Classification of Fetal Images using Deep Learning Methodologies: The Smart Embryo Project *

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Abstract

This paper provides a technical report on the Smart Embryo project. The Smart Embryo project (Project code: KP6-0079459) combines computer vision, image processing, and artificial intelligence methodologies to classify and characterize fetal images for assisted reproduction applications

1 Introduction

Millions of children owe their existence to the advancements in in-vitro fertilization (IVF) technology. However, despite the lengthy and costly procedures involved, only one-third of couples undergoing IVF treatment successfully conceive a child. To address challenges such as age, embryo quality, and technological limitations, embryologists and researchers are actively seeking new tools and methods to improve outcomes. One such method introduced over a decade ago is time-lapse imaging incubators (TLI) as part of the IVF process. TLI captures photographs at regular intervals, creating a video showcasing the embryo's development. This technique allows for precise control over culture conditions while capturing and annotating key developmental events, known as morphokinetic parameters, such as cell divisions, blastocyst formation, and expansion.

Deep learning (DL), a subset of machine learning techniques, has gained significant traction in the field of computer vision (CV) and is recognized as the most successful approach. Convolutional neural networks (CNNs), renowned for their accomplishments in image classification tasks, have emerged as the dominant method in CV and have found widespread applications, including medical imaging. Over the past five years, there has been a growing research trend in employing DL for IVF-related applications [2]. In this paper, we present a DL model based on convolution, which is trained on a proprietary dataset to classify images of blastocysts, a crucial stage in IVF.

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2 Results

Preliminary results related to the Smart Embryo project were carried out during the period 2022-2023. Several CNN architectures were designed and applied to our dataset. Furthermore, transfer learning approaches have been also utilized. In 2023 a custom CNN that is based on the VGG architecture, was combined with two state-of-the-art DL models, to construct an ensemble learner that achieved satisfactory results [1].

In this paper, a custom VGG model with eight convolution layers, and five max-pooling layers, using the rectified linear unit function (ReLU) as an activation function, and three fully connected layers, is trained to classify blastocysts' images in terms of their quality. To study the generalization capabilities of our approach, 5-fold cross-validation is used. Four super-classes are formed to create a balanced dataset. The results are presented in Table 1 and Table 2.

Training Accuracy	Validation Accuracy	Test Accuracy
47.53	45.91	45.74

Table 1: Performance of proposed DL model: Accuracy

Precision	Recall	F1-score
0.45	0.46	0.45

Table 2: Performance of proposed DL model: Statistical measures

3 Conclusions

The main objectives of the Smart Embryo Project are the classification and the characterization of fetal images for IVF applications using SOTA DL and CV methodologies. Preliminary results show that DL models can achieve satisfactory performance. Future research includes the development of novel DL and ensemble learning approaches, utilizing transfer learning methods, and creating an application that will be tested in real-world case scenarios.

References

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