Tracking by Detection and Counting by Tracking of RBCs and Sperm cells in Imaging Cytometry

Naveen Paluru [1], Mohana Murali [1], Sai Siva Gorthi [2], and Gorthi. R.K. Sai Subrahmanyam [1]

[1] Department of Electrical Engineering, Indian Institute of Technology Tirupati, Andhra Pradesh, India – 517506

naveenpaluru95@gmail.com, dmmiitkgp@gmail.com, rkg@iittp.ac.in

[2] Department of Instrumentation and Applied Physics, Indian Institute of Science Bangalore, Karnataka, India – 560012

saisiva@iisc.ac.in

MedImage 2018

Introduction

- The count and properties of the cells in human body fluids provide vital information about health and are of key interest in bio-medical research. Specifically various morphological and photometric properties like size, shape and color or contrast of blood cells and flow velocity of sperm cells etc. play a major role in providing information about inflammatory process. The recent developing field in the cell imaging and microscopy is Imaging Cytometry (IC). The advantage of IC is that it has a very high throughput of the order of several hundred cells per second, as the (live) cells are imaged. As each instance of a cell is imaged, we propose that efficient tracking of the cells play a key role in enhanced feature extraction and classification in this setting. This further provides additional and complimentary information about the motion characteristics of the cells for better diagnosis.

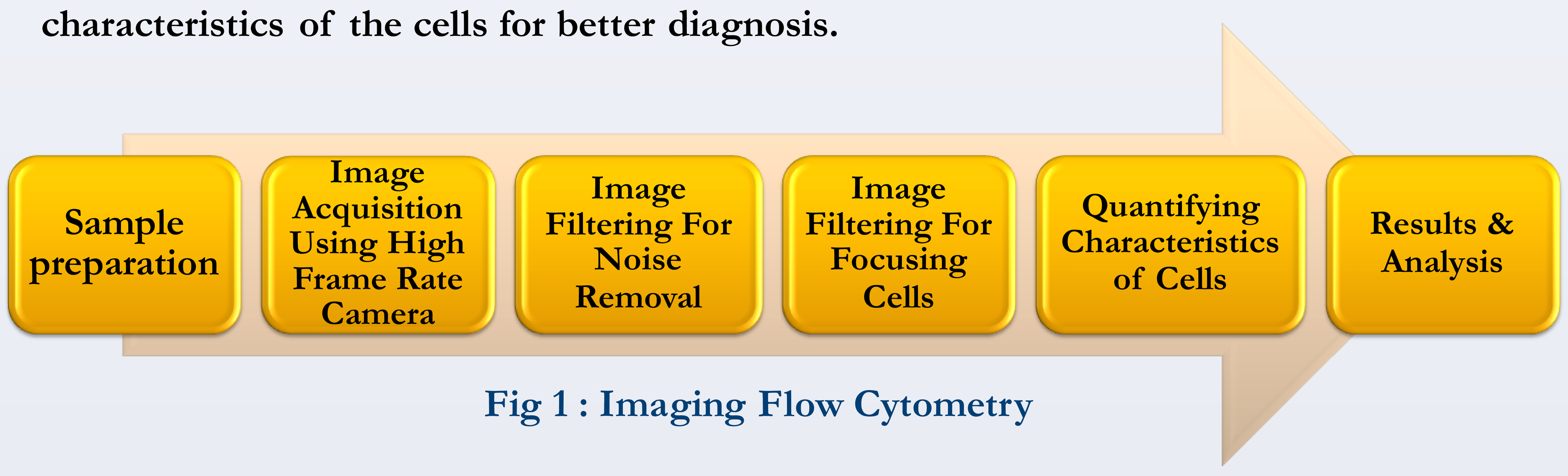


Fig 1 : Imaging Flow Cytometry

- We specifically, propose an extension of efficient and fast Kernelized Correlation Filter (KCF) referred to as "Discriminative Correlation Filter Tracking by Blob Detection" for multi-object tracking in this scenario along with an appropriate association mechanism for efficient tracking of RBCs and sperm cells.

Problem Definition

To identify and to localize RBCs and Sperm cells in the given video sequence.

- The sperm cells imaged by IC are shown in Fig : 2. Usually, these images have poor contrast due to low-level staining. This low contrast hinders the extraction of appropriate morphological properties of the cells and it makes image processing part for separating the cells from the background more challenging. In Fig : 3 RBCs (circled) undergoing deformation due to the presence of clump in microfluidic channel. This deformation boosts the velocity of RBCs and they finally overlap and settle down towards end of the channel.

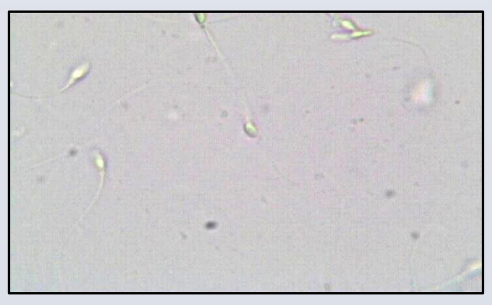


Fig : 2 Sperm cells imaged by IC

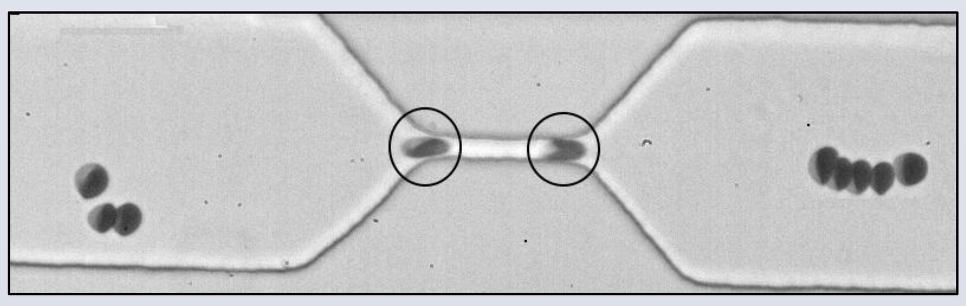
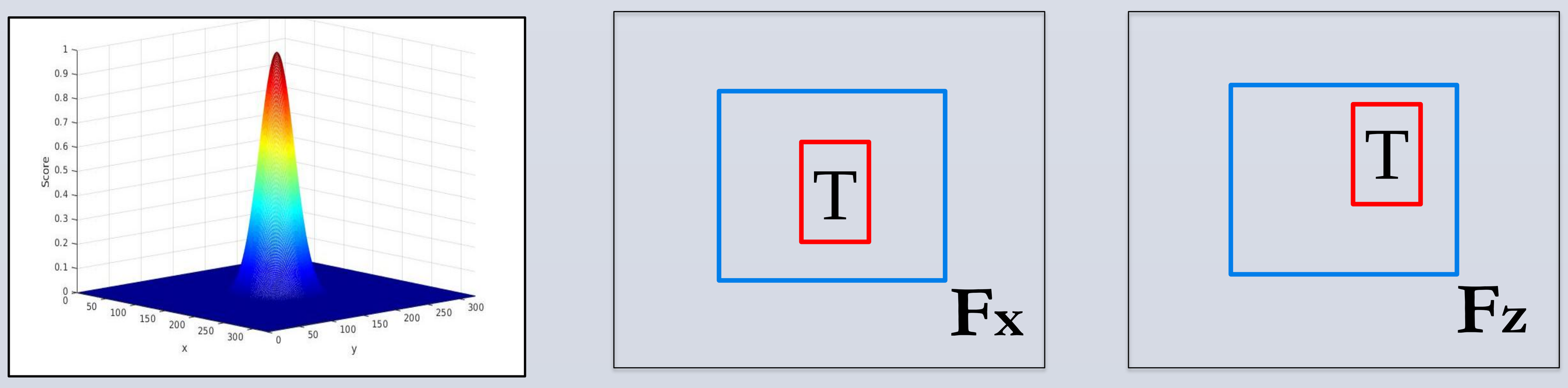


Fig : 3 RBCs Undergoing deformation in microfluidic channel

Building Blocks

Kernelized Correlation Filter (KCF Tracker) [.]



Gaussian Targets (Y) Frame ' n ' Frame ' n+1 '

Fig : 4 KCF Approach

$$\alpha = \frac{\mathrm{FFT2}(Y)}{\mathrm{FFT2}(K^{FxFx}) + \lambda}$$

$$\text{Response map} = \mathrm{real}(\mathrm{IFFT2}(\alpha \;.\!*\; \mathrm{FFT2}(K^{FzFx})))$$

- Henriques, J.F., Caseiro, R., Martins, P., Batista, J.: High-speed tracking with Kernelized correlation filters. IEEE Transactions on Pattern Analysis and Machine Intelligence 37(3), 583- 596 (2015)

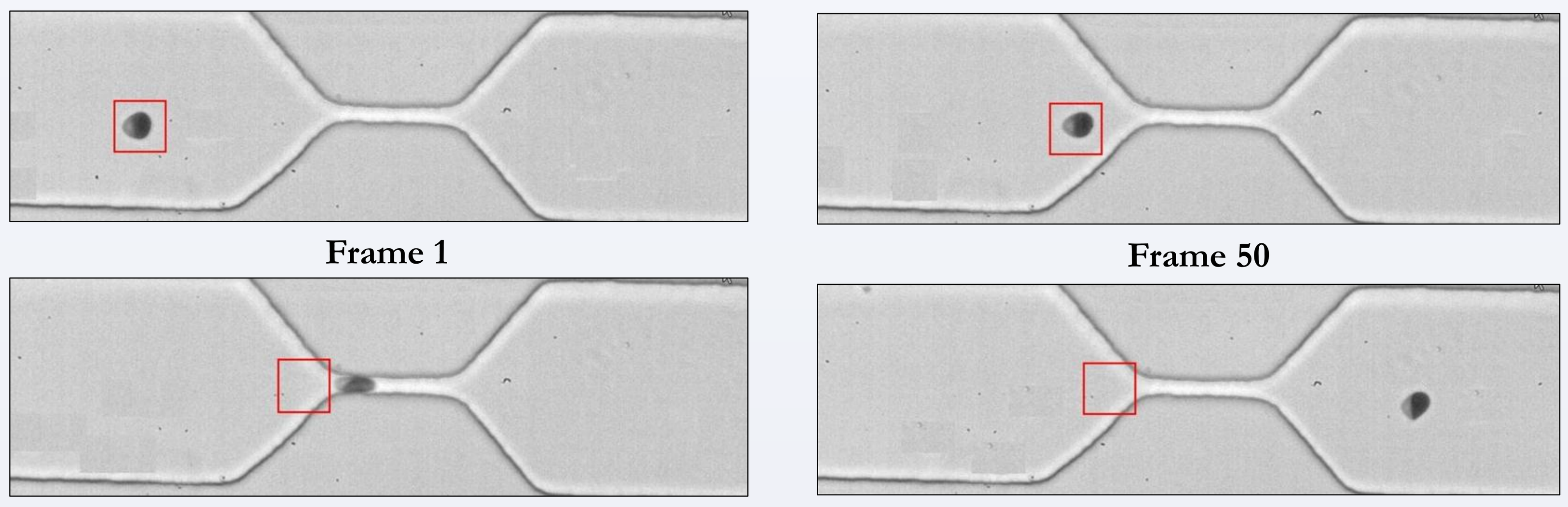
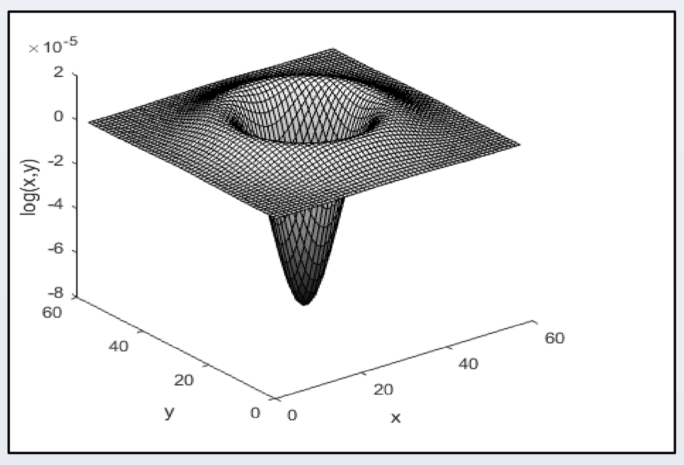


Fig 5 : Performance of KCF Tracker on single RBC

Blob Detector (Laplacian of Gaussian)



$$\mathrm{LoG}\ (x, y) = \frac{-1}{\sigma\pi^4}\left(1 - \frac{x^2+y^2}{2\sigma^2}\right)e^{-\left(\frac{x^2+y^2}{2\sigma^2}\right)}$$

Fig 6 : Laplacian of Gaussian

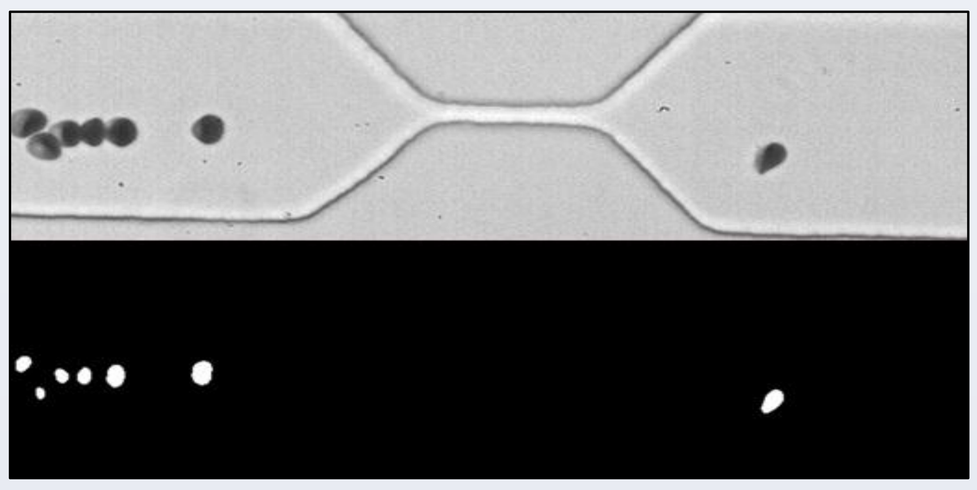


Fig : 7. RBCs(above) and corresponding detections (below).These detections are obtained by performing convolution between the frame and LoG filter of size 29x29 with sigma = 8.

Proposed Approach

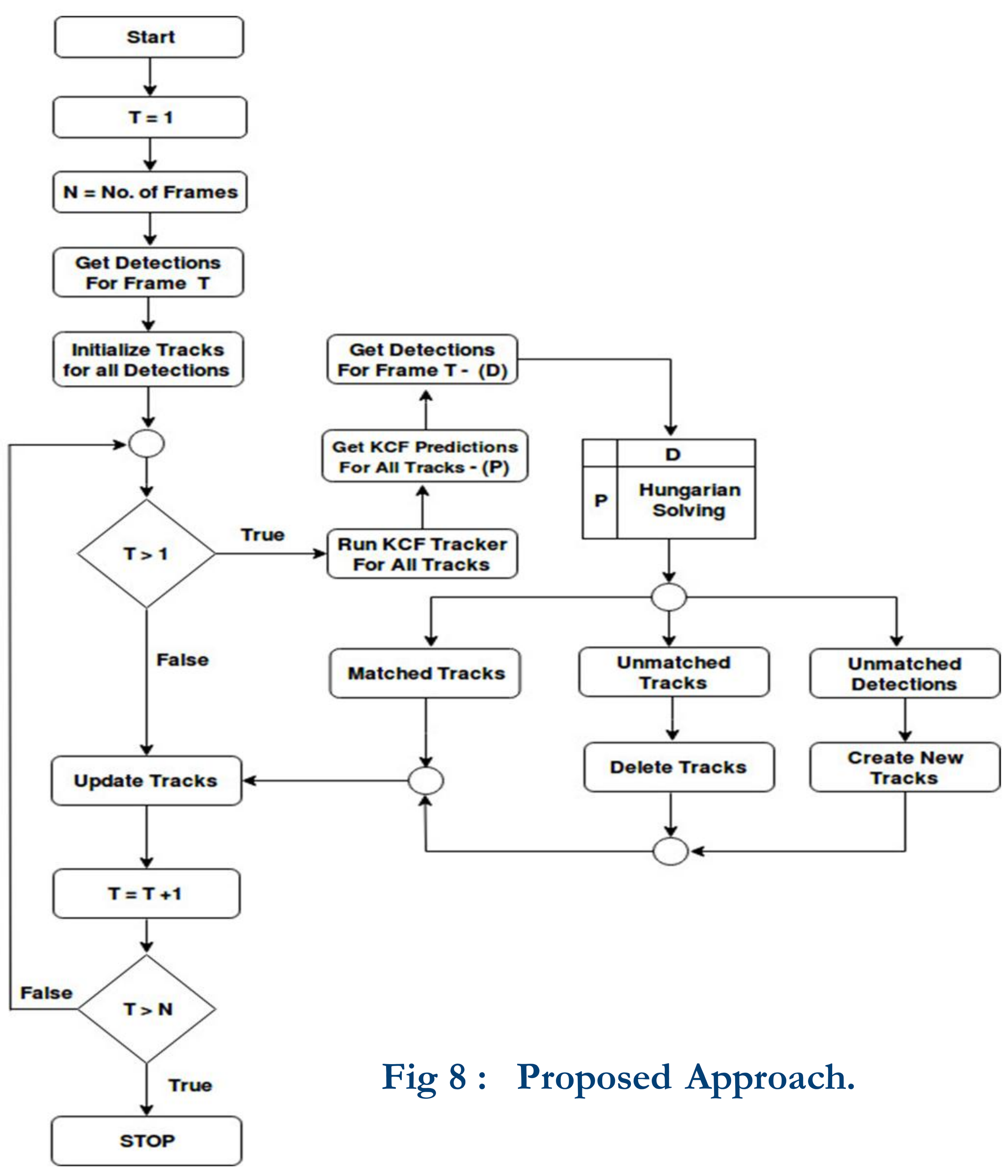


Fig 8 : Proposed Approach.

Results

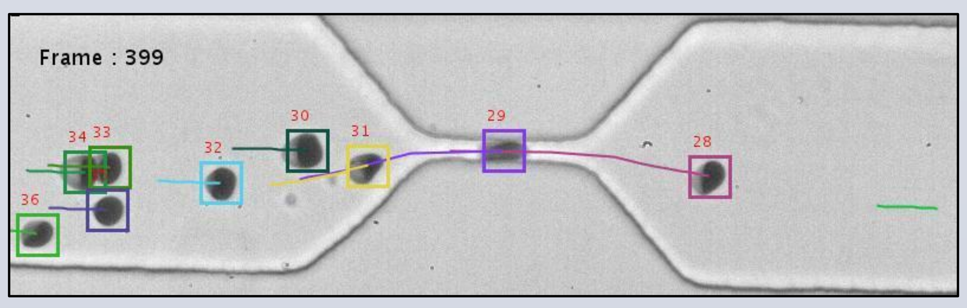


Fig : 9 Performance of proposed approach on RBCs

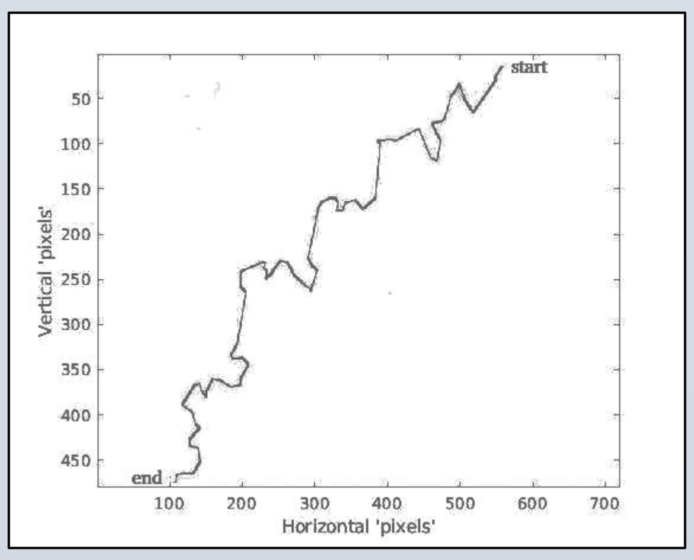


Fig : 10 Trajectory of Sperm cell 15 given by the proposed approach

Conclusion

- The count and properties of the cells in human body fluids provide vital information about health.
- A continuous track of the cell contains it's trajectory information, which can be used for evaluating motility parameters.
- To have a continuous track, Tracking by Detection mechanism can be applied, where the tracker and detector perform complimentary function i.e. when one fails the other takes care of the track.