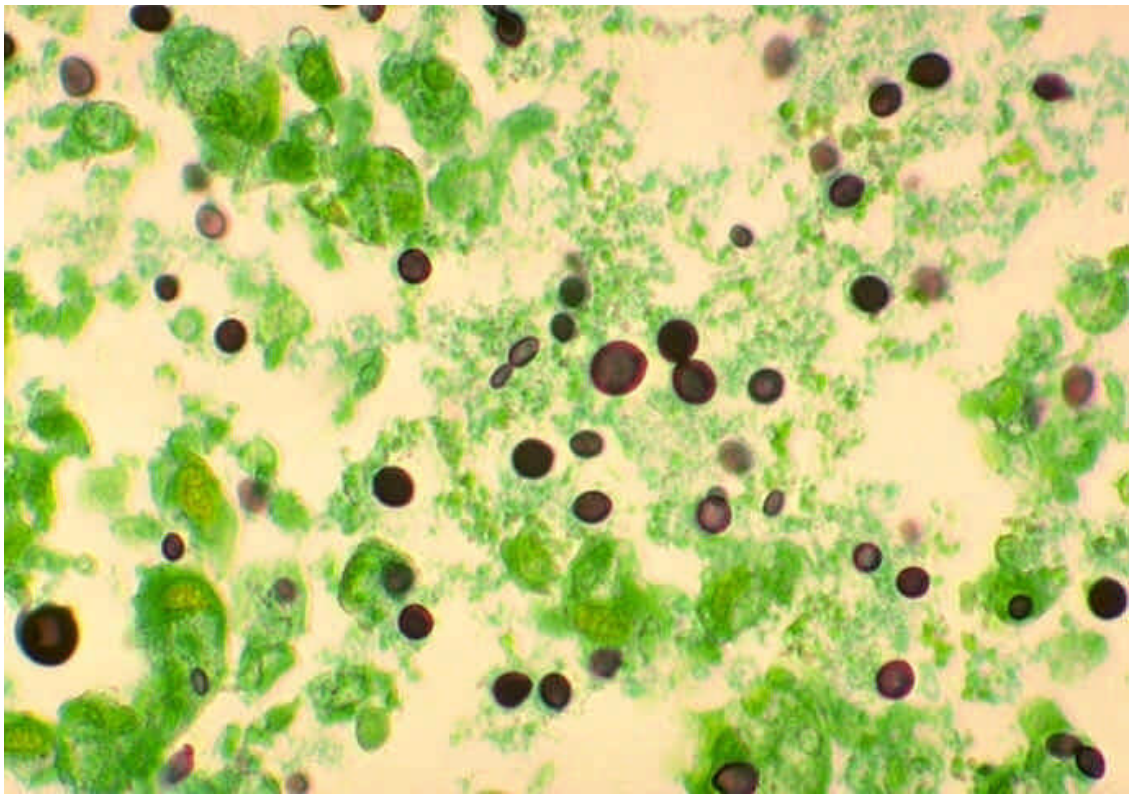
Approaches for classification and counting by image analyses



A. Conci
aconci@ic.uff.br
UFF
Universidade Federal Fluminense
Brazil

Applications:

- ceramic micrography
- petrology and petrography
- mineralogy
- metallurgy
- quality controls
- biological cells
- medical exams
- geology
- civil engineering
- astronomy
- microscopic analysis

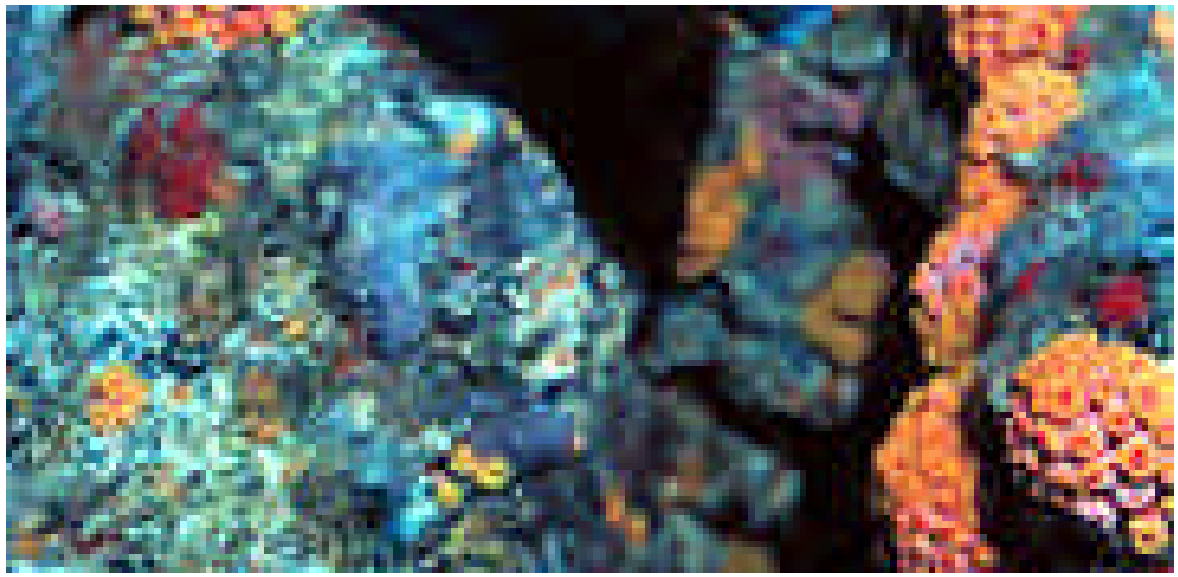
Particles size distribution and identification = granulometry

Granulometry by using:

mathematical morphology;

best fitting shapes;

Hough Transform;



Counting Cells by Mathematical Morphology

- **Main idea:** image simplification by removing not relevan details **preserving** essential characteristics of **form**
- Basic operations : **dilation, erosion, opening** and **closing**

Dilation on gray value image

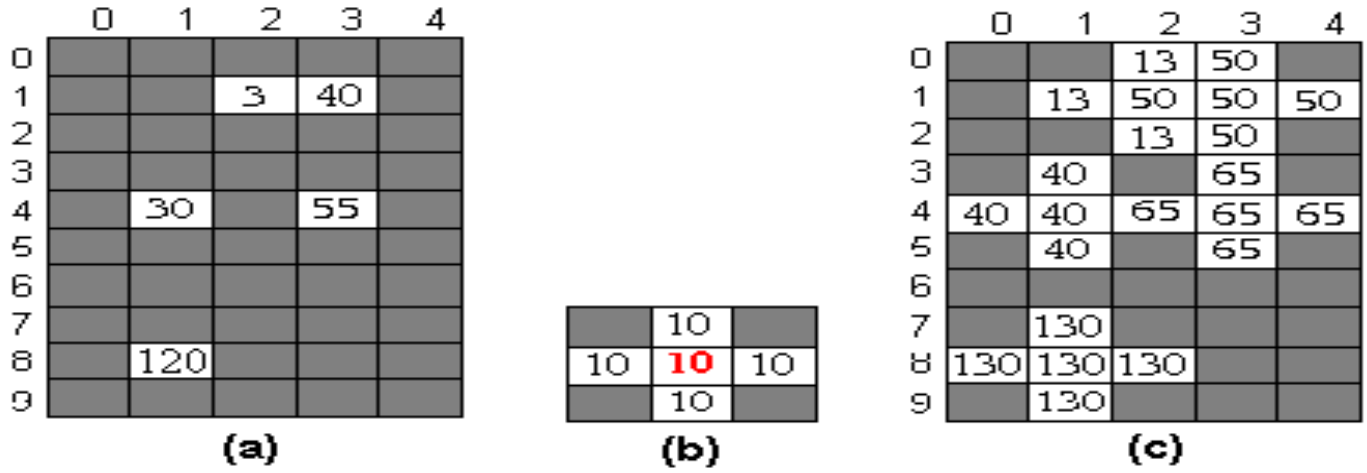
- are defined by:

$$f \oplus k = (f \oplus k)(x) = \max \{ z \in K, x\text{-}z \in F \mid f(x\text{-}z) + k(z) \}$$

where F , K be the domains of functions: **f (x , y) and k (x , y),**

x **,** ***y*** **Î Z**

- **it gives an "expansion" or "grow" on the image**

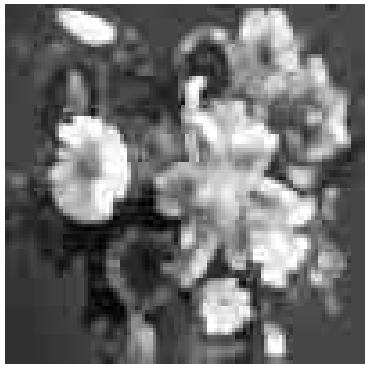


- f is normally the image, while k is named **structuring element**

Dilation on color image

- each **RGB**, **HSV** or **YIQ** channel must be considered

original



3x3{1} for each channel: *red*, *green* e *blue*

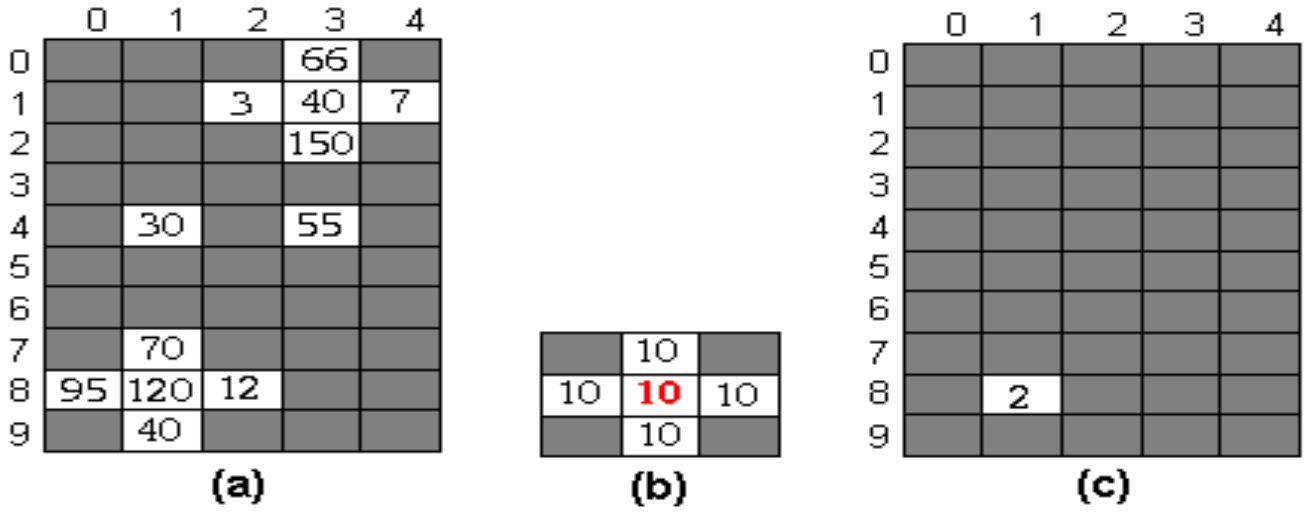
result

Erosion on gray value image:

- Let F , K be the domains of functions: **f (x , y)** **and** **k (x , y)**

where ***x , y*** **Î Z**, then Erosion can be defined as:

$$f \ominus k = \min \{ z \in K, x+z \in F \mid f(x+z) - k(z) \}$$



Erosion results to color images:

original

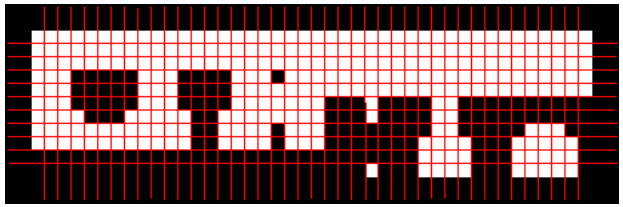
3x3{1} for each chanel: *red*, *green* e *blue*

result

Closing and opening

- These operations are a combination of dilation and erosion:

original image:



Erosion of the original image by a 3 x 3 structural element

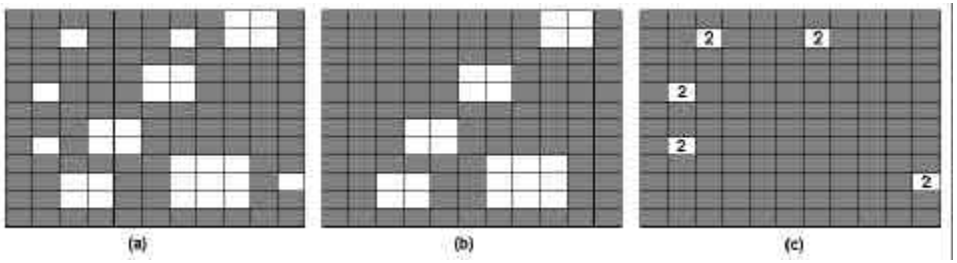
Dilation by a 3 x 3 structural element.

Followed by a dilation of the previous eroded image = opening

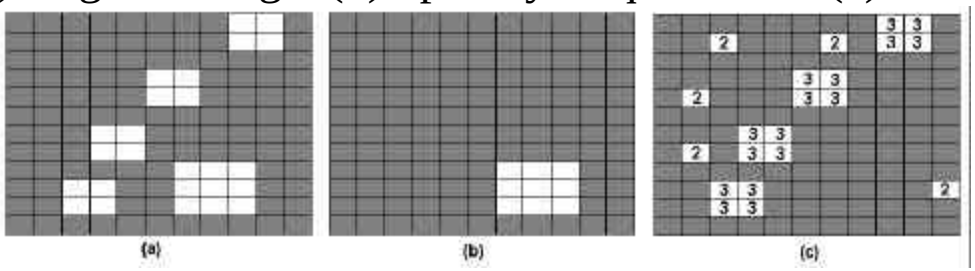
Followed by a erosion of the previous dilateded image = closing

Morphological Granulometrie:

set of Opening using $l\ B$
(series of virtual **sieve** with meshed defined by the **structuring element** size *)*

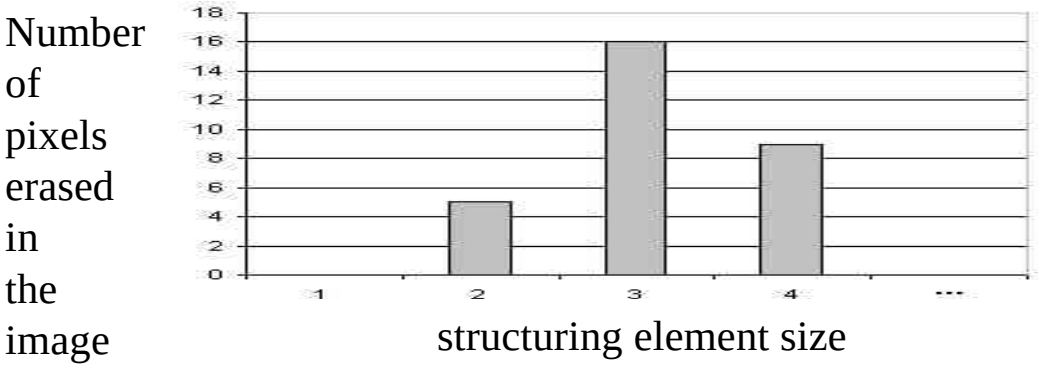


1st step: (a) original image, (b) open by a square **2x2**, (c) result



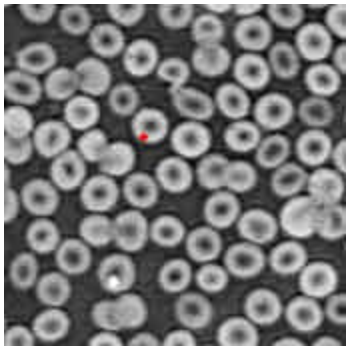
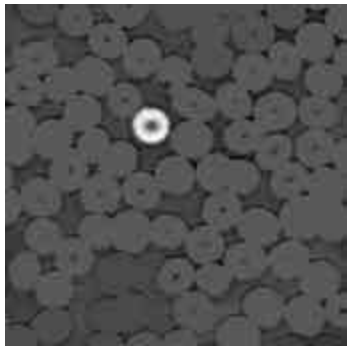
2nd step: (a) Image of firts step (b) open by a square **3x3**, (c) result

etc. to size distribuition:

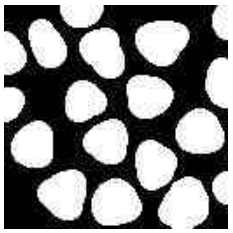
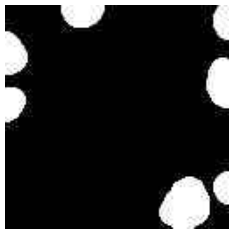
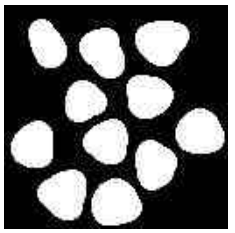


Morphological Reconstruction

- inserts the **concept of connectivity** in images;
- **with** Reconstruction **:**
  - only **complete cells eliminated by** opening using $l\ B$
  - elements **inside** cells can be identify

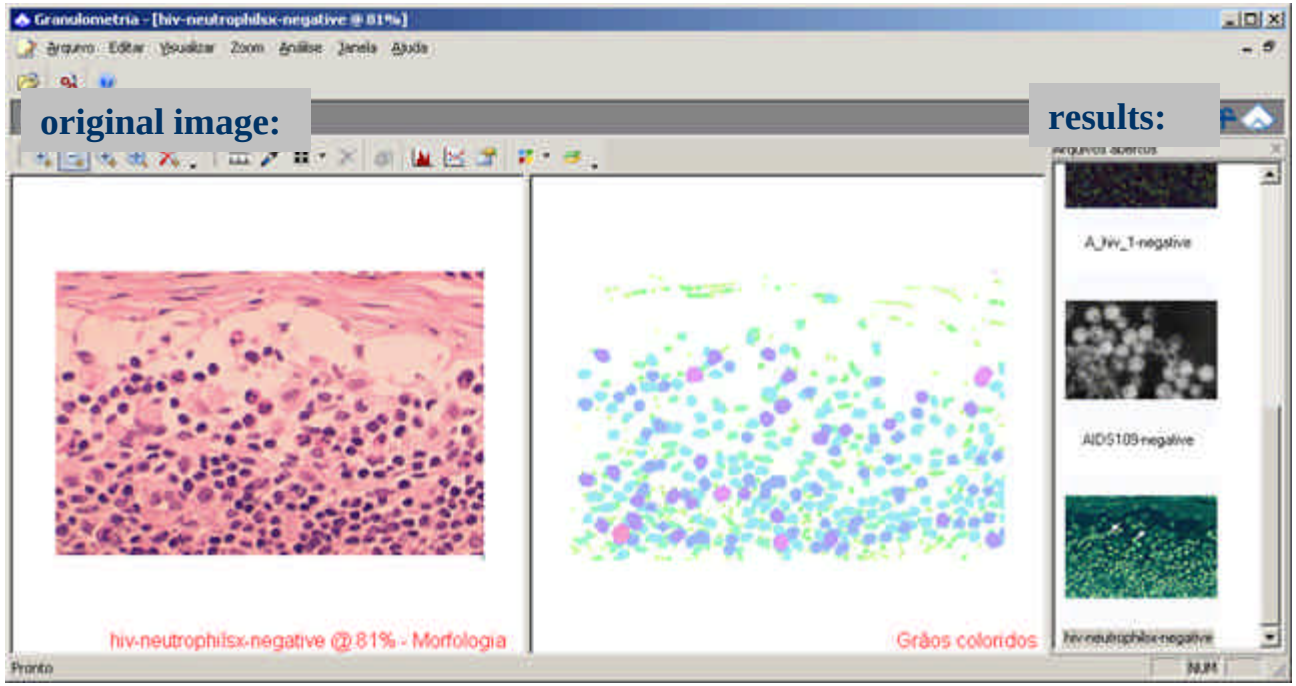



  - only **complete cells** in the frame are counted

Example:

extract
blood and
HIV cells and
from microscopic

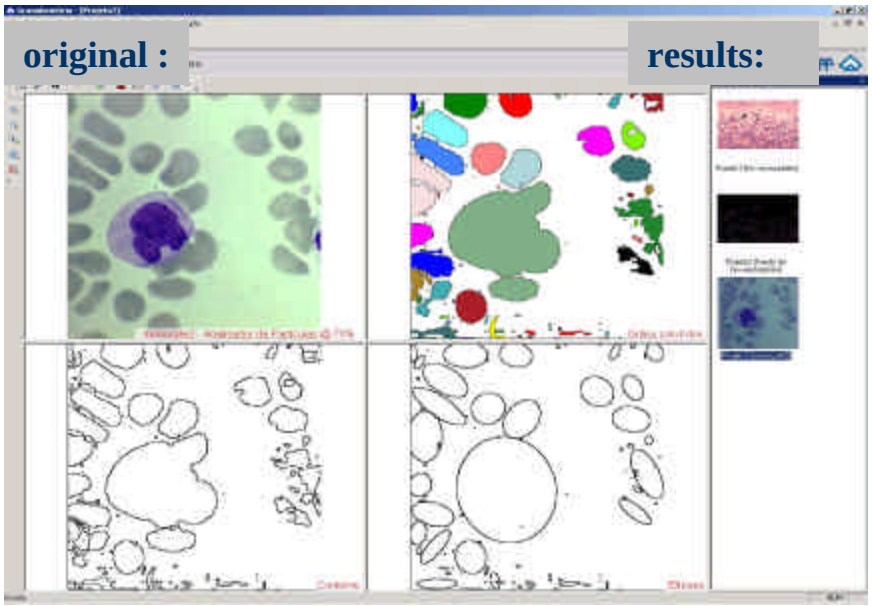


(different color => different number of nuclei)

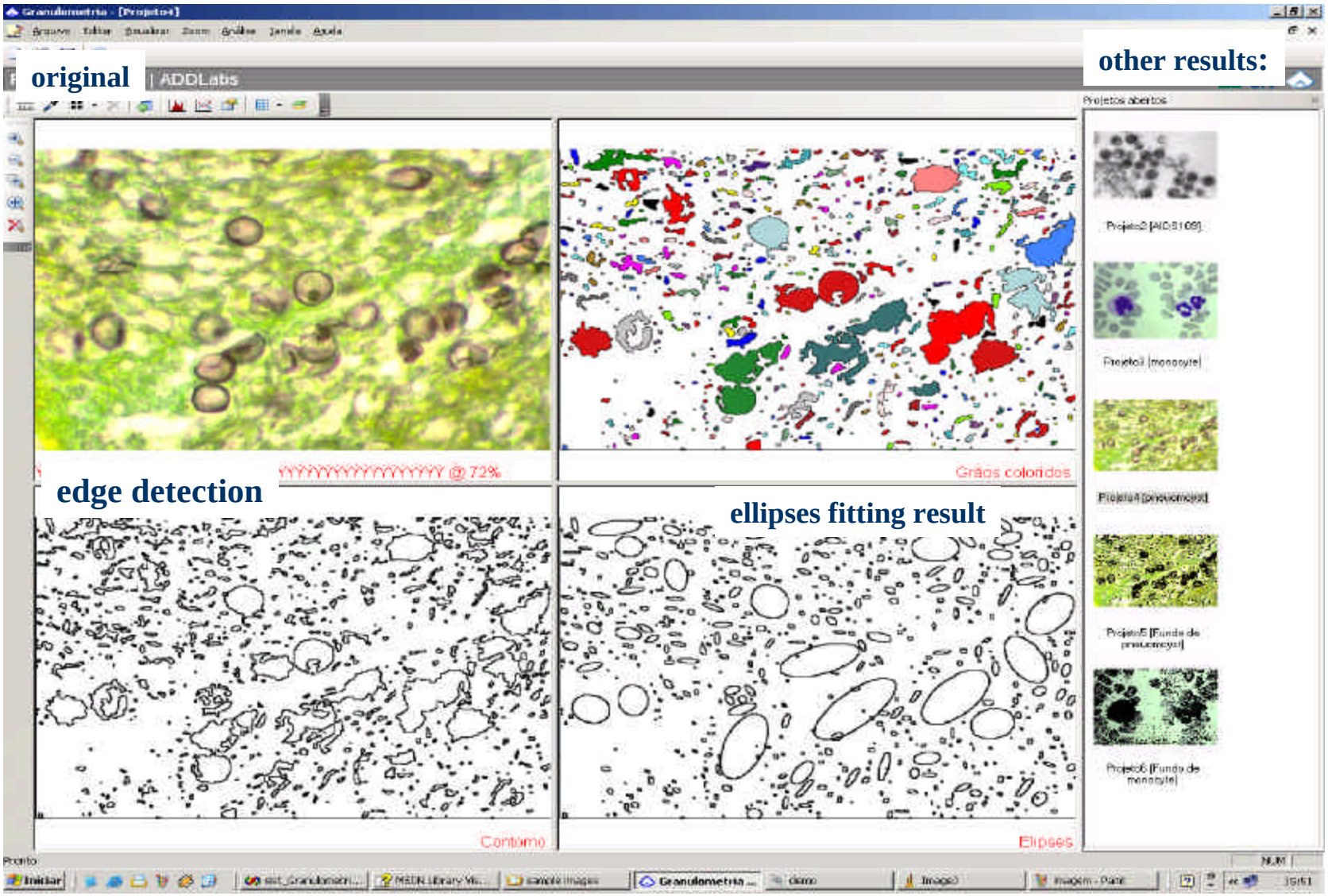
Granulometry by using best fitting shapes

Hybrid image
processing techniques:

- background extraction
- HSV color space
- windowed threshold
- adaptive edge segmentation
- ellipses fitting of the cells

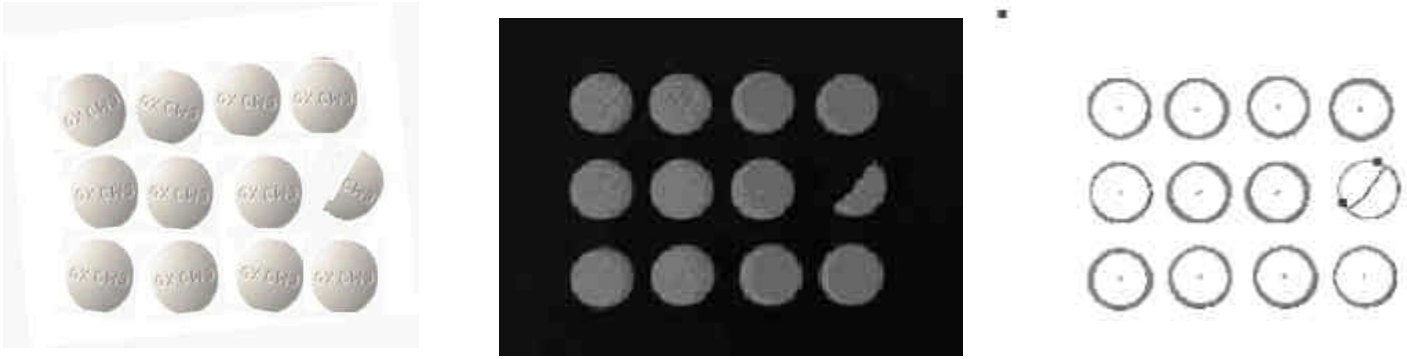


Example on cell identification and counting:



Granulometry by Hough Transform

Main idea use of Hough transform methodology for detection of circle, arcs and ellipses of predefined dimension and perfect shape



Examples on detect fails in the industrial production of pills

Conclusions

- **Mathematical Morphology**
  - can be used for
    - 3D and 2D elements
    - color ,
    - gray scale
    - binary images
    - partial elements
    - can recognize
      - inside properties
      - all shapes
- **Limits of others approaches:**
  - image processing techniques:
    - **touching shapes**
  - **Hough Transform**
    - **only shapes with known equations**