Rensselaer

Department of Computer Science, School of Science

Course : AI for Conservation (CSCI 6965)

Homework 01

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Homework 01 : CSCI 6965 – AI for Conservation

Question 01 : What are a few of the advantages and disadvantages of using camera trap images, especially in comparison to images from hand-held cameras taken by volunteers?

Answer : Camera traps are the image-based stationary sensors that provide close-range continuous monitoring over long time scales, which are designed to mitigate the labor-intensiveness and reduce time-consumption of the data collection method carried out by humans (using hand-held cameras). The biggest advantages of using camera traps include : (1) continuous surveillance of wildlife without causing any disturbance, (2) collection of large amount of data over an extended period, which allows researchers to analyze long-term trends & behaviors, and (3) ensuring standardization & consistency in data collection protocols across different locations and times (which is very challenging to achieve with volunteers using hand-held cameras). Apart from these, camera traps are inexpensive, easy to install, and sufficient to specify animal species, sex, age, health, behavior, predator-prey interactions. There are some disadvantages of camera traps; mainly related to (1) technical issues such as battery failures, memory card issues, triggering errors (resulting in loss of data collection), (2) need of proper annotation and validation for the huge quantity of images. Another disadvantage is limited field of view, which may miss certain wildlife behaviors or species that are not within the camera's range.

Question 02 : What are some of the difficulties of using satellite imagery to count animals?

Answer : Despite having the advantages of continuous large-scale coverage and reduced disturbance to wildlife, satellite imagery has some difficulties when it comes to count animals; such as :

1. Counting individual animals from satellite images becomes challenging due to the occlusion caused by vegetation, since small animals may be hidden by obstructions like trees, rocks, or other structures.
2. Satellite imagery typically has limited spatial resolution, meaning that smaller-bodies species or those clustered together may not be accurately distinguishable (i.e. countable), especially in densely populated areas.
3. Some animals have natural camouflage that blends with their surroundings. Satellite imagery may not capture/distinguish these animals well.
4. Satellite imagery is not an effective approach to counting animals that live underground. Also, as it primarily depends on natural light, it is difficult to count nocturnal animals accurately.

Question 03 : Why is identification of species easier than identification of individual animals?

Answer : Identification of species relies on certain physical or genetic characteristics, such as color patterns, size of a particular organ, which are consistent among the animals of that species; whereas identification of individual animals requires identifying distinctive body patterns of that individual which can be very subtle and difficult to distinguish. For instance, compared to Plains zebras, Grévy's zebras have narrower stripes on their faces, larger ears combined with a longer neck – based on these physical traits, Grévy's zebras can be identified. On the other hand, each zebra has distinctive stripes, which is why without having sufficient records of the stripes of any particular zebra it is very difficult to accurately identify an individual one (e.g. if a zebra's stripes has only been recorded from the left

side, it will not be possible to identify that zebra from its right-side stripes). Another important fact is, although species have distinctive features, individuals within species share similar behavioral traits, characteristics, making it very challenging to differentiate them solely based on physical traits.

Question 04 : In the era of big data, why is the use of domain knowledge/ecological expertise still important?

Answer : In this era of big data, the huge amount of data is processed using Machine Learning (ML) & Deep Learning (DL) models, which are designed to follow black box approach and learn correlations from data directly without any domain knowledge; such ubiquity & universality often cause negative impacts on the performance, which is why we need 'hybrid models' that bridge ecological expertise & data science, to improve the performance. Incorporated with ML & DL, domain knowledge/ecological expertise not only facilitates efficient model learning and interpretability but also constrains solution spaces, mitigates data limitations, and fosters interdisciplinary research, ensuring the ML models are relevant, adaptable, and aligned with the goal of impactful ecological preservation. An example of such hybrid models is Context R-CNN [1] for animal detection and species classification; which has increased mean species identification precision in the Snapshot Serengeti dataset [2] by 17.90%.

Question 05 : Find an issue / idea / technology discussed in the paper that we have not discussed by the end of class on Thursday. Explain the issue and explain some beneficial and harmful concerns associated with it.

Answer : The paper discusses about the implementation of the Microsoft AI for Earth MegaDetector as a powerful tool for global-scale human, animal, and vehicle detection in camera trap data for wildlife conservation; which has been adopted by various organizations, including the Wildlife Conservation Society, San Diego Zoo Global, and Island Conservation. While the highly-successful open-source AI tool provides several benefits, there are also few potential drawbacks and ethical concerns associated with its widespread implementation. The biggest advantage is the complete automation in analyzing majority of the images (9.5 million out of 11 million), which would take roughly 5 years manually. Another major benefit is the labeling cost reduction to 50%, reported by the Idaho Department of Fish and Game. Other advantages include efficiency of processing large-scale data, real-time detection of threats to wildlife, estimation of wildlife population. In terms of potential drawbacks, these can mainly be privacy related issues and ethical concerns. Apart from these, the MegaDetector may not always be perfectly accurate and can sometimes produce false positives or negatives, which might lead to missed threats or unnecessary interventions. But overall I view this as a highly successful venture in terms of automating the wildlife conservation process and reducing human labors.

REFERENCES

[1] S. Beery, G. Wu, V. Rathod, R. Votel, and J. Huang. Context RCNN: Long term temporal context for per-camera object detection. In 2020 IEEE Conference on Computer Vision and Pattern Recognition (CVPR), pages 13075–13085, 2020.

[2] A. Swanson, M. Kosmala, C. Lintott, R. Simpson, A. Smith, C. Packer. Snapshot Serengeti, high-frequency annotated camera trap images of 40 mammalian species in an African savanna. Scientific data, 2(1):1–14, 2015.