Question

What about gray-scale images ?

Grayscale Erosion

TRANSLATION INVARIANCE

$$\Psi_\varepsilon(F(x-h)) = [\Psi_\varepsilon(F)](x-h)$$
$$\Psi_\varepsilon(F(x)+v) = [\Psi_\varepsilon(F)](x)+v$$

"LINEARITY"

$$\Psi_\varepsilon(F_1 \wedge F_2) = \Psi_\varepsilon(F_1) \wedge \Psi_\varepsilon(F_2)$$

MINIMUM

$$[\Psi_\varepsilon(F)](x) = F \tilde{\square} B(x) = \bigwedge_h [F(h) - B(h-x)]$$

Grayscale Dilation

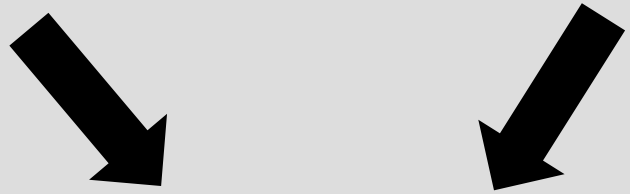
TRANSLATION INVARIANCE

"LINEARITY"

$$\Psi_\delta(F_1 \vee F_2) = \Psi_\delta(F_1) \vee \Psi_\delta(F_2)$$

MAXIMUM

$$\Psi_\delta(F(x-h)) = [\Psi_\delta(F)](x-h)$$
$$\Psi_\delta(F(x)+v) = [\Psi_\delta(F)](x)+v$$



$$[\Psi_\delta(F)](x) = F \oplus B(x) = \bigvee_h [F(h) + B(x-h)]$$

Remark

$$B(x) = \begin{cases} 0, & \text{for } x \in B \\ -\infty, & \text{otherwise} \end{cases}$$

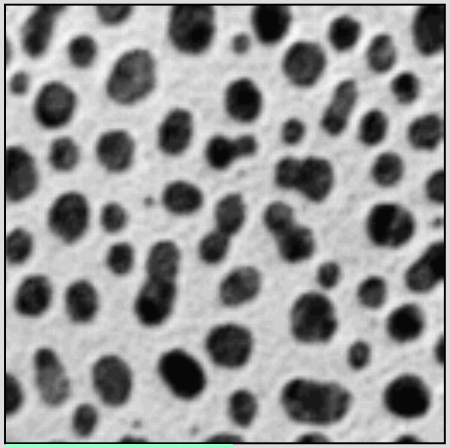
Flat Erosion

$$F \ominus B(x) = \bigwedge_{h \in B_x} F(h)$$

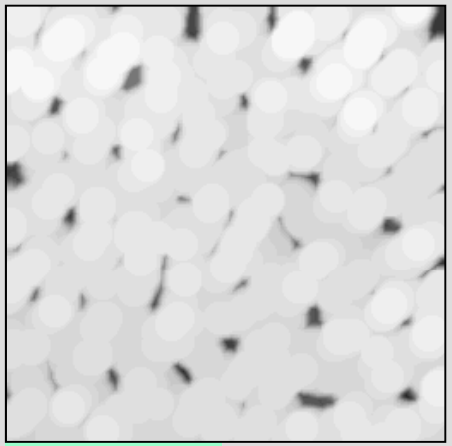
Flat

$$F \oplus B(x) = \bigvee F(h)$$

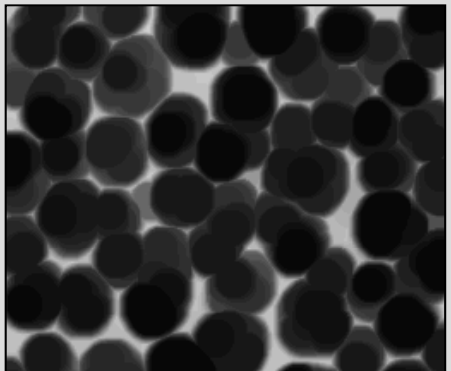
Grayscale Morphology

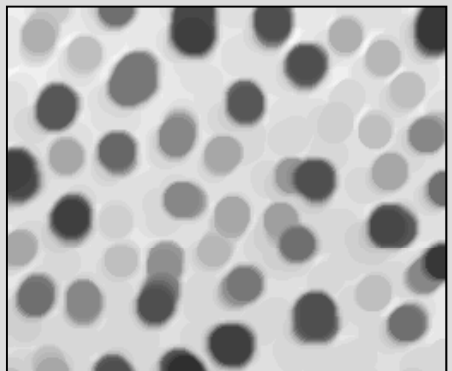


ORIGINAL

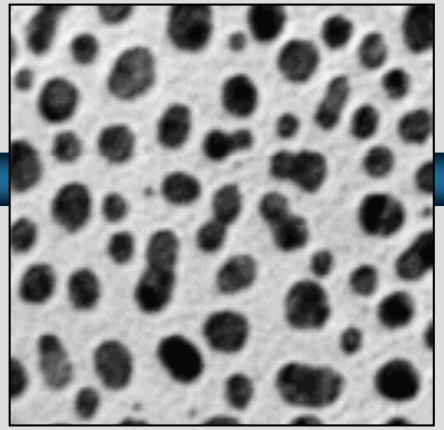


EROSION



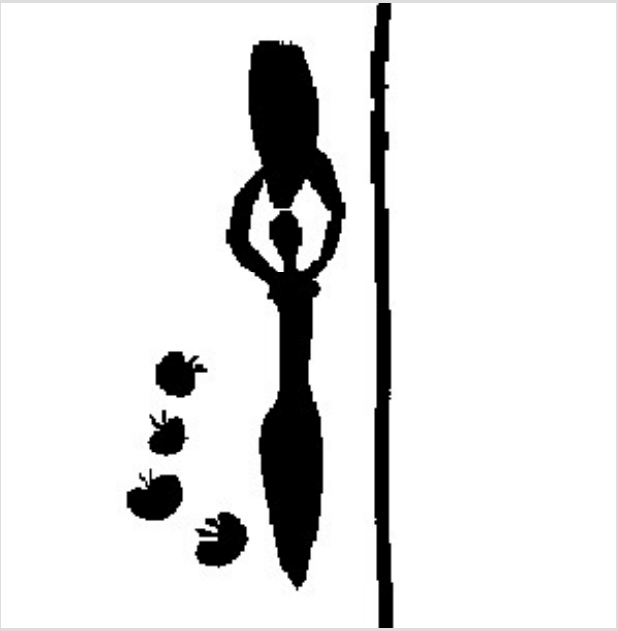


Grayscale Opening



Structuring Element

Question



Henri Matisse, *Woman with Amphora and Pomegranates*, 1952

Can we automatically extract the largest connected component (the woman's body) in this image ?

Answer

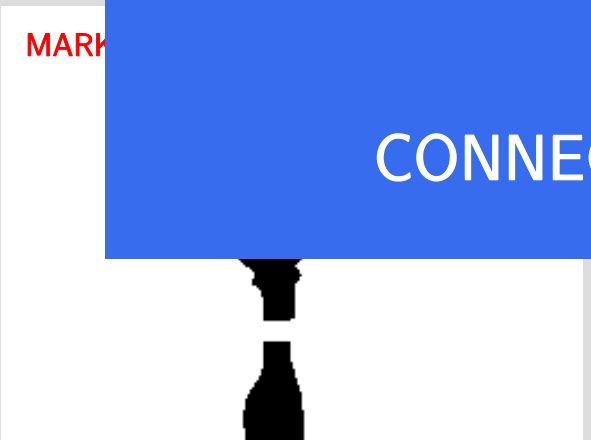
ORIGINAL

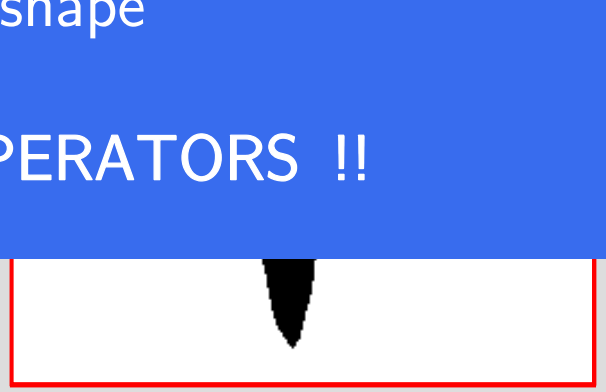
$$(\text{MARKER} \oplus B) \bigcap \text{ORIGINAL}$$

This is a morphological operator that filters out connected image components of a certain size and shape

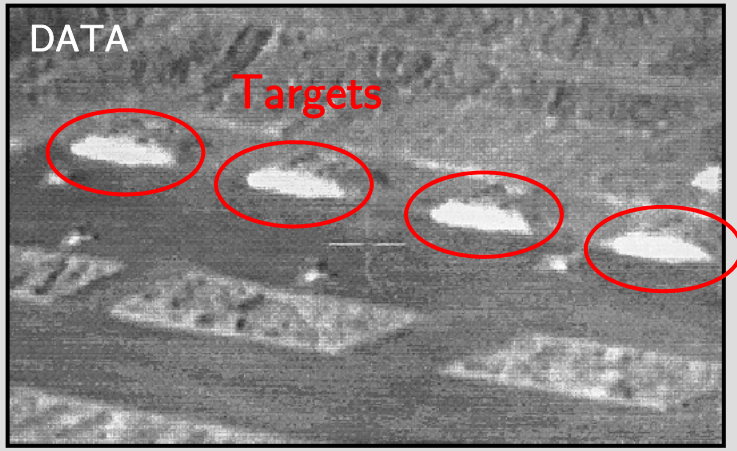
CONNECTED OPERATORS !!

MARK



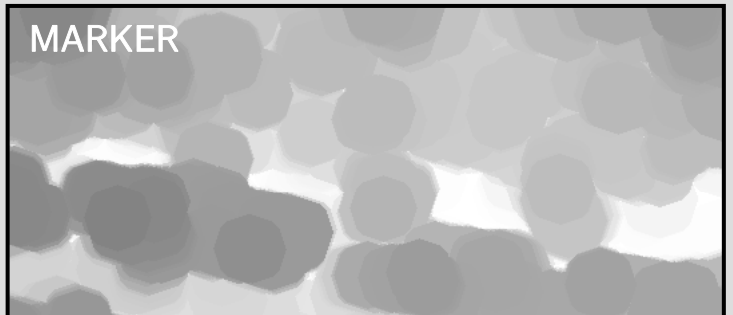


An Application - Target Detection



MORPHOLOGICAL RECONSTRUCTION

OPENING



An Application: Target Detection

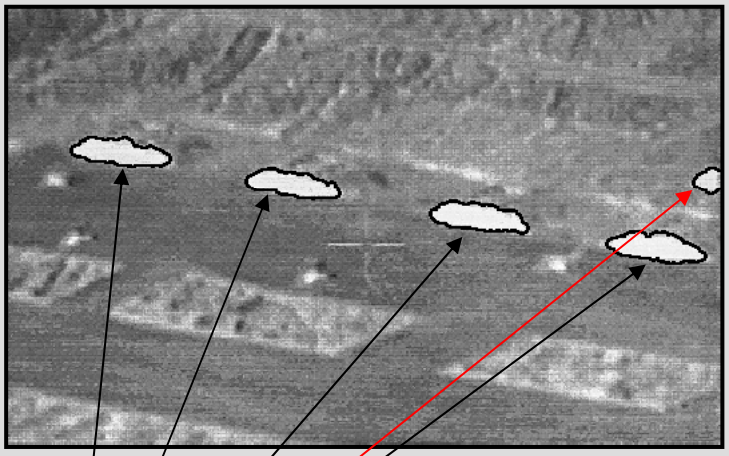
MORPHOLOGICAL RECONSTRUCTION

CLOSING

An Application: Target Detection

THRESHOLDING

FINAL RESULT



Incorrectly detected target