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Tiger Census Using Low Quality Foot Print Image

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Abstract *Today, bio-diversity in the world is reducing to an unpredictable level. Animals can be perfectly recognized using their footprints and numerous features contained in it can be used to support the identification of an animal. This is normally carried out at forest by a series of process. An animal census is a difficult job for the forest officials especially in counting the tiger number. Obviously, the conventional pugmark census could not live up to scientific scrutiny. It is difficult, timing consuming and it needs a minimum of three officials. All these shortcomings can be eliminated by our method. Image processing techniques are used for footprint matching and then the footprint image was matched with a data base. The analysis was done by either Forest officials or automatically by the system.*

Keywords *Biodiversity, Animal Footprint, Animal Pugmark, Forest, Counting Tiger, Footprint matching*

I. INTRODUCTION

For years scientists have tried to learn animals. This has been done to examine where they go in order to conclude why they go there [1]. One of the important animal species in the world especially in India is tiger because tiger is the national animal of our country. The world's biodiversity is now reducing in to an unpredictable level due to many reasons. The population of the remaining rare animals in the forests needs to be protected. Animals are normally identified by their foot print because the animal footprint is the unique identity of the animal world. Animal behavior study is important for the scientists and forest officials. Several techniques are available now to study the behavior of animals. Using the information that was found in a footprint was accurately classified as hoofed, padded or full print. The proposed method is safe and brilliant way to detect the presence of an animal in a place. Several features associated with an animal foot print are used to identify the animals.

Tiger census is usually carried out by pouring plaster of paris in the footprint pug mark that was seen in the forests. Then they collect these foot print clays next day. This process is repeated in the entire forest for a period of 3 to 6 months because most of the animals find the way in an unknown environment is the common task carried out by them. Footprint left by animal is not a perfect one. The foot print is usually dirty and partially visible. Animal foot print recognition can be done by software and it will solve many problems associated in this field of study. But this software must be cheaper. The number of foot print exists in an area gives the estimate of how many animals present in an area. The number and size of the blobs in footprint are the commonly used features to identify the animals. This can be effectively done with the use of image processing algorithms. "Fig 1" shows the rear side of the left leg of a tiger and the "Fig. 2" shows the pugmark image that was seen in a zoo.

Figure.1View of a Tiger Leg

Figure 2 Tiger Pugmarks

"Fig. 3" shows the pugmark obtained in the plaster of paris by the conventional method of tiger census. This image was collected from the database of the agencies related with this field.

Figure 3Tiger pugmark in plaster of paris

1. Tiger Census in India

Counting of tigers in India was carried out in three phases. This method was created by the National Tiger Conservation Authority (NTCA) & Wildlife Institute of India, Dehradun to follow the uniformly across the country. In India, tiger census is performed in every four years. Lastly, It was carried out in 2010 (before that in 2006). The Tiger Census of 2010 in India puts estimated tiger population in the country at 1636 (lower limit – 1571, upper limit – 1875). The population estimate for Tiger Census 2006 was total 1411 (lower limit – 1165, upper limit – 1675). The following are the facts about tigers [6].

- Tigers are the largest of the big cats.
- Wild tigers are at the very top of the food chain.
- There were originally eight subspecies of tiger,
- Extinct (Bali, Caspian and Javan tiger)
- Present (Indochinese, Sumatran, the Bengal, the Siberian,
- The South China tiger is believed to be the antecedent of all tigers.
- They are spread out across Asia and are thought to have originated from Southern China.
- A captive tiger can live up to 20 years, while a wild Tiger can expect to live 10 to 15 years.
- The Bengal tiger is found in Indian and around the Nepal / China border, it is the second largest of the subspecies weighing in at around 480 pounds, and is 9ft 5' long (average).
- The heaviest recorded tiger was a Siberian weighing in at an amazing 1,025 pounds.
- The Bengal tiger has the largest population with around 1411 (2011 estimate)
- The tigers saliva is antiseptic and comes in handy for cleaning their wounds.

- An adult wild tiger is a solitary animal and will establish its own territory, which can cover over 100 square miles. (Depending on the prey availability)
- A tiger marks its territory by spraying surrounding trees and bushes with urine, dropping prominently placed scat, and leaving deep scratch marks on tree trunks.
- A males territory can overlap several females territories.
- Tiger stripes are individually as unique as the human finger print. If you were to shave the fur from a tiger it would still have stripes.
- Tiger stripes act as perfect camouflage in tall weeds and grasses.
- The tigers most developed sense is its hearing.
- Success rate of a Tiger is one in every 20 attempts.
- Tigers main prey comprises of pig, deer and buffalo, but will also eat smaller prey such as rabbit and fish.
- A tiger can spend up to eighteen hours sleeping.
- Tigers can swim and like to cool down by sitting neck deep in water holes.
- The tiger's foot print is known as the pug mark, and its measurement is sometimes the only method of recording wild tigers.
- There are five toes on a tiger's forefoot and four on its hind feet.
- A tiger's night vision is six times greater than a human's.
- Adult tigers have thirty teeth.
- On average a tiger's tail is around four feet long or half the length of its body. The tail gives the tiger extra balance when running and is also used to communicate to other tigers.
- A white tiger is not an a lbino, all white tigers are believed to have descended from a single white Bengal male called Mohan.
- Tigers are an umbrella species, which means to save the wild tiger we must also commit to saving its habitat and prey.

2. Various methods used for counting tigers [7]

- Pug Mark Method: In this method, the pug mark i.e. the foot print of the tiger is important. It is considered that each pug mark is unique in itself & by analyzing various foot prints in the areas of tigers, the number of tigers in that area can be counted. (Note: Accuracy is not that good. It is the cheapest method available. It generates employment in the region by way of jobs for local people as volunteers for analyzing the tiger foot prints)
- Camera Trap: In this various method, cameras are installed in the tiger areas having night vision facility (the ability of the camera to record at night) as well. By recording various tigers in the camera, the number of tigers can be estimated. (Note: Accuracy is same as Pug Mark method but the labour survey done in Pug Mark method is minimized in Camera trap as there involves no use of people for surveys. It is more costly than Pug Mark Method. It doesn't generate employment in the local areas. This method becomes useless in areas having salty waters. It damages the camera)
- Poop/scat Method: In this method the number of tigers is counted by poop/scat (droppings of the tiger). The poop is analyzed by DNA sampling and then we can arrive at a more accurate count. (Note: It is not always that someone will get the poop of all the tigers in an area)
- Radio Collar Method: Tigers are captured in this method & are fitted with a radio collar. In this way the tigers can be counted. (This method fails when the concerned tiger enters the salty water)

The Disadvantages of the pug mark method are [10]

- Based on Enumerators Subjective Ability to identify individual Tigers from Pugmarks.
- Variation in Pugmarks with substratum, gait, and observers recording skills.
- Not possible to obtain Pugmarks from all Tiger Occupied Landscapes.

3. Why Saving Tigers is Such a big thing in India

Tiger has become a national symbol & hence India is in deep need to protect Tigers. It is not just about money, but it is matter of keeping human intervention sufficiently at bay [10].

- India has many challenges to ensure that balance is maintained between development and environmental ecology.
- Charismatic Large Carnivore at the Apex of the Food Chain.
- Acts as an umbrella species for conserving the biodiversity of forested ecosystems.

India's National Tiger Conservation Authority (NTCA) is now following through by establishing a country-wide database of wild tigers captured in camera trap surveys conducted by multiple research and governmental institutions at increasing intensity across the country. The objective of this project is to assign Unique Tiger Identification (UTID) numbers to a large sample of tigers. A major objective of the project is avoiding multiple counting of individual tigers in multiple areas, a problem that dogged the now defunct pug-mark tiger census method, which was finally abandoned in 2006 in favor of camera trapping. Another key objective is to ensure that the rigorous protocols for assigning unique IDs are followed and that the origin of each camera-trapped tiger image is authenticated by responsible officials or scientists. This avoids the 'contamination' of the database through deliberate or accidental introduction of spurious tiger images of dubious origin. A third objective is to ensure that photo capture dates and locations are entered accurately, to facilitate rigorous analyses of the data [8].

"Fig. 4" shows the basics steps involved in the general observation system that consists of a camera to capture the foot print image and some significant steps to pre process the captured image. The input image that comes from either wired cameras or wireless cameras. The major modules in the proposed system are the footprint detection, blob identification, feature extraction modules. The detection unit is mainly used to get the black and white image. To get high-quality outcome from tiger senses system, the algorithm used for these elements must be robust.

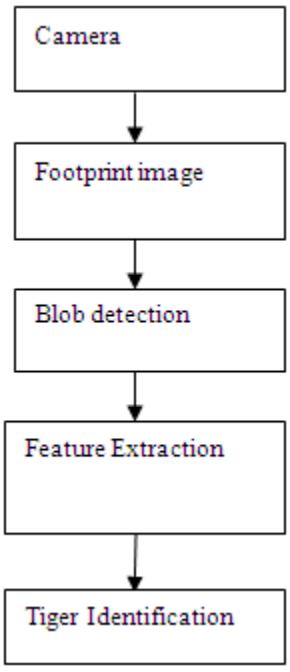

Figure 4 General Architecture of Tiger Senses System. (TSS).

The section II describes the main methods of tiger senses that can be incorporated with the proposed concept specified in this paper. Section III states the proposed method that was used for animal footprint detection. Section IV and V shows the results and conclusion respectively.

II. LITERATURE REVIEW

In 1932, the world?s first tiger census was carried out in the Palamau forests. It was based on a pug mark count, and is the system still preferred today for both tigers and leopards. This is not because it is considered accurate, but because it is the best of a limited choice of options. The 'pugmark census' was invented

in 1966 by Indian forester S.R Choudhury. In this method, during a 1–2-week period, thousands of personnel would simultaneously fan out across India to search for tiger tracks. They were expected to locate tiger tracks and obtain plaster casts or tracings of the left hind pugmark.
Pugmark method of counting tigers leaves some loopholes in the process. The pugmarks collected would be later compared to identify individual tigers relying on perceived differences in shape and other measurements. These 'individual tiger identifications' would be then refined through cross-comparisons among census blocks, reserves and larger regions to obtain 'reliable estimates' of wild tiger numbers in India. The pugmark method was questioned by scientists, who pointed out that the following assumptions must hold true for the pugmark method to be statistically valid [9].

- The entire potential tiger habitat in India had to be effectively covered during the pugmark census.
- All the four paw prints of every individual tiger in the surveyed area had to be detected during the censuses.
- The same hind pugmark of each one of these individual tigers must be lifted from suitable and comparable substrates or from standardized soil track-plots.
- The shape of each pugmark lifted had to be recorded without distortion by the thousands of census personnel involved in the operation.
- Supervisory officials were expected to be subsequently able to segregate the pugmarks of each individual tiger correctly, based on footprint shape, track measurements, and prior local knowledge.

Failure of assumptions 1 and 2 would lead to under-counts; failure of assumptions 3 and 4 would lead to over counts; and failure of assumption 5 could lead to either undercounts or over counts. Unsurprisingly, the 'pugmark census' could not live up to this scrutiny.
The following are some of the relevant methods of identifying the tiger using tiger footprints. Parameter such as total tiger count, life time can be determined using an intelligent system. The researchers working in this field are concentrating to build the verity of algorithms for tiger detection based on foot print either manually or automatically.
Yuan et.al. [1] used footprint identification techniques in order to track and record rat species in New Zealand. Their motivation was that three rat species dominated the island, caused extinction of other species and caused devastation in their wake. The use of footprint recognition had to be used because, distinguishing different species would be difficult due to the similarities between the footprint. The techniques they have used are broken into four categories: (i) track acquisition, (ii) footprint template extraction, (iii) template matching and (iv) template updating.
An attractive point mentioned regarding template extraction was:"A large number of templates will dramatically increase computation complexity, while a small number might not be sufficient" [1]. They illustrated two techniques for template matching: (a) binarization and (b) segmentation. Binarization was used to obtain a threshold value and change the image to black and white. This was to ensure that, footprints would be visible. Segmentation further segmented the image by distinguishing pad prints from toe prints. In this way the distance between toes could be calculated to conclude which species of rat was being tracked.
Hasler et.al. [2] used footprint identification techniques to identify rat, mouse and insect tracks in New Zealand. The aim was to use their findings to determine the amount of this pest to eradicate. They also exclusively used tracking tunnels to obtain their footprints. Two classification methods were used for the study: a simple Naive Bayes Classifier (NBC) and the Principle Component Analysis (PCA). It was found that the PCA performed better than the NBC, but a combination of both methods performed best.
Riorden [3] used a neural network based method called the Kohonen self-organizing map and a Bayesian method called AutoClass to assess the footprints of captive tigers and snow leopards under standardized conditions. Auto Class was found
to be more successful although it had a greater accuracy for identifying tigers. It was also found that the self-organizing map did not provide accurate classification of either animal.
Geng et.al. [4] demonstrated a rule-based method for automated footprint recognition which was used to classify small species. The first step used was the pre-processing. Rules for pre-processing included: if the point of interest contained a point which was smaller than 6 pixels it was removed, if an interest point fully contained another interest point then the outer interest point was removed and if an interest point A partially contained the interest point B, if the distance between their centres is less than 6 pixels then the previous rule is applied,

otherwise A is removed. Likewise rules are set for the matching of footprints against templates. The results of this technique were favorable having an 85.7% accuracy rate.

III. PROPOSED METHOD

Biologists have documented around one million species, which represent only 1–10% of all those on earth. The rapid increase of tiger in forest may create problems such as in balance in animal life cycle in the forest and the tiger attacks towards human life. Tiger population should be eliminated mainly in human territory areas to avoid tiger attack and thereby saving the human life. A well-organized system should monitor the presence of tiger in the prohibited areas. Based on the total time in which a tiger seems to present in an area of interest (ROI) can be taken as a serious problem. To protect endangered species and understand extinction threats, we need effective monitoring techniques [8], [9].

Tiger senses and analysis is a key area in the smart computer vision system for identification of foot print images in real-time. Nowadays the development of fully automated system is in use for the identification of tiger from the lively foot print images. The main requirements of this system for monitoring foot print images are good speed and accuracy.

These systems that are used for collecting, analyzing and recording of foot print image can deal some complex job such as animal senses. In the diverse use of computers, animal detection using foot print images are the famous areas in which the researchers are concentrated. Animals can be classified by monitoring and comparing the foot print images with data base. In the earlier methods, the forest officials have to identify the tiger with the footprint die that is collected from the tiger interacting areas. This method may give false identification.

Newer and more advanced methods are proposed to assess the tiger population and the results are shocking. Modern techniques like camera-trap capture–recapture surveys help estimate absolute densities of prey and tigers. The present large-scale, labour-intensive pugmark censuses can be modified into surveys of tiger-sign this involves merely recording the presence of tiger tracks and other signs under a rigorous sampling design. Such surveys will not involve the impossible task of individually trying to identify all wild tigers from track prints under field conditions. Our aim is to identify the individual tiger from their footprint image. For that, we have proposed two techniques one is based on image matching and second is based on blob identification [8], [9].

Binarization, Noise removal, Orientation checking and foot print matching are the normal steps performed in the proposed footprint matching method. In the first phase, Black and white footprint images are saved in a database after Binarization and noise cancellation techniques. In the second phase ie in the next census time, the newly collected footprint image after binarization and noise removal is compared with the database. In the second method, the footprint was identified with number of blobs that contains in the footprint image and the size of the blobs. Connected components concept in the image processing can be used to count the number of blobs and to measure the blob count contained in a foot print. But in this proposed work, the scope is limited to matching method of footprint identification. Solving of the blob method was left as future work. The prettiness of these proposed concepts are the applications of tiger identification using footprint can be solved effectively using a simple system from low quality footprint images. Image processing techniques using MATLAB platform was used to solve the proposed concept.

"Fig. 5 shows the basics steps involved in the proposed system that consists of a camera to capture the image and some significant steps are performed to pre process the video using the proposed algorithms.

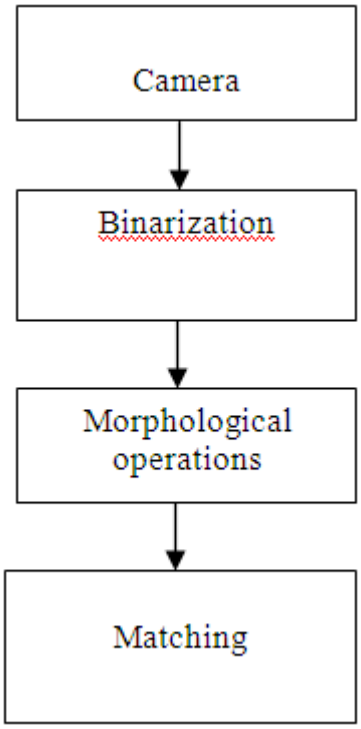

Figure 5 Important steps involved in the design of the proposed system.

1. Binarization

Many methods are available to binarize an image based on image processing techniques. By utilizing the benefits of threshold detection based on the pixel intensity, binarization was performed in this work. After binarization, the blobs in the footprint images are converted in to black pixels and the surrounding areas were seemed as white. To simply the steps, simple matlab function can be utilized to perform binarization.

2. Noise Removal

The noisy pixel that was present at footprint image after binarization can be clean out with the use of morphological operations. The noises are normally appeared as white pixels in background and black pixels in foreground. The morphological operations are to search the image with a simple pre- defined shape, illustrating conclusions on how this shape fits or misses the shapes in the image. Morphological operations consists of some structure elements like disk, square and cross shaped elements of 3x3 sizes. The essential operations of binary morphology operations are dilation, erosion, closing, and opening. Dilation operation enlarges the region, while erosion makes the region small. Closing operation is defined as performing erosion after dilation and it can fill the internal holes in the region. In opening operation dilation is performed after erosion and it can clear small portions that are just out from the boundary in to background. The mathematical operators "bwmorph" is used on each image frames perform erosion and dilation. The syntax of morphological operators in commonly used formats is given below. Assume that our current image or frame is stored in a variable (IMG1)

1. IMG2 = bwmorph (IMG1, YY)
2. IMG2=bwmorph (IMG1, YY, X)

Where IMG2 = Variable for storing O/P image, YY= Dilate, Erode etc, X= No of times the process is to be repeated.

3. Matching

In the footprint matching phase, the newly collected tiger footprints are compared with the database after simple pre processing steps based on image processing. If the new image is not matched with any one of the images contained in the database, the image is compared again with database with different orientation. These steps are repeated many times and the results is displayed. To orient the image in different position, two

vertical axis are created. This concept was implemented using image processing concepts. This orientation matching was also implemented using simple matlab functions.

IV. RESULT AND DISCUSSIONS

1. Footprint Image collection

Foot print images was collected from different agencies in kerala state those who participating the tiger censes. Recording of the latest footprint image is a time consuming process if we performed it in forests. For simplicity only one image is shown in "Fig 6".

Figure 6 Footprint Image of a tiger

2. Binarization

"Fig 7" shows the result of binarization. The white pixels and black pixels are associated with object blobs are the noisy pixels.

Figure 7 Results of Binarization

3. Noise Elimination

In "Fig 7" the white pixels and black pixels are associated with object blobs. These noise pixels are to be removed from the blobs. Noises can be removed using morphological operations. After these operations, the noise pixels are removed and the resulting frames are shown in "Fig 8".

Figure 8 Results after Noise Elimination

V. CONCLUSION AND FUTURE SCOPE

Nowadays computer based systems are used in almost all the areas of real life. Likewise such systems are used for the surveillance of animals in many sites. Animal census especially tiger census is important to preserve the population of tigers in the forest. The tiger census is normally carried out by a time consuming process of collecting the pug marked plaster of paris die from the forests. The proposed concept is to make a foot step to design automatic but to simply the existing method of tiger census with the help of computer and associated software. Two concepts are proposed in this paper based on footprint matching and blob identification. In future, the blob concept can be utilized to identify the tiger based on connected components and central vertical axis. The attractiveness of the future concept is that, it can perform the tiger census in a very efficient manner.

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