

# Measuring, clustering and classifying pores of surgical meshes with an ImageJ plug-in

Sebastian Vogt<sup>(1)</sup>, Carolin Ritter<sup>(2)</sup>, Jürgen Trzewik<sup>(3)</sup>, Klaus Brinker<sup>(4)</sup>

<sup>(1)</sup> University of Applied Sciences Hamm Lippstadt  
Marker Allee 76-78, 59063 Hamm, Germany

E-Mail: [Sebastian.Vogt@stud.hshl.de](mailto:Sebastian.Vogt@stud.hshl.de)

<sup>(2)</sup> University of Applied Sciences Hamm Lippstadt

E-Mail: [Carolin.Ritter@exam.hshl.de](mailto:Carolin.Ritter@exam.hshl.de)

<sup>(3)</sup> University of Applied Sciences Hamm Lippstadt

E-Mail: [Juergen.Trzewik@hshl.de](mailto:Juergen.Trzewik@hshl.de)

<sup>(4)</sup> University of Applied Sciences Hamm Lippstadt

E-Mail: [Klaus.Brinker@hshl.de](mailto:Klaus.Brinker@hshl.de)

## Abstract

The pore structure and pore size is a crucial characteristic of surgical meshes. A huge amount of different approaches for mesh classification based on the pore size or materials are available. It is hard to use these classifications because of the big variety in knitting structures and pore shapes. Therefore, a new approach is applied which characterizes pores based on two parameters: the biggest inscribed circle (Fig.1 (a)), the smallest circumscribing circle (Fig.1 (b)) and the area (Fig. 1 (a)). These parameters are identified with the help of ImageJ. Therefore, a plug-in for ImageJ has been developed which needs a scaled binary input image to be able to characterize pores.

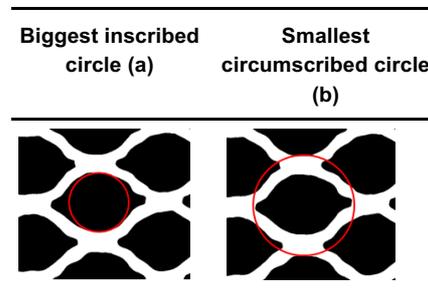


Fig.1: Measurements of a pore as defined for the ImageJ plug-in

The biggest inscribed circle is computed by using the Euclidean Distance Map (Fig.2 (a)) based on an algorithm of Leymarie and Levine [1] and the smallest circumscribing circle is computed by using the convex hull (Fig.2 (b)) of the pore and applying the mathematics of Jon Rokne's "An easy bounding circle" [2].

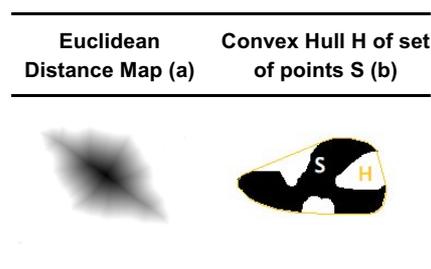


Fig.2: EDM and Convex Hull

Using these measurements of the pores, two different algorithms are applied to cluster the pores in categories, each category with similar pores, and a nearest-neighbour algorithm is applied to classify the pores and put them in categories, too. The categories are determined by the diameter of the biggest inscribed circle, the diameter of the smallest circumscribing circle and the ratio of these, which is an indicator of the pore's shape.

For clustering the K-Means and the DBSCAN (Density Based Spatial Clustering of Applications with Noise) algorithms are applied.

The K-Means algorithm is in analogy to "Least squares quantization in pcm" by Lloyd [3]. The expected number of categories has to be chosen manually at first, then the algorithm aims to minimize the total of squared deviations of the data points to the centers of the cluster. The formula

$$E = \sum_{i=1}^k \sum_{x_j \in C_i} d(x_j, \mu(C_i))$$

is optimized, where  $k$  is the number of clusters,  $x_j$  is a data point from Cluster  $C_i$  and  $\mu(C_i)$  is the center. The runtime complexity is  $O(t)$ .

The DBSCAN is based on „A Density-Based Algorithm for Discovering Clusters in Large Spatial Databases with Noise“ [4]. The main idea behind the algorithm is, that the density of data points within a cluster is higher than outside the cluster. Unlike the K-Means algorithm, the DBSCAN does not need to know the number of cluster before being applied, it clusters the data points automatically.

For classifying the pores, the procedure is different. Before letting an algorithm put each pore in a category, at least one pore has to be chosen manually to represent a category. Afterwards the nearest-neighbour algorithm is applied to find similar pores for each chosen category. To be able to reuse results and make them comparable despite having collected a vast amount of data, the categories are sorted by the diameter of the biggest inscribed circle. The result is marked by colour. If a pore does not belong to the category the user wants it to, the category of the pore can be changed manually.

Moreover, the plug-in generates an ImageJ results table which contains information about the amount of pore types, the ratio of inner and outer diameter, the inner diameter (mm), the outer diameter (mm), the area (mm<sup>2</sup>) and the percentage of the total area which is covered by the pore types. Furthermore, a histogram shows the percentage of covered area by the single pore types.

## References

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