OmniBeat: A Non-invasive Visualization Platform of Cardiomyocyte Beating for Drug Screening

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Heart pumping is driven by cardiomyocyte (CM)contraction. However, there has been no direct approach to measuring CM beat. Fluorescent probes and electrical physiological techniques require expertise and harm cells. Therefore, we aim to develop a non-invasive and user-friendly video-based dynamic imaging toolkit to quantify CM beating status for future genetic or pharmaceutical screening. By focusing on cell morphology with Python, OmniBeat reveals subtle changes in cell behavior that are not detectable by traditional methods. It analyzes motion areas of each frame, calculates beating frequency and amplitude, visualizes flow directions with a color-coded wheel for representing motion characteristics, and generates videos that juxtapose original frames with motion analysis, which greatly improves screening efficiency and highlights the alteration of CM beating from baseline. It only takes 6 minutes to process 600 frames and gives analysis and comparison of all samples at once. The program can also perform global multi-point tracking of cell positions. We also cross-validate the performance of different foreground segmentation methods and prove the functionality of this method through intersection over union (IoU). The user can set the range of frequency and amplitude, the decay range and function, and score weight, and the program returns the score of all samples to achieve quick screening of drugs. Based on the output of the high-throughput analysis toolkit, we found that drug X has a significant effect on CM beating. Further studies have proved its functions on cardiac pacing. Thus, OmniBeat can be used to efficiently screen drugs. Additionally, it can be used to observe cell migration and IPSC-induced CM development, to achieve congenital heart disease mapping, etc.