Phase Imaging with Computational Specificity (PICS) for Label-free Correlation of Sperm Morphology and Fertility Outcomes

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Fluorescence microscopy has been proven a valid method of classifying sperm [1] with different characteristics such as gender. However, as these techniques approach clinical use, it has been observed that they introduced an increase in oxidative stress as well as undesired bias due to the fragmentation of DNA. Because of the reduction of cell viability introduced by fluorescence-based methods, the use of intrinsic contrast has becoming more popular in the field. Quantitative Phase Imaging (QPI) [2], with its capability to operate on transparent samples without fluorescence, has emerged as an important imaging method for biomedical research in the recent years. We show that spatial light interference microscopy, a QPI method that can reveal the intrinsic contrast of cell structures, is ideal for the study of sperm. However, the analysis has often relied on tedious manual annotation or other ad-hoc image processing techniques. To enable high-throughput sperm quality assessment we propose a new approach to provide morphological specificity based on deep learning and an optimized U-Net architecture [3]. Specifically, our model performs semantic segmentation, categorizing each pixel in the phase image into four different classes (background, sperm head, sperm midpiece, and sperm tail) and giving us an estimate of their surface areas and cellular dry mass. We show that the model can achieve satisfying precision and accuracy and that it can be integrated within our image acquisition software for near real-time analysis.

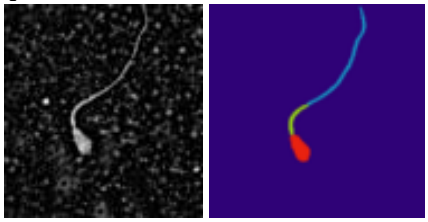

Figure 1 Left: SLIM image; Right: Automated segmentation output produced by our model on label-free data, showing the head, neck, and tail, with high specificity.

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