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SCHOOL OF COMPUTER SCIENCE

PhD Defense

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DEEP LEARNING METHODS USING COMPUTER VISION METHODS FOR ANIMAL RE-IDENTIFICATION

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ABSTRACT:

Animal re-identification (re-ID) is fundamental to our understanding of community ecology, population dynamics and ethological analyses.

Currently, two methods for animal re-ID are successfully utilized. The first involves tagging/scarring animals, which is reliable, but expensive and invasive. The second involves the use of camera traps images/video placed at strategic locations to capture footage animals as they walk into frame. Camera traps are inexpensive by comparison, less invasive, however require an expert and has low-moderate reliability depending on the species and are subject to human judgment bias. Both methods have been utilized to perform formal mark and recapture studies to estimate population size. From planning to results, current surveys take approximately two years to complete, a delay that can have detrimental impacts by the time policy decisions are made.

Recent advances in the area of deep learning for computer vision offer a promising solution to improve upon the current methodologies for animal re-ID. The success of deep learning methods for human re-ID is well documented when ample training images are available for each individual. Despite this success, little has been done utilizing their capabilities for animal re-ID.

The task of animal re-ID provides an opportunity to improve upon current methods for animal behavioural analyses and monitoring ecosystem health, but it also provides the opportunity to explore how deep learning methods perform using real-world, often 'messy' data sets.

In order to implement animal re-ID systems in practice, deep learning systems must be able to accomplish a variety of computer vision objectives. These include: quantifying the number of animals in an image, classifying the animal species within an image, localizing and extracting animal individuals within an image, and lastly re-identifying animal individuals.

This work begins with a review of computer vision methods for animal re-ID (Chapter 2). I explore the quantification of animal individuals from images considering fish and dolphin counts in the Amazon River (Chapter 3). I demonstrate the success of deep learning methods considering species identification, strategies for handling class imbalance, and quantifying performance when testing on background locations that are included/excluded from training (Chapter 4). I demonstrate the ability of deep learning systems to classify and localize animal species from camera trap images considering three global environments (Chapter 5). I then utilize five animal individual data sets to compare the success and generality of similarity comparison deep learning methods for animal re-ID (Chapter 6). Finally, demonstrate these techniques in combination to successfully implement animal re-ID for an entirely novel study of *Octopus tetricus* social behaviour (Chapter 7).

This work describes the complete animal re-identification pipeline for ecologists to follow in practice, outlining expected accuracies and guidelines for best practices. It imprints results to the machine learning research community considering tasks relative to the under represented task of animal re-ID. This work provides details on the necessary components required to achieve real-time camera trap survey systems. Such systems would allow for results used for researchers or policy decisions to occur at a rate of days-weeks rather than years. Lastly, this work encourages the progress of interdisciplinary areas of science