Automatic detection and classification of leukocytes by combining microscopy techniques with an artificial intelligence algorithm

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Disclosure: The study is a joint project with the company KML-Vision

Objective

We apply fluorescence techniques and machine learning to raise blood smear microscopy to a new level. In cooperation with the company KML Vision, we intend to apply AI algorithms to classify White Blood Cells into their respective subtypes and to establish advanced methods of qualitative and quantitative analysis to assess health states such as acute or chronic inflammation.

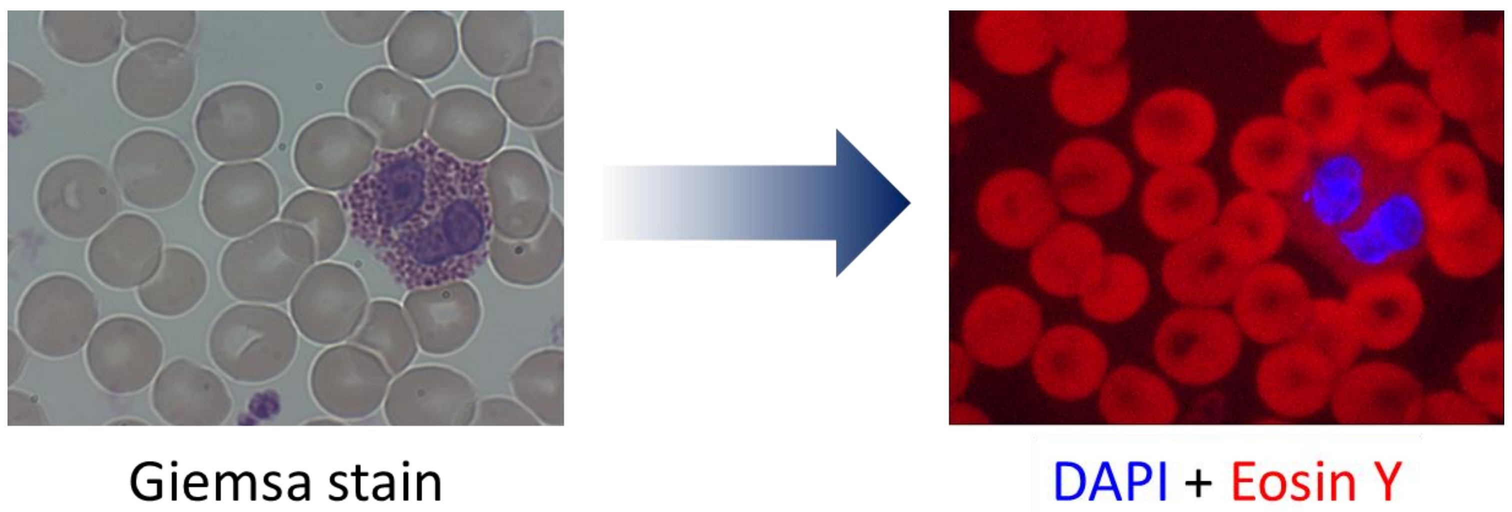

Figure 1. From traditional to fluorescence imaging

Methods

Blood is drawn from a healthy subject and smeared on a glass slide. The smear is fixed and stained with DAPI and Giemsa dye. The stained images are then imaged brightfield as well as fluorescence microscopy.

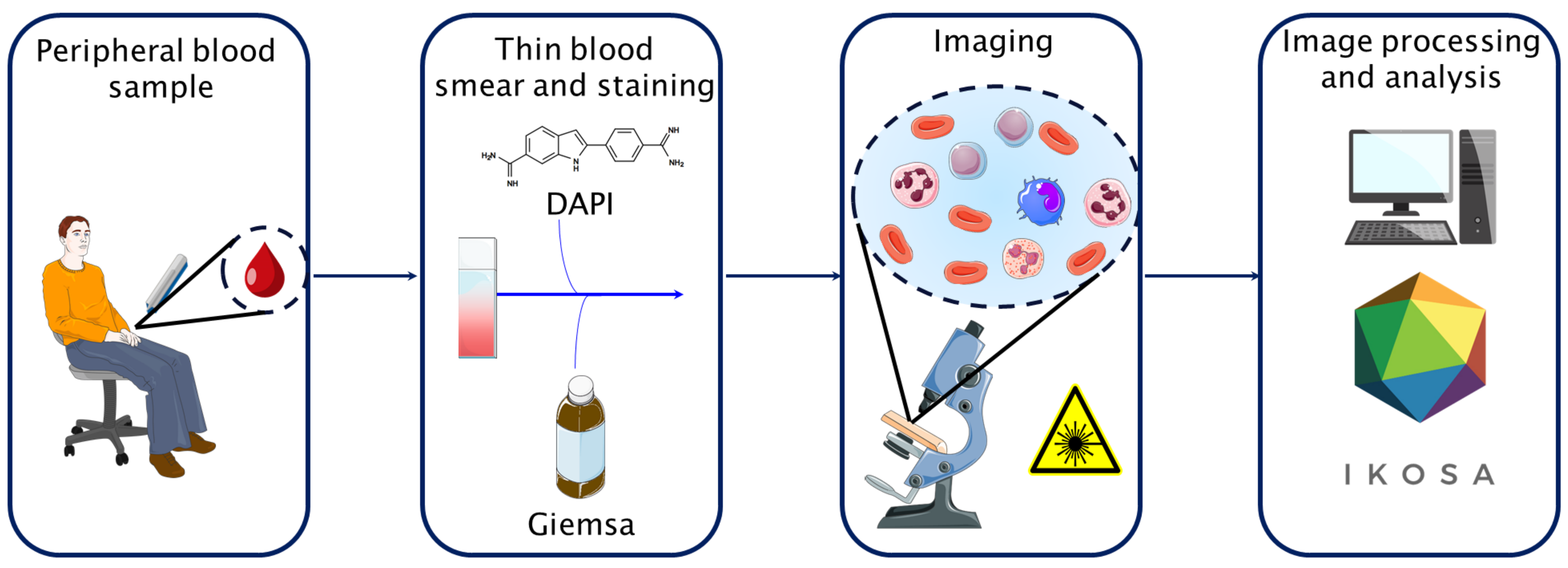

Figure 2. Simplified workflow

The set of images taken is composed of color and monochromatic frames (Transmission + fluorescence), which are captured by two different cameras. Which is why the image processing consists of resizing and matching the set of images before being uploaded to the IKOSA platform provided by our industrial partner.

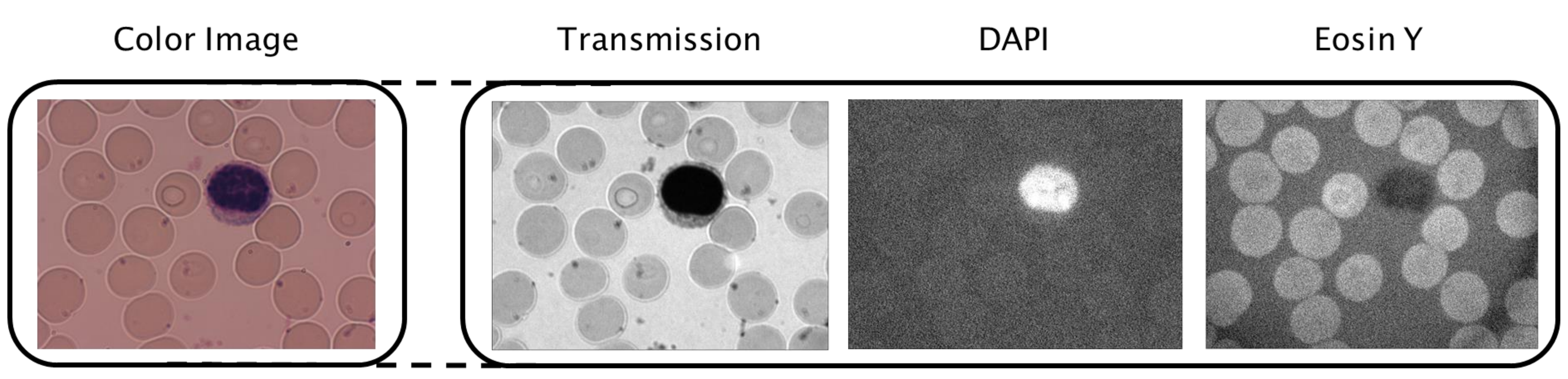

Figure 3. Image processing

The processed images are then used to train the AI algorithm. The training consists of annotating white blood cells, red blood cells, and platelets in all the images, teaching the algorithm the correct classification and then validating its learning with new images. With a ratio of 80/20 of Teaching/Validation images, the algorithm is trained to automatically detect the different types of blood cells. a) Color images, and b) grey scale brightfield images + DAPI and Eosin fluorescence were used to train the algorithm (with 2 types of segmentation procedures).

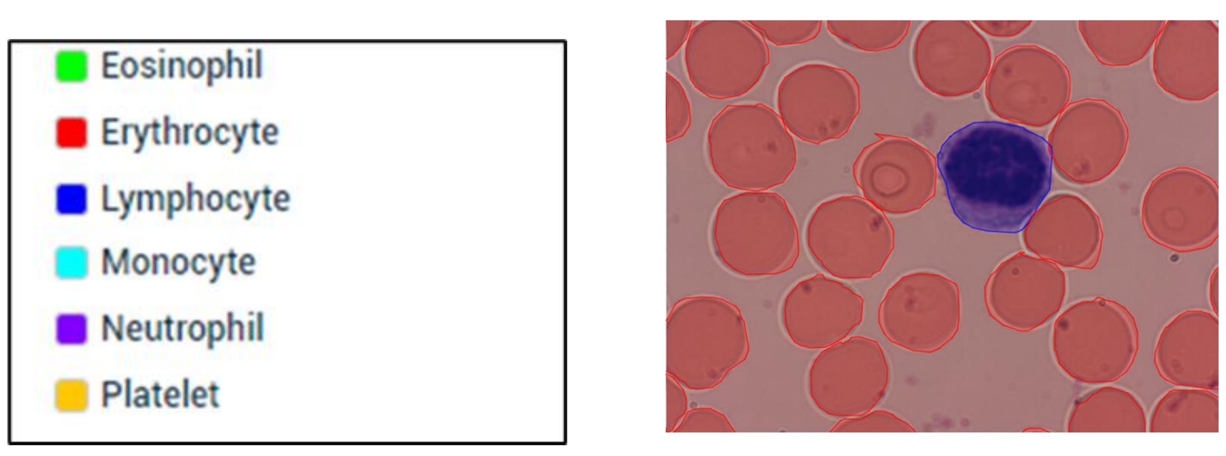

Figure 4. Annotations and label assignment

Results

Once trained, both color images and grey scale + fluorescence were used to detect and classify blood cells in images that were not part of the training process. The images were taken from smears prepared following the same staining protocol.

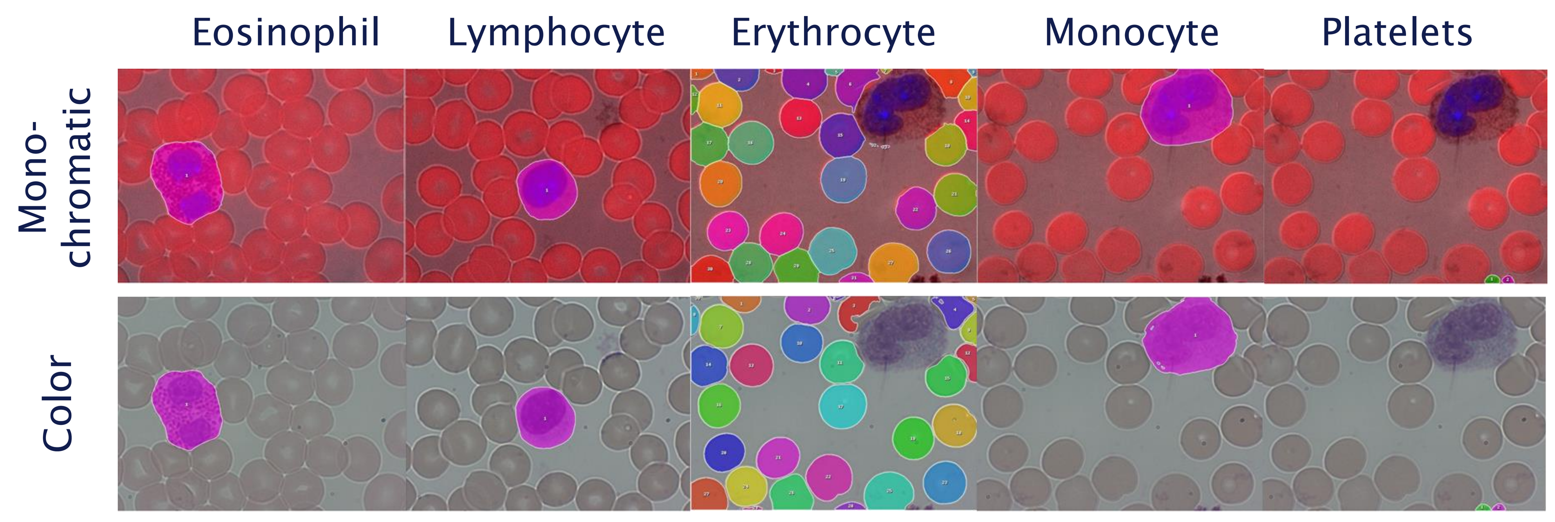

Figure 5. Blood cell detection and classification

The performance of the AI-based classification is shown in the image below with the accuracy plotted for each studied blood cell. Training the AI with monochromatic images + fluorescence yielded an appreciable advantage in the classification of Young (Band) Neutrophils and Eosinophils. For the other types of blood cells there were not significant trends found.

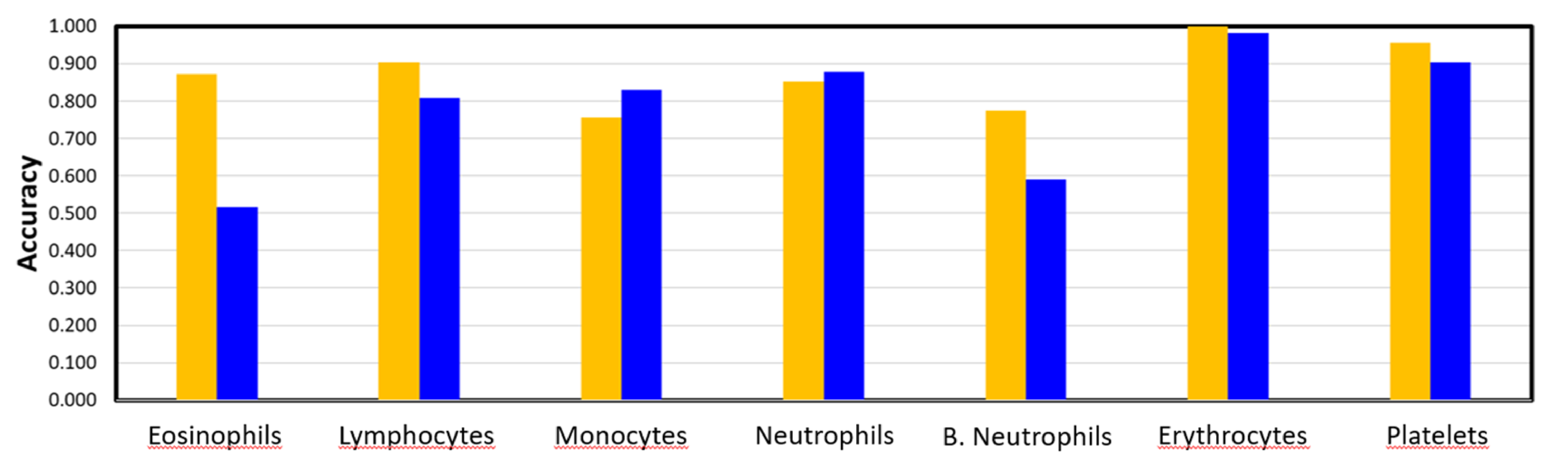

Figure 6. Blood cell detection performance. Blue: Color images, Orange: Monochromatic images

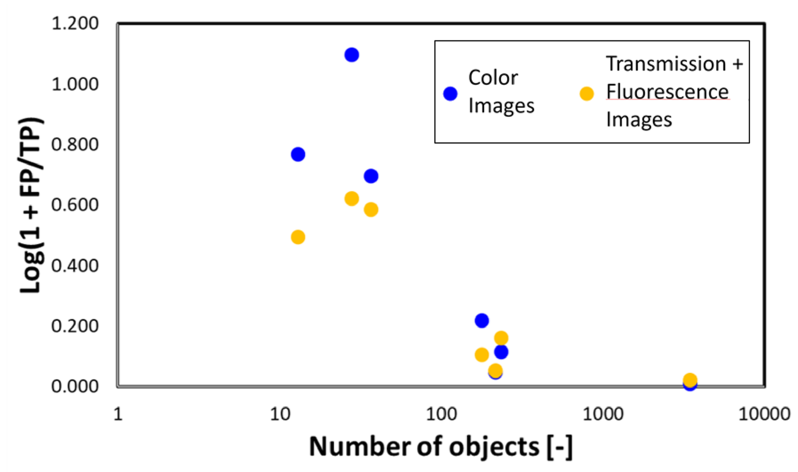

Figure 7. False positive dependence on number of objects

The number of false positives decreases logarithmically as the number of objects (cells annotated) increases. The number of false positives is the highest on Band Neutrophils and lowest on erythrocytes.

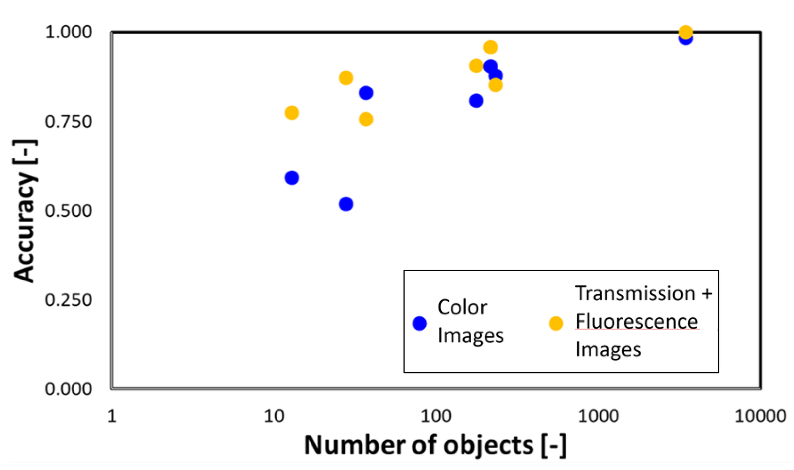

Figure 8. Blood cell detection's dependence on number of objects

Similarly to the trend observed in the number of false positives, the accuracy of the algorithm improves logarithmically with the number of objects used in the training.

Conclusion

The size of the database has a significant effect on the performance of the algorithm.
The algorithm trained with the monochromatic set of images (Transmission + DAPI + Eosin Y) was able to identify and classify Eosinophils and B. Neutrophils better than its color-image-trained counterpart.
The IKOSA AI platform provides a valid tool for developing a blood cell detection and classification algorithm.