Chapter 8
A Comparative Study of Machine Learning Algorithms for Embryo Selection in In Vitro Fertilization

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ABSTRACT

Embryo selection plays a critical role in the success of In Vitro Fertilization (IVF), yet conventional methods relying on morphological assessment and expert judg-

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ment are often subjective and inconsistent. To address these limitations, this study investigates the application of machine learning (ML) algorithms for automated, objective, and accurate embryo classification. A comparative analysis was conducted on six prominent ML models: Support Vector Machine (SVM), Random Forest (RF), k-Nearest Neighbors (k-NN), Convolutional Neural Network (CNN), ResNet, and ConvNeXT. Publicly available datasets, including IVF time-lapse sequences and the Early Embryo Viability Assessment (Eeva) dataset, were utilized for training and validation. Evaluation metrics such as accuracy, precision, recall, F1-score, and Area Under the Curve (AUC) were employed to assess model performance. The results show that deep learning models, especially ConvNeXT and ResNet, performed better than traditional algorithms, reaching accuracy scores over 93% and high AUC values.

1. INTRODUCTION

In Vitro Fertilization (IVF) has come as a landmark development in reproductive medicine, and couples faced with the problem of infertility have got a new hope. Ideas and innovations Technological and clinical advances since the birth of the first IVF baby in 1978 have greatly enhanced treatment regimes, laboratory procedures, and outcomes regarding the number of babies born. Nevertheless, despite these breakthroughs, the cumulative live birth rate per IVF cycle is less than ideal. It remains at 20% to 30% on average in most parts of the world, again based on maternal age, clinical status, and the quality of the embryos (Yang et al., 2022). The Transfer of a viable embryo is one of the most strongly cited factors affecting the success of IVF, among the many factors that affect the success of IVF. Correct embryo selection increases the chances of implantation, minimizes the chances of multiple pregnancies, and makes the best use of resources for clinicians and patients.

Manual evaluation of embryos by light microscopy has traditionally involved subjective evaluation of stationary morphological features, including blastomere symmetry, cell fragmentation, and the developmental stage. More recently, in more advanced clinical practices, time-lapse imaging systems (EmbryoScope -, Geri -) have become available to track embryonic development dynamically regarding morphogenetic parameters. These tools offer valuable insights, but grading and ranking are subjective. Interpretation of embryonic characteristics is subject to inter- and intra-observer variation, and even between skilled embryologists, results may be inconsistent. Also, static measurements could miss minute-time aspects important to the embryo's viability. This subjectivity highlights the requirement for more standardized, reproducible, and objective methods of embryo assessment.