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Sperm Flagellum Center-Line Tracing in 4D Stacks Using an Iterative Minimal Path Method

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Abstract : Intracellular calcium ([Ca2+]i) regulates sperm motility. The analysis of [Ca2+]i has been traditionally achieved in two dimensions while the real movement of the cell takes place in three spatial dimensions. Due to optical limitations (high speed cell movement and low light emission) important data concerning the three dimensional movement of these flagellated cells had been neglected. Visualizing [Ca2+]i in 3D is not a simple matter since it requires complex fluorescence microscopy techniques where the resulting images have very low intensity and consequently low SNR (Signal to Noise Ratio). In 4D sequences, this problem is magnified since the flagellum oscillates (for human sperm) at least at an average frequency of 15 Hz. In this paper, a novel approach to extract the flagellum's center-line in 4D stacks is presented. For this purpose, an iterative algorithm based on the fast-marching method is proposed to extract the flagellum's center-line. Quantitative and qualitative results are presented in a 4D stack to demonstrate the ability of the proposed algorithm to trace the flagellum's center-line. The method reached a precision and recall of 0.96 as compared with a semi-manual method.
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