Intelligent Acoustic Tweezer System for Characterizing Invasion Potential of Suspended Breast Cancer Cells

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The single-beam acoustic tweezer technique has been utilized as a promising tool for various biomedical applications. In this study, we demonstrate intelligent acoustic tweezers equipped with a fully-automatic deep learning-based calcium analysis technique for determining the invasion potential of breast cancer cells. We developed single beam acoustic tweezers with a focused high-frequency ultrasound transducer and combined with an epifluorescence microscope to monitor calcium changes in breast cancer cells with different invasiveness due to acoustic trapping forces. However, the conventional acoustic trapping systems offered only a manual method for the determination of invasion potentials of breast cancer cells. The manual method is too laborious and slow. Therefore, to shorten the analysis time for the determination of invasion potentials of breast cancer cells via better quantification of calcium intensity changes in the breast cells, a fully-automatic deep learning-based calcium analysis method was devised and applied to the acoustic tweezers. The deep-learning-based analysis method automatically segment cells, detect a trapped cell among the cells, track the trapped cell, and monitor its calcium response for the determination of invasion potentials of breast cancer cells in an acoustic trap. The results showed that the developed deep learning model outperformed other conventional deep learning-based models in cell segmentations. Also, it was found that the outcomes obtained by using the fully-automatic deep learning techniques have good agreements with the outcomes obtained by a manual method, demonstrating that the intelligent acoustic tweezer has potentials as a novel biophysical tool to fully-automatically determine the invasion potential of breast cancer cells in an acoustic trap.