

An automated approach for embryo morphokinetic analysis in small ruminants using machine learning and computer vision techniques

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Introduction

Assisted reproductive technologies have revolutionized the breeding practices for small ruminants, such as sheep and goats, by offering a more efficient and reliable method for proliferation of genetics from superior females. Yet, the success of these techniques relies heavily on accurate and timely embryo analysis, which has traditionally been a subjective process. Recently, embryo morphokinetic analysis has emerged as a new technique to determine the quality and developmental potential of embryos. Traditional analysis of embryo morphokinetics has been performed in time-lapse embryo systems, many of which are not available for use in small ruminant embryology. Thus, the goal of this study was to determine if machine learning and computer vision (ML/CV) could be applied to detect caprine embryo morphokinetic activity levels from short real-time videos. It was hypothesized that ML/CV will be able to detect differences in morphokinetic activity of these embryos.

Materials and methods

This study is comprised of 2 experiments and the following video and ML/CV techniques were the same for both experiments. A 30s video was recorded of caprine embryos using standard cell phone and microscope equipment. Each 30s video was recorded at 30 frames per second leading to a total of 900 frames for analysis (30 fps × 30 s video = 900 total frames). Object recognition and background image subtraction computer vision techniques were applied to videos to quantify action area pixel changes. In Experiment 1, action areas (n = 97) were used to identify individual embryos within each video and randomly generated control areas within each video that did not contain any embryos. Action areas for both groups were subjected to the background subtraction process to generate computer identified pixel changes for quantification of activity analysis. In experiment 2, action areas (n = 95) identified embryos from videos and were categorized into “transferrable” or “non-transferrable” groups for comparison of computer identified activity levels. The embryos were stage and quality graded by one experienced embryologist in accordance with the International Embryo Technology Society Standards. Data analyzed using ANOVA with a *P*-value of 0.05 for significance.

Results

Results from analysis are presented as (mean ± standard deviation) of computer identified activity levels derived from ML/CV object detection and background subtraction for action areas of real-time 30-second videos captured under the microscope. In experiment 1, there was evidence that action areas that contained embryos had greater identified activity (0.633 ± 0.2) than the control action areas, or those identified within the video where there was no embryo present (0.295 ± 0.2) (*P* < 0.05). In experiment 2, there was evidence that action areas that contained non-transferrable caprine embryos (0.706 ± 0.1) had greater computer identified activity levels than action areas with transferrable caprine embryos (0.553 ± 0.2) (*P* < 0.05).

Significance

Preliminary data suggest that there is evidence for machine learning and computer vision models to identify activity differences of caprine embryos from real-time video analysis captured on a smart phone connected to a microscope. As identified in current literature, embryo morphokinetic activity levels have been linked with metabolism and embryo developmental potential, and it is hypothesized that the computer identified activity levels of action areas in this study could be reflective of these changes. The increased activity levels of non-transferrable embryos could be reflective of a higher metabolic state of stressed embryos while the transferrable embryos are in a more quiescent state in these videos. Future work aims to collect more data, explore additional outcomes, and apply more advanced ML/CV techniques as it relates to embryo morphokinetic activity and analysis of small ruminant embryos.

