SEAL-IT: The Implementation of Pattern-Extraction Algorithms in a Computer-Assisted System for Photographic Mark-Recapture Analysis

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***Abstract*— In animal mark-recapture studies, the identification of individuals allows accurate tracking of distribution, and contributes to better estimates for management. Mark-Recapture Studies are effective when key points are detectable and feature matching is repeatable, making Harbor Seals a model organism due to their distinctive patterns. A program was implemented in Python for the pattern extraction and pattern matching of digital images of Harbor Seals. The Scale Invariant Feature Transform (SIFT) operator was used to extract distinctive features invariant to image scale and rotation. A created program implemented this algorithm along with the Flann Based-Matcher to develop a matching software capable of identifying *Phoca vitulina* based on spot patterns. The program using SIFT, when compared to ones implementing Speeded-Up Robust Features (SURF) and Oriented FAST and Rotated BRIEF (ORB), ranked highest when using the same database, and was the most efficient operator with 96% reliability.**

INTRODUCTION

To study changes in survival, reproduction, and/or movement in wild animals, methods for identification are needed for effective conservation and management. **[1]** Traditionally, this recognition has been accomplished by capturing animals and placing visible and unique marks on them, however, the possible animal welfare consequences and the difficulty and cost of doing so has lead researchers to search for and develop non-invasive techniques for individual recognition. One non-invasive method includes photographic mark-recapture techniques, or PMR, paired with photo-identification software. **[1]** Most photo-ID software, however, are ineffective in field studies because of two major limitations of the pattern-extraction component: scale and rotation variance. **[2]** This project aims to alleviate these constraints through the use of rotation and scale invariant algorithms. **[3]**

METHODS

Images of Harbor Seals were collected at Cupsogue Beach, NY for analysis of spot patterns. As shown below, a model image taken would show the ventral portion of the harbor seal clearly and an individual seal is depicted.

The OPENCV library was utilized to implement functions intended for the created program. Then, the SIFT (Scale Invariant Feature-Transform) algorithm was modified to remove the minimum extrema portion (light point detection) and focus only on maximum local extrema (dark point detection). As shown in equation (1), the modified extrema equation was intended to focus dark spots of the seal, rather than common deformities in images such as "sun spots."

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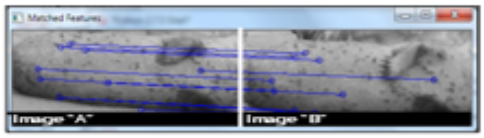
DISCUSSION/RESULTS

Using the modified SIFT algorithm, the program was intended to detect pelage patterns of harbor seals as unique identifiers for the images, as shown in figure (2). The new modified program also solved some of the problems of the SIFT algorithm, as the program was intended to solve the gaps of shape context, as well as specific trait attribution for photos. **[3]**

$$\frac{(\operatorname{tr} D(x,y,\sigma))^2}{\det D(x,y,\sigma)}, \quad D = \begin{bmatrix} \frac{\partial^2 \mathrm{DoG}}{\partial x^2} & \frac{\partial^2 \mathrm{DoG}}{\partial x \partial y} \\ \frac{\partial^2 \mathrm{DoG}}{\partial x \partial y} & \frac{\partial^2 \mathrm{DoG}}{\partial y^2} \end{bmatrix}. \quad (1)$$



(2)

Three popular algorithm/software used in mark-recapture studies (SURF, ORB, i3s) were compared with the modified program to test the accuracy and efficiency rates using the same images. For Statistical Analysis, two common biometric methods, False Acceptance Rate (FAR) and False Rejection Rate (FRR) tested the validity of the software and algorithms. Values of less than .05 were deemed significant. (*)

Comparison of SURF, SIFT, ORB, I3s		
Algorithms	***Accuracy Rate***	***Efficiency Rate***
Modified SIFT	95%*	96%*
SURF	65%	74%
ORB	45%	40%
I3s Software	40%	78%

Our results conclude that SIFT was more efficient and more accurate than SURF, ORB, and i3s when put under the same mark-recapture scenario. Using automated photo-identification techniques drastically decreases the amount of time spent manually identifying seals and allows more time for scientists to work in the field rather than conduct matching and analyzing images. As a result, photo-identification is a viable alternative to traditional methods for mark-recapture such as tagging.

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