3D Blood Cell Prediction by 2D Microscopic Images

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Common blood-instruments such as haematology analysers or confocal microscopes are costly and time consumable endavours. To analyse properties of red blood cells (RBC) such as shape and volume, alternatively, 2D images of cells reconstructed into a 3D shape by a machine learning approach, can be a possible time and cost saving solution. The feasibility and accuracy of this approach is tested in this thesis.

Introduction and Objectives

Analysing blood cells and especially red blood cells (RBC) can yield important insights into the current health situation of a person. To measure important metrics of RBCs such as their shape, morphology volume, and haemoglobin concentration, modern and costly flowcytometries are used in state-of-the-art laboratories. To reduce costs and time, an automized microscope alternative at the point-of-care could be favoured that analyses the shape of an RBC based on a single microscopic image. The objective is therefore to present a method on how the real 3D shape of the cell and thus also its volume and morphology can be predicted, based on a single 2D image.

Methods

The SHAPR-Framework (Shape PRediction) provides an open-source package to predict the shape of single RBCs. The framework is trained in a supervised manner on multiple publicly available confocal images, thus RBC images with genuine 3D information, with differently shaped RBCs. As a result, multiple Generative-Adversarial-Networks (GANs) are generated to predict new cell shapes based on 2D images. These 2D blood cell images are provided by the Swiss Institute for Translational and Entrepreneurial Medicine (SITEM) together with the Human-Centered Engineering (HuCE) BFH institute and the Insel hospital.

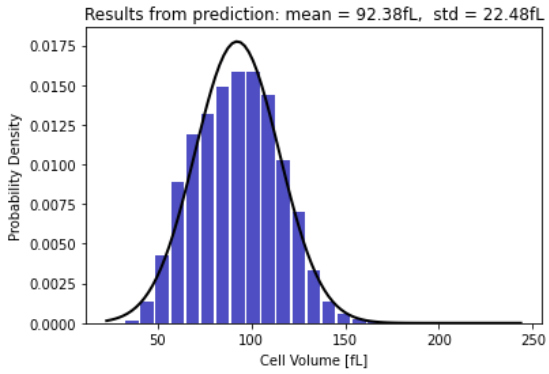

Figure 1: Normal distribution histogram of the predictions, where only discocytes were included in the training set.

These 2D images are pre-processed, before the GAN predicts their 3D shape. Over 10'000 RBC images are processed from one patient to compare the results with the mean volume and the distribution width of the volume (see Fig. 1), which are common metrics from flowcytometers used by hospitals.

Results

After the first prediction were generated, the cells did not resemble a typically „disk-like" shaped RBC, also called "discocyte". This is since in the training set, multiple RBC types were included, with different unhealthy shapes and sizes. That is why the training set was changed, so that only healthy discocytes were included in it. The results from the altered dataset show that the predicted mean cell volume of 92.38fL are in close agreement to the measured 91fL from the Insel hospital. The standard deviation, on the other hand, is nearly the double from the true value of 11.56fL, which may be due to the unprecise pre-processing in some images. Also, the predicted shapes resemble perfectly to a typical discocyte with thick edges and a flattened middle part, as seen in the cross-section in the figure 2.

Implications and Recommendations

The thesis shows that it is not only possible to predict the volume of the RBC accurately, but also the morphological structure of each cell. It is recommended to further validate the models with additional blood samples from other patients. For future work, the presented approach could be integrated in a small device for point-of-care diagnoses.

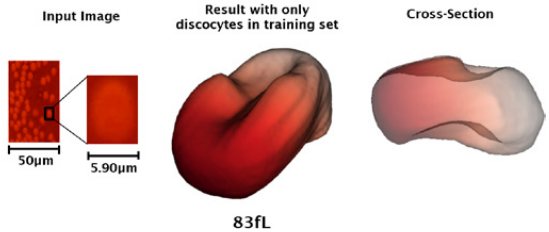

Figure 2: 3D shape prediction from an input image, where one pixel equals 75.5nm.

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