

Application of Machine Learning aided convolution based algorithm for nuclear track detector (NTD) image analysis

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Presentation at MoEDAL group meeting on NTD and ML

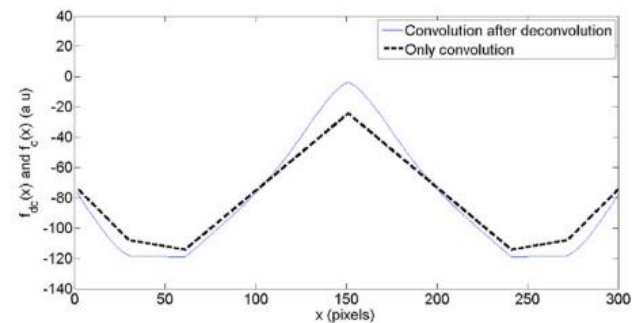
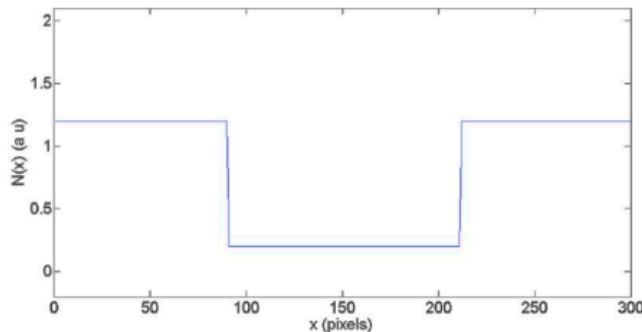
26/06/20

Introduction

- ▶ Image processing is an integral part of the NTD microscope image analysis.
- ▶ Many of the common image processing techniques require manual intervention to some extent.
- ▶ Relatively simple yet effective image processing technique based on deconvolution followed by convolution aided with Machine Learning for NTD images was presented in the meeting held on 4th April 2020.
- ▶ Proposed algorithm applied on the NTD images obtained from Queen Mary University of London.

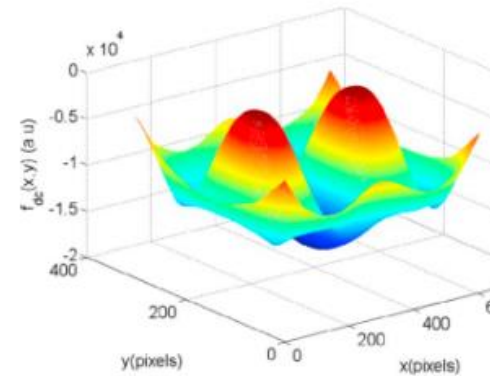
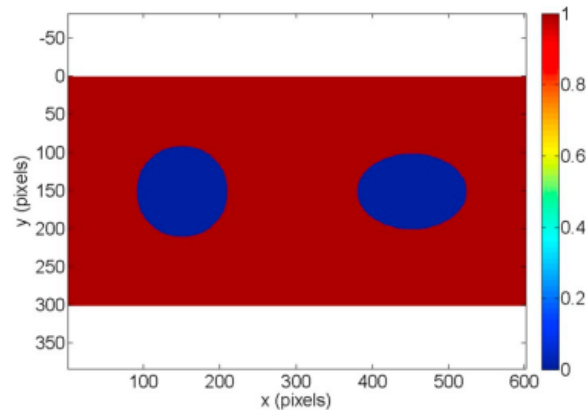
Applied Method

- ▶ Mask selection $M(x, y)$ using a suitable NTD track from objects $N(x, y)$ (NTDs present within image)
- ▶ First, a gaussian mask $G(x, y)$ chosen for deconvolution with $N(x, y)$
- ▶ Next, $M(x, y)$ convolved with entire image resulting in following images:
- ▶ For 1D:



Applied Method (Contd.)

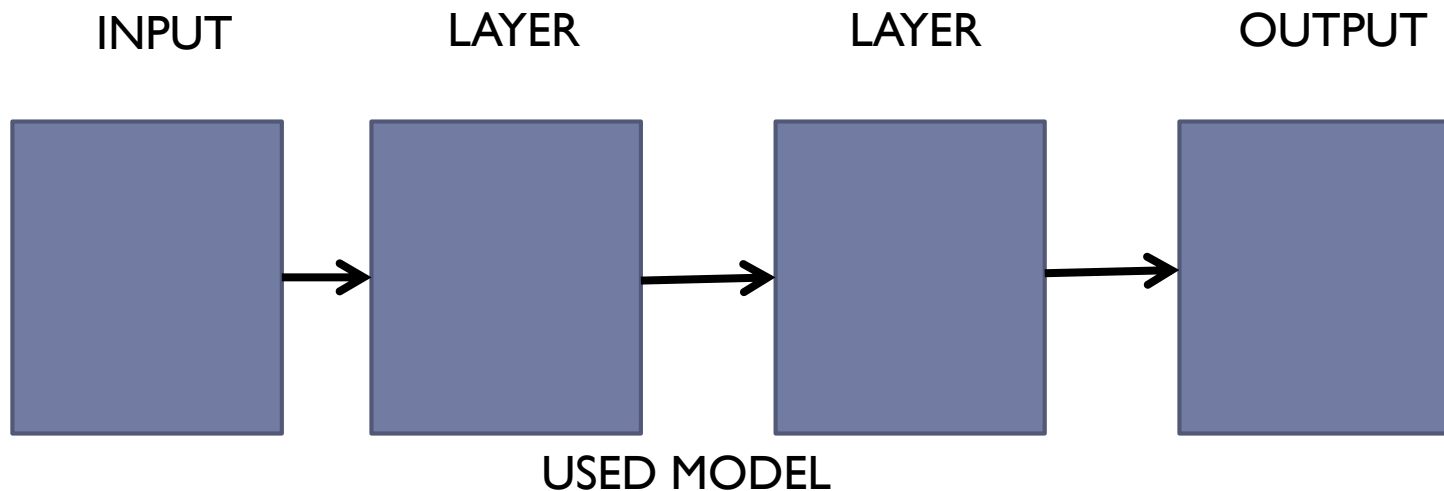
► For 2D:



- Feed-forward network
- Predicted threshold based on the average intensity for the sample
- Predicted threshold used and marking using morphological technique

Applied Method (Contd.)

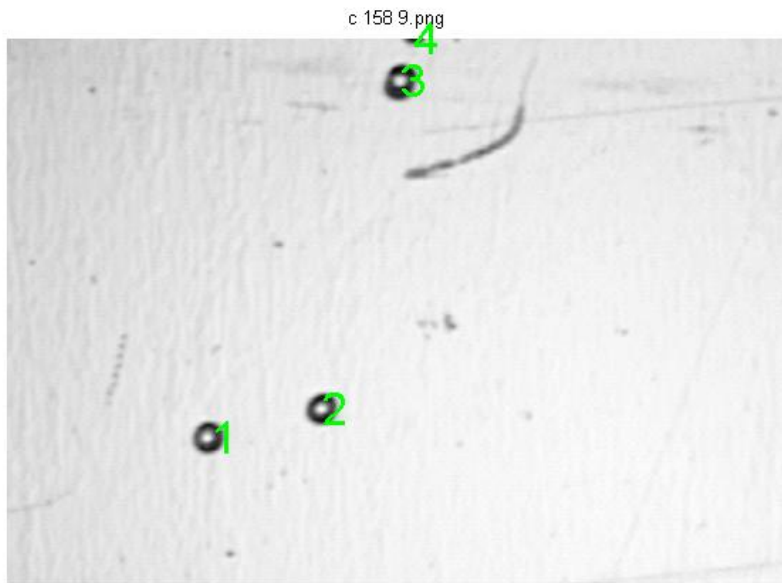
- ▶ For dirty images, all the images given a constant threshold as pre-processing
- ▶ Pre-processing not applied to the cleaner images.



Some results

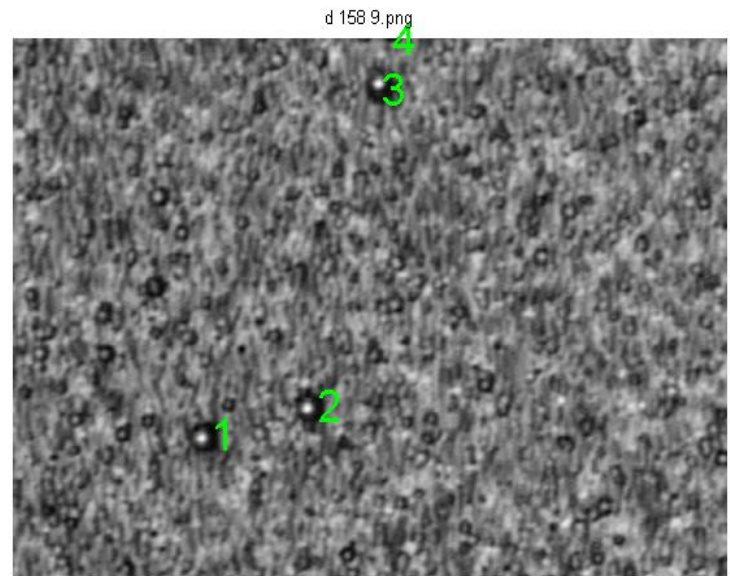


Image names: c158 (left) and d158 (right)



Count: 4

Pre-processing not used



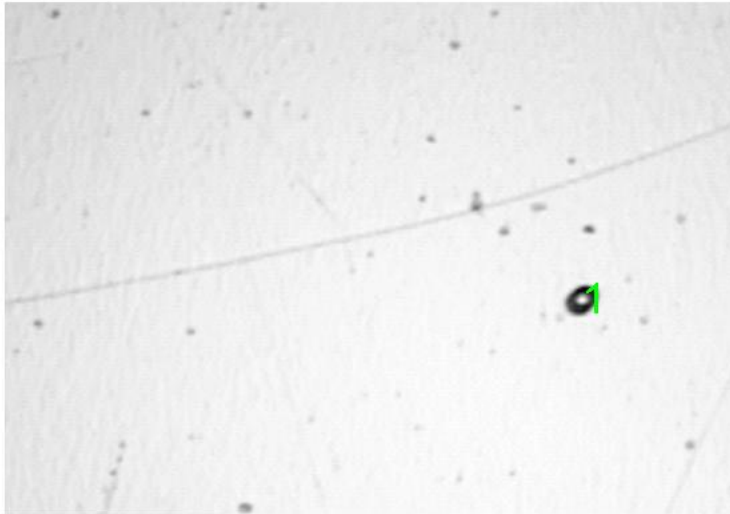
Count: 4

Pre-processing used



Image names: c161(left) and d161(right)

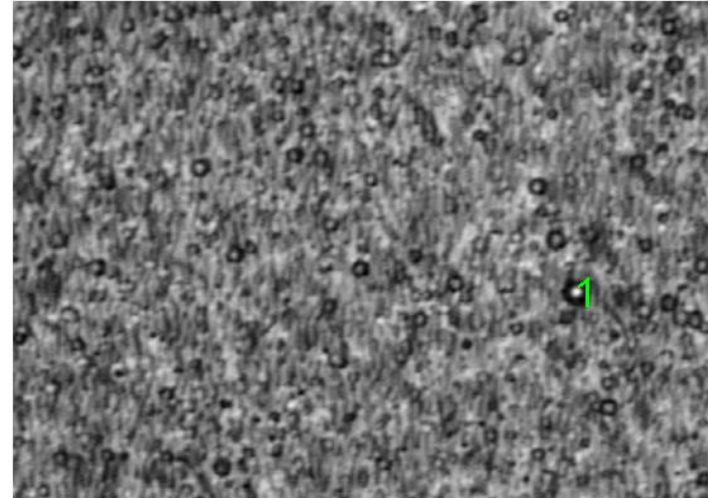
c 161 9.png



Count: 1

Pre-processing not used

d 161 9.png



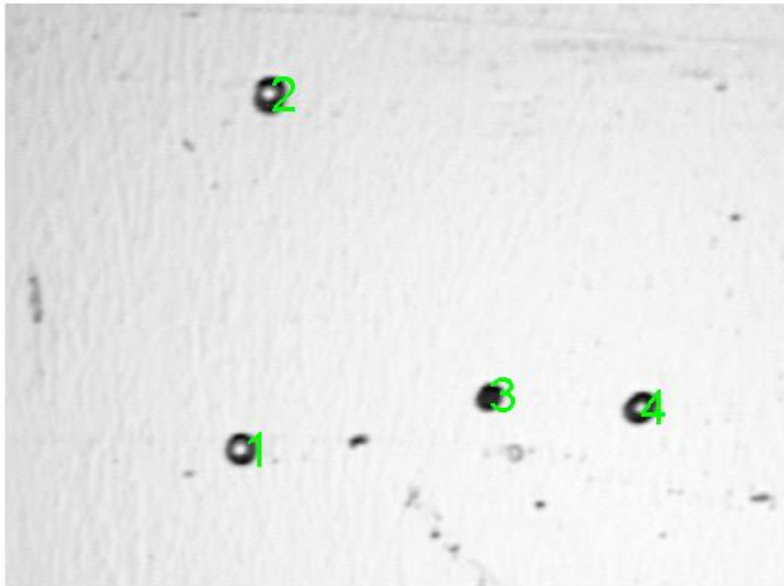
Count: 1

Pre-processing used



Image names: c183 (left) and d183 (right)

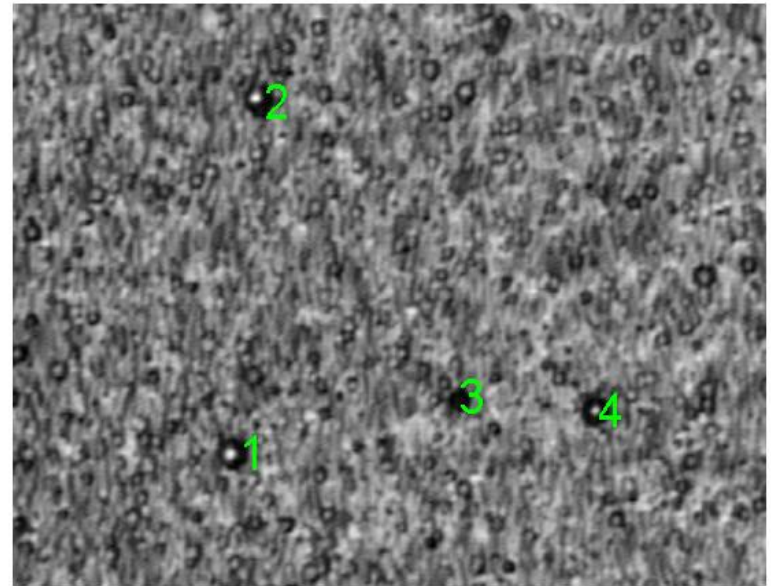
c 183 9.png



Count: 4

Pre-processing not used

d 183 9.png



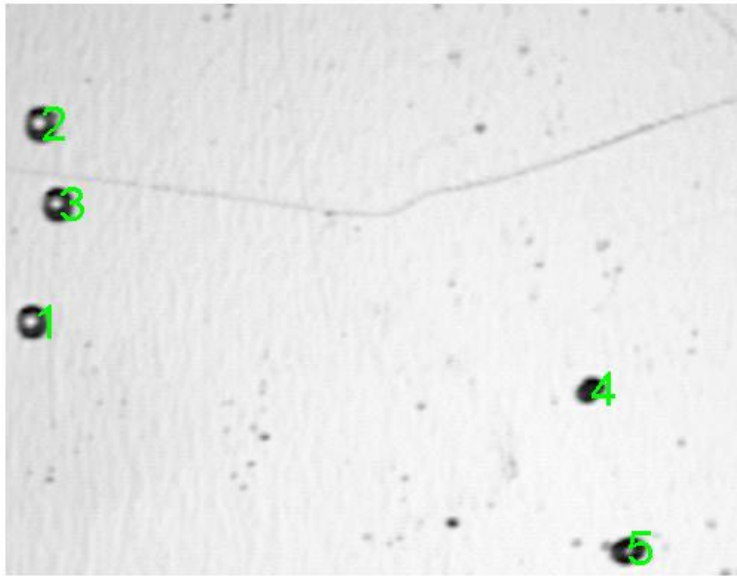
Count: 4

Pre-processing used



Image names: c186(left) and d186(right)

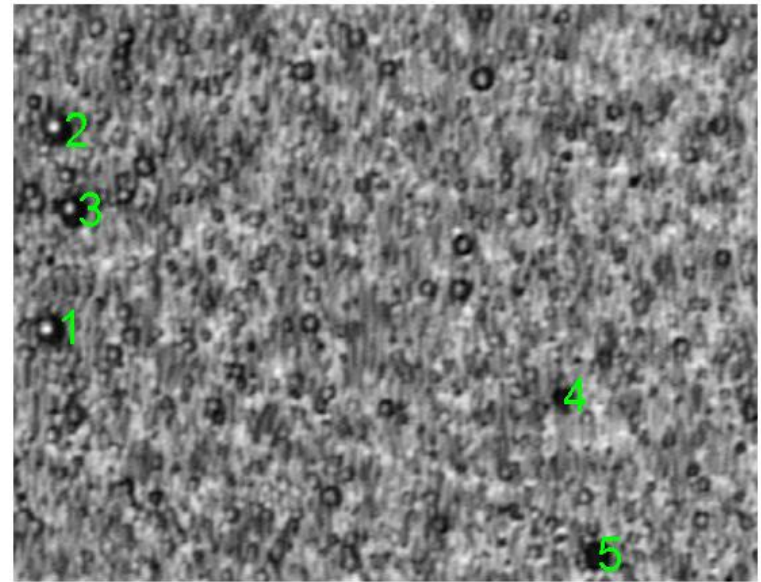
c 186 9.png



Count: 5

Pre-processing not used

d 186 9.png



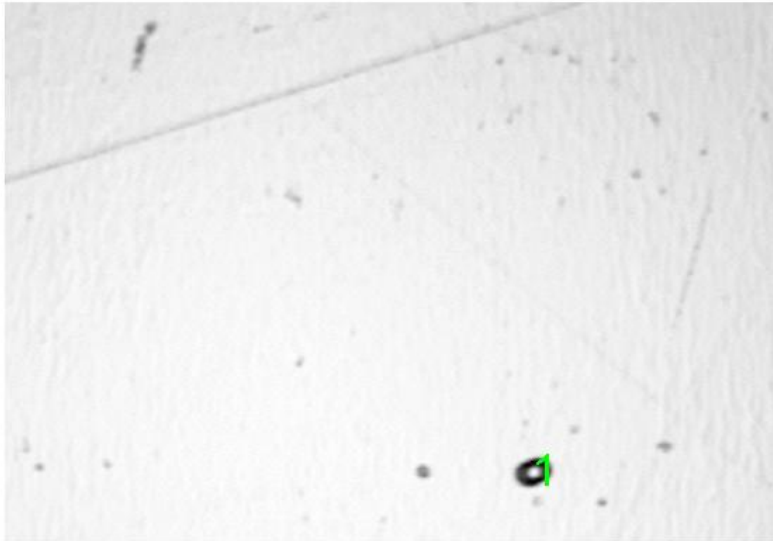
Count: 5

Pre-processing used



Image names: c193(left) and d193(right)

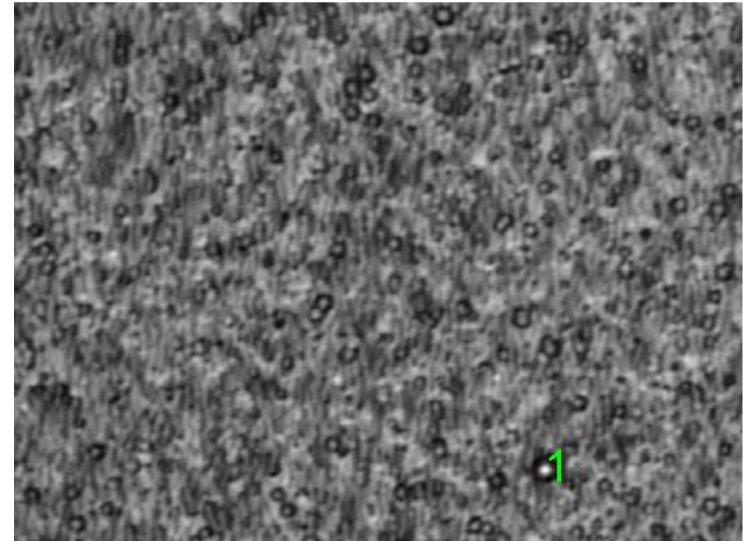
c 193 9.png



Count: 1

Pre-processing not used

d 193 9.png



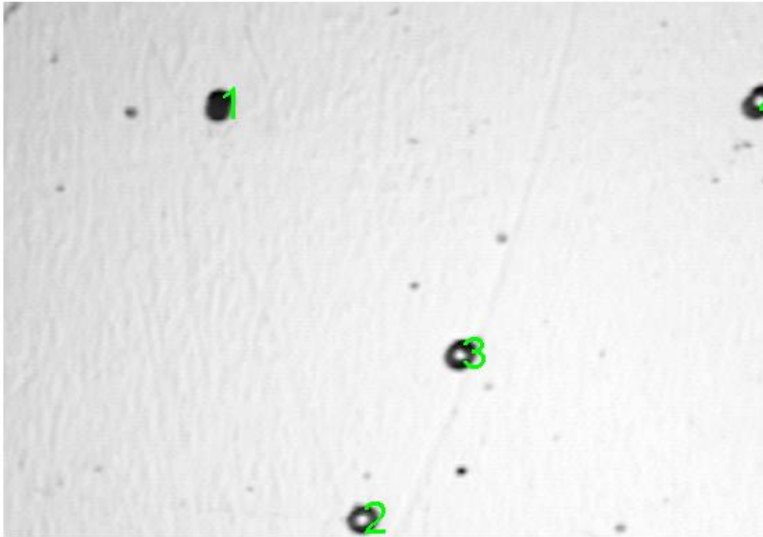
Count: 1

Pre-processing used



Image names: c33 (left) and d33 (right)

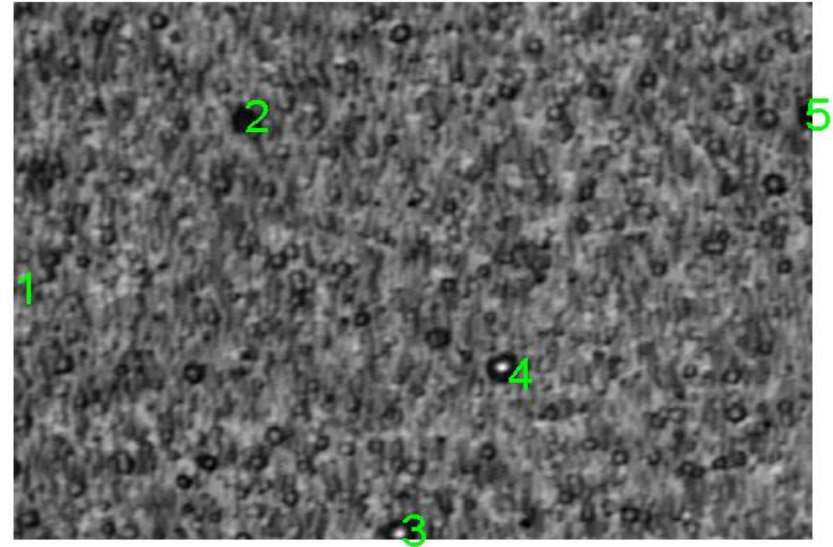
c 33 9.png



Count: 4

Pre-processing not used

d 33 9.png



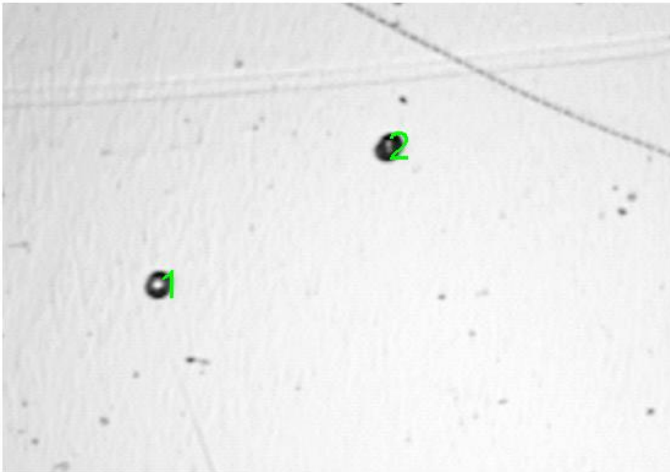
Count: 5

Pre-processing used



Image names: c35 (left) and d35(right)

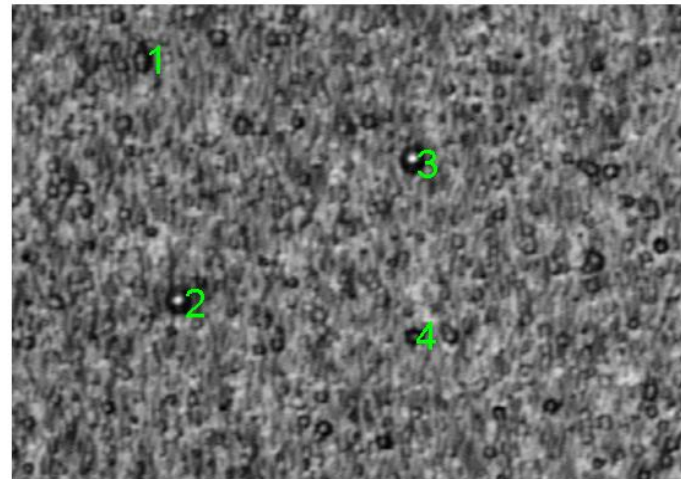
c 35 9.png



Count: 2

Pre-processing not used

d 35 9.png



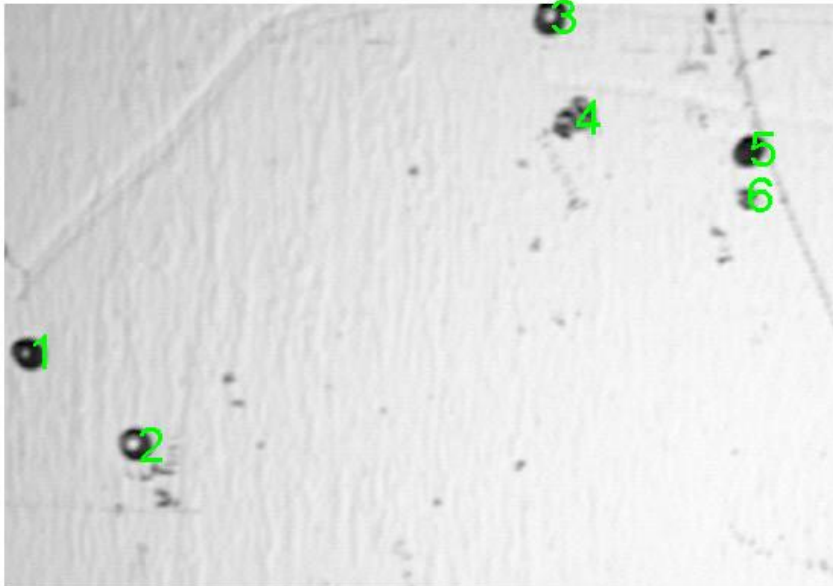
Count: 4

Pre-processing used



Image names: c153(left) and d153(right)

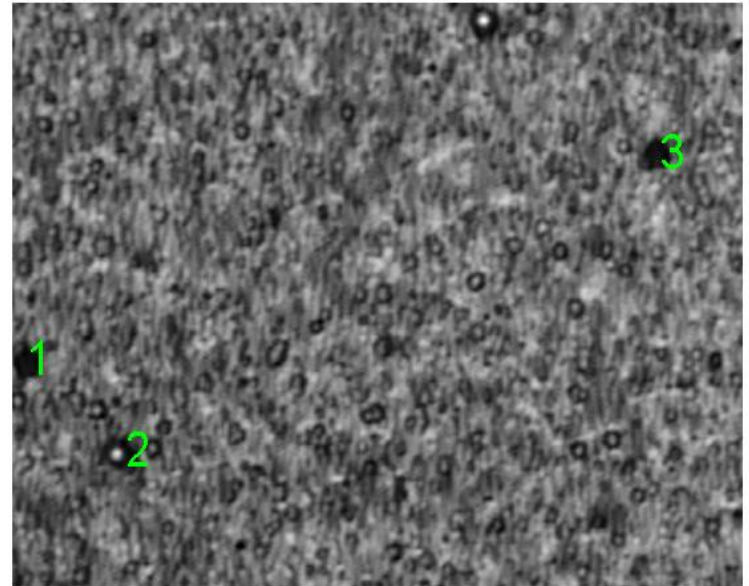
c 153 9.png



Count: 6

Pre-processing not used

d 153 9.png

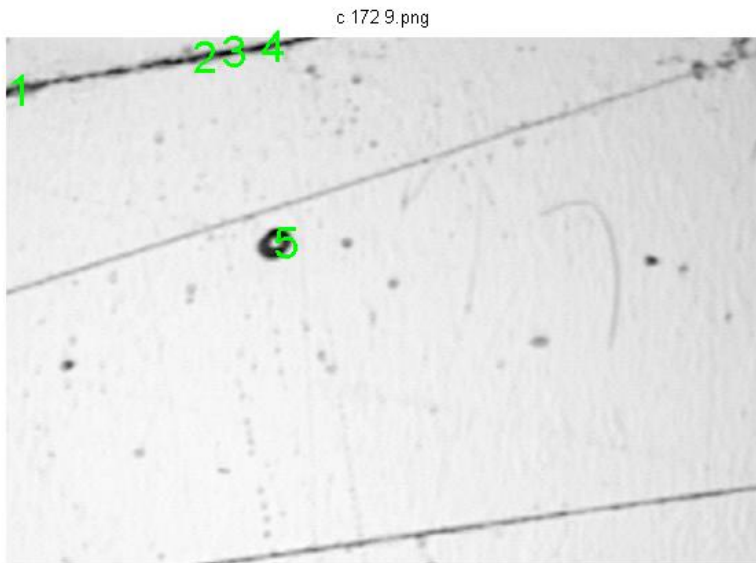


Count: 3

Pre-processing used

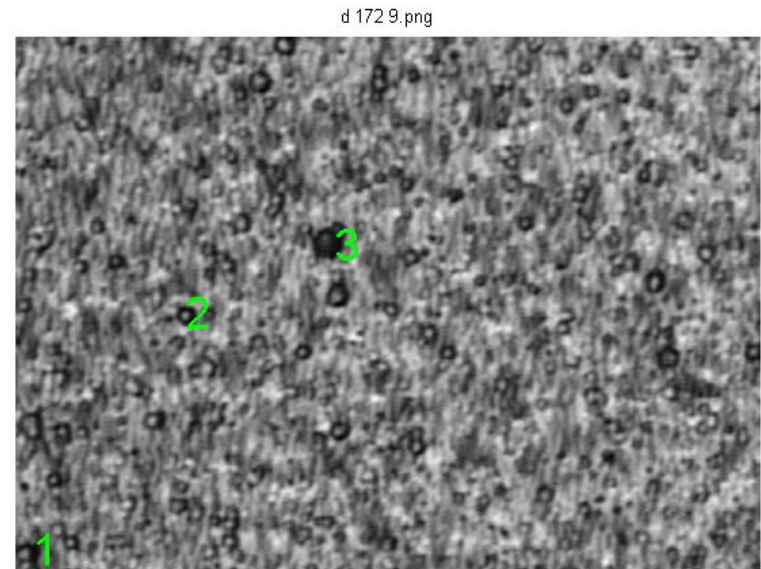


Image names: c172 (left) and d172 (right)



Count: 5

Pre-processing not used



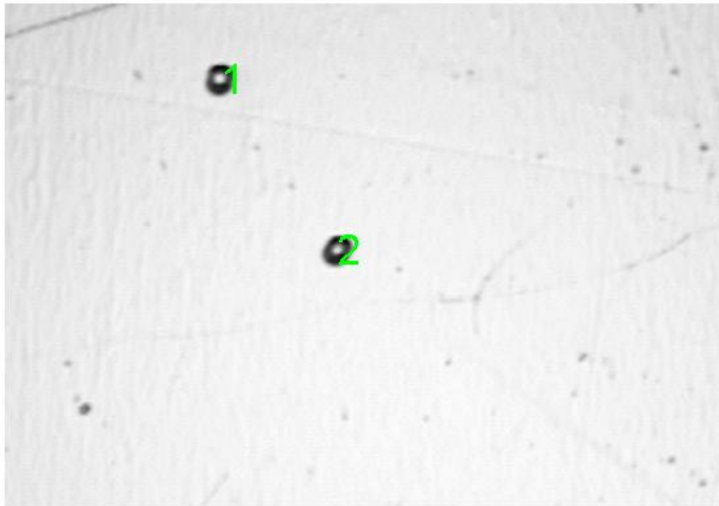
Count: 3

Pre-processing used



Image names: c188 (left) and d188 (right)

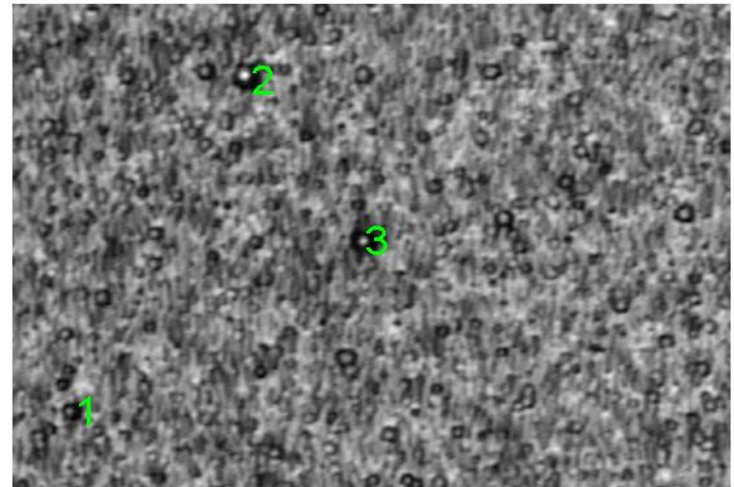
c 188 9.png



Count: 2

Pre-processing not used

d 188 9.png



Count: 3

Pre-processing used



Dataset distribution and computation time after training

Clean images		Dirty images	
Training	Test	Training	Test
149 images	58 images	149 images	58 images

Image Type	Total Actual Count	Total Automated Count	Total No. of Tracks Missed (false negative)	Total over-count (false positive)
Clean Images	108	124	1 (0.93 %)	17 (15.74 %)
Dirty Images	88	101	4 (4.55 %)	17 (19.32 %)

Computation time ~ 25 seconds



Some estimates related to automated scanning

- ▶ Magnification $\sim 30\times \Rightarrow$ Area of 1 image frame ~ 2 mm \times 2 mm
- ▶ For a NTD foil of size 25 cm \times 25 cm ~ 15625 image frames
- ▶ If each image size is ~ 100 kB \Rightarrow Total size of data corresponding to each side of the foil ~ 1.5 GB
- ▶ Computation time for each image after training is of the order of 10 seconds.



A proposed set-up of scanning and simultaneous data acquisition and processing

- ▶ Optical scanning of PET-sheets (with objects / holes) based on moving cylindrical lens is proposed here.
- ▶ Appropriate design / validation is required for suitable magnification and better imaging characteristics (LSF).
 - ▶ LSF – Line spread function
- ▶ Synchronized movement of the sheet and the lens assembly with stitching of array images is required here.
- ▶ After obtaining complete stitched image, processing can be done using different techniques.
- ▶ Placing slit before the source and the detector, a depth information may be obtained (similar to confocal).

Discussion

Image processing

- ▶ No separate position determination algorithm is required.
- ▶ The marking is also automated.
- ▶ Partial visibility is also detectable to a large extent.

Optical set-up

- ▶ A cylindrical lens based scanning system has been proposed.
- ▶ The development demands knowledge of optical instrumentation and image processing and time investment.

THANK YOU