pyCAPS: A Python Extension Module for the Computational Aircraft Prototype Syntheses (CAPS)

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0.1 Introduction

0.1.1 Overview

pyCAPS is a Python extension module to interact with Computational Aircraft Prototype Syntheses (CAPS) routines in the Python environment. Written in Cython, pyCAPS natively handles all type conversions/casting, while logically grouping CAPS function calls together to simplify a user's experience. Additional functionality not directly available through the CAPS API (such has saving a geometric view) is also provided.

An overview of the basic pyCAPS functionality is provided in gettingStarted.

0.1.2 Key differences between pyCAPS and CAPS

- Manipulating the "owner" information for CAPS objects isn't currently supported

0.1.3 Clearance Statement

0.2 Hierarchical Index

0.2.1 Class Hierarchy

This inheritance list is sorted roughly, but not completely, alphabetically:

0.3 Class Index

0.3.1 Class List

Here are the classes, structs, unions and interfaces with brief descriptions:

0.4 Class Documentation

0.4.1 Analysis Class Reference

Defines a CAPS Analysis Object.

Inherits object.

Inherited by capsAnalysis.

Public Member Functions

- def preAnalysis (self)

  Run the pre-analysis function for the AIM.
- def runAnalysis (self)

  Run the pre/exec/post functions for the AIM (if AIM execution is available).
- def system (self, cmd, rpath=None)

  Execute the Command Line String Notes:
- def postAnalysis (self)

  Run post-analysis function for the AIM.
- def analysisDir (self)

  Property returns the path to the analysis directory.
- def name (self)

  Property returns the name of the CAPS Analysis Object.
- def dirty (self)

  Returns linked analyses that are dirty.
- def info (self, printInfo=False, ∗∗kwargs)

  Gets analysis information for the analysis object.
- def createTree (self, filename="name", ∗∗kwargs)

  Create a HTML dendrogram/tree of the current state of the analysis.
- def createOpenMDAOComponent (self, inputVariable, outputVariable, ∗∗kwargs)

  Create an OpenMDAO Component[1.7.3]/ExplicitComponent[2.8+] object; an external code component (External↩ Code[1.7.2]/ExternalCodeComp[2.8+]) is created if the executeCommand keyword arguement is provided.

0.4.1.1 Detailed Description

Defines a CAPS Analysis Object.

Created via Problem.analysis.create().

Parameters

Analysis.geometry	AnalysisGeometry instances representing the bodies associated with the analysis
Analysis.input	ValueInSequence of ValueIn inputs
Analysis.output	ValueOutSequence of ValueOut outputs
Analysis.attr	AttrSequence of ValueIn attributes

0.4.1.2 Member Function Documentation

0.4.1.2.1 createOpenMDAOComponent() `def createOpenMDAOComponent (`

```
self,
inputVariable,
outputVariable,
** kwargs )
```

Create an OpenMDAO Component[1.7.3]/ExplicitComponent[2.8+] object; an external code component (External↩ Code[1.7.2]/ExternalCodeComp[2.8+]) is created if the executeCommand keyword arguement is provided.

This functionality should work with either verison 1.7.3 or >=2.8 of OpenMDAO.

Parameters

inputVariable	Input variable(s)/parameter(s) to add to the OpenMDAO component. Variables may be either analysis input variables or geometry design parameters. Note, that the setting of analysis inputs supersedes the setting of geometry design parameters; issues may arise if analysis input and geometry design variables have the same name. If the analysis parameter wanting to be added to the OpenMDAO component is part of a capsTuple the following notation should be used: "AnalysisInput:TupleKey:DictionaryKey", for example "AVL_Control:ControlSurfaceA:deflectionAngle" would correspond to the AVL_Control input variable, the ControlSurfaceA element of the input values (that is the name of the control surface being created) and finally deflectionAngle corresponds to the name of the dictionary entry that is to be used as the component parameter. If the tuple's value isn't a dictionary just "AnalysisInput:TupleKey" is needed.
outputVariable	Output variable(s)/parameter(s) to add to the OpenMDAO component. Only scalar output variables are currently supported
∗∗*kwargs*	See below.

Valid keywords:

Parameters

changeDir	Automatically switch into the analysis directory set for the AIM when executing an external code (default - True).
saveIteration	If the generated OpenMDAO component is going to be called multiple times, the inputs and outputs from the analysis and the AIM will be automatically bookkept (= True) by moving the files to a folder within the AIM's analysis directory (analysisDir) named "Iteration_#" were # represents the iteration number (default - False). By default (= False) input and output files will be continously overwritten. Notes: • If the AIM has 'parents' their genertated files will not be bookkept. • If previous iteration folders already exist, the iteration folders and any other files in the directory will be moved to a folder named "Instance_#". • This bookkeeping method will likely fail if the iterations are run concurrently!
executeCommand	Command to be executed when running an external code. Command must be a list of command line arguements (see OpenMDAO documentation). If provided an ExternalCode[1.7.2]/ExternalCodeComp[2.8+] object is created; if not provided or set to None a Component[1.7.3]/ExplicitComponent[2.8+] object is created (default - None).
inputFile	Optional list of input file names for OpenMDAO to check the existence of before OpenMDAO excutes the "solve_nonlinear"[1.7.3]/"compute"[2.8+] (default - None). This is redundant as the AIM automatically does this already.
outputFile	Optional list of output names for OpenMDAO to check the existence of before OpenMDAO excutes the "solve_nonlinear"[1.7.3]/"compute"[2.8+] (default - None). This is redundant as the AIM automatically does this already.
stdin	Set I/O connection for the standard input of an ExternalCode[1.7.2]/ExternalCodeComp[2.8+] component. The use of this depends on the expected AIM execution.
stdout	Set I/O connection for the standard ouput of an ExternalCode[1.7.2]/ExternalCodeComp[2.8+] component. The use of this depends on the expected AIM execution.

Parameters

setSensitivity	Optional dictionary containing sensitivity/derivative settings/parameters. Currently only Finite difference is is supported!. See OpenMDAO documentation for addtional details of "deriv_options"(version 1.7) or "declare_partials"(version 2.8). Common values for a finite difference calculation would be setSensitivity['type'] = "fd" (Note in the version 2.8 documentation this varibale has been changed to "method" both variations will work when using version 2.8+), setSensitivity['form'] = "forward" or "backward" or "central", and setSensitivity['step_size'] = 1.0E-6 (Note in the version 2.8 documentation this varibale has been changed to "step" both variations will work when using version 2.8+).

Returns

Returns the reference to the OpenMDAO component object created.

0.4.1.2.2 createTree() `def createTree (`

```
self,
filename = "name",
** kwargs )
```

Create a HTML dendrogram/tree of the current state of the analysis.

The HTML file relies on the open-source JavaScript library, D3, to visualize the data. This library is freely available from https://d3js.org/ and is dynamically loaded within the HTML file. If running on a machine without internet access a (miniaturized) copy of the library may be written to a file alongside the generated HTML file by setting the internetAccess keyword to False. If set to True, internet access will be necessary to view the tree.

Parameters

filename	Filename to use when saving the tree (default - "aimName"). Note an ".html" is automatically appended to the name (same with ".json" if embedJSON = False).
∗∗*kwargs*	See below.

Valid keywords:

Parameters

embedJSON	Embed the JSON tree data in the HTML file itself (default - True). If set to False a seperate file is generated for the JSON tree data.
internetAccess	Is internet access available (default - True)? If set to True internet access will be necessary to view the tree.
analysisGeom	Show the geometry currently load into the analysis in the tree (default - False).
internalGeomAttr	Show the internal attributes (denoted by starting with an underscore, for example "_AttrName") that exist on the geometry (default - False). Note: "analysisGeom" must also be set to True.
reverseMap	Reverse the attribute map (default - False). See attrMap for details.

0.4.1.2.3 dirty() `def dirty ( self )`

Returns linked analyses that are dirty.

Returns

A list of dirty analyses that need to be exeuted before executing this analysis. An empty list is returned if no linked analyses are dirty.

0.4.1.2.4 info() `def info ( self, printInfo = False, ** kwargs )`

Gets analysis information for the analysis object.

Parameters

printInfo	Print information to sceen if True.
∗∗*kwargs*	See below.

Returns

Cleanliness state of analysis object or a dictionary containing analysis information (infoDict must be set to True)

Valid keywords:

Parameters

infoDict	Return a dictionary containing analysis information instead of just the cleanliness state (default - False)

0.4.1.2.5 system() `def system ( self, cmd, rpath = None )`

Execute the Command Line String Notes:

1. only needed when explicitly executing the appropriate analysis solver (i.e., not using the AIM)
2. should be invoked after caps_preAnalysis and before caps_postAnalysis
3. this must be used instead of the OS system call to ensure that journaling properly functions

Parameters

cmd	the command line string to execute
rpath	the relative path from the Analysis' directory or None (in the Analysis path)

The documentation for this class was generated from the following file:

- pyCAPS/problem.py

0.4.2 AnalysisGeometry Class Reference

Defines Analysis Geometry Object.

Inherits object.

Public Member Functions

- def bodies (self)

  Get dict of geometric bodies.
- def save (self, filename, directory=os.getcwd(), extension=".egads", writeTess=True)

  Save the current geometry used by the AIM to a file.
- def view (self, ∗∗kwargs)

  View the geometry associated with the analysis.
- def attrList (self, attributeName, ∗∗kwargs)

  Retrieve a list of geometric attribute values of a given name ("attributeName") for the bodies loaded into the analysis.
- def attrMap (self, getInternal=False, ∗∗kwargs)

  Create geometric attribution map (embeded dictionaries) for the bodies loaded into the analysis.

0.4.2.1 Detailed Description

Defines Analysis Geometry Object.

Parameters

AnalysisGeometry.despmtr	ValueInSequence of ValueIn CSM design parameters
AnalysisGeometry.cfgpmtr	ValueInSequence of ValueIn CSM configuration parameters
AnalysisGeometry.conpmtr	ValueInSequence of ValueIn CSM constant parameters
AnalysisGeometry.outpmtr	ValueOutSequence of ValueOut CSM outputs

0.4.2.2 Member Function Documentation

0.4.2.2.1 attrList() `def attrList (`

```
self,
attributeName,
** kwargs )
```

Retrieve a list of geometric attribute values of a given name ("attributeName") for the bodies loaded into the analysis.

Level in which to search the bodies is determined by the attrLevel keyword argument. See analysis3.py for a representative use case.

Parameters

attributeName	Name of attribute to retrieve values for.
∗∗*kwargs*	See below.

Returns

A list of attribute values.

Valid keywords:

Parameters

bodyIndex	Specific body in which to retrieve attribute information from.
attrLevel	Level to which to search the body(ies). Options: 0 (or "Body") - search just body attributes 1 (or "Face") - search the body and all the faces [default] 2 (or "Edge") - search the body, faces, and all the edges 3 (or "Node") - search the body, faces, edges, and all the nodes

0.4.2.2.2 attrMap() `def attrMap (`

```
self,
getInternal = False,
** kwargs )
```

Create geometric attribution map (embeded dictionaries) for the bodies loaded into the analysis.

Dictionary layout:

- Body 1
  - Body : Body level attributes
  - Faces
    - 1 : Attributes on the first face of the body
    - 2 : Attributes on the second face of the body
    - " : ...
  - Edges
    - 1 : Attributes on the first edge of the body
    - 2 : Attributes on the second edge of the body

        - " : ...
    - Nodes :
        - 1 : Attributes on the first node of the body
        - 2 : Attributes on the second node of the body
        - " : ...
- Body 2
    - Body : Body level attributes
    - Faces
        - 1 : Attributes on the first face of the body
        - " : ...
    - ...
- ...

Dictionary layout (reverseMap = True):

- Body 1
    - Attribute : Attribute name
        - Value : Value of attribute
            - Body : True if value exist at body level, None if not
            - Faces : Face numbers at which the attribute exist
            - Edges : Edge numbers at which the attribute exist
            - Nodes : Node numbers at which the attribute exist
        - Value : Next value of attribute with the same name
            - Body : True if value exist at body level, None if not
            - " : ...
        - ...
    - Atribute : Attribute name
        - Value : Value of attribute
            - " : ...
        - ...
- Body 2
    - Attribute : Attribute name
        - Value : Value of attribute
            - Body : True if value exist at body level, None if not
            - " : ...
        - ...
    - ...
- ...

Parameters

getInternal	Get internal attributes (denoted by starting with an underscore, for example "_AttrName") that exist on the geometry (default - False).
∗∗*kwargs*	See below.

Valid keywords:

Parameters

reverseMap	Reverse the attribute map (default - False). See above table for details.

Returns

Dictionary containing attribution map

0.4.2.2.3 bodies() `def bodies ( self )`

Get dict of geometric bodies.

Returns

Returns a dictionary of the bodies in the Analysis Object, as well a the capsLength unit. Keys use the body "_name" attribute or "Body_#".

0.4.2.2.4 save() `def save ( self, filename, directory = os.getcwd(), extension = ".egads", writeTess = True )`

Save the current geometry used by the AIM to a file.

Parameters

filename	File name to use when saving geometry file.
directory	Directory where to save file. Default current working directory.
extension	Extension type for file if filename does not contain an extension.
writeTess	Write tessellations to the EGADS file (only applies to .egads extension)

0.4.2.2.5 view() `def view ( self, ** kwargs )`

View the geometry associated with the analysis.

If the analysis produces a surface tessellation, then that is shown. Otherwise the bodies are shown with default tessellation parameters. Note that the geometry must be built and will not autoamtically be built by this function.

Parameters

∗∗*kwargs*	See below.

Valid keywords:

Parameters

portNumber	Port number to start the server listening on (default - 7681).

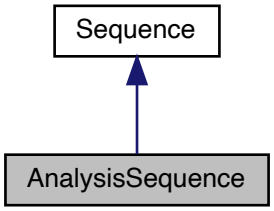
The documentation for this class was generated from the following file:

- pyCAPS/problem.py

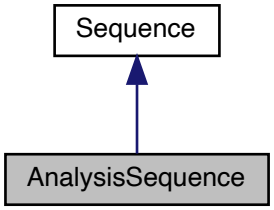
0.4.3 AnalysisSequence Class Reference

Defines a Sequence of CAPS Analysis Objects.

Inheritance diagram for AnalysisSequence:



Collaboration diagram for AnalysisSequence:



Public Member Functions

- def create (self, aim, name=None, capsIntent=None, unitSystem=None, autoExec=True)

  Create a CAPS Analysis Object.
- def copy (self, src, name=None)

  Create a copy of an CAPS Analysis Object.
- def dirty (self)

  Returns analyses that are dirty.

0.4.3.1 Detailed Description

Defines a Sequence of CAPS Analysis Objects.

0.4.3.2 Member Function Documentation

0.4.3.2.1 copy() `def copy (`

```
self,
src,
name = None )
```

Create a copy of an CAPS Analysis Object.

Parameters

src	Name of the source Analysis Object or an Analysis Object
name	Name of the new Analysis Object copy

0.4.3.2.2 create() `def create (`

```
self,
aim,
name = None,
capsIntent = None,
unitSystem = None,
autoExec = True )
```

Create a CAPS Analysis Object.

Parameters

aim	Name of the AIM module
name	Name (e.g. key) of the Analysis Object. Must be unique if specified. If None, the defalt is aim+str(instanceCount) where instanceCount is the count of the existing 'aim' instances.
capsIntent	Analysis intention in which to invoke the AIM.
unitSystem	See AIM documentation for usage.
autoExec	If false dissable any automatic execution of the AIM.

Returns

The new Analysis Object is added to the sequence and returned

0.4.3.2.3 dirty() `def dirty ( self )`

Returns analyses that are dirty.

Returns

A list of dirty analyses. An empty list is returned if no analyses are dirty.

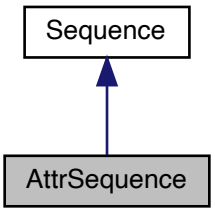
The documentation for this class was generated from the following file:

- pyCAPS/problem.py

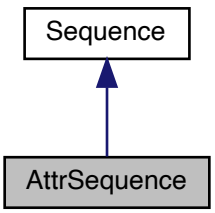
0.4.4 AttrSequence Class Reference

Defines a Sequence of CAPS Attribute Value Objects.

Inheritance diagram for AttrSequence:



Collaboration diagram for AttrSequence:



Public Member Functions

- def create (self, name, data, overwrite=False)

  Create an attribute (that is meta-data) to the CAPS Object.

0.4.4.1 Detailed Description

Defines a Sequence of CAPS Attribute Value Objects.

0.4.4.2 Member Function Documentation

0.4.4.2.1 create() `def create ( self, name, data, overwrite = False )`

Create an attribute (that is meta-data) to the CAPS Object.

See example

Parameters

name	Name used to define the attribute.
data	Initial data value(s) for the attribute. Note that type casting in done automatically based on the determined type of the Python object.
overwrite	Flag to overwrite any existing attribute with the same 'name'

Returns

The new Value Object is added to the sequence and returned

The documentation for this class was generated from the following file:

- pyCAPS/problem.py

0.4.5 Bound Class Reference

Defines a CAPS Bound Object.

Inherits object.

Inherited by capsBound.

Public Member Functions

- def name (self)

  Property returns the name of the CAPS Bound Object.
- def close (self)

  Closes the bound indicating it's complete.
- def info (self, printInfo=False, ∗∗kwargs)

  Gets information for the bound object.
- def createTree (self, filename="boundName", ∗∗kwargs)

  Create a HTML dendrogram/tree of the current state of the bound.

0.4.5.1 Detailed Description

Defines a CAPS Bound Object.

Created via Problem.bound.create().

Parameters

Bound.vertexSet	VertexSetSequence of VertexSet instances
Bound.attr	AttrSequence of ValueIn attributes

0.4.5.2 Member Function Documentation

0.4.5.2.1 createTree() `def createTree ( self, filename = "boundName", ** kwargs )`

Create a HTML dendrogram/tree of the current state of the bound.

The HTML file relies on the open-source JavaScript library, D3, to visualize the data. This library is freely available from `https://d3js.org/` and is dynamically loaded within the HTML file. If running on a machine without internet access a (miniaturized) copy of the library may be written to a file alongside the generated HTML file by setting the internetAccess keyword to False. If set to True, internet access will be necessary to view the tree.

Parameters

filename	Filename to use when saving the tree (default - "boundName"). Note an ".html" is automatically appended to the name (same with ".json" if embedJSON = False).
∗∗*kwargs*	See below.

Valid keywords:

Parameters

embedJSON	Embed the JSON tree data in the HTML file itself (default - True). If set to False a seperate file is generated for the JSON tree data.
internetAccess	Is internet access available (default True)? If set to True internet access will be necessary to view the tree.

0.4.5.2.2 info()

```
def info (
        self,
        printInfo = False,
      ** kwargs )
```

Gets information for the bound object.

Parameters

printInfo	Print information to sceen if True.
∗∗*kwargs*	See below.

Returns

State of bound object.

Valid keywords:

Parameters

infoDict	Return a dictionary containing bound information instead of just the state (default - False)

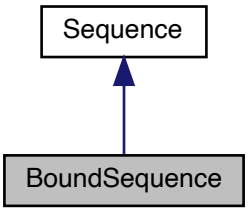
The documentation for this class was generated from the following file:

- pyCAPS/problem.py

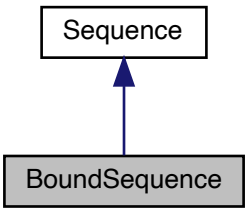
0.4.6 BoundSequence Class Reference

Defines a Sequence of CAPS Bound Objects.

Inheritance diagram for BoundSequence:



Collaboration diagram for BoundSequence:



Public Member Functions

- def create (self, capsBound, dim=2)
  Create a CAPS Bound Object.

0.4.6.1 Detailed Description

Defines a Sequence of CAPS Bound Objects.

0.4.6.2 Member Function Documentation

0.4.6.2.1 create() `def create ( self, capsBound, dim = 2 )`

Create a CAPS Bound Object.

Parameters

capsBound	The string value of the capsBound geometry attributes
dim	The dimension of the bound

Returns

The new Bound Object is added to the sequence and returned

The documentation for this class was generated from the following file:

- pyCAPS/problem.py

0.4.7 DataSet Class Reference

Defines a CAPS DataSet Object.

Inherits object.

Public Member Functions

- def name (self)

  Property returns the name of the CAPS DataSet Object.
- def data (self)

  Executes caps_getData on data set object to retrieve data set variable.
- def xyz (self)

  Executes caps_getData on data set object to retrieve XYZ coordinates of the data set.
- def connectivity (self)

  Executes caps_triangulate on data set's vertex set to retrieve the connectivity (triangles only) information for the data set.
- def link (self, source, dmethod=caps.dMethod.Interpolate)

  Link this DataSet to an other CAPS DataSet Object.
- def view (self, fig=None, numDataSet=1, dataSetIndex=0, ∗∗kwargs)

  Visualize data set.
- def writeTecplot (self, filename=None, file=None)

  Write data set to a Tecplot compatible data file.

0.4.7.1 Detailed Description

Defines a CAPS DataSet Object.

Created via VertexSet.dataSet.create().

Parameters

DataSet.attr	AttrSequence of ValueIn attributes

0.4.7.2 Member Function Documentation

0.4.7.2.1 connectivity() `def connectivity (`

```
self )
```

Executes caps_triangulate on data set's vertex set to retrieve the connectivity (triangles only) information for the data set.

Returns

Optionally returns a list of lists of connectivity values (e.g. [[node1, node2, node3], [node2, node3, node7], etc.]) and a list of lists of data connectivity (not this is an empty list if the data is node-based) (eg. [[node1, node2, node3], [node2, node3, node7], etc.]

0.4.7.2.2 data() `def data (`

```
self )
```

Executes caps_getData on data set object to retrieve data set variable.

Returns

Optionally returns a list of data values. Data with a rank greater than 1 returns a list of lists (e.g. data representing a displacement would return [[Node1_xDisplacement, Node1_yDisplacement, Node1_zDisplacement], [Node2_xDisplacement, Node2_yDisplacement, Node2_zDisplacement], etc.]

0.4.7.2.3 link() `def link (`

```
self,
source,
dmethod = caps.dMethod.Interpolate )
```

Link this DataSet to an other CAPS DataSet Object.

Parameters

source	The source DataSEt Object
dmethod	Transfter method: dMethod.Interpolate or "Interpolate", tMethod.Conserve or "Conserve"

0.4.7.2.4 view() `def view (`

```
self,
fig = None,
numDataSet = 1,
```

```
    dataSetIndex = 0,
** kwargs )
```

Visualize data set.

The function currently relies on matplotlib to plot the data.

Parameters

fig	Figure object (matplotlib::figure) to append image to.
numDataSet	Number of data sets in $fig.
dataSetIndex	Index of data set being added to $fig.
∗∗*kwargs*	See below.

Valid keywords:

Parameters

filename	Save image(s) to file specified (default - None).
colorMap	Valid string for a, matplotlib::cm, colormap (default - 'Blues').
showImage	Show image(s) (default - True).
title	Set a custom title on the plot (default - VertexSet= 'name', DataSet = 'name', (Var. '#')).

0.4.7.2.5 writeTecplot() `def writeTecplot (`

```
self,
filename = None,
file = None )
```

Write data set to a Tecplot compatible data file.

A triagulation of the data set will be used for the connectivity.

Parameters

file	Optional open file object to append data to. If not provided a filename must be given via the keyword arguement $filename.
filename	Write Tecplot file with the specified name.

0.4.7.2.6 xyz() `def xyz (`

```
self )
```

Executes caps_getData on data set object to retrieve XYZ coordinates of the data set.

Returns

Optionally returns a list of lists of x,y, z values (e.g. [[x2, y2, z2], [x2, y2, z2], [x3, y3, z3], etc.])

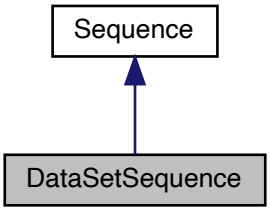
The documentation for this class was generated from the following file:

- pyCAPS/problem.py

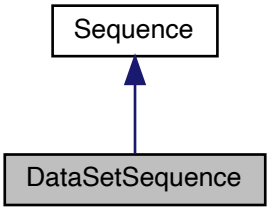
0.4.8 DataSetSequence Class Reference

Defines a Sequence of CAPS DataSet Objects.

Inheritance diagram for DataSetSequence:



Collaboration diagram for DataSetSequence:



Public Member Functions

- def create (self, dname, ftype, init=None, rank=None)

  Create a CAPS DataSet Object.
- def fields (self)

  Returns a list of the fields in the Analysis Object associated with this DataSet.

0.4.8.1 Detailed Description

Defines a Sequence of CAPS DataSet Objects.

0.4.8.2 Member Function Documentation

0.4.8.2.1 create() `def create ( self, dname, ftype, init = None, rank = None )`

Create a CAPS DataSet Object.

Parameters

dname	The name of the data set
ftype	The field type (FieldIn, FieldOut, GeomSens, TessSens, User)
init	Inital value assiged to the DataSet. Length must be consistent with the rank.
rank	The rank of the data set (only needed for un-connected data set)

Returns

The new DataSet Object is added to the sequence and returned

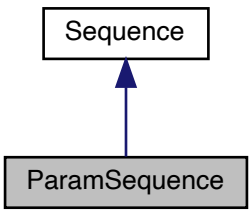
The documentation for this class was generated from the following file:

- pyCAPS/problem.py

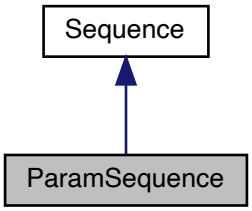
0.4.9 ParamSequence Class Reference

Defines a Sequence of CAPS Parameter Value Objects.

Inheritance diagram for ParamSequence:



Collaboration diagram for ParamSequence:



Public Member Functions

- def create (self, name, data, limits=None, fixedLength=True, fixedShape=True)

  Create an parameter CAPS Value Object.

0.4.9.1 Detailed Description

Defines a Sequence of CAPS Parameter Value Objects.

0.4.9.2 Member Function Documentation

0.4.9.2.1 create() `def create (`

```
self,
name,
data,
limits = None,
fixedLength = True,
fixedShape = True )
```

Create an parameter CAPS Value Object.

Parameters

name	Name used to define the parameter.
data	Initial data value(s) for the parameter. Note that type casting in done automatically based on the determined type of the Python object.
limits	Limits on the parameter values
fixedLength	Boolean if the value is fixed length
fixedShape	Boolean if the value is fixed shape

Returns

The new Value Object is added to the sequence and returned

The documentation for this class was generated from the following file:

- pyCAPS/problem.py

0.4.10 Problem Class Reference

Defines a CAPS Problem Object.

Inherits object.

Inherited by capsProblem.

Public Member Functions

- def __init__ (self, problemName, phaseName=None, capsFile=None, outLevel=1, useJournal=False)

  Initialize the problem.
- def close (self)

  Exlicitly closes CAPS Problem Object.
- def name (self)

  Property returns the name of the CAPS Problem Object.
- def journaling (self)

  Indicates if the CAPS Problem Object is currently journaling.
- def setOutLevel (self, outLevel)

  Set the verbosity level of the CAPS output.
- def autoLinkParameter (self, param=None)

  *Create a link between a created CAPS parameter and analyis inputs of **all** loaded AIMs, automatically.*
- def createTree (self, filename="myProblem", ∗∗kwargs)

  Create a HTML dendrogram/tree of the current state of the problem.

0.4.10.1 Detailed Description

Defines a CAPS Problem Object.

The Problem Object is the top-level object for a single mission/problem. It maintains a single set of interrelated geometric models (see ProblemGeometry), analyses to be executed (see Analysis), connectivity and data (see Bound) associated with the run(s), which can be both multi-fidelity and multi-disciplinary.

Parameters

Problem.geometry	ProblemGeometry instances representing the CSM geometry
Problem.analysis	AnalysisSequence of Analysis instances
Problem.parameter	ParamSequence of ValueIn parameters
Problem.bound	BoundSequence of Bound instances
Problem.attr	AttrSequence of ValueIn attributes

0.4.10.2 Constructor & Destructor Documentation

0.4.10.2.1 __init__() `def __init__ (`

```
self,
problemName,
phaseName = None,
capsFile = None,
outLevel = 1,
useJournal = False )
```

Initialize the problem.

Parameters

problemName	CAPS problem name that serves as the root directory for all file I/O.
phaseName	the current phase name (None is equivalent to 'Scratch')
capsFile	CAPS file to load. Options: ∗.csm or ∗.egads.
outLevel	Level of output verbosity. See setOutLevel .
useJournal	Use Journaling to continue execution of an interrupted script.

0.4.10.3 Member Function Documentation

0.4.10.3.1 autoLinkParameter() `def autoLinkParameter (`

```
self,
param = None )
```

Create a link between a created CAPS parameter and analyis inputs of **all** loaded AIMs, automatically.

Valid CAPS value, parameter objects must be created with Problam.parameter.create(). Note, only links to ANALYSISIN inputs are currently made at this time.

Parameters

param	Parameter to use when creating the link (default - None). A combination (i.e. a single or list) of ValueIn dictionary entries and/or value object instances (returned from a call to Problam.parameter.create()) can be used. If no value is provided, all entries in the ValueIn dictionary (ValueIn) will be used.

0.4.10.3.2 createTree() `def createTree (`

```
self,
filename = "myProblem",
** kwargs )
```

Create a HTML dendrogram/tree of the current state of the problem.

See example problem6.py for a representative use case. The HTML file relies on the open-source JavaScript library, D3, to visualize the data. This library is freely available from https://d3js.org/ and is dynamically loaded within the HTML file. If running on a machine without internet access a (miniaturized) copy of the library may be written to a file alongside the generated HTML file by setting the internetAccess keyword to False. If set to True, internet access will be necessary to view the tree.

Parameters

filename	Filename to use when saving the tree (default - "myProblem"). Note an ".html" is automatically appended to the name (same with ".json" if embedJSON = False).
∗∗*kwargs*	See below.

Valid keywords:

Parameters

embedJSON	Embed the JSON tree data in the HTML file itself (default - True). If set to False a seperate file is generated for the JSON tree data.
internetAccess	Is internet access available (default - True)? If set to True internet access will be necessary to view the tree.
analysisGeom	Show the geometry for each analysis entity (default - False).
internalGeomAttr	Show the internal attributes (denoted by starting with an underscore, for example "_AttrName") that exist on the geometry (default - False).
reverseMap	Reverse the geometry attribute map (default - False).

0.4.10.3.3 setOutLevel() `def setOutLevel ( self, outLevel )`

Set the verbosity level of the CAPS output.

See problem5.py for a representative use case.

Parameters

outLevel	Level of output verbosity. Options: 0 (or "minimal"), 1 (or "standard") [default], and 2 (or "debug").

The documentation for this class was generated from the following file:

- pyCAPS/problem.py

0.4.11 ProblemGeometry Class Reference

Defines Problem Geometry Object.

Inherits object.

Inherited by capsGeometry.

Public Member Functions

- def build (self)

  Exlicitly build geometry.
- def save (self, filename="myGeometry", directory=os.getcwd(), extension=".egads")

  Save the current geometry to a file.
- def view (self, ∗∗kwargs)

  View or take a screen shot of the geometry configuration.
- def attrList (self, attributeName, ∗∗kwargs)

  Retrieve a list of attribute values of a given name ("attributeName") for the bodies in the current geometry.
- def attrMap (self, getInternal=False, ∗∗kwargs)

  Create attribution map (embeded dictionaries) of each body in the current geometry.
- def createTree (self, filename="myGeometry", ∗∗kwargs)

  Create a HTML dendrogram/tree of the current state of the geometry.
- def bodies (self)

  Get dict of geometric bodies.
- def lengthUnit (self)

  Get the lenght Unit of geometric bodies.
- def writeParameters (self, filename)

  Write an OpenCSM Design Parameter file to disk.
- def readParameters (self, filename)

  Read an OpenCSM Design Parameter file from disk and and overwrites (makes dirty) the current state of the geometry.

0.4.11.1 Detailed Description

Defines Problem Geometry Object.

Parameters

ProblemGeometry.despmtr	ValueInSequence of ValueIn CSM design parameters
ProblemGeometry.cfgpmtr	ValueInSequence of ValueIn CSM configuration parameters
ProblemGeometry.conpmtr	ValueInSequence of ValueIn CSM constant parameters
ProblemGeometry.outpmtr	ValueOutSequence of ValueOut CSM outputs

0.4.11.2 Member Function Documentation

0.4.11.2.1 attrList()

```
def attrList (
    self,
    attributeName,
    ** kwargs )
```

Retrieve a list of attribute values of a given name ("attributeName") for the bodies in the current geometry.

Level in which to search the bodies is determined by the attrLevel keyword argument.

Parameters

attributeName	Name of attribute to retrieve values for.
∗∗*kwargs*	See below.

Returns

A list of attribute values.

Valid keywords:

Parameters

bodyIndex	Specific body in which to retrieve attribute information from.
attrLevel	Level to which to search the body(ies). Options: 0 (or "Body") - search just body attributes 1 (or "Face") - search the body and all the faces [default] 2 (or "Edge") - search the body, faces, and all the edges 3 (or "Node") - search the body, faces, edges, and all the nodes

0.4.11.2.2 attrMap()

```
def attrMap (
    self,
    getInternal = False,
  ** kwargs )
```

Create attribution map (embeded dictionaries) of each body in the current geometry.

Dictionary layout:

- Body 1
  - Body : Body level attributes
  - Faces
    - 1 : Attributes on the first face of the body
    - 2 : Attributes on the second face of the body
    - " : ...
  - Edges
    - 1 : Attributes on the first edge of the body
    - 2 : Attributes on the second edge of the body
    - " : ...
  - Nodes :
    - 1 : Attributes on the first node of the body
    - 2 : Attributes on the second node of the body
    - " : ...
- Body 2
  - Body : Body level attributes
  - Faces

        - 1 : Attributes on the first face of the body
        - " : ...
    - ...
- ...

Dictionary layout (reverseMap = True):

- Body 1
  - Attribute : Attribute name
    - Value : Value of attribute
      - Body : True if value exist at body level, None if not
      - Faces : Face numbers at which the attribute exist
      - Edges : Edge numbers at which the attribute exist
      - Nodes : Node numbers at which the attribute exist
    - Value : Next value of attribute with the same name
      - Body : True if value exist at body level, None if not
      - " : ...
    - ...
  - Atribute : Attribute name
    - Value : Value of attribute
      - " : ...
    - ...
- Body 2
  - Attribute : Attribute name
    - Value : Value of attribute
      - Body : True if value exist at body level, None if not
      - " : ...
    - ...
  - ...
- ...

Parameters

getInternal	Get internal attributes (denoted by starting with an underscore, for example "_AttrName") that exist on the geometry (default - False).
∗∗*kwargs*	See below.

Valid keywords:

Parameters

reverseMap	Reverse the attribute map (default - False). See above table for details.

Returns

Dictionary containing attribution map

0.4.11.2.3 bodies() `def bodies ( self )`

Get dict of geometric bodies.

Returns

Returns a dictionary of the bodies and the capsLength unit. Keys use the body "_name" attribute or "Body_#".

0.4.11.2.4 createTree() `def createTree ( self, filename = "myGeometry", ** kwargs )`

Create a HTML dendrogram/tree of the current state of the geometry.

The HTML file relies on the open-source JavaScript library, D3, to visualize the data. This library is freely available from https://d3js.org/ and is dynamically loaded within the HTML file. If running on a machine without internet access a (miniaturized) copy of the library may be written to a file alongside the generated HTML file by setting the internetAccess keyword to False. If set to True, internet access will be necessary to view the tree.

Parameters

filename	Filename to use when saving the tree (default - "myGeometry"). Note an ".html" is automatically appended to the name (same with ".json" if embedJSON = False).
∗∗*kwargs*	See below.

Valid keywords:

Parameters

embedJSON	Embed the JSON tree data in the HTML file itself (default - True). If set to False a seperate file is generated for the JSON tree data.
internetAccess	Is internet access available (default - True)? If set to True internet access will be necessary to view the tree.
internalGeomAttr	Show the internal attributes (denoted by starting with an underscore, for example "_AttrName") that exist on the geometry (default - False).
reverseMap	Reverse the attribute map (default - False). See attrMap for details.

0.4.11.2.5 lengthUnit() `def lengthUnit ( self )`

Get the lenght Unit of geometric bodies.

Returns

Returns the length unit defined by capsLength attribute.

0.4.11.2.6 readParameters() `def readParameters (`

```
self,
filename )
```

Read an OpenCSM Design Parameter file from disk and and overwrites (makes dirty) the current state of the geometry.

Parameters

filename	Filename of the OpenCSM Design Parameter file

0.4.11.2.7 save() `def save (`

```
self,
filename = "myGeometry",
directory = os.getcwd(),
extension = ".egads" )
```

Save the current geometry to a file.

Parameters

filename	File name to use when saving geometry file.
directory	Directory where to save file. Default current working directory.
extension	Extension type for file if filename does not contain an extension.

0.4.11.2.8 view() `def view (`

```
self,
** kwargs )
```

View or take a screen shot of the geometry configuration.

The use of this function to save geometry requires the **matplotlib** module. ***Important***: If both showImage = True and filename is not None, any manual view changes made by the user in the displayed image will be reflected in the saved image.

Parameters

∗∗*kwargs*	See below.

Valid keywords:

Parameters

viewerType	What viewer should be used (default - "capsViewer"). Options: "capsViewer" or "matplotlib" (options are case insensitive). Important: if $filename is not None, the viewer is changed to matplotlib.
portNumber	Port number to start the server listening on (default - 7681).
title	Title to add to each figure (default - None).
filename	Save image(s) to file specified (default - None). Note filename should not contain '.' other than to indicate file type extension (default type = $*$.png). 'file' - OK, 'file2.0Test' - BAD, 'file2_0Test.png' - OK, 'file2.0Test.jpg' - BAD.
directory	Directory path were to save file. If the directory doesn't exist it will be made. (default - current directory).
viewType	Type of view for the image(s). Options: "isometric" (default), "fourview", "top" (or "-zaxis"), "bottom" (or "+zaxis"), "right" (or "+yaxis"), "left" (or "-yaxis"), "front" (or "+xaxis"), "back" (or "-xaxis").
combineBodies	Combine all bodies into a single image (default - False).
ignoreBndBox	Ignore the largest body (default - False).
showImage	Show image(s) (default - False).
showAxes	Show the xyz axes in the image(s) (default - False).
showTess	Show the edges of the tessellation (default - False).
dpi	Resolution in dots-per-inch for the figure (default - None).
tessParam	Custom tessellation paremeters, see EGADS documentation for makeTessBody function. values will be scaled by the norm of the bounding box for the body (default - [0.0250, 0.0010, 15.0]).

0.4.11.2.9 writeParameters() `def writeParameters (`

```
self,
filename )
```

Write an OpenCSM Design Parameter file to disk.

Parameters

filename	Filename of the OpenCSM Design Parameter file

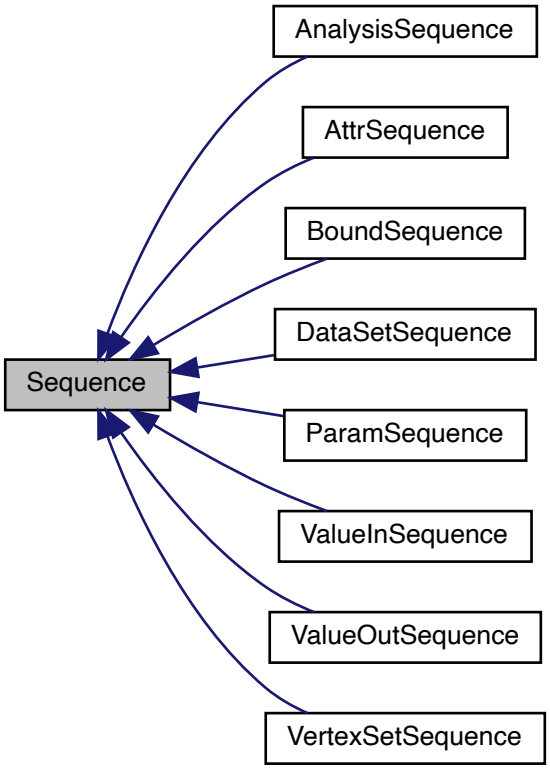
The documentation for this class was generated from the following file:

- pyCAPS/problem.py

0.4.12 Sequence Class Reference

Base class for all CAPS Sequence classes.

Inheritance diagram for Sequence:



Public Member Functions

- def keys (self)

  Returns the keys of the Sequence.
- def values (self)

  Returns the values of the Sequence.
- def items (self)

  Returns the items of the Sequence.

0.4.12.1 Detailed Description

Base class for all CAPS Sequence classes.

A CAPS Sequence only contains instances of a single type Items are added to the Seqence via the 'create' method in derived classes Items cannot be removed from the sequence (except for CAPS Attributes)

The documentation for this class was generated from the following file:

- pyCAPS/problem.py

0.4.13 ValueIn Class Reference

Defines a CAPS input Value Object.

Inherits object.

Public Member Functions

- def value (self)

  Property getter returns a copy the values stored in the CAPS Value Object.
- def value (self, val)

  Property setter sets the value in the CAPS Value Object.
- def limits (self)

  Property getter returns a copy the limits of the CAPS Value Object.
- def limits (self, limit)

  Property setter sets the limits in the CAPS Value Object (if changable)
- def name (self)

  Property returns the name of the CAPS Value Object.
- def link (self, source, tmethod=caps.tMethod.Copy)

  Link this input value to an other CAPS Value Object.
- def unlink (self)

  Remove an existing link.
- def transferValue (self, tmethod, source)

  Transfer values from src to self.

0.4.13.1 Detailed Description

Defines a CAPS input Value Object.

0.4.13.2 Member Function Documentation

0.4.13.2.1 link()

```
def link (
    self,
    source,
    tmethod = caps.tMethod.Copy )
```

Link this input value to an other CAPS Value Object.

Parameters

source	The source Value Object
tmethod	Transfter method: tMethod.Copy or "Copy", tMethod.Integrate or "Integrate", tMethod.Average or "Average"

0.4.13.2.2 transferValue() `def transferValue ( self, tmethod, source )`

Transfer values from src to self.

Parameters

tmethod	0 - copy, 1 - integrate, 2 - weighted average – (1 & 2 only for DataSet src)
source	the source value object

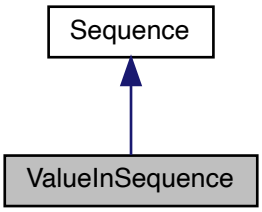
The documentation for this class was generated from the following file:

- pyCAPS/problem.py

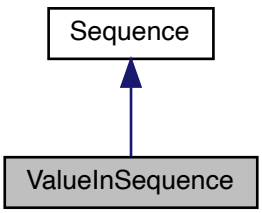
0.4.14 ValueInSequence Class Reference

Defines a Sequence of CAPS input Value Objects.

Inheritance diagram for ValueInSequence:



Collaboration diagram for ValueInSequence:



Additional Inherited Members

0.4.14.1 Detailed Description

Defines a Sequence of CAPS input Value Objects.

The documentation for this class was generated from the following file:

- pyCAPS/problem.py

0.4.15 ValueOut Class Reference

Defines a CAPS output Value Object Not a standalone class.

Inherits object.

Public Member Functions

- def value (self)

  Property getter returns a copy the values stored in the CAPS Value Object.
- def name (self)

  Property returns the name of the CAPS Value Object.
- def props (self)

  Property getter returns a copy the values stored in the CAPS Value Object.
- def hasDeriv (self)

  Returns a string list of of the input Value Object names that can be used in deriv.
- def deriv (self, name=None)

  Returns derivatives of the output Value Object.

0.4.15.1 Detailed Description

Defines a CAPS output Value Object Not a standalone class.

0.4.15.2 Member Function Documentation

0.4.15.2.1 deriv() `def deriv ( self, name = None )`

Returns derivatives of the output Value Object.

Parameters

name	Name of the input Value Object to take derivative w.r.t. if name is None then a dictionary with all dervatives from hasDeriv are returned

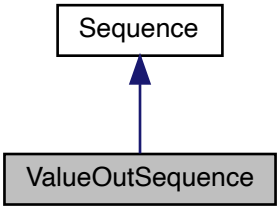
The documentation for this class was generated from the following file:

- pyCAPS/problem.py

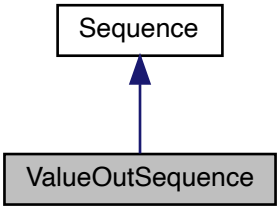
0.4.16 ValueOutSequence Class Reference

Defines a Sequence of CAPS output Value Objects.

Inheritance diagram for ValueOutSequence:



Collaboration diagram for ValueOutSequence:



Additional Inherited Members

0.4.16.1 Detailed Description

Defines a Sequence of CAPS output Value Objects.

The documentation for this class was generated from the following file:

- pyCAPS/problem.py

0.4.17 VertexSet Class Reference

Defines a CAPS VertexSet Object.

Inherits object.

Public Member Functions

- def name (self)

  Property returns the name of the CAPS VertexSet Object.
- def getDataConnect (self)

  Executes caps_triangulate on data set's vertex set to retrieve the connectivity (triangles only) information for the data set.

0.4.17.1 Detailed Description

Defines a CAPS VertexSet Object.

Created via Bound.vertexSet.create().

Parameters

VertexSet.dataSet	DataSetSequence of DataSet instances
VertexSet.attr	AttrSequence of ValueIn attributes

0.4.17.2 Member Function Documentation

0.4.17.2.1 getDataConnect() `def getDataConnect ( self )`

Executes caps_triangulate on data set's vertex set to retrieve the connectivity (triangles only) information for the data set.

Returns

Optionally returns a list of lists of connectivity values (e.g. [[node1, node2, node3], [node2, node3, node7], etc.]) and a list of lists of data connectivity (not this is an empty list if the data is node-based) (eg. [[node1, node2, node3], [node2, node3, node7], etc.]

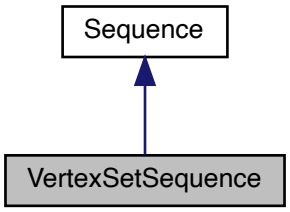
The documentation for this class was generated from the following file:

- pyCAPS/problem.py

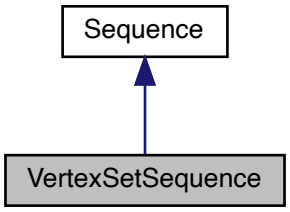
0.4.18 VertexSetSequence Class Reference

Defines a Sequence of CAPS Bound Objects.

Inheritance diagram for VertexSetSequence:



Collaboration diagram for VertexSetSequence:



Public Member Functions

- def create (self, analysis, vname=None)
  Create a CAPS VertexSet Object.

0.4.18.1 Detailed Description

Defines a Sequence of CAPS Bound Objects.

0.4.18.2 Member Function Documentation

0.4.18.2.1 create()

```
def create (
        self,
        analysis,
        vname = None )
```

Create a CAPS VertexSet Object.

Parameters

analysis	A CAPS Analysis Object or the string name of an Analsysis Object instance
vname	Name of the VertexSet (same as the Analysis Object if None)

Returns

The new VertexSet Object is added to the sequence and returned

The documentation for this class was generated from the following file:

- pyCAPS/problem.py

0.5 Example Documentation

0.5.1 problem5.py

Basic example for setting the verbosity of a problem using pyCAPS.Problem.setOutLevel() function.

```
#Use case set verbosity of the problem
import pyCAPS

# Load a *.csm file "./csmData/cfdMultiBody.csm" into our newly created problem. The
# project name "basicTest" may be optionally set here;  if no argument is provided
# the CAPS file provided is used as the project name.
print("Loading file into our Problem")
myProblem = myProblem.Porblem(problemName = "outLevelExample",
                              capsFile="csmData/cfdMultiBody.csm",
                               outLevel="debug")


# Change verbosity to minimal - 0 (integer value)
myProblem.setOutLevel("minimal")

# Change verbosity to standard - 1 (integer value)
myProblem.setOutLevel("standard")

# Change verbosity to back to minimal using integer value - 0
myProblem.setOutLevel(0)

# Change verbosity to back to debug using integer value - 2
myProblem.setOutLevel(2)

# Give wrong value (raises and Error)
myProblem.setOutLevel(10)
```

0.5.2 problem6.py

Example use case for the pyCAPS.capsProblem.createTree() function.

```
# Use: Check creating a tree on the problem
import pyCAPS

# Load a *.csm file "./csmData/cfdMultiBody.csm" into our newly created problem.
myProblem = myProblem.Porblem(problemName = "outLevelExample",
                              capsFile="csmData/cfdMultiBody.csm",
                              outLevel="debug")

# Create problem tree
myProblem.createTree()
```

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