Unsupervised Learning - Vehicle Silhouettes

Context:

The purpose is to classify a given silhouette as one of four types of vehicle, using a set of features extracted from the silhouette. The vehicle may be viewed from one of many different angles.

The features were extracted from the silhouettes by the HIPS (Hierarchical Image Processing System) extension BINATTS, which extracts a combination of scale independent features utilising both classical moments based measures such as scaled variance, skewness and kurtosis about the major/minor axes and heuristic measures such as hollows, circularity, rectangularity and compactness.

Four "Corgie" model vehicles were used for the experiment: a double decker bus, Cheverolet van, Saab 9000 and an Opel Manta 400. This particular combination of vehicles was chosen with the expectation that the bus, van and either one of the cars would be readily distinguishable, but it would be more difficult to distinguish between the cars.

Data:

The data contains features extracted from the silhouette of vehicles in different angles. Four "Corgie" model vehicles were used for the experiment: a double decker bus, Cheverolet van, Saab 9000 and an Opel Manta 400 cars. This particular combination of vehicles was chosen with the expectation that the bus, van and either one of the cars would be readily distinguishable, but it would be more difficult to distinguish between the cars.

The images were acquired by a camera looking downwards at the model vehicle from a fixed angle of elevation (34.2 degrees to the horizontal). The vehicles were placed on a diffuse backlit surface (lightbox). The vehicles were painted matte black to minimise highlights. The images were captured using a CRS4000 framestore connected to a vax 750. All images were captured with a spatial resolution of 128x128 pixels quantised to 64 greylevels. These images were thresholded to produce binary vehicle silhouettes, negated (to comply with the processing requirements of BINATTS) and thereafter subjected to shrink-expand-expand-shrink HIPS modules to remove "salt and pepper" image noise.

The vehicles were rotated and their angle of orientation was measured using a radial graticule beneath the vehicle. 0 and 180 degrees corresponded to "head on" and "rear" views respectively while 90 and 270 corresponded to profiles in opposite directions. Two sets of 60 images, each set covering a full 360 degree rotation, were captured for each vehicle. The vehicle was rotated by a fixed angle between images. These datasets are known as e2 and e3 respectively.

Citation :

I-Cheng Yeh, "Modeling of strength of high performance concrete using artificial

neural networks," Cement and Concrete Research, Vol. 28, No. 12, pp. 1797-1808 (1998)

Attribute Information:

- All the features are geometric features extracted from the silhouette.
- All are numeric in nature.

Attributes:

- COMPACTNESS (average perim)**2/area
- CIRCULARITY (average radius)**2/area
- DISTANCE CIRCULARITY area/(av.distance from border)**2
- RADIUS RATIO (max.rad-min.rad)/av.radius
- PR.AXIS ASPECT RATIO (minor axis)/(major axis)
- MAX.LENGTH ASPECT RATIO (length perp. max length)/(max length)
- SCATTER RATIO (inertia about minor axis)/(inertia about major axis)
- ELONGATEDNESS area/(shrink width)**2
- PR.AXIS RECTANGULARITY area/(pr.axis length*pr.axis width)
- MAX.LENGTH RECTANGULARITY area/(max.length*length perp. to this)
- SCALED VARIANCE ALONG MAJOR AXIS (2nd order moment about minor axis)/area
- SCALED VARIANCE ALONG MINOR AXIS (2nd order moment about major axis)/area
- SCALED RADIUS OF GYRATION (mavar+mivar)/area
- SKEWNESS ABOUT MAJOR AXIS (3rd order moment about major axis)/sigma_min**3
- SKEWNESS ABOUT MINOR AXIS (3rd order moment about minor axis)/sigma_maj**3
- KURTOSIS ABOUT MINOR AXIS (4th order moment about major axis)/sigma_min**4
- KURTOSIS ABOUT MAJOR AXIS (4th order moment about minor axis)/sigma_maj**4
- HOLLOWS RATIO (area of hollows)/(area of bounding polygon)

Where sigma_maj**2 is the variance along the major axis and sigma_min**2 is the variance along the minor axis, and

area of hollows= area of bounding poly-area of object

The area of the bounding polygon is found as a side result of the computation to find the maximum length. Each individual length computation yields a pair of calipers to the object orientated at every 5 degrees. The object is propagated into an image containing the union of these calipers to obtain an image of the bounding polygon.

NUMBER OF CLASSES: 4 OPEL, SAAB, BUS, VAN

Key asks:

- Classify a given silhouette as one of three types of vehicle, using a set of features extracted from the silhouette. The vehicle may be viewed from one of many different angles.
- Apply dimensionality reduction technique – PCA and train a model using principal components instead of training the model using raw data.

Learning Outcomes:

- Exploratory Data Analysis
- Reduce number dimensions in the dataset with minimal information loss
- Train a model using Principal Components

Objective:

Apply dimensionality reduction technique – PCA and train a model using principal components instead of training the model using raw data.

Steps and tasks:

1. Data pre-processing - Understand the data and treat missing values (Use box plot), outliers (15 points)
2. Understanding the attributes - Find relationships between different attributes (Independent variables) and choose carefully which all attributes have to be a part of the analysis and why (15 points)
3. Use PCA from scikit learn and elbow plot to find out reduced number of dimension (which covers more than 95% of the variance) - 20 points
4. Use Support vector machines to classify the class(y) of vehicles and find the difference of accuracy with and without PCA on predictors(X). 20 points
5. Optional - Use grid search (try C values - 0.01, 0.05, 0.5, 1 and kernel = linear, rbf) and find out the best hyper parameters and do cross validation to find the accuracy.