A Fusion approach for Bird Classification by Machine learning Techniques Ensembling Contour and Statistical Features

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Abstract: - Bird classification approach is a mind perplexing work especially for human vision due to the presence of enormous number of classes with identical features. The approach of sorting is more tedious in traditional methods compared to machine learning techniques because approximately there are ten thousand species grouped into thirty sets of birds from albatrosses to woodpeckers. Birds play a vital role in the landscape helping agriculturalists and to maintain the food chain of nature. But still there is no proper classification methods available to group the birds and ornithologists are in research for a standard scheme since birds accompany human race from the evolution. This paper deliberates novel method for bird classification using machine learning techniques. The classification process is enriched by feature extraction methods namely statistical features along with shape and edge detection methods. The features extracted are used for categorizing the birds and the basic four groups are considered for this method. Totally three classification techniques namely Random Forest, Support Vector Machine and KNN methods are implemented and their accuracy is compared for best selection. The precise method is Random Forest method based on the performance metrics and the accuracy is proved to be highest.
Keywords: - Machine learning, Random Forest, Support Vector Machine, KNN, statistical features, shape, and edge detection.

1. Introduction

Birds are living creatures similar to reptiles described as warm blooded vertebrates grouped separately for their unique feature called feather that discriminates from other animals. They belong to class Aves with four chambered heart and front side of the body converted into wings with deep vision and sensory organs. Birds rule the environment by offering various supports like fertilization, seed distribution, clear the soil by eradicating poisonous worms. The unique characters like feathers, wings and beaks of the birds help to survive in this world and are ecofriendly to maintain the food chain and act as fecal manure for plants. The classification of birds has become an important issue due to their migration and image recognition has gained its popularity using machine learning methods to sort the birds according to their features. Some categories of birds are given as Fig.1.

Fig 1: Bird categories

Even before the training of image processing skills developed, bird classification was carried out based on attributes like kingdom, phylum, class, order, family and species. [1]. Birds were classified based on their shape, color, dwelling types but could not produce accuracy due to their maximum similarity. And the images of birds are considered for grouping which is another drawback. Since the capturing of images is not accurate due to different angles and postures classification cannot provide agreeable results. Classification was advanced by the emerging techniques like machine learning and deep learning methods to provide best sorting of birds.

Machine learning methods and algorithms prove to be efficient since they are related to statistical features and artificial intelligence and produce results based on input data. They practice the characteristics from the feature extraction methods used and build the classification models for the features retrieved. The algorithms make use of the images from the data set provided and preprocess the images. The features are extracted from the images taken as a whole figure and the values produced are used for sorting the birds into different classes.

Various statistical features including first order and second order entities are used for organization. The classification model is basically created by dividing the data set into training and testing group. The data set is first trained with the given classes and in the testing phase the birds are categorized into the given classes.

2. Related Study

Clarifications about the genetic factors of the bird categories simplify the classification to some extent. Responding to the recent effort [2] machine learning framework is developed based on supervised and unsupervised methods. Airborne images are used to train the proposed classifier with latest sensory and tracking methods to monitor the behavior of birds. In another work machine learning algorithms are developed to categorize birds with their sound. [3]. Using the sound of birds the system was trained to automatically identify the birds using the species possessions collected.

The recent collaborative method [4] combines both Python and Mat lab classification method making use of MFCC features with spectrograms. Random forest method along with Linear Discriminant Analysis classifiers are used for sorting of birds. Another type of classification is discussed based on sound of the birds. [5]. For this work five species of birds are considered and thirty five features are retrieved from the audio. The classification models enumerated are support vector machine and K-nearest neighbor method. Bird classification can be done by deep learning method also. In the latest work [6] convolutional neural network method is implemented where the color image is converted into grey scale image and using Pytorch model classification of birds is carried out.

3. Impact and Framework of the work

The proposed methodology concentrates in the classification of birds using machine learning models with suitable algorithms. For grouping purpose the images of birds are taken as a whole picture and the data set are derived from

After the images are extracted from the data collection they are preprocessed which includes resizing of images. After preprocessing stage features are extracted using first order and second order statistical methods. Next shape feature is calculated from Hu moments and edges are studied using two methods namely Canny Edge detection method and Local Binary Pattern method. The extracted features are used for classification purpose where three models are used namely Random Forest method, Support Vector Machine and K-nearest neighbor method. The result from all the three models are derived and compared for accuracy.

The outline of the paper is deliberated as follows. The leading section contains the description about the data set followed by the proposed methodology. The succeeding segment contains the steps like preprocessing, feature extraction and classification. The following section describes the experimental results and performance measures. The final sector contains the conclusion part followed by references.

4. Proposed Methodology

The proposed method for this work is explained in this section. There are many phases that are discussed. The suggested procedures are clearly explained as the block diagram given as Fig.2. The steps used for classification of birds are depicted pictorially as follows.

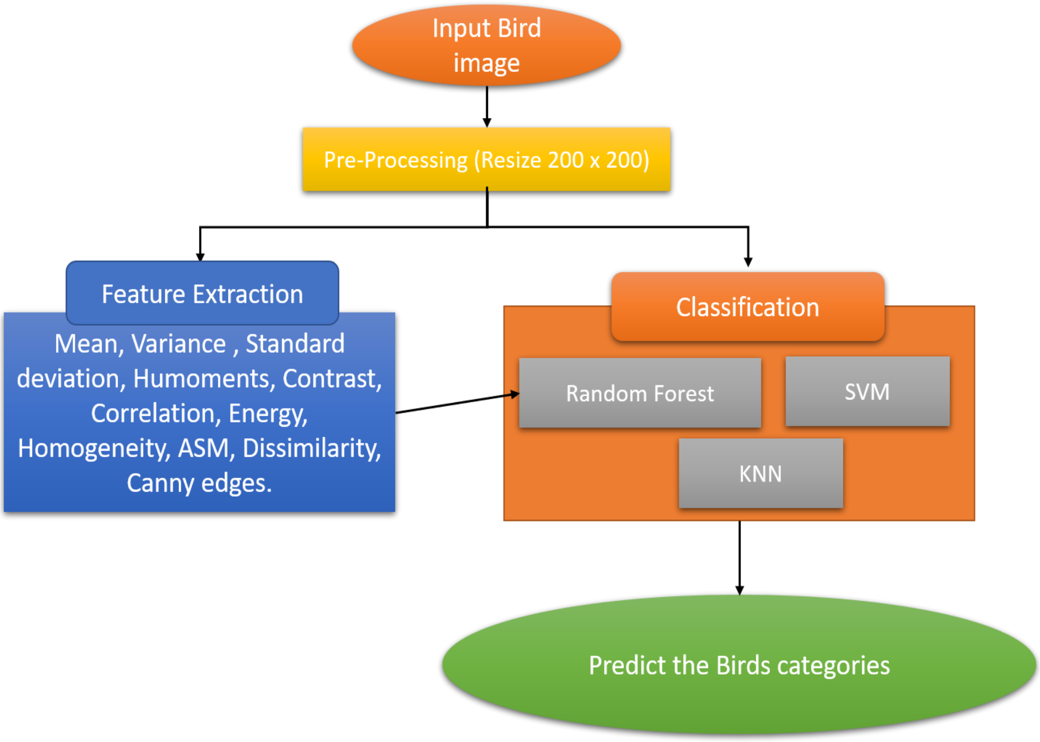

Fig 2: Block diagram of proposed method

Image Attainment

Different varieties of bird images are collected from various data sets. Some of the predominant data sets are Kaggle where nearly 400 species of birds are given. Other data sets are Bird snap and L-Bird consisting of more than 500 types of birds. Data set contains training, testing and validation set by augmenting the available images using Keras image data generator with flow_from_directory function.

Image Preprocessing

After the images are reclaimed from the data set they are preprocessed suitable for feature extraction method. The preprocessing step used in this method is rescaling of images and there are two methods suggested. One is shrinking and other is enlarging the images suitable for further handling.

The parameters needed for resizing is the image to resize, next is the calculated dimensions for new image and the final is the interpolation method used which is the procedure working mainly to correct the size of the image. Another important function is the aspect ratio which is the relationship between the width and height of the image. There are two interpolation methods used based on whether to increase or decrease the size to the standard size of the image.

(i) **Shrinking the image:** For reducing the size of the image the method used is inter_area pixel relation method by determining the value of the new pixel using the adjacent pixels value both in length and breadth wise of the image. So the new image with condensed size is produced without losing the information of the image.

(ii) **Enlarging the image:** For increasing the size the method used is inter linear interpolation method where the images are zoomed to the standard size. The technique used is sampling first in one direction and then in other thereby covering only the four adjacent pixels in diagonals to evaluate unknown new pixel values by taking the mean of the old nearby four pixels.

Feature Extraction Methods

The next step in processing of images is extracting the features from the images for classification purpose. In order to gather the entire information from the image without any loss the feature extraction methods are implemented to find the statistical structures, edges, shape and local pattern of the image. Both first order and second order statistical features are computed using standard methods. All the methods applied are explained in detail. They are

A. First order statistical measures

The first order statistic is the minute sample value selected in the group of values sorted in ascending order. The values discussed are Mean, Variance and Standard Deviation used for deriving the features like center value, deviation from the center point and the area covered from mean to the other points in the image.

(i) **Mean:** The first moment is the mean value which is the average computed between the highest and lowest pixel value to find the center mass of the image. It gives the clarity of the image by measuring the illumination of one image with another. [7].Similar attributes are derived which is the basis for classification. The formula is

$$\text{Mean} \quad \mu=\sum_{i=1}^{n} Xi/n$$

Where X is the value of pixels and n is the total number of the pixels

(ii) **Variance:** Variance is the measure of distribution covering the area of all data points circulated in the image from the center point that is mean value. It shows the variation by calculating average of the squared deviations from the mean value. Variance provides the degree of spread in the image. The formula is

$$\text{Variance} \quad S^2 = \sum_{i=1}^{n} (Xi - \mu)2/n$$

(iii) **Standard Deviation:** Standard Deviation is the amount of the area spread in the image from the center point. It affords the square root of the mean of the squares of all values in the image and called root mean square deviation. It is also the square root of the variance. The formula is

$$\text{Standard Deviation} \quad S= \sqrt{S^2}$$

From the above mentioned methods the sample images are processed and the values are computed and compared for classification. The images which belong to same group show similar values and the extracted sample values are shown in the Table 1 below. Three features are extracted from this method. Here images 1 and 5 belong to same class.

Table1: Sample values of first order statistical features

Images	Mean	Variance	Standard Deviation
1	1.13	7.96	2.82
2	8.42	9.20	3.03
3	1.03	1.11	3.33
4	1.05	1.46	3.82
5	1.13	7.96	2.82

B. Second Order Statistical Features

Second order values are used for shortening the test time of processing the images while first order is used for improving the sampling methods. [17] Second order properties are used for checking the texture to classify the images. First order measure provides only the information of the particular pixels but not the relative positions of the distribution within the image. Second order method provides this information as matrix format with pixels taken as pairs [8] called co-occurrence matrix providing features about the image. Out of 13 features only six important features are considered for calculating the intensity and texture of the image. Sample values are calculated for six features and given as Table 2 below. They are

(i) **Contrast:** Contrast gives the measures of spatial frequency of the pixels within the image. It provides the divergence by distinguishing the biggest and smallest pixels values. The limited discrepancies between the pixel values are measured

Contrast = $\sum_{i,j=0}^{N-1} P_{ij}\,(i-j)^2$ Where i and j are values of the pixels

(ii) **Correlation:** Correlation measures the relationship between two pixels values in the image and the direction of the relationship. The value is calculated by first computing the variance of the pixel intensity values and dividing by the product of the pixel standard deviation.

Correlation = $\Sigma(X-X)(Y-Y)/\sqrt{(X-X)^2\,(Y-Y)^2}$

(iii) **Energy:** Energy provides the consistency and is called Angular second moment. It provides the similarity between the pairs of pixel values and identifies texture dissimilarities.

Energy = $\sum_{i,j=0}^{N-1} P^2\, I, j$

(iv) **Homogeneity:** Also called Inverse difference moment and measures the uniformity within the pixel values of the image. The value is maximum when the pixel values are same in the image

Homogeneity = $\sum_{i=1}^{n} (O_i - E_i)^2 \,/\, E_i$

Where O_i and E_i are observed and expected values.

(v) **ASM:** Angular Second Moment represents the regularity of the distribution of the pixel values level in the image. It is the monotonic gray level transition.

ASM = $\sum_i . \sum_j P(i, j)^2$

(vi) **Dissimilarity:** Dissimilarity is the degree of space covered by the pair of pixels in the image. It provides the relationship of the local values of the pixel.

Dissimilarity = $\sum_{i=1}^{n} |X_{1(i)} - X_{2(i)}| \,/\, n$

Table 2: Second order statistical method results

Images	contrast	correlation	energy	homogeneity	ASM	dissimilarity
1	1.68	9.02	5.84	9.30	3.42	1.44
2	1.63	9.16	6.13	9.32	3.76	1.39
3	3.32	8.56	3.64	8.43	1.33	3.15
4	3.25	8.92	3.89	8.63	1.51	2.81
5	1.68	9.02	5.84	9.30	3.42	1.44

C. Hu Moments

Hu moments are called shape matching features extracting attributes like area, perimeter, centroid, eccentricity and roundness of the values from the images. Using these features similarity between the images is calculated by functions like translation, scale and rotational invariance. Using the function moments the characteristics of the pattern in the image can be figured. The intensity of the pixel is calculated based on their location thereby capturing information about shape of the image. For shape matching the moments are calculated invariant to three functions based on the formula. The first invariant Translation is called central moments providing same moment value if the shape is same even if the pattern in the image varies.

$$\text{Translation invariance} = \mathbf{M_{pq}} = \sum_{x=0}^{n} \cdot \sum_{y=0}^{n} (x - \bar{x})^{p} (y - \bar{y})^{q} \, \mathbf{I(x, y)}$$

Where I(x,y) gives basic 2d geometric moments of order (p+q) of the image
x^P, y^Q gives basics of the moments and
p and q are weights of horizontal and vertical dimensions.
The second invariant Scaling is obtained by the normalization of central moments and provides same moment value even if the image size is reduced or zoomed.

$$\text{Scale Invariance} = \mathbf{N_{pq} = M_{pq} / M_{00}}^{\mathbf{1+p+q/2}}$$

Where M_{00} is the total mass of the image.

The third invariant Rotationrecords the location of each pixel onto a new position by rotating through different angles producing various values. It consists of 7 numbers from h1 to h7calculated using central moments invariant to image transformations. Using the formulas given below Hu moment values are calculated and these values are computed for classification. The rotational invariance are

$h1 = \eta20 + \eta02$

$h2 = (\eta20 - \eta02)\ 2 + 4(\eta11)^{2}$

$h3 = (\eta30 - 3\ \eta12)^{2} + 3(\eta03 - 3\eta21)^{2}$

$h4 = (\eta30 - \eta12)^{2} + (\eta03 + \eta21)^{2}$

$h5 = (\eta30 - \eta12)\ (\eta30 + \eta12)[\ (\eta30 + \eta12)^{2} - 3(\eta03 + \eta21)\ 2\ ] + (3\ \eta21 - \eta03)(\ \eta03 + \eta21)\ [3(\eta30 + 3\eta12)^{2} - (\eta03 + \eta21)^{2}]$

$h6 = (\eta20 - \eta02)\ [(\eta30 + \eta12)^{2} - 7\ (\eta03 + \eta21)^{2}] + 4\ \eta11\ (\eta30 + \eta12)(\ \eta03 + \eta21)$

$h7 = (3\eta21 - \eta03)(\ \eta30 + \eta12)[(\ \eta30 + \eta12)^{2} - 3(\eta03 + \eta21)^{2}] + (\eta30 - 3\eta12)(\ \eta03 + \eta21)\ [3(\eta30 + \eta12)^{2} - (\eta03 + \eta21\ )^{2}]$

The values calculated using the formulas are given as Table 3 and compared with different images. Same class images give same values while the values vary for different classes.

Table 3: Hu Moments resultant values

Images	H0	H1	H2	H3	H4	H5	H6
1	1.44	4.07	4.92	1.14	-7.38	-2.17	4.31
2	1.85	6.23	7.03	1.94	-2.27	-4.25	-1.16
3	1.66	3.55	5.15	1.12	-7.95	3.33	-3.24
4	1.44	2.03	9.45	3.66	2.08	2.78	5.42
5	1.44	4.07	4.92	1.14	-7.38	-2.17	4.31

D. Canny Features

Canny method is used for detecting the various edges in the image and the edges are used as features [16] for classification. The edges are defined as strident variations in the pixel intensities [9] and canny edge detector is used to identify different edges in the image using the following steps.

1. First step is to preprocess the image using Gaussian Filter method to evade the noise. To avoid false results the image is filtered to remove disturbance in the image. Also the entire image is not needed instead only the sketch and shape of the objects are considered.
2. Next is to calculate gradients of the pixel intensities in the image. For this four edge values in four directions are computed using filters. Two derivatives G_x and G_y from horizontal and vertical sides are derived and using these values edge slope and directions are calculated.

3. The next step is to apply thresholding for [15] slope degree to remove false reaction to identify the edges in the image. The edge thinning technique is implemented to identify the sudden change in the intensity level of the pixel. There are two steps

- First compare the edge value of the new pixel with the pixels in positive and negative slope directions.
- If the new pixel value is more that value is considered and the edge is selected otherwise the edges are removed.

4. Twofold threshold values are applied to detect the possible edges. After steps 2 and 3 false edges are eradicated. However some edge pixels may remain with small slope value. To identify such pixels two threshold values are selected with high and low values. Comparing with these two values weak entities are detected and the edges are detached from the image.
5. The last step is to track the edges by hysteresis by isolating small value edges and removing them from the image by disconnecting their relation with the solid edges. Blob analysis is done to examine [18] the edge values and its adjacent values and if a strong edge is identified it is conserved to look for weak edges.

E. Local Binary Pattern Features

LBP is the easiest and successful method for describing the texture of the image called as visual descriptor by assigning the values for a pixel based on the values of the adjacent pixels. [10]. The output is the binary number which is converted into decimalvalue.The following are the steps

- First the given image is divided into cells with equal number of rows and columns of pixel values.
- Each pixel value is compared with its adjacent pixels in all eight directions.
- A binary pattern of 8 digits are formed with a series of 0 and 1.When the middle pixel is larger than its nearby value, 0 is assigned otherwise 1 is assigned. This binary number is converted to decimal.

The parameters used are radius and number of neighboring pixels represented as R and P. The formula used is

$$LBP_{P,R} = \sum_{p=0}^{P-1} s(Gp - Gc)2p$$

Where Gp is neighbor pixel and Gc is center pixel.

For calculating LBP values the radius is taken as 3 which is suitable for the data set and the adjacent pixels are computed as 8 from all directions.

From the above described methods the features are extracted used for classification of birds.

Classification Methods

Classification is the way for grouping the pixels into diverse classes based on some criteria like the features extracted from the images. The types and number of features extracted from the methods discussed in the previous section are given in the form of Table 4

Table 4: Details of Features Extracted

NO	METHOD	NUMBER OF FEATURES	FEATURE FACTS
1	Statistical Method	3	Brightness, edges
2	Hu Moments	7	shape
3	GLCM Method	6	texture
4	Canny Method	1	edges
5	LBP Method	1	texture

Classifications of birds using the features extracted are discussed in this section. There are three standard machine learning methods used for classifying the birds. They are Random Forest, Support vector Machine and K-nearest neighbor methods explained in detail.

A. Random Forest Method

The machine learning supervised method which builds a forest is an ensemble of decision trees combined to form multiple model to get output by adding in parallel the results from the model. Random forest classifier belongs to bagging method and bootstrap aggregation scheme is followed in this classification. Following are the steps and parameters used for [11] classification

- First select the samples from the data set with replacement. This approach is called Bootstrap.
- Features are selected with low entropy and high information gain used for every split.
- Using the features different decision trees are constructed with root node as the primary feature and based on other features right and left tree is built.
- All decision trees are trained with different data set and different features and finally the results are combined. This process is called Aggregation.
- Voting scheme is used and the output which gets majority is finalized as the result.

The Hyper parameters used for this method are

Estimator	200
Random state	10
Shuffle	True
Features selected	100
Test size	0.2

For classification of birds 200 decision trees are constructed with replacement and the number of features used are 100 for classifying the given data set into four classes namely Albatross, Auklet, Blackbird and Kingfisher [19].

B. Support vector Machine

A supervised machine learning method used for multi-class classification [14]. The technique works by creating hyper plane representing various classes in high dimensional space. The aim is to group the data set into the defined classes to achieve the maximum hyper plane. The Fig. 3.shows the model of SVM.

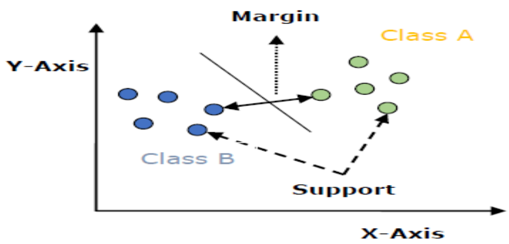

Fig 3: SVM model

The algorithm for SVM is

1. Import the packages and load the data set
2. Split the data into training and testing subsets
3. Use classifier to classify the given data set into required four classes
4. Create scatterplot by taking only two features and repeat this step iteratively to train the model with SVC.

A model is created for classification of birds and the data set is trained to classify the birds into four classes. Finally the data set is used for testing to find the accuracy of this model.

C. K-nearest neighbor

A non-parametric supervised machine learning [12] method used for classification based on the belief that the points adjacent to one another are same. This method first loads the data set and groups a [13] new data value based on the similar features of the data set. It is called lazy learner because in the training phase first the dataset is saved and only on the new arrival classification is carried out. The following steps implemented are

- First select the number K of the neighbors. Here K=3, defines the number of adjacent points to be tested for classification of a new point.
- Calculate the distance between the new point and the adjacent point using Euclidean method to value a narrow line between the target and nearby points. The formula is $D(x, y) = \sqrt{\sum_{i=1}^{n}}(y-x)2$
- Select the adjacent points as the nearest using the Euclidean distance
- From the selected data points group the data points in each class to find the maximum number.
- Allocate the new point to the class having maximum adjacent data points.
- The model is ready for training and testing phase

This method is very simple compared to other methods because it needs only 2 parameters namely K and the distance metrics p. By using this model, bird data set is classified into four groups.

The classification of birds is carried out using the above mentioned methods and the results are compared for accuracy [20]. The next section provides the results and the performance metrics for the classification method.

5. Experimental Analysis

The bench mark data set for bird classification is composed and processed to classify the given collection of birds into four classes. Features are extracted from the given image and with the features the data set is classified using three standard machine learning supervised methods. The classification for each model provides the result and all the results are compared for accuracy. Performance metrics are calculated to find the following measures

Accuracy- Accuracy gives the correct prediction of result. It is calculated by

$$(TP + TN)/ (TP+FP + TN+FN)$$

Precision- represents how many of true positive results are precise.

TP /(TP+ FP)

F1-Score- uses precision and recall to measure the accuracy of the results.

2*Recall*Precision/ Recall+Precision

The calculated measures are given in the form of Table 5 for all the three classifications.

Table 5: Comparison of Performance Metrics for the given methods

PERFORMANCE METRICS	**VALUES IN (%)**		
	SVM	**RF**	**KNN**
Accuracy	33.00	86.22	86.22
Precision	40.55	86.83	86.25
Recall	33.06	86.56	86.76
F1-Score	29.88	85.95	85.65

6. Conclusion

This paper elaborates about the classification of birds into four main classes namely Albatross, Auklet, Blackbird and Kingfisher. For handling this data set, the images are first preprocessed and then features like statistical features, edges and shape with texture features are retrieved. Using these features the given data set is classified into four declared classes using machine learning models. The models used for classification is three and the results are compared for accuracy. This work can be further extended using deep learning methods and the number of classes can be increased more in number.

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