SimulAI

Release 0.0.1

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CONTENTS:

SimulAi is a library that, through the use of Artificial Intelligence (AI) techniques, allows optimization of variables derived from the Simulation of Flexible Manufacturing Systems (FMS).

Given that decision-making in organizations is a complex task, due to the unpredictable dynamic nature and the large number of variables that intervene in the normal functioning of an organization, Simulai is presented with the objective, through the use of digital twins , improve the decision-making process in organizations, making it more efficient and secure.

Development

Initially the work will focus on the integration of Tecnomatix Plant Simulation software with diverse methods of optimization, which will be submitted to a process of improvement throughout the Doctorate stage in development.

In the future, it is expected to achieve a library of greater accessibility, allowing the application in various simulation software, as required by the user.

OS Windows, Tecnomatix Plant Simulation version 15.0 and pywin32 library are currently required for its operation.

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Repository

https://github.com/carosaav/SimulAI

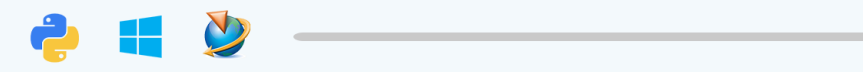
CHAPTER

ONE

REQUIREMENTS

You need:

- **Python 3.7 or later**
- **OS Windows**
- **Tecnomatix Plant Simulation version 15.0**



CHAPTER

TWO

INSTALLATION

The easiest way to install is using pip:

```
$ pip install simulai
```

This will install the latest stable version on PIPy.

If you want to use the latest development version from github, unpack or clone the repo on your local machine, change the directory to where setup.py is, and install using setuptools:

```
$ python setup.py install
```

or pip:

```
$ pip install -e .
```

CHAPTER

THREE

API MODULE

SimulAI has the development of two automatic learning techniques:

- **Q-Learning**: is an off-policy TD control policy. It doesn't follow a policy to find the next action but rather chooses the action in a greedy fashion.
- **SARSA**: is an on-policy TD control method. Policy maps the action to be taken at each state. .

3.1 Module simulai.sim

Plant simulation with autonomous decision system.

class simulai.sim.**DiscreteVariable**(*name*, *lower_limit*, *upper_limit*, *step*, *path*)

Bases: object

Initialize the input Tecnomatix Plant Simulation Variables.

These variables will be used in the AI method. Up to 4 discrete variables are allowed in the problem which can form up to 625 possible states in the algorithm. For example, if 4 variables are chosen, each of them can take 5 possible values and states formed will be S = (Var1, Var2, Var3, Var4).

Parameters

- **name** (*str*) – Name of the Variable.
- **lower_limit** (*positive int*) – Lower limit of the Variable. Should be a positive integer.
- **upper_limit** (*positive int*) – Upper limit of the Variable. Should be a positive integer.
- **step** (*positive int*) – Step of the Variable. Should be a positive integer.
- **path** (*str*) – Path of the Variable in Tecnomatix Plant Simulation.

class simulai.sim.**OutcomeVariable**(*name*, *path*, *column*, *num_rows*)

Bases: object

Initialize the output Tecnomatix Plant Simulation Variables.

These variables will be used in the AI method and must be stored in a Data Table. The chosen column from which to extract the results and the number of rows it has must be indicated.

Parameters

- **name** (*str*) – Name of the Variable.
- **path** (*str*) – Path of the Variable in Tecnomatix Plant Simulation.

- **column** (*positive int*) – Column of the table where the result is stored. Should be a positive integer.
- **num_rows** (*positive int*) – Number of rows in the results table. Should be a positive integer.

class simulai.sim.**Plant**(*method*)

Bases: object

Metaclass to generate various simulated manufacturing plants.

Parameters
method (*str*) – Name of the chosen AI method.

connection()

Connect function.

abstract get_file_name_plant()

Name of the given plant file.

abstract process_simulation()

Simulate in Tecnomatix.

abstract update(*data*)

Update.

Parameters
data (*int*) – Simulation data.

class simulai.sim.**BasePlant**(*method*, *v_i*, *v_o*, *filename*, *modelname='Model'*)

Bases: *Plant*

A particularly adaptable plant.

Parameters

- **method** (*str*) – Name of the chosen AI method.
- **v_i** (*list*) – List of chosen input variables.
- **v_o** (*list*) – List of chosen output variables.
- **filename** (*str*) – Tecnomatix Plant Simulation complete file name (.spp)
- **modelname** (*str*) – Model frame name of the file, Default value="Model".

get_file_name_plant()

Get the name of the plant file.

Returns
filename – Name of the file.

Return type
str

update(*data*)

Update.

Parameters
data (*int*) – Simulation data.

Returns
r – Reward value.

Return type
float

process_simulation()

Process simulation.

class simulai.sim.**AutonomousDecisionSystem**

Bases: object

Autonomous decision system class.

register(*who*)

Subscribe registration.

Parameters
who (*str*) – Node to subscribe.

abstract process()

Process.

class simulai.sim.**Qlearning**(*v_i*, *episodes_max*, *steps_max*, *alfa=0.1*, *gamma=0.9*, *epsilon=0.1*, *s=_Nothing.NOTHING*, *a=_Nothing.NOTHING*, *seed=None*)

Bases: *AutonomousDecisionSystem*

Implementation of the artificial intelligence method Q-Learning.

Whose purpose is to obtain the optimal parameters from the trial and error method, in which it is penalized if the goal is not reached and is rewarded if it is reached, requiring for this a number of episodes. The Q table has a maximum of 625 rows, that is, up to 625 states are supported. These states are made up of 1 to 4 variables of the Tecnomatix Plant Simulation. Actions also depend on the chosen variables and their steps. The reward function depends on the results defined in the respective plant class.

Parameters

- **v_i** (*list*) – List of chosen input variables.
- **episodes_max** (*positive int*) – Total number of episodes to run. Should be a positive integer.
- **steps_max** (*positive int*) – Total number of steps in each episode. Should be a positive integer.
- **alfa** (*float*) – Reinforcement learning hyperparameter, learning rate, varies from 0 to 1. Default value= 0.10
- **gamma** (*float*) – Reinforcement learning hyperparameter, discount factor, varies from 0 to 1. Default value= 0.90
- **epsilon** (*float*) – Reinforcement learning hyperparameter, probability for the epsilon-greedy action selection, varies from 0 to 1. Default value= 0.10
- **seed** (*int*) – Seed value for the seed() method. Default value=None.

arrays()

Arrays for states and actions.

ini_saq()

Initialize states, actions and Q table.

choose_action(*row*)

Choose the action to follow.

Parameters
row (*int*) – Number of rows.

Returns
i – Selected row.

Return type
int

`process()`

Learning algorithms.

Returns
r_episode – Episode reward

Return type
float

`class simulai.sim.Sarsa(`*v_i*, *episodes_max*, *steps_max*, *alfa=0.1*, *gamma=0.9*, *epsilon=0.1*, *s=_Nothing.NOTHING*, *a=_Nothing.NOTHING*, *seed=None*`)`

Bases: *Qlearning*

Implementation of the artificial intelligence method Sarsa.

Whose purpose is to obtain the optimal parameters from the trial and error method, in which it is penalized if the goal is not reached and is rewarded if it is reached, requiring for this a number of episodes. The Q table has a maximum of 625 rows, that is, up to 625 states are supported. These states are made up of 1 to 4 variables of the Tecnomatix Plant Simulation. Actions also depend on the chosen variables and their steps. The reward function depends on the results defined in the respective plant class.

Parameters

- **v_i** (*list*) – List of chosen input variables.
- **episodes_max** (*positive int*) – Total number of episodes to run. Should be a positive integer.
- **steps_max** (*positive int*) – Total number of steps in each episode. Should be a positive integer.
- **alfa** (*float*) – Reinforcement learning hyperparameter, learning rate, varies from 0 to 1. Default value= 0.10
- **gamma** (*float*) – Reinforcement learning hyperparameter, discount factor, varies from 0 to 1. Default value= 0.90
- **epsilon** (*float*) – Reinforcement learning hyperparameter, probability for the epsilon-greedy action selection, varies from 0 to 1. Default value= 0.10
- **seed** (*int*) – Seed value for the seed() method. Default value=None.

`process()`

Learning algorithm.

Returns
r_episode – Episode reward

Return type
float

3.2 Module simulai.interface

Class makes the connection with Tecnomatix Plant Simulation.

exception simulai.interface.**ConnectionError**

Bases: Exception

Connection failed exception.

exception simulai.interface.**ModelNotFoundError**

Bases: FileNotFoundError

Custom error for Not found Model.

simulai.interface.**check_connection**(*method*)

Check the connection status, returning an error.

Parameters
method (*str*) – Name of the method.

Return type
A message indicating failure.

class simulai.interface.**CommunicationInterface**(*model_name*, *is_connected=False*, *plant_simulation=''*)

Bases: object

Definition of the function of communication.

Parameters
model_name (*str*) – Name of the Tecnomatix Plant Simulation file.

is_connected

Connection status

Type
bool

plant_simulation

Attribute for the return of the connection object.

Type
str

get_path_file_model()

Return the complete file path.

Returns
file path – Path of Tecnomatix Plant Simulation file.

Return type
str

connection()

Return the connection object.

Returns
connection status – Connection indicator.

Return type
bool

setvisible(*value*)

Execute the application Tecnomatix.

Parameters
value (*bool*) – User-selected value.

setvalue(*ref*, *value*)

Set the values in the simulator.

Parameters

- **ref** (*str*) – Path of the variable.
- **value** (*int*) – User-selected value.

getvalue(*ref*)

Get the values of the simulator.

Parameters
ref (*str*) – Path of the variable.

startsimulation(*ref*)

Make the simulation start.

Parameters
ref (*str*) – Path of the model.

resetsimulation(*ref*)

Make the simulation reset.

Parameters
ref (*str*) – Path of the model.

stopsimulation(*ref*)

Make the simulation stop.

Parameters
ref (*str*) – Path of the model.

closemodel()

Close the simulation model.

execute_simtalk(*ref*, *value*)

Execute the simulation programming language.

Parameters

- **ref** (*str*) – Path of the variable.
- **value** (*int*) – User-selected value.

is_simulation_running()

Check if the simulation is running.

loadmodel(*ref*, *value*)

Perform the load of the model.

Parameters

- **ref** (*str*) – Path of the file.
- **value** (*int*) – User-selected value.

newmodel()

Create a new model.

openconsole_logfile(*ref*)

Open the simulation result in the console.

Parameters
ref (*str*) – Path of the file.

quit()

Clear all result.

quit_aftertime(*value*)

Clear all result after a time.

Parameters
value (*int*) – User-selected value.

savemodel(*ref*)

Save the model result.

Parameters
ref (*str*) – Path of the file.

set_licensetype(*ref*)

Set the type of the license.

Parameters
ref (*str*) – Path of the file.

set_no_messagebox(*value*)

Delete the messages on the screen.

Parameters
value (*int*) – User-selected value.

set_pathcontext(*ref*)

Set the context.

Parameters
ref (*str*) – Path of the file.

set_suppress_start_of_3d(*value*)

Eliminate the start of 3D model.

Parameters
value (*int*) – User-selected value.

set_trustmodels(*value*)

Set the real model.

Parameters
value (*int*) – User-selected value.

transfermodel(*value*)

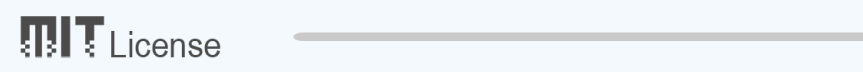
Transfer the model.

Parameters
value (*int*) – User-selected value.

CHAPTER

FOUR

LICENSE



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FIVE

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