Industrial Control By Vision

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Industry - Research Relations

Industrial Vision is structured as follows :

Industry :

- Problem definition;
- Socio-economical context.

Industry :

- Commercial device ;
- Marketing.

Research:

- Solution for a Reference Image Base;
- Prototype.

The seven Pilars of Industrial Vision

the interaction between industry wishes and technical constraints involves **seven themes :**

Choice of a **Representation**

Possible Presence of **Individuals**

Translation Invariance

Metrology

Preferential Directions

Speed

Motion .

Representations

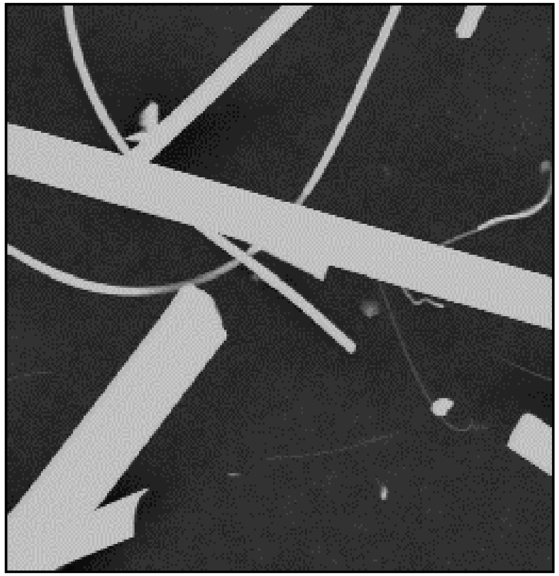
The "Images" involved in image processing are **representations** of the real world, which depend on :

- **magnifications** (*e.g.* two maps of a same region at two scales);
- **light** (*e.g.* polarisation, infra red sources);
- **sampling** (*e.g.* scanner of the human body versus X-ray projections);
- **various pre-treatments** (*e.g.* staining) .

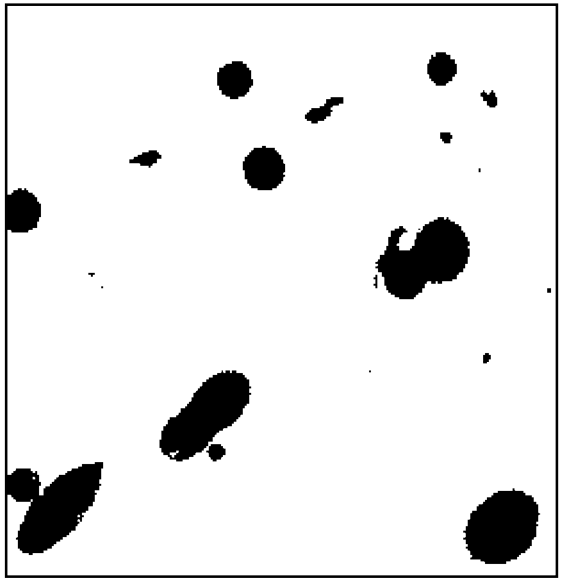
Therefore, in Industrial Control by Vision, we must choose and master these parameters.

For example, in size control of glass fibres, should we lay down the fibres, or embed them in resin and make cross sections?

Example n° 1 : Glass fibers (H. Talbot, *Isover - S^t Gobain*)



a : electron micrograph



b : optical micrograph on a cross section of a

Individuals

- An **Individual** is a sub-part of the image that **we** decide to consider as a whole:

  - a city, seen from aerial photograph,
  - a mitosis, in chromosome analysis,

  ..are (disconnected) individuals

- Usually, image processing begins on the **complete image**:

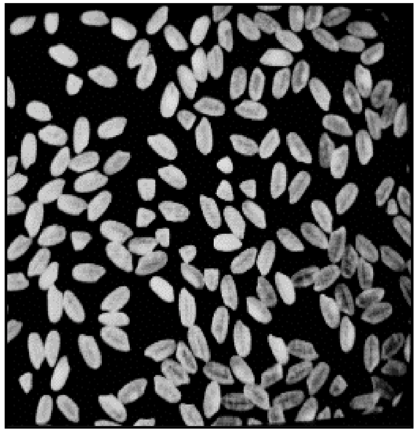
  - threshold, filtering, overall measurements, ...**ignore** individuals.

- Do we need to shift to individual approach ? If so, when ?

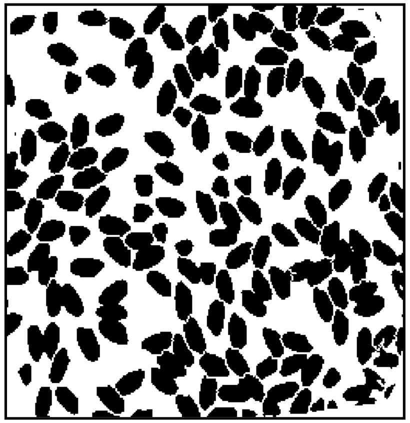
  - In the rice example, the segmentation step holds on the whole image, and **generates** the individuals,

  - in the motor case, the individual is the central region, not the vannes.

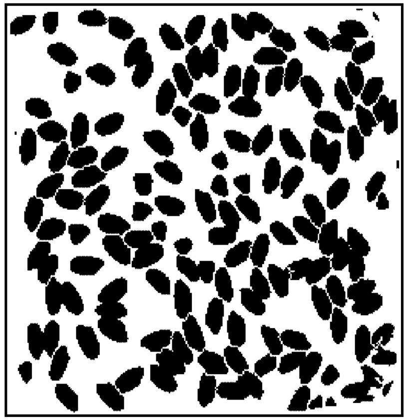
Example n° 2 : Broken Rice Grains (J. Serra, *Sciro-Mines*)



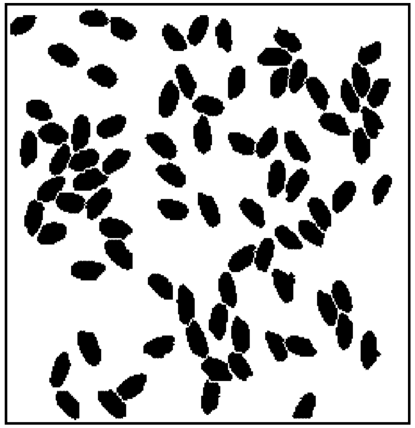
a : initial image



b : segmentation of a

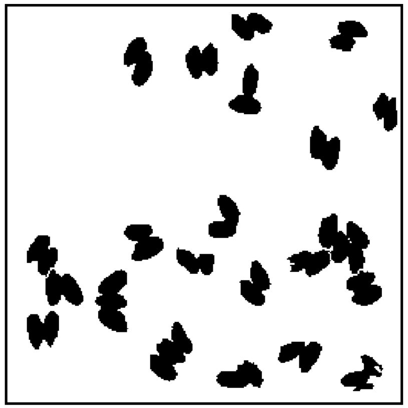


c : internal grains



d : integer grains

e : broken grains



f : clustered grains

Translation Invariance

- The operations ψ we perform may commute, or not, under translation. If so, they are said to be **translation invariant**.

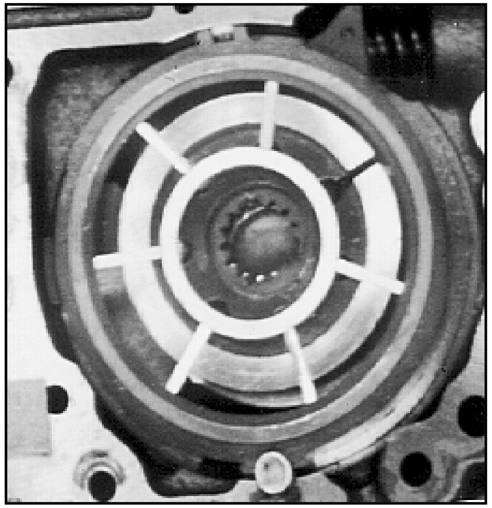
- Such a **decision** relates to ***operators***, it is not an **assumption** on a possible stationarity for the ***images*** under study.

  However, if set X is the support of function f, and W a moving window whose random centre follows the uniform law over $X \oplus W$, then f is **stationary inside W.**

- Examples:

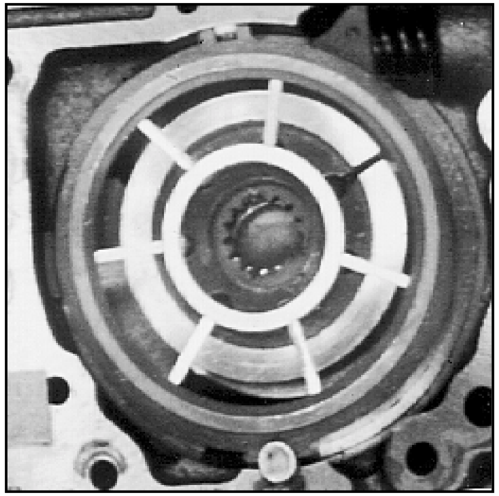
  - the radial vannes (n° 6) occupy a typical place in the field of view, which should be exploited in a convenient processing;
  - unlike, the grains of rice (n° 2) spread out uniformly;
  - in between, the antibiograms (n° 3) are roughly periodic.

Example n° 3 : Oil Pump Inspection (S.R. Sternberg, *G^{al} Motors*)

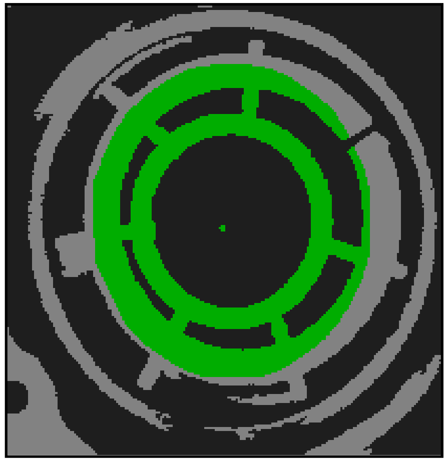


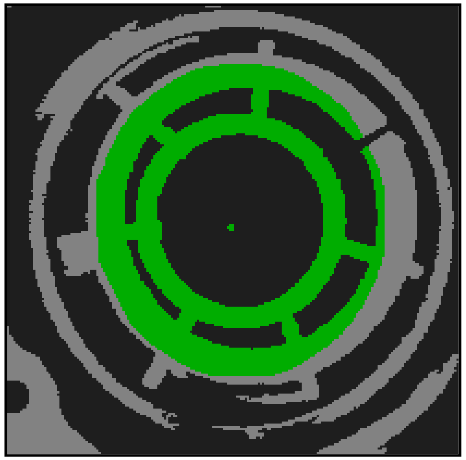
one missing vanne

no missing vanne



5 holes





7 holes

Metrology

- The final steps of the processing usually yield **measurements** such as volumes, areas, sizes, counts . Now,

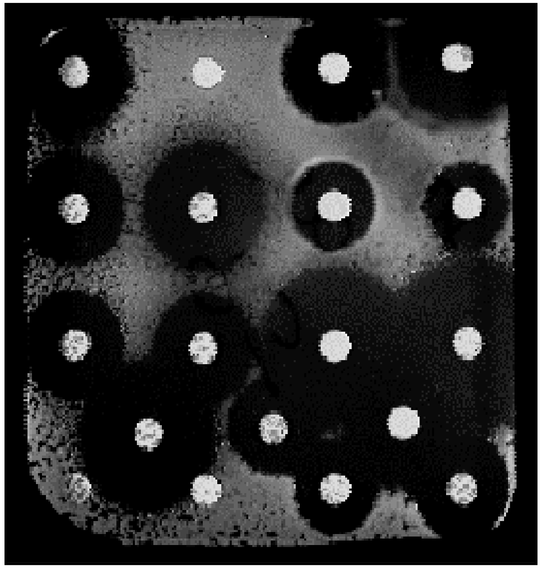
  - How to measure a radius (for example) ?
  - What accuracy is really needed ?

- The **robustness** of the ***final result*** has to be associated with the ***whole treatment***. Some operations reduce robustness (*e.g.* derivations). Other ones increase it (*e.g.* filters), and may serve to improve the first ones.

- The three major causes of **bias** are

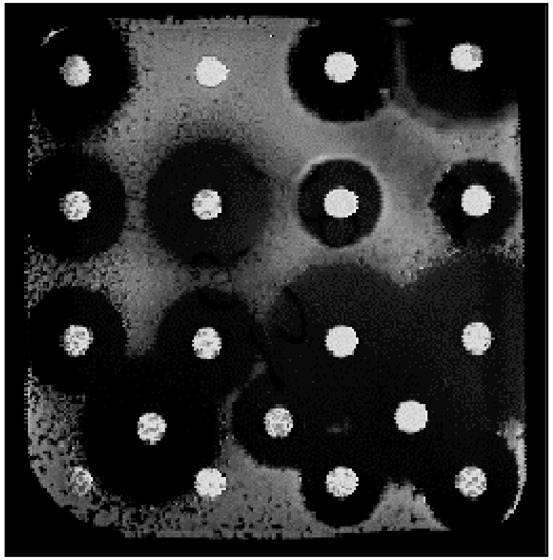
  - edge effects, specially in individual analysis
  - preferential orientations;
  - sectioning (stereological properties).

Example n° 4 : Antibiograms
(J. Serra, *Inst. Pasteur*)

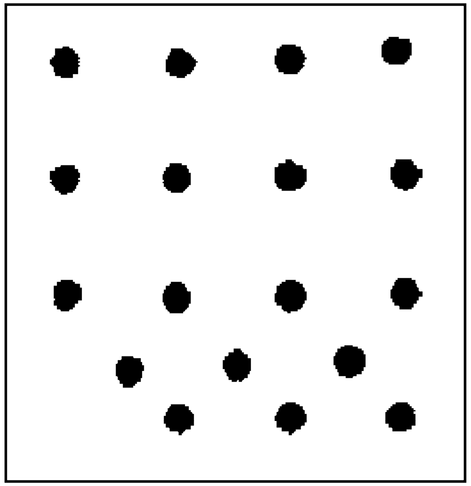


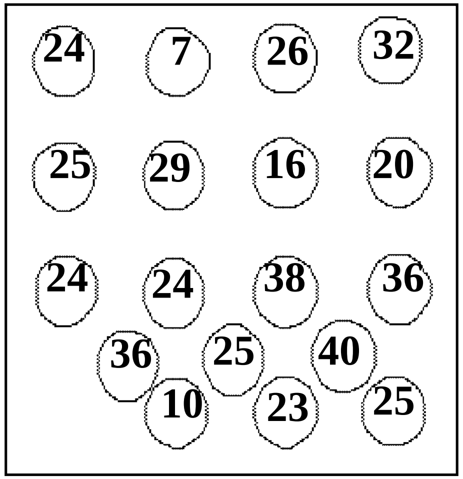
Initial Image a)

Distance function on a thershold of a)



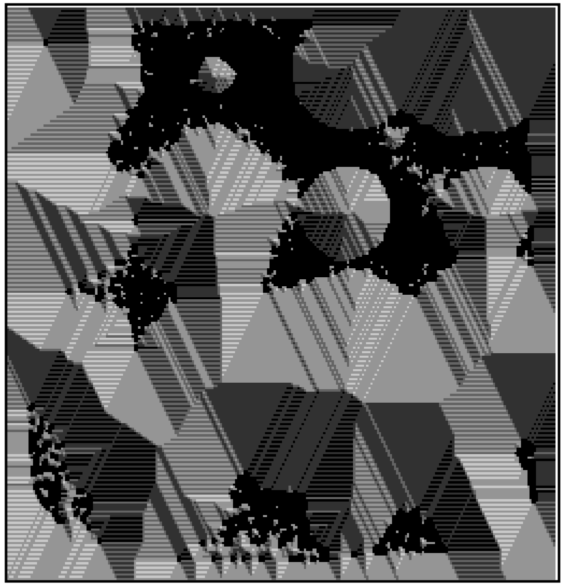
Pastilles: threshold on the residual of a) after a filter by reconstruction.



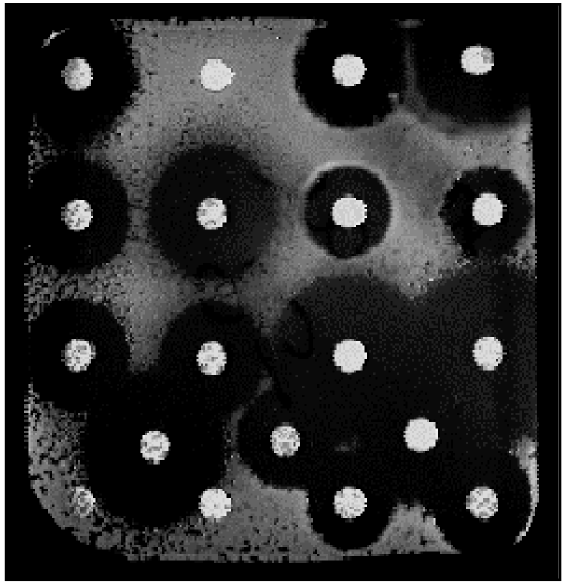


Sizes of the halos: maxima of the distance function, taken inside the pastilles.

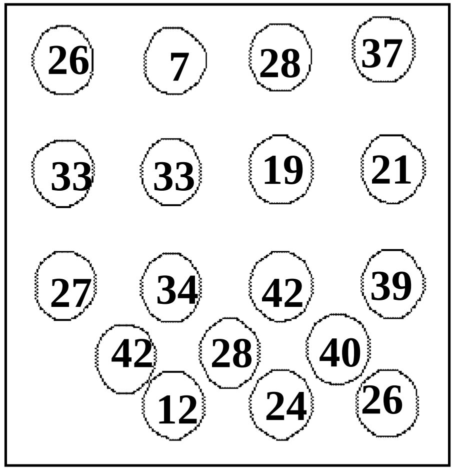
Example n° 4 : Antibiograms(robustness)

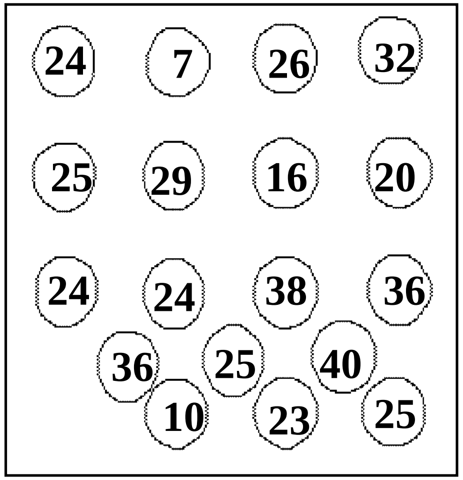


Distance functions corresponding to two different thresholds of a)



Sizes of the halos: maxima of the distance function, taken inside the pastilles for the two cases





Note the robustness of the result

Preferential Directions

- Preferential directions may correspond

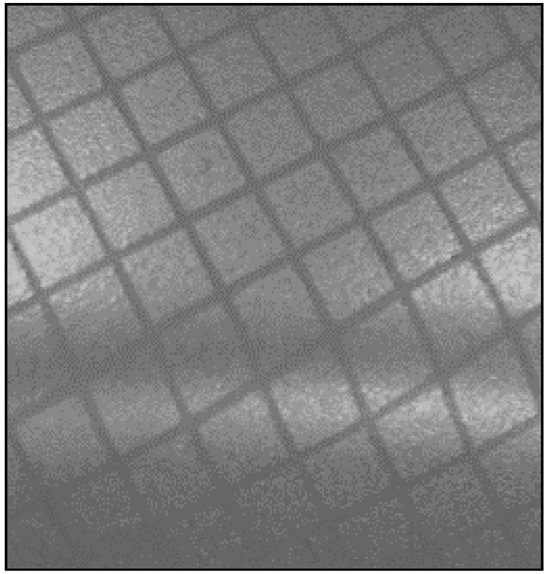
  - to linear objects or to **alignments** ;
  - in some given **directions** of the space, or not ;
  - in association with other **anisotropies**, or not.

- They always set problems

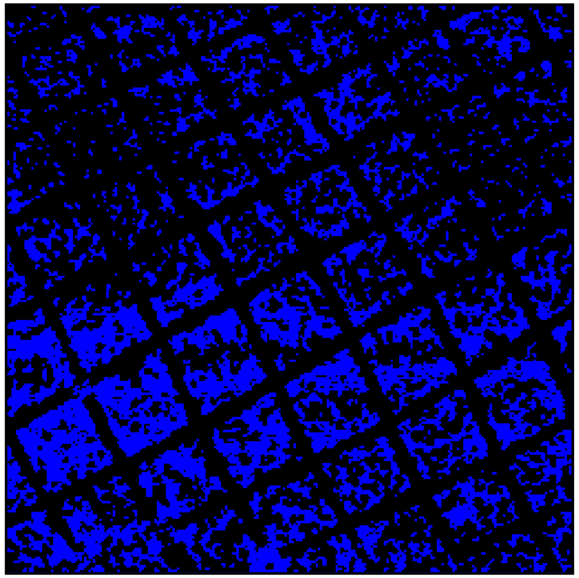
  - of **computational complexity** (one more degree of freedom, long distances involved);
  - of **digitisation**, since their orientations interfere with those of the image raster.

- Also, the definition of such lines is sometimes circular (the alignments will be what **your** algorithm finds as alignments...).

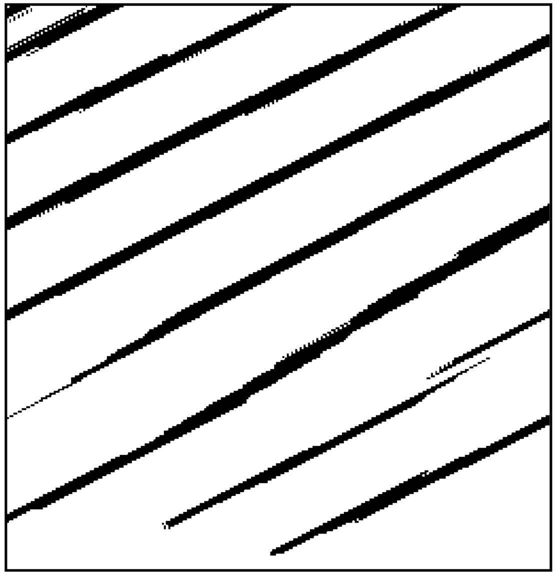
Example n° 5 : Stamped Metal Sheets (J.C Klein, *Ocas*)



a : Initial image of stamped sheet

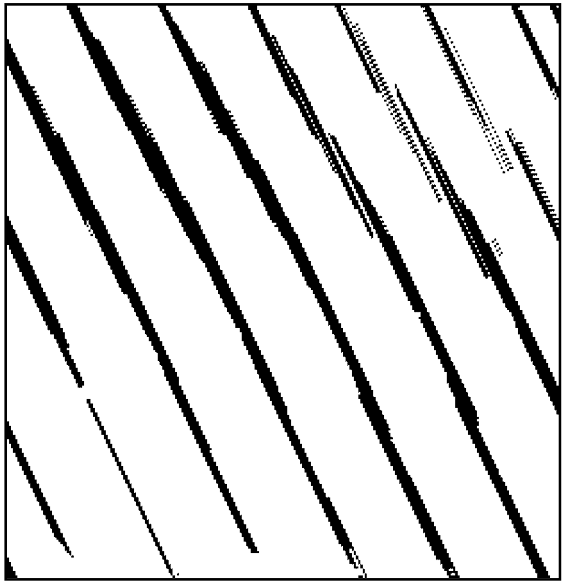


b :Threshold after top-hat by closure

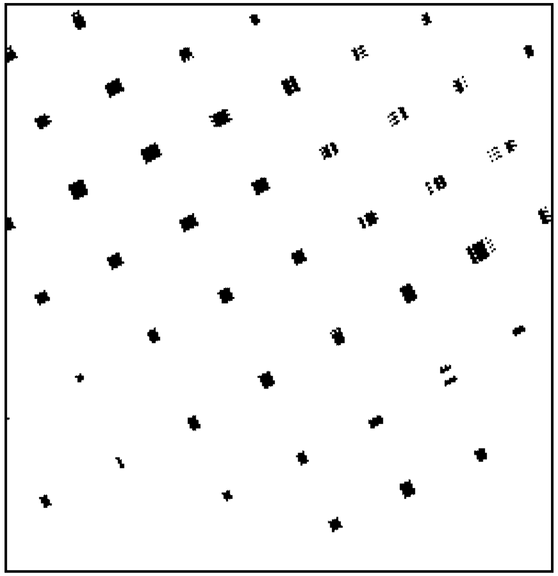


c : Opening in the 1st main direction

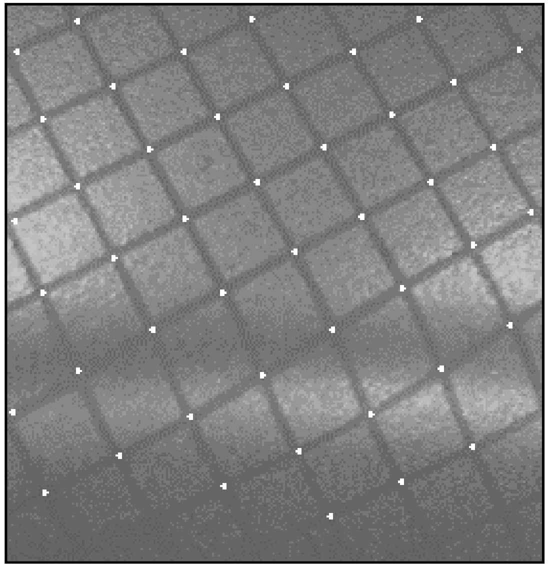
Example n° 5 : Stamped Metal Sheets (II)



d : Opening in the 2nd main direction



e : Intersection between sets c and d



f : Final result

Speed

- In each situation, wonder what **speed** is required.

The confused notion of ***real time*** does not tell which reality is referred to. Practically, a **computing time** can always be defined.

- Examples of non drastic cases :

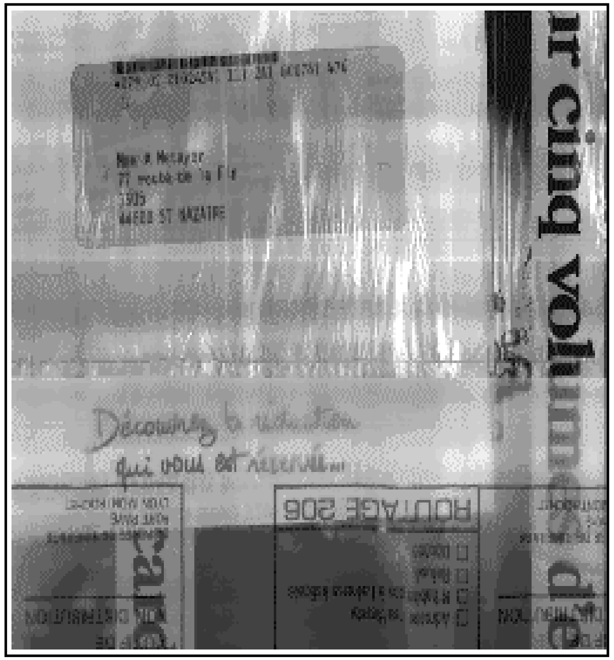
- for antibiograms, this time is that of the reaction, *i.e.* **half a day**,
- for motor inspection, the time, imposed by the production line, reduces to **a few seconds**,

- The drastic cases occur with the conjunction of

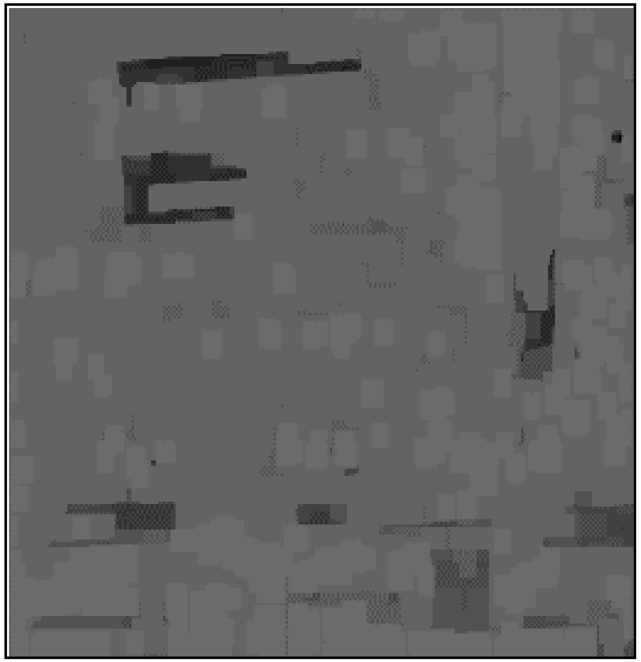
  - **high data flow**,
  - and **complex algorithms**.

Typically: cytological smears (number of fields) ; envelopes reading .

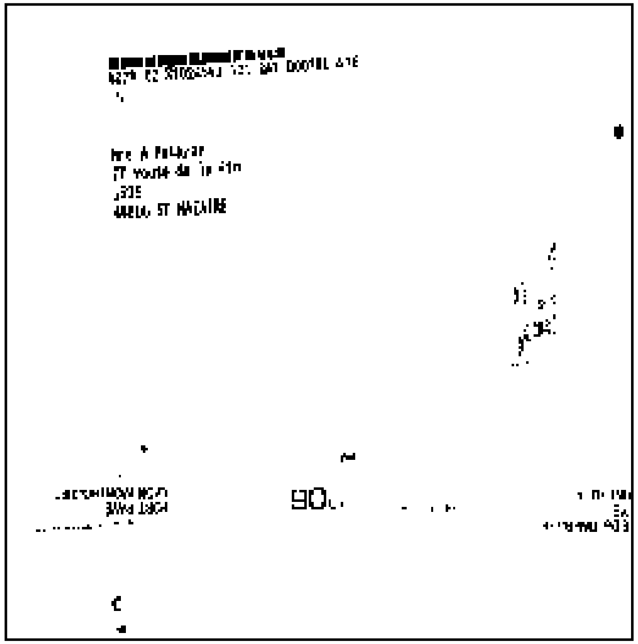
Example n° 6 : Addresses Reading
(S. Beucher, *CRTP*)



Initial Image a)

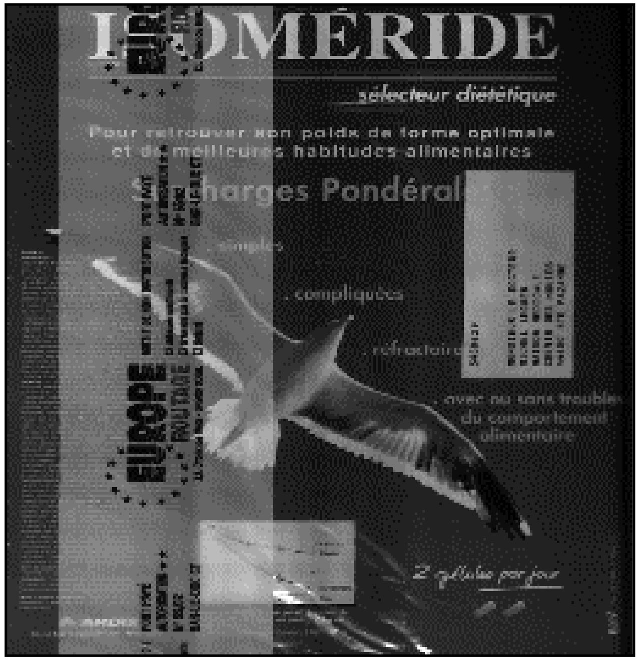


Inf of geodesic dilations of a) in 44 directions, followed by an alternated filter .

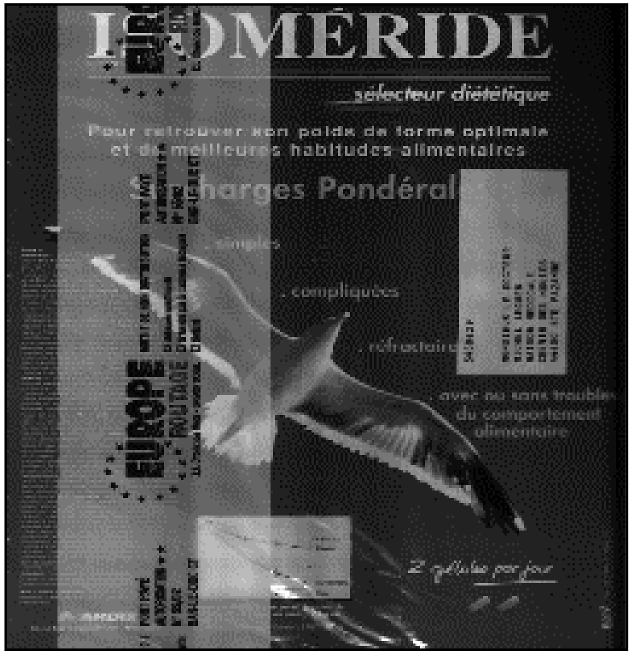


Threshold of the previous image according to the depth of the minima.

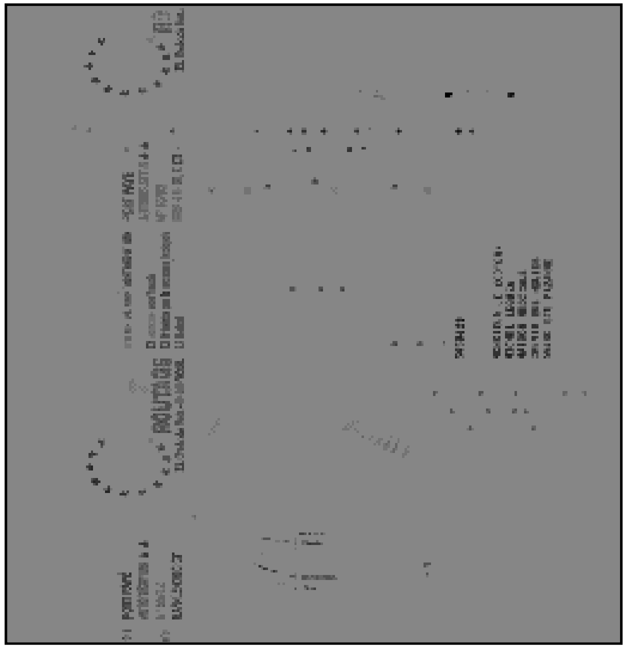
Example n° 6 : Addresses Reading (II)



Initial Image a).



Processing of a)
by inf of 44
geodesic dilations
(followed by a filter).



Processing of a)
by a unique small
geodesic dilation
(followed by a filter).

Control and Motion

- Quality control by Vision concerns also **image sequences**. There are two major domains of application: Physico-Chemistry and films (or video).

- The challenge is to try and extract significant features from variation along the time. For instance, is it preferable to consider the product **Space ⊗ time** as a whole, or to use slipping windows along the time axis?

- Examples in **Physico-Chemistry** :
  - Fluidisation Processes (bubbles, particle flows,..)
  - Kinetics of Deformations (under heath or mechanical constraints).

- In **films (or Video) Industry** :
  - restoration of old movies;
  - automatic control and tracking of persons or objects.

Example n° 7 : Restoration of old movies
(*E. Decencière, E.U Program “Noblesse”*)

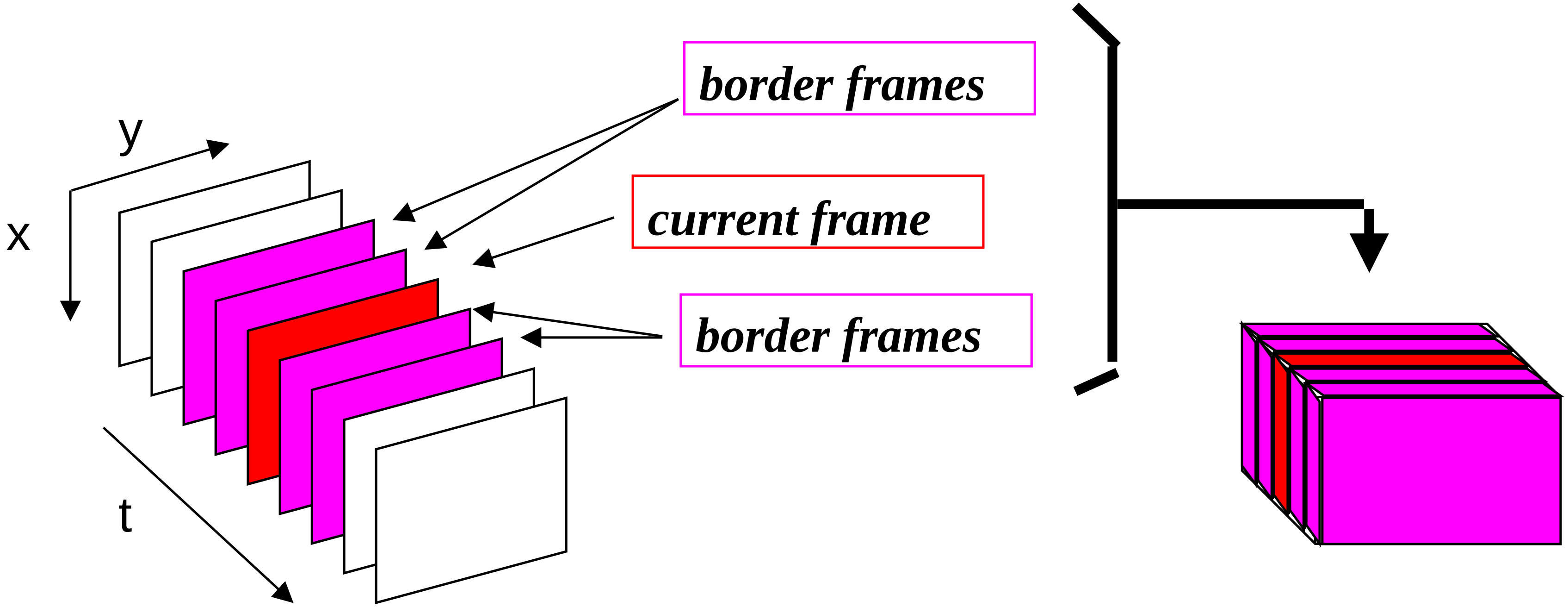
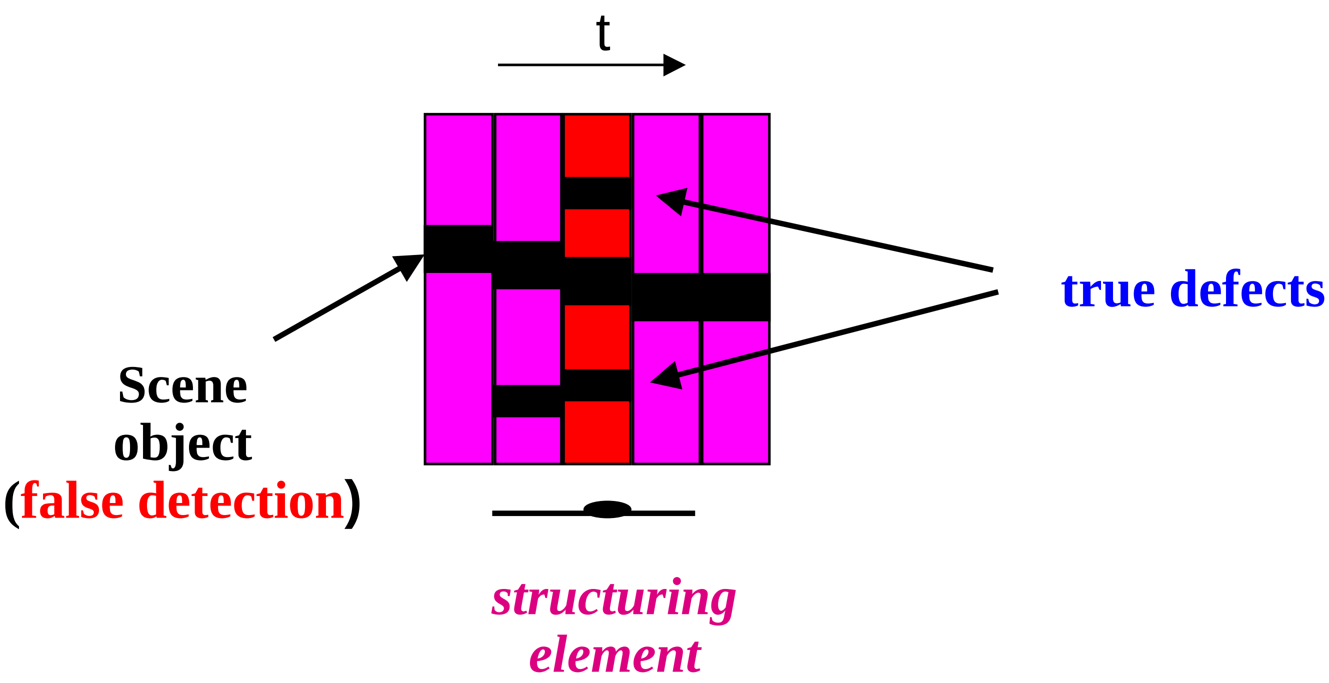


Image Sequence

Working Image

Example n° 7 : Restoration of old movies (II)

Detection along the time axis ⇨ sorting between false detections and true defects



(*operator* : top-hat by reconstruction along the time axis)

Application to the first Australian Movie

Train entering Sydney Station
(*Louis Lumière 1897)*

Conclusions

- There are two types of controls, namely

  - **On-line** ones, and
  - **indirect** ones, when experimental protocols attempt to understand what is going on, and to find key parameters.

- The first type requires **global** optimisations (*e.g.* envelopes reading), whereas the laboratory approach focuses on some **particular** steps.

- However, in both cases, a situation is correctly set **only** when both

  - industrialist (or physicist),
  - and engineer in vision

  do agree on **a set of representative images** of the current study .

- *N.B.*: a solution does not exist always, and if so, it is rarely unique.

References

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