the results of steps 7 and later, and needs to update 7-10, then just execute `cardflow.start(start_step=7,end_step=10)` and the previous results do not need to be re-executed.

For most users, after configuring the configuration file, CardFlow is the only component you need to interact with. The interaction method is very simple: `cardflow.start(start_step=a,end_step=b)`

CardFlow adds an extra stage to the 10 stages: rejection inference. If the user specifies the data location for rejection inference, you can set `end_step` to 11 to enable training of the rejection inference model.

```
from rascpy.ScoreCard import CardFlow
if __name__ == '__main__': # Windows must write a main function (but not in jupyter), Linux and MacOS do not
    need to write a main function
    # Pass in the command file
    scf = CardFlow('./inst.txt')
    scf.start(start_step=1,end_step=11)# will automatically give the score card + the score card for rejection inference

    # You can stop at any step, as follows:
    scf.start(start_step=1,end_step=10)#No scorecard will be developed for rejection inference
    scf.start(start_step=1,end_step=9)#No model report will be output

    # If the results of the run have not been modified, there is no need to run again. As shown below, steps 1-4 that
    have been run will be automatically loaded (will not be affected by restarting the computer)
    scf.start(start_step=5,end_step=8)

    # You can also omit start_step and end_step, abbreviated as:
    scf.start(1,10)
```

## **\_\_init\_\_**

`__init__(self, config_file=None, encoding='utf-8', **cover_conf)`

Build the CardFlow instance. If successful, the configuration items will be saved in the specified `{workspace}/O_conf.pkl`.

### **Parameters**

-----

`inst_file` : str

Specify the location of the directive file

None: Do not use the command file

Default: None

`encoding` : str

Configuration file encoding

Default: 'utf-8'

`**cover_inst` : dict

The configuration in `cover_inst` will supplement and replace the configuration in the `inst_file` file.

## **do\_load\_datas**

`do_load_datas(self)`

The first step in the rasc modeling process. It divides the data into five directories: `model_data`, `psi_data`, `oot_data`, `performance_data`, and `reject_model_data`. These directories correspond to the file directories specified in the configuration: `model_data_file_path`, `psi_data_file_path`, `oot_data_file_path`, `performance_data_file_path`, and `reject_data_file_path`. (Only `model_data_file_path` is required.) `do_load_datas` reads all files in these five directories (directories not specified are automatically ignored) and constructs a data set structure with nested dicts.

`dict<data usage, dict<data file name, DataFrame>>`. Use the name of the data file as the name of the dataset

Data uses include:

`model_data`: data used for modeling, which can be classified into training set, validation set and test set.

`psi_data`: used to store data for checking variable stability, such as when the performance period is insufficient but there is already data for X

`oot_data`: used to store data for viewing model indicators on OOT

`performance_data`: Data that needs to be used to view the model's performance on the dataset can be included in this data.

`reject_model_data`: data used to train the rejection inference model

After the data is read, the nested dict dataset structure is saved in the specified `$(work_space)/1_datas.pkl` file. It can also be obtained through the CardFlow instance `scf.datas`.

Data categories are only used to help users remember and are not used to calculate metrics. For example, the model effects of the data in `oot_data` will also be displayed. The data in `model_data` can also be used to calculate the PSI metric to filter variables .

## **do\_freq\_bins**

`do_freq_bins(self)`

The second step in the rasc modeling process uses a dataset whose data usage is `model_data` and is set to train by the user to perform node calculations for equal-frequency binning, with special values and null values in separate bins. It then splits all data from all data usages according to the calculated equal-frequency binning nodes, and finally calculates information for each bin, including:

Quantity, distribution. For data with a target, the number of sample points where the event did not occur, the number of sample points where the event occurred, the event occurrence rate, woe, and IV are also counted.

The equal-frequency binning nodes of each variable in each data set remain consistent, and other indicators are calculated based on the variables themselves.

After `do_freq_bins` successfully runs, it generates two results, which can be obtained through the CardFlow instances `scf.train_freqbins` and `scf.freqbins_stat`, respectively. The first is the binning nodes calculated based on the training set. The second is the statistics of all data after being segmented by the binning nodes of the first result. `scf.freqbins_stat` is a two-level nested dict structure: `dict<data purpose, dict<data name, equal frequency binning statistics>>>`.

Combine the two results into a tuple and save it in `${work_space}/2_freqbins.pkl`. For user convenience, the second result will also be written to `${work_space}/2_freqbins.xlsx`. Each sheet contains the equal frequency bin statistics of a data set. The naming convention of the sheet is: 'Data set file name (data purpose)' See [Bins.FreqBin](#), [Bins. x1FreqBin](#)

## do\_fore\_filter

`do_fore_filter(self)`

The third step in the rasc modeling process is to pre-filter the variables.

Because equal-frequency binning is unconstrained, its IV value must be greater than or equal to the IV value of the optimal binning. Therefore, when the IV value of the equal-frequency binning is below the threshold specified by `small_iv`, these variables can be filtered out and excluded from the subsequent optimal binning (because the IV value of the optimal binning is always below the threshold). When there are many variables and many of them are below the threshold specified by `small_iv`, this feature can be enabled to reduce the number of variables and thus shorten the time it takes to run the optimal binning.

Because equal-frequency binning usually produces more bins than optimal binning, the `big_homogeneity` of equal-frequency binning is smaller than the `big_homogeneity` of optimal binning. Therefore, when the `big_homogeneity` of equal-frequency binning is greater than the threshold, these variables can be filtered out first to reduce the running time of subsequent steps.

Missing values will not change whether it is equal-frequency binning or optimal binning, so when the `big_miss` of equal-frequency binning is greater than the threshold, these variables can be filtered out first to reduce the running time of subsequent steps.

When `do_fore_filter` runs successfully, it generates two results, which can be called through the `CardFlow` instances `scf.fore_col_indices` and `scf.fore_filtered_cols` respectively. The first is the filter index value calculated for each variable based on the distribution of equal frequency bins, and the second is the variable that was filtered out and the reason for filtering out. The format of the filtered out reason record is as follows:

[fore] filter metric > or < filter threshold [dataset name]

...(records deleted by multiple filters, wrapped in newlines)

[fore]: Indicates that the variable is deleted in the pre-filtering stage

Filter indicators: iv, homogeneity, miss, user extension

[Dataset Name]: The name of the dataset that produces the maximum or minimum value

These two results will form a tuple and be saved in `${work_space}/3_fore_filter.pkl`.

For more detailed information, see the description of the `fore_filters` and `filters` configuration items in the configuration file description.

## do\_mono\_suggest

`do_mono_suggest(self)`

The fourth step in the rasc modeling process. If `mono_suggest=True` is configured, rasc will use all datasets under the data purpose `model_data` to calculate the monotonicity of variables at the data level and provide users with suggestions for monotonicity settings. The calculated results are:

L+: linear monotonically increasing, the larger the variable value, the higher the event rate

L-: Linear monotonically decreasing, the larger the variable value, the lower the event rate

Uu: U-shaped concave

Un: U-shaped convex (inverted U-shaped)

Unordered categorical variables do not require the recommended monotonicity constraints because the codes for unordered categories are themselves calculated using event rates.

After `do_mono_suggest` runs successfully, two results will be generated. The first is a monotonicity suggestion for all variables (the suggestion is a tuple, only the first element is useful, and the remaining elements are for backward compatibility extensions). The second is the event rate of each equal-frequency bin of each data set. Users can use this result to check whether the suggested trend should be adopted. The two results can be obtained through the CardFlow instances `scf.mono_suggests` and `scf.mono_suggests_eventproba` respectively. The two results will be combined into a tuple and saved in `${work_space}/4_mono_suggest.pkl`. For user convenience, the second result will also be written to `${work_space}/4_mono_suggest.xlsx`.

See [Bins.MonoSuggest](#) , [Bins. x1MonoSuggest](#)

## do\_optim\_bins

do\_optim\_bins(self)

The fifth step in the rasc modeling process uses the dataset specified as train in the data usage model \_data to calculate the optimal binning nodes for rasc ( see the introduction to [the Bins module](#) for more information on optimal binning for rasc ). It then divides all data in all data usages according to the calculated optimal binning nodes, and finally summarizes the information for each bin, including:

Quantity, distribution, For data with target, the number of sample points where the event did not occur, the number of sample points where the event occurred, and the event occurrence rate, woe, IV will also be counted.

The rasc optimal binning node for each variable in each data set remains consistent, and other indicators are calculated based on the variable itself.

After do\_optim\_bins runs successfully, two results will be generated, which can be obtained through the CardFlow instances scf.train\_optbins and scf.optbins\_stat respectively. The first is the optimal binning node calculated based on the training set, and the second is the statistical information of each box after all data are divided according to the optimal binning node. scf.optbins\_stat is a two-level dict nested structure: dict<data purpose, dict<data name, optimal binning statistics>>. These two results will form a tuple and be saved in \${work\_space}/5\_optbins.pkl. For the convenience of user reading, the second result will also be written to \${work\_space}/5\_optbins.xlsx. Each sheet is the binning statistics of a data set. The naming convention of the sheet is: 'data set file name (data purpose)'

See [Bins.OptBin](#), [Bins\\_x1OptBin](#)

## do\_woe

do\_woe(self)

Step 6 of the rasc modeling process. Perform a WOE conversion on all data for all data purposes, based on the user-specified mapping between training set bins and WOE. The converted results can be retrieved via scf.woes and saved in \${work\_space}/6\_woe.pkl.

scf.woes is a nested dict structure:

dict<data usage, dict<data file name, data set WOE value>>

## do\_filter

do\_filter(self)

Step 7 of the rasc module process. Variables are filtered according to the user's settings. When `do_filter` runs successfully, it generates four results: the first is the filter index value calculated for each variable in each dataset, and the second is the filtered variable and the reason for filtering. The format of the filtered reason record is as follows:

```
filter_metric > or < filter_threshold [dataset_name]
```

```
...(records deleted by multiple filters, wrapped in newlines)
```

Filter metrics: iv, homogeneity, miss, ivCoV, corr, psi, user-extended

[Dataset Name]: On which dataset does the maximum or minimum value occur?

The third column contains intermediate data from the indicator calculation process. This intermediate data can be output to the model report to help users better understand the data. The fourth column records variables that the user has forced to retain and set. For the difference between retaining and setting, see the description of the `user_save` and `user_set` configuration items in the command file.

These four results will form a tuple and be saved in `${work_space}/7_filter.pkl`.

For more detailed information, see the description of the filters configuration item in the command file.

## **do\_model**

```
do_model(self)
```

The eighth step of the rasc modeling process is implemented by calling the built-in two-way stepwise logistic regression function of rasc (see the [Reg Step Wise MP module](#)).

After `do_model` runs successfully, 7 results will be generated:

The first one is all the variables entered into the model

The second is the variable deleted by the model

The third one is the constructed model:

The main methods are:

`predict(X)` model outputs the predicted probability

The main properties are:

`intercept_` intercept term

`coef_[0]` coefficients of each variable (excluding the intercept term)

`tvalues` is the t statistic of each model variable. Where `const` is the t statistic of the intercept term

`pvalues` Two-tailed P-value of each model variable

resid\_pearson Pearson residual

resid\_deviance residual deviation

The fourth is a summary of the model building information, mainly including: Link Function, No. Observations (sample size), Df Model, Df Residuals, Method (optimization algorithm), AIC, BIC, Log-Likelihood, LL-Null, Deviance, Pearson chi2, Scale

The fifth is the coefficient of each input variable, including the constant term, which contains the following information: Coef, Std.Err (standard error), Wald Chi-Square, P-Values, confidence interval [0.025 ~ 0.975], Standardized Coefficients (standardized coefficients)

The sixth is the reason for deleting each variable

The seventh is a detailed record of each round of modeling process, including: adding or removing variables, model performance indicators

They can be accessed through the CardFlow instances `scf.in_clf_cols`, `scf.clf_del_cols`, `scf.clf`, `scf.clf_perf`, `scf.clf_coef`, `scf.del_reason`, and `scf.step_proc` respectively.

These seven results are combined into a tuple and saved in `{work_space}/8_model.pkl`. For easier reading, the results of steps 4, 5, 6, and 7 are also written to `{work_space}/8_reg_mstep.xlsx`.

See [Reg Step Wise MP.LinearReg](#) , [Reg Step Wise MP.LogisticReg](#)

## do\_card

`do_card(self)`

The 9th step of the rasc modeling process. A scorecard is constructed based on the generated model and WOE. It can be accessed through the CardFlow instance `rasc.card` and saved in `{work_space}/9_card.pkl`.

## do\_report

`do_report(self)`

10th step in the rasc modeling process . After the run is complete, a model report file `{work_space}/{model_name}_Report.xlsx` will be generated. The file contents are:

1. Sample Y statistics: Lists the number of good and bad samples, the number of good and bad samples (weighted), the weighted event rate, and other information for all target-labeled data sets under all data uses
2. Suggested Monotonicity: Gives the suggested monotonicity and user-set monotonicity for each variable.

Lists the event rates of all data sets under model\_data after equal frequency binning, making it easier for users to confirm the suggested monotonicity trend.

3. Variable selection: List the indicator values of each variable (the included indicators are set by the user through the filters configuration item), whether to enter the model, and the reason for deletion
4. Variable selection intermediate table: When calculating variable selection, some useful intermediate results will be generated. These intermediate results will be output to the model report to facilitate users to deeply understand the details of variable selection
5. Scorecard: Comparison table of binning and scores of output variables, scorecard conversion parameters, variable weights of standardized coefficient caliber, and variable weights of range caliber
6. Model Performance: List the model metrics (including KS, AUC, LIFTn) of all target-labeled datasets for each data usage, and a pivot table of scores and frequency segments (including number, cumulative number, distribution, cumulative distribution, event rate, cumulative event rate, ODDS, cumulative ODDS, etc.)
7. Logistic regression model: The content is the same as \${work\_space}/8\_reg\_mstep.xlsx generated in step 8. See the API documentation of [CardFlow.do\\_model](#)
8. Correlation coefficient: List the correlation coefficients between each pair of model variables
- 9.VIF: List the VIF of each input variable
10. Equal frequency binning: The content of \${work\_space}/2\_freqbins.xlsx generated in step 2 is the same as that of \${work\_space}/2\_freqbins.xlsx. See the API documentation of [CardFlow.do\\_freq\\_bins](#)
11. rasc optimal binning: Same as the content of \${work\_space}/5\_optbins.xlsx generated in step 5. See the API documentation of [CardFlow.do\\_optim\\_bins](#)

Different contents belong to different sheets.

In addition to generating a model report file, a prediction result is also generated, which saves the (target, predicted value, sample weight) of all datasets under each data use. It can be accessed through the CardFlow instance rasc.preds and saved in \${work\_space}/10\_preds.pkl.

## do\_reject

The 11th step of the rasc modeling process. If the user sets reject\_data\_file\_path and end\_step=ScoreCard.REJECT\_STEP/11, CardFlow will generate a rejection inference scorecard model.

After the rejection inference scorecard is generated, it will produce the same information as the normal scorecard.

The calling method is similar to the normal scorecard, except that the prefix rejInfer is added.

```
scf.rejInfer.train_freqbins,scf.rejInfer.freqbins_stat,  
scf.rejInfer.fore_col_indices,scf.rejInfer.fore_filtered_cols,  
scf.rejInfer.mono_suggests,scf.rejInfer.mono_suggests_eventproba,  
scf.rejInfer.train_optbins,scf.rejInfer.optbins_stat,scf.rejInfer.woes,  
scf.rejInfer.col_indices,scf.rejInfer.filtered_cols,scf.rejInfer.filters_middle_data,scf.rejInfer.used_cols  
scf.rejInfer.in_clf_cols,scf.rejInfer.clf_del_cols,scf.rejInfer.clf,scf.rejInfer.clf_perf,scf.rejInfer.clf_coef,scf.rejInfer.del_r  
eason,scf.rejInfer.step_proc  
scf.rejInfer.card,scf.rejInfer.preds  
And store the newly synthesized dataset for rejection inference in scf.datas['rejData']['__synData']
```

## redo\_bins

redo\_bins(self)

If the user needs to update the equal frequency binning nodes or optimal binning nodes of individual variables after running do\_freq\_bins or do\_optim\_bins, they need to call scf.redo\_bins(). This method will recalculate the equal frequency or optimal binning for the variables in [MODIFY BINS INST]:redo\_bins\_cols in the instruction file according to the current instructions in [BINS INST], and update and save the mono\_suggest, Bins, and WOE of the variables involved. The update principle is:

1. If equal-frequency binning is set in redo\_type, redo\_bins modifies the equal-frequency binning nodes of the variables in redo\_bins\_cols, incrementally updates the two results generated in step \${do\_freq\_bins}, and updates the files saved by \${do\_freq\_bins} in \${work\_space}. If the user has already run step 4, \${do\_mono\_suggest}, redo\_bins modifies the monotonicity suggestions for the variables in redo\_bins\_cols, incrementally updates the results generated in step \${do\_mono\_suggest}, and updates the files saved by \${do\_mono\_suggest} in \${work\_space}. Finally, a new file, \${work\_space}/redo\_freqbins\_Compare.xlsx, is generated to compare the changes before and after the equal-frequency binning of the specified variables in all datasets for each data use.
2. If optimal binning is set in redo\_type, redo\_bins modifies the optimal binning nodes of the variables in redo\_bins\_cols, incrementally updates the two results generated in step \${do\_optim\_bins}, and updates the file saved by \${do\_optim\_bins} in \${work\_space}. If the user has already run step 6 \${do\_woe}, the Word of Equivalence (WOE) values of the variables in redo\_bins\_cols are modified, the results generated in step \${do\_woe} are incrementally updated, and the file saved by \${do\_woe} in \${work\_space} is updated. A new file \${work\_space}/redo\_optbins\_Compare.xlsx is also generated to compare the optimal binning changes before and after the change for the specified variable rasc in all datasets for each data use.

## dat\_update

```
dat_update(self, dat_uses, only_dat=False)
```

Update all data sets under the specified data usage, update the result scf.datas generated by step 1\${do\_load\_datas}, and update '1\_datas.pkl' under \${work\_space}.

If step 2\${do\_freq\_bins} has been completed, all data sets under the specified data purpose in scf.freqbins\_stat will be updated, and the '2\_freqbins.pkl' and '2\_freqbins.xlsx' saved in step 2\${do\_freq\_bins} under \${work\_space} will be updated.

If step 5\${do\_optim\_bins} has been completed before, all data sets under the specified data purpose, namely scf.optbins\_stat, will be updated, and step 5\${do\_optim\_bins} will be saved in '5\_optbins.pkl' and '5\_optbins.xlsx' under \${work\_space} for update.

If step 6\${do\_woe} has been completed before, all datasets under the specified data purpose, namely scf.woes, will be updated, and step 6\${do\_woe} will be saved in '6\_woe.pkl' under \${work\_space} for update.

Note: dat\_update only changes the statistics of scf.freqbins\_stat or scf.optbins\_stat, but does not change scf.train\_freqbins and scf.train\_optbins. If you need to modify the dataset and also modify the binning nodes, namely scf.train\_freqbins and scf.train\_optbins, you need to re-execute the already run process, such as scf.start(1,5), or use it with redo\_bins.

### Parameters

-----

dat\_uses : list

Specifies the purpose of the data to be updated. It is a subset of ['model\_data', 'performance\_data', 'psi\_data', 'oot\_data', 'REJECT\_MODEL\_DATA']

only\_dat: boolean

True: only update data

False: In addition to updating the data, the statistics of the equal frequency and optimal binning of the dataset will also be updated (but the binning nodes and woe

If you need to update the data node, please use it in conjunction with redo\_bins

## start

`start(self, start_step=1, end_step=10, load_step=None)`

Call start to start the modeling process. The code corresponding to each step is:

`LOAD_DATAS_STEP=1`

`FREQ_BINS_STEP = 2`

`FORE_FILTER_STEP = 3`

`MONO_SUGGEST_STEP = 4`

`OPT_BINS_STEP = 5`

`WOE_STEP=6`

`FILTER_STEP=7`

`MODEL_STEP=8`

`CARD_STEP=9`

`REPORT_STEP=10`

`REJECT_STEP=11` (reject inference step. Reject inference will continue to build a rejection inference model based on the normal model. If the user sets `reject_data_file_path`, after the first 10 steps are completed, running step 11 will generate a rejection inference model for the user)

example:

`scf.start(start_step=ScoreCard.LOAD_DATAS_STEP,end_step=ScoreCard.REPORT_STEP)`

If you can remember the number of each step, you can also write: `scf.start(start_step=1,end_step=10)`

If you have calculated some steps, even if you restart the computer, `start_step` does not need to start from 1. For example, if you run `scf.start(start_step=1,end_step=4)`, you can continue to run `scf.start(start_step=5,end_step=8)` even after restarting the computer.

Parameters

-----

`start_step` : int

Which step to start running

Default: 1

end\_step : int

At which step does the operation end?

Default: 10.

load\_step : float

Loads the specified step and all previous steps without recalculating. If some steps have not been calculated before, they will be automatically calculated.

If load\_step is not empty, the settings of start\_step and end\_step will be automatically ignored.

Advanced users may use rasc semi-automatically, in which case the load\_step parameter is useful.

Default: None.

## Functions

### get\_row\_score

get\_row\_score(card,row,err\_handle=np.min)

Given a piece of data, calculate the score of the data based on the card

Parameters

-----

card : dict

Comparison table of bin labels and scores

row : dict

The value of each variable

ex. {'x1':1,'x2':2}

err\_handle : TYPE, optional

This method is used to calculate scores when the values of the variable cannot match the bins.

The default is np.min.

Returns

-----

score : float

The score of the row .

### get\_X\_score

get\_X\_score(card, X, cores=None)

Returns the subscores and total score of X in the given scorecard.

#### Parameters

-----

card : dict<var\_name,DataFrame(cols=['Bins','Points'])>

A comparison table of Bins and sub-scores for each variable.

Can be extracted via rasc .card.

X : DataFrame

Data to be scored

cores : int

Number of CPU cores used

None: All CPUs

err\_handle : TYPE, optional

This method is used to calculate scores when the values of the variable cannot match the bins.

The default is np.min.

#### Returns

-----

scores : DataFrame

According to the card, each variable is converted into Bins and then into the corresponding sub-bins

total\_scores : Series

The total score of each sample point. It is also the sum of all sub-scores in each row of scores

## make\_card

make\_card(base\_points,base\_event\_rate,pdo,clf,bins\_stat)

do not use rasc automated modeling. After users use Reg\_Step\_Wise\_MP to build a model and use the Bins module to build bins, they can use this method to generate a scorecard.

Parameters

-----

base\_points : float

Benchmark score corresponding to the benchmark probability

base\_event\_rate : float

Baseline probability

pdo : float

PDO

clf : Reg\_Step\_Wise\_MP.LogisticReg

rasc built- in logistic regression model

bins\_stat : dict

rasc built- in binning module and binning information

Returns

-----

card : dict

Comparison table of bins and scores for each variable

## StepwiseRegressionSKLearn

New since version 2025.10.2

from version== 2025.10.2 , it replaces Reg\_Step\_Wise\_MP as the built-in two-way stepwise regression model in rascpy.

Compared to Reg\_Step\_Wise\_MP, this significantly reduces computation time. In Reg\_Step\_Wise\_MP, a sin

gle algorithmic step might slightly improve the model with a very small probability, but this would require a significant amount of computation time. This step is omitted in `StepwiseRegressionSKLearn`, thus reducing computation time.

It is a Python implementation of linear bidirectional stepwise regression and logistic bidirectional stepwise regression, which adds the following features to traditional bidirectional stepwise regression:

Functions retained from `Reg_Step_Wise_MP` are:

1. When performing stepwise variable selection for logistic regression, AUC, KS, or LIFT can be used instead of AIC and BIC. For some business scenarios, AUC and KS are more relevant. For example, in ranking tasks, models built using the KS metric have the advantage of using fewer variables while maintaining a consistent KS performance across multiple test sets.
2. During stepwise variable selection, you can use other datasets to calculate model evaluation metrics instead of the modeling dataset. Especially when the data volume is large and a validation set is included in addition to the training and test sets, it is recommended to use the validation set to calculate evaluation metrics to guide variable selection. This helps reduce overfitting.
3. Supports using partial data to calculate model evaluation metrics to guide variable selection. For example, if the business needs to maintain a certain pass rate of N%, then the bad event rate of the top N% of samples can be minimized, without requiring all samples to be included in the calculation. Based on past experience, in appropriate scenarios, using partial data as evaluation metrics results in fewer variables than using full data, but the metrics of interest to users do not decrease across multiple test sets. Because the model focuses only on the top, more easily distinguishable sample points, it can achieve business goals without requiring too many variables.
4. Supports setting multiple conditions. Variables must meet all conditions simultaneously before they can be included in the model. This allows variable selection and model diagnosis to be performed simultaneously, avoiding repeated modeling due to model diagnosis failure. Built-in conditions include: P-Value, VIF, correlation coefficient, and coefficient sign.
5. Supports specifying variables that must be entered into the model. If the specified variables conflict with the conditions in point 4, a comprehensive mechanism has been designed to resolve the problem.
6. The modeling process is exported to EXCEL, recording the reasons for deleting each variable and the process information of each round of stepwise regression.

New features added in version== 2025.10.2 are:

7. Support users to specify the number of variables that can be included in each variable group
8. Added sklearn interface, which can be used in sklearn's pipeline

In most cases, users do not need to interact directly with the Reg\_Step\_Wise\_MP component. However, rascpy is designed to be pluggable, so advanced users can use the Reg\_Step\_Wise\_MP module independently, just like any other Python module.

## Classes

### LinearReg

from version== 2025.10.2 , Reg\_Step\_Wise\_MP.LinearReg has been replaced as the built-in bidirectional stepwise linear regression model in rascpy. Reg\_Step\_Wise\_MP is still retained and can still be used, but it is recommended to use StepwiseRegressionSKLearn.LinearReg because the calculation time is greatly reduced.

Functions retained from Reg\_Step\_Wise\_MP:

1. During stepwise variable selection, you can use other datasets to calculate model evaluation metrics instead of the modeling dataset. Especially when the data volume is large and a validation set is included in addition to the training and test sets, it is recommended to use the validation set to calculate evaluation metrics to guide variable selection. This helps reduce overfitting.
2. Supports setting multiple conditions. Variables must meet all conditions simultaneously before they can be included in the model. This allows for simultaneous variable selection and model diagnosis, avoiding repeated modeling due to model diagnosis failure. Built-in conditions include: P-Value, VIF, correlation coefficient, and coefficient sign.
3. Supports specifying variables that must be entered into the model. If the specified variables conflict with the conditions in point 4, a comprehensive mechanism has been designed to resolve the problem.
4. The modeling process is exported to EXCEL, recording the reasons for deleting each variable and the process information of each round of stepwise regression.

New since version 2025.10.2

5. Support users to specify the number of variables that can be entered into the model in each variable group
6. Added sklearn interface, which can be used in sklearn's pipeline

### **`__init__`**

```
__init__(self,user_save_cols=[],user_set_cols=[],measure='r2',measure_frac=1
        ,pvalue_max=0.05,vif_max=3,corr_max=0.7,coef_sign={},default_coef_sign=None
        ,X_group_format=None,cnt_in_group={},default_cnt_in_group=None,fea_cnt=15,results_save=None)
```

Parameters

-----

user\_save\_cols : array like, optional

Forced variables into the module

default:[]

user\_set\_cols : array like, optional

Only these variables can be entered into the model, without addition or deletion.

If user\_set\_cols is not empty and has length greater than 0, stepwise regression degenerates to ordinary regression.

default:[]

measure : str, optional

In bidirectional stepwise regression, an indicator is used to determine whether the model has improved.

Indicators include: r2

Default: 'r2'.

measure\_frac : float, optional

Sort by predicted value from large to small or small to large, and take the first N sample points from \${MODEL CONFIG:measure\_data\_name} as the evaluation index of the model

None: Take all sample points from \${MODEL CONFIG:measure\_data\_name} to calculate the model evaluation index. Equivalent to measure\_frac=1.

measure\_frac > 1: Take the first N = measure\_frac sample points from large to small

0 <measure\_frac <= 1: Take the first N = sample\_n\*measure\_frac sample points from largest to smallest (round down)

-1 <= measure\_frac < 0: Take the first N = sample\_n\*measure\_frac\*-1 sample points from smallest to largest (round down)

measure\_frac < -1: Take the first N = measure\_frac\*-1 sample points from small to large

Default: 1

pvalue\_max : float, optional

The p-value of the coefficients of all model variables (excluding the intercept term) must be less than or equal to the threshold

Variables that the user requires to be entered into the model are not subject to this restriction

If a non-mandatory variable is included in the model and causes the p-value of a mandatory variable whose p-value is originally less than the threshold to exceed the threshold, the non-mandatory variable will not be included in the model. However, if the p-value of a mandatory variable originally exceeds the threshold, that is, the p-value caused by other mandatory variables exceeds the threshold, the introduction of the non-mandatory variable will not be affected.

None: No constraints are placed on the p-value of the model variable.

Default: 0.05

vif\_max : float, optional

The vif of all model variables (excluding the intercept term) must be less than or equal to the threshold

Variables forced into the module are not affected by this constraint

If a non-mandatory variable is included in the model and causes the vif of a mandatory variable whose vif is originally less than the threshold to exceed the threshold, the non-mandatory variable will not be included in the model. However, if the vif of a mandatory variable itself exceeds the threshold, that is, the vif caused by other mandatory variables exceeds the threshold, the introduction of the non-mandatory variable will not be affected.

None: No restrictions are placed on the vif of the input variables

Default: 3

corr\_max : float, optional

The correlation coefficients between all input variables must be less than or equal to the threshold

If the correlation coefficient of a non-forced variable with a forced variable exceeds the threshold, the non-forced variable will not be introduced into the model.

Even if the correlation coefficient between two forced variables is above this threshold, both variables will be included.

None: No restriction on the correlation coefficient of the model variables

Default: 0.7

coef\_sign : dict, optional

Sign constraints on variable coefficients

ex. {"x1":"+","x2":-"} or file://xx/xx.json read from the file

Value Description:

+ The coefficient of this variable is positive

- The coefficient of this variable has a negative sign

None This variable does not constrain the coefficient sign

coef\_sign = None: No constraints are placed on the coefficient signs of all variables

Variables that the user forces to be entered into the model are not subject to this constraint

If the introduction of a non-mandatory variable causes a mandatory variable that originally satisfied the sign constraint to no longer satisfy the sign constraint, the non-mandatory variable cannot be included in the model. If the sign of the mandatory variable itself does not satisfy the sign constraint, the introduction of the non-mandatory variable will not be affected.

default: {}

default\_coef\_sign : str, optional

When a variable is not in coef\_sign, the default value of the variable symbol constraint is

None: The default value of all variables is None

Default: None

X\_group\_format : str, optional

New in version 2025.10.2

How to express groups in X variables

In business, X can sometimes be categorized and managed by groups. For example, all data provided by data service company A can be divided into one group, and all variables provided by data service company B can be divided into another group.

ex1. X\_group\_format = \_g

ex2. X\_group\_format = g\$\$

Value Description:

A character must be g and can only appear at the beginning or end. If g appears at the beginning, it means the group name is the prefix of the variable name. If g appears at the end, it means the group name is the suffix of the variable name. The situation where the group name is in the middle of the variable name cannot be handled.

The remaining characters are group separators, which are strings that do not contain the letter g. This separator is used to separate the group name from the variable name.

For example: If the variable name format is x1\_group1, then this should be configured as \_g

If the variable naming format is group1##x1, then this should be configured as g##

If a variable name does not contain the configured separator, it means that the variable is not in any group, and subsequent instructions for operating variables by group will not be applied to this variable.

None: All X do not need to be grouped

Default: None

cnt\_in\_group : dict, optional

Set the maximum number of variables allowed in each variable group

Example: {"g1":1,"g2":2}

Default: {} means no group will be restricted by the number of variables entered into the model

default\_cnt\_in\_group : int, optional

If a variable group is not set in cnt\_group, the maximum number of variables allowed to be entered in to the module is

None: There is no default maximum limit on the number of variables that can be entered into the model. If the variable group does not appear in cnt\_in\_group, there is no limit on the number of variables that can be entered into the model within the group.

Default: None

fea\_cnt : int, optional

The number of variables entered into the model

Each stepwise regression has two operations:

1. Find a variable from all remaining variables that meets the constraints and whose addition will improve the model index by the highest amount. Introduce this variable into the model.
  2. Find a variable from all the variables in the model that meets the constraints and whose removal will improve the model index more than the current one, and the one with the highest improvement. Remove this variable from the model.
- If N variables have been entered into the model ( $N < \text{fea\_cnt}$ ), and adding or removing variables cannot further improve the performance of the model, the stepwise regression is terminated early.

Default: 15

results\_save : str, optional

The file name that records the modeling process. In addition to common information, the file also records the process of variable selection and elimination in stepwise regression, as well as the reasons for variable deletion.

None: Do not record the process

Default: None.

Returns

-----

None.

## fit

fit (self,X,y,sample\_weight=None,fit\_args={},X\_val=None,y\_val=None,sample\_weight\_val=None,val\_args={})

Training the model

Parameters

-----

X : pandas.DataFrame

Feature dataset used for model training

y : pandas.Series

y labels for model training

sample\_weight : pandas.Series, optional

Sample weights used for training

None: Each sample has the same weight

Default: None.

fit\_args : dict, optional

Other parameters used for model training

default: {}

X\_val : pandas.DataFrame, optional

Feature dataset for validation

Default: None.

y\_val : pandas.Series, optional

y labels for validation

Default: None.

sample\_weight\_val : pandas.Series, optional

Sample weights for validation

None: Each sample has the same weight

Default: None.

val\_args : dict, optional

Other parameters used for model evaluation

default: {}

## Returns

-----

The trained `StepwiseRegressionSKLearn.LinearReg` instance (self)

## Attributes

After calling `fit`, the `StepwiseRegressionSKLearn.LinearReg` instance generates the following Attributes

-----

`in_vars` : list

Model variables

`intercept_` : float

Intercept term

`coef_` : `pandas.Series`

Coefficients of each variable (excluding the intercept term)

`estimator_` : `statsmodels.regression.linear_model.RegressionResultsWrapper`

When deploying online applications, if the `rascpy` library is not installed in Python, but `statsmodels` is installed, users can directly use `estimator_` to deploy the model.

`perf` : `DataFrame`

Model building information: R-squared, adjusted R-squared, AIC, BIC, Log-Likelihood, F-statistic, Prob (F-statistic), etc.

`coef` : `DataFrame`

Model parameter information: Coef, Std.Err, coefficient test t statistic, t statistic Pvalue, confidence interval, Standardized Coefficients

`del_reasons` : `pandas.Series`

The reason for deletion of each deleted variable

step\_proc : DataFrame

Detailed records of each round of modeling process, including: adding or removing variables, model performance indicators , etc.

## predict

predict(self,X)

Returns the predicted value for each sample point

Parameters

-----

X : pd.DataFrame

Feature dataset to be predicted

Returns

-----

hat: array, shape (n\_samples,)

Predicted value

## LogisticReg

from version== 2025.10.2 , Reg\_Step\_Wise\_MP.LogisticReg has been replaced as the built-in two-way stepwise logistic regression model in rascpy. Reg\_Step\_Wise\_MP is still retained and can still be used, but it is recommended to use StepwiseRegressionSKLearn.LogisticReg because the calculation time is greatly reduced.

Functions retained from Reg\_Step\_Wise\_MP:

1. When performing stepwise variable selection for logistic regression, AUC, KS, or LIFT can be used instead of AIC and BIC. For some business scenarios, AUC and KS are more relevant. For example, in ranking tasks, models built using the KS metric have the advantage of using fewer variables while maintaining a consistent KS performance across multiple test sets.
2. During stepwise variable selection, you can use other datasets to calculate model evaluation metrics instead of the modeling dataset. Especially when the data volume is large and a validation set is included in addition to the training and test sets, it is recommended to use the validation set to calculate evaluation metrics to guide variable selection. This helps reduce overfitting.

3. Supports using partial data to calculate model evaluation metrics to guide variable selection. For example, if the business needs to maintain a certain pass rate of N%, then the bad event rate of the top N% of samples can be minimized, without requiring all samples to be included in the calculation. Based on past experience, in appropriate scenarios, using partial data as evaluation metrics results in fewer variables than using full data, but the metrics of interest to users do not decrease across multiple test sets. Because the model focuses only on the top, more easily distinguishable sample points, it can achieve business goals without requiring too many variables.
4. Supports setting multiple conditions. Variables must meet all conditions simultaneously before they can be included in the model. This allows variable selection and model diagnosis to be performed simultaneously, avoiding repeated modeling due to model diagnosis failure. Built-in conditions include: P-Value, VIF, correlation coefficient, and coefficient sign.
5. Supports specifying variables that must be entered into the model. If the specified variables conflict with the conditions in point 4, a comprehensive mechanism has been designed to resolve the problem.
6. The modeling process is exported to EXCEL, recording the reasons for deleting each variable and the process information of each round of stepwise regression.

New since version 2025.10.2

7. Support users to specify the number of variables that can be entered into the model in each variable group
8. Added sklearn interface, which can be used in sklearn's pipeline

## **\_\_init\_\_**

```
__init__(self,y_label=None,user_save_cols=[],user_set_cols=[]
        ,measure='roc_auc',measure_frac=1,pvalue_max=0.05,vif_max=3,corr_max=0.7
        ,coef_sign={},default_coef_sign=None,X_group_format=None
        ,cnt_in_group={},default_cnt_in_group=None,fea_cnt=15,results_save=None)
```

Parameters

-----

**y\_label** : dict, optional

Define which value in y means the event has occurred, and which value means the event has not occurred.

The value of keys can only be unevent or event

The value of values should be filled in according to the value of y

Example: {'unevent':'good','event':'bad'}

Generally, defining the things users care about most as events makes explanation easier. For example, if you want to emphasize the incidence of lung cancer, you can say that smokers have a 50% higher incidence of lung cancer than non-smokers. In this case, you can write {'unevent':'No lung cancer','event':'Lung cancer'}. If you write {'unevent':'Lung cancer','event':'No lung cancer'}, although it does not affect the use of the model, the explanation will become "Smokers have a 50% lower incidence of lung cancer than non-smokers." Obviously, the first expression emphasizes the event you are concerned about.

Default: {'unevent': 0, 'event': 1}.

**user\_save\_cols** : array like, optional

Forced variables into the module

default:[]

**user\_set\_cols** : array like, optional

Only these variables can be entered into the model, without addition or deletion.

If `user_set_cols` is not empty and has length greater than 0, stepwise regression degenerates to ordinary regression.

default:[]

`measure` : str, optional

In bidirectional stepwise regression, an indicator is used to determine whether the model has improved.

Indicators include: `aic`, `bic`, `roc_auc`, `ks`, `lift_n` (under development), `ks_price` (under development)

Cannot be None

Default: 'roc\_auc'.

`measure_frac` : float, optional

Sort the predicted event probability from large to small or small to large, and take the first N sample points from `$(MODEL CONFIG:measure_data_name)` as the model evaluation index

None: Take all sample points from `$(MODEL CONFIG:measure_data_name)` to calculate the model evaluation index. Equivalent to `measure_frac=1`.

If `measure_index` is `aic` or `bic`, the `measure_frac` configuration is ignored. Only the entire modeling data can be used.

`measure_frac > 1`: Take the first N = `measure_frac` sample points from large to small

`0 < measure_frac <= 1`: Take the first N = `sample_n*measure_frac` sample points from largest to smallest (round down)

`-1 <= measure_frac < 0`: Take the first N = `sample_n*measure_frac*-1` sample points from smallest to largest (round down)

`measure_frac < -1`: Take the first N = `measure_frac*-1` sample points from small to large

Default: 1

`pvalue_max` : float, optional

The p-value of the coefficients of all model variables (excluding the intercept term) must be less than or equal to the threshold

Variables that the user requires to be entered into the model are not subject to this restriction

If a non-mandatory variable is included in the model and causes the p-value of a mandatory variable whose p-value is originally less than the threshold to exceed the threshold, the non-mandatory variable will not be included in the model. However, if the p-value of a mandatory variable originally exceeds the threshold, that is, the p-value caused by other mandatory variables exceeds the threshold, the introduction of the non-mandatory variable will not be affected.

None: No constraints are placed on the p-value of the model variable.

Default: 0.05

`vif_max` : float, optional

The vif of all model variables (excluding the intercept term) must be less than or equal to the threshold

Variables forced into the module are not affected by this constraint

If a non-mandatory variable is included in the model and causes the vif of a mandatory variable whose vif is originally less than the threshold to exceed the threshold, the non-mandatory variable will not be included in the model. However, if the vif of a mandatory variable itself exceeds the threshold, that is, the vif caused by other

mandatory variables exceeds the threshold, the introduction of the non-mandatory variable will not be affected.

None: No restrictions are placed on the vif of the input variables

Default: 3

corr\_max : float, optional

The correlation coefficients between all input variables must be less than or equal to the threshold

If the correlation coefficient of a non-forced variable with a forced variable exceeds the threshold, the non-forced variable will not be introduced into the model.

Even if the correlation coefficient between two forced variables is above this threshold, both variables will be included.

None: No restriction on the correlation coefficient of the model variables

Default: 0.7

coef\_sign : dict, optional

Sign constraints on variable coefficients

ex. {"x1": "+", "x2": "-"} or file://xx/xx.json read from the file

Value Description:

+ The coefficient of this variable is positive

- The coefficient of this variable has a negative sign

None This variable does not constrain the coefficient sign

coef\_sign = None: No constraints are placed on the coefficient signs of all variables

Variables that the user forces to be entered into the model are not subject to this constraint

If the introduction of a non-mandatory variable causes a mandatory variable that originally satisfied the sign constraint to no longer satisfy the sign constraint, the non-mandatory variable cannot be included in the module.

If the sign of the mandatory variable itself does not satisfy the sign constraint, the introduction of the non-mandatory variable will not be affected.

default: {}

default\_coef\_sign : str, optional

When a variable is not in coef\_sign, the default value of the variable symbol constraint is

None: The default value of all variables is None

Default: None

X\_group\_format : str, optional

New in version 2025.10.2

How to express groups in X variables

In business, X can sometimes be categorized and managed by groups. For example, all data provided by data service company A can be divided into one group, and all variables provided by data service company B can be divided into another group.

ex1. X\_group\_format = \_g

ex2. X\_group\_format = g\$\$

Value Description:

A character must be g and can only appear at the beginning or end. If g appears at the beginning, it means the group name is the prefix of the variable name. If g appears at the end, it means the group name is the suffix of the

variable name. The situation where the group name is in the middle of the variable name cannot be handled. The remaining characters are group separators, which are strings that do not contain the letter g. This separator is used to separate the group name from the variable name.

For example: If the variable name format is x1\_group1, then this should be configured as \_g

If the variable naming format is group1##x1, then this should be configured as g##

If a variable name does not contain the configured separator, it means that the variable is not in any group, and subsequent instructions for operating variables by group will not be applied to this variable.

None: All X do not need to be grouped

Default: None

cnt\_in\_group : dict, optional

Set the maximum number of variables allowed in each variable group

Example: {"g1":1,"g2":2}

Default: {} means no group will be restricted by the number of variables entered into the model

default\_cnt\_in\_group : int, optional

If a variable group is not set in cnt\_group, the maximum number of variables allowed to be entered into the module is

None: There is no default maximum limit on the number of variables that can be entered into the model. If the variable group does not appear in cnt\_in\_group, there is no limit on the number of variables that can be entered into the model within the group.

Default: None

fea\_cnt : int, optional

The number of variables entered into the model

Each stepwise regression has two operations:

1. Find a variable from all remaining variables that meets the constraints and whose addition will improve the model index by the highest amount. Introduce this variable into the model.
2. Find a variable from all the variables in the model that meets the constraints and whose removal will improve the model index more than the current one, and the one with the highest improvement. Remove this variable from the model.

If N variables have been entered into the model ( $N < \text{fea\_cnt}$ ), and adding or removing variables cannot further improve the performance of the model, the stepwise regression is terminated early.

Default: 15

results\_save : str, optional

The file name that records the modeling process. In addition to common information, the file also records the process of variable selection and elimination in stepwise regression, as well as the reasons for variable deletion.

None: Do not record the process

Default: None.

Returns

-----

None.

## **fit**

`fit(self,X,y,sample_weight=None,fit_args={},X_val=None,y_val=None,sample_weight_val=None,val_args={})`

Training the model

Parameters

-----

**X** : pandas.DataFrame

Feature dataset used for model training

**y** : pandas.Series

y labels for model training

**sample\_weight** : pandas.Series, optional

Sample weights used for training

None: Each sample has the same weight

Default: None.

**fit\_args** : dict, optional

Other parameters used for model training

default: {}

**X\_val** : pandas.DataFrame, optional

Feature dataset for validation

Default: None.

**y\_val** : pandas.Series, optional

y labels for validation

Default: None.

sample\_weight\_val : pandas.Series, optional

Sample weights for validation

None: Each sample has the same weight

Default: None.

val\_args : dict, optional

Other parameters used for model evaluation

default: {}

Returns

-----

The trained StepwiseRegressionSKLearn.LogisticReg instance (self)

Attributes

After calling fit, the StepwiseRegressionSKLearn.LogisticReg instance generates the following Attributes

-----

in\_vars : list

Model variables

intercept\_ : float

Intercept term

coef\_ : pandas.Series

Coefficients of each variable (excluding the intercept term)

estimator\_ : statsmodels.discrete.discrete\_model.BinaryResultsWrapper

When deploying online applications, if the online Python does not have the rascpy library installed, but statsmodels is installed, users can directly use estimator\_ to deploy the model.

perf : DataFrame

Model building information: R-squared, adjusted R-squared, AIC, BIC, Log-Likelihood, F-statistic, Prob (F-statistic), etc.

coef : DataFrame

Model parameter information: Coef, Std.Err, coefficient test t statistic, t statistic Pvalue, confidence interval, Standardized Coefficients

del\_reasons : pandas.Series

The reason for deletion of each deleted variable

step\_proc : DataFrame

Detailed records of each round of modeling process, including: adding or removing variables, model performance indicators, etc.

## **predict\_proba**

predict\_proba(self,X)

Returns the probability of each label category prediction. The order is the lexicographic order of the labels.

Parameters

-----

X : pd.DataFrame

Feature dataset to be predicted

Returns

-----

proba\_hat : array-like of shape (n\_samples, n\_classes)

The probability of each label category prediction. The order is the lexicographic order of the labels.

For example:

```
[  
[0.2,0.8],  
[0.6,0.4],  
...  
]
```

# Tool

## Functions

### value\_counts\_weight

value\_counts\_weight(data,weight=None)

The functionality is the same as pandas.Series.value\_counts(), but value\_counts\_weight supports weights

#### Parameters

-----

data : array like

The sequence to be counted.

weight : array like

The weight of the data point

None: Each data point has a weight of 1

Default: None.

#### Returns

-----

Series

The number of each data point (with weight)

Series

The proportion of each data point (with weight)

## value\_counts\_weight\_y

value\_counts\_weight\_y(dat,y,y\_label=None,weight=None)

Count the occurrence and non-occurrence of events for each value

### Parameters

-----

dat : array like

A series of numbers

y : array like

The target column(not column name).

y\_label : dict

Define which value in y means the event has occurred, and which value means the event has not occurred.

The value of keys can only be unevent or event

The value of values should be filled in according to the value of y

Default: None.

None is equivalent to {'unevent': 0, 'event': 1}.

weight : Series

The weight of the data point(not column name).

None: All weights are 1

Default: None.

### Returns

-----

DataFrame

columns = ['Number of each value', 'Proportion', 'Number of events that occurred', 'Number of events that did not occur', 'Event rate']

## profit

```
profit(y,pred,weight=None
,score_reverse=True,fea_count=None,avg_fea_cost=None
,avg_quota=10000,day_call=10000
,pass_rate=0.4,use_rate=0.7
,avg_profit_rate=0.2,avg_loss_rate=0.8,y_label=None)
```

Based on the actual performance and the predicted value given by the model , a rough profit estimate is given

Parameters

-----

y : Series

Real performance

pred : Series

Predicted value

weight : Series, optional

Sample weight

Default: None

score\_reverse: bool , optional

Relationship between pred and event rate

True: Inverse relationship. The higher the pred value, the lower the event rate.

False: Positive relationship. The higher the pred value, the higher the event rate.

Default: True

fea\_count : int

The number of features of the variables included in the model

avg\_fea\_cost : float

Average unit price of a feature

avg\_quota : float, optional

Sample amount (average)

Default: 10000

day\_call : int, optional

Average number of model calls per day

Default: 10000

pass\_rate : float, optional

Model pass rate

Default: 0.4

use\_rate : float, optional

User withdrawal rate

Default: 0.7

avg\_gain\_rate : float, optional

Average profit per transaction for normal customers

Default: 0.2

avg\_loss\_rate : float, optional

Average loss per defaulting customer

Default: 0.8

y\_label : dict, optional

Defines which value of y is considered as the event occurring and which value is considered as the event not occurring.

The keys can only be 'unevent' or 'event'.

The values should be filled according to the actual values of y.

Default: None

The meaning of None is equivalent to {'unevent': 0, 'event': 1}.

Returns

-----

dict

day\_bad: The number of default samples generated daily based on the provided y and pred, converted into day\_call visits

day\_good: According to the provided y and pred, it is converted into the normal sample generated daily under the day\_call visit volume

bad\_rate: default rate calculated according to the provided y, pred and pass\_rate

day\_total: day\_bad + day\_good

year\_gain: annual income (100 million yuan)

year\_loss: annual bad debt amount (100 million yuan),

year\_fea\_cost: annual credit investigation cost (100 million yuan),

year\_profit: annual profit (100 million yuan), year\_gain - year\_loss - year\_fea\_cost

## prob2score

prob2score(p,base\_points=500,base\_event\_rate=0.05,pdo=50)

Convert a probability into an integer fraction

## Parameters

-----

p : float

The probability of being converted

base\_points : float, optional

Benchmark scores

The default value is 500.

base\_event\_rate:float, optional

Probability corresponding to the benchmark score (note: not a ratio)

Default is 0.05.

pdo : float, optional

PDO

Default is 50.

## Returns

-----

int

The returned score value.

## load\_all\_files

load\_all\_files(path)

Read all data under path, but does not support nested folders

The supported data formats are csv, excel, and pkl. The corresponding suffixes must be csv, xlsx, or pkl.

## Parameters

-----

path : str

Folder Address

Returns

-----

datas : dict{str,dataframe}

All datasets in the folder

key is the name of the file without the suffix as the name of the dataset

## **get\_decimals**

get\_decimals(i)

Get the number of decimal places in a number

Support scientific notation

Numbers such as 1.0, 2.00, ... are considered to have no decimal places.

Parameters

-----

i : numeric

Any value

Returns

-----

int

Number of decimal places.

## **\_spec\_None**

\_spec\_None(data,spec\_value)

If the set empty value does not include 'None', but the data contains empty values, a '{None}' is automatically appended to spec\_value

#### Parameters

-----

data : array like

Raw data

spec\_value : list

Special Values

#### Returns

-----

new\_spec\_value : list

Special value after adding '{None}'. If there is 'None' in the original spec\_value, it will not be added.

For example, if the original spec\_value=[['{-1,-2}','{None}']] or spec\_value=[['{-1,-2}','{-997,None}']] or spec\_value=[['{-1,-2}','{-997,None}','{-998}']], the original spec\_value will not be changed.

## **\_spec\_del**

`_spec_del(data,spec_value)`

Remove special values from a sequence

#### Parameters

-----

data : array like

A column of numbers.

spec\_value : list

The value of a special value.

If a special value is not in the sequence, it will be automatically ignored

Example. [{"-9997}","{-9999,-9998}"]

Returns

-----

array like has the same type as data

The new array after removing special values.

## **is\_spec\_value**

is\_spec\_value(value,spec\_value)

Determine whether the value is a special value

Parameters

-----

value : float or str

Value to be judged

spec\_value : list

Special values. Example: [{"-999,-888}","{-1000}"]

Returns

-----

bool

Whether the value is a special value.

## **predict\_proba**

Calculate the predicted probability of the model. It provides the following convenient functions:

1. If clf is statsmodels.generalized\_linear\_model, a constant term is automatically added, that is, sm.add\_constant is automatically called .

2. If clf contains columns with feature\_importances\_==0 (not actually needed), and these columns do not exist in X, the model can continue to run without errors or inconsistent results .
3. If there are columns in X that are not needed in clf, the model can continue to run without errors or inconsistent results.
4. It will directly return the probability of the event occurring, instead of returning a two-dimensional array consisting of the two probabilities of the event not occurring and the event occurring to other predict\_proba methods (for binary classification)

#### Parameters

-----

clf : any model

Model.

X : DataFrame

data

decimals : int, optional

Number of decimal places for probability

Default: 4.

#### Raises

-----

Exception

If the columns actually required by clf are not in X, an exception is thrown.

#### Returns

-----

pd.Series

Probability of an event occurring

## mean\_weight

Same functionality as pandas.Series.mean(), but mean\_weight supports weights

#### Parameters

-----

dat : pandas.Series

Number series.

weight : pandas.Series, optional

Sample weight. None: Each sample has the same weight.

Default: None.

decimals: int  
Number of decimal places  
Default: 4

Returns

-----

float  
Weighted mean.

## Tree

## Functions

### auto\_xgb

auto\_xgb(train\_X,train\_y,val\_X,val\_y,train\_w=None,val\_w=None,metric='ks',cost\_time=60\*5,cands\_num=10,variance\_level = 1,y\_label=None)

Provides automatic parameter tuning for xgboost. According to tests, models created with other parameter tuning frameworks often have large differences between the training set and validation set metrics. However, the xgboost automatic parameter tuning framework provided by rascpy minimizes the difference between the training set and validation set metrics.

Parameters

-----

train\_X : DataFrame  
Training set X

train\_y : Series  
Training set target

val\_X : DataFrame  
Validation set X

val\_y : Series  
Validation set target

train\_w : Series, optional  
Training set weights.  
Default: None, each sample has the same weight

`val_w` : Series, optional

Validation set weights.

Default: None, each sample has the same weight

`metric` : str, optional

Model evaluation indicator, currently supports 'ks' or 'auc'

Default: 'auc'

`cost_time` : int, optional

The time it takes for `auto_xgb` to run. Because parameter search is essentially a combinatorial explosion, the goal of any algorithm is to find the most likely optimal set of hyperparameters within a limited time. Therefore, a longer `cost_time` is, the more likely it is to find the optimal set of hyperparameters.

However, in practice, setting `cost_time` to 3-5 minutes has yielded the optimal model for most cases. Setting it longer rarely yields a higher-scoring model. If you're not satisfied with the model, you can try increasing `cost_time`, but increasing it to more than 8 minutes is not recommended and will likely be ineffective.

If the user is not satisfied with the bias or variance of the model, the best approach is not to increase `cost_time`, but to try using a more accurate sampling method, such as `rascpy.Impute.BCSpecValImpute`

`cands_num` : int, optional

When `auto_xgb` automatically searches for hyperparameters, it gives a score to each hyperparameter it tries. The higher the score, the more recommended the model trained with that hyperparameter is. It then sorts the scores from high to low and returns the models with the top `cands_num` scores.

In most cases, the model with the highest score (`clf_cands[0]`) is the best model. However, users can still select their favorite model from the candidate models according to their preferences.

Default: 5

`variance_level` : int, optional

In actual use, the author generally sets this value to 1, which is sufficient in most cases.

If the difference between the training set and the validation set is small, the user can try to increase this value to increase the model variance and reduce the bias (further improving the model performance on the validation set).

In actual use, the maximum value is set to 2.

Default: 1

`y_label` : dict, optional

Defines which value in `y` represents the occurrence of the event and which value represents the non-occurrence of the event.

Keys can only be 'unevent' or 'event'.

Values should be set according to the actual values in `y`.

Default: None.

None is equivalent to {'unevent': 0, 'event': 1}.

Raises

-----

#### Exception

Metric currently only supports ks and auc. If set to other metrics, an exception will be thrown.  
If either val\_X or val\_y is None, an exception is thrown.

#### Returns

-----

tpule(perf\_cands,params\_cands,clf\_cands,vars\_cands)

perf\_cands:list<dict>

Metrics for all candidate models. Each set of metrics contains three pieces of information: train\_ks(train\_auc), val\_ks(val\_auc), |train - val| (the absolute value of the difference between the training set and the validation set)

params\_cands:list<dict>

Hyperparameters for each candidate model

clf\_cands:list

Candidate models can be used directly for prediction

vars\_cands:list<list>:

The input variables of each candidate model

Note: The indexes of these 4 return values are relative. If the user decides to use the clf\_cands[0] model, he can view the model's metrics through perf\_cands[0], the model's hyperparameters through params\_cands[0], and the model's input variables through vars\_cands[0].

## param\_plot

param\_plot(cv\_results\_,figsize=(10,10),stats='pi')

By using the cv\_results\_ generated by various grid searches of sklearn to make a graph, users can easily understand the impact of parameters on model performance by observing the graph.

Because we want to compare the difference between train and test in terms of indicators, we must set return\_train\_score to True when performing grid search.

For example: GridSearchCV(clf, distributions, return\_train\_score=True)

The graph is a symmetric matrix-like graph.

The diagonal line shows the impact of changing a single parameter on model performance. The horizontal axis is the parameter's range of values, the left vertical axis is the metrics scaled for the training and test sets, and the right vertical axis is the difference between the metrics on the training and test sets. There are three lines: the first is the average of the metrics on the training set obtained when the parameter is fixed and other parameters are exhausted (i.e., the partial effect; this approach ignores the influence of other parameters and only observes the impact of the current parameter on the model m

etric), with a confidence interval. The second line is similar, but for the average of the metrics on the test set, with a confidence interval. The third line is the average of the difference between the metrics on the training and test sets.

The lower triangle is a heat map between two parameters. The heat map value is the mean value of the training set obtained by fixing these two parameters and exhaustively enumerating other parameters.

The larger the value, the darker the color.

The upper triangle is a heat map of the relationship between two parameters. The heat map value is the mean difference between the training set and the test set obtained by fixing the two parameters and exhaustively enumerating other parameters. The larger the value, the darker the color.

Because the image area is limited, it is recommended to adjust 2-3 parameters at a time, which also helps to reduce the number of combinations and speed up training.

## Parameters

-----

`cv_results_` : GridSearchCV(HalvingGridSearchCV, HalvingRandomSearchCV, RandomizedSearchCV).`cv_results_`  
`cv_results_` generated after adjusting the hyperparameters with grid

`figsize` : tuple

The canvas size passed into the plot

The default is (10,10).

`stats` : str, optional

Value range: 'ci', 'pi'

Confidence interval calculation method. In most cases, you can choose pi, which marks the range of quantiles from 2.5% to 97.5%. If you get an error when entering pi, you can enter ci

The default is 'pi'.

## Returns

-----

Generate and display parameter graphs

# TreeRej

## Functions

### auto\_rej\_xgb

```
auto_rej_xgb(train_X,train_y,val_X,val_y,rej_train_X,rej_val_X,train_w=None,val_w=None,rej_train_w=None,rej_val_w=None,metric='ks',iter_cost_time=60*5,y_label=None)
```

xgb refuses to infer the model

Parameters

-----

train\_X : DataFrame  
training set

train\_y : Series  
Training target

val\_X : DataFrame  
Validation set

val\_y : Series  
Verify target

rej\_train\_X : DataFrame  
Refuse to infer the training set

rej\_val\_X : DataFrame  
Reject inference on validation set

train\_w : Series, optional  
Training set weights  
Default: None.

val\_w : Series, optional  
Validation set weight  
Default: None.

rej\_train\_w : Series, optional  
Refuse to infer training set weights

Default: None.

rej\_val\_w : Series, optional

Refuse to infer validation set weights

Default: None.

metric : TYPE, optional

Model evaluation indicator, currently supports 'ks' or 'auc'

Default: 'auc'

iter\_cost\_time : int, optional

The time taken for each iteration

Default: 60\*5.

y\_label : dict, optional

Defines which value in y represents the occurrence of the event and which value represents the non-occurrence of the event.

Keys can only be 'unevent' or 'event'.

Values should be set according to the actual values in y.

Default: None.

None is equivalent to {'unevent': 0, 'event': 1}.

Returns

-----

not\_rej\_clf : xgboost

Non-rejection inference of the xgb model

rej\_clf : xgboost

Rejecting the inferred xgb model

syn\_train : DataFrame

Synthetic data used to train the final round of rejection inference model

syn\_val : DataFrame

Synthetic data used to validate the final round of rejection inference models