Better than the human eye – machine learning models to objectively analyze bovine embryo quality

C. E. Wells, BS, PhD; R. Killingsworth, BS, DVM
EmGenisys, 845 Texas Avenue Suite 4040, Houston TX 77002

Introduction

Machine learning (ML) is a type of artificial intelligence that allows software applications to become more accurate at predicting outcomes without being explicitly programmed. ML models use millions of parameters to detect patterns and generate algorithms which can provide image analysis and predictive output superior to the human eye. ML models offer value to many biological applications, including the evaluation and selection of bovine embryos in conventional embryo transfer (ET) and in vitro fertilization (IVF). The objective of this study was to train ML models to evaluate bovine embryo viability and test their prediction accuracy against known pregnancy outcomes.

Materials and methods

Thirty-second videos of 3,500 IVD and IVP grade 1 and 2 bovine embryos were recorded with standard video equipment during routine practice in field conditions. Up to 8 bovine morulas or blastocysts were present in each video, oriented with >10 um of space between each embryo. Embryos were transferred into eligible recipients. Pregnancy outcomes were confirmed with rectal palpation, ultrasound or upon calving.

Videoed embryos were identified with object detection techniques and "chopped" into a new video file with a single embryo per file. Eighty percent of videos were labeled as either positive (embryo established pregnancy) or negative (embryo did not establish pregnancy) and fed into 6 frameworks of convolutional neural networks (CNN). Each CNN used between 2,000,000-23,000,000 parameters to generate predictive algorithms. CNN were then tested on the remaining 20% of the data, in which they made a prediction on each video frame (30s x 15 fps = 450 frames per video). Predictions were stacked up and graphically represented as sigmoid curves. Results were then compared against known pregnancy outcomes to test prediction accuracy.

Results

Fifty-four percent of transferred embryos resulted in pregnancy. Twenty-eight hundred embryos were used in the training set and tested with 700 embryos, with known pregnancy outcomes. ML models generated varying predictions ranging from strong likelihood for negative outcomes, weak likelihood for negative outcomes, weak likelihood for positive outcomes and strong likelihood for positive outcomes. When thresholds were set to binary outcomes, Xception and MobileNet models performed with 85-95% prediction accuracy.

Significance

This data suggests ML models can be used to identify poor-quality embryos and aid in embryo selection decision making. As the models identify 17% of grade 1 and 2 bovine embryos to have a strong likelihood for negative outcomes, closely relating to published data suggesting 20% of transferred embryos are non-viable at time of transfer (Prien et al., 2015), these embryos can be discarded and the practitioner can elect to transfer only the healthiest embryos into recipient females and subsequently improve pregnancy outcomes of ET in beef and dairy cattle. Future work aims to increase training dataset to improve prediction accuracy and develop a user interface to enable on-site assessment.

