Study of size-based isolation and detection of circulating tumour cells (cancer cells) using micro-fluidics and image processing

In recent years, micro-fluidics has offered an immense contribution in the area of circulating tumour cells (cancer cells) isolation from whole blood. The conventional micro-fluidic approaches utilize expensive and sophisticated instruments to fabricate micro-channels with precise geometry. At this juncture, a cost-effective and user-friendly fabrication method is required. In this context, a spiral micro-fluidic device has been developed, in this research, via laser-based machining. As an initial attempt, two different sizes (25µm and 10µm) of polystyrene micro-particles (by mimicking the size or dimensions of cancer cells and healthy blood cells) have been used for size-based isolation purpose. Inside the fabricated spiral micro-channel, the development of Dean vortices or counter-rotating vortices due to centrifugal forces not only has helped in isolation but also has reduced the effect of clogging. A 3D simulation study has been performed to understand the flow behaviour inside the developed spiral microchannel.

Post isolation analysis of circulating tumour cells (cancer cells) is also necessary as cancer cells are rare in peripheral blood. Image processing, in this regard, has become popular to analyse and identify cancer cells with the advancement of computing hardware and the machine vision algorithms, recently. Generally, the CTCs have been identified from stained blood sample images, where staining is costly and operator dependent technique. However, classification and detection of cancer cells from unstained blood from its microscopic images is still challenging. Therefore, in this study, an attempt has been made to classify and identify CTCs (cancer cells) using image processing. At first, classification between unstained healthy blood samples and blood samples spiked with cancer cells has been accomplished from their microscopic images. Image pre-processing based on unsharp masking and contrast limited adaptive histogram equalization (CLAHE) to enhance the cell boundaries has been performed. Then statistical texture analyses based on gray level co-occurrence matrix (GLCM) and run length statistics (RLS) have been used on pre-processed images for features extraction. Operating parameters of the texture analyses are adaptively selected for making this more operator independent. Fisher Discriminant Ratio (FDR) based feature selection has been used for overcoming rigorous manual feature selection, where eight features have been selected out of twenty extracted features. Then the eight features are fed to train k-nearest neighbour (k-NN), support vector machine (SVM), Naïve-Bayes classification (NBC) and LogitBoost classification models where 60% data has been utilized for training and remaining for testing purpose. These four machine learning methods have been compared on the testing data based on performance metrics i.e., accuracy, precision, recall and F1-score. SVM and LogitBoost classifier achieved the best classification accuracy. In the next step, detection of cancer cells has been performed on images classified as spiked blood sample or blood samples spiked with cancer cells, where edge detection based on ant colony optimization (ACO) has been used to identify the cell boundaries. Finally, circular hough transform (CHT) has been applied to detect cancer cells.