K-Means, PCA, and Dendrogram on the Animals with Attributes Dataset

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About the dataset: This is a small dataset that has information on about 50 animals. The animals are listed in classes.txt. For each animal, the information consists of values for 85 features: does the animal have a tail, is it slow, does it have tusks, etc. The details of the features are in the predicates.txt. The full data consists of a 50 x 85 matrix of real values, in predicate-matrix-continuous.txt. There is also a binarized version of this data, in predicate-matrix-binary.txt.

In [1]:
```
%matplotlib inline
import pandas as pd
import matplotlib.pyplot as plt
import numpy as np
from scipy.cluster.hierarchy import dendrogram, linkage
from sklearn.cluster import KMeans
from sklearn import metrics
from sklearn.decomposition import PCA
from sklearn.preprocessing import scale
from pylab import rcParams
```

Minor Bash Scripting

In [3]:
```
!wget -O data.tar.bz2 http://attributes.kyb.tuebingen.mpg.de/AwA-base.tar.bz2

# -C changes to the specified directory before unpacking (or packing).
# --strip-components removes the specified number of directories from the filenames stored in t

!mkdir data && tar xf data.tar.bz2 -C data --strip-components 1

# Looking at various text files and removing old zipped file
!ls data && rm data.tar.bz2
```

```
--2016-03-28 03:19:57--  http://attributes.kyb.tuebingen.mpg.de/AwA-base.tar.bz2
Resolving attributes.kyb.tuebingen.mpg.de (attributes.kyb.tuebingen.mpg.de)... 192.124.27.50
Connecting to attributes.kyb.tuebingen.mpg.de (attributes.kyb.tuebingen.mpg.de)|192.124.27.50|:80... co
HTTP request sent, awaiting response... 200 OK
Length: 1062822 (1.0M) [application/x-bzip2]
Saving to: 'data.tar.bz2'

data.tar.bz2        100%[=====================>]   1.01M   316KB/s   in 3.3s

2016-03-28 03:20:02 (316 KB/s) - 'data.tar.bz2' saved [1062822/1062822]

Features                        predicate-matrix-continuous.txt
```

```
README-attributes.txt          predicate-matrix.png
classes.txt                    predicates.txt
lampert-cvpr2009.pdf           testclasses.txt
predicate-matrix-binary.txt    trainclasses.txt
```

Loading the real-valued array, and also the animal names into Python.

```
In [65]: samples_features = pd.read_fwf("data/predicate-matrix-continuous.txt", header=None).values
         print samples_features.shape
         # 50 is the number of samples n (number of animals)
         # 85 is the number of features m (number of features)
```

```
(50, 85)
```

```
In [66]: classes=pd.read_fwf("data/classes.txt", header=None)[1].values
         classes
```

```
Out[66]: array(['antelope', 'grizzly+bear', 'killer+whale', 'beaver', 'dalmatian',
                'persian+cat', 'horse', 'german+shepherd', 'blue+whale',
                'siamese+cat', 'skunk', 'mole', 'tiger', 'hippopotamus', 'leopard',
                'moose', 'spider+monkey', 'humpback+whale', 'elephant', 'gorilla',
                'ox', 'fox', 'sheep', 'seal', 'chimpanzee', 'hamster', 'squirrel',
                'rhinoceros', 'rabbit', 'bat', 'giraffe', 'wolf', 'chihuahua',
                'rat', 'weasel', 'otter', 'buffalo', 'zebra', 'giant+panda', 'deer',
                'bobcat', 'pig', 'lion', 'mouse', 'polar+bear', 'collie', 'walrus',
                'raccoon', 'cow', 'dolphin'], dtype=object)
```

In order to make the real_value array data (samples_features) clearer, I put it into a pandas dataframe. Please notice how all the animals differ from each other. For example, notice how the dalmation has the column spots at 100 and the other dogs have values around 10.

```
In [67]: feature_names=pd.read_fwf("data/predicates.txt", header=None)[1].values
         classes_features = pd.DataFrame(data = samples_features, columns = feature_names)
         classes_features.index = classes
         classes_features.loc[['german+shepherd', 'collie', 'dalmatian']]
         #classes_features
```

```
Out[67]:                  black  white  blue  brown   gray  orange  red  yellow  \
         german+shepherd  43.54  15.88     5  54.16  26.82    3.12  2.5    0.38
         collie           10.13  41.37     0  47.27   3.75    8.00  0.5    0.00
         dalmatian        69.58  73.33     0   6.39   0.00    0.00  0.0    0.00

                          patches   spots    ...     water  tree  cave  fierce  timid  \
         german+shepherd    48.78   11.59    ...      3.75  0.00   2.5   57.44  10.00
         collie             37.00    9.09    ...      0.00  0.00   0.0    5.25  43.09
         dalmatian          37.08  100.00    ...      1.25  6.25   0.0    9.38  31.67

                          smart  group  solitary  nestspot  domestic
         german+shepherd  57.53  12.50     35.11     16.53     68.55
         collie           42.17   0.62     45.99     18.57     79.11
         dalmatian        53.26  24.44     29.38     11.25     72.71

         [3 rows x 85 columns]
```

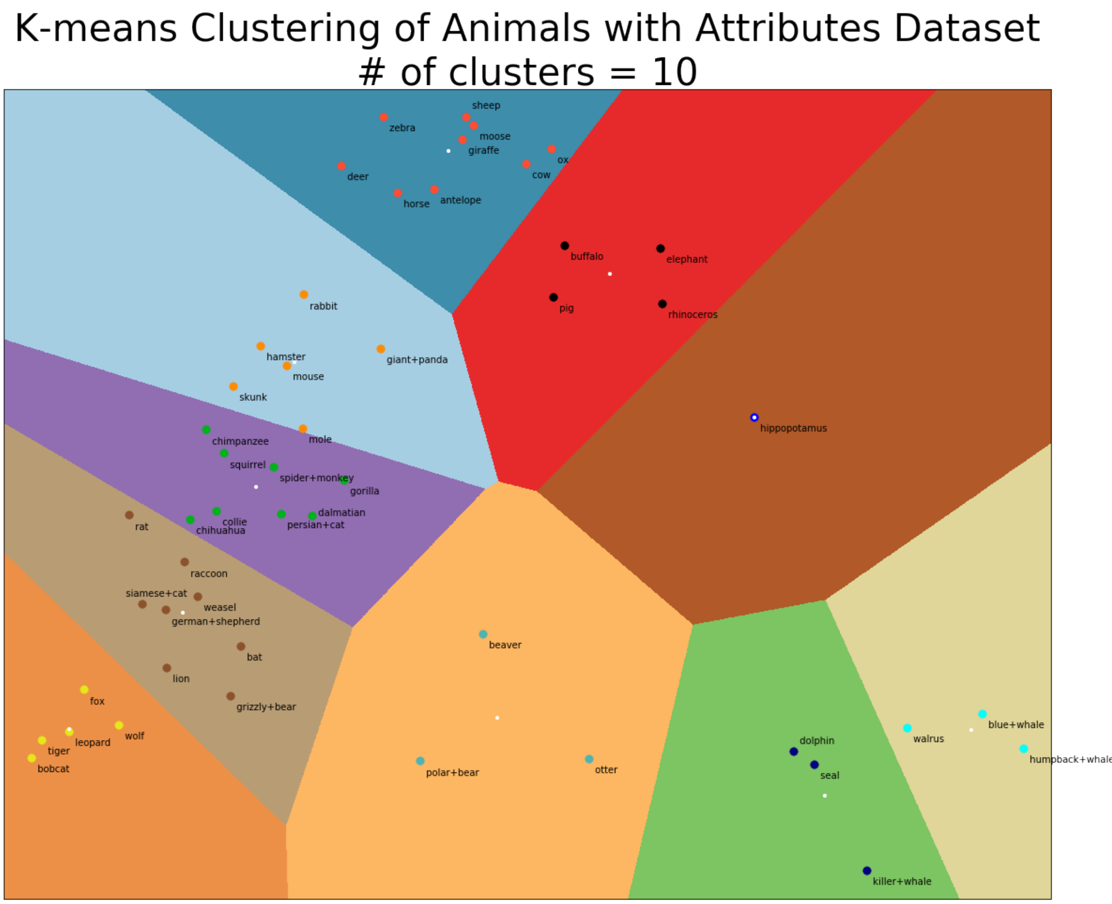
k-means grouping of the animals into an arbitrary number (10) of clusters

In [57]:
```
# Visualize the results on PCA-reduced data
reduced_data = PCA(n_components=2).fit_transform(samples_features)
kmeans = KMeans(init='k-means++', n_clusters=10, n_init=10)
kmeans.fit(reduced_data, classes)

grouping = {i:[] for i in xrange(0,10)} #dictionary comprehension

for i,animal in enumerate(classes):
    grouping[kmeans.labels_[i]].append(animal)
grouping
```

Out[57]:
```
{0: ['skunk', 'mole', 'hamster', 'rabbit', 'giant+panda', 'mouse'],
 1: ['antelope',
  'horse',
  'moose',
  'ox',
  'sheep',
  'giraffe',
  'zebra',
  'deer',
  'cow'],
 2: ['killer+whale', 'seal', 'dolphin'],
 3: ['grizzly+bear',
  'german+shepherd',
  'siamese+cat',
  'bat',
  'rat',
  'weasel',
  'lion',
  'raccoon'],
 4: ['elephant', 'rhinoceros', 'buffalo', 'pig'],
 5: ['beaver', 'otter', 'polar+bear'],
 6: ['tiger', 'leopard', 'fox', 'wolf', 'bobcat'],
 7: ['dalmatian',
  'persian+cat',
  'spider+monkey',
  'gorilla',
  'chimpanzee',
  'squirrel',
  'chihuahua',
  'collie'],
 8: ['blue+whale', 'humpback+whale', 'walrus'],
 9: ['hippopotamus']}
```

In [121]:
```
# Step size of the mesh. Decrease to increase the quality
h = .1     # point in the mesh [x_min, m_max]x[y_min, y_max].

# Plot the decision boundary.
x_min, x_max = reduced_data[:, 0].min() - 10, reduced_data[:, 0].max() + 10
y_min, y_max = reduced_data[:, 1].min() - 10, reduced_data[:, 1].max() + 10
xx, yy = np.meshgrid(np.arange(x_min, x_max, h), np.arange(y_min, y_max, h))

Z = kmeans.predict(np.c_[xx.ravel(), yy.ravel()])

# Put the result into a color plot
```

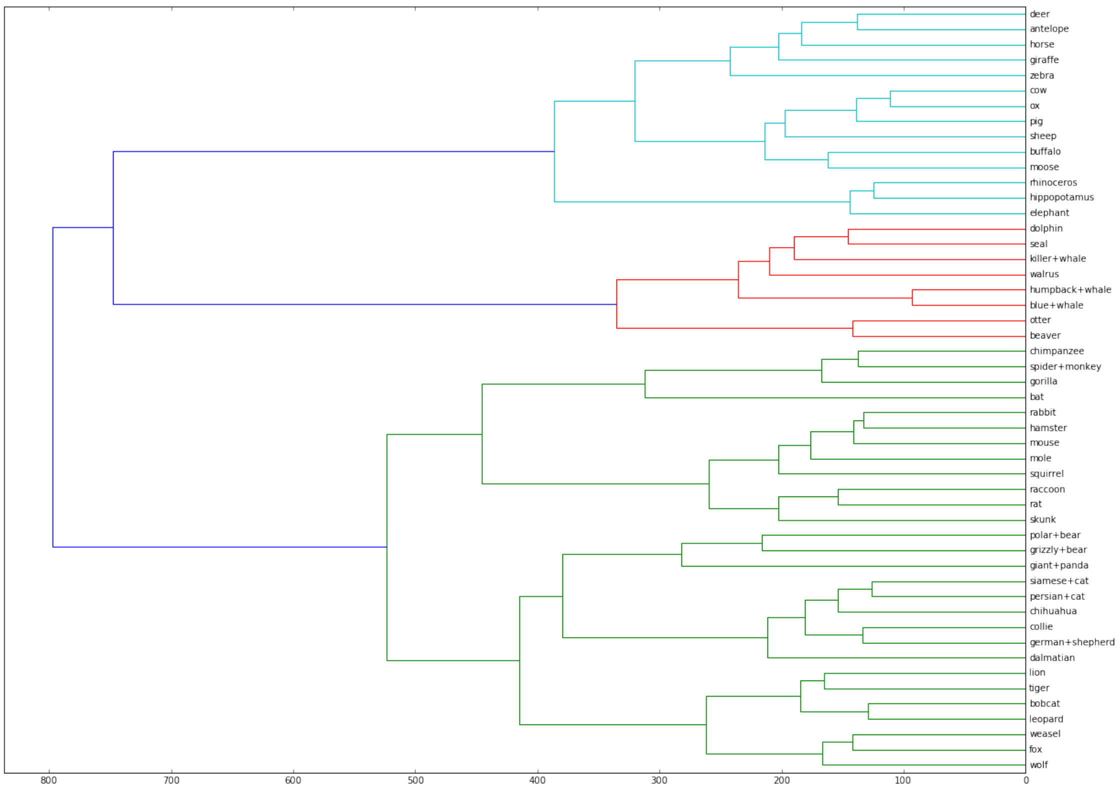
```
Z = Z.reshape(xx.shape)
plt.figure(1, figsize=(20, 20))
plt.clf()
plt.imshow(Z, interpolation='nearest',
           extent=(xx.min(), xx.max(), yy.min(), yy.max()),
           cmap=plt.cm.Paired,
            origin='lower')

# Plot the centroids as a white o
centroids = kmeans.cluster_centers_
plt.scatter(centroids[:, 0], centroids[:, 1],
            marker='o', s=10, linewidths=1,
            color='w', zorder=10)

# Plot the Animals
for i,animal in enumerate(classes):
    # colors is just an array of tuples containing RGB values
    colors = [(1,.55,0),(1,.3,.2),(0,0, .5), (.545, .322, .176), (0,0, 0), (.3,.7, .7), (.9,.9
    plt.plot(reduced_data[i, 0], reduced_data[i, 1], color = colors[kmeans.labels_[i]], marker
    if animal == 'dalmatian':
        plt.annotate('  ' + animal, xy = (reduced_data[i,0], reduced_data[i, 1]), xytext = (re
    elif animal == 'german+shepherd':
        plt.annotate('  ' + animal, xy = (reduced_data[i,0], reduced_data[i, 1]), xytext = (re
    elif animal == 'sheep' or animal == 'dolphin' :
        plt.annotate('  ' + animal, xy = (reduced_data[i,0], reduced_data[i, 1]), xytext = (re
    elif animal == 'siamese+cat':
        plt.annotate('  ' + animal, xy = (reduced_data[i,0], reduced_data[i, 1]), xytext = (re
    else:
        plt.annotate('  ' + animal, xy = (reduced_data[i,0], reduced_data[i, 1]), xytext = (re

plt.title('K-means Clustering of Animals with Attributes Dataset\n # of clusters = 10 ', fonts
plt.xlim(x_min, x_max)
plt.ylim(y_min, y_max)
plt.xticks(())
plt.yticks(())
plt.savefig('images/animals_attributes.png')
plt.show()
```



From the clustering, it is clear that the groups that are clustered together make some intuitive sense. Water dwelling creatures are grouped close together as well as other creatures such as the various types of dogs. However, more work needs to be done to group the animals better (change algorithm, increase number of clusters etc).

Hierarchical Clustering of the Data

```
In [123]: # cluster_link array (contains the hierarchical clustering information)
          cluster_link = linkage(samples_features, method='ward');

          dendrogram(cluster_link, orientation="right", labels=classes)
          rcParams['figure.figsize']=[20,15]
```



The dendrogram seems more sensible to me since it makes more intuitive sense. The grouping of polar and grizzly bears together plus the other hierarchical relationships makes this an intriguing option

```
In [ ]:
```