Particle Analyzer: an hybrid system for **microscopic granulometry**

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Importance:

- **HIV** - causative agent of **AIDS**;

- Slower progression of immune deficiency with use of **Highly Active Anti-Retroviral Therapy** (**HAART**);

- To **monitoring - count** and a **viral load** laboratory test are **periodically recommended;**

- Generic approches to **identify and count** cells of interest
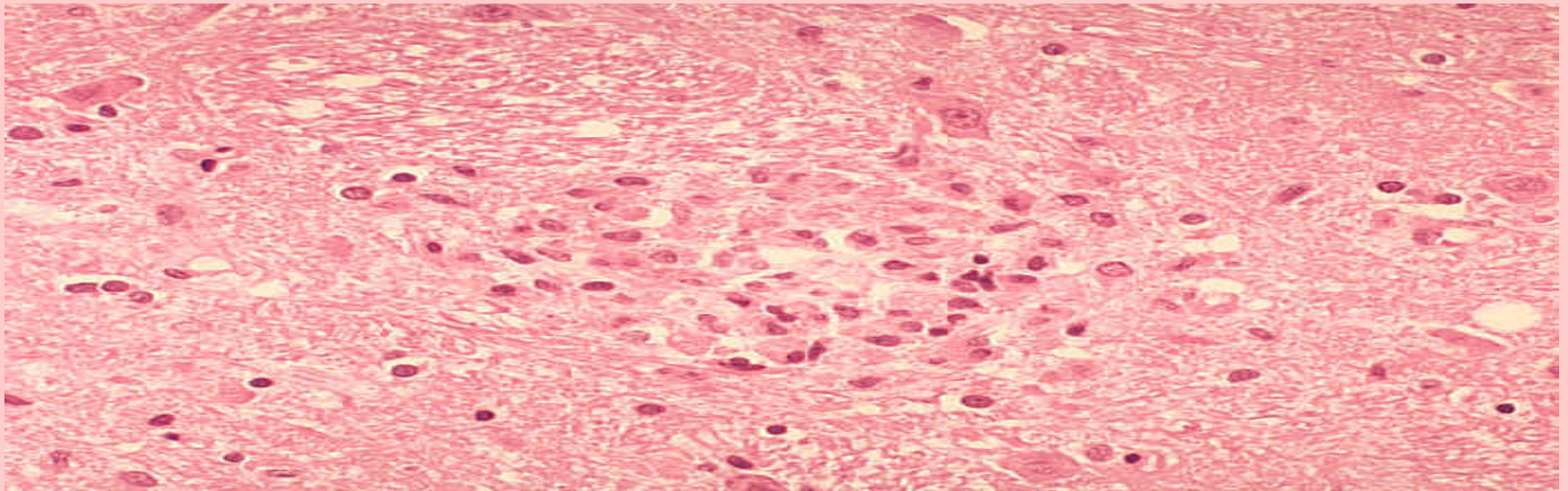
Synopsis:

- **particles size distribution and identification** = granulometrie
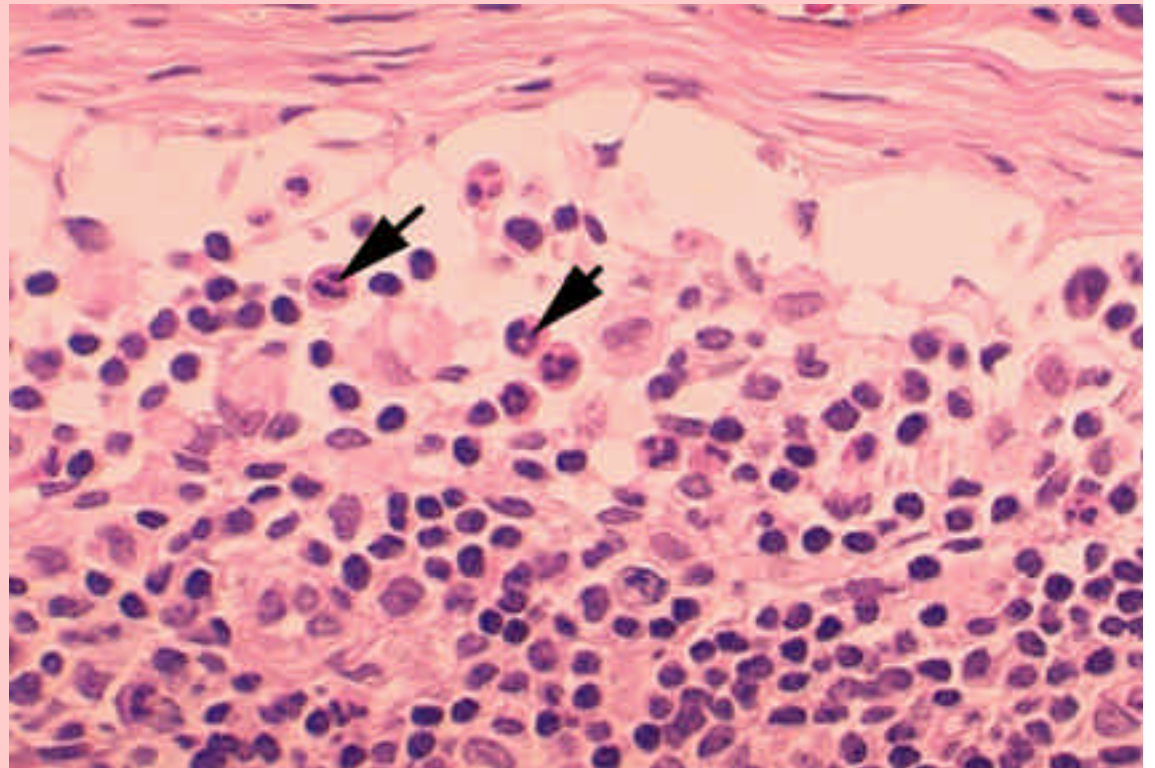
- morphological granularity

adapted to:

extract

blood and
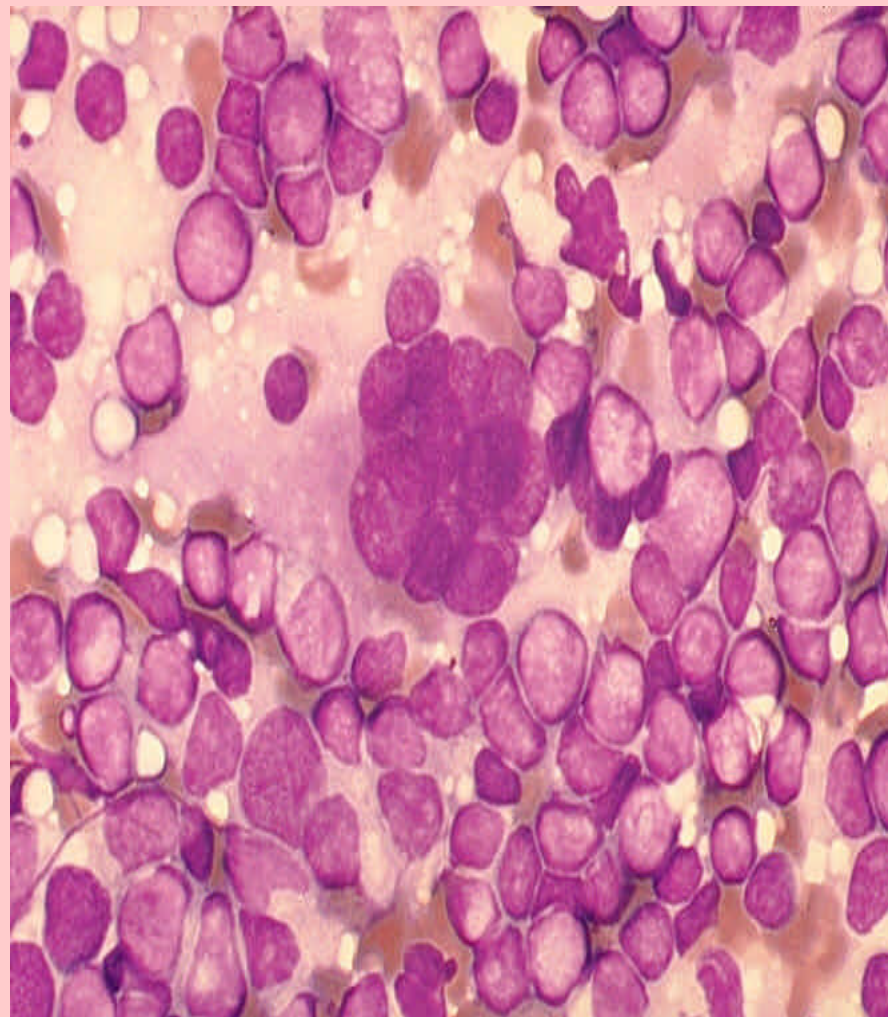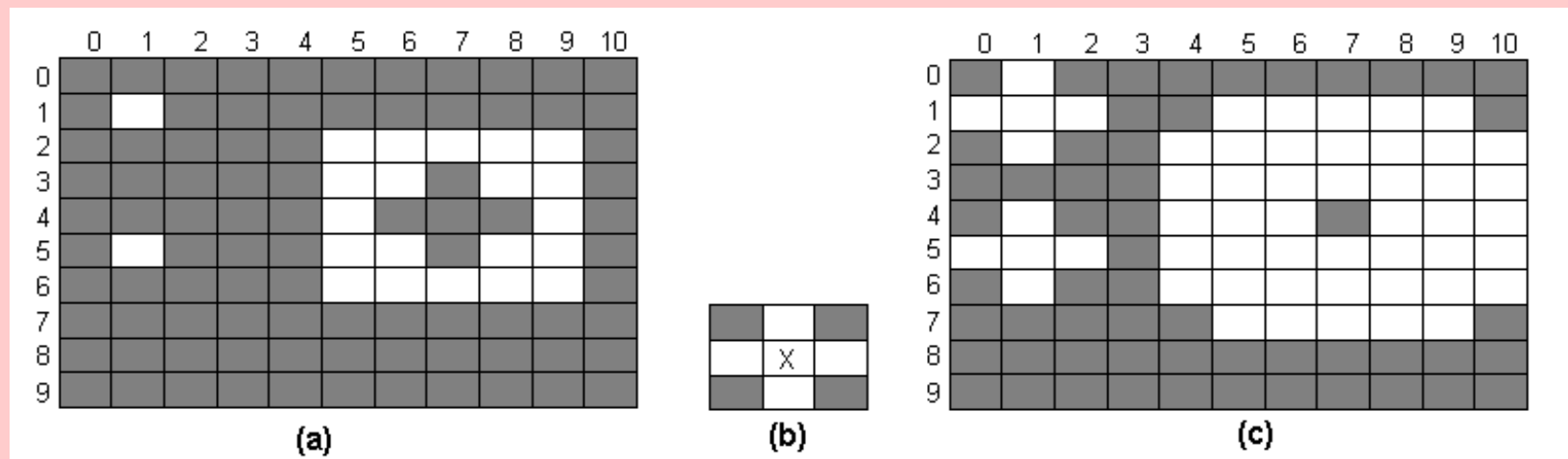
HIV cells and

from microscopic

images

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**

The **dilation** on binary sets
are defined by:

$$A \oplus B =$$
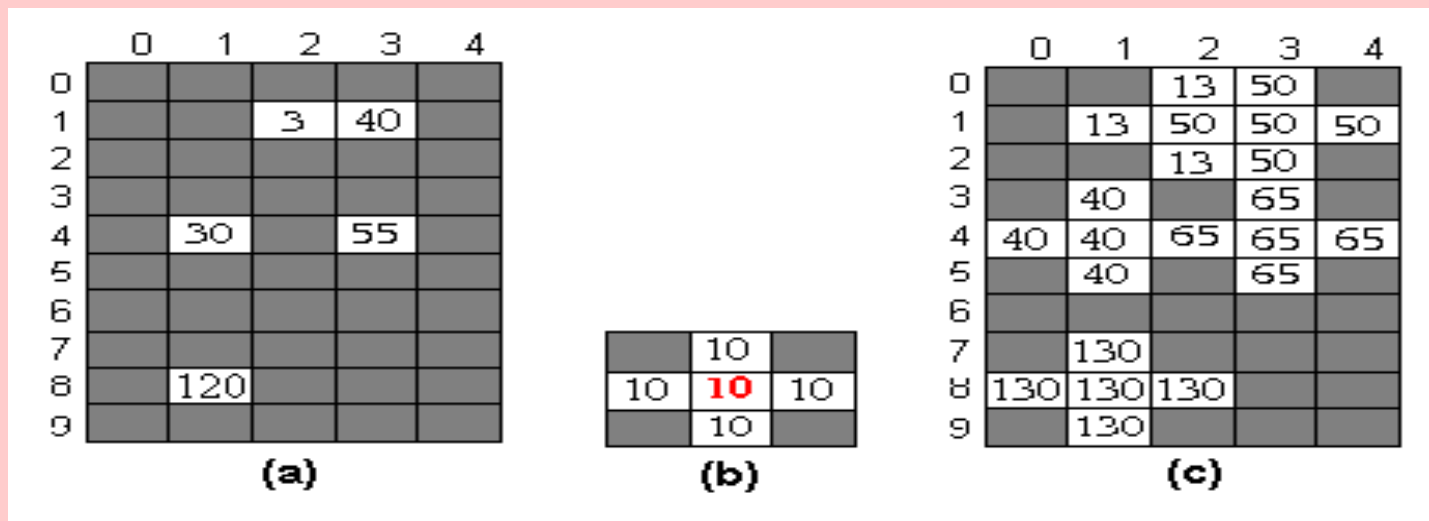$$\{ c \mid c = a + b, \text{ for some } a \in A, b \in B \}$$

(a)   (b)   (c)

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

Dilation applied to gray value image

- Let F , K be the domains of functions: **f (x , y) and k (x , y)**
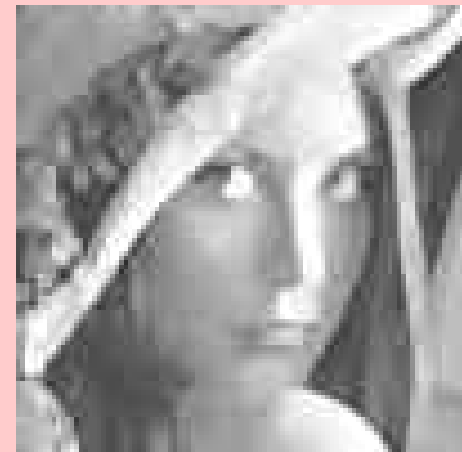 where **x , y Î Z** , then **Dilation** can be defined as:

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

(a)   (b)   (c)

- f is normally the image, while k is named **structuring element**.
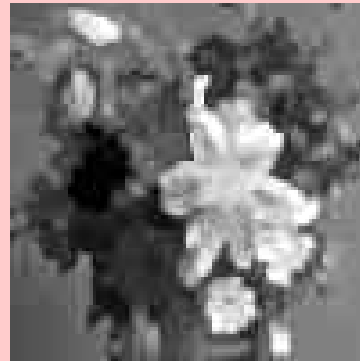- on color image, each **RGB**, **HSV** or **YIQ** channel must be considered

Dilation results: bright

- On the left is the original image on the center and right the result after Dilation with a discrete **3x3{1}** and **3x3{50}** element .
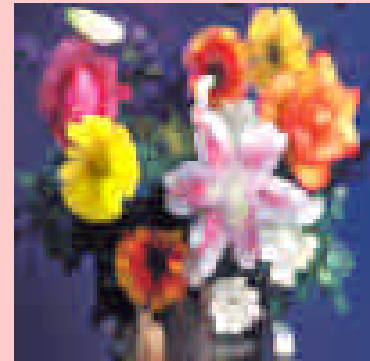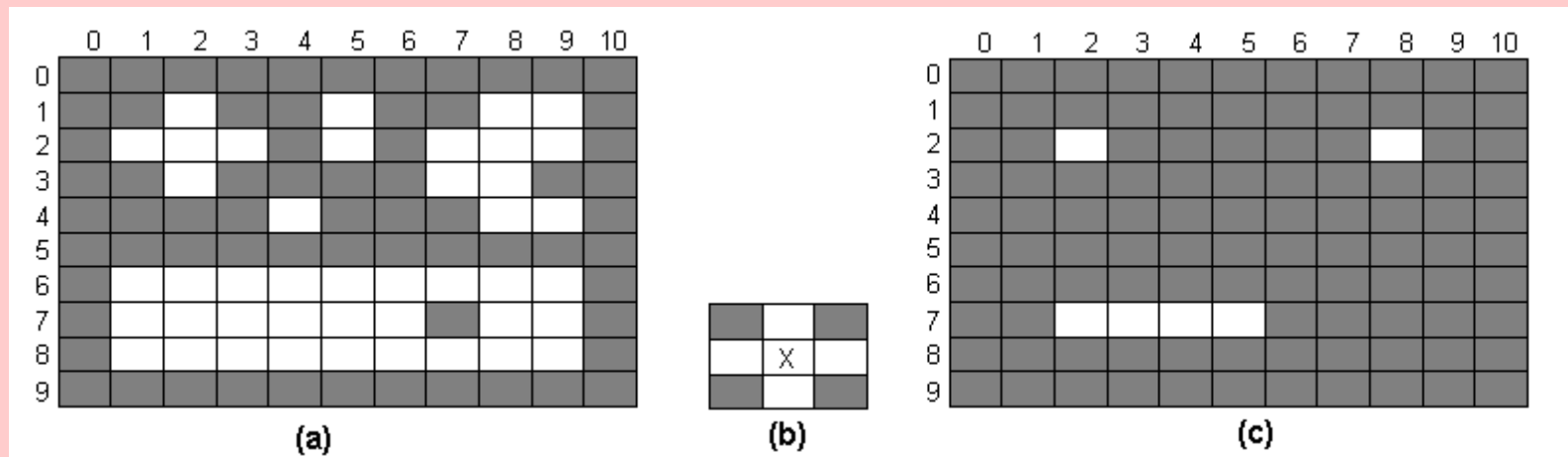
Dilation to color images

original

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

Erosion on binary sets are defined by:

- several equivalent definitions which can be given for erosion on binary sets but all resulting:

(a) (b) (c)

in "shrinking" of the original image

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:

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

(a)   (b)   (c)
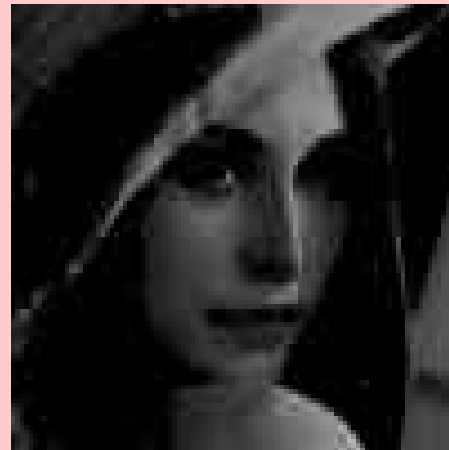
- **f** is normally the image, while **k** is often the **structuring element**.

- on color image, each **RGB**, **HSV** or **YIQ** channel must be considered
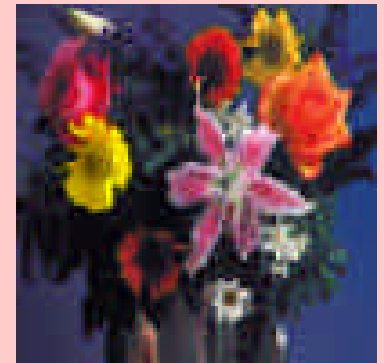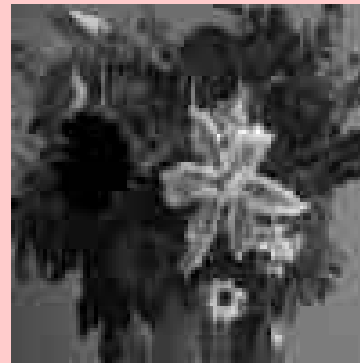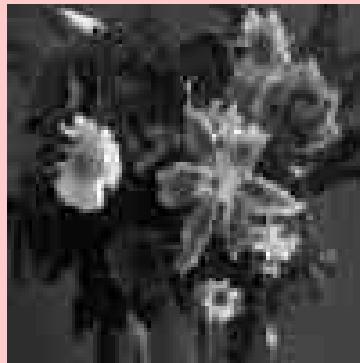
Erosion results: a dark image

- on the left result after erosion with a discrete **3x3{1}** element .
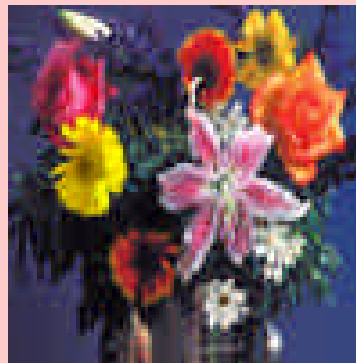 - on the right the result after erosion with a discrete **3x3{50}** element .

Erosion results to color images

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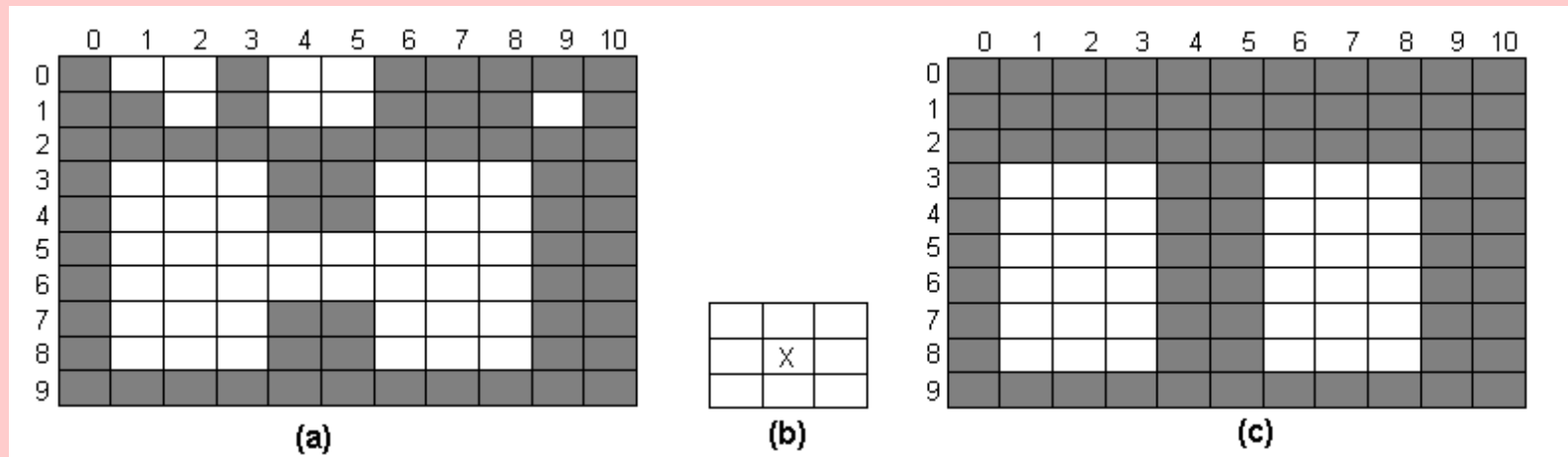

result

original

Opening

- This operation is a combination of an **erosion** and then an **dilation** :

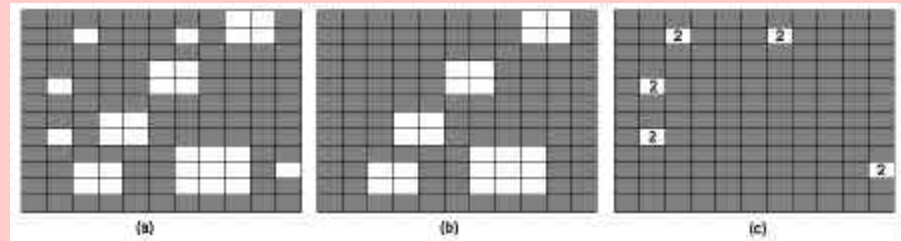(a)   (b)   (c)

- Thus opening :

  - breaks thin connections within an object

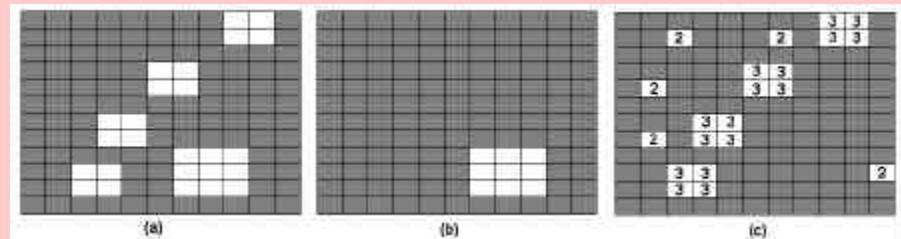 - eliminates small islands and sharp protrusions

Morphological Granulometrie:

- by a set of Opening using *l B*

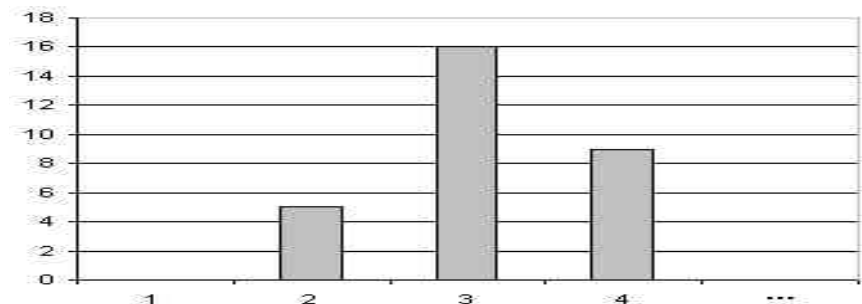*(series of virtual **sieve** with meshed defined by the **structuring element** size)*

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:

Number of pixels erased in the image

structuring element size

Morphological Reconstruction

- inserts the **concept of connectivity** in images;
- reconstruction can be built by an **infinite sequence of dilation and intersection**, until the result reaches a stability
- **with** Reconstruction **:**

  - only **complete cells eliminated by** opening using l B
  - black **nucleus inside** cells can be identify
  - only **complete cells** in the frame are counted
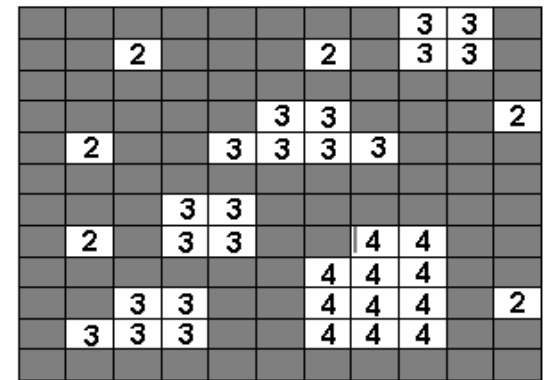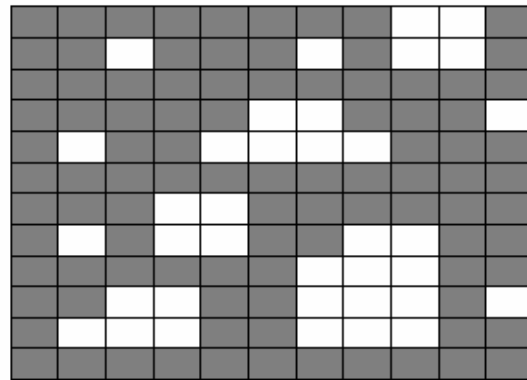
Example: **pixels** sieving

without
reconstruction:

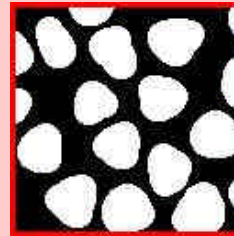partial cells
eliminated by a
square element *B*
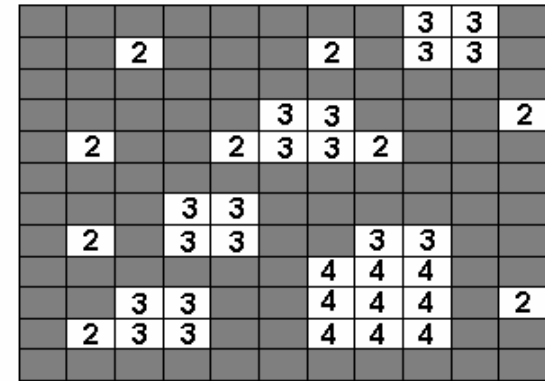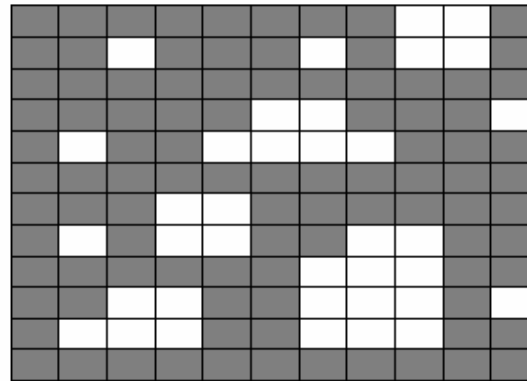
with reconstruction:

only **complete cells
eliminated by**
opening using *l B*

Detection **cells** on the **image border** that is not complete because they touch the acquired limits

- the image frame, shown in red.

- **Reconstruction detects all the pixels that are connected to the borders**. The reconstruction of the image detects **all the blobs that touch the image frame**. It is possible then, to **subtract** this from the original to get only complete **blobs**.
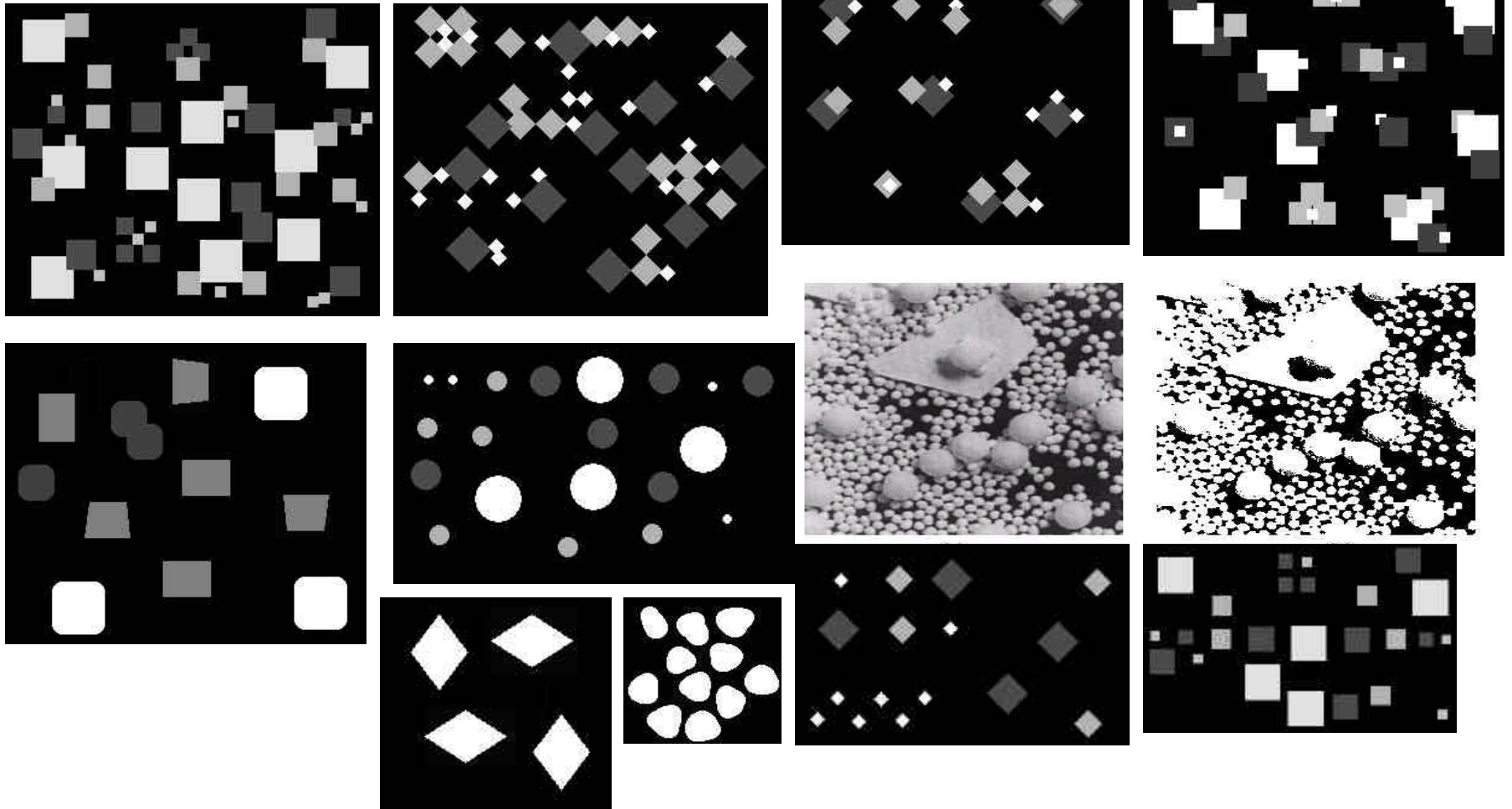
 - =

Detecting a single Black Nucleus cell

- A marker is placed over **one nucleus** in the negated cell image. The result of the **reconstruction enhances this black blood** cell because it is surrounded by dark pixels.
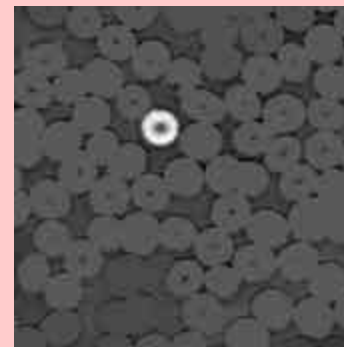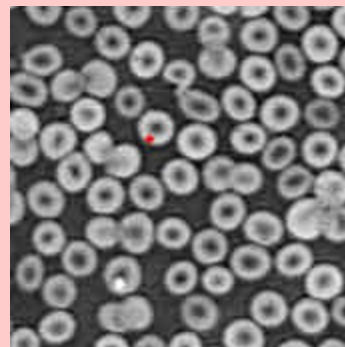
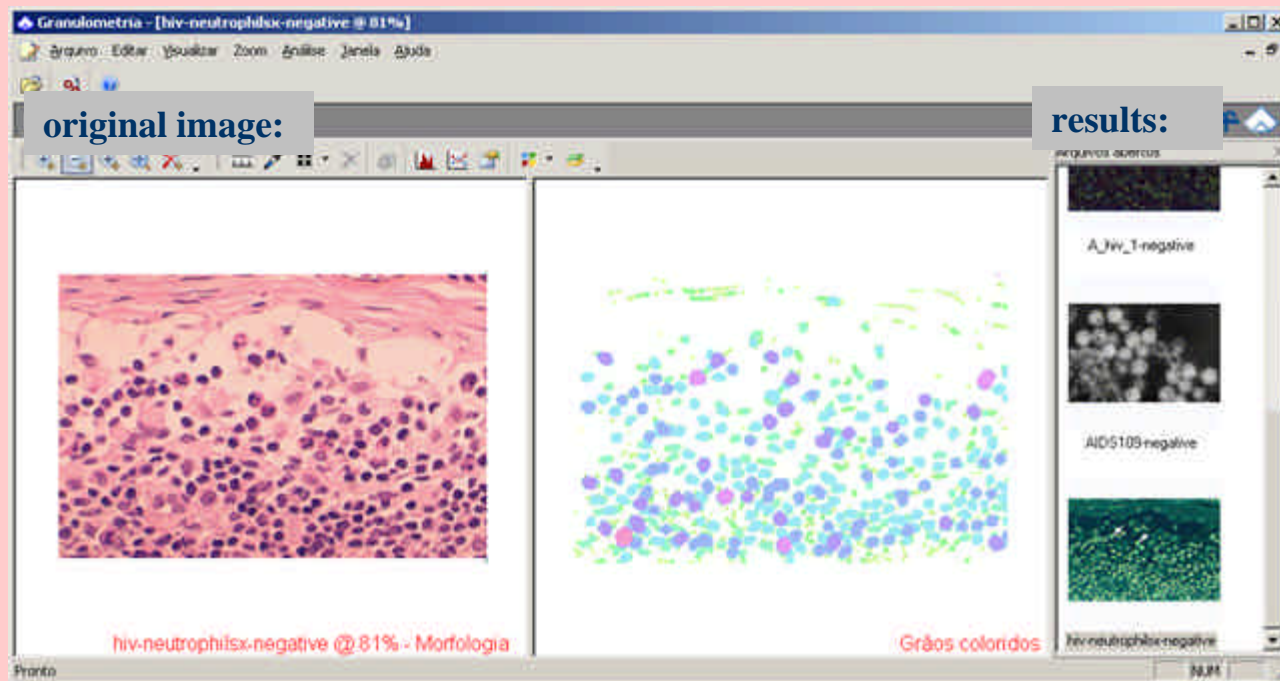# System result of granulometrie using morphologic techniques

Some **synthetic** images or known results
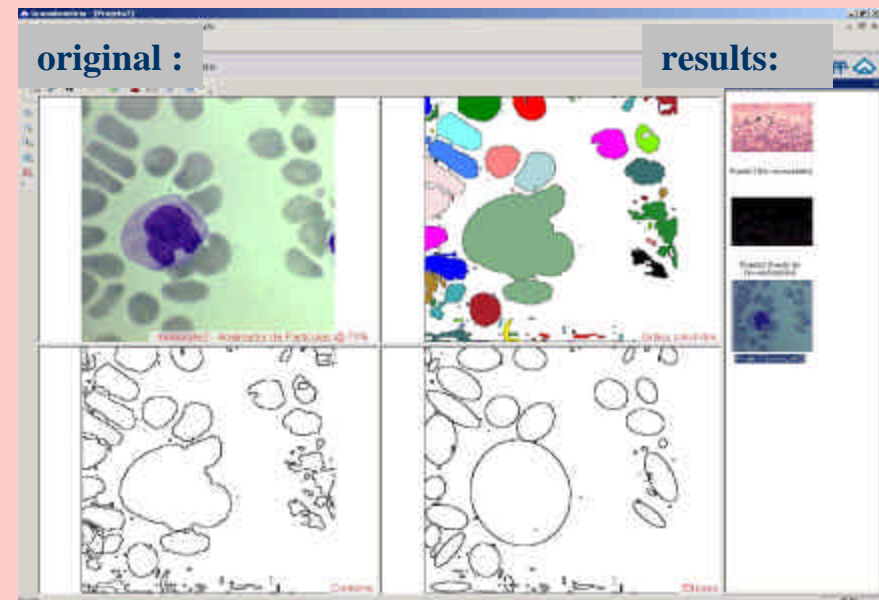
Real result

- identify count the HIV and blood cells

  (different color => different number of nuclei)

Hybrid image processing techniques:

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

Examples using hybrid image processing techniques:

background extraction

cells identification by different colors

adaptive edge segmentation

ellipses fitting of the cells
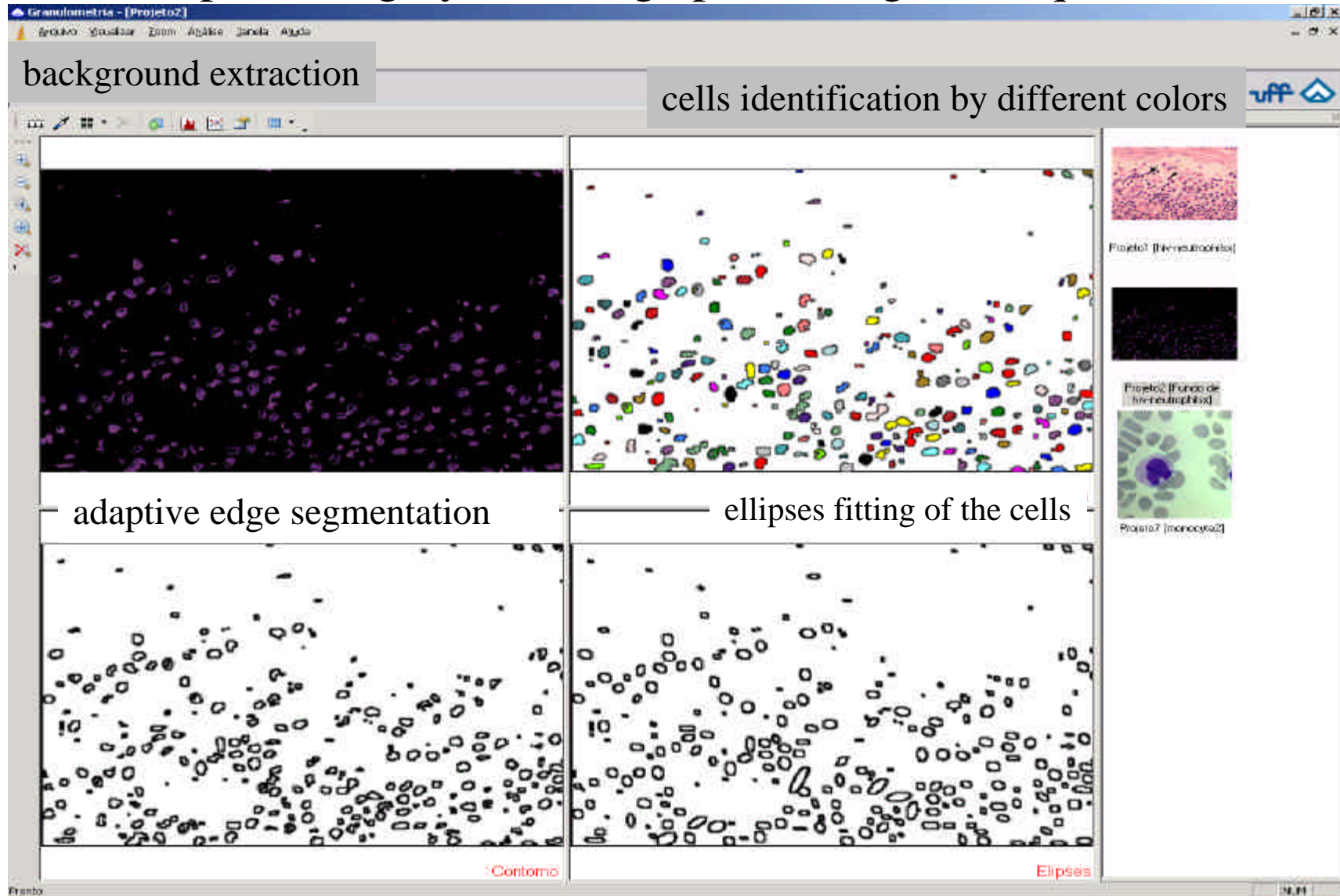
Hybrid image processing techniques:
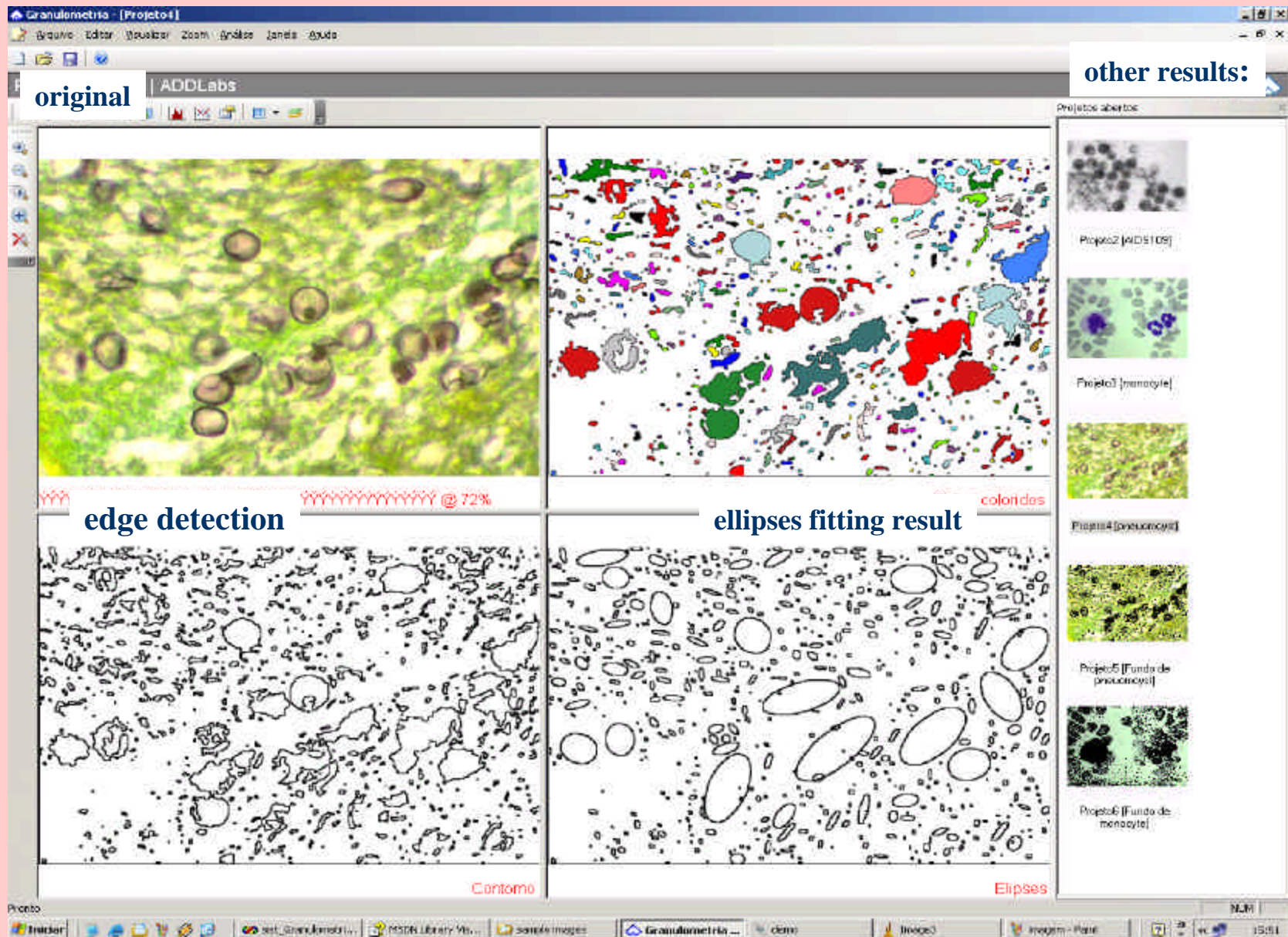
Conclusions:

- It was possible to extract and count virusor blood cells by the proposed **approach**;

- Techniques here presented for cell-size statistics can be used in others types of cells analysis whether **differentiation is** relevant as

  – ceramic micrography
  – petrology and petrography
  – mineralogy
  – metallurgy