

# Texture Featuring Based on Watershed

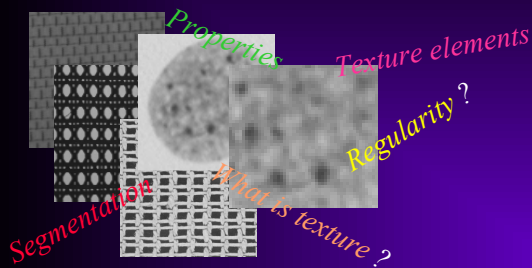
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## Introduction

- Textures



## Some remarks about *watershed*

- Definition

Given an image and a local maximum at point  $m$ . Consider all monotonous decreasing paths  $w(m, l)$  starting from  $m$  and ending in  $l$ .

The set of all points  $l$  is a connected region.

The set of all such regions is a partition of the input image, the order corresponds with the number of local maximums.

The borders of the regions are the *watersheds*

## Some remarks about *watershed*

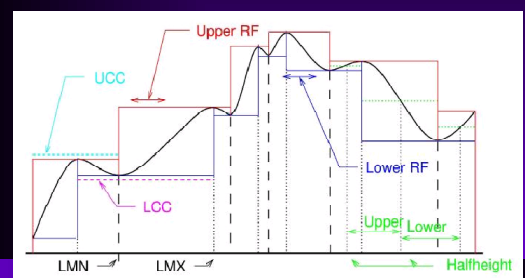
- Definition (continued)

The inversion of the above definition concerning *maximum* by *minimum* and *decreasing* by *increasing* delivers a second type of watershed.

## Some remarks about *watershed*

- Explanation

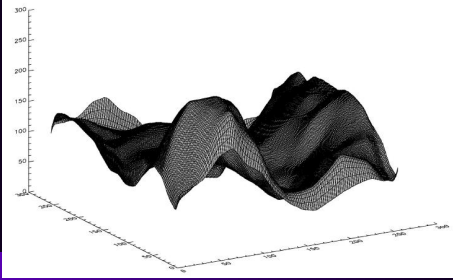
1-dimensional



## Some remarks about *watershed*

- Explanation

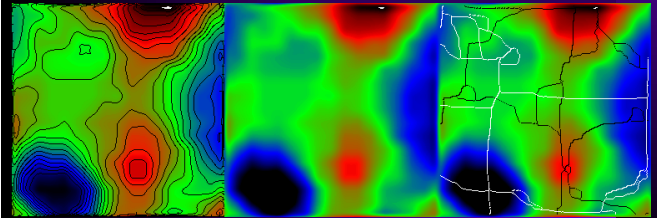
2-dimensional



## Some remarks about *watershed*

- Explanation

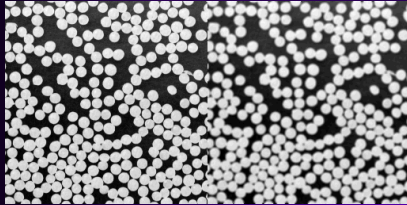
2-dimensional



## Some remarks about *watershed*

- Result of transformation

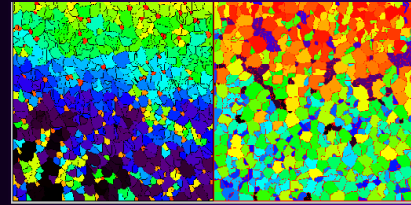
Input image (*original, smoothed 3x3*)



## Some remarks about *watershed*

- Result of transformation

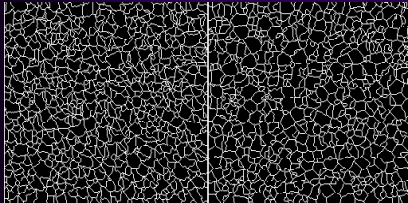
Watersheds (*labelled regions*)



## Some remarks about *watershed*

- Result of transformation

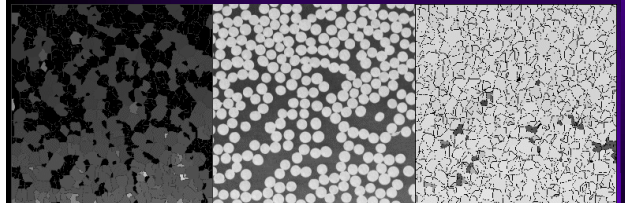
Watersheds



## Some remarks about *watershed*

- Result of transformation

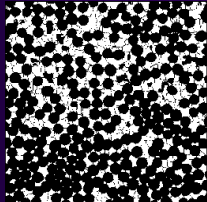
Lower, upper ricefield



## Some remarks about *watershed*

- Result of transformation

Half height segmentation HU (black)/HL (white)



## Textural featuring

- global

Statistical estimators (*moments*) from:

- half height segmentations and original
- topological gradient

Derived parameters

- stereological (*volume densities*)
- densitometric
- morphometric

## Textural featuring

- global, e.g.

$$VV_v = \frac{HUA}{A}$$

*volume density*

$$PA_v = \frac{HUA}{HUNO}$$

*mean particle area*

$$E = HUNO - HLNO$$

*Euler number*

$$RDD = \frac{HUM1 - HLM1}{M1}$$

*Rel. density difference*

## Textural featuring

- heuristic

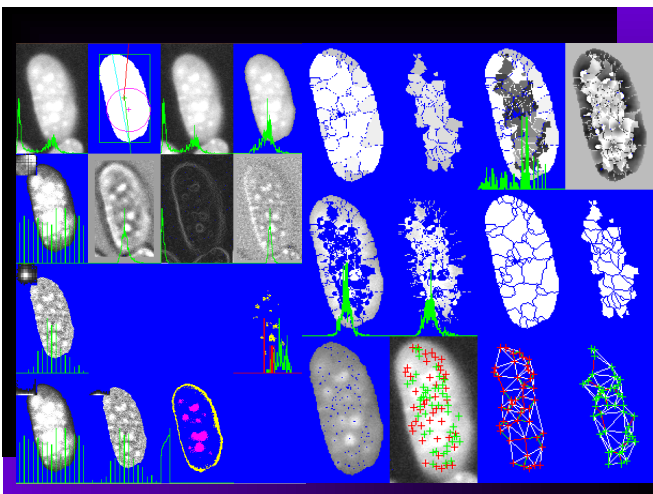
neighborhood related of connected regions  
(*graph theoretical approach*)

- connectivity
- distances

neighborhood AND intensity related

- pattern matching

...



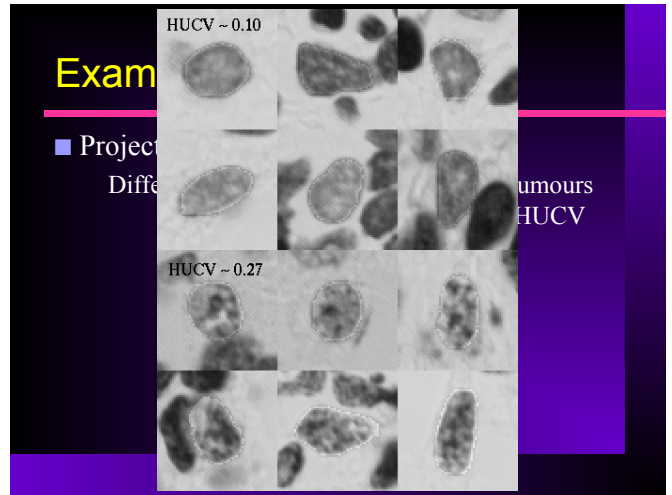
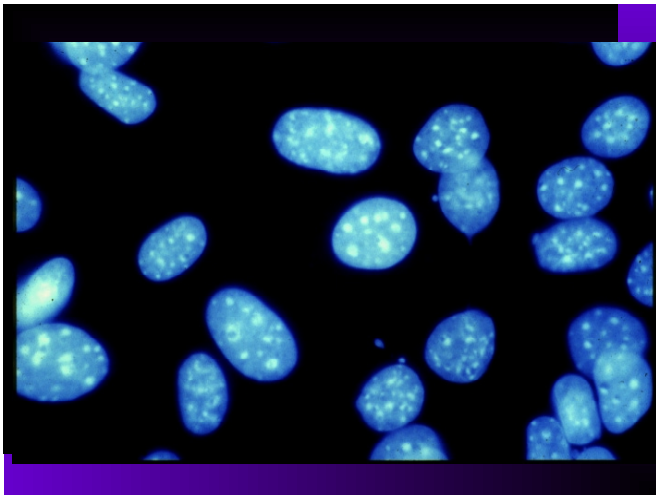
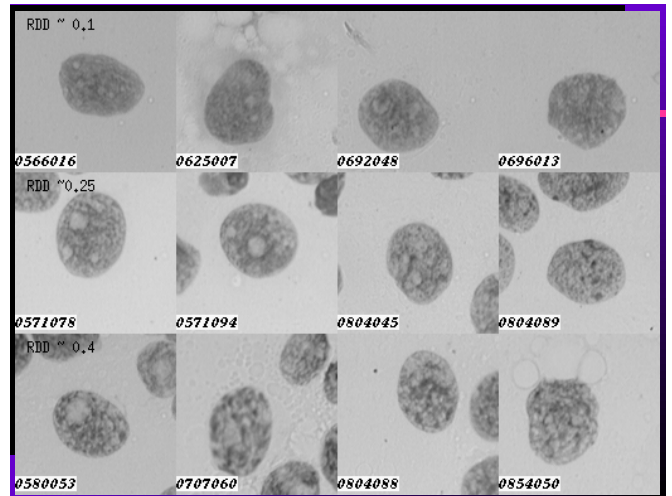
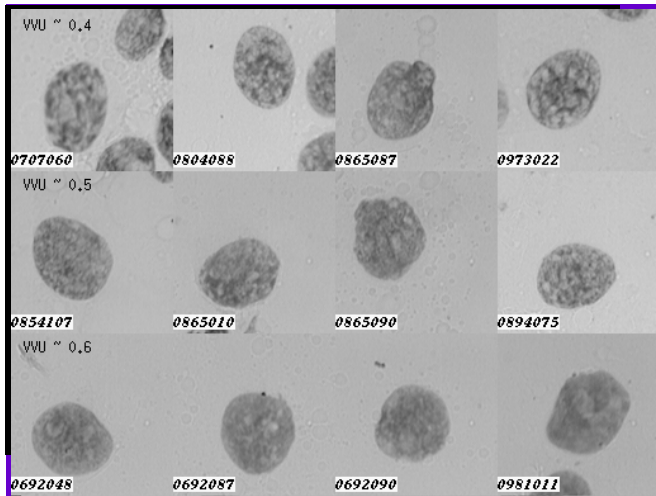
## Examples

- Projects

Differentiation of hormone status of breast carcinoma patients  $VV_v, RDD$

Differentiation of osteoblasts under different growth conditions (*Osteoporosis*)  $RHUA$

Differentiation of neuroendocrine lung tumours  $HUCV$



## Summary

- + Topology by watershed
  - Taxonomy of transformation results
- + Segmentation
- + Parameter free featurig
- Noise sensitivity of watershed
- Difficulties of interpretation for natural images (*reflected light, shadows, ...*)