



DEPARTAMENTO DE
**INGENIERÍA
INFORMÁTICA**
UNIVERSIDAD DE SANTIAGO DE CHILE

Procesamiento y Análisis de Imágenes

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Créditos por slides: José M. Saavedra

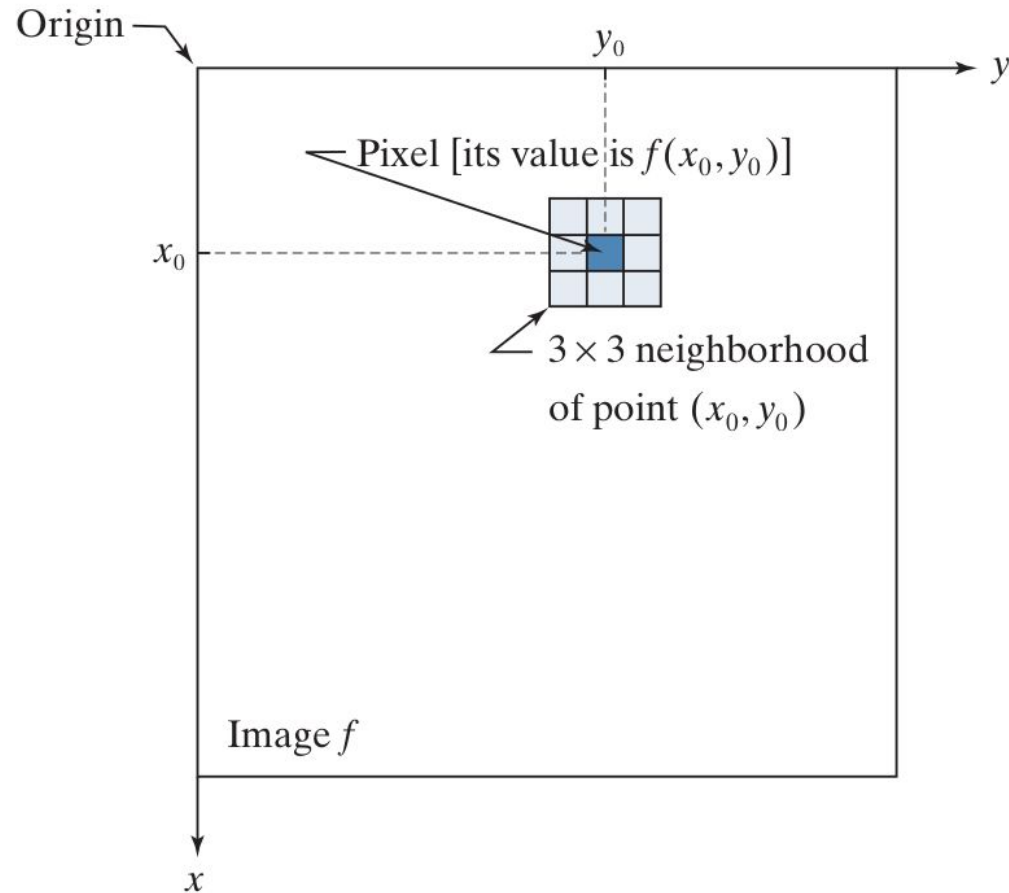


Actividad de diagnóstico

- ¿Cómo definirías una imagen digital en escala de grises?



TIPOS DE OPERACIONES

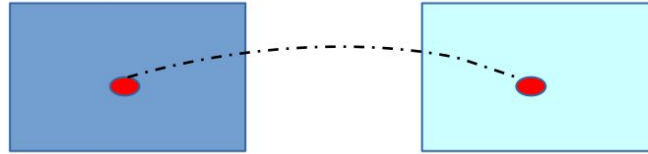


OPERACIONES

- Una operación T sobre una imagen I permite generar otra imagen G procesando los pixeles de I .
- Tipos de Operación

Puntual

(pixelwise)



$$G(x) = T(I(x))$$

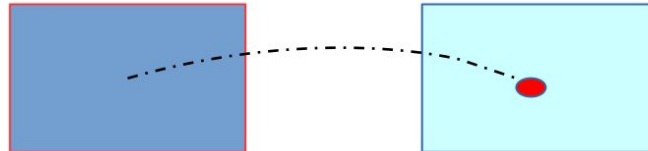
Local

(neighborhood)



$$G(x) = T(\text{region}(I, x))$$

Global



$$G(x) = T(I)$$



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OPERACIONES DE PUNTO



OPERACIONES DE PUNTO

- Negativo (imagen negativa)**

$$G(x) = M - I(x)$$

M = máximo valor del espectro (255 en grises, 1 en b/w)





OPERACIONES DE PUNTO

• Blending

$$G(x) = \alpha I_1(x) + (1 - \alpha) I_2(x)$$

im1 0.4



im2 0.6



blended





OPERACIONES DE PUNTO

- **Blending**



Warping + Blending



OPERACIONES DE PUNTO

- Binarización (Thresholding)**

imagen

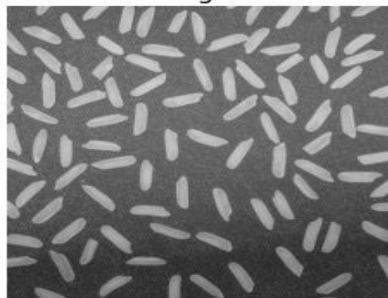


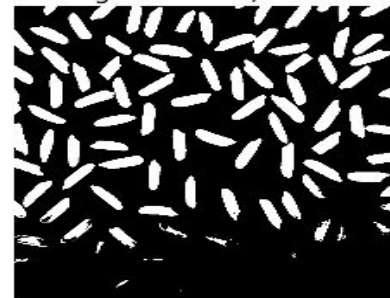
imagen binaria, th=90



imagen binaria, th=120



imagen binaria, th=150



BINARIZACIÓN

- Objetivo : Separar el objeto de interés del fondo de la imagen
- Entrada : Imagen en escala de grises
- Salida : Imagen Binaria
- Imagen Binaria : Imagen con sólo dos tonos de gris presentes (negro y blanco \rightarrow 0 y 255)
- Valor UMBRAL θ

BINARIZACIÓN

$$G_{ij} = \begin{cases} 0 & \text{si } I_{ij} \leq \theta \\ 1 & \text{si } I_{ij} > \theta \end{cases}$$

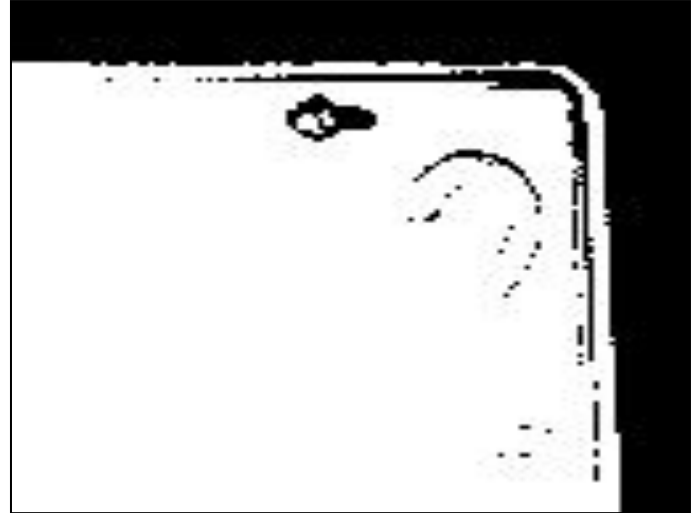
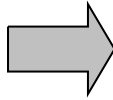
entonces

$$\left[I_{ij} \right]_{1 \leq i \leq N, 1 \leq j \leq M} \xrightarrow{\text{BINARIZACIÓN}} \left[G_{ij} \right]_{1 \leq i \leq N, 1 \leq j \leq M}$$

BINARIZACIÓN



Imagen Original

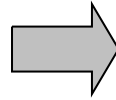


Umbral $\theta = 150$

BINARIZACIÓN



Imagen Original

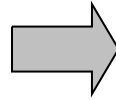


Umbral $\theta = 200$

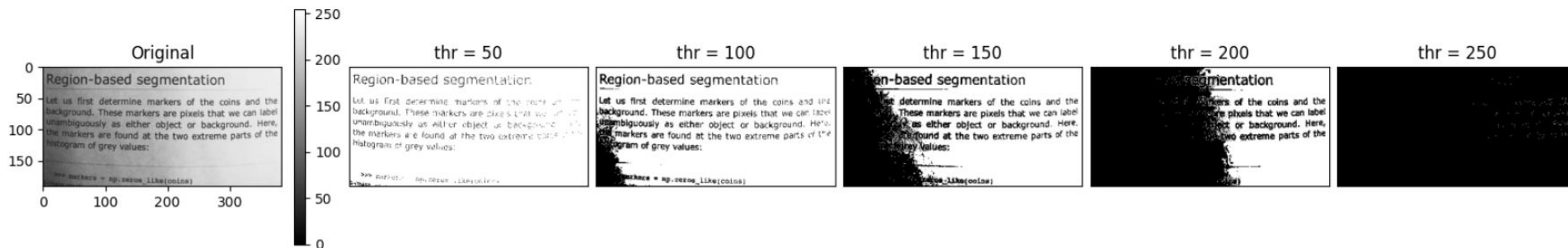
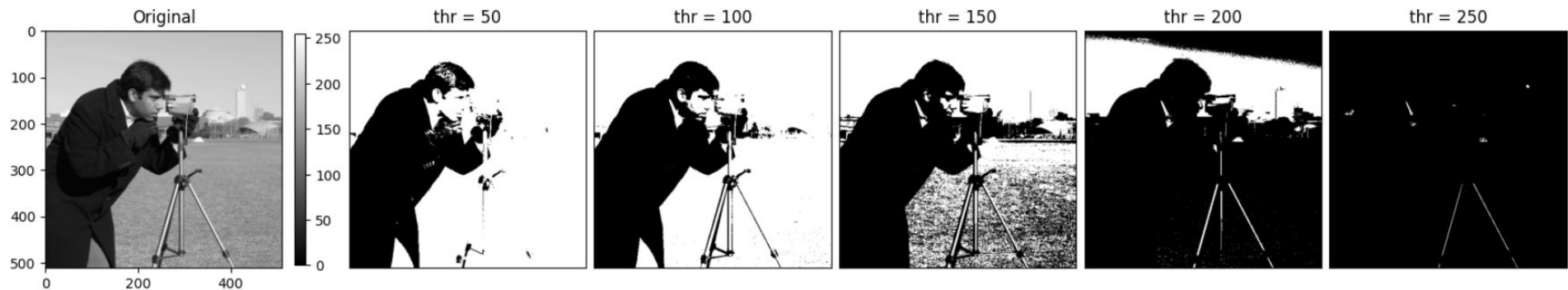
BINARIZACIÓN



Imagen Original



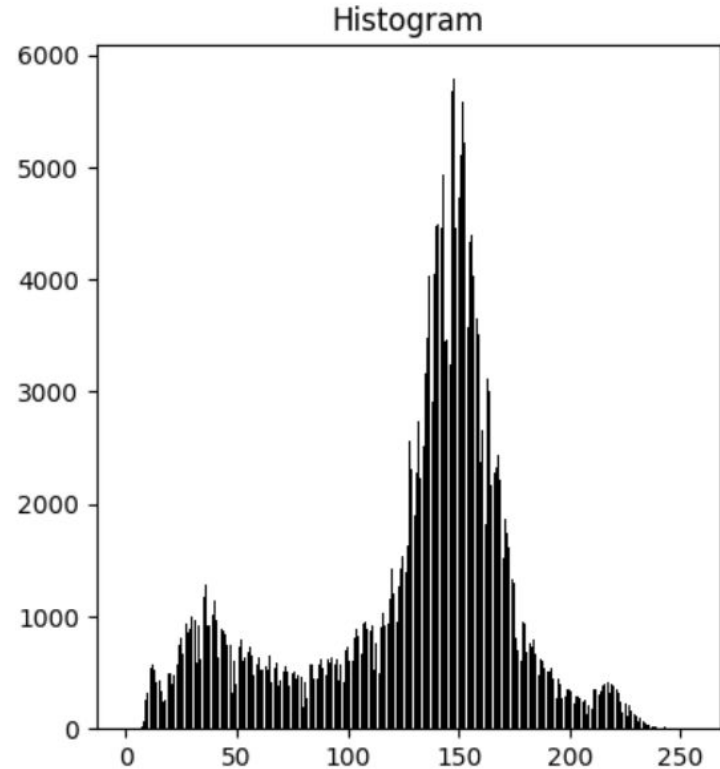
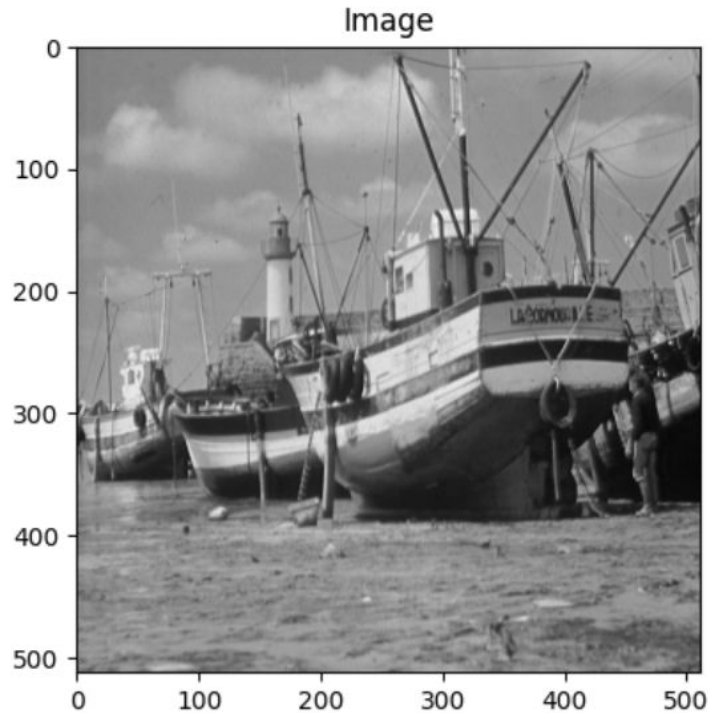
Umbral $\theta = 250$



BINARIZACIÓN

- ¿Cómo encontrar el valor umbral adecuado?
- Usando el histograma de la imagen
- Existen varios métodos globales y locales

Recordatorio: Histograma

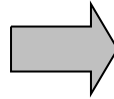


USANDO ISODATA

- Técnica iterativa cuyo proceso consiste en:
 - Umbral inicial θ_0
 - Valores promedio $p_{\text{objeto}, 0}$ y $p_{\text{fondo}, 0}$
 - Siguiendo umbral θ_1 : promedio de p's
- Cuándo detenerse?

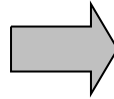
$$\theta_i = \theta_{i-1}$$

USANDO ISODATA



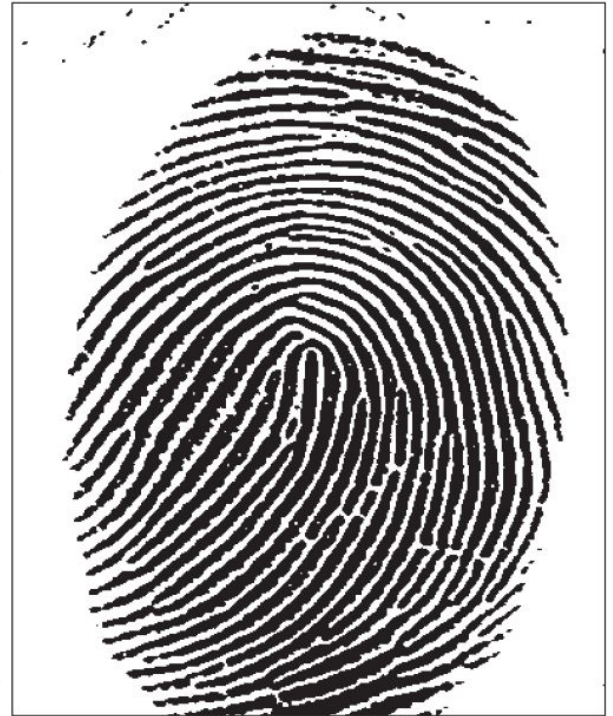
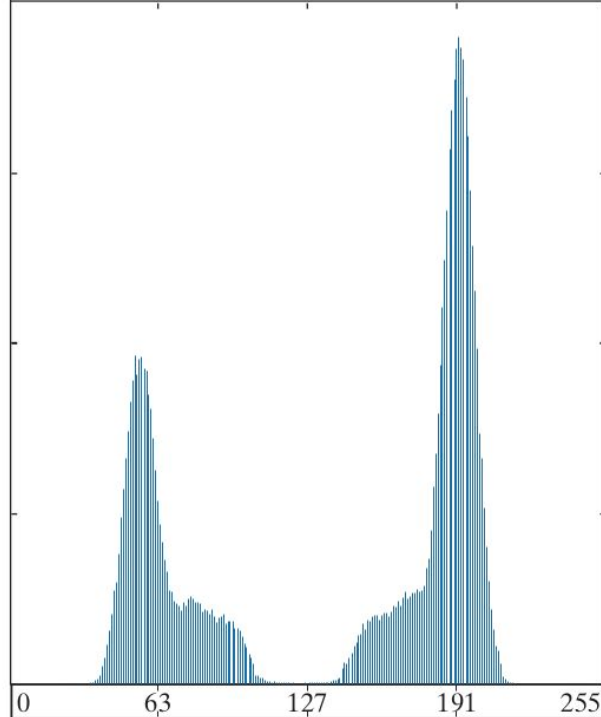
Umbral $\theta = 162$

USANDO ISODATA



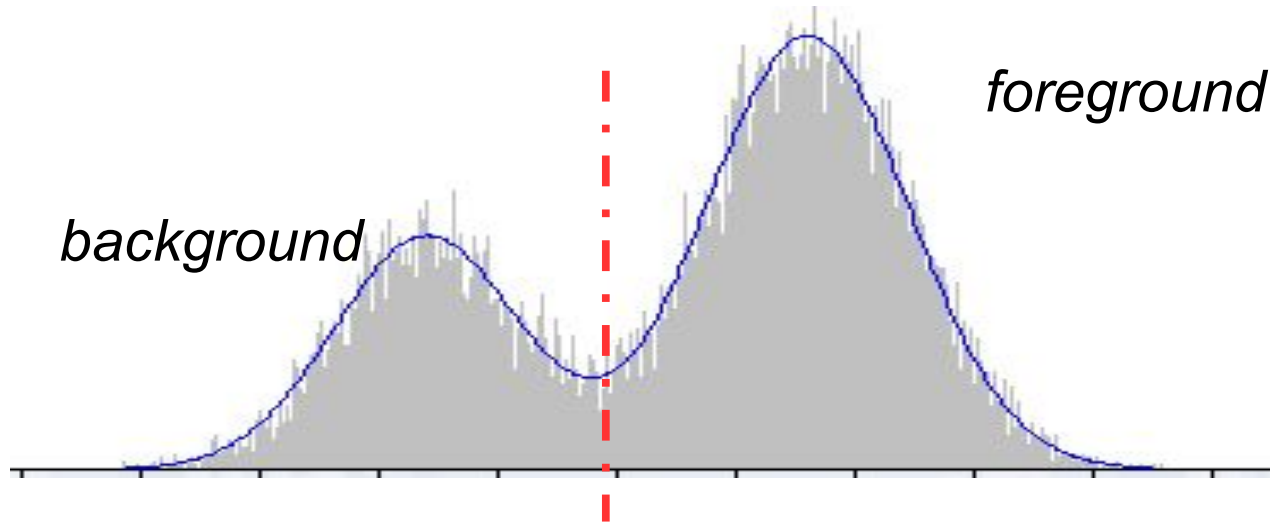
Umbral $\theta = 168$

USANDO ISODATA



. ALGORITMO DE OTSU

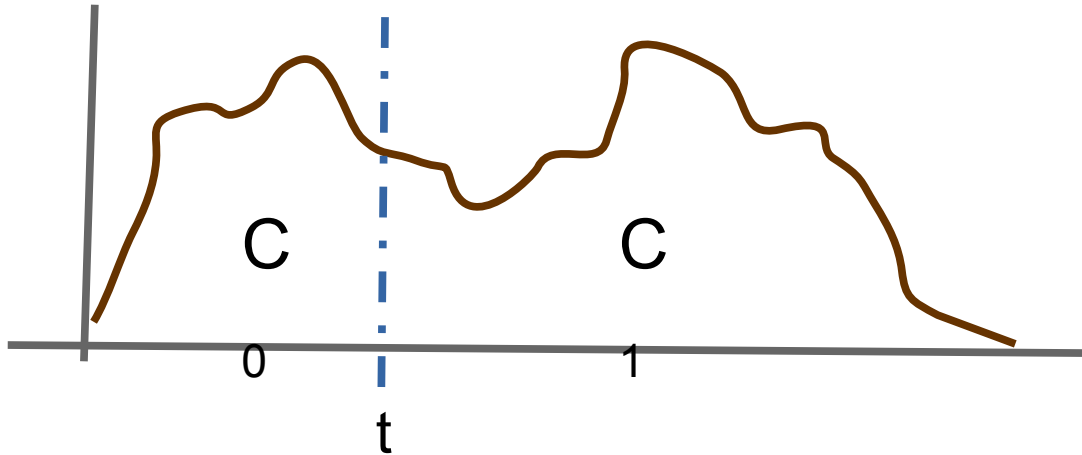
- Supuesto: Histograma bimodal (2 clases $\{C_0, C_1\}$)
- **Umbral** [*threshold*]: Aquel valor que permita minimizar la dispersión intra-clase y maximizar la dispersión entre clases.



. ALGORITMO DE OTSU

. Objetivo

- . Maximizar varianza entre clases



ALGORITMO DE OTSU

- $\lambda_1 \lambda_2 \lambda_3 \dots \lambda_L$: tonos de gris admisibles
- Probabilidad P_v que (i,j) tenga λ_v es:

$$P(I_{ij} = \lambda_v) = P_v = \frac{\text{Nro. de puntos de la imagen con tono } \lambda_v}{\text{Nro. total de puntos de la imagen}}$$

- Tomando $\theta = \lambda_l$, resultan dos conjuntos inducidos por este valor

$${}^l\Omega_1 = \{I_{ij} : I_{ij} \leq \lambda_l\} \quad y \quad {}^l\Omega_2 = \{I_{ij} : I_{ij} > \lambda_l\}$$

ALGORITMO DE OTSU

- Probabilidad que un punto esté en uno de los conjuntos Ω_1 o Ω_2 es:

$$P(\Omega_1) = \sum_{v=1}^L P_v \quad , \quad P(\Omega_2) = 1 - P(\Omega_1)$$

- Consideraciones:
 - Diferentes de cero
 - Diferencia absoluta de valores medios mayor posible

ALGORITMO DE OTSU

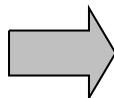
- Función objetivo que cumple con consideraciones:

$$J_l = P(l|\Omega_1) P(l|\Omega_2) \left\{ \sum_{v=1}^l \frac{P_v \lambda_v}{P(l|\Omega_1)} - \sum_{v=l+1}^L \frac{P_v \lambda_v}{P(l|\Omega_2)} \right\}^2$$

- F.O. debe maximimarse respecto de l:

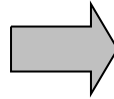
$$l = \arg \max_{l'} J_{l'}$$

ALGORITMO DE OTSU



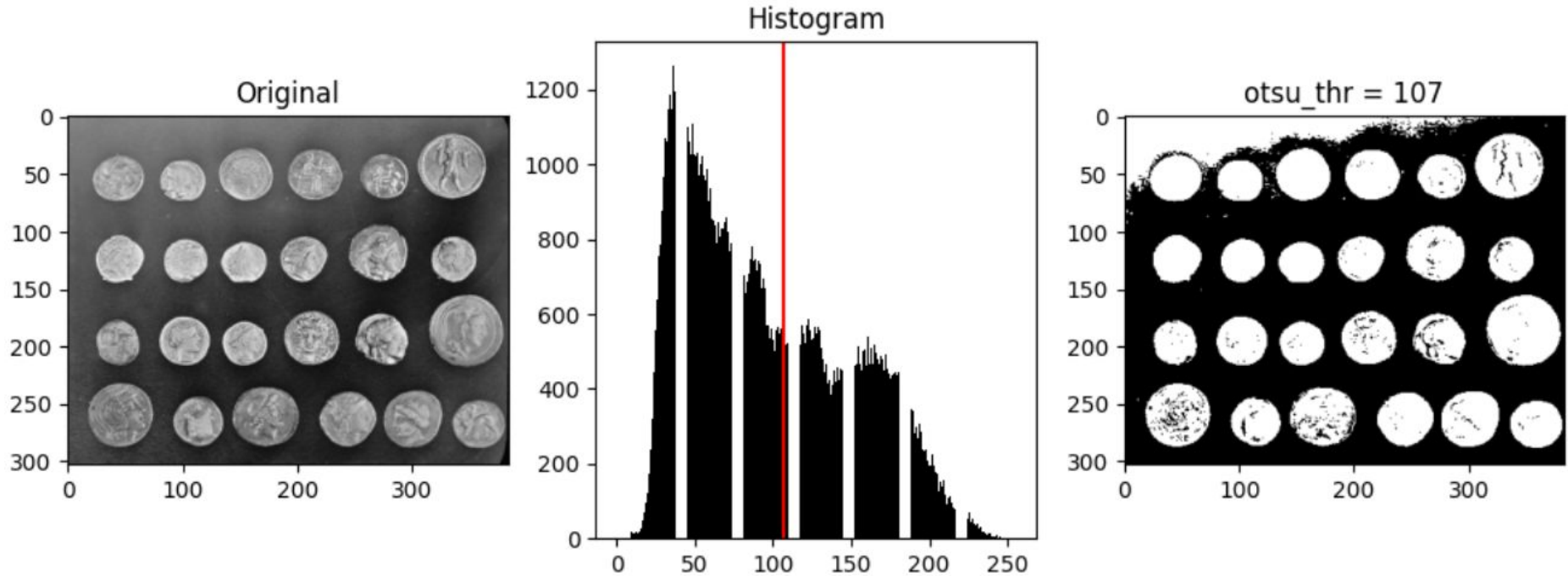
Umbral $\theta = 148$

ALGORITMO DE OTSU

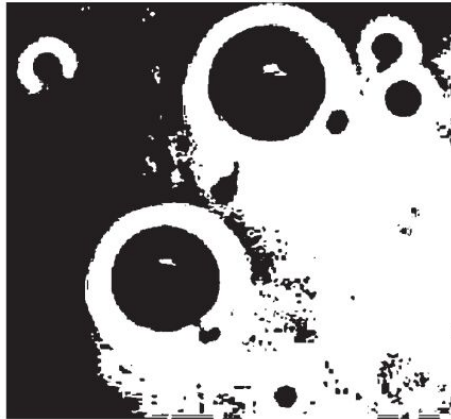
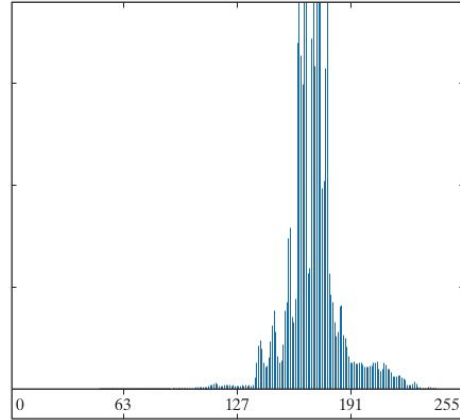
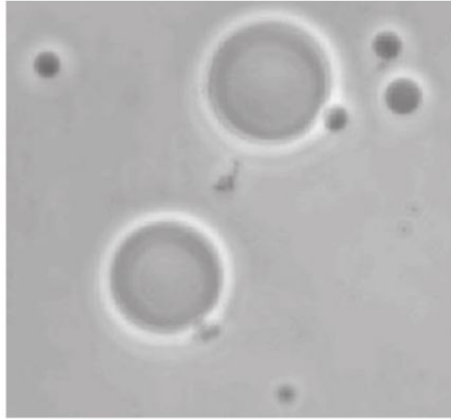


Umbral $\theta = 190$

ALGORITMO DE OTSU

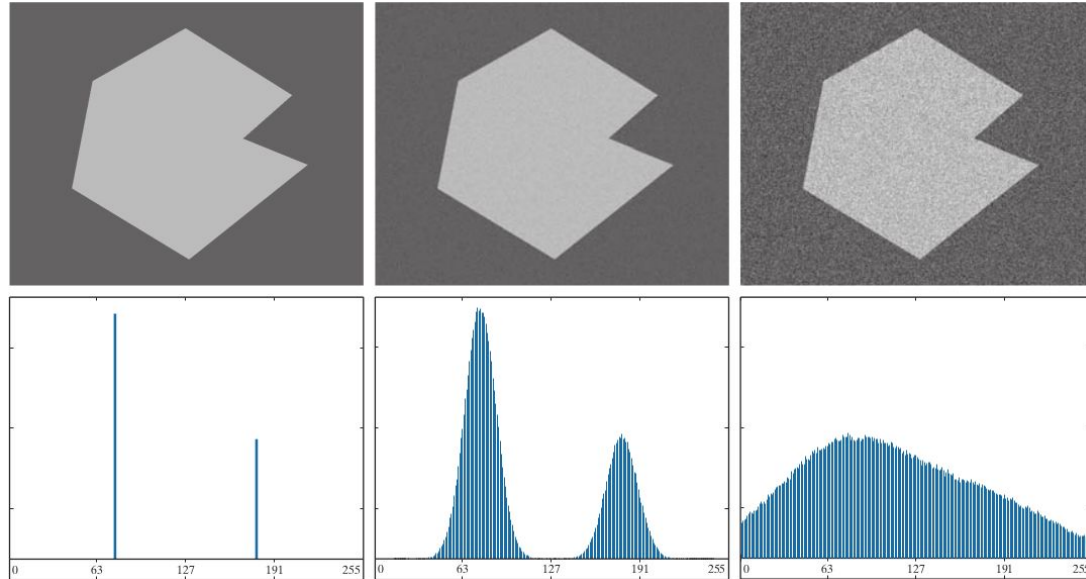


ISODATA VS OTSU



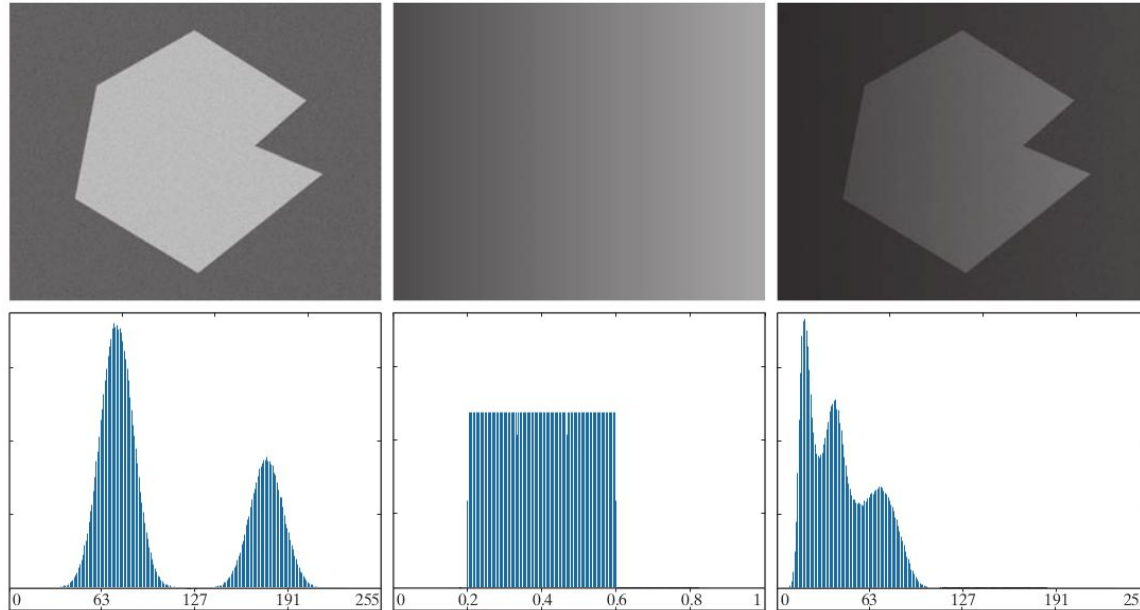
. BINARIZACIÓN ADAPTATIVA

- El ruido así como iluminación no-uniforme juega un rol importante en los algoritmo de binarización (thresholding).



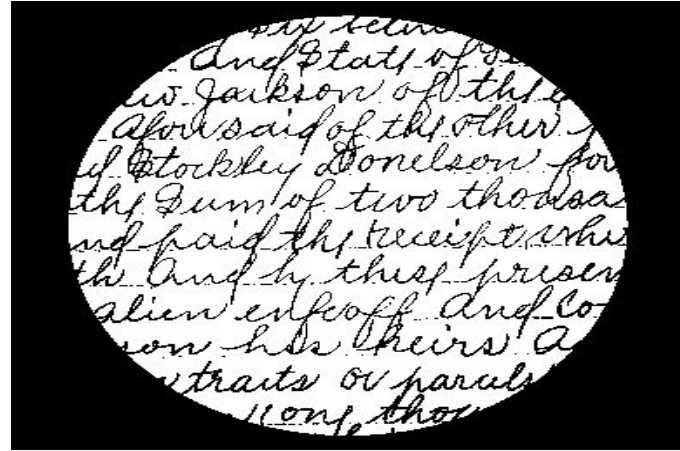
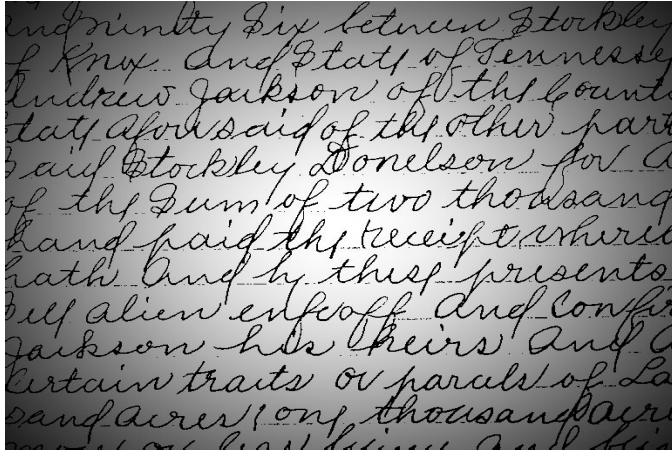
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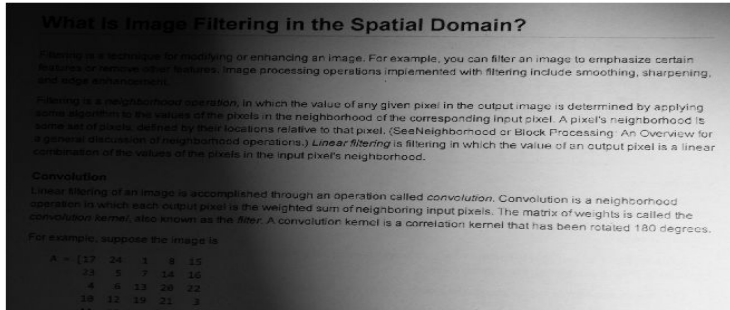


Binarización con Otsu

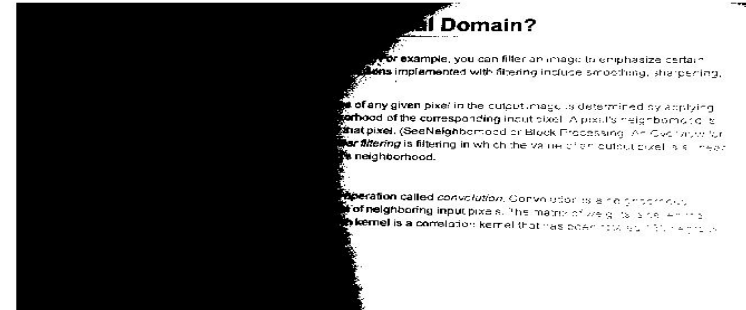
. BINARIZACIÓN ADAPTATIVA

- El ruido así como iluminación no-uniforme juega un rol importante en los algoritmo de binarización.

Original



Thresholded image

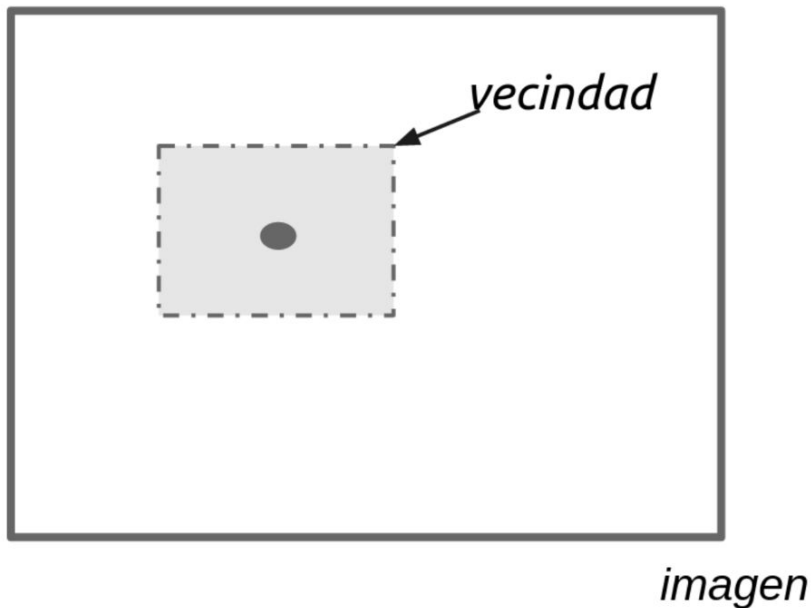


Binarización con Otsu

BINARIZACIÓN ADAPTATIVA

- Cambia umbral según la vecindad de cada pixel
- Cuál es el umbral para cada vecindad?
 - Ej: valor promedio de tonos de gris
- En general, se toman en cuenta propiedades locales (varianza y media de la vecindad)

. BINARIZACIÓN ADAPTATIVA



Propiedades Locales

σ_p : Varianza local

μ_p : Media local

$$T_p = a\mu_p + b\sigma_p$$

$$G(p) = \begin{cases} 1 & I(p) > T_p \\ 0 & \text{en otro caso} \end{cases}$$

BINARIZACIÓN ADAPTATIVA

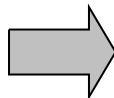
Variantes

- $b = 0$

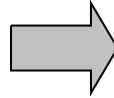
$$G(p) = \begin{cases} 1 & I(p) > T_p - C \\ 0 & \text{en otro caso} \end{cases}$$

C es una constante que típicamente varía entre -20 y 20.

BINARIZACIÓN ADAPTATIVA

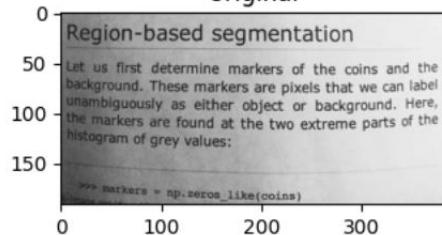


BINARIZACIÓN ADAPTATIVA

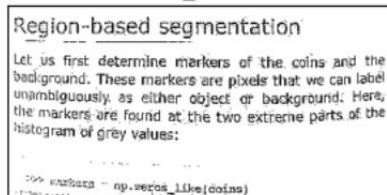


BINARIZACIÓN ADAPTATIVA

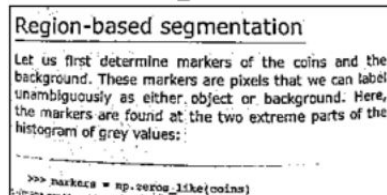
Original



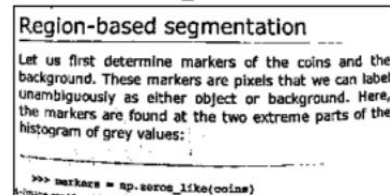
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block_size=15

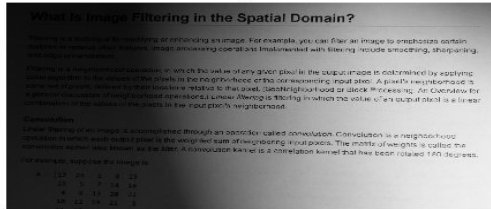


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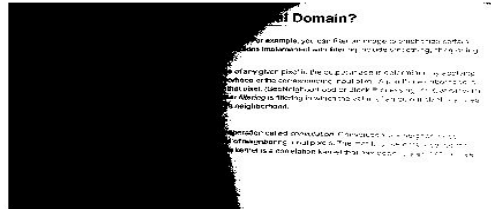


. BINARIZACIÓN ADAPTATIVA

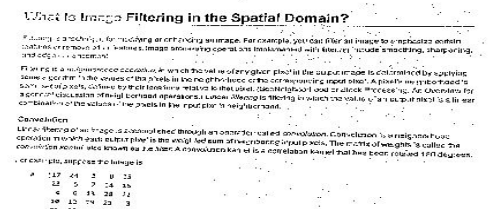
Original



Otsu

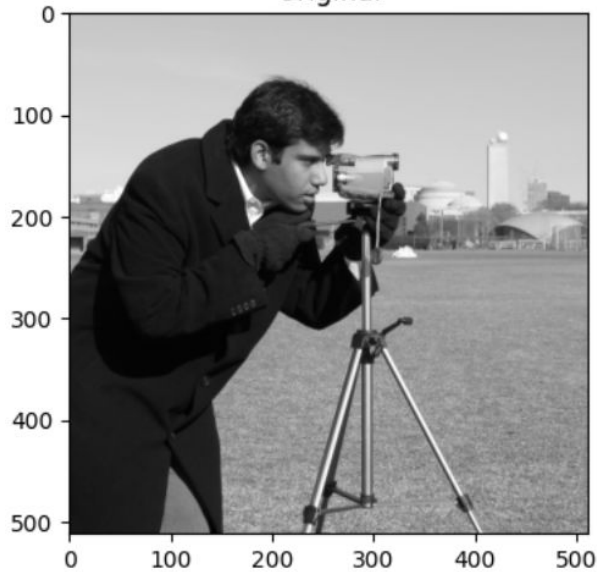


Adaptive

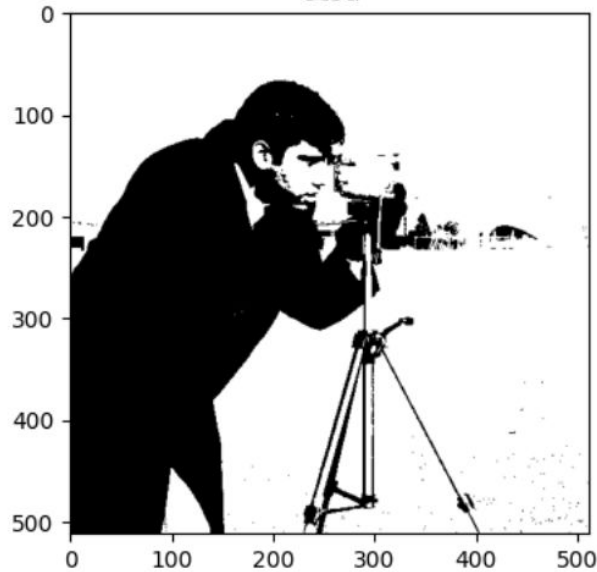


. BINARIZACIÓN ADAPTATIVA

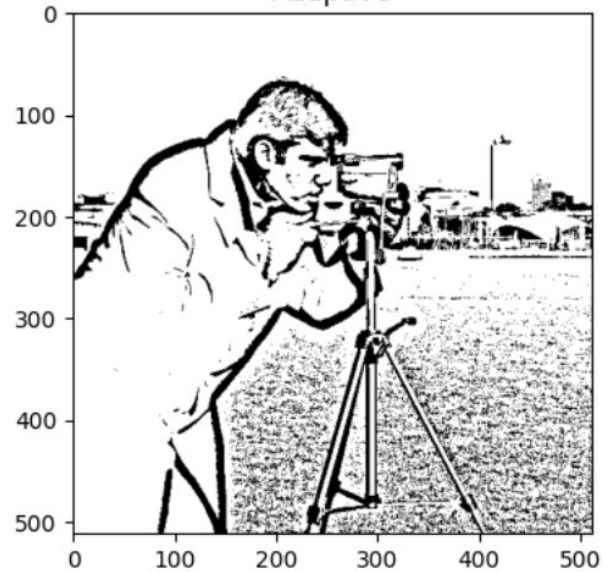
Original



Otsu



Adaptive



. BINARIZACIÓN ADAPTATIVA

- Para procesamiento de documentos:

- Niblack's Thresholding

$$T_p = \mu_p + b\sigma_p \quad b = -0.2$$

- Sauvola's Thresholding

$$T_p = \mu_p \left[1 + b \left(\frac{\sigma_p}{R} - 1 \right) \right]$$

$b = 0.5 \quad R = 128$

. BINARIZACIÓN ADAPTATIVA

Local

What Is Image Filtering in the Spatial Domain?

Filtering is a technique for modifying an entire image. For example, you can filter an image to emphasize certain features or remove other features. Image processing operations implemented with filters include thresholding, image averaging, and edge detection.

Filtering is a neighborhood operation in which the value of every pixel in the output image is determined by applying some function to the values of the pixels in the neighborhood of the corresponding input pixel. A pixel's neighborhood is some collection of pixels relative to that pixel, such as its four or eight neighbors. An operation for a given neighborhood of pixels is called a filter. Filtering is working in which the value of a pixel in the output is a function of the values of the pixels in the input's neighborhood.

Convolution

Linear filtering of an image is accomplished through an operation called convolution. Convolution is a neighborhood operation in which each output pixel is the weighted sum of the corresponding input pixels. The matrix of weights is called the convolution kernel, also known as the filter. A convolution kernel is a nonempty kernel that has been rotated 180 degrees.

For example, suppose the image is

```
A = [ 12 45 8 9 23
      24 5 7 24 16
      6 6 15 28 12
      39 12 74 23 3
      ... .. ]
```

Niblack

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Sauvola

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      ... .. ]
```

. BINARIZACIÓN ADAPTATIVA

Local



2190.

This image shows the handwritten text '2190.' with a Local thresholding algorithm. The background is heavily noisy, with many black and white pixels scattered throughout, making the text difficult to read.

Niblack



2190.

This image shows the handwritten text '2190.' with a Niblack thresholding algorithm. The background is still noisy, but the text is more clearly defined than in the Local thresholding image.

Sauvola



2190.

This image shows the handwritten text '2190.' with a Sauvola thresholding algorithm. The background is almost entirely white, and the text is very clear and well-defined.



Evaluación formativa

- ¿Qué método utilizarías para binarizar la siguiente imagen y por qué?





Actividad de cierre

- ¿Qué aprendiste en la clase de hoy?