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ESA NEOCC PYTHON INTERFACE

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APPROVAL

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Table of Contents:

1. Introduction 4

2. Installation..... 4

3. Requirements 4

4. ESANEOCC.neocc 5

5. ESANEOCC.lists 12

6. ESANEOCC.tabs..... 14

This is the documentation for the ESA NEOCC Portal Python interface library.

1. INTRODUCTION

ESA NEOCC Portal Python interface library makes the data that [ESA NEOCC](#) provides easily accessible through a Python program.

The main functionality of this library is to allow a programmer to easily retrieve:

- All the NEAs
- Other data that the NEOCC provides (risk list, close approach list, etc.)
- All basic and advanced information regarding a NEA
- An ephemeris service for NEAs

2. INSTALLATION

The library is contained in ESANEOCC folder. In order to install the library:

1. Navigate to the proper directory where the *setup.py* is located.
2. The installation is doable through *pip install* command:

```
$ pip install .
```

3. REQUIREMENTS

ESA NEOCC Portal Python Interface Library works with Python 3.

The following packages are required for the library installation & use:

- [beautifulsoup4](#) = 4.9.3
- [lxml](#) = 4.6.2
- [pandas](#) = 1.2.2
- [parse](#) = 1.19.0
- [requests](#) = 2.25.1
- [scipy](#) = 1.6.1

For tests the following packages are required:

- [pytest](#)

4. ESANEOCC.NEOCC

Main module from ESA NEOCCS library. This module contains the two main methods of the library: *query_list* and *query_object*. The information is obtained from ESA Near-Earth Object Coordination Centres (NEOCC) web portal: <https://neo.ssa.esa.int/>.

- Project: NEOCC portal Python interface
- Property: European Space Agency (ESA)
- Developed by: Elecnor Deimos
- Author: C. Álvaro Arroyo Parejo
- Issue: 1.1
- Date: 24-03-2021
- Purpose: Main module which gets NEAs data from <https://neo.ssa.esa.int/>
- Module: neocc.py
- History:

Version	Date	Change History
1.0	26-02-2021	Initial version
1.1	24-03-2021	New docstrings

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`ESANEOCC.neocc.query_list(list_name)`

Get requested list data from ESA NEOCC.

Different lists that can be requested are:

- All NEA list: *nea_list*
- Risk list (normal): *risk_list*
- Risk list (special): *risk_list_special*
- Close approaches (upcoming): *close_appr_upcoming*
- Close approaches (recent): *close_appr_recent*
- Priority list (normal): *priority_list*
- Priority list (faint): *priority_list_faint*

These lists are referenced in <https://neo.ssa.esa.int/computer-access>

Parameters `list_name` (*str*) – Name of the requested list. Valid names are: *nea_list*, *risk_list*, *risk_list_special*, *close_appr_upcoming*, *close_appr_recent*, *priority_list*, *priority_list_faint*.

Returns neocc_lst – Data Frame which contains the information of the requested list

Return type *pandas.Series* or *pandas.DataFrame*

Examples

NEA list: The output of this list is a *pandas.Series* which contains the list of all NEAs currently considered in the NEOCC system.

```
>>> from ESANEOCC import neocc
>>> list_data = neocc.query_list(list_name='nea_list')
>>> list_data
0          433 Eros
1          719 Albert
2          887 Alinda
3         1036 Ganymed
4         1221 Amor
...
25191          2021DY
25192        2021DY1
25193        2021DZ
25194        2021DZ1
25195        6344P-L
Name: 0, Length: 25196, dtype: object
```

Each asteroid can be accessed using its index. This information can be used as input for *query_object* method.

```
>>> list_data[4]
'1221 Amor'
```

Other lists: The output of this list is a *pandas.DataFrame* which contains the information of the requested list.

```
>>> from ESANEOCC import neocc
>>> list_data = neocc.query_list(list_name='close_appr_upcoming')
>>> list_data
```

	Object Name	Date	...	Rel. vel in km/s
0	2021DE	2021.156164	...	26.0
1	2021DM	2021.158904	...	10.2
2	2011DW	2021.161644	...	13.6
3	2011EH17	2021.161644	...	16.8
4	2016DV1	2021.164384	...	18.6
..
141	2020DF	2022.120548	...	8.6
142	2018CW2	2022.131507	...	10.8
143	2020CX1	2022.131507	...	8.2
144	455176 1999VF22	2022.142466	...	25.1

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```
145          2017CX1  2022.145205  ...          5.0
[146 rows x 10 columns]
```

The information of the columns can be accessed through (see [pandas](#) for further information about data access):

```
>>> list_data['Object Name']
0          2021DE
1          2021DM
2          2011DW
3          2011EH17
4          2016DV1
...
141         2020DF
142         2018CW2
143         2020CX1
144  455176 1999VF22
145         2017CX1
Name: Object Name, Length: 146, dtype: object
```

And the information of the rows can be accessed using:

```
>>> list_data.iloc[2]
Object Name          2011DW
Date              2021.16
Miss Distance in km  5333057
Miss Distance in au   0.035649
Miss Distance in LD   13.874
Diameter in m         90
*=Yes                *
H                   22.9
Max Bright           16.4
Rel. vel in km/s     13.6
Name: 2, dtype: object
```

Note: If the contents request fails the following message will be printed:

Initial attempt to obtain list failed. Reattempting

Then a second request will be automatically sent to the NEOCC portal.

ESANE OCC.neocc.**query_object** (*name, tab, **kwargs*)

Get requested object data from ESA NEOCC.

Parameters

- **name** (*str*) – Name of the requested object

- **tab** (*str*) – Name of the request tab. Valid names are: summary, orbit_properties, physical_properties, observations, ephemerides, close_approaches and impacts.
- ****kwargs** (*str*) – Tabs orbit_properties and ephemerides tabs required additional arguments to work:
 - *orbit_properties*: the required additional arguments are:
 - * *orbit_element* : str (keplerian or equinoctial)
 - * *orbit_epoch* : str (present or middle)
 - *ephemerides*: the required additional arguments are:
 - * *observatory* : str (observatory code, e.g. 500, J04, etc.)
 - * *start* : str (start date in YYYY-MM-DD HH:MM)
 - * *stop* : str (end date in YYYY-MM-DD HH:MM)
 - * *step* : str (time step, e.g. 2, 15, etc.)
 - * *step_unit* : str (e.g. days, minutes, etc.)

Returns neocc_obj – Object data which contains different attributes depending on the tab selected.

Return type object

Examples

Impacts, Physical Properties and Observations: This example tries to summarize how to access the data of this tabs and how to use it. Note that this classes only require as inputs the name of the object and the requested tab.

The information can be obtained introducing directly the name of the object, but it can be also added from the output of a *query_list* search:

```
>>> from ESANEOCC import neocc
>>> ast_impacts = neocc.query_object(name='99942 Apophis', tab='impacts'
→')
```

or

```
>>> nea_list = neocc.query_list(list_name='nea_list')
>>> nea_list[403]
'99942 Apophis'
>>> ast_impacts = neocc.query_object(name=nea_list[403], tab='impacts')
```

or


```
>>> risk_list = neocc.query_liss(list_name='risk_list')
>>> risk_list[8]
'99942 Apophis'
>>> ast_impacts = neocc.query_object(name=risk_list[8], tab='impacts')
```

The output provides an object with the different attributes:

```
>>> ast_impacts.
ast.additional_note      ast.impacts
ast.arc_end              ast.info
ast.arc_start            ast.observation_accepted
ast.computation          ast.observation_rejected
```

By adding the attribute its information can be accessed:

```
>>> ast_impacts.impacts
      date      MJD  sigma  ...  Exp. Energy in MT  PS
↪TS
0  2056-04-13.094  72101.094  2.221  ...      0.000129 -4.55
↪0
1  2065-04-13.131  75388.131  2.430  ...      0.000044 -5.10
↪0
2  2068-04-12.634  76483.634  2.723  ...      0.000830 -3.86
↪0
3  2074-04-13.359  78675.359  2.396  ...      0.000022 -5.48
↪0
4  2075-04-13.212  79040.212  1.356  ...      0.000244 -4.44
↪0
5  2077-04-13.112  79771.112  2.714  ...      0.000020 -5.54
↪0
6  2098-10-16.481  87627.481  2.398  ...      0.000058 -5.21
↪0
7  2103-04-14.311  89267.311  2.706  ...      0.000041 -5.38
↪0
[8 rows x 11 columns]
```

Another example is shown to obtain the physical properties:

```
>>> from ESANEOCC import neocc
>>> properties = neocc.query_object(name='433', tab='physical_
↪properties')
```

Again, the output provides an object with different attributes:

```
>>> properties.
properties.physical_properties  properties.sources
>>> properties.physical_properties
```

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	Property	Values	Unit	Source
0	Rotation Period	5.27	h	[4]
1	Quality	4	-	[4]
2	Amplitude	0.04-1.49	mag	[4]
3	Rotation Direction	PRO	-	[1]
4	Spinvector L	16	deg	[1]
5	Spinvector B	9	deg	[1]
6	Taxonomy	Sq	-	[2]
7	Taxonomy (all)	S	-	[3]
8	Absolute Magnitude (H)	10.31	mag	[5]
9	Slope Parameter (G)	0.46**	mag	[6]
10	Albedo	0.24	-	[9]
11	Diameter	23300	m	[10]
12	Color Index Information	0.39	R-I	[11]
13	Sightings	Visual S	-	[13]

Note: Some physical properties (e.g. *Absolute Magnitude (H)*, *Slope Parameter (G)*, etc) may have several values which come from different sources. Currently, the library will only show one value as it is done in the NEOCC portal.

Note: For the case of tab Observations there are objects which contain Roving observer and satellite observations. In the original requested data the information of these observations produces two lines of data, where the second line does not fit the structure of the data frame (<https://www.minorplanetcenter.org/iau/info/OpticalObs.html>). In order to solve this problem those second lines have been extracted in another attribute (e.g. `sat_observations` or `roving_observations`) to make the data more readable.

Since this information can be requested in pairs, i.e. it is needed to access both lines of data, this can be made using the date of the observations which will be the same for both attributes:

```
>>> ast_observations = neocc.query_object(name='99942',
tab='observations')
>>> sat_obs = ast_observations.sat_observations
>>> sat_obs
   Design.  K  T  N  YYYY  MM  DD.ddddddd  ...  Obs  Code
0    99942  S  s   2020  12   18.97667  ...      C51
1    99942  S  s   2020  12   19.10732  ...      C51
...      ...
10   99942  S  s   2021   1   16.92315  ...      C53
11   99942  S  s   2021   1   19.36233  ...      C53
12   99942  S  s   2021   1   19.36927  ...      C53
>>> opt_obs = ast_observations.optical_observations
```

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```
>>> opt_obs.loc[opt_obs['DD.dddddd'] == sat_obs['DD.dddddd'][0]]
      Design.  K  T  N  YYYY  MM  ...  Obs Code  Chi  A  M
4582    99942   S  S    2020  12  ...      C51  1.13  1  1
[1 rows x 33 columns]
```

Close Approaches: This example corresponds to the class close approaches. As for the previous example, the information can be obtained by directly introducing the name of the object or from a previous *query_list* search.

In this particular case, there are no attributes and the data obtained is a DataFrame which contains the information for close approaches:

```
>>> close_appr = neocc.query_object(name='99942', tab='close_approaches
↳ ')
>>> close_appr
      BODY      CALENDAR-TIME  ...      WIDTH  PROBABILITY
0  EARTH  1957/04/01.13908  ...  1.318000e-08      1.000
1  EARTH  1964/10/24.90646  ...  1.119000e-08      1.000
2  EARTH  1965/02/11.51118  ...  4.004000e-09      1.000
...      ...      ...      ...      ...
16 EARTH  2080/05/09.23878  ...  1.206000e-06      0.821
17 EARTH  2087/04/07.54747  ...  1.254000e-08      0.327
[18 rows x 10 columns]
```

Orbit Properties: In order to access the orbit properties information, it is necessary to provide two additional inputs to *query_object* method: **orbit_elements** and **orbit_epoch**.

It is mandatory to write these two parameters as: *orbit_epoch=* to make the library works.

```
>>> ast_orbit_prop = neocc.query_object(name='99942',
tab='orbit_properties', orbit_elements='keplerian', orbit_epoch='present
↳ ')
>>> ast_orbit_prop.
ast_orbit_prop.anode      ast_orbit_prop.moid
ast_orbit_prop.aphelion   ast_orbit_prop.ngr
ast_orbit_prop.cor        ast_orbit_prop.perihelion
ast_orbit_prop.cov        ast_orbit_prop.period
ast_orbit_prop.dnode      ast_orbit_prop.pha
ast_orbit_prop.epoch      ast_orbit_prop.rectype
ast_orbit_prop.form       ast_orbit_prop.refsys
ast_orbit_prop.kep        ast_orbit_prop.rms
ast_orbit_prop.lsp        ast_orbit_prop.u_par
ast_orbit_prop.mag        ast_orbit_prop.vinfty
```

Ephemerides: In order to access ephemerides information, it is necessary to provide five additional inputs to *query_object* method: **observatory**, **start**, **stop**, **step** and **step_unit***.

It is mandatory to write these five parameters as: *observatory=* to make the library works.

```
>>> ast_ephemerides = neocc.query_object(name='99942',
tab='ephemerides', observatory='500', start='2019-05-08 01:30',
stop='2019-05-23 01:30', step='1', step_unit='days')
>>> ast_ephemerides.
ast_ephemerides.ephemerides  ast_ephemerides.tinit
ast_ephemerides.observatory  ast_ephemerides.tstep
ast_ephemerides.tfinal
```

5. ESANEOCC.LISTS

This module contains all the methods required to request the list data, obtain it from the ESA NEOCC portal and parse it to show it properly.

- Project: NEOCC portal Python interface
- Property: European Space Agency (ESA)
- Developed by: Elecnor Deimos
- Author: C. Álvaro Arroyo Parejo
- Issue: 1.1
- Date: 24-03-2021
- Purpose: Module which request and parse list data from ESA NEOCC
- Module: lists.py
- History:

Version	Date	Change History
1.0	26-02-2021	Initial version
1.1	24-03-2021	New docstrings

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`ESANEOCC.lists.get_dec_year (date)`

Get decimal year from a date.

Parameters `date (datetime)` – Date in YYYY/MM/DD.dddd format.

Returns `decimal_year` – Date in decimal year format YYYY.yyyyyy.

Return type float64

`ESANEOCC.lists.get_list_data (url, list_name)`

Get requested parsed list from url.

Parameters

- **list_name** (*str*) – Name of the requested list.
- **url** (*str*) – URL of the requested list.

Returns **neocc_lst** – Data frame which contains the data of the requested list.

Return type *pandas.Series* or *pandas.DataFrame*

`ESANEOCC.lists.get_list_url(list_name)`

Get url from requested list name.

Parameters **list_name** (*str*) – Name of the requested list. Valid names are: *nea_list*, *risk_list*, *risk_list_special*, *close_appr_upcoming*, *close_appr_recent*, *priority_list*, *priority_list_faint*.

Returns **url** – Final URL string.

Return type *str*

Raises **KeyError** – If the requested list_name is not in the dictionary

`ESANEOCC.lists.parse_clo(data_byte_d)`

Parse and arrange close approaches lists.

Parameters **data_byte_d** (*object*) – Decoded StringIO object.

Returns **neocc_lst** – Data frame with close approaches list data parsed.

Return type *pandas.Series* or *pandas.DataFrame*

`ESANEOCC.lists.parse_list(list_name, data_byte_d)`

Switch function to select parse method.

Parameters

- **list_name** (*str*) – Name of the requested list.
- **data_byte_d** (*object*) – Decoded StringIO object.

Returns **neocc_lst** – Data frame with data from the list parsed.

Return type *pandas.Series* or *pandas.DataFrame*

`ESANEOCC.lists.parse_nea(data_byte_d)`

Parse and arrange all NEA list.

Parameters **data_byte_d** (*object*) – Decoded StringIO object.

Returns **neocc_lst** – Data frame with NEA list data parsed.

Return type *pandas.Series* or *pandas.DataFrame*

`ESANEOCC.lists.parse_pri(data_byte_d)`

Parse and arrange priority lists.

Parameters **data_byte_d** (*object*) – Decoded StringIO object.

Returns **neocc_lst** – Data frame with priority list data parsed.

Return type *pandas.Series* or *pandas.DataFrame*

`ESANEOCC.lists.parse_risk(data_byte_d)`

Parse and arrange risk lists.

Parameters `data_byte_d` (*object*) – Decoded StringIO object.

Returns `neocc_lst` – Data frame with risk list data parsed.

Return type *pandas.Series* or *pandas.DataFrame*

6. ESANEOCC.TABS

This module contains all the methods required to request the data from a particular object, obtain it from the ESA NEOCC portal and parse it to show it properly. The information of the object is shown in the ESA NEOCC in different tabs that correspond to the different classes within this module.

- Project: NEOCC portal Python interface
- Property: European Space Agency (ESA)
- Developed by: Elecnor Deimos
- Author: C. Álvaro Arroyo Parejo
- Issue: 1.1
- Date: 24-03-2021
- Purpose: Module which request and parse list data from ESA NEOCC
- Module: tabs.py
- History:

Version	Date	Change History
1.0	26-02-2021	Initial version
1.1	24-03-2021	Physical properties functionality added

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class `ESANEOCC.tabs.AsteroidObservations`

This class contains information of asteroid observations.

version

File version.

Type `int`

errmod

Error model for the data.

Type str

rmsast

Root Mean Square for asteroid observations.

Type float

rmsmag

Root Mean Square for magnitude.

Type float

optical_observations

Data frame which contains optical observations (without roving observer and satellite observation).

Type pandas.DataFrame

radar_observations

Data structure which contains radar observations.

Type pandas.DataFrame

roving_observations

Data structure which contains roving observer observations.

Type pandas.DataFrame

sat_observations

Data structure which contains satellite observations.

Type pandas.DataFrame

class ESANEOCC.tabs.**CloseApproaches**

This class contains information of object close approaches.

static **clo_appr_parser** (*data_obj*, *name*)

Parse and arrange the close approaches data.

Parameters *data_obj* (*object*) – Object in byte format.

Returns **df_close_appr** – Data frame with the close approaches information.

Return type pandas.DataFrame

Raises **ValueError** – If file is empty.

class ESANEOCC.tabs.**Ephemerides**

This class contains information of object ephemerides.

observatory

Name of the observatory from which ephemerides are obtained.

Type str

tinit

Start date from which ephemerides are obtained.

Type str

tfinal

End date from which ephemerides are obtained.

Type str

tstep

Time step and time unit used during ephemerides calculation.

Type str

ephemerides

Data frame which contains the information of the object ephemerides

Type pandas.DataFrame

class ESANEOCC.tabs.**EquinoctialOrbitProperties**

This class contains information of equinoctial asteroid orbit properties. This class inherits the attributes from OrbitProperties.

equinoctial

Data frame which contains the equinoctial elements information.

Type pandas.DataFrame

rms

Root Mean Square for equinoctial elements.

Type DataFrame

eig

Eigenvalues for the covariance matrix.

Type pandas.DataFrame

wea

Eigenvector corresponding to the largest eigenvalue.

Type pandas.DataFrame

cov

Covariance matrix for equinoctial elements.

Type pandas.DataFrame

nor

Normalization matrix for equinoctial elements.

Type pandas.DataFrame

class ESANEOCC.tabs.**Impacts**

This class contains information of object possible impacts.

impacts

Data frame where are listed all the possible impactors.

Type pandas.DataFrame

arc_start

Starting date for optical observations.

Type str

arc_end

End date for optical observations.

Type str

observations_accepted

Total number of observations subtracting rejected observations.

Type int

observations_rejected

Number of observations rejected.

Type int

computation

Date of computation (in format YYYYMMDD MJD TimeSys)

Type str

info

Information from the footer of the requested file.

Type str

additional_note

Additional information. Some objects (e.g. 99942 Apophis) have an additional note after the main footer.

Type str

class ESANEOCC.tabs.KeplerianOrbitProperties

This class contains information of keplerian asteroid orbit properties. This class inherits the attributes from OrbitProperties.

kep

Data frame which contains the keplerian elements information.

Type pandas.DataFrame

perihelion

Orbit perihelion in au.

Type int

aphelion

Orbit aphelion in au.

Type int

anode

Ascending node-Earth separation in au.

Type int

dnode

Descending node-Earth separation in au.

Type int

moid

Minimum Orbit Intersection distance in au.

Type int

period

Orbit period in days.

Type int

pha

Potential hazardous asteroid classification.

Type string

vinfty

Infinite velocity.

Type int

u_par

Uncertainty parameter as defined by MPC.

Type int

rms

Root mean square for keplerian elements

Type pandas.DataFrame

cov

Covariance matrix for keplerian elements

Type pandas.DataFrame

cor

Correlation matrix for keplerian elements

Type pandas.DataFrame

class ESANEOCC.tabs.OrbitProperties

This class contains information of asteroid orbit properties.

form

File format.

Type str

rectype

Record type.

Type str

refsys

Default reference system.

Type str

epoch

Epoch in MJD format.

Type str

mag

Data frame which contains magnitude values.

Type pandas.DataFrame

lsp

Data structure with information about non-gravitational parameters (model, number of parameters, dimension, etc.).

Type pandas.DataFrame

ngr

Data frame which contains non-gravitational parameters.

Type pandas.DataFrame

class ESANEOCC.tabs.**PhysicalProperties**

This class contains information of asteroid physical properties

physical_properties

Data structure containing property, value, units and source from the complete set of physical properties

Type DataFrame

sources

Data structure containing source number, name and additional information

Type DataFrame

Raises ValueError – If the name of the object is not found

class ESANEOCC.tabs.**Summary**

This class contains the information from the Summary tab.

physical_properties

Data frame which contains the information of the object physical properties, their value and their units.

Type pandas.DataFrame

discovery_date

Provides the object discovery date

Type str

observatory

Provides the name of the observatory where object was discovered

Type str

ESANEOCC.tabs.get_indexes(dfobj, value)

Get a list with location index of a value or string in the DataFrame requested.

Parameters

- **dfobj** (pandas.DataFrame) – Data frame where the value will be searched.
- **value** (str, int, float) – String, integer or float to be searched.

Returns listofpos – List which contains the location of the value in the Data frame. The first elements will correspond to the index and the second element to the columns

Return type list

ESANEOCC.tabs.get_object_data(url)

Get object in byte format from requested url.

Parameters url (str) – URL of the requested data.

Returns data_obj – Object in byte format.

Return type object

ESANEOCC.tabs.get_object_url(name, tab, **kwargs)

Get url from requested object and tab name.

Parameters

- **name** (str) – Name of the requested object.
- **tab** (str) – Name of the request tab. Valid names are: *summary*, *orbit_properties*, *physical_properties*, *observations*, *ephemerides*, *close_approaches* and *impacts*.
- ****kwargs** (str) – orbit_properties and ephemerides tabs required additional arguments to work:
 - *orbit_properties*: the required additional arguments are:

- * *orbit_element* : str (keplerian or equinoctial)
- * *orbit_epoch* : str (present or middle)
- *ephemerides*: the required additional arguments are:
 - * *observatory* : str (observatory code, e.g. 500, J04, etc.)
 - * *start* : str (start date in YYYY-MM-DD HH:MM)
 - * *stop* : str (end date in YYYY-MM-DD HH:MM)
 - * *step* : str (time step, e.g. 2, 15, etc.)
 - * *step_unit* : str (e.g. days, minutes, etc.)

Returns *url* – Final url from which data is requested.

Return type string

Raises

- **KeyError** – If the requested tab is not in the dictionary.
- **ValueError** – If the elements requested are not valid.