1478
doi:10.1017/S1431927620018267

Microsc. Microanal. 26 (Suppl 2), 2020

Making Image Analysis Easier with Machine Learning: A Foam Cell Size Study

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Quantitative image analysis often follows microscopy to help researchers characterize and quantify material structure features. However, development of image analysis programs can be time consuming and often results in programs that are limited in use to the types of images for which they were developed; any changes of the samples or imaging techniques consequently require recreation of the image analysis program. For research environments that have limited resources, doing quantitative image analysis routinely can therefore be challenging.

There were a lot of great developments of machine learning technology in recent years due to the improvements of computation power and algorithms. Free (and open source) machine learning programs are even available for image analysis, such as "Trainable Weka Segmentation"[1] and "ilastik" [2], and have both been used for solving challenging image analysis problems. Besides solving the most challenging problems, machine learning tools can also be incorporated into image analysis programs to make them more flexible and able to analyze more than one type of image. The same image analysis program may be used on different types of images, e.g. images taken from the same sample but by different microscopy techniques or even images from different types of samples, if the machine learning tool is used at the beginning in the program to handle the variations of image contrast and quality. When processing different types of images, users just need to re-train the program with new examples, then the newly developed classifiers will be able to remove the new types of noise/artifacts in the new type of images. In one example, we analyzed polymer foam images, collected via different imaging techniques (optical microscopy vs. scanning electron microscopy), and also images of foam samples with very different cell morphology (polyisocyanurate foam vs. expanded polystyrene foam). Using the "trainable Weka segmentation" plugin in each case, and a new trained classifier for each image type, the same program can be used without any further changes for 2D cell size analysis (Figure 1). In another example, images from 12 polyisocyanurate foam samples having a range of cell sizes were analyzed by both "automatic image analysis program with Weka machine learning (WEKA)" and "manual measure and mark (M&M)" methods. Matched Pairs statistical analysis showed consistent results between the two methods, suggesting that the "WEKA" program is also very accurate. With the potential improvements of flexibility/usability and accuracy, it is recommended to utilize machine learning capability in image analysis programs when possible.

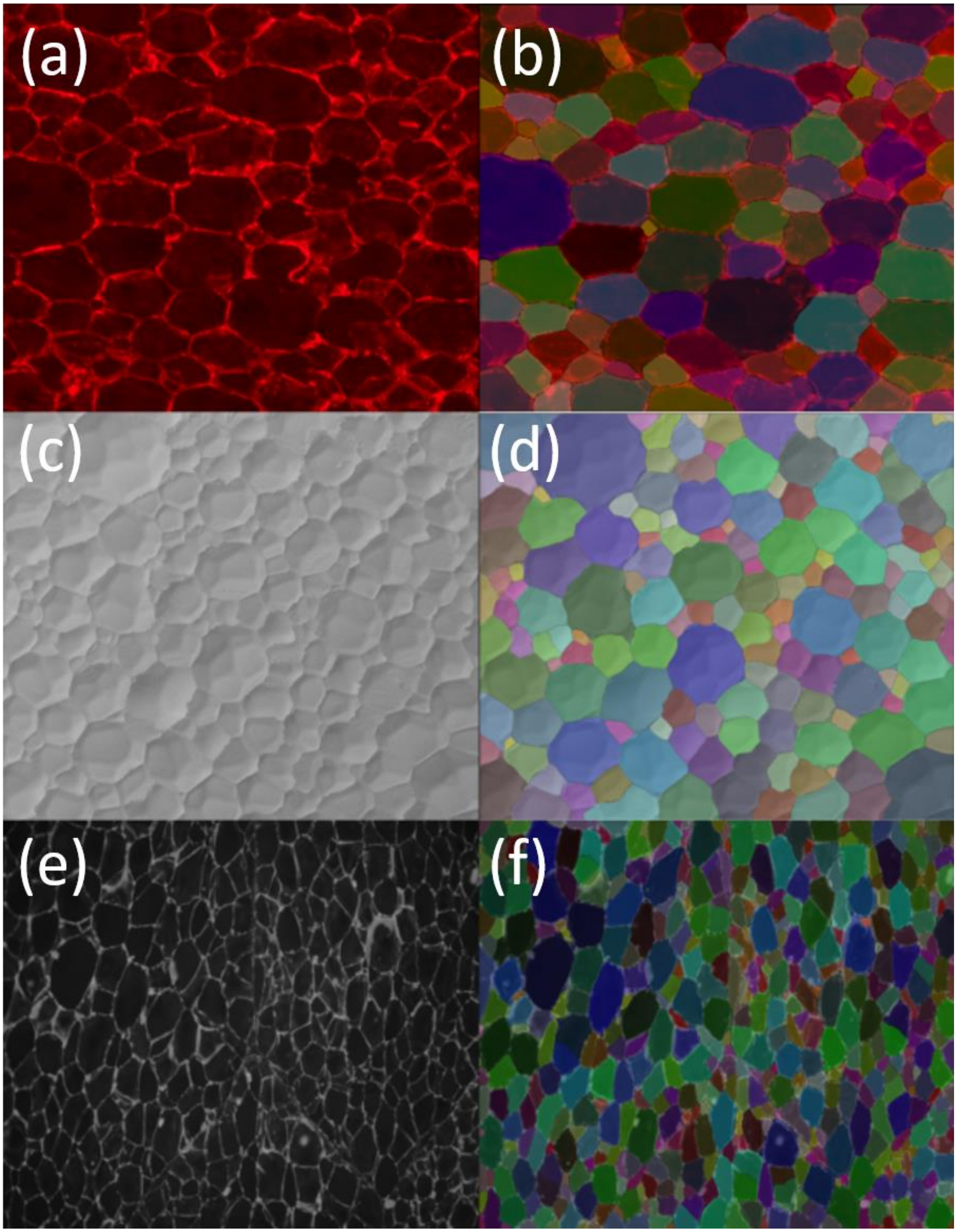

Figure 1. (a) An optical image of a polyisocyanurate foam, (b) image (a) with the identified cells color-coded, (c) a scanning electron microscopy image (back-scattered electron image) of a poly-isocyanate foam, (d) image (c) with the identified cells color-coded , (e) an optical image of an expanded polystyrene foam sample after transformed from color to gray scale, (f) image (e) with the identified cells color-coded.

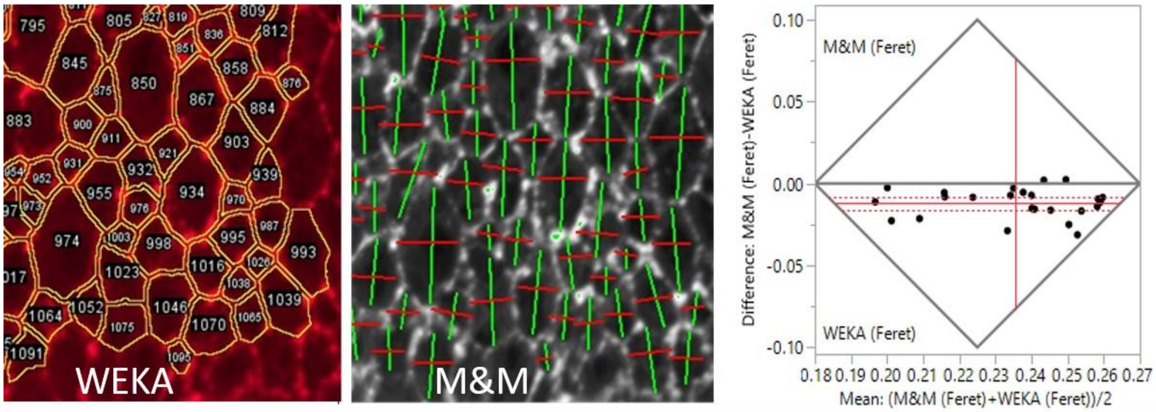

Figure 2. Matched pairs analysis of automatic cell size analysis with WEKA ("WEKA") and manual Measure and Mark method ("M&M") results.

References
[1] https://imagej.net/Trainable_Weka_Segmentation
[2] https://www.ilastik.org/

https://doi.org/10.1017/S1431927620018267 Published online by Cambridge University Press