ahds Documentation

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CHAPTER 1

ahds

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· *Classes describing Amira (R) data streams*
· *Conversion classes*

1.1 Overview

`ahds` is a Python package to parse and handle Amira (R) files. It was developed to facilitate reading of Amira (R) files as part of the EMDB-SFF toolkit.

Note: Amira (R) is a trademark of Thermo Fisher Scientific. This package is in no way affiliated with with Thermo Fisher Scientific.

1.2 License

`ahds` is free software and is provided under the terms of the Apache License, Version 2.0.

```
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```

1.2.1 Use Cases

- Detect and parse Amira (R) headers and return structured data
- Decode data (`HxRLEByte`, `HxZip`)
- Easy extensibility to handle previously unencountered data streams

`ahds` was written and is maintained by Paul K. Korir but there is a list of contributors. Feel free to join this initiative.

1.3 Installation

`ahds` works with Python 2.7, 3.5, 3.6 and 3.7. It requires `numpy` to build.

```
pip install numpy
```

Afterwards you may run

```
pip install ahds
```

Todo: Figure out a way to avoid the need for `numpy` as part of the build.

1.4 Getting Started

You can begin playing with `ahds` out of the box using the provided console command `ahds`.

```
me@home ~$ ahds ahds/data/FieldOnTetraMesh.am
********************************************************************************
AMIRA (R) HEADER AND DATA STREAMS
--------------------------------------------------------------------------------
↪-----------------------------------------------------
+-ahds/data/FieldOnTetraMesh.am                                                 ⌟
↪           AmiraFile [is_parent? True ]
|  +-meta                                                                       ⌟
↪               Block [is_parent? False]
|  |  +-file: ahds/data/FieldOnTetraMesh.am
|  |  +-header_length: 182
|  |  +-data_streams: 1
|  |  +-streams_loaded: False
|  +-header                                                                     ⌟
↪         AmiraHeader [is_parent? True ]
|  |  +-filetype: AmiraMesh
|  |  +-dimension: 3D
|  |  +-format: BINARY
|  |  +-endian: BIG
|  |  +-version: 2.0
|  |  +-extra_format: None
|  |  +-Parameters                                                              ⌟
↪               Block [is_parent? False]
|  |  +-Tetrahedra                                                              ⌟
↪               Block [is_parent? False]
|  |  |  +-length: 23685
|  +-data_streams                                                               ⌟
↪               Block [is_parent? False]
********************************************************************************
```

The `ahds` command takes the following arguments

```
me@home ~$ ahds -h
usage: ahds [-h] [-s] [-d] [-l] file [file ...]

Python tool to read and display Amira files

positional arguments:
  file                a valid Amira file with an optional block path

optional arguments:
  -h, --help          show this help message and exit
  -s, --load-streams  whether to load data streams or not [default: False]
  -d, --debug         display debugging information [default: False]
  -l, --literal       display the literal header [default: False]
```

You can specify a **dotted path** after the filename to only render that the content of that field in the header:

```
me@home ~$ ahds ahds/data/FieldOnTetraMesh.am header
********************************************************************************
ahds: Displaying path 'header'
--------------------------------------------------------------------------------
↪----------------------------------------
+-header
↪         AmiraHeader [is_parent? True ]
|  +-filetype: AmiraMesh
|  +-dimension: 3D
|  +-format: BINARY
|  +-endian: BIG
|  +-version: 2.0
|  +-extra_format: None
|  +-Parameters
↪               Block [is_parent? False]
|  +-Tetrahedra
↪               Block [is_parent? False]
|  |  +-length: 23685
```

For debugging you can display the literal header (the exact header present in the file) using the `-l/--literal` flag. Also, you can display the parsed data structure using the `-d/--debug` flag.

```
me@home ~$ ahds --literal --debug ahds/data/FieldOnTetraMesh.am
********************************************************************************
ahds: Displaying literal header
--------------------------------------------------------------------------------
↪----------------------------------------
# AmiraMesh 3D BINARY 2.0
# CreationDate: Tue Nov  2 11:46:31 2004


nTetrahedra 23685

TetrahedronData { float[3] Data } @1
Field { float[3] f } Constant(@1)

# Data section follows
********************************************************************************
ahds: Displaying parsed header data
--------------------------------------------------------------------------------
↪----------------------------------------
[{'designation': {'dimension': '3D',
                  'filetype': 'AmiraMesh',
                  'format': 'BINARY',
                  'version': '2.0'}},
 {'comment': {'date': 'Tue Nov  2 11:46:31 2004'}},
 {'array_declarations': [{'array_dimension': 23685,
                          'array_name': 'Tetrahedra'}]},
 {'data_definitions': [{'array_reference': 'Tetrahedra',
                        'data_dimension': 3,
                        'data_index': 1,
                        'data_name': 'Data',
                        'data_type': 'float'},
                       {'array_reference': 'Field',
                        'data_dimension': 3,
                        'data_index': 1,
```

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```
                        'data_name': 'f',
                        'data_type': 'float',
                        'interpolation_method': 'Constant'}]}]

********************************************************************************************************
AMIRA (R) HEADER AND DATA STREAMS
--------------------------------------------------------------------------------------------
↪-----------------------------------------------------
+-ahds/data/FieldOnTetraMesh.am                                                              ⌞
↪           AmiraFile [is_parent? True ]
|  +-meta                                                                                    ⌞
↪               Block [is_parent? False]
|  |  +-file: ahds/data/FieldOnTetraMesh.am
|  |  +-header_length: 182
|  |  +-data_streams: 1
|  |  +-streams_loaded: False
|  +-header                                                                                  ⌞
↪         AmiraHeader [is_parent? True ]
|  |  +-filetype: AmiraMesh
|  |  +-dimension: 3D
|  |  +-format: BINARY
|  |  +-endian: BIG
|  |  +-version: 2.0
|  |  +-extra_format: None
|  |  +-Parameters                                                                           ⌞
↪               Block [is_parent? False]
|  |  +-Tetrahedra                                                                           ⌞
↪               Block [is_parent? False]
|  |  |  +-length: 23685
|  +-data_streams                                                                            ⌞
↪               Block [is_parent? False]
********************************************************************************************************
```

By default, data streams are not read — only the header is parsed. You may obtain the data streams using the `-s/--load-streams` flag.

```
me@home ~$ ahds --load-streams ahds/data/FieldOnTetraMesh.am
********************************************************************************************************
AMIRA (R) HEADER AND DATA STREAMS
--------------------------------------------------------------------------------------------
↪-----------------------------------------------------
+-ahds/data/FieldOnTetraMesh.am                                                              ⌞
↪           AmiraFile [is_parent? True ]
|  +-meta                                                                                    ⌞
↪               Block [is_parent? False]
|  |  +-file: ahds/data/FieldOnTetraMesh.am
|  |  +-header_length: 182
|  |  +-data_streams: 1
|  |  +-streams_loaded: True
|  +-header                                                                                  ⌞
↪         AmiraHeader [is_parent? True ]
|  |  +-filetype: AmiraMesh
|  |  +-dimension: 3D
|  |  +-format: BINARY
|  |  +-endian: BIG
|  |  +-version: 2.0
```

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```
|   |   +-extra_format: None
|   |   +-Parameters                                                                             ␣
↪                  Block [is_parent? False]
|   |   +-Tetrahedra                                                                             ␣
↪                  Block [is_parent? False]
|   |   |   +-length: 23685
|   +-data_streams                                                                               ␣
↪                  Block [is_parent? True ]
|   |   +-Data                                                                                   ␣
↪ AmiraMeshDataStream [is_parent? False]
|   |   |   +-data_index: 1
|   |   |   +-dimension: 3
|   |   |   +-type: float
|   |   |   +-interpolation_method: None
|   |   |   +-shape: 23685
|   |   |   +-format: None
|   |   |   +-data: [   0.8917308    0.9711809 300.        ],...,[   1.4390504    1.1243758␣
↪300.        ]
*****************************************************************************************************************
```

1.5 Future Plans

- Write out valid Amira (R) files

1.6 Background and Definitions

`ahds` presently handles two types of Amira (R) files:

- *AmiraMesh* files, which typically but not necessarily have a `.am`, `.elm`, `.lmb` extension, and
- *HyperSurface* files, which have `.surf` and represent an older filetype.

Both file types consist of two parts:

- a *header*, and
- one or more *data streams*.

Headers are structured in a modified VRML-like syntax and differ between AmiraMesh and HyperSurface files in some of the keywords used.

A data stream is a sequence of encoded bytes either referred to in the header by some delimiter (usually `@<data_stream_index>`, where `<data_stream_index>` is an integer) or a set of structural keywords (e.g. `Vertices`, `Patches`) expected in a predefined sequence.

1.6.1 Headers in Detail

AmiraMesh and HyperSurface headers can be divided into four main sections:

- **designation**
- **definitions**
- **parameters**, and

- **data pointers**.

The *designation* is the first line and conveys several important details about the format and structure of the file such as:

- filetype (either `AmiraMesh` or `HyperSurface`)
- dimensionality (`3D`)
- format (`BINARY-LITTLE-ENDIAN`, `BINARY` or `ASCII`)
- version (a decimal number e.g. `2.1`
- extra format data e.g. `<hxsurface>` specifying that an AmiraMesh file will contain HyperSurface data

A series of *definitions* follow that refer to data found in the data pointer sections that either begin with the word â€~defineâ€™ or have â€~nâ€™ prepended to a variable. For example:

```
define Lattice 862 971 200
```

or

```
nVertices 85120
```

This is followed by grouped *parameters* enclosed in a series of braces beginning with the word â€~Parametersâ€™. Various parameters are then enclosed each beginning with the name of that group of parameters e.g. â€~Materialsâ€™

```
Parameters {
    # grouped parameters
    Material {
        # the names of various materials with attributes
        Exterior {
            id 0
        }
        Inside {
            id 1,
            Color 0 1 1,
            Transparency 0.5
        }
    }
    Patches {
    # patch attributes
        InnerRegion â€œInsideâ€,
        OuterRegion â€œExteriorâ€,
        BoundaryID 0,
        BranchingPoints 0
    }
    # inline parameters
    GridSize <value>,
    â€¦
}
```

The most important set of parameters are materials as these specify colours and identities of distinct segments/datasets within the file.

Finally, AmiraMesh files list a set of *data pointers* that point to data labels within the file together with additional information to decode the data. We refer to these as data streams because they consist of continuous streams of raw byte data that need to be decoded. Here is an example of data pointers that refer to the location of 3D surface primitives:

```
Vertices { float[3] Vertices } @1
TriangleData { int[7] Triangles } @2
Patches-0 { int Patches-0 } @3
```

These refer to three raw data streams each found beginning with the delimiter `@<number>`. Data stream one (`@1`) is called `Vertices` and consists of float triples, two is called `TriangleData` and has integer 7-tuples and three called `Patches-` is a single integer (the number of patches). In some cases the data pointer contains the data encoding for the corresponding data pointer.

```
Lattice { byte Labels } @1(HxByteRLE,234575740)
```

which is a run-length encoded data stream of the specified length, while

```
Lattice { byte Data } @1(HxZip,919215)
```

contains zipped data of the specified length.

1.6.2 Data Streams in Detail

AmiraMesh data streams are very simple. They always have a start delimiter made of `@` with an index that identifies the data stream. A newline character separates the delimiter with the data stream proper which is either plain ASCII or a binary stream (raw, zipped or encoded).

HyperSurface data streams structured to have the following sections:

```
# Header
Vertices <nvertices>
# vertices data stream

NBranchingPoints <nbranching_points>
NVerticesOnCurves <nvertices_on_curves>
BoundaryCurves <nboundary_curves>
Patches <npatches>
{
InnerRegion <inner_region_name>
OuterRegion <outer_region_name>
BoundaryID <boundary_id>
BranchingPoints <nbranching_points>
Triangles <ntriangles>
# triangles data stream
} # repeats for as <npatches> times
```

HyperSurface data streams can be either plain ASCII or binary.

1.7 ahds Modules

`ahds` has three main modules:

- `ahds.grammar` specifies an EBNF grammar
- `ahds.header`
- `ahds.data_stream`

These modules are tied into a user-level class called `ahds.AmiraFile` that does all the work for you.

```
>>> from ahds import AmiraFile
>>> # read an AmiraMesh file
>>> af = AmiraFile('am/test7.am')
>>> af.header
<AmiraHeader with 4 bytes>
>>> # empty data streams
>>> af.data_streams
>>> print af.data_streams
None
>>> # we have to explicitly read to get the data streams
>>> af.read()
>>> af.data_streams
<class 'ahds.data_stream.DataStreams'> object with 13 stream(s): 1, 2, 3, 4, 5, 6, 7,␣
↪8, 9, 10, 11, 12, 13
>>> for ds in af.data_streams:
...     print ds
...
<class 'ahds.data_stream.AmiraMeshDataStream'> object of 2,608 bytes
<class 'ahds.data_stream.AmiraMeshDataStream'> object of 2,608 bytes
<class 'ahds.data_stream.AmiraMeshDataStream'> object of 2,608 bytes
<class 'ahds.data_stream.AmiraMeshDataStream'> object of 2,608 bytes
<class 'ahds.data_stream.AmiraMeshDataStream'> object of 2,608 bytes
<class 'ahds.data_stream.AmiraMeshDataStream'> object of 2,608 bytes
<class 'ahds.data_stream.AmiraMeshDataStream'> object of 2,608 bytes
<class 'ahds.data_stream.AmiraMeshDataStream'> object of 2,608 bytes
<class 'ahds.data_stream.AmiraMeshDataStream'> object of 2,608 bytes
<class 'ahds.data_stream.AmiraMeshDataStream'> object of 2,608 bytes
<class 'ahds.data_stream.AmiraMeshDataStream'> object of 2,608 bytes
<class 'ahds.data_stream.AmiraMeshDataStream'> object of 2,608 bytes
<class 'ahds.data_stream.AmiraMeshDataStream'> object of 2,608 bytes
# we get the n-th data stream using the index/key notation
>>> af.data_streams[1].encoded_data
'1 \n2 \n3 \n'
>>> af.data_streams[1].decoded_data
[1, 2, 3]
>>> af.data_streams[2].encoded_data
'69 \n120 \n116 \n101 \n114 \n105 \n111 \n114 \n0 \n73 \n110 \n115 \n105 \n100 \n101␣
↪\n0 \n109 \n111 \n108 \n101 \n99 \n117 \n108 \n101 \n0 \n'
>>> af.data_streams[2].decoded_data
[69, 120, 116, 101, 114, 105, 111, 114, 0, 73, 110, 115, 105, 100, 101, 0, 109, 111,␣
↪108, 101, 99, 117, 108, 101, 0]
```

```
>>> # read an HyperSurface file
>>> af = AmiraFile('surf/test4.surf')
>>> af.read()
>>> af.data_streams
<class 'ahds.data_stream.DataStreams'> object with 5 stream(s): Patches,␣
↪NBranchingPoints, BoundaryCurves, Vertices, NVerticesOnCurves
# HyperSurface files have pre-set data streams
>>> af.data_streams['Vertices'].decoded_data[:10]
[(560.0, 243.0, 60.96875), (560.0, 242.9166717529297, 61.0), (559.5, 243.0, 61.0),␣
↪(561.0, 243.0, 60.95833206176758), (561.0, 242.5, 61.0), (561.0384521484375, 243.0,␣
↪61.0), (559.0, 244.0, 60.94444274902344), (559.0, 243.5, 61.0), (558.9722290039062,␣
↪244.0, 61.0), (560.0, 244.0, 60.459999084472656)]
```

1.7.1 ahds.grammar

This module describes the header grammar for Amira (R) (AmiraMesh and HyperSurface) files and so depends on `simpleparse` Python package. It defines a single class (`ahds.grammar.AmiraDispatchProcessor`) and four functions.

`ahds.grammar.AmiraDispatchProcessor` is a subclass of `simpleparse.dispatchprocessor` which implements the core functionality required to use the grammar. Each grammar token has a corresponding method defined on this class which determines how the data associated with that token will be rendered. Data can be rendered as a single or multimap, string, number, or in custom format.

- `ahds.grammar.get_parsed_data(fn, *args, **kwargs)()` is the user-level function that takes a filename and returns structured parsed data. It depends on the other three functions defined:
- `ahds.grammar.detect_format(fn, format_bytes=50, verbose=False)()` returns either `AmiraMesh` or `HyperSurface` given a file name and arguments,
- `ahds.grammar.get_header(fn, file_format, header_bytes=20000, verbose=False)()` returns the header portion based on the file format determined by detect_format(...), and
- `ahds.grammar.parse_header(data, verbose=False)()` converts the raw header data returned by `ahds.grammar.get_header(...)()` into a structured header based on AmiraDispatchProcessor.

1.7.2 ahds.header

This module converts the structured header from the `ahds.grammar` module into an object with the sections of the header (`designation`, `definitions`, `parameters ``and ``data pointers`) and corresponding structured data available as attributes. That is, it converts the header:

```
# AmiraMesh BINARY-LITTLE-ENDIAN 2.1


define Lattice 862 971 200

Parameters {
    Materials {
        Exterior {
            Id 1
        }
        Inside {
            Color 0.64 0 0.8,
            Id 2
        }
        Mitochondria {
            Id 3,
            Color 0 1 0
        }
        Mitochondria_ {
            Id 4,
            Color 1 1 0
        }
        mitochondria__ {
            Id 5,
            Color 0 0.125 1
        }
        NE {
```

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```
            Id 6,
            Color 1 0 0
        }
    }
    Content "862x971x200 byte, uniform coordinates",
    BoundingBox 0 13410.7 0 15108.4 1121.45 4221.01,
    CoordType "uniform"
}

Lattice { byte Labels } @1(HxByteRLE,4014522)
```

into an `ahds.header.AmiraHeader` object.

```
>>> from ahds.header import AmiraHeader
>>> amira_header = AmiraHeader.from_file('am/test2.am')
>>> amira_header.designation.attrs
['filetype', 'dimension', 'format', 'version', 'extra_format']
>>> amira_header.designation.filetype
'AmiraMesh'
>>> amira_header.designation.dimension
>>> amira_header.designation.format
'BINARY-LITTLE-ENDIAN'
>>> amira_header.definitions.attrs
['Lattice']
>>> amira_header.definitions.Lattice
[862, 971, 200]
>>> amira_header.parameters.attrs
['Materials', 'Content', 'BoundingBox', 'CoordType']
>>> amira_header.parameters.Materials.attrs
['Exterior', 'Inside', 'Mitochondria', 'Mitochondria_', 'mitochondria__', 'NE']
>>> amira_header.parameters.Materials.Exterior.attrs
['Id']
>>> amira_header.parameters.Materials.Exterior.Id
1
>>> amira_header.parameters.Content
'"862x971x200 byte, uniform coordinates",'
>>> amira_header.parameters.BoundingBox
[0, 13410.7, 0, 15108.4, 1121.45, 4221.01]
>>> amira_header.parameters.CoordType
'"uniform"'
>>> amira_header.data_pointers.attrs
['data_pointer_1']
>>> amira_header.data_pointers.data_pointer_1.attrs
['pointer_name', 'data_format', 'data_dimension', 'data_type', 'data_name', 'data_
↪index', 'data_length']
>>> amira_header.data_pointers.data_pointer_1.pointer_name
'Lattice'
>>> amira_header.data_pointers.data_pointer_1.data_format
'HxByteRLE'
>>> amira_header.data_pointers.data_pointer_1.data_dimension
>>> amira_header.data_pointers.data_pointer_1.data_type
'byte'
>>> amira_header.data_pointers.data_pointer_1.data_name
'Labels'
>>> amira_header.data_pointers.data_pointer_1.data_index
1
>>> amira_header.data_pointers.data_pointer_1.data_length
```

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```
4014522
```

This module consists of two main classes: `ahds.header.AmiraHeader` is the user-level class and `ahds.header.Block` which is a container class for a block of structured data from an Amira (R) header.

AmiraHeader has one constructor: `ahds.header.AmiraHeader.from_file(fn, *args, **kwargs)()` which takes an Amira (R) file by name and arguments and returns an `ahds.header.AmiraHeader` object with all attributes set as described above. Alternatively, one can use the initiator form to pass structured data directly: `ahds.header.AmiraHeader(parsed_data)` which returns an `ahds.header.AmiraHeader` object configured appropriately.

- The raw data structured data is available as read-only property: `ahds.header.AmiraHeader.raw_header`
- Internally the `ahds.header.AmiraHeader` class implements a set of private methods which individually load the four data sections (`designation`, `definitions`, `parameters`, and `data pointers`).

The `ahds.header.Block` class is a container class which converts structured groups to attributes and has two main attributes:

- `ahds.header.Block.name` provides the name of the current block

```
>>> amira_header.designation.name
'designation'
>>> amira_header.parameters.Materials.name
'Materials'
>>> amira_header.parameters.Materials.Exterior.name
'Exterior'
```

- `ahds.header.Block.attrs` provides the attributes available on this `ahds.header.Block`

```
>>> amira_header.designation.attrs
['filetype', 'dimension', 'format', 'version', 'extra_format']
>>> amira_header.designation.format
'BINARY-LITTLE-ENDIAN'
A given Materials block has two special features:
Block.ids returns the list of ids for all materials. This is important when decoding␣
↪HxByteRLE compressed data
Block[id] returns the material for the given id using index notation.
>>> amira_header.parameters.Materials.ids
[1, 2, 3, 4, 5, 6]
>>> amira_header.parameters.attrs
['Materials', 'Content', 'BoundingBox', 'CoordType']
# ids attribute is only available for â€~Materialâ€™ blocks within â€~parametersâ€™␣
↪section
>>> amira_header.parameters.Content.ids
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
AttributeError: 'str' object has no attribute 'ids'
# we can get the name of a material of the given id
>>> amira_header.parameters.Materials[4].name
'Mitochondria_'
```

1.7.3 ahds.data_stream

This is most complex module implementing a hierarchy of classes describing various data streams within Amira (R) files. It has 22 classes and five functions

Classes

There are three categories of classes:

- A user-level class that encapsulates (2) below.
- Classes describing Amira (R) data streams
- Classes describing AmiraMesh data streams
- Classes describing HyperSurface data streams
- Data conversion classes (AmiraMesh only)
- Classes abstracting images
- Classes abstracting contours

The user-level `ahds.data_stream.DataStreams` class is the preferred way to use the module. It takes the name of an Amira (R) file and encapsulates an iterator of data streams.

```
>>> from ahds import data_stream
>>> data_streams = data_stream.DataStreams('am/test6.am')
>>> data_streams
<class 'ahds.data_stream.DataStreams'> object with 2 stream(s): 1, 2
>>> for ds in data_streams:
...   print ds
...
<class 'ahds.data_stream.AmiraMeshDataStream'> object of 968,909 bytes
<class 'ahds.data_stream.AmiraMeshDataStream'> object of 968,909 bytes
```

Functions

The functions implemented in this module decode data streams.

- `ahds.data_stream.hxbyterle_decode()` decodes `HxByteRLE` data streams
- `ahds.data_stream.hxzip_decode(data_size, data)()` unzips zlib-compressed data streams
- `ahds.data_stream.unpack_binary(data_pointer, definitions, data)()` unpacks the structured data stream according to the attributes specified in the dataâ€™s data pointer
- `ahds.data_stream.unpack_ascii(data)()` converts rows of ASCII data into numerical data

Classes in Detail

DataStreams class

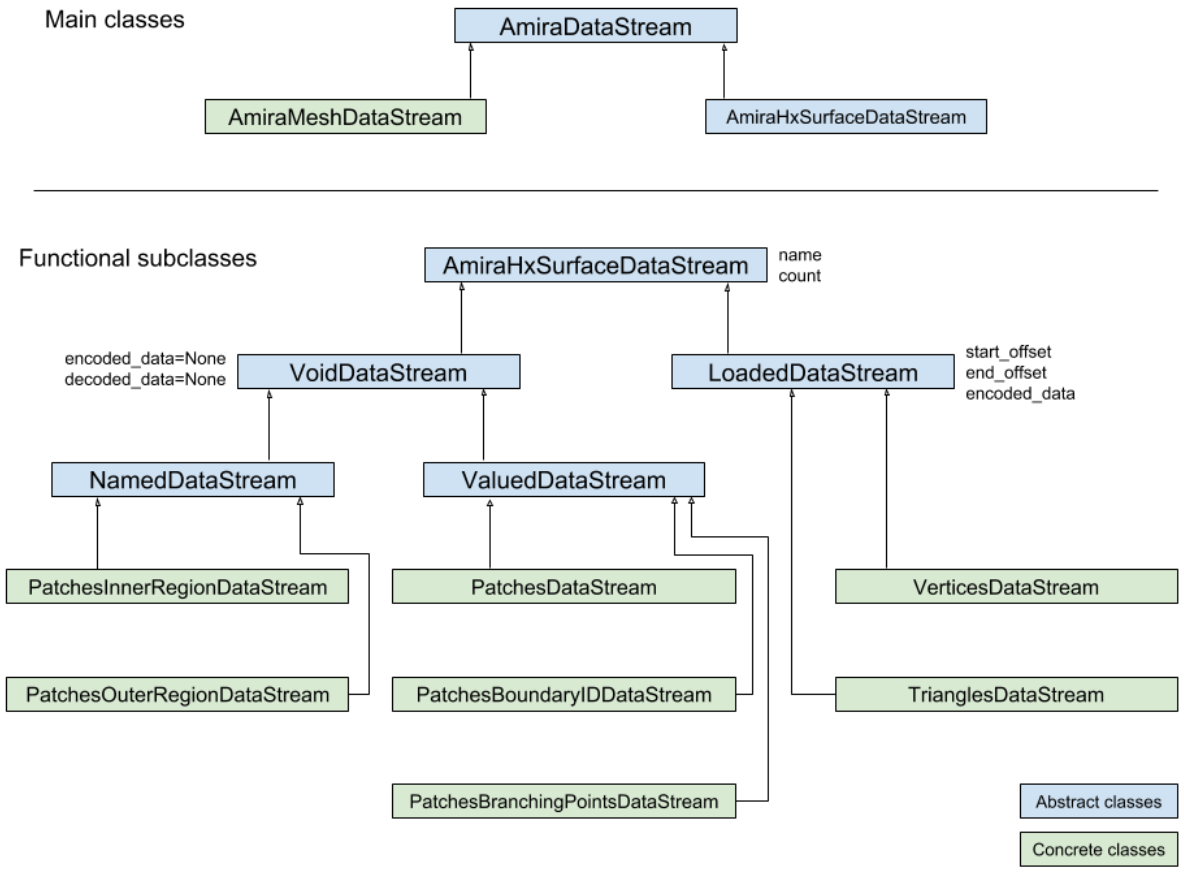
The following attributes are available on objects of this class:

- `ahds.data_stream.DataStreams.file` - filename of Amira (R) file
- `ahds.data_stream.DataStreams.header` - an object of class `ahds.header.AmiraHeader` encapsulating the header data in four sections (`designation`, `definitions`, `parameters`, and `data pointers`)
- `ahds.data_stream.DataStreams.filetype` - the filetype as specified in (ii) above.
- `ahds.data_stream.DataStreams.stream_data` - all raw data from the file (including the header)
- `len(DataStreams)` - the number of data streams contained

- `ahds.data_stream.DataStreams[<index>]` - returns the data stream of the index specified (as defined in the data_pointers section of the header object

Classes describing Amira (R) data streams

The following diagrams illustrates the hierarchy of classes:



Classes describing Amira (R) data streams

- `ahds.data_stream.AmiraDataStream` is the base class for all data stream classes and defines the following attributes:
- `ahds.data_stream.AmiraDataStream.header` - an `ahds.header.AmiraHeader` object
- `ahds.data_stream.AmiraDataStream.data_pointer` - the `ahds.header.AmiraHeader.data_pointers.data_pointer_X` for this data stream
- `ahds.data_stream.AmiraDataStream.stream_data` - the raw file data
- `ahds.data_stream.AmiraDataStream.encoded_data` - the encoded data for this stream; `None` for `VoidDataStream` subclasses
- `ahds.data_stream.AmiraDataStream.decoded_data` - the decoded data for this stream; `None` for `VoidDataStream` subclasses
- `ahds.data_stream.AmiraDataStream.decoded_length` - the number of items (tuples, integers) in decoded data

The two main subclasses of `ahds.data_stream.AmiraDataStream` are `ahds.data_stream.AmiraMeshDataStream`, which is a concrete class representing all AmiraMesh data streams, and `ahds.data_stream.AmiraHxSurfaceDataStream`, which abstractly defines HyperSurface data streams.

There are two main AmiraHxSurfaceDataStream subclasses:

- `ahds.data_stream.VoidDataStream` represents `ahds.data_stream.AmiraHxSurfaceDataStream` data streams that only have a name and value but no actual encoded data (on the following line). There are two subclasses:
  - `ahds.data_stream.NamedDataStream` subclasses have a strings after data stream name. The two concrete subclasses are:
  - `ahds.data_stream.PatchesInnerRegionDataStream` for the name of an inner region of a patch (see `PatchesDataStream`), and
  - `ahds.data_stream.PatchesOuterRegionDataStream` for corresponding name of the outer region of a patch.
  - `ahds.data_stream.ValuedDataStream` have an integer value after the data stream name. The three concrete subclasses are:
  - `ahds.data_stream.PatchesBoundaryIDDataStream` hold the boundary ID of a patch,
  - `ahds.data_stream.PatchesBranchingPointsDataStream` stores the number of branching points, and
  - `ahds.data_stream.PatchesDataStream` with the number of patches, which is a special `ahds.data_stream.ValueDataStream` that contains an iterable of patches each containing a `Patches<X>DataStream` objects.
  - `ahds.data_stream.LoadedDataStream` represent `ahds.data_stream.AmiraHxSurfaceDataStream` data streams that have a name, a value and encoded data. The two main concrete subclasses are:
  - `ahds.data_stream.VerticesDataStream` represents data streams with float-triples, and
  - `ahds.data_stream.PatchesTrianglesDataStream` represents data streams within a patch with triples of 1-based indices (triangles) of vertices specified in the `ahds.data_stream.VerticesDataStream`.

Conversion classes

There are two groups of conversion classes which only apply to (some) AmiraMesh data streams: Conversion classes

- Image conversion classes consist of a image container class `ahds.data_stream.ImageSet` and an `ahds.data_stream.Image` class. ImageSet objects that can be iterated to give `ahds.data_stream.Image` objects are returned from the `ahds.data_stream.AmiraMeshDataStream.to_images()` method call.

```
>>> # decode the data stream to images
>>> images = ds[1].to_images()
>>> images
<ImageSet with 200 images>
>>> for image in images:
...     print image
...
<Image with dimensions (971, 862)>
<Image with dimensions (971, 862)>
<Image with dimensions (971, 862)>
```

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```
...
<Image with dimensions (971, 862)>
<Image with dimensions (971, 862)>
```

- Contour conversion classes convert individual images into sets of contours (`ahds.data_stream.ContourSet`) iterable as individual `ahds.data_stream.Contours` objects. They are obtained from calls to the `ahds.data_stream.Image.as_contours` property. Furthermore, the `ahds.data_stream.Image.as_segments` property call returns a dictionary of the corresponding `ahds.data_stream.ContourSet` object indexed by the z plane.

```
>>> # contours per image
>>> # the dictionary key is the Amira Id for the segment (the Id of the Material)
>>> # a segment can have several non-overlapping contours (or polylines)
>>> for image in images:
...     print image.as_contours
...
{2: <class 'ahds.data_stream.ContourSet'> with 15 contours, 3: <class 'ahds.data_
↪stream.ContourSet'> with 3 contours, 5: <class 'ahds.data_stream.ContourSet'> with␣
↪2 contours}
{2: <class 'ahds.data_stream.ContourSet'> with 18 contours, 3: <class 'ahds.data_
↪stream.ContourSet'> with 3 contours, 5: <class 'ahds.data_stream.ContourSet'> with␣
↪2 contours}
...
{2: <class 'ahds.data_stream.ContourSet'> with 15 contours, 3: <class 'ahds.data_
↪stream.ContourSet'> with 1 contours, 5: <class 'ahds.data_stream.ContourSet'> with␣
↪3 contours}
{2: <class 'ahds.data_stream.ContourSet'> with 15 contours, 3: <class 'ahds.data_
↪stream.ContourSet'> with 1 contours, 5: <class 'ahds.data_stream.ContourSet'> with␣
↪3 contours}


>>> # separate individual segments
>>> images.segments
{1: {110: <class 'ahds.data_stream.ContourSet'> with 1 contours}, 2: {0: <class 'ahds.
↪data_stream.ContourSet'> with 15 contours, 1: <class 'ahds.data_stream.ContourSet'>␣
↪with 18 contours, ..., 198: <class 'ahds.data_stream.ContourSet'> with 3 contours,␣
↪199: <class 'ahds.data_stream.ContourSet'> with 3 contours}}
```

CHAPTER 2

ahds package

2.1 ahds.grammar module

2.2 ahds.header module

2.3 ahds.data_stream module

CHAPTER 3

Indices and tables

- genindex
- modindex
- search