1 Package modules 3
  1.1 core module ......................................................... 3
  1.2 reports module ...................................................... 25

2 Tutorial 27
  2.1 Basic usage ............................................................. 27
  2.2 Work with boundaries .............................................. 32

3 Installation 35

4 Usage 37

5 Contributing 39
  5.1 Types of Contributions ............................................. 39
  5.2 Get Started! ............................................................. 40
  5.3 Pull Request Guidelines .......................................... 40
  5.4 Tips ........................................................................ 41

6 Credits 43
  6.1 Development Lead ..................................................... 43
  6.2 Contributors ............................................................. 43

7 Changes 45
  7.1 0.1 (13 Feb 2015) ..................................................... 45
  7.2 0.2 (18 Apr 2015) ..................................................... 45
  7.3 0.3 (22 Feb 2016) ..................................................... 45
  7.4 0.4 (20 Jun 2016) ..................................................... 45
  7.5 0.5 (XX YYY 2017) .................................................. 47
Contents:
PolyLX provides following modules:

### 1.1 core module

Python module to visualize and analyze digitized 2D microstructures.

@author: Ondrej Lexa

**Examples:**

```python
>>> from polylx import *
>>> g = Grains.from_shp()
>>> b = g.boundaries()
```

```python
class polylx.core.Boundaries (shapes, classification=None)
Bases: polylx.core.PolySet

Class to store set of Boundaries objects

__init__(shapes, classification=None)

affine_transform (matrix)
Returns a transformed geometry using an affine transformation matrix. The matrix is provided as a list or tuple with 6 items: [a, b, d, e, xoff, yoff] which defines the equations for the transformed coordinates: 

\[ x' = a \times x + b \times y + xoff \]

\[ y' = d \times x + e \times y + yoff \]

agg (*pairs)
Returns concatenated result of multiple aggregations (different aggregation function for different attributes) based on actual classification. For single aggregation function use directly pandas groups, e.g. g.groups('lao', 'sao').agg(circular.mean)

**Example:**

```python
>>> g.agg('area', np.sum, 'ead', np.mean, 'lao', circular.mean)
```

```
<table>
<thead>
<tr>
<th>class</th>
<th>area</th>
<th>ead</th>
<th>lao</th>
</tr>
</thead>
<tbody>
<tr>
<td>ksp</td>
<td>2.443733</td>
<td>0.089710</td>
<td>76.875488</td>
</tr>
<tr>
<td>pl</td>
<td>1.083516</td>
<td>0.060629</td>
<td>94.197847</td>
</tr>
<tr>
<td>qtz</td>
<td>1.166097</td>
<td>0.068071</td>
<td>74.320337</td>
</tr>
</tbody>
</table>
```
barplot(val, **kwargs)
Plot seaborn swarmplot.

bootstrap(num=100, size=None)
Bootstrap random sample generator.

Args:
num: number of bootstrapped samples. Default 100
size: size of bootstrapped samples. Default number of objects.

Examples:
```python
>>> bsmean = np.mean([gs.ead.mean() for gs in g.bootstrap()])
```
boundary_segments()
Create Boundaries from object boundary segments.

Example:
```python
>>> g = Grains.from_shp()
>>> b = g.boundary_segments()
```
boxplot(val, **kwargs)
Plot seaborn boxplot.

class_iter()

classify(*args, **kwargs)
Define classification of objects.

When no arguments are provided, default unique classification based on name attribute is used.

Args:
vals: name of attribute (str) used for classification or array of values

Keywords:
label: used as classification label when vals is array k: number of classes for continuous values rule: type of classification

*unique*: unique value mapping (for discrete values) *equal*: k equally spaced bins (for continuous values) *user*: bins edges defined by array k (for continuous values) *natural*: natural breaks. Default rule.

(beware not always unique solution)

*jenks*: fischer jenks scheme
cmap: matplotlib colormap. Default 'viridis'

Examples:
```python
>>> g.classify('name', rule='unique')
>>> g.classify('ar', rule='jenks', k=5)
```
clip(other)

clipstrap(num=100, f=0.3)
Bootstrap random rectangular clip generator.

Args:
num: number of bootstrapped samples. Default 100
f: area fraction clipped from original shape. Default 0.3

Examples:
```python
>>> csmean = np.mean([gs.ead.mean() for gs in g.clipstrap()])
```
countplot(**kwargs)
Plot seaborn countplot.
**df (**\*attrs\*)**

Returns pandas.DataFrame of object attributes.

Example:

```python
>>> g.df('ead', 'ar')
```

**feret (**angle=0\*)**

Returns array of feret diameters for given angle.

**Args:** angle: Caliper angle. Default 0

**get (**attr\*)**

Returns pandas.Series of object attribute.

Example:

```python
>>> g.get('ead')
```

**get_class (**key\*)**

**getindex (**name\*)**

Return the indices of the objects with given name.

**gridsplit (**m=1, n=1\*)**

Rectangular split generator.

**Args:** m, n: number of rows and columns to split.

**Examples:**

```python
>>> smean = np.mean([gs.ead.mean() for gs in g.gridsplit(6, 8)])
```

**groups (**\*attrs\*)**

Returns pandas.GroupBy of object attributes.

Note that grouping is based on actual classification.

Example:

```python
>>> g.classify('ar', 'natural')
```

```python
>>> g.groups('ead').mean()
```

<table>
<thead>
<tr>
<th>class</th>
<th>ead</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.01765-1.31807</td>
<td>0.067772</td>
</tr>
<tr>
<td>1.31807-1.5445</td>
<td>0.076042</td>
</tr>
<tr>
<td>1.5445-1.83304</td>
<td>0.065900</td>
</tr>
<tr>
<td>1.83304-2.36773</td>
<td>0.073338</td>
</tr>
<tr>
<td>2.36773-12.1571</td>
<td>0.084016</td>
</tr>
</tbody>
</table>

**nndist (**\*kwargs\*)**

**paror (**angles=range(0, 180), normalized=True\*)**

Returns paror function values. When normalized maximum value is 1 and correspond to max feret.

**Args:** angles: iterable angle values. Default range(180) normalized: whether to normalize values. Default True

**plot (**\*kwargs\*)**

Plot set of Grains or Boundaries objects.

**Keywords:** show: If True matplotlib show is called. Default True alpha: transparency. Default 0.8 pos: legend position “top”, “right” or “none”. Default “auto” ncol: number of columns for legend. legend: Show legend. Default True show_fid: Show FID of objects. Default False show_index: Show index of objects. Default False

When show=False, returns matplotlib axes object.
**proj** *(angle=0)*  
Returns array of cumulative projection of object for given angle. **Args:**  
angle: angle of projection line

**regularize** (**kwargs**)

**rose** (**kwargs**)
Plot polar histogram of Grains or Boundaries orientations

**Keywords:**  
- show: If True matplotlib show is called. Default True  
- attr: property used for orientation. Default ‘lao’  
- bins: number of bins  
- weights: if provided histogram is weighted  
- density: True for probability density otherwise counts  
- grid: True to show grid

When show=False, returns matplotlib axes object.

**rotate** *(angle, **kwargs)**
Returns a rotated geometry on a 2D plane. The angle of rotation can be specified in either degrees (default) or radians by setting use_radians=True. Positive angles are counter-clockwise and negative are clockwise rotations. The point of origin can be a keyword ‘center’ for the object bounding box center (default), ‘centroid’ for the geometry’s centroid, or coordinate tuple (x0, y0) for fixed point.

**savefig** (**kwargs**)
Save grains or boundaries plot to file. **Args:**  
filename: file to save figure. Default “figure.png”  
dpi: DPI of image. Default 150  
See **plot** for other kwargs

**scale** (**kwargs**)
Returns a scaled geometry, scaled by factors along each dimension. The point of origin can be a keyword ‘center’ for the object bounding box center (default), ‘centroid’ for the geometry’s centroid, or coordinate tuple (x0, y0) for fixed point. Negative scale factors will mirror or reflect coordinates.

**simplify** *(method='vw', **kwargs)**

**skew** (**kwargs**)
Returns a skewed geometry, sheared by angles ‘xs’ along x and ‘ys’ along y direction. The shear angle can be specified in either degrees (default) or radians by setting use_radians=True. The point of origin can be a keyword ‘center’ for the object bounding box center (default), ‘centroid’ for the geometry’s centroid, or a coordinate tuple (x0, y0) for fixed point.

**smooth** *(method='chaikin', **kwargs)**

**surfor** *(angles=range(0, 180), normalized=True)*
Returns surfor function values. When normalized maximum value is 1 and correspond to max feret. **Args:**  
- angles: iterable angle values. Default range(180)  
- normalized: whether to normalize values. Default True

**swarmplot** *(val, **kwargs)**
Plot seaborn swarmplot.

**translate** (**kwargs**)
Returns a translated geometry shifted by offsets ‘xoff’ along x and ‘yoff’ along y direction.

**ar**
Returns array of axial ratios  
Note that axial ratio is calculated from long and short axes calculated by actual **shape** method.

**area**
Return array of areas of the objects. For boundary returns 0.

**centroid**
Returns the 2D array of geometric centers of the objects

**class_names**
extent
  Returns minimum bounding region (minx, miny, maxx, maxy) of all objects

fid
  Return array of fids of objects.

height
  Returns height of extent.

la
  Return array of long axes of objects according to shape_method.

lao
  Return array of long axes of objects according to shape_method

length
  Return array of lengths of the objects.

ma
  Returns mean axis
  Return array of mean axes calculated by actual shape method.

name
  Return list of names of the objects.

names
  Returns list of unique object names.

representative_point
  Returns a 2D array of cheaply computed points that are guaranteed to be within the objects.

sa
  Return array of long axes of objects according to shape_method

sao
  Return array of long axes of objects according to shape_method

shape
  Return list of shapely objects.

shape_method
  Set or returns shape methods of all objects.

width
  Returns width of extent.

class polylx.core.Boundary (shape, name='None-None', fid=0)
  Bases: polylx.core.PolyShape
  Boundary class to store polyline boundary geometry
  A two-dimensional linear ring.
__init__ (shape, name='None-None', fid=0)
  Create Boundary object

affine_transform (matrix)
  Returns a transformed geometry using an affine transformation matrix. The matrix is provided as a list or tuple with 6 items: [a, b, d, e, xoff, yoff] which defines the equations for the transformed coordinates: x' = a * x + b * y + xoff y' = d * x + e * y + yoff

boundary_segments ()
  Create Boundaries from object boundary segments.

Example:
```python
>>> g = Grains.from_shp()
>>> b = g.boundaries()
>>> bs1 = g[10].boundary_segments()
>>> bs2 = b[10].boundary_segments()
```

`chaikin(**kwargs)`

Chaikin corner-cutting smoothing algorithm.

**Keywords:** repeat: Number of repetitions. Default 2

`contains(other)`

Returns True if the geometry contains the other, else False

`copy()`

`cov()`

*shape_method*: cov

Short and long axes are calculated from eigenvalue analysis of coordinate covariance matrix.

`crosses(other)`

Returns True if the geometries cross, else False

`difference(other)`

Returns the difference of the geometries

`disjoint(other)`

Returns True if geometries are disjoint, else False

`distance(other)`

Unitless distance to other geometry (float)

`dp(**kwargs)`

Douglas–Peucker simplification.

**Keywords:** tolerance: All points in the simplified object will be within the tolerance distance of the original geometry. Default Auto

`equals(other)`

Returns True if geometries are equal, else False

`equals_exact(other, tolerance)`

Returns True if geometries are equal to within a specified tolerance

`feret(angle=0)`

Returns the ferret diameter for given angle.

**Args:** angle: angle of caliper rotation

`intersection(other)`

Returns the intersection of the geometries

`intersects(other)`

Returns True if geometries intersect, else False

`maxferet()`

*shape_method*: maxferet

Long axis is defined as the maximum caliper of the polyline. Short axis correspond to caliper orthogonal to long axis. Center coordinates are set to centroid of polyline.

`overlaps(other)`

Returns True if geometries overlap, else False

`paror(angles=range(0, 180), normalized=True)`

Returns paror function values. When normalized maximum value is 1 and correspond to max feret.

**Args:** angles: iterable angle values. Default range(180) normalized: whether to normalize values. Default True
plot(**kwargs)
View Boundary geometry on figure.

proj(angle=0)
Returns the cumulative projection of object for given angle.

Args:
angle: angle of projection line

regularize(**kwargs)
Boundary vertices regularization.

Returns Boundary object defined by vertices regularly distributed along original Boundary.

Keywords:
N: Number of vertices. Default 128. length: approx. length of segments. Default None

relate(other)
Returns the DE-9IM intersection matrix for the two geometries (string)

rotate(angle, **kwargs)
Returns a rotated geometry on a 2D plane. The angle of rotation can be specified in either degrees (default) or radians by setting use_radians=True. Positive angles are counter-clockwise and negative are clockwise rotations. The point of origin can be a keyword ‘center’ for the object bounding box center (default), ‘centroid’ for the geometry’s centroid, or coordinate tuple (x0, y0) for fixed point.

scale(**kwargs)
Returns a scaled geometry, scaled by factors along each dimension. The point of origin can be a keyword ‘center’ for the object bounding box center (default), ‘centroid’ for the geometry’s centroid, or coordinate tuple (x0, y0) for fixed point. Negative scale factors will mirror or reflect coordinates.

show(**kwargs)
Show plot of Boundary objects.

skew(**kwargs)
Returns a skewed geometry, sheared by angles ‘xs’ along x and ‘ys’ along y direction. The shear angle can be specified in either degrees (default) or radians by setting use_radians=True. The point of origin can be a keyword ‘center’ for the object bounding box center (default), ‘centroid’ for the geometry’s centroid, or a coordinate tuple (x0, y0) for fixed point.

surfor(angles=range(0, 180), normalized=True)
Returns surfor function values. When normalized maximum value is 1 and correspond to max feret.

Args:
angles: iterable angle values. Default range(180) normalized: whether to normalize values. Default True

symmetric_difference(other)
Returns the symmetric difference of the geometries (Shapely geometry)

touches(other)
Returns True if geometries touch, else False

translate(**kwargs)
Returns a translated geometry shifted by offsets ‘xoff’ along x and ‘yoff’ along y direction.

union(other)
Returns the union of the geometries (Shapely geometry)

vw(**kwargs)
Visvalingam-Whyatt simplification.

The Visvalingam-Whyatt algorithm eliminates points based on their effective area. A points effective area is defined as the change in total area of the polygon by adding or removing that point.

Keywords:
threshold: Allowed total boundary length change in percents. Default 1

within(other)
Returns True if geometry is within the other, else False
ar
Returns axial ratio
Note that axial ratio is calculated from long and short axes calculated by actual shape method.

area
Area of the shape. For boundary returns 0.

bounds
Returns minimum bounding region (minx, miny, maxx, maxy)

centroid
Returns the geometric center of the object

hull
Returns array of vertices on convex hull of boundary geometry.

length
Unitless length of the geometry (float)

ma
Returns mean axis
Mean axis is calculated as square root of long axis multiplied by short axis. Both axes are calculated by actual shape method.

representative_point
Returns a cheaply computed point that is guaranteed to be within the object.

shape_method
Returns shape method in use

xy
Returns array of vertex coordinate pair.

class polylx.core.Grain(shape, name='None', fid=0)
Bases: polylx.core.PolyShape
Grain class to store polygonal grain geometry
A two-dimensional grain bounded by a linear ring with non-zero area. It may have one or more negative-space “holes” which are also bounded by linear rings.

Properties:
shape: shapely.geometry.polygon.Polygon object name: string with phase name. Default “None” fid: feature id. Default 0 shape_method: Method to calculate axes and orientation

__init__ (shape, name='None', fid=0)
Create Grain object

affine_transform (matrix)
Returns a transformed geometry using an affine transformation matrix. The matrix is provided as a list or tuple with 6 items: [a, b, d, e, xoff, yoff] which defines the equations for the transformed coordinates: x’ = a * x + b * y + xoff y’ = d * x + e * y + yoff

boundary_segments ()
Create Boundaries from object boundary segments.

Example:

```python
>>> g = Grains.from_shp()
>>> b = g.boundaries()
>>> bs1 = g[10].boundary_segments()
>>> bs2 = b[10].boundary_segments()
```

chaikin (**kwargs)
Chaikin corner-cutting smoothing algorithm.

Keywords: repeat: Number of repetitions. Default 2
contains (other)
Returns True if the geometry contains the other, else False

copy ()
cov ()
    shape_method: cov
    Short and long axes are calculated from eigenvalue analysis of coordinate covariance matrix. Center coordinates are set to centroid of exterior.
crosses (other)
Returns True if the geometries cross, else False
difference (other)
Returns the difference of the geometries
direct ()
    shape_method: direct
    Short, long axes and centre coordinates are calculated from direct least-square ellipse fitting. If direct fitting is not possible silently fallback to moment. Center coordinates are set to centre of fitted ellipse.
disjoint (other)
Returns True if geometries are disjoint, else False
distance (other)
Unitless distance to other geometry (float)
dp (**kwargs)
    Douglas–Peucker simplification.
    Keywords: tolerance: All points in the simplified object will be within the tolerance distance of the original geometry. Default Auto
equals (other)
Returns True if geometries are equal, else False
equals_exact (other, tolerance)
Returns True if geometries are equal to within a specified tolerance
feret (angle=0)
Returns the ferret diameter for given angle.
    Args: angle: angle of caliper rotation
classmethod from_coords (x, y, name=’None’, fid=0)
Create Grain from coordinate arrays
    Example:

    >>> g=Grain.from_coords([0,0,2,2],[0,1,1,0])
    >>> g.xy
    array([[ 0., 0., 2., 2., 0.],
           [ 0., 1., 1., 0., 0.]])

intersection (other)
Returns the intersection of the geometries
intersects (other)
Returns True if geometries intersect, else False
maee ()
    shape_method: maee
    Short and long axes are calculated from minimum volume enclosing ellipse. The solver is based on Khachiyan Algorithm, and the final solution is different from the optimal value by the pre-specified amount of tolerance of EAD/100. Center coordinates are set to centre of fitted ellipse.

1.1. core module
maxferet()
    shape_method: maxferet
    Long axis is defined as the maximum caliper of the polygon. Short axis correspond to caliper orthogonal to long axis. Center coordinates are set to centroid of exterior.

minbox()
    shape_method: minbox
    Short and long axes are calculated as width and height of smallest area enclosing box. Center coordinates are set to center of box.

minferet()
    shape_method: minferet
    Short axis is defined as the minimum caliper of the polygon. Long axis correspond to caliper orthogonal to short axis. Center coordinates are set to centroid of exterior.

moment()
    shape_method: moment
    Short and long axes are calculated from area moments of inertia. Center coordinates are set to centroid. If moment fitting failed silently fallback to maxferet. Center coordinates are set to centroid.

overlaps(other)
    Returns True if geometries overlap, else False

paror(angles=range(0, 180), normalized=True)
    Returns paror function values. When normalized maximum value is 1 and correspond to max feret.
    Args: angles: iterable angle values. Default range(180) normalized: whether to normalize values. Default True

plot(**kwargs)
    Plot Grain geometry on figure.
    Note that plotted ellipse reflects actual shape method

proj(angle=0)
    Returns the cumulative projection of object for given angle.
    Args: angle: angle of projection line

regularize(**kwargs)
    Grain vertices regularization.
    Returns Grain object defined by vertices regularly distributed along boundaries of original Grain.
    Keywords: N: Number of vertices. Default 128. length: approx. length of segments. Default None

relate(other)
    Returns the DE-9IM intersection matrix for the two geometries (string)

rotate(angle, **kwargs)
    Returns a rotated geometry on a 2D plane. The angle of rotation can be specified in either degrees (default) or radians by setting use_radians=True. Positive angles are counter-clockwise and negative are clockwise rotations. The point of origin can be a keyword ‘center’ for the object bounding box center (default), ‘centroid’ for the geometry’s centroid, or coordinate tuple (x0, y0) for fixed point.

scale(**kwargs)
    Returns a scaled geometry, scaled by factors along each dimension. The point of origin can be a keyword ‘center’ for the object bounding box center (default), ‘centroid’ for the geometry’s centroid, or coordinate tuple (x0, y0) for fixed point. Negative scale factors will mirror or reflect coordinates.

shape_vector(**kwargs)
    Returns shape (feature) vector.
    Shape (feature) vector is calculated from Fourier descriptors (FD) to index the shape. To achieve rotation invariance, phase information of the FDs are ignored and only the magnitudes \( |FDn| \) are used.
Scale invariance is achieved by dividing the magnitudes by the DC component, i.e., $|\text{FD}_0|$. Since centroid distance is a real value function, only half of the FDs are needed to index the shape.

**Keywords:**

- **N**: number of points to regularize shape. Default 128  
  Routine return $N/2$ of FDs

```
show(**kwargs)
Show plot of Grain objects.
```

```
skew(**kwargs)
Returns a skewed geometry, sheared by angles ‘xs’ along x and ‘ys’ along y direction. The shear angle can be specified in either degrees (default) or radians by setting use_radians=True. The point of origin can be a keyword ‘center’ for the object bounding box center (default), ‘centroid’ for the geometry’s centroid, or a coordinate tuple (x0, y0) for fixed point.
```

```
spline(**kwargs)
Spline based smoothing of grains.
```

```
surfor(angles=range(0, 180), normalized=True)
Returns surfor function values. When normalized maximum value is 1 and correspond to max feret.
```

```
symmetric_difference(other)
Returns the symmetric difference of the geometries (Shapely geometry)
```

```
touches(other)
Returns True if geometries touch, else False
```

```
translate(**kwargs)
Returns a translated geometry shifted by offsets ‘xoff’ along x and ‘yoff’ along y direction.
```

```
union(other)
Returns the union of the geometries (Shapely geometry)
```

```
vw(**kwargs)
Visvalingam-Whyatt simplification.
```

```
vw
Visvalingam-Whyatt algorithm eliminates points based on their effective area. A points effective area is defined as the change in total area of the polygon by adding or removing that point.
```

```
within(other)
Returns True if geometry is within the other, else False
```

```
ar
Returns axial ratio
```

```
area
Area of the shape. For boundary returns 0.
```

```
bounds
Returns minimum bounding region (minx, miny, maxx, maxy)
```

```
cdir
Returns centroid-vertex directions of grain exterior
```

```
cdist
Returns centroid-vertex distances of grain exterior
```

```
centroid
Returns the geometric center of the object
```

1.1. core module
ead
   Returns equal area diameter of grain

hull
   Returns array of vertices on convex hull of grain geometry.

interiors
   Returns list of arrays of vertex coordinate pair of interiors.

length
   Unitless length of the geometry (float)

ma
   Returns mean axis
   Mean axis is calculated as square root of long axis multiplied by short axis. Both axes are calculated by actual shape method.

nholes
   Returns number of holes (shape interiors)

representative_point
   Returns a cheaply computed point that is guaranteed to be within the object.

shape_method
   Returns shape method in use

xy
   Returns array of vertex coordinate pair.
   Note that only vertexes from exterior boundary are returned. For interiors use interiors property.

class polylx.core.Grains(shapes, classification=None)
   Bases: polylx.core.PolySet

Class to store set of Grains objects

   __init__ (shapes, classification=None)

affine_transform (matrix)
   Returns a transformed geometry using an affine transformation matrix. The matrix is provided as a list or tuple with 6 items: [a, b, d, e, xoff, yoff] which defines the equations for the transformed coordinates: x' = a * x + b * y + xoff y' = d * x + e * y + yoff

agg (*pairs)
   Returns concatenated result of multiple aggregations (different aggregation function for different attributes) based on actual classification. For single aggregation function use directly pandas groups, e.g. g.groups('lao', 'sao').agg(circular.mean)

Example:

>>> g.agg('area', np.sum, 'ead', np.mean, 'lao', circular.mean)

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<tr>
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<td>qtz</td>
<td>1.166097</td>
<td>0.068071</td>
<td>74.320337</td>
</tr>
</tbody>
</table>

barplot (val, **kwargs)
   Plot seaborn swarmplot.

bootstrap (num=100, size=None)
   Bootstrap random sample generator.

   Args: num: number of boostraped samples. Default 100 size: size of bootstraped samples. Default number of objects.

   Examples:
```python
>>> bsmean = np.mean([gs.ead.mean() for gs in g.bootstrap()])
```

**boundaries** *(T=None)*

Create Boundaries from Grains.

Example:

```python
>>> g = Grains.from_shp()
>>> b = g.boundaries()
```

**boundary_segments** ()

Create Boundaries from object boundary segments.

Example:

```python
>>> g = Grains.from_shp()
>>> b = g.boundary_segments()
```

**boxplot** *(val, **kwargs)*

Plot seaborn boxplot.

**class_iter** ()

**classify** (*args, **kwargs)*

Define classification of objects.

When no arguments are provided, default unique classification based on name attribute is used.

**Args:**

vals: name of attribute (str) used for classification or array of values

**Keywords:**
label: used as classification label when vals is array k: number of classes for continuous values

rule: type of classification

- ‘unique’: unique value mapping (for discrete values)
- ‘equal’: k equaly spaced bins (for continuos values)
- ‘user’: bins edges defined by array k (for continuos values)
- ‘natural’: natural breaks. Default rule.

(beware not always unique solution)

- ‘jenks’: fischer jenks scheme

cmap: matplotlib colormap. Default ‘viridis’

**Examples:**

```python
>>> g.classify('name', rule='unique')
>>> g.classify('ar', rule='jenks', k=5)
```

**clip** *(other)*

**clipstrap** *(num=100, f=0.3)*

Bootstrap random rectangular clip generator.

**Args:**
num: number of boostraped samples. Default 100 f: area fraction clipped from original shape. Default 0.3

**Examples:**

```python
>>> csmean = np.mean([gs.ead.mean() for gs in g.clipstrap()])
```

**countplot** (**kwargs)*

Plot seaborn countplot.

**df** (**attrs)*

Returns pandas.DataFrame of object attributes.
**Example:**

```python
g.df('ead', 'ar')
```

**feret** *(angle=0)*

Returns array of feret diameters for given angle.

**Args:**

- `angle`: Caliper angle. Default 0

**classmethod from_shp** *(filename='/home/docs/checkouts/readthedocs.org/user_builds/polylx/checkouts/develop/polylx/example/sg2.shp', phasefield='phase', phase='None')*

Create Grains from ESRI shapefile.

**Args:**

- `filename`: filename of shapefile. Default sg2.shp from examples
- `phasefield`: name of attribute in shapefile that holds names of grains or None. Default “phase”.
- `phase`: value used for grain phase when phasefield is None

**get** *(attr)*

Returns pandas.Series of object attribute.

**Example:**

```python
g.get('ead')
```

**get_class** *(key)*

**getindex** *(name)*

Return the indices of the objects with given name.

**gridsplit** *(m=1, n=1)*

Rectangular split generator.

**Args:**

- `m`, `n`: number of rows and columns to split.

**Examples:**

```python
>>> smean = np.mean([gs.ead.mean() for gs in g.gridsplit(6, 8)])
```

**groups** *(**attrs**)*

Returns pandas.GroupBy of object attributes.

Note that grouping is based on actual classification.

**Example:**

```python
>>> g.classify('ar', 'natural')
>>> g.groups('ead').mean()
```

```
<table>
<thead>
<tr>
<th>class</th>
<th>ead</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.01765-1.31807</td>
<td>0.067772</td>
</tr>
<tr>
<td>1.31807-1.5445</td>
<td>0.076042</td>
</tr>
<tr>
<td>1.5445-1.83304</td>
<td>0.065900</td>
</tr>
<tr>
<td>1.83304-2.36773</td>
<td>0.073338</td>
</tr>
<tr>
<td>2.36773-12.1571</td>
<td>0.084016</td>
</tr>
</tbody>
</table>
```

**nndist** *(**kwargs)***

Returns paror function values. When normalized maximum value is 1 and correspond to max feret.

**Args:**

- `angles`: iterable angle values. Default range(180)
- `normalized`: whether to normalize values. Default True

**paror** *(angles=range(0, 180), normalized=True)*

Returns paror function values. When normalized maximum value is 1 and correspond to max feret.

**Args:**

- `angles`: iterable angle values. Default range(180)
- `normalized`: whether to normalize values. Default True

**plot** *(**kwargs)***

Plot set of Grains or Boundaries objects.
**Keywords:** show: If True matplotlib show is called. Default True alpha: transparency. Default 0.8
pos: legend position “top”, “right” or “none”. Default “auto” ncol: number of columns for legend.
legend: Show legend. Default True show_fid: Show FID of objects. Default False show_index:
Show index of objects. Default False

When show=False, returns matplotlib axes object.

proj \((angle=0)\)

Returns array of cumulative projection of object for given angle. Args:
angle: angle of projection line

regularize (**kwargs)

rose (**kwargs)

Plot polar histogram of Grains or Boundaries orientations

**Keywords:** show: If True matplotlib show is called. Default True attr: property used for orientation.
Default ‘lao’ bins: number of bins weights: if provided histogram is weighted density: True for
probability density otherwise counts grid: True to show grid

When show=False, returns matplotlib axes object.

rotate \((angle, **kwargs)\)

Returns a rotated geometry on a 2D plane. The angle of rotation can be specified in either degrees
(default) or radians by setting use_radians=True. Positive angles are counter-clockwise and negative
are clockwise rotations. The point of origin can be a keyword ‘center’ for the object bounding box
center (default), ‘centroid’ for the geometry’s centroid, or coordinate tuple \((x0, y0)\) for fixed point.

savefig (**kwargs)

Save grains or boundaries plot to file.

Args: filename: file to save figure. Default “figure.png” dpi: DPI of image. Default 150 See plot for
other kwargs

scale (**kwargs)

Returns a scaled geometry, scaled by factors along each dimension. The point of origin can be a
keyword ‘center’ for the object bounding box center (default), ‘centroid’ for the geometry’s centroid,
or coordinate tuple \((x0, y0)\) for fixed point. Negative scale factors will mirror or reflect coordinates.

shape_vector (**kwargs)

Returns array of shape (feature) vectors.

**Keywords:**

\(N\): number of points to regularize shape. Default 128 Routine return \(N/2\) of FDs

simplify \(\text{method}='vw', **kwargs\) 

skew (**kwargs)

Returns a skewed geometry, sheared by angles ‘xs’ along x and ‘ys’ along y direction. The shear angle
can be specified in either degrees (default) or radians by setting use_radians=True. The point of origin
can be a keyword ‘center’ for the object bounding box center (default), ‘centroid’ for the geometry’s centroid,
or coordinate tuple \((x0, y0)\) for fixed point.

smooth \(\text{method}='chaikin', **kwargs\)

surfor \((\text{angles}=\text{range}(0, 180), \text{normalized}=\text{True})\)

Returns surfor function values. When normalized maximum value is 1 and correspond to max feret.

Args: angles: iterable angle values. Defaut range(180) normalized: whether to normalize values.
Default True

swarmplot \((\text{val}, **kwargs)\)

Plot seaborn swarmplot.

translate (**kwargs)

Returns a translated geometry shifted by offsets ‘xoff’ along x and ‘yoff’ along y direction.
ar
  Returns array of axial ratios
  Note that axial ratio is calculated from long and short axes calculated by actual shape method.

area
  Return array of areas of the objects. For boundary returns 0.

centroid
  Returns the 2D array of geometric centers of the objects

class_names

ead
  Returns array of equal area diameters of grains

extent
  Returns minimum bounding region (minx, miny, maxx, maxy) of all objects

fid
  Return array of fids of objects.

height
  Returns height of extent.

la
  Return array of long axes of objects according to shape_method.

lao
  Return array of long axes of objects according to shape_method

length
  Return array of lengths of the objects.

ma
  Returns mean axis
  Return array of mean axes calculated by actual shape method.

name
  Return list of names of the objects.
	names
  Returns list of unique object names.

nholes
  Returns array of number of holes (shape interiors)

representative_point
  Returns a 2D array of cheaply computed points that are guaranteed to be within the objects.

sa
  Return array of long axes of objects according to shape_method

sao
  Return array of long axes of objects according to shape_method

shape
  Return list of shapely objects.

shape_method
  Set or returns shape methods of all objects.

width
  Returns width of extent.

class polylx.core.PolySet (shapes, classification=None)
  Bases: object
  Base class to store set of Grains or Boundaries objects
Properties: polys: list of objects extent: tuple of (xmin, ymin, xmax, ymax)

__init__(shapes, classification=None)

affine_transform(matrix)
Returns a transformed geometry using an affine transformation matrix. The matrix is provided as a list or tuple with 6 items: [a, b, d, e, xoff, yoff] which defines the equations for the transformed coordinates: x’ = a * x + b * y + xoff y’ = d * x + e * y + yoff

tag(*pairs)
Returns concatenated result of multiple aggregations (different aggregation function for different attributes) based on actual classification. For single aggregation function use directly pandas groups, e.g. g.groups('lao', 'sao').agg(circular.mean)

Example:
```python
g.agg('area', np.sum, 'ead', np.mean, 'lao', circular.mean)
group
table
area ead lao
class
ksp 2.443733 0.089710 76.875488
pl 1.083516 0.060629 94.197847
qtz 1.166097 0.068071 74.320337
```

barplot(val, **kwargs)
Plot seaborn swarmplot.

bootstrap(num=100, size=None)
Bootstrap random sample generator.

Args:
num: number of bootstrapped samples. Default 100 size: size of bootstraped samples. Default number of objects.

Examples:
```python
>>> bsmean = np.mean([gs.ead.mean() for gs in g.bootstrap()])
```

boundary_segments()
Create Boundaries from object boundary segments.

Example:
```python
>>> g = Grains.from_shp()
>>> b = g.boundary_segments()
```

boxplot(val, **kwargs)
Plot seaborn boxplot.

class_iter()

classify(*args, **kwargs)
Define classification of objects.
When no aruments are provided, default unique classification based on name attribute is used.

Args:
vals: name of attribute (str) used for classification or array of values

Keywords:
label: used as classification label when vals is array k: number of classes for continuous values rule: type of classification

‘unique’: unique value mapping (for discrete values) ‘equal’: k equally spaced bins (for continuos values) ‘user’: bins edges defined by array k (for continuos values) ‘natural’: natural breaks. Default rule.

(beware not always unique solution)

‘jenks’: fischer jenks scheme

1.1. core module
cmap: matplotlib colormap. Default ‘viridis’

Examples:

```python
>>> g.classify('name', rule='unique')
>>> g.classify('ar', rule='jenks', k=5)
```

clip (other)

clipstrap (num=100, f=0.3)
Bootstrap random rectangular clip generator.

**Args:** num: number of boostraped samples. Default 100 f: area fraction clipped from original shape. Default 0.3

**Examples:**

```python
>>> csmean = np.mean([gs.ead.mean() for gs in g.clipstrap()])
```

countplot (**kwargs)
Plot seaborn countplot.

def (**attrs)
Returns pandas.DataFrame of object attributes.

**Example:**

```python
>>> g.df('ead', 'ar')
```

feret (angle=0)
Returns array of feret diameters for given angle.

**Args:** angle: Caliper angle. Default 0

get (attr)
Returns pandas.Series of object attribute.

**Example:**

```python
>>> g.get('ead')
```

get_class (key)

getindex (name)
Return the indices of the objects with given name.

gridsplit (m=1, n=1)
Rectangular split generator.

**Args:** m, n: number of rows and columns to split.

**Examples:**

```python
>>> smean = np.mean([gs.ead.mean() for gs in g.gridsplit(6, 8)])
```

groups (**attrs)
Returns pandas.GroupBy of object attributes.

Note that grouping is based on actual classification.

**Example:**

```python
>>> g.classify('ar', 'natural')
>>> g.groups('ead').mean()
```
nndist(**kwargs)

paror(angles=range(0, 180), normalized=True)

Returns paror function values. When normalized maximum value is 1 and correspond to max feret.

Args:
angles: iterable angle values. Default range(180) normalized: whether to normalize values.
Default True

plot(**kwargs)

Plot set of Grains or Boundaries objects.

Keywords:
show: If True matplotlib show is called. Default True alpha: transparency. Default 0.8
pos: legend position “top”, “right” or “none”. Default “auto” ncol: number of columns for legend.
legend: Show legend. Default True show_fid: Show FID of objects. Default False show_index:
Show index of objects. Default False

When show=False, returns matplotlib axes object.

proj(angle=0)

Returns array of cumulative projection of object for given angle. Args:
angle: angle of projection line

regularize(**kwargs)

rose(**kwargs)

Plot polar histogram of Grains or Boundaries orientations

Keywords:
show: If True matplotlib show is called. Default True attr: property used for orientation.
Default ‘lao’ bins: number of bins weights: if provided histogram is weighted density: True for
probability density otherwise counts grid: True to show grid

When show=False, returns matplotlib axes object.

rotate(angle, **kwargs)

Returns a rotated geometry on a 2D plane. The angle of rotation can be specified in either degrees
(default) or radians by setting use_radians=True. Positive angles are counter-clockwise and negative
are clockwise rotations. The point of origin can be a keyword ‘center’ for the object bounding box
center (default), ‘centroid’ for the geometry’s centroid, or coordinate tuple (x0, y0) for fixed point.

savefig(**kwargs)

Save grains or boudaries plot to file.

Args:
filename: file to save figure. Default “figure.png” dpi: DPI of image. Default 150 See plot for
other kwargs

scale(**kwargs)

Returns a scaled geometry, scaled by factors along each dimension. The point of origin can be a
keyword ‘center’ for the object bounding box center (default), ‘centroid’ for the geometry’s centroid,
or coordinate tuple (x0, y0) for fixed point. Negative scale factors will mirror or reflect coordinates.

simplify(method=’vw’, **kwargs)

skew(**kwargs)

Returns a skewed geometry, sheared by angles ‘xs’ along x and ‘ys’ along y direction. The shear angle
can be specified in either degrees (default) or radians by setting use_radians=True. The point of origin
can be a keyword ‘center’ for the object bounding box center (default), ‘centroid’ for the geometry’s
centroid, or a coordinate tuple (x0, y0) for fixed point.

smooth(method=’chaikin’, **kwargs)

surfor(angles=range(0, 180), normalized=True)

Returns surfor function values. When normalized maximum value is 1 and correspond to max feret.
Args: angles: iterable angle values. Default range(180) normalized: whether to normalize values. Default True

swarmplot(val, **kwargs)
Plot seaborn swarmplot.

translate(**kwargs)
Returns a translated geometry shifted by offsets ‘xoff’ along x and ‘yoff’ along y direction.

ar
Returns array of axial ratios
Note that axial ratio is calculated from long and short axes calculated by actual shape method.

area
Return array of areas of the objects. For boundary returns 0.

centroid
Returns the 2D array of geometric centers of the objects

class_names
extent
Returns minimum bounding region (minx, miny, maxx, maxy) of all objects

fid
Return array of fids of objects.

height
Returns height of extent.

la
Return array of long axes of objects according to shape_method.

lao
Return array of long axes of objects according to shape_method

length
Return array of lengths of the objects.

ma
Returns mean axis
Return array of mean axes calculated by actual shape method.

name
Return list of names of the objects.

names
Returns list of unique object names.

representative_point
Returns a 2D array of cheaply computed points that are guaranteed to be within the objects.

sa
Return array of long axes of objects according to shape_method

sao
Return array of long axes of objects according to shape_method

shape
Return list of shapely objects.

shape_method
Set or returns shape methods of all objects.

width
Returns width of extent.
class polylx.core.PolyShape(shape, name, fid)

Bases: object

Base class to store polygon or polyline

Properties:
shape: shapely.geometry object
name: name of polygon or polyline
fid: feature id

Note that all properties from shapely.geometry object are inherited.

__init__(shape, name, fid)

affine_transform(matrix)

Returns a transformed geometry using an affine transformation matrix. The matrix is provided as
a list or tuple with 6 items: [a, b, d, e, xoff, yoff] which defines the equations for the transformed
coordinates: x' = a * x + b * y + xoff y' = d * x + e * y + yoff

boundary_segments()

Create Boundaries from object boundary segments.

Example:

```
>>> g = Grains.from_shp()
>>> b = g.boundaries()
>>> bs1 = g[10].boundary_segments()
>>> bs2 = b[10].boundary_segments()
```

contains(other)

Returns True if the geometry contains the other, else False

crosses(other)

Returns True if the geometries cross, else False

difference(other)

Returns the difference of the geometries

disjoint(other)

Returns True if geometries are disjoint, else False

distance(other)

Unitless distance to other geometry (float)

dp(**kwargs)

Douglas–Peucker simplification.

Keywords:
tolerance: All points in the simplified object will be within the tolerance distance of the
original geometry. Default Auto

equals(other)

Returns True if geometries are equal, else False

equals_exact(other, tolerance)

Returns True if geometries are equal to within a specified tolerance

feret(angle=0)

Returns the ferret diameter for given angle.

Args:
angle: angle of caliper rotation

intersection(other)

Returns the intersection of the geometries

intersects(other)

Returns True if geometries intersect, else False

overlaps(other)

Returns True if geometries overlap, else False

paror(angles=range(0, 180), normalized=True)

Returns paror function values. When normalized maximum value is 1 and correspond to max feret.
**Args:** angles: iterable angle values. Default range(180) normalized: whether to normalize values. Default True

**proj** \[(angle=0)\]
Returns the cumulative projection of object for given angle.

**Args:** angle: angle of projection line

**relate** \[(other)\]
Returns the DE-9IM intersection matrix for the two geometries (string)

**rotate** \[(angle, **kwargs)\]
Returns a rotated geometry on a 2D plane. The angle of rotation can be specified in either degrees (default) or radians by setting use_radians=True. Positive angles are counter-clockwise and negative are clockwise rotations. The point of origin can be a keyword ‘center’ for the object bounding box center (default), ‘centroid’ for the geometry’s centroid, or coordinate tuple (x0, y0) for fixed point.

**scale** \[(**kwargs)\]
Returns a scaled geometry, scaled by factors along each dimension. The point of origin can be a keyword ‘center’ for the object bounding box center (default), ‘centroid’ for the geometry’s centroid, or coordinate tuple (x0, y0) for fixed point. Negative scale factors will mirror or reflect coordinates.

**skew** \[(**kwargs)\]
Returns a skewed geometry, sheared by angles ‘xs’ along x and ‘ys’ along y direction. The shear angle can be specified in either degrees (default) or radians by setting use_radians=True. The point of origin can be a keyword ‘center’ for the object bounding box center (default), ‘centroid’ for the geometry’s centroid, or a coordinate tuple (x0, y0) for fixed point.

**surfor** \[(angles=range(0, 180), normalized=True)\]
Returns surfor function values. When normalized maximum value is 1 and correspond to max feret.

**Args:** angles: iterable angle values. Default range(180) normalized: whether to normalize values. Default True

**symmetric_difference** \[(other)\]
Returns the symmetric difference of the geometries (Shapely geometry)

**touches** \[(other)\]
Returns True if geometries touch, else False

**translate** \[(**kwargs)\]
Returns a translated geometry shifted by offsets ‘xoff’ along x and ‘yoff’ along y direction.

**union** \[(other)\]
Returns the union of the geometries (Shapely geometry)

**within** \[(other)\]
Returns True if geometry is within the other, else False

**ar**
Returns axial ratio

Note that axial ratio is calculated from long and short axes calculated by actual shape method.

**area**
Area of the shape. For boundary returns 0.

**bounds**
Returns minimum bounding region (minx, miny, maxx, maxy)

**centroid**
Returns the geometric center of the object

**length**
Unitless length of the geometry (float)

**ma**
Returns mean axis
Mean axis is calculated as square root of long axis multiplied by short axis. Both axes are calculated by actual shape method.

**representative_point**
Returns a cheaply computed point that is guaranteed to be within the object.

**shape_method**
Returns shape method in use

```python
class polylx.core.Sample(name="")
```

**Properties:**
- **g:** Grains object
- **b:** Boundaries.objects
- **T:** networkx.Graph storing grain topology

```python
__init__(name="")
```

**bids** *(idx, name=None)*

**classmethod from_grains** *(grains, name="")*

**classmethod from_shp** *(filename="/home/docs/checkouts/readthedocs.org/user_builds/polylx/checkouts/develop/polylx/example/sg2.shp", phasefield='phase', name="")*

**neighbors** *(idx, name=None, inc=False)*
Returns array of indexes of neighbouring grains.
If name keyword is provided only neighbours with given name are returned.

**neighbors_dist** *(show=False, name=None)*
Return array of nearest neighbors distances.
If name keyword is provided only neighbours with given name are returned. When keyword show is True, plot is produced.

**plot** (**kwargs**)
Plot overlay of Grains and Boundaries of Sample object.

**Args:**
- **alpha:** Grains transparency. Default 0.8
- **pos:** legend position “top” or “right”. Defaul Auto
- **ncol:** number of columns for legend. **show_fid:** Show FID of objects. Default False
- **show_index:** Show index of objects. Default False

Returns matplotlib axes object.

**show** (**kwargs**)
Show plot of Sample objects.

**triplets**()

### 1.2 reports module


Created on Wed Feb 5 21:42:54 2014

@author: Ondrej Lexa

**Example:**
```python
from polylx import * from polylx.reports import Report
g = Grains.from_shp()
fig, ax = plt.subplots() x = np.linspace(-8,8,200) ax.plot(x,np.sin(x))
r = Report(‘Test report’) r.add_chapter(‘Things will start here’) r.savefig(fig, width=’75%’) r.table([[1,2,120],[2,6,213],[3,4,118]], title=’Table example’, header=[‘No’,’Val’,’Age’]) r.grainmap(g, width=’75%’) r.write_pdf()
```
class polylx.reports.Report(title='Report')
    Bases: object
    __init__(title='Report')
    add_chapter(title)
    add_section(title)
    add_subsection(title)
    dataframe(df, title='Table', header=None, format=None, stub_columns=None, widths=None)
    figure(filename, width=None, height=None)
    fin()
    matplotlib_fig(fig, width=None, height=None, bbox_inches='tight', dpi=150)
    pagebreak()
    plot(g, legend=None, loc='auto', alpha=0.8, dpi=150, width=None, height=None)
    table(rows, title='Table', header=None, format=None, stub_columns=None, widths=None)
    transition()
    write_pdf(file='report.pdf')
    write_rst(file='report.rst')
The microstructural analysis is a powerful, but underused tool of petrostructural analysis. Except acquirement of common statistical parameters, this technique can significantly improve understanding of processes of grain nucleation and grain growth, can bring insights on the role of surface energies or quantify duration of metamorphic and magmatic cooling events as long as appropriate thermodynamical data for studied mineral exist. This technique also allows systematic evaluation of degree of preferred orientations of grain boundaries in conjunction with their frequencies. This may help to better understand the mobility of grain boundaries and precipitations or removal of different mineral phases.

We introduce a new platform, object-oriented Python package PolyLX providing several core routines for data exchange, visualization and analysis of microstructural data, which can be run on any platform supported by Scientific Python environment.

## 2.1 Basic usage

To start working with PolyLX we need to import polylx package. For convinience, we will import polylx into actual namespace:

```python
>>> from polylx import *
```

To read example data, we can use `Grains.from_shp` method without arguments. Note that we create new `Grains` object, which store all imported features (polygons) from shapefile:

```python
>>> g = Grains.from_shp()
```

To visualize grain objects from shape file, we can use `show` method of `Grains` object:

```python
>>> g.show()
```
To show only ‘qtz’ phase, we can use fancy indexing:

```python
>>> g['qtz'].show()
```
Grains support dot notation to access individual properties. Note that most of properties are returned as numpy array:

```python
>>> g['qtz'].ar  # get axial ratios
array([ 1.46370088,  3.55371458,  1.43641139,  1.26293055,  2.10676277,
        1.45200805,  1.9873326 ,  1.97308557,  2.13420187,  1.76682269,
        1.7083897 ,  1.38205897,  1.88811465,  1.59948827,  2.50452919,
        1.60296389,  1.4918233 ,  2.15318719,  1.27665794,  1.38714959,
        1.67235338,  2.33179583,  1.30609967,  2.73148246,  1.02760669,
        1.33627299,  2.65451284,  1.29069569,  1.73051094,  1.25763409,
        1.90027316,  2.56110638,  1.78555385,  2.40926108,  2.25741705,
        1.71957235,  1.79168709,  1.04770164,  1.293186   ,  1.29420065,
        1.48331817,  2.15510614,  2.21246419,  1.57101091,  2.01989715,
        1.1428675 ,  2.02888455,  4.07405108,  1.47968881,  1.24770095,
        1.4750185 ,  1.37946472,  1.49048108,  1.56668345,  1.43715721,
        1.59756777,  1.58948843,  2.12557437,  2.54316052,  1.98917177,
        1.29809155,  1.70022052,  1.40121941,  1.24674038,  1.50255058,
        1.42880415,  1.73447054,  2.3548111 ,  1.52891827,  3.26773221,
        1.33011244,  2.26173396,  3.2151532 ,  2.15638456,  1.61026249,
        1.1389611 ,  2.91625233,  1.94275485,  2.68487563,  1.12446842,
        1.48814907,  1.79425743,  1.9512385 ,  1.28301942,  1.39853133,
        1.5980483 ,  3.80709622,  1.75016693,  1.59940152,  1.43972155,
        1.09439109,  2.00023212,  1.87470191,  1.04157011,  1.48561371,
        1.14172901,  1.48211332,  1.52569202,  1.59357336,  1.58054224,
        1.86890813,  1.84729576,  1.45085424,  1.4400654 ,  2.6284034 ,
        1.62077026,  1.35218688,  1.69040095,  1.2829313 ,  2.7308623 ,
        1.55901231,  1.72569674,  1.18396915,  1.67684681,  2.40971617,
        2.08496247,  2.12907657,  1.20981316,  1.46045276,  1.55428179,
        4.6980536 ,  2.32570855,  1.95106722,  1.81174297,  4.08295286,
        2.04530043,  1.56215221,  1.42587721,  1.70016792,  1.78878212,
        2.1723986 ,  2.47995119,  4.5960941 ,  3.43961286,  3.04193455,
        2.91162332,  2.98704073,  2.55352686,  1.33076709,  7.09385883,
        1.04157011,  1.48561371,  1.43972155,  1.48561371])
```
More convenient way to work with Grains attributes is collect any properties to pandas.DataFrame using `df` method:

```python
>>> g.df('la', 'sa', 'lao', 'area', 'length', 'ead', 'ar').head(10)
    la   sa  lao  area   length   ead   ar
 0  0.066027  0.045110  70.596636  0.002286  0.186196  0.053956  1.463701
 1  0.099033  0.057029  70.983857  0.004409  0.258753  0.074922  1.736522
 2  0.074248  0.020893  61.438248  0.001123  0.175821  0.037813  3.553715
 3  0.045232  0.031489  85.088587  0.001005  0.134427  0.037579  1.436411
 4  0.136445  0.108038  170.839835  0.011489  0.398558  0.120948  1.262931
 5  0.073578  0.044938  123.223347  0.002471  0.201258  0.056090  1.637319
 6  0.103567  0.065119  149.397514  0.005213  0.283110  0.081474  1.323142
 7  0.187049  0.036611  23.758847  0.005951  0.318774  0.087048  1.323142
 8  0.270513  0.128402  76.193288  0.024576  0.729051  0.176894  2.106763
```

Once you have pandas.DataFrame, check pandas manual to what you can do. Here is few examples:

```python
>>> g.df('ead').describe()
      ead
count 701.000000
mean  0.072812
std   0.056812
min   0.000350
25%   0.037140
50%   0.058338
75%   0.093503
max   0.638144
```

agg method aggregate properties according to defined classification (name by default):

```python
>>> g.agg('area','sum', 'ead', 'mean', 'name', 'count')
       area  ead
name_class
ksp  2.443733  0.089710  254
pl   1.083516  0.060629  292
qtz  1.166097  0.068071  155
```

The groups method return pandas.GroupBy object which allows any pandas-style manipulation:

```python
>>> g.groups('ead', 'area', 'la', 'sa').describe().T
      ead  area
name_class count  2.540000e+02  292.000000  1.550000e+02
mean  9.620995e-03  0.003711  7.523208e-03
std   1.548182e-02  0.004170  2.778736e-02
min   3.464873e-07  0.000003  9.629176e-08
25%   1.341681e-03  0.001148  6.930225e-04
50%   7.403298e-02  0.053984  4.794577e-02
75%   1.191733e-01  0.077308  7.892656e-02
max   1.323812e-01  0.087071  3.198359e-01
```
The `classify` method could be used to define new classification, based on any property and using variety of methods:

```python
>>> g.classify('ead', k=6)
>>> df = g.df('class', 'name', 'area')
>>> df.head()

<table>
<thead>
<tr>
<th>fid</th>
<th>ead_class</th>
<th>name</th>
<th>area</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0.048-0.066</td>
<td>qtz</td>
<td>0.002286</td>
</tr>
<tr>
<td>1</td>
<td>0.066-0.091</td>
<td>pl</td>
<td>0.004409</td>
</tr>
<tr>
<td>2</td>
<td>0.030-0.048</td>
<td>qtz</td>
<td>0.001123</td>
</tr>
<tr>
<td>3</td>
<td>0.030-0.048</td>
<td>qtz</td>
<td>0.001005</td>
</tr>
<tr>
<td>4</td>
<td>0.091-0.141</td>
<td>qtz</td>
<td>0.011489</td>
</tr>
</tbody>
</table>
```

To summarize results for individual phases per class we can use `pandas.pivot_table`:

```python
>>> pd.pivot_table(df,index=['ead_class'], columns=['name'], aggfunc=np.sum)

<table>
<thead>
<tr>
<th>area</th>
<th>name</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ksp</td>
</tr>
<tr>
<td>ead_class</td>
<td></td>
</tr>
<tr>
<td>0.000-0.030</td>
<td>0.017510</td>
</tr>
<tr>
<td>0.030-0.048</td>
<td>0.035587</td>
</tr>
<tr>
<td>0.048-0.066</td>
<td>0.077185</td>
</tr>
<tr>
<td>0.066-0.091</td>
<td>0.214921</td>
</tr>
<tr>
<td>0.091-0.141</td>
<td>0.612776</td>
</tr>
<tr>
<td>0.141-0.638</td>
<td>0.485754</td>
</tr>
</tbody>
</table>
```

or we can directly plot it:

```python
>>> pd.pivot_table(df,index=['ead_class'], columns=['name'], aggfunc=np.sum).plot(kind='bar')
```
2.2 Work with boundaries

The Boundaries object could be created from grains with correct topology (use OpenJUMP, QGIS or ArcGIS to validate grain shapefile topology):

```python
>>> b = g.boundaries()
>>> b.show()
```
Most of methods and properties demonstrated for Grains are valid also for boundaries:

```python
>>> b.agg('sum', 'length')

<table>
<thead>
<tr>
<th>name_class</th>
<th>length</th>
</tr>
</thead>
<tbody>
<tr>
<td>ksp-ksp</td>
<td>23.383974</td>
</tr>
<tr>
<td>ksp-pl</td>
<td>38.592227</td>
</tr>
<tr>
<td>ksp-qtz</td>
<td>17.920424</td>
</tr>
<tr>
<td>pl-pl</td>
<td>11.302490</td>
</tr>
<tr>
<td>pl-qtz</td>
<td>11.535006</td>
</tr>
<tr>
<td>qtz-qtz</td>
<td>6.617133</td>
</tr>
</tbody>
</table>
```
CHAPTER 3

Installation

At the command line:

$ easy_install polylx

Or, if you have virtualenvwrapper installed:

$ mkvirtualenv polylx
$ pip install polylx

With conda you can install from personal channel:

$ conda install -c ondrolexa polylx
CHAPTER 4

Usage

To use PolyLX in a project:

```
import polylx
```
Contributions are welcome, and they are greatly appreciated! Every little bit helps, and credit will always be given.

You can contribute in many ways:

## 5.1 Types of Contributions

### 5.1.1 Report Bugs


If you are reporting a bug, please include:
- Your operating system name and version.
- Any details about your local setup that might be helpful in troubleshooting.
- Detailed steps to reproduce the bug.

### 5.1.2 Fix Bugs

Look through the GitHub issues for bugs. Anything tagged with “bug” is open to whoever wants to implement it.

### 5.1.3 Implement Features

Look through the GitHub issues for features. Anything tagged with “feature” is open to whoever wants to implement it.

### 5.1.4 Write Documentation

PolyLX could always use more documentation, whether as part of the official PolyLX docs, in docstrings, or even on the web in blog posts, articles, and such.
5.1.5 Submit Feedback

The best way to send feedback is to file an issue at https://github.com/ondrolexa/polylx/issues.

If you are proposing a feature:

- Explain in detail how it would work.
- Keep the scope as narrow as possible, to make it easier to implement.
- Remember that this is a volunteer-driven project, and that contributions are welcome :)

5.2 Get Started!

Ready to contribute? Here’s how to set up polylx for local development.

1. Fork the polylx repo on GitHub.
2. Clone your fork locally:
   
   ```
   $ git clone git@github.com:your_name_here/polylx.git
   ```

3. Install your local copy into a virtualenv. Assuming you have virtualenvwrapper installed, this is how you set up your fork for local development:

   ```
   $ mkvirtualenv polylx
   $ cd polylx/
   $ python setup.py develop
   ```

4. Create a branch for local development:

   ```
   $ git checkout -b name-of-your-bugfix-or-feature
   ```

   Now you can make your changes locally.

5. When you’re done making changes, check that your changes pass flake8 and the tests, including testing other Python versions with tox:

   ```
   $ flake8 polylx tests
   $ python setup.py test
   $ tox
   ```

   To get flake8 and tox, just pip install them into your virtualenv.

6. Commit your changes and push your branch to GitHub:

   ```
   $ git add .
   $ git commit -m "Your detailed description of your changes."
   $ git push origin name-of-your-bugfix-or-feature
   ```

7. Submit a pull request through the GitHub website.

5.3 Pull Request Guidelines

Before you submit a pull request, check that it meets these guidelines:

1. The pull request should include tests.
2. If the pull request adds functionality, the docs should be updated. Put your new functionality into a function with a docstring, and add the feature to the list in README.rst.
3. The pull request should work for Python 2.6, 2.7, 3.3, and 3.4, and for PyPy. Check https://travis-ci.org/ondrolexa/polylx/pull_requests and make sure that the tests pass for all supported Python versions.

5.4 Tips

To run a subset of tests:

```
$ python -m unittest tests.test_polylx
```
6.1 Development Lead

- Ondrej Lexa <lexa.ondrej@gmail.com>

6.2 Contributors

None yet. Why not be the first?
7.1 0.1 (13 Feb 2015)

• First release

7.2 0.2 (18 Apr 2015)

• Smooth and simplify methods for Grains implemented
• Initial documentation added
• *phase* and *type* properties renamed to *name*

7.3 0.3 (22 Feb 2016)

7.3.1 0.3.1 (22 Feb 2016)

• classification is persistent through fancy indexing
• empty classes allowed
• bootstrap method added to PolySet

7.3.2 0.3.2 (04 Jun 2016)

• PolyShape name forced to be string
• Creation of boundaries is Grains method

7.4 0.4 (20 Jun 2016)

• Sample neighbors_dist method to calculate neighbors distances
• Grains and Boundaries nndist to calculate nearest neighbors distances
• Fancy indexing with slices fixed
• Affine transformations affine_transform, rotate, scale, skew, translate methods implemented for Grains and Boundaries
• Sample name attribute added
• Sample bids method to get boundary id’s related to grain added

7.4.1 0.4.1 (20 Jun 2016)
• Examples added to distribution

7.4.2 0.4.2 (02 Sep 2016)
• Sample has pairs property(dictionary) to map boundary id to grains id
• Sample triplets method returns list of grains id creating triple points

7.4.3 0.4.3 (02 Sep 2016)
• IPython added to requirements

7.4.4 0.4.4 (12 Jan 2017)
• Added MAEE (minimum area enclosing ellipse) to grain shape methods
• Removed embedded IPython and IPython requirements

7.4.5 0.4.5 (12 Jan 2017)
• shell script ipolylx opens interactive console

7.4.6 0.4.6 (04 Mar 2017)
• added plots module (initial)
• representative_point for Grains implemented
• moments calculation including holes
• surfor and parror functions added
• orientation of polygons is unified and checked
• minbox shape method added

7.4.7 0.4.8 (04 Mar 2017)
• bugfix
7.4.8 0.4.9 (12 Dec 2017)

- `getindex` method of Grains and Boundaries implemented
- Grain `cdist` property return centroid-vertex distance function
- Grain `cdir` property return centroid-vertex direction function
- Grain `shape_vector` property returns normalized Fourier descriptors
- Grain `regularize` method returns Grain with regularly distributed vertices
- Classification could be based on properties or any other values
- `boundary_segments` method added
- Smoothing, simplification and regularization of boundaries implemented
- Colortable for legend is persistent through indexing. `Classify` method could be used to change it
- Default color table is seaborn muted for unique classification and matplotlib `viridis` for continuous classes

7.5 0.5 (XX YYY 2017)

- rose plot grouped according to classification
- `get_class`, `class_iter` methods added to Grains and Boundaries
- seaborn added to requirements
- several seaborn categorical plots are added as methods (swarmplot, boxplot, barplot, countplot)
Symbols

__init__ (polylx.core.Boundaries method), 3
__init__ (polylx.core.Boundary method), 7
__init__ (polylx.core.Grain method), 10
__init__ (polylx.core.Grains method), 14
__init__ (polylx.core.PolyShape method), 23
__init__ (polylx.core.Sample method), 25
__init__ (polylx.reports.Report method), 26

A
add_chapter() (polylx.reports.Report method), 26
add_section() (polylx.reports.Report method), 26
add_subsection() (polylx.reports.Report method), 26
affine_transform() (polylx.core.Boundaries method), 3
affine_transform() (polylx.core.Boundary method), 7
affine_transform() (polylx.core.Grain method), 10
affine_transform() (polylx.core.Grains method), 14
affine_transform() (polylx.core.PolyShape method), 23
agg() (polylx.core.Boundaries method), 3
agg() (polylx.core.Grains method), 14
agg() (polylx.core.PolySet method), 19
ar (polylx.core.Boundaries attribute), 6
ar (polylx.core.Boundary attribute), 10
ar (polylx.core.Grain attribute), 13
ar (polylx.core.Grains attribute), 17
ar (polylx.core.PolySet attribute), 22
ar (polylx.core.PolyShape attribute), 24
area (polylx.core.Boundaries attribute), 6
area (polylx.core.Boundary attribute), 10
area (polylx.core.Grain attribute), 13
area (polylx.core.Grains attribute), 18
area (polylx.core.PolySet attribute), 22
area (polylx.core.PolyShape attribute), 24

B
barplot() (polylx.core.Boundaries method), 3
barplot() (polylx.core.Grains method), 14
barplot() (polylx.core.PolySet method), 19
bids() (polylx.core.Sample method), 25
bootstrap() (polylx.core.Boundaries method), 4
bootstrap() (polylx.core.Grains method), 14
bootstrap() (polylx.core.PolySet method), 19
Boundaries (class in polylx.core), 3
boundaries() (polylx.core.Grains method), 15
Boundary (class in polylx.core), 7
boundary_segments() (polylx.core.Boundaries method), 4
boundary_segments() (polylx.core.Boundary method), 7
boundary_segments() (polylx.core.Grains method), 10
boundary_segments() (polylx.core.PolySet method), 19
boundary_segments() (polylx.core.PolyShape method), 23
bounds (polylx.core.Boundary attribute), 10
bounds (polylx.core.Grains attribute), 13
bounds (polylx.core.PolyShape attribute), 19
boxplot() (polylx.core.Boundaries method), 4
boxplot() (polylx.core.Grains method), 15
boxplot() (polylx.core.PolySet method), 19

C
cdir (polylx.core.Grain attribute), 13
cdist (polylx.core.Grain attribute), 13
centroid (polylx.core.Boundaries attribute), 6
centroid (polylx.core.Boundary attribute), 10
centroid (polylx.core.Grains attribute), 13
classify() (polylx.core.Boundaries method), 4
classify() (polylx.core.Grains method), 15
classify() (polylx.core.PolySet method), 19
class_iter() (polylx.core.Boundaries method), 4
class_iter() (polylx.core.Grains method), 15
class_iter() (polylx.core.PolySet method), 19
class_names (polylx.core.Boundaries attribute), 6
class_names (polylx.core.Grains attribute), 18
class_names (polylx.core.PolySet attribute), 22
classify() (polylx.core.Boundaries method), 4
classify() (polylx.core.Grains method), 15
classify() (polylx.core.PolySet method), 19
clip() (polylx.core.Boundaries method), 4
clip() (polylx.core.Grains method), 15
clip() (polylx.core.PolySet method), 20
clipstrap() (polylx.core.Boundaries method), 4
clipstrap() (polylx.core.Grains method), 15
clipstrap() (polylx.core.PolySet method), 20
contains() (polylx.core.Boundary method), 8
contains() (polylx.core.Grain method), 10
contains() (polylx.core.PolyShape method), 23
copy() (polylx.core.Boundary method), 8
copy() (polylx.core.Grain method), 11
countplot() (polylx.core.Boundaries method), 4
countplot() (polylx.core.Boundary method), 15
countplot() (polylx.core.PolySet method), 20
cov() (polylx.core.Boundary method), 8
cov() (polylx.core.Grain method), 11
crosses() (polylx.core.Boundary method), 8
crosses() (polylx.core.Grain method), 11
crosses() (polylx.core.PolyShape method), 23
dataframe() (polylx.reports.Report method), 26
df() (polylx.core.Boundaries method), 4
df() (polylx.core.Grains method), 16
df() (polylx.core.PolySet method), 20
difference() (polylx.core.Boundary method), 8
difference() (polylx.core.Grain method), 11
difference() (polylx.core.PolyShape method), 23
direct() (polylx.core.Grain method), 11
disjoint() (polylx.core.Boundary method), 8
disjoint() (polylx.core.Grain method), 11
disjoint() (polylx.core.PolyShape method), 23
distance() (polylx.core.Boundary method), 8
distance() (polylx.core.Grain method), 11
distance() (polylx.core.PolyShape method), 23
dp() (polylx.core.Boundary method), 8
dp() (polylx.core.Grain method), 11
dp() (polylx.core.PolyShape method), 23
ead (polylx.core.Grain attribute), 13
ead (polylx.core.Grains attribute), 18
equals() (polylx.core.Boundary method), 8
equals() (polylx.core.Grain method), 11
equals() (polylx.core.PolyShape method), 23
equals_exact() (polylx.core.Boundary method), 8
equals_exact() (polylx.core.Grain method), 11
equals_exact() (polylx.core.PolyShape method), 23
extent (polylx.core.Boundaries attribute), 6
extent (polylx.core.Grains attribute), 18
extent (polylx.core.PolySet attribute), 22
feret() (polylx.core.Boundaries method), 5
feret() (polylx.core.Boundary method), 8
feret() (polylx.core.Grain method), 11
feret() (polylx.core.Grains method), 16
feret() (polylx.core.PolySet method), 20
fid (polylx.core.Boundaries attribute), 7
fid (polylx.core.Grain attribute), 18
fid (polylx.core.Grains attribute), 18
fid (polylx.core.PolySet attribute), 22
figure() (polylx.reports.Report method), 26
finish() (polylx.reports.Report method), 26
from_coords() (polylx.core.Grain class method), 11
from_grains() (polylx.core.Sample class method), 25
from_shp() (polylx.core.Grains class method), 16
from_shp() (polylx.core.Sample class method), 25
Grain (class in polylx.core), 10
Grains (class in polylx.core), 14
gridsplit() (polylx.core.Boundaries method), 5
gridsplit() (polylx.core.Grains method), 16
gridsplit() (polylx.core.PolySet method), 20
groups() (polylx.core.Boundaries method), 5
groups() (polylx.core.Grains method), 16
groups() (polylx.core.PolySet method), 20
height (polylx.core.Boundaries attribute), 7
height (polylx.core.Grains attribute), 18
height (polylx.core.PolySet attribute), 22
hull (polylx.core.Boundary attribute), 10
hull (polylx.core.Grains attribute), 14
interiors (polylx.core.Grain attribute), 14
intersection() (polylx.core.Boundary method), 8
intersection() (polylx.core.Grain method), 11
intersection() (polylx.core.PolyShape method), 23
intersects() (polylx.core.Boundary method), 8
intersects() (polylx.core.Grain method), 11
intersects() (polylx.core.PolyShape method), 23
la (polylx.core.Boundaries attribute), 7
la (polylx.core.Grains attribute), 18
la (polylx.core.PolySet attribute), 22
lao (polylx.core.Boundaries attribute), 7
lao (polylx.core.Grains attribute), 18
lao (polylx.core.PolySet attribute), 22
length (polylx.core.Boundaries attribute), 7
length (polylx.core.Boundary attribute), 10
length (polylx.core.Grain attribute), 14
length (polylx.core.Grains attribute), 18
length (polylx.core.PolySet attribute), 22
length (polylx.core.PolyShape attribute), 24
ma (polylx.core.Boundaries attribute), 7
ma (polylx.core.Boundary attribute), 10
ma (polylx.core.Grain attribute), 14
ma (polylx.core.Grains attribute), 18
ma (polylx.core.PolySet attribute), 22
ma (polylx.core.PolyShape attribute), 24
maee() (polylx.core.Grain method), 11
maxferet() (polylx.core.Boundary method), 8
maxferet() (polylx.core.Grain method), 11
minbox() (polylx.core.Grain method), 12
minferet() (polylx.core.Grain method), 12
moment() (polylx.core.Grain method), 12
name (polylx.core.Boundaries attribute), 7
name (polylx.core.Grains attribute), 18
name (polylx.core.PolySet attribute), 22
names (polylx.core.Boundaries attribute), 7
names (polylx.core.Grains attribute), 18
names (polylx.core.PolySet attribute), 22
neighbors() (polylx.core.Sample method), 25
neighbors_dist() (polylx.core.Boundaries method), 5
neighbors_dist() (polylx.core.Boundary method), 9
neighbors_dist() (polylx.core.Grain method), 12
neighbors_dist() (polylx.core.Grains method), 17
neighbors_dist() (polylx.core.PolySet method), 21
neighbors_dist() (polylx.core.PolyShape method), 24
nholes (polylx.core.Boundary method), 9
nholes (polylx.core.Grain method), 12
nholes (polylx.core.Grains method), 17
nholes (polylx.core.PolySet method), 21
nholes (polylx.core.PolyShape method), 24
nndist() (polylx.core.Boundaries method), 5
nndist() (polylx.core.Boundary method), 9
nndist() (polylx.core.Grain method), 12
nndist() (polylx.core.Grains method), 17
nndist() (polylx.core.PolySet method), 21
nndist() (polylx.core.PolyShape method), 24
overlaps() (polylx.core.Boundary method), 8
overlaps() (polylx.core.Grain method), 12
overlaps() (polylx.core.PolyShape method), 23
pagebreak() (polylx.reports.Report method), 26
paror() (polylx.core.Boundaries method), 5
paror() (polylx.core.Boundary method), 8
paror() (polylx.core.Grains method), 12
paror() (polylx.core.PolySet method), 21
paror() (polylx.core.PolyShape method), 24
plot() (polylx.core.Boundaries method), 5
plot() (polylx.core.Boundary method), 9
plot() (polylx.core.Grains method), 12
plot() (polylx.core.Grain method), 15
plot() (polylx.core.PolySet method), 21
plot() (polylx.core.PolyShape method), 24
polylx.core (module), 3
polylx.reports (module), 25
PolySet (class in polylx.core), 18
PolylxShape (class in polylx.core), 22
proj() (polylx.core.Boundaries method), 5
proj() (polylx.core.Boundary method), 9
proj() (polylx.core.Grains method), 17
proj() (polylx.core.PolySet method), 21
proj() (polylx.core.PolyShape method), 24
regularize() (polylx.core.Boundaries method), 6
regularize() (polylx.core.Boundary method), 9
regularize() (polylx.core.Grains method), 12
regularize() (polylx.core.PolySet method), 21
relate() (polylx.core.Boundary method), 9
relate() (polylx.core.Grains method), 12
relate() (polylx.core.PolyShape method), 24
Report (class in polylx.reports), 26
representative_point (polylx.core.Boundaries attribute), 7
representative_point (polylx.core.Boundary attribute), 10
representative_point (polylx.core.Grain attribute), 14
representative_point (polylx.core.Grains attribute), 18
representative_point (polylx.core.PolySet attribute), 22
representative_point (polylx.core.PolyShape attribute), 25
rose() (polylx.core.Boundaries method), 6
rose() (polylx.core.Grains method), 17
rose() (polylx.core.PolySet method), 21
rotate() (polylx.core.Boundaries method), 6
rotate() (polylx.core.Boundary method), 9
rotate() (polylx.core.Grains method), 12
rotate() (polylx.core.Grains method), 17
rotate() (polylx.core.PolySet method), 21
rotate() (polylx.core.PolyShape method), 24
sa (polylx.core.Boundaries attribute), 7
sa (polylx.core.Grains attribute), 18
sa (polylx.core.PolySet attribute), 22
Sample (class in polylx.core), 25
sao (polylx.core.Boundaries attribute), 7
sao (polylx.core.Grains attribute), 18
sao (polylx.core.PolySet attribute), 22
scale() (polylx.core.Boundaries method), 5
scale() (polylx.core.Boundary method), 9
scale() (polylx.core.Grains method), 12
scale() (polylx.core.Grain method), 15
scale() (polylx.core.PolySet method), 21
scale() (polylx.core.PolyShape method), 24
shape (polylx.core.Boundaries attribute), 7
shape (polylx.core.Grains attribute), 18
shape (polylx.core.PolySet attribute), 22
shape (polylx.core.PolyShape attribute), 24
shape_method (polylx.core.Boundaries attribute), 7
shape_method (polylx.core.Boundary attribute), 10
shape_method (polylx.core.Grains attribute), 14
shape_method (polylx.core.Grain attribute), 17
shape_method (polylx.core.PolySet attribute), 22
shape_method (polylx.core.PolyShape attribute), 25
shape_vector() (polylx.core.Grain method), 12
shape_vector() (polylx.core.Grains method), 17
show() (polylx.core.Boundary method), 9