Deep learning-based automated robust system for predicting human sperm DNA fragmentation index

Determining the DNA fragmentation index (DFI) by the sperm chromatin dispersion test involves manual counting of stained sperms with halo and no halo, differentiating the degree of fragmentation of sperms. This can lead to biased results. Presently, automated detection involves the use of expensive microscopes with coordinating software. Our objective is to build a robust artificial intelligence-based solution to predict the DFI by leveraging human-annotated stained images to produce unbiased results inexpensively.

We obtained 24,415 images from 30 patients after the sperm chromatin dispersion using a phase-contrast microscope. Different approaches were explored to classify sperm appearance into binary (halo/no halo) and multi-class (big/ medium/ small halo/degraded/ dust) problems. Our approach consists of 1) Training and 2) the Prediction phase. The 30 patients' images were divided into training (24) and prediction (6) sets. A pre-processing method *M* was developed to automatically segment the images to detect sperm-like regions. It enabled efficient collection of fine-grained annotations which formed our training data used to train a deep learning model *C*. We assessed *C's* performance with multiple metrics including testing on images from multiple microscopes.

Binary and a multi-class dataset containing 8887 and 15528 cropped sperm image regions showed an accuracy of 80.15% vs 75.25%. The binary and multiclass dataset obtained an F1 score of 0.81 vs 0.72.

Confusion matrix for predicted and actual classes for multi-class approach where, small halo and medium halo confusion are highest

Our proposed Machine Learning model can standardize, reduce intra-observer and inter-observer variability, and aid in arriving at accurate results without using expensive software. The binary approach performed better with our model. However, the multiclass approach can highlight the distribution of fragmented and non-fragmented sperms.

DFI plays a vital role in predicting clinical pregnancy. Our AI model offers insights to determine the best sperm selection process for samples with their corresponding DFI. It provides accurate information about healthy and degraded sperms in a given sample thereby, attaining better clinical outcomes.