RADSSo

RIASC Automated Decision Support Software

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1-Initial considerations

RIASC Automated Decision Support Software (RADSSo) is a tool developed by the **Research Institute of Applied Sciences (RIASC) in Cybersecurity** at the **Universidad de León** that is able to solve the multi-CASH machine learning problem making use of the library scikit-learn that can be found at https://github.com/scikit-learn/scikit-learn.

This software does not include a preprocessing step, so the values of the features in the provided dataset must be numbers (**except the name of the events**).

A feature selection algorithm **based on the mutual information function** is run before training the models to adjust the selection of the features for the specific event and target in an automated way.

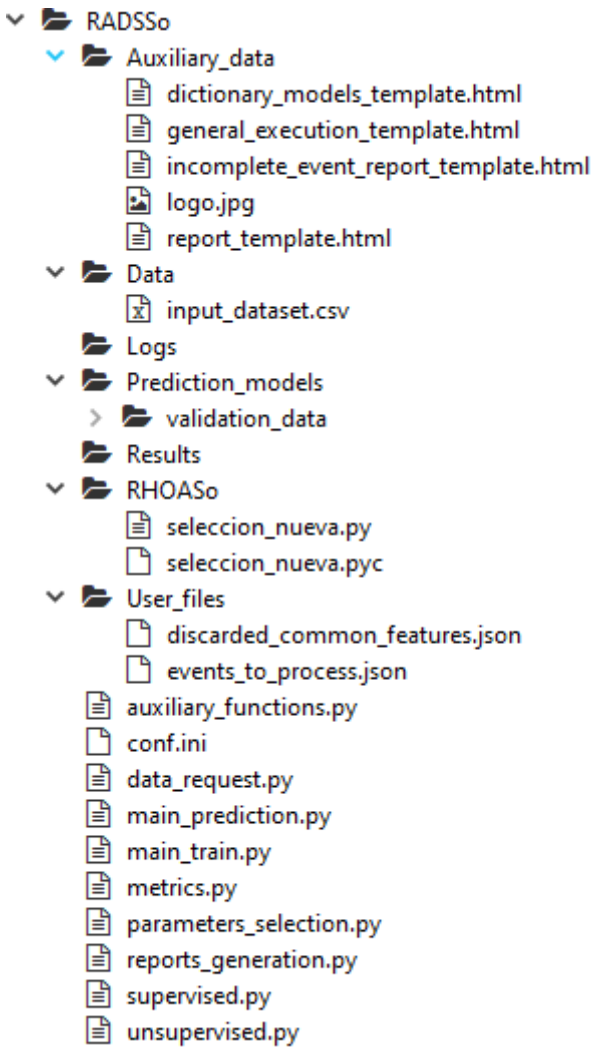
RHOASo algorithm, also developed by RIASC, is used to get the optimal parameters for each model, adjusting them for the current event and target. The project can be obtained at *https://github.com/amunc/RHOASo.*

The available models are Decision Tree, Ada Boost, Gradient Boosting, Random Forest, Multi-Layer Perceptron and Kmeans.

The optimal model for each event and target is obtained according to a ranking based on the metrics computed during the training process. The string sorting is achieve using the functions from Natural string sorting by Connelly Barnes https://github.com/ActiveState/code/tree/master/recipes/Python/285264_Natural_string_sorting

2-Directories structure

The next structure of directories must be maintained in order to use the tool. It can be modified changing the right parameters in the *conf.ini* file, but it is recommended to maintain it:



Auxiliary_Data: This directory contains the templates of the pdf files that will be generated during the processing of the input files and the creation of the models.

general_execution_template.html: It allows to create a pdf with an overview of the execution process (events to process, features, models to generate, etc.).

report_template.html: It allows to create a pdf with the results of the performance of each model.

incomplete_report_template.html: It allows to create a pdf that indicates why an execution for a concrete event can not be achieved.

Dictionary_models_template.html: It allows to generate a pdf with the current status of the dictionary that contains the relationships between the events and the best model obtained after the execution.

Data: This directory contains the input dataset/s with the features for each event in csv format. If **must not contain subdirectories and, if there are more than one input dataset, the header must be the same for all.**

Logs:* The log files of the process, that can be checked to obtain additional information about the process or to verify that there were no errors, are generated under this directory. **This directory is created at the beginning of the execution.

Prediction_models:* This directory contains the best model for each event and the dictionary that allows to link events and prediction models in the **training step. Validation data is placed in a subdirectory called **Validation_data,** if validation option is set in the *conf.ini*, otherwise the user must create this subdirectory and place in it **the data that must be classified using the models.** The directory is **created at the beginning of the execution but the Validation_data directory will be created or not according to the parametrization of the conf.ini** (by default it will be created).

**Results:* This directory will contain the pdf with the general overview of the current execution, a pdf with the current status of the dictionary that relates events and models and one directory for each processed event that contains the intermediate output.

RHOASo: This directory contains a python module obtained from another open source github project that selects optimal parameters for each model using an own algorithm.

User_files: This directory contains two JavaScript Object Notation files:

discarded_common_features.json: It is used to create a 'simple dictionary', easy to modify and to be adapted to the current problem (target), that allows to simplify the removal process of features from the start.

events_to_process.json: It **is used in semi-automated execution mode,** in order to process only the events with the relevant and discarded features specified by the user.

**Directories created at execution time*

3-Main files description

auxiliary_functions.py: A python file that contains functions related to auxiliary operations or utilities.

data_request.py: A python file that contains functions related to the **automatic recognition of events** or the introduction of data by the user (**semi-automated mode**).

metrics.py: A python file that contains functions related to the computation of the metrics (learning curves, confusion matrices and their derived indicators) of the models.

parameters_selection.py: A python file that uses the **RHOASo module** to compute the optimal parameters for each model according to the current event.

reports_generation.py: A python file that allows to dump the information gathered during the process into pdf files using the html templates located at the directory *Auxiliary_data.*

supervised.py: A python file that allows to compute the supervised models.

unsupervised.py: A python file that allows to compute the unsupervised models.

main_train.py: A python file that allows to process the input data to generate the prediction models (**training and test phase).** The reports with the results will be stored at the correct location under *Results* directory.

*main_prediction.*py: A python file that allows to process the validation/non classified data to generate a classified dataset using the models obtained in the **training and test phase** (main_train.py). It is **mandatory to obtain the models before using this script in order to predict.**

conf.ini: This file contains the basic parameters to achieve a successful execution. It is divided in several sections:

- Logs section: Parameters related to the creation of the *Logs* directory and the files that it will be generated at execution time. By default there is one log for the execution process and another log for the computation of the time in each one of the phases (training and prediction).

- Input data section: Parameters related to the to the main_train.py execution process. **It is recommended not to modify them if not sure.** There are several parameters that are fundamental:
    - *event_name_feature*: Its value must be **the name of the feature in the dataset that contains the names of the events to generate the prediction models for.** It is the only feature that **can contain textual values.** If the feature does not exist in the provided dataset the process will end.
    - *label_non_catalogued*: Numeric value of the target feature that is associated with the unknown classification (**it must be a number).**
    - *obsnumber*: This key contains the name of the feature that will be inserted at the beginning of the execution in order **to trace**

the samples that were incorrectly classified in training, test and prediction phases. It is recommended not to modify it.

- *input_files_delimiter*: The delimiter of the fields for the input dataset/s.
- path_to_root_directory_input_files: Name of the directory that contains csv files, by default its named *Data.* **The directory must be at the same level of the .py files.**
- user_files_directoryname: Name of the directory that contains the files to be processed that are defined in the keys *events_filename* and *user_discarded_variables_filename.*
- *events_filename*: It contains the name of the file that gathers the events and features for the semi-automatic recognition.
- *user_discarded_variables_filename*: It contains the name of the file that gathers the common discarded features (features discarded for all the events).
- *maximum_number_files_to_read:* If there is more than one input dataset under *Data* directory, it can be specified the total number of csv to read. **0 value means all and other value the specified number.**
- *maximum_number_observations_to_read*: Similar to the previous parameter but related to the events, it limits the maximum number of observations to process for each event individually.
- *train_test_division_percentaje*: Percentage of division in the **interval [0.6, 0.9]** in train a test datasets. The default value is 0.8 (80% of the available catalogued data for the train and 20% for the test).
- *percentaje_relevant_variables*: In fact this number in the **interval [0, 100]** refers to the percentile value of features that will be considered to train the models. Those features are computed at execution time using the mutual information function and the final percentile value is computed using the inserted one according to the scores derived from the mutual information function.
- *main_metric*: The ranking of models is computed according to the metrics derived in the execution process and the value of this parameter. **It can take the value acc by default,** if the user wants the accuracy of the models to be the predominant factor in the ranking formula, or the value **mcc** (Matthews Correlation Coefficient) that will generate a more accurate ranking when input dataset has unbalanced data.
- *default_matrix:* This parameter takes the value True, if the matrix of weights wants to be computed at execution time **(recommended option, it can be adjusted to the number of values in the target)**, or the value False, in this case the program will take the matrix from the parameter *matrix_of_weights_fp_fn.*

- *matrix_of_weights_fp_fn*: This parameters must be specified **only and only if the user wants a customized matrix of weights** to ponderate the metrics derived from the confusion matrix (False Positives, True Positives, False Negatives and True Negatives). The parameter *default_matrix* **must be set to False in order to use the customized matrix of weights**.

- Auxiliary data section: It contains the name of the *Auxiliary_data* directory under the key *auxiliary_directory_filename.*

- Ouput data section: It contains all the parameters related to the results of the training phase:
  - *output_files_delimiter:* Field delimiter for the output csv files generated at execution time.
  - *output_directory_rootname:* Name of the root directory for the results.
  - *output_directory_name_mif:* Name of the directory that stores the generated csv with the scores of the features computed using Mutual Information Function so they can be checked by the user after the process.
  - *output_directory_name_report:* Name of the directory that will gather all the reports with the results of the performance of the generated models for the current execution.
  - *output_directory_name_prediction_models:* Name of the directory where the optimal computed models (in pickle format) and the dictionary (*prediction_models_dictionary_filename*), that links them with the events, is stored.
  - *validation_data_directory_name:* Name of the directory to store the validation data or the data to predict in the prediction phase.
  - *prediction_models_dictionary_filename*: Key that stores the name of the dictionary (in pickle format) that links optimal models with events. It is generated after the first execution (if there is at least one model after training process) and it is updated after each execution.

- Prediction section: parameters related to the prediction phase are defined inside this section:
  - *target_to_predict:* It specifies the name of the feature with the target values. This feature should contain numeric values. **It must be the same target specified as parameter in the training phase** (see section *How to get started*).
  - *path_to_prediction_models_pkl:* This key contains the path of to the dictionary, generated and updated in the training phase, with the prediction models linked to the events (defined in the key *prediction_models_dictionary_filename*).

- *non_catalogued_data_csv_separator:* This key contains the delimiter of the **input dataset/s** for the **prediction phase.**
- *number_files_to_catalogue:* Maximum number of input csv files to catalogue. 0 specifies all in de directory and other positive number specifies that maximum number of files to read.
- *path_to_directory_input_files_to_catalogue:* Path to the directory that contains the input files that must be labeled (which target must be predicted) using the optimal models.

- Validation: This section is used to specify if the *main_train.py* must create a validation dataset *(validation_mode* key must be set to **True**) and which percentage of the total number of observations in the input dataset/s must be destinated to the validation step(*validation_division_percentaje*) taking real values in the interval [0,1]

4-General directories and files overview

Figure 1 shows Input (black), Intermediate Output Files (blue) and Final Output (Red)

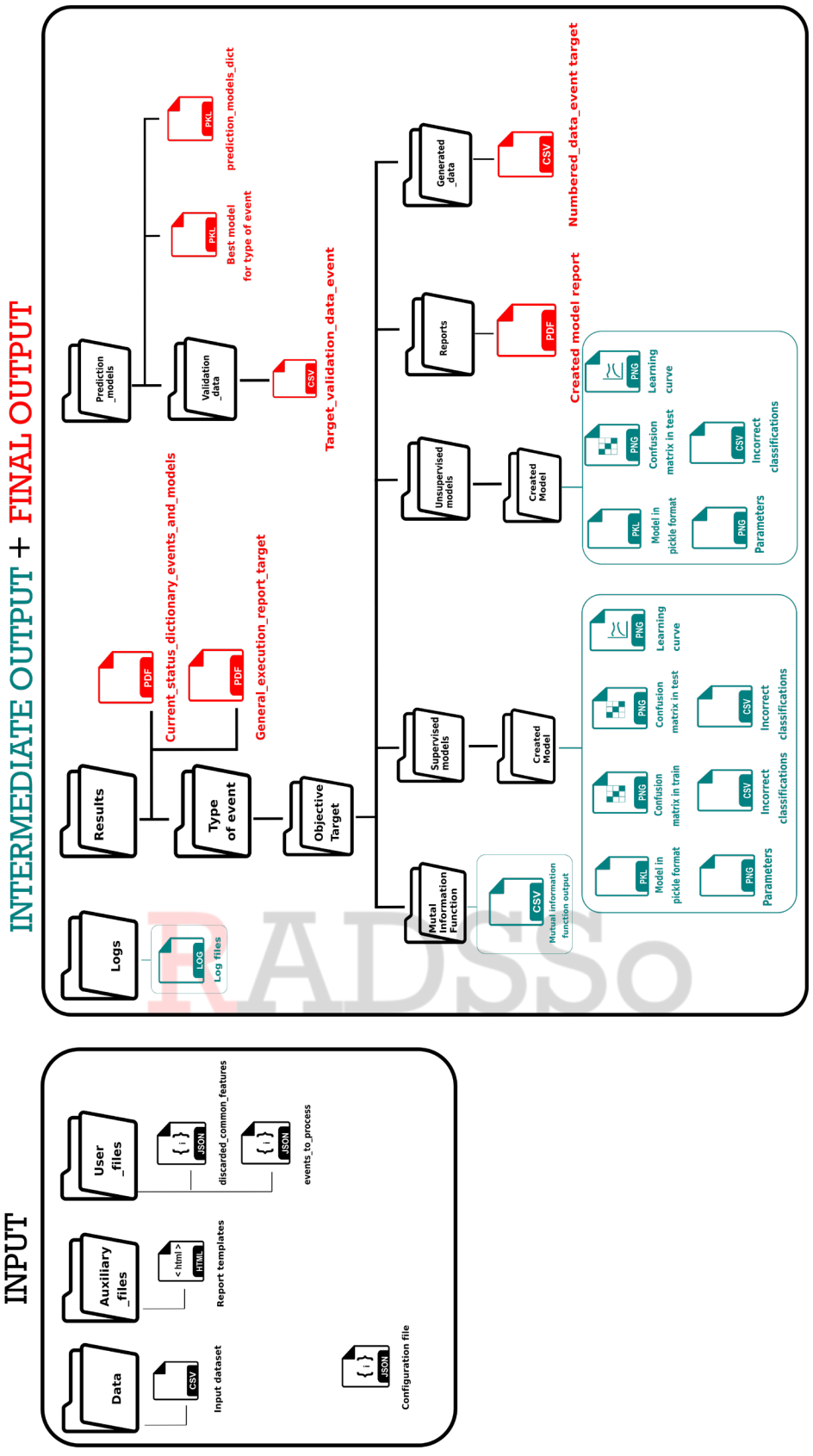


Figure 1. Input, intermediate and final output

5-Workflow overview

1- Training Phase

The first phase in the process in the training phase using a target feature. In this phase the events can be extracted automatically (based on the feature that contains them) or from the *events_to_process.json* to solve the multi-CASH problem.

Once the events have been determined, the dataset for the current event is created and it is split in train, test and validation sub-datasets (when corresponding).

The relevant features vary from one event to another, so the prominent ones are selected event by event to configure the models according to the important ones. **The mutual information function** select these features.

The models are created with the optimal parameters using **RHOASo library** and the available models are trained and tested.

The obtained models are compared using a scoring ranking and the best one for the current event and target is stored in the *Prediction_models* directory. The intermediate output files and the reports can be checked at the correct locations (see Figure 1).

To start this phase it must be executed the file main_train.py:

2- Prediction Phase

The models obtained in the training phase can be used in the prediction phase to classify the events that have an unknown value for the target feature.

Figure 2 shows execution workflow.

Figure 2. Training and Prediction

6-How to get started

To train the models:

Input data in csv files must be place in *Data* directory (**do not create subdirectories inside *Data*** folder).

Automated way

The tool will try to create the models for the *target* (target feature to train the models) extracting the names of the events from the feature specified in the key *event_name_feature* from the *Input Data Section* of the conf.ini

Execution:

$ python main_train.py **target**

Semi-automated way

The tool will read the event from the *events_to_process.json* with the relevant features, if any, specified by the user and the discarded features, if any, specified by the user. The process is also automated but it offers more freedom to the user.

Execution:

$ python main_train.py **target semi-automated**

To predict using the trained models:

Input data in csv files must be place in *Prediction_models/Validation_data* directory (**do not create subdirectories in Data folder)** to obtain the predictions for the events.

The predictions are made using the **features that were relevant for training the models** and using the feature **obsnumber inserted** at the beginning of the training phase in training and test datasets and in the validation dataset. **Be sure that obsnumber feature is present in the validation dataset before predicting.**

*It the prediction phase was successful there must be a *prediction_models_dict.pickle* insdie *Prediction_models* directory and the corresponding pkl files of the models related to each specific event.

The data with the predicted values of the target is stored in a csv file created in *Prediction_models* directory and a Log with the accuracy of the predictions for the event is also generated.

Execution:

$ python main_prediction.py