Drop distribution determination in a liquid-liquid dispersion by image processing

Brás, L.M.R.*, Gomes, E.F.*+, Ribeiro, M.M.M.*+, Guimarães M.M.L.+

*ISEP, Instituto Superior de Engenharia do Porto

+CIGAR-SIPROM

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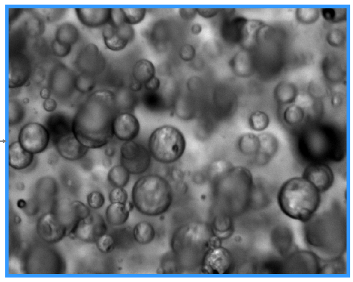
▪ Statement of the problem

Image processing is a very relevant area of computer science with applications in many domains. Quantitative analysis and interpretation of digitized images is currently an important tool in several scientific domains. Namely in multiphase systems modelling in Chemical Engineering, the acquisition and treatment of images of particulate phases become essential for the calculation of particle size and shape distributions. In the modelling of liquid-liquid systems these are of major importance.

In this approach (implemented in Matlab), given one of these **photographic images** of a dispersion, automatically identifies the contour of existing drops and classifies them according to their diameter

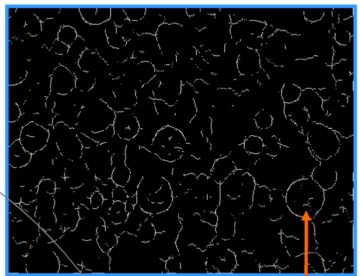


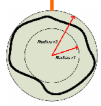
▪ Description of the method

The detection of the drops in a image, was done in two distinct phases.

▪**First**, we proceed to the edges detection of the drops in the original image, manipulating the gradient and the descending thickness and creating an **output image with those contours**.

▪**Second**, we **detect the drops** in this contour image, using the Hough Transform.The contour of each drop can be represented as one object with irregular form, centred in a point and with a radius that varies from r1 to r2. Votes will be generated from the successive application of the Hough Transform to the range r1:r2.





▪ Results

The results presented in Table 1, show the results obtained on one of the images for the **recall** and **precision** values, where *TP* is the true positives, *FN* the false negatives and *FP* the false positives.

$$recall = \frac{TP}{TP + FN}$$

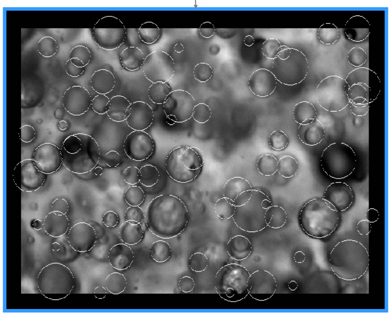
$$precision = \frac{TP}{TP + FP}$$

Radius (pixels)	Recall	Precision	Radius (pixels)	Recall	Precision
7	0.25	1.00	22	0.60	1.00
8	0.50	1.00	23	0.67	1.00
9	0.57	1.00	24	0.33	1.00
11	1.00	0.67	25-26	1.00	0.75
13	0.67	1.00	28-30	1.00	1.00
14	0.80	1.00	32-33	1.00	1.00
15	0.67	1.00	34	1.00	1.00
16	0.75	0.75	36	1.00	1.00
17-19	1.00	0.90	39	1.00	1.00
20	0.75	1.00	44	1.00	1.00
21	0.60	0.60			

For a radius less then 7 pixels the program cannot find any drop. For the radius 10, not in the table because recall=0 and precision not defined, we have a TP=0, FP=0 and FN=3. For the radius 12, also not in the table, because recall=0 and precision not defined, we have a TP=0, FP=0 and FN=1. For the other values of the radius not represented in the table, we have TP=0, FP=0 and FN=0. As final results, taking into account all the values of radius, we have for this image a recall of 0.71 and a precision of 0.89.

Radius (pixels)	Recall	Precision	Radius (pixels)	Recall	Precision
7	0.44	0.80	19	0.50	1.00
8	0.50	1.00	20	0.50	0.60
9	0.40	1.00	22	0.25	0.33
11	0.25	1.00	23	0.75	1.00
12	0.25	1.00	24-26	1.00	1.00
13	0.25	0.50	29	1.00	1.00
14	0.57	0.57	31	1.00	1.00
15	0.57	1.00	33	1.00	1.00
16	0.57	1.00	41	1.00	1.00
17	0.77	1.00	43	1.00	1.00
18	0.57	1.00			

For the second image, which has a lower photographic quality, we have worse results, having a total 0.55 for recall and 0.87 for precision, as we can see in Table 2. Nevertheless we have, for many values of radius in the image, maximum recall and precision. For several values of radius from 7 to 23 and for radius equal to 35, 40 and 45, recall and precision are not shown in the table, for the same reasons as in the previous image. We believe the cause for these worse results with respect to the previous image is the lower quality of this second image.



▪Conclusions and future work

We describe a method for the automatic identification of drops in images taken from agitated liquid-liquid dispersion. The results obtained with two images lead to the conclusion that our program is able to detect a good percentage of the drops. In the case of a better quality image, the program recognized 71% of the drops. For the other image, with lower quality, only 55% were detected. We have also observed that the approach is less efficient for smaller values of the radius, since very small drops can be easily mistaken by noise. We think we can achieve yet better results if we can obtain a better contour image (with less noise) in the first step of the process, so we will do further work in this part of the process.

E-mail to contact author: efg@isep.ipp.pt