An artificial neural network-based toolbox for the orphological analysis of red blood cells in flow

Marcelle Lopes, Stephan Quint

Cysmic GmbH, Germany
marcelle.lopes@cysmic.de, stephan.quint@cysmic.de

Abstract. We present a toolbox that combines image processing techniques with artificial intelligence to enable single-cell the detection and characterization of red blood cells observed in microfluidic flow. In healthy subjects, red blood cells show a smooth transition between an axis-symmetric ("croissant") and non-axis-symmetric ("slipper") shape depending on their flow velocity. However, in subjects with blood diseases this shape dynamics is disturbed and results in deviating blood flow properties. Current diagnostic methods rely on the identification of genetic mutations in addition to functional tests, including the manual evaluation of red blood cells in stasis. Although the latter technique is considered a clinical standard, it is not sufficient to discriminate between blood diseases and their severities. The automation of the characterization of images of single red blood cells in flow is an unbiased technique that could set new standards in blood disease clinical diagnostics. Considering the large variety of red blood cells shape deformations, we developed a semi-supervised neural network for a reliable and reproducible cell shape evaluation. By arranging ideal shapes as cornerstones of the training data set, cell shape transitions are self-learned during the training process of the neural network. This highly reduces the amount of required training data as well as the need for a manual pre-classification. Our approach , in addition to avoiding errors due to manually selected training data (supervised training), also enables the definition of custom thresholds and metrics for further discrimination and statistical analysis. The technique will be tested on blood of patients with inherited rare anemias, e.g., sickle-cell disease, as well as on transfusion blood and chronic and infectious diseases, such as COVID-19.

Keywords: Artificial Neural Networks, Variational Autoencoders, Red Blood cells, Blood disease clinical diagnostics