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HOTSPOTTER: LESS MANIPULATING, MORE LEARNING, AND BETTER VISION FOR TURTLE PHOTO IDENTIFICATION

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The value of individual animals in research increases with the ability to identify each one from other individuals in the population. Individuals are often identified through markings, yet these may impact animal behavior and physiology. Photo ID (PID) has successfully been used to evaluate population dynamics, growth rates, behaviors, and movement in many animal studies, yet only recently emerged in sea turtle research with several studies still reliant on manual photo matching. Turtle studies using computer-assisted programs to match photographs have reported four common challenges that reduce efficiency and viability. These are: 1) the requirement to acquire clear, high-quality images at restricted angles, 2) time-consuming pre-processing of photographs before submission to the database, 3) the potential for high numbers of false matches in program outputs, and 4) the requirement for manual verification of many potential matches provided by the program. The computer vision program HotSpotter (HS), developed for PID of the Kenyan population of Grévy's zebra (*Equus grevyi*), works by

localizing and matching SIFT keypoints using the Local Naive Bayes Nearest Neighbor search algorithm. We used HS to build a database of hawksbill photographs taken in-water during 2014 and 2015. We trained the program by submitting multiple photos of the head and both faces, and queried the program for matches. Initially, whether matches were found or not found, we labelled all photos from a single individual with that turtle's ID number until all photos from 2014 and 2015 were identified and the program trained for all individuals from those years. In 2016, we photographed, captured, and tagged turtles. Tags provided a positive measure of some individuals. Some turtles were photographed, but not captured for tagging. We then tested the database by submitting several head and face photos from each individual photographed in 2016, without providing tag numbers (if available). From each test a turtle ID number was returned and checked against the tagging record. For each query we visually inspected the top two results. If either of these was correct the query was marked as returning a correct match. We analyzed for 4 classes of results (true tag match, true untagged match, true negatives, and false positives). We developed a database of 251 images from 2014 and 2015 used to initially train HS. From June – December 2016, we introduced an additional 1,155 images to the database. From these, we used a small subset to test HS matching. Out of 58 tests, HS correctly predicted and matched 90% of queries, and incorrectly predicted only 10% of queries. Advantages of HS are that the time required to manipulate photos is greatly reduced from other programs, since it requires only inserting two points on each photo to generate a "chip" (the examination field), photos of low quality can be used, and photos taken from many different angles are of benefit in training the program to recognize individuals. Future developments will automatically orient the photo and generate the chip, allowing input of photos and matching processes to integrate without the need for user manipulation.

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