Title of the Project: **BIRD CENSUS USING DIGITAL PHOTOGRAPH**

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**Introduction**

Bird census is an important area of study which cannot be ignored because of immense environmental value of birds as essential parts of the biosphere. Study of bird population is indicative of the environment they live in and the critical areas in conservation that must be taken into account. The data in the field of bird census has been managed and collected by bird watchers, park-rangers, environmental enthusiasts and ornithologists, manually, using techniques like: Sampling, Stratification, Grid based estimation etc. However, the results obtained are often either: over-estimated or under-estimated. These results are thus not consistent. The results are found to improve with training of volunteers through sample images. Photography has been a great asset in bird census, as it enables to see long term changes in scenarios and massive changes. There is also a higher degree of convenience for the observer since he can just focus his attention on capturing picture rather than counting the birds immediately, counting can be done after the survey ends. With the use of high resolution cameras it becomes easier to gather images, from a distance without disturbing the birds. The digital photographs which are too tedious for humans to analyse can be handled with the help of computer vision and image processing techniques. Satellite trackers give the output showing the locations the birds move to for the purpose of sea feeding. Transmitters are fitted on to the birds before they move to the sea for feeding. Trackers transmit signals which are detected by the satellites overhead. Even after existence of all these techniques available the problem of needing an experienced expert, for estimating the correct bird count prevails. Our project aims to solve the same through achieving a good degree of automation through software.
Objective

The primary objective of the project was to take a digital photograph as an input and output the estimated count of the number of birds present in the bird flock. This has been implemented in python (considering it is an open source programming language), using the knowledge from the domains of machine learning and image processing. The packages used for implementing the same include: pandas, scipy, skimage, open cv, matplotlib etc. Towards the end of the project we were able to successfully apply three techniques the first two being Morphological techniques and Haar-Cascades the third technique being image kernel in which we used extensive techniques of matrix manipulation. One of the underlying agendas of the project was to make use of the fact that this process is not fully automated meaning that there is anyways the presence of a technical end user who can ease the process of computation by using his inherent knowledge of birds and identifying a few instances on behalf of the machine because otherwise it would become the need to write a classifier for each specie, which again is a costly task, both in terms of effort and funding, hence we make use of a user interface so that the user can participate to a great extent in the pre-processing phase. Later on when the machine knows of what a correct instance of a bird looks like in terms of vectors, it becomes easier for it to just interpolate the given space and match similar instances based on the similarity parameter decided by the user. The lessons learned during the Morphological operation were used extensively during defining the parameters which define similarity parameters some of them being max pixel values, min pixel values, first two maxima’s in the histogram denoting pixel presence, grey-scaling, thresholding, watershedding and a few more. The knowledge of Haar-cascades was useful in understanding how features are extracted from a group of pixels and how can we generate xml data which may be later used in a model to provide it with the much necessary learning.
Methodology

We came up with a new idea to estimate the birds. In this technique, we select a block of image that potentially has a bird to compare with other blocks. We draw a rectangle on that region of interest and we take the coordinates of that region of interest that is called image kernel. By using these coordinates, we transform image into NumPy array which is basically an image in the form of array. Now, we have two NumPy arrays one is smaller array i.e., snapshot or region of interest or image kernel. One more is the larger array which contains original image. Considering one of the color channels to know the region of interest as there are three color channels red, green and blue.

Now, the number of blocks present in large image corresponds to number of image kernels that can be put in it. We subtract image kernel values (i.e. nothing but matrix) from the original image. Then, we consider the block with minimal difference. Hence, we get the original image with the region of interest with high probability of presence of bird.

But, this may depend on closeness of birds present, background colors. So, to pre-process the image we use various techniques such as grayscale processing, blurring, erosion and dilation, Contour detection, median blur, distance transformation, watershed algorithm. And, we use convex hull algorithm to detect the birds present in an image.

Pseudo-Code

The approach for achieving the desired goal is simple, we are interested in identifying the number of instances of areas of interest ,since, the baseline is that all the data structure we are dealing with are two dimensional arrays we need to identify matrices of pixel values which match with the desired area in the image and thereby count it. The pseudo code regarding the same is as mentioned below:

- Open the base image in a window where the user may interact with it.
- The user selects an area of interest by cropping the image subsection which is the region of interest (ROI), call this say, segment.
- The kernel which performs the comparisons between segment and base image starts at the top left and progresses left to right in the downwards direction.
- The origin from where the kernel starts iterating is determined through a random number generator, so that multiple instances are obtained.
- The pixel values of the segment and those of the base image where the kernel presently is (sub-section) are compared on the basis of matrix properties viz. maxima, minima, variance etc.
- The count value for all instances are calculated, finally we take a mean of all the predictions made so that error is minimized.
- The mean value of all iterations is our result

Some of the techniques used to pre-process the image to make it ready before being used for computation purposes are given below:

- Grayscale processing
- Thresholding
- Erosion and dilation
- Contour detection
- Median Blur
- Distance transformation
- Watershed technique
- Convex hull algorithm
- Image Kernel

Snapshots of the implementation
In [54]: gry = cv2.cvtColor(img, cv2.COLOR_BGR2GRAY)
disp(gry)

In [57]: gry, array(img erosion)
   ...: F = np.mean(gry)
   ...: w = 99 # np.max(gry)+np.max(gry)/2
   ...: resp, var(g)
   ...: if img.shape[0] :
   ...:     th = threshold(img, cv2.THRESH_BINARY_INV+cv2.TRESH_OTSU)
   ...:     disp(threshold)
Result and Conclusion
The following table explains the different techniques along with their description used and the associated errors. We can easily visualize the rule base derived from the pattern observed in the results, for an instance it is quite evident that the degree of error increases exponentially as the number of bird instances increases for manual method of prediction, because humans have heavy biases to numbers, hence, for 500 birds the prediction can lie anywhere between 300 to 700 which are both undesired cases of underestimation and overestimation, which we would like to avoid on all costs. In case of digital techniques it must be observed like conditions on ground may heavily affect the prediction results viz. image quality, the amount of light present depending upon the time of the day, clear background etc. Thus, each one has a specific set of parameters which will produce the ideal output; depending upon multiple rounds under each techniques has produced the following results stated below.

Table showing results and accuracies of various techniques learnt and implemented

<table>
<thead>
<tr>
<th>Sl.no</th>
<th>Description</th>
<th>Expected Output</th>
<th>Actual Output</th>
<th>Error (in Percentage)</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Wildlife Count (Human Estimate)</td>
<td>79 birds</td>
<td>69 birds</td>
<td>14.49</td>
<td>Fail (Overestimate)</td>
</tr>
<tr>
<td>2</td>
<td>Morphological technique</td>
<td>34 birds</td>
<td>28 birds</td>
<td>21.42</td>
<td>Pass</td>
</tr>
<tr>
<td>3</td>
<td>Haar-Cascade technique</td>
<td>18 birds</td>
<td>15 birds</td>
<td>16.66</td>
<td>Pass</td>
</tr>
<tr>
<td>4</td>
<td>Image Kernel technique</td>
<td>7 birds</td>
<td>6 birds</td>
<td>14.28</td>
<td>Pass</td>
</tr>
</tbody>
</table>

It must be noted that even though the experimental value of the error generated by image kernel technique and manual technique appear to be the same however the consistency in case of manual technique is absent.

**Scope for future work**

The project applies techniques of image processing to a digital photograph to estimate the birds in a given flock in a nesting colony or habitat at a given instance of time. We applied
multiple techniques in order to accomplish the above goal. In the morphological-operations technique we tried to reduce the birds into patches or blobs and tried counting these blobs based on area parameter. Another approach regarding the same was the use of custom Haar-cascades for the birds, which aimed at finding the most probable regions where a bird was present on the image, the predicted areas were then counted to obtain the bird count. In the image kernel technique, we are concerned with finding an area which is congruent or similar to the section made by the user and then interpolating the image area to find such similar instances, when such an instance is encountered the coordinates are recorded. Hence finally a mean regarding is calculated and thus the count-value error is minimized.

The future work might include the manual removal of background in a similar manner by selecting pixels to be removed while preprocessing. This would create a higher contrast between the region of interest and background and hence would increase accuracy. This can be also followed by multiple iterations of the frame interpolation in which the starting point of the frame coordinates can vary randomly and thereby multiple grids can be placed on the same image. This would ensure that all birds were considered while carrying out the process of counting and would also ensure that birds are not ignored if they happen to fall at the intersection of multiple grids. The mean count value for each grid layout can be used to ascertain the final output.