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Scale and Rotation Invariant Shape Features for Animal Identification

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Abstract— ***Nowadays animal identification is an emerging area, due to extinction and endangering of animals. In order to identify an animal in an image, the image has to be described or represented by certain features. Shape is an important visual feature of an image. We can identify the animals using shape properties of different animals like dog, deer, camel, elephant etc. The main objective of this paper is to identification of animal. First label the multiple animals in image by using component labeling method. After labeling each animal by using image operation extract scale and rotation invariant shape features of the animal images, then creation of feature vectors for every animal in animal database to get the feature database. Finally using K-means clustering method used for identification of animal that achieves efficient animal identification System.***

Keywords- Image pre-processing, Component Labeling Method, scale and rotation invariant features, K-means Clustering Method.

I. INTRODUCTION

Animals play a vital role in our environment. In today's generation day by day numbers of animals are decreasing. Identifying the animals through machine learning techniques. Using this application we can identify the animal and prevent from dangerous animal entering in the residential area, avoiding collision of vehicles and animals on the roads [9].

Animal identification system involves mainly 5 steps those are Capture the animal image, Image Preprocessing, Component labeling, image Feature Extraction, Classification or Clustering. Capture the animal image step is collection of animal images is from variety of animals. Pre-processing used to remove the noise part in image. It separates every object in the image. Image Feature Extraction step for animal identification uses some of scale and rotation invariant features methods used to classify the animals. After extracting each animal by using scale and rotation invariant shape features of the animal images, creation of feature vectors for every animal in animal database to get the feature database. Finally using K- means clustering method for identification of animal that achieves efficient animal identification System.

II. PROPOSED METHODOLOGY

In this paper a methodology has been proposed which will learn the shape features of the animal and stores it in a database and finally identifies it when given as a query. The proposed methodology consists of 2 main phases

1) Learning Phase
2) Identification Phase

Fig 1 shows the Schematic diagram of diagram of the proposed method.

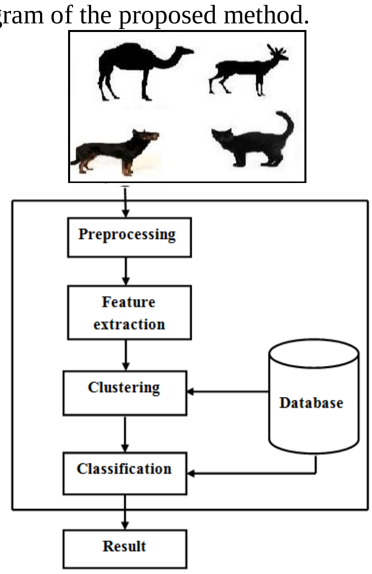

Fig 1: Overall System Diagram

A. Learning Phase

This is the phase where the proposed system learns about its database. In this phase the unknown animal are collected and stored in the database. Features which are invariant to translation, rotation and scaling are extracted and are stored in the database. These features are then clustered such that features that are most similar are grouped together. Learning phase involves the following steps "data collection, pre-processing, feature extraction, feature normalization and Clustering Algorithms".

Identification Phase: This is the phase where the proposed system identifies the query animals by comparing their features with the features in the database and retrieves those animals whose features match exactly or the nearest matched animals are retrieved.

1) Image Acquisition

Image of the animal is acquired in a simple set up of Machine Vision System, a set of 40 animal images have been captured. The captured leaves should have white background. Figure 2 shows sample database of input animal database and figure 3 shows database of image with multiple animals

Fig 2 Example of animals Stored in Database

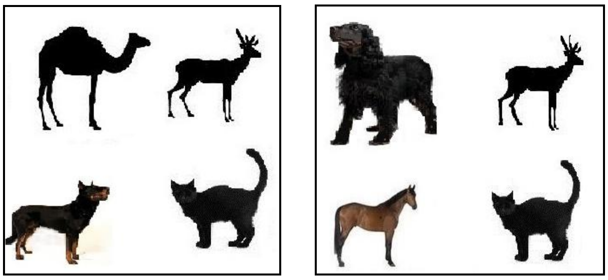

Fig 3: Input image with multiple animals Stored in Database

2) Pre- Processing

The raw data, depending on the data acquisition type is subjected to a number of pre processing steps to make it usable for subsequent processing. Pre processing aims to generate image data that is easy for the animal Identification system and can operate quickly and accurately.

The acquired animal image which is in RGB format is converted to a gray scale image using the Equation (1):

$$Gray = 0.2989 * R + 0.5870 * G + 0.1140 * B \quad (1)$$

Where R, G, B correspond to the Red, Green and Blue color of the pixel, respectively [3-4]. Fig 4 shows steps involved in pre-processing .

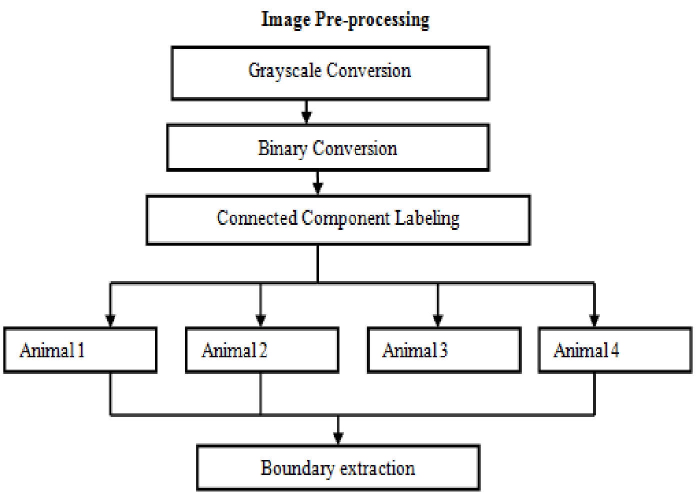

Fig 4 Steps Involved In Pre-Processing

Next step is Thresholding, where objects of interest are separated from the background. Output of thresholding operation is a binary image in which pixels belonging to the object are represented by one gray level and all other pixels belonging to background are represented by another gray level. In the present work, Otsu's thresholding [2] method is used to calculate the threshold value to convent the grayscale image into binary image. The Binarization processing is shown in Equation (2).

$$d(x,y)=\begin{cases}1 & g(x,y)\geq t\\ 0 & g(x,y)<t\end{cases} \qquad (2)$$

g(x,y) is the gray value of a pixel, t is the threshold calculated by the OTSU method and d(x,y) is the binary value of the pixel.

The binary image obtained after thresholding the connected component algorithm is applied to label the each animal from multiple animal image then contour extraction to determine the boundary of the object.

Connected Component Labelling [6]
Algorithm:
Input: Binary Image
Output: Components
First scan
Step1: Initialize an array Eq_label with labels [0-255] and curr_ label =0
For each foreground pixel encountered
Step 2: check its top and left neighbor
Step 3: if the top and left neighbor is a background pixel then
Step 4: curr_label++;
Step 5: Else if the top or the left neighbor is a background pixel then
Step 6: Assign the label of the pixel which is not background
Step 7: Else if label of the top pixel is not equal to the label of the left pixel and both the pixels are not background pixels then
Step 8: Scan the Eq_label array from the beginning and replace the label of the top pixel by the label of the left pixel in the Eq_label array
Second scan
Step 9: For each foreground pixel encountered replace it with the label in the Eq_label array.

3) Feature Extraction

Shape Feature extraction involves the extraction of counter based feature methods [1] are Perimeter, Centroid Distance Method, Extreme Distance Ratio method, Diagonal Ratio Method, Perimeter area ratio, Diagonal Ratio Method and region based feature methods are Area, Waddell's Ratio, Regional moment of Inertia, Shape square matrix, Area Ratio, Extent, [10] Axis Ratio of all of whom represent the shape of the animal.

- **Area:** Animal Area can be defined as total number of black pixel in the binary image
- **Perimeter :** Animal Perimeter is the number of pixels along the closed contour of the animal
- **Waddell's Ratio**

$$\text{Waddell's ratio} = \frac{2\sqrt{\pi * \text{area}}}{(\text{perimeter})^2} \qquad (3)$$

- **Drainage- Basin Ratio**
  Drainage basin ratio= pi*Area/Perimeter
- **Axis Ratio**: Minor Axis Length / Major Axis Length.
- **Area Ratio:** Image area / image Filled Area.
- **Perimeter area ratio**: Image Perimeter / Image Area.
- **Rectangularity:** Rectangularity=As/Ar
  Rectangularity = (area)/(area of bounding box).

- **Centroid Distance Method:**

Convert the gray image into binary image then Find the Centroid of the image (x_i), Find the distance between each boundary pixel to centroid using Euclidian distance. Find maximum distance [11].

Centroid Distance Method=maximum distance*size of the image /all distances

Algorithm of Centroid Distance Method:
Step1: Convert the gray image into binary image
Step2: Find the Centroid of the image(x_i)
Step3: Find the distance between each boundary pixel to centroid using Euclidian distance.
Step4: Find maximum distance
Step5: Centroid distance Method=maximum distance*size of the image /all distances

Figure 6 shows representation of extreme distance method and Equation 4 is Central Point Determination formulas=

$$x_c = \sum_{i=1}^{n} x_i/_n$$

$$y_c = \sum_{i=1}^{n} y_i/_n \qquad (4)$$

- **Square Shape Matrix:** figure 5(a),(b),(c) shows flow of Square Shape Matrix.

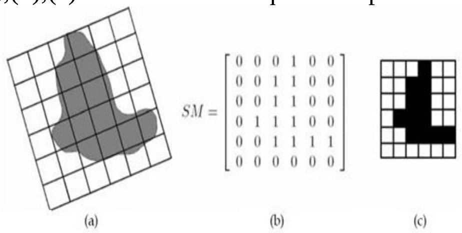

Fig 5 a) Original Shape Region (b) Square Model (c) Reconstruction Of The Shape

Algorithm of Square Shape Matrix:
Step1: convert grey scale image to binary image.
Step2: Image is divided into number of blocks (64)
Step3: Count the number of black pixels in each block
Step 4: If the block contains the pixels more than the threshold value then make entire block black otherwise make entire block as white.
Step5: repeat step 3 and 4 for all for all blocks.
To make this feature scale invariant divide number of blocks covered by object and total number of blocks

- **Extreme Distance Ratio method :**

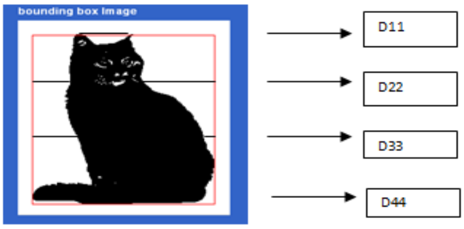

Fig 6 Representation of extreme distance method

Extreme distance ratio =D11/(D11+D22+D33+D44) (5)

- **Extreme distance method**

Algorithm of Extreme distance method
Step1:convert grey scale image to binary image.
Step2:image height is divided into number(3) of parts.
Step3:scan from left to right and right to left direction and take the extreme black pixel coordinates(x,y) for each part.
Step 4: find out the distance between both extreme points using Euclidian distance formula.
Step5: repeat step 3 and 4 for all parts.
Step 6: compute the extreme distance ratio by the formula
Figure 6 shows representation of extreme distance method

$$\text{Extreme distance ratio} = \frac{\text{distance of individual part}}{\text{sum of distance of all parts}} \qquad (6)$$

- **Diagonal Ratio Method:**
  Fig 7 shows Representation of Diagonal Ratio Method

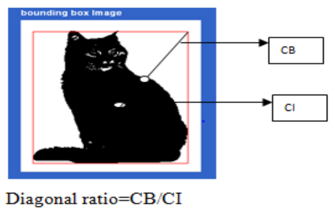

Fig 7. Representation of Diagonal Ratio Method

- **Diagonal Ratio Method**

Algorithm of Diagonal Ratio Method:

Step1: convert grey scale image to binary image.
Step 2: draw the bounding box around the image.
Step3: find the centroid of bounding box.
Step 4: find the distance from centroid to each corner of bounding box using Euclidian distance formula.
Step 5: find the distance from centroid to extreme diagonal point of the image in all directions.
Step 6: compute the diagonal ratio by the formula
Diagonal ratio =

$$\frac{\text{Distance from centroid to bounding box}}{\text{Distance from centroid to edge of image}}$$

- **Regional moments of inertia:**

Regional moment of inertia describes pixel distribution information of the animal at different positions on its vertical axis [8]. Animals preserve steady orientation and are bilaterally symmetric concerning their vertical axis; P_{xx} quantities for four different regions are used as a descriptor, where P_{xx} is the variable that holds the pixel distribution value. It is scale invariant. Fig.8 shows Regional moment of inertia of animal. P_{xx} can be calculated using the Equation (3).

$$P_{XX} = \frac{1}{N}\sum_{x_i \in R}(x_i - x_{centroid})2 \qquad (7)$$

Where
Xi : Vertical coordinates of the animal.
X centroid: Vertical coordinates of centroid animal image.
N : Number of black pixels in each region
Figure 8 shows representation of regional moment of inertia
Table 1 shows result analysis of the scale invariant features.

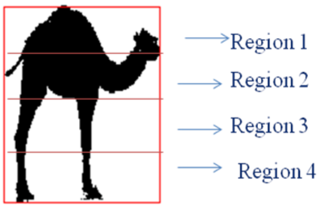

Fig 8. Regional Moment of Inertia

TABLE I RESULT ANALYSIS OF ALL SCALE INVARIANT FEATURES OF CAMEL

Image Size / Features	128x128	256x256	300x300	400x400
Drainage Basin Ratio	0.168955	00.168363	0.164513	0.159568
Extreme Distance Ratio(D1,D2,D3)	0.367947	0.365234	0.365000	0.364544
	0.281722	0.287109	0.286667	0.287141
	0.318212	0.318359	0.318333	0.318352
Diagonal Ratio Method (R1,R2,R3,R4)	1.655662	1.666120	1.677450	1.690798
	1.020143	1.023510	1.022956	1.023696
	2.274244	2.270559	2.267824	2.260657
	1.073696	1.073423	1.075344	1.073383
Area Ratio	0.395020	0.395231	0.394167	0.394219
Axis Ratio	1.000000	1.000000	1.000000	1.000000
Extent	0.407659	0.401265	0.399475	0.394219
Circularity	0.087764	0.084954	0.087546	0.082354
Centroid distance Method	1.394994	1.398644	1.400586	1.401991
ROI	0.018042	0.018899	0.019032	0.019116
	0.104465	0.105418	0.105532	0.105714
	0.288340	0.288409	0.288408	0.288603
	0.589153	0587282	0.587028	0.586522
Shape Matrix	0.385000	0.383789	0.398101	0.391200

Moment Invariant Features

The Invariant Moments are widely applied because of their unique property of "translation, rotation and scale invariance"[5].In our proposed work Hu moments were used. Moment Invariants were first introduced by Hu. He proposed 6 orthogonal invariant moments and one skew invariant moment [3] based on algebraic moments. A two dimensional central moment is given by

$$m_{pq} = \int_{-\infty}^{\infty}\int_{-\infty}^{\infty} x^p \; y^q \, f(x,y)dxdy$$

$$p\,,q=0,1,2$$

The 7 invariant moments introduced by Hu are as follows

$$\phi_1 = \eta_{20} + \eta_{02}$$

$$\phi_2 = (\eta_{20} - \eta_{02})^2 + 4\eta_{11}^2$$

$$\phi_3 = (\eta_{30} - 3\eta_{12})^2 + (3\eta_{21} - \mu_{03})^2$$

$$\phi_4 = (\eta_{30} + \eta_{12})^2 + (\eta_{21} + \mu_{03})^2$$

$$\phi_5 = (\eta_{30} - 3\eta_{12})(\eta_{30} + \eta_{12})[(\eta_{30} + \eta_{12})^2 - 3(\eta_{21} + \eta_{03})^2] + (3\eta_{21} - \eta_{03})(\eta_{21} + \eta_{03})[3(\eta_{30} + \eta_{12})^2 - (\eta_{21} + \eta_{03})^2]$$

$$\phi_6 = (\eta_{20} - \eta_{02})[(\eta_{30} + \eta_{12})^2 - (\eta_{21} + \eta_{03})^2] + 4\eta_{11}(\eta_{30} + \eta_{12})(\eta_{21} + \eta_{03})$$

$$\phi_7 = (3\eta_{21} - \eta_{03})(\eta_{30} + \eta_{12})[(\eta_{30} + \eta_{12})^2 - 3(\eta_{21} + \eta_{03})^2] - (\eta_{30} - 3\eta_{12})(\eta_{21} + \eta_{03})[(3(\eta_{30} + \eta_{12})^2 - (\eta_{21} + \eta_{03})^2]$$

TABLE 2 RESULT ANALYSIS OF HUE MOMENT INVARIANT FEATURES OF CAT

Features	**M1**	**M2**	**M3**	**M4**	**M5**	**M6**	**M7**
Original(128x128)	0.292599	0.008760	0.0006357	0.001170	0.000003	0.000006	0.000001
10'	0.293915	0.009995	0.006047	0.000913	0.000002	0.000004	0.000001
20'	0.296275	0.012214	0.005786	0.000774	0.000002	0.000008	0.000001
30'	0.299969	0.014211	0.005673	0.000738	0.000002	0.000008	0.000001
256x256	0.292599	0.008760	0.0063860	0.001182	0.00002	0.000019	0.000001
10'	0.293764	0.009892	0.0062 8	0.00965	0.00003	0.00004	0.000001
20'	0.296653	0.012028	0.005938	0.000839	0.00002	0.000005	0.000001
30'	0.298666	0.014205	0.005600	0.000720	0.00002	0.000003	0.000001

4) Clustering

Clustering is an unsupervised machine learning technique. The purpose of clustering is to put data points into related groups without having prior knowledge of the group definitions where every group is termed as cluster. In proposed work clustering is used to cluster database animals in groups where animals in one cluster are similar between them and are dissimilar to the animals belongs to the other clusters [7].

K –Means Algorithm

INPUT: Set of feature values.

OUTPUT: Clusters of feature values**.**

Step1: Place K points into the space represented by the objects that are being clustered.

These points represent initial group centroid.

Step2: Assign each object to the group that has the closest centroid.

Step3: When all objects have been assigned, recalculate the positions of the K centroid.

Step4: Repeat Steps 2 and 3 until the centroid no longer move. This produces a separation of the objects into groups from which the metric to be minimized can be calculated.

B. Identification Phase

In this phase, animals which are to be identified are placed in from of the camera and its image is acquired, it is then pre-processed and then component labeling method is used to detect multiple animals, features of each animal from the query image is extracted, they are then normalized and matched with the database based on the distance measure and the animals are identified. The query input can be a single animal or multiple leaves.

III. EXPERIMENTAL RESULTS

A. Results of Component Labeling

The query image consisting of multiple animals is given as input to the proposed system, after preprocessing Component labeling method is applied to identify multiple animals. Figure 9(a) shows sample input image to the application and figure 9(b) shows results of connected component labeling.

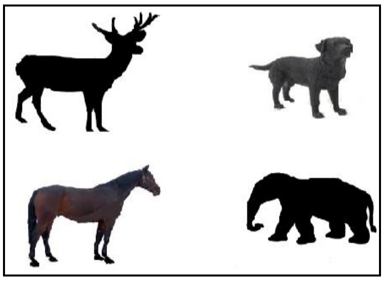

Fig 9(a) Input Image

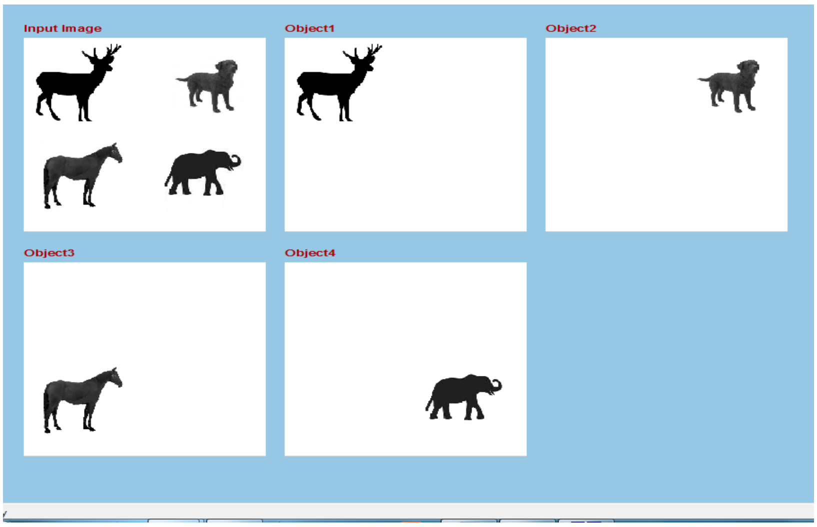

Fig 9(b) Results of Component Labeling

B. Results of animal Identification

Figure 10(a)(b)(c)(d)(e) shows the results of multiple animal identification. As seen in the figure 4 animal have been identified.

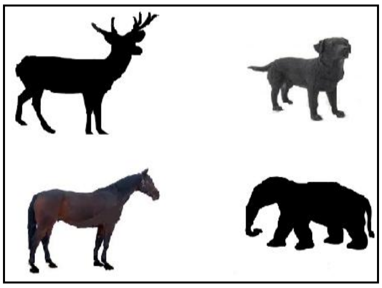

Fig 10(a) Input Image

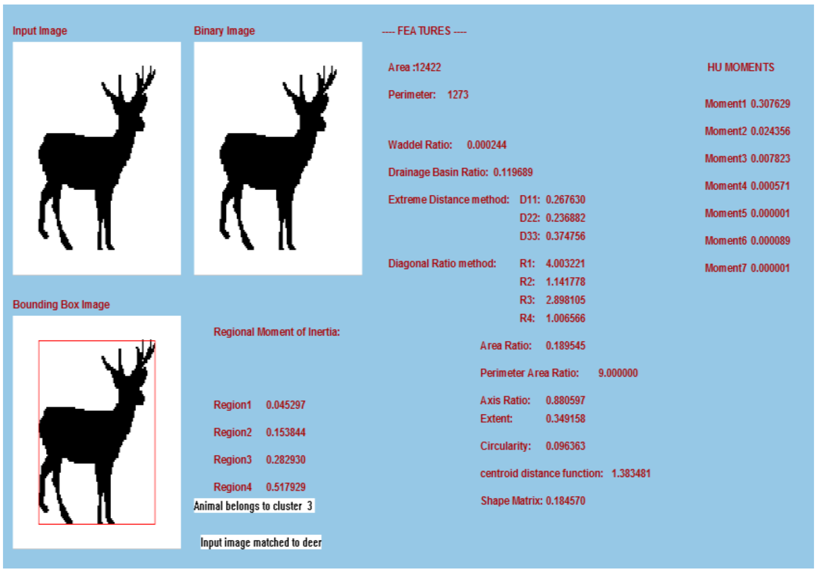

Fig 10(b) Identified animal: Deer

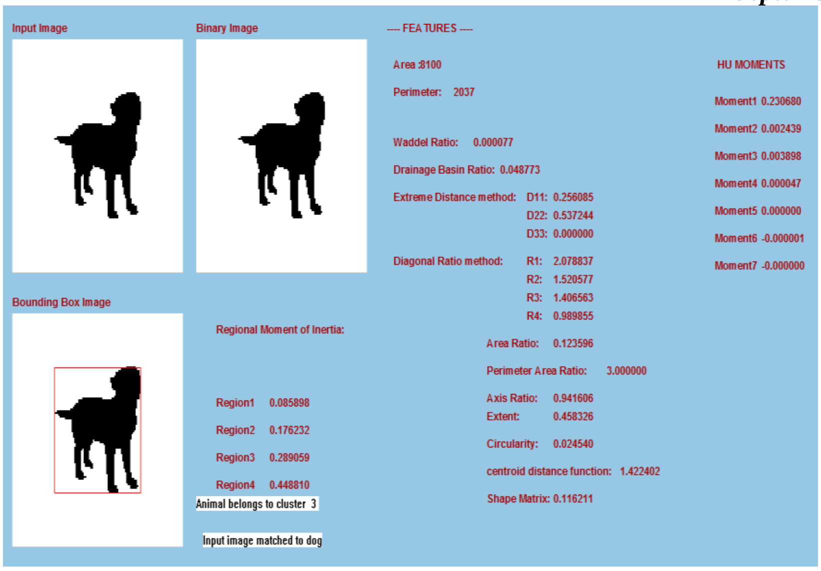

Fig 10(c) Identified animal: Dog

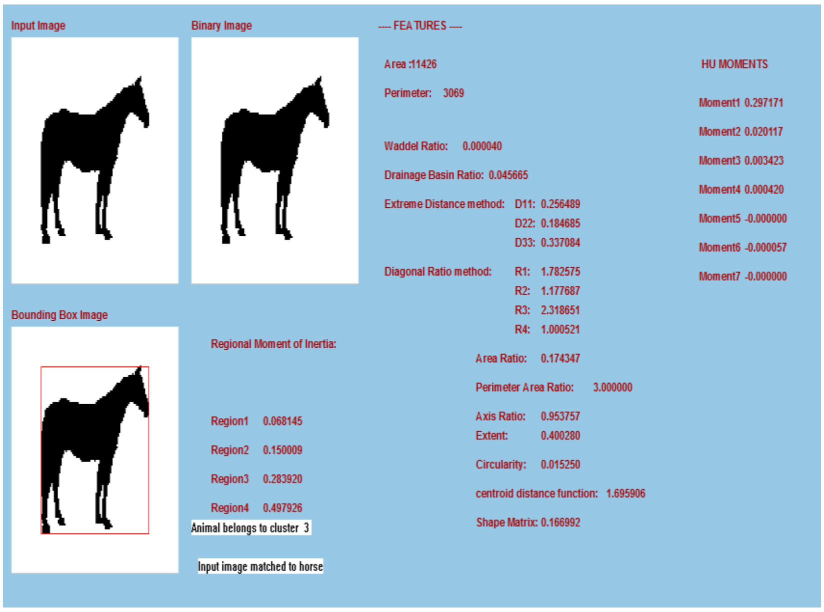

Fig 10(d) Identified animal: horse

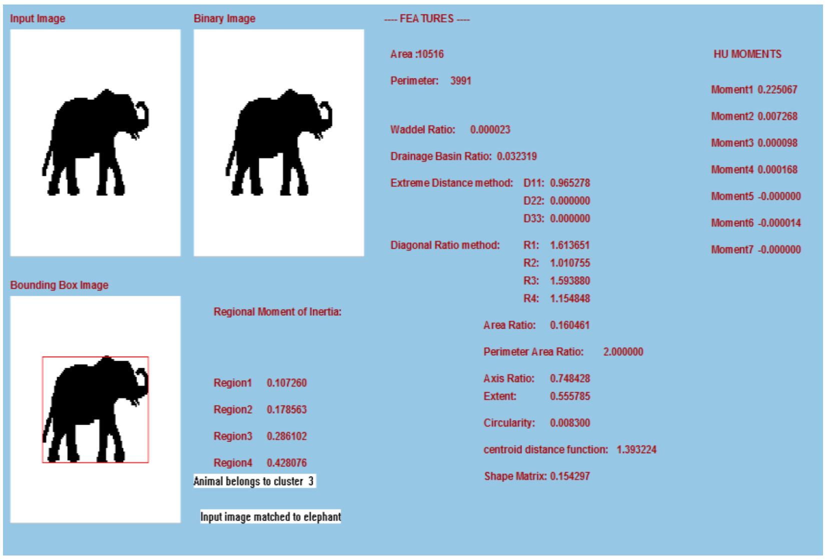

Fig 10(e) Identified animal: elephant

Figure (10a) Query Image containing 4 animals, 10(b-e) shows the results of identified animal

IV. CONCLUSION AND FUTURE WORK

In this paper of animal identification has been concerned with the two challenging steps in which are scale and rotation invariant retrieval of features and Identification. In proposed system different scale and rotation invariant features extraction methods those are describes the shape of the animal and moment invariants method are implemented. In Identification phase the K-means clustering algorithm is used to group the similar animals having the similar shape feature values.

The proposed methods restrict the animal identification to the simple animal with white background. Future scope is identification of animal with complex background, accuracy and performance improvement of animal identification.

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