Analisi di Immagini e Video (Computer Vision)

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Crediti

- Slides adattate da vari corsi
  - Analisi di Immagini (F. Angiulli) – Unical
  - Intro to Computer Vision (J. Tompkin) – CS Brown Edu
  - Computer Vision (I. Gkioulekas), CS CMU Edu

Recap: Gradient-based filtering

1. Scegli la derivata

$$\boldsymbol{S}_x = \begin{array}{|c|c|c|}\hline 1 & 0 & -1 \\ \hline 2 & 0 & -2 \\ \hline 1 & 0 & -1 \\ \hline \end{array} \qquad \boldsymbol{S}_y = \begin{array}{|c|c|c|}\hline 1 & 2 & 1 \\ \hline 0 & 0 & 0 \\ \hline -1 & -2 & -1 \\ \hline \end{array}$$

2. Convolvi con l'immagine

$$\frac{\partial \boldsymbol{f}}{\partial x} = \boldsymbol{S}_x * \boldsymbol{f} \qquad \frac{\partial \boldsymbol{f}}{\partial y} = \boldsymbol{S}_y * \boldsymbol{f}$$

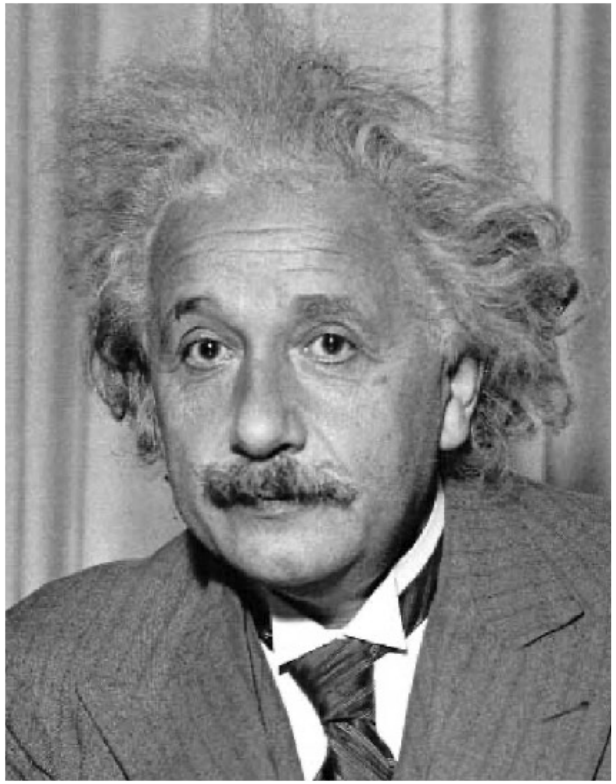
3. Calcola direzione e ampiezza del gradiente.

$$\nabla \boldsymbol{f} = \left[\frac{\partial \boldsymbol{f}}{\partial x}, \frac{\partial \boldsymbol{f}}{\partial y}\right] \qquad \theta = \tan^{-1}\left(\frac{\partial f}{\partial y} / \frac{\partial f}{\partial x}\right) \qquad ||\nabla f|| = \sqrt{\left(\frac{\partial f}{\partial x}\right)^2 + \left(\frac{\partial f}{\partial y}\right)^2}$$

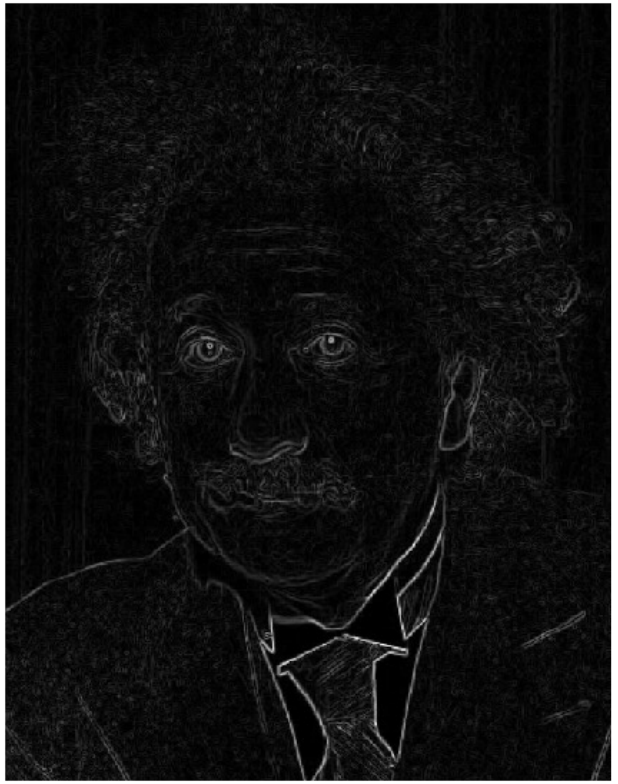
gradient direction amplitude

Gradient-Based Filtering

originale



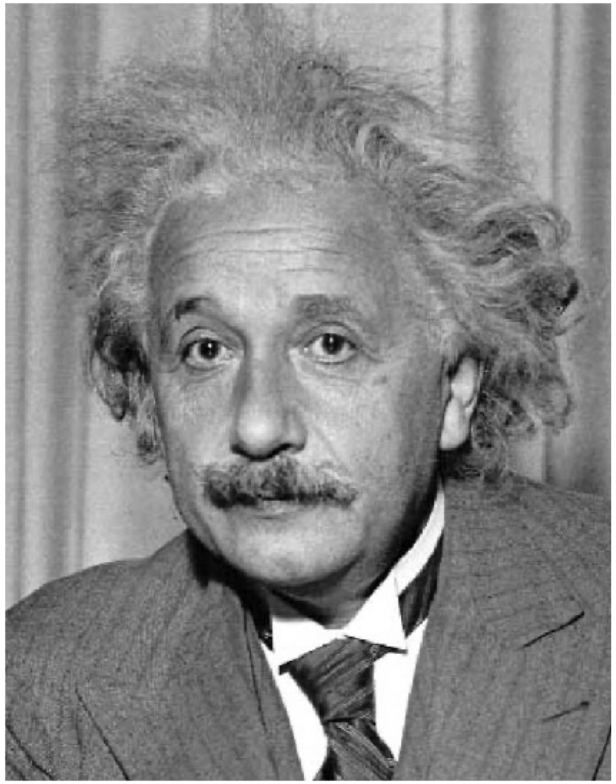
Ampiezza



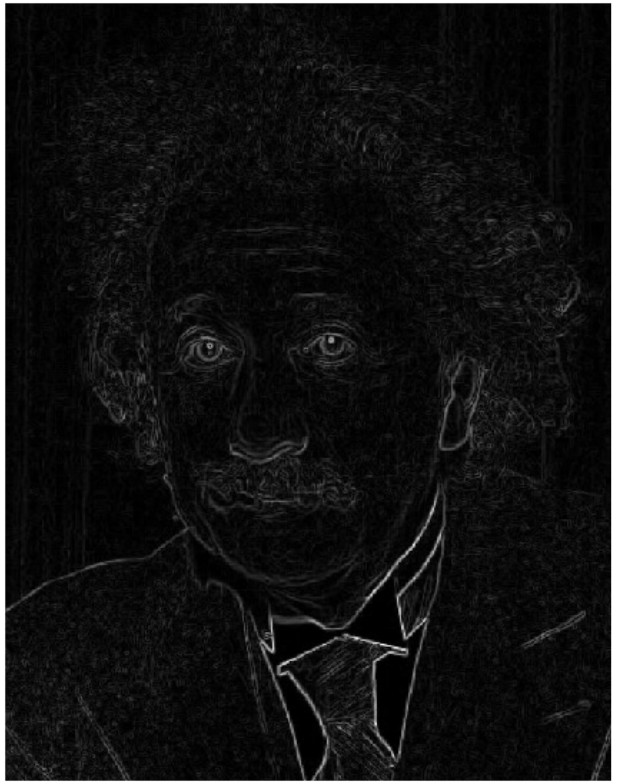
- Cosa c’è che non va?

Gradient-Based Filtering

originale



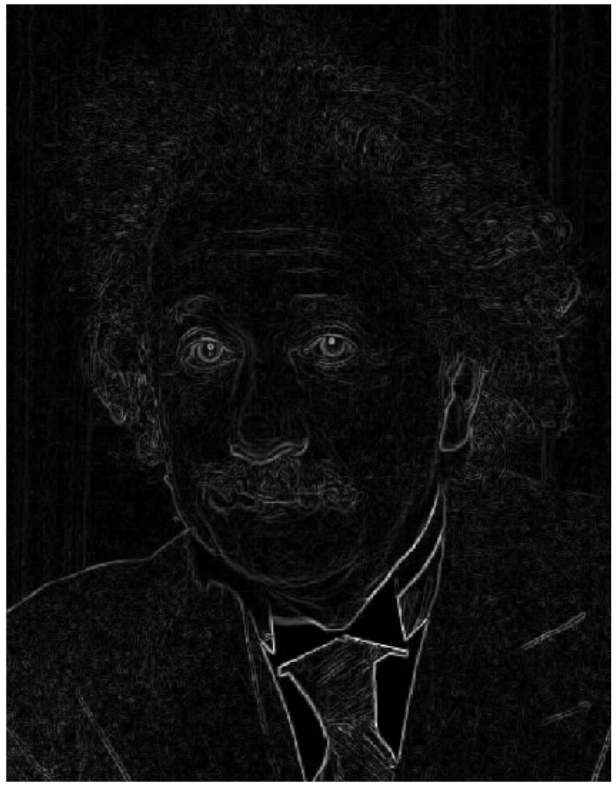
Ampiezza

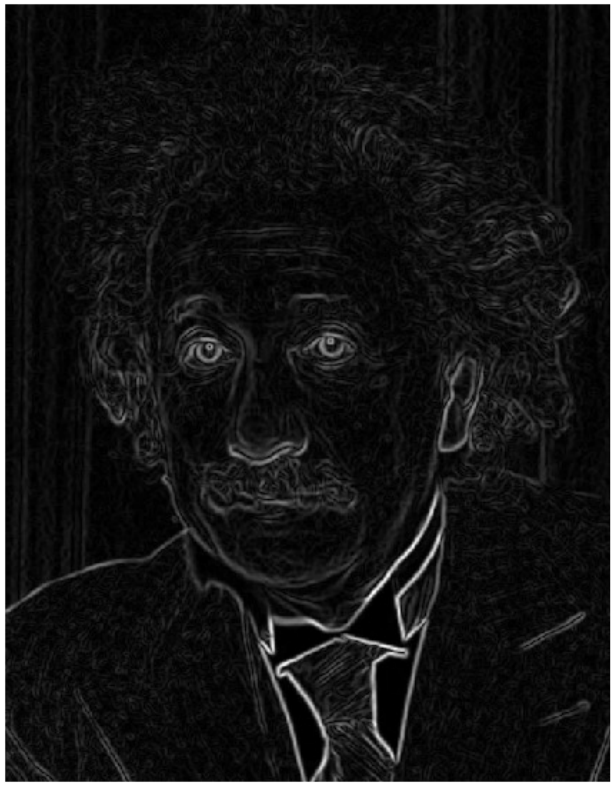


- Cosa c’è che non va?
  - Troppi artefatti

Gradient-Based Filtering

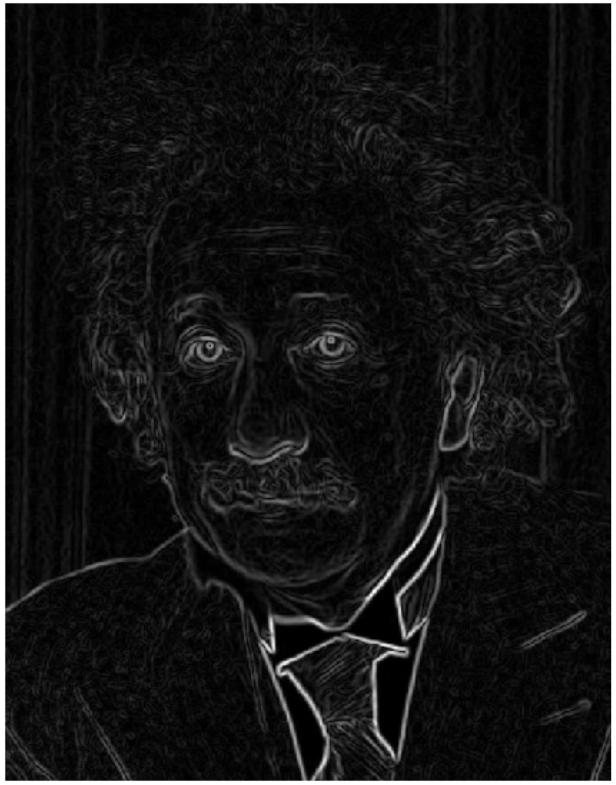
- Noise
  - Lo trattiamo con il filtro gaussiano





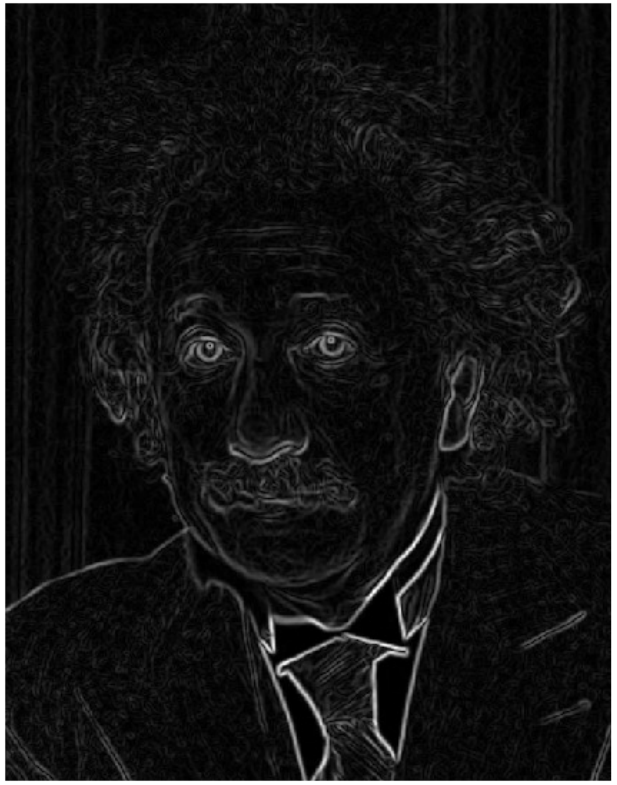
Gradient-Based Filtering

- Troppi toni di grigio
  - Thresholding



Gradient-Based Filtering

- Diversi spessori
  - ?

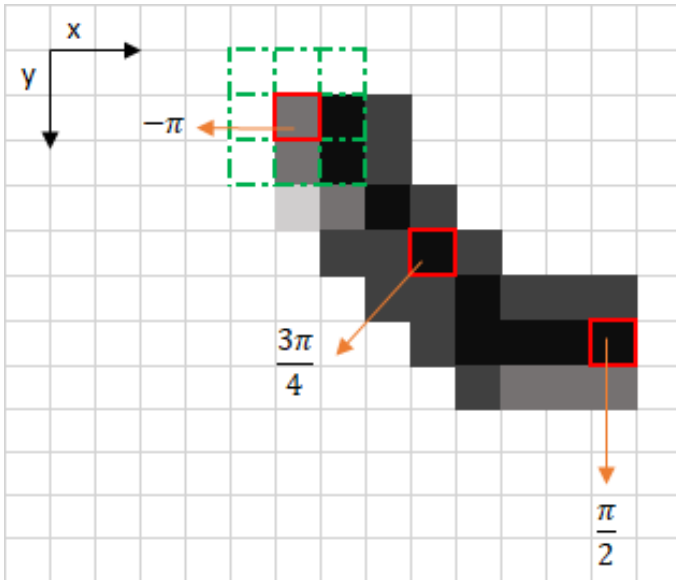


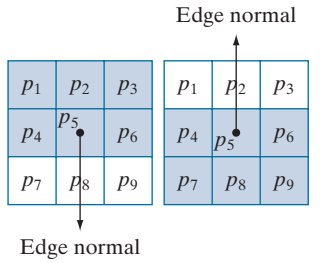
Canny Edge Detector

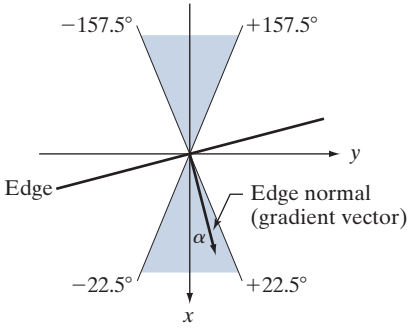
- Algoritmo semplice
  - Estensione del gradient-based filtering
  - Spessori uniformi
    - Non-maximal suppression
  - Rimozione di artefatti
    - Double thresholding, hysteresis

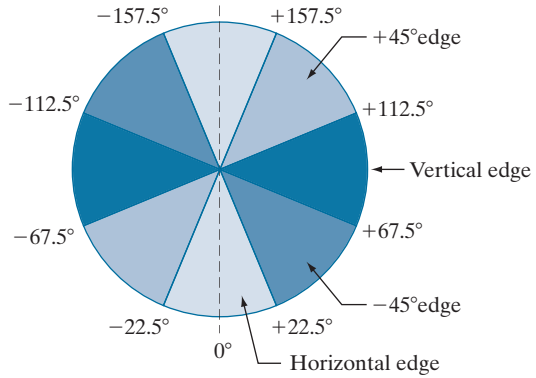
Non maximal suppression

- Basata sulla direzione del gradiente $\theta = \tan^{-1}\left(\frac{\partial f}{\partial y} / \frac{\partial f}{\partial x}\right)$





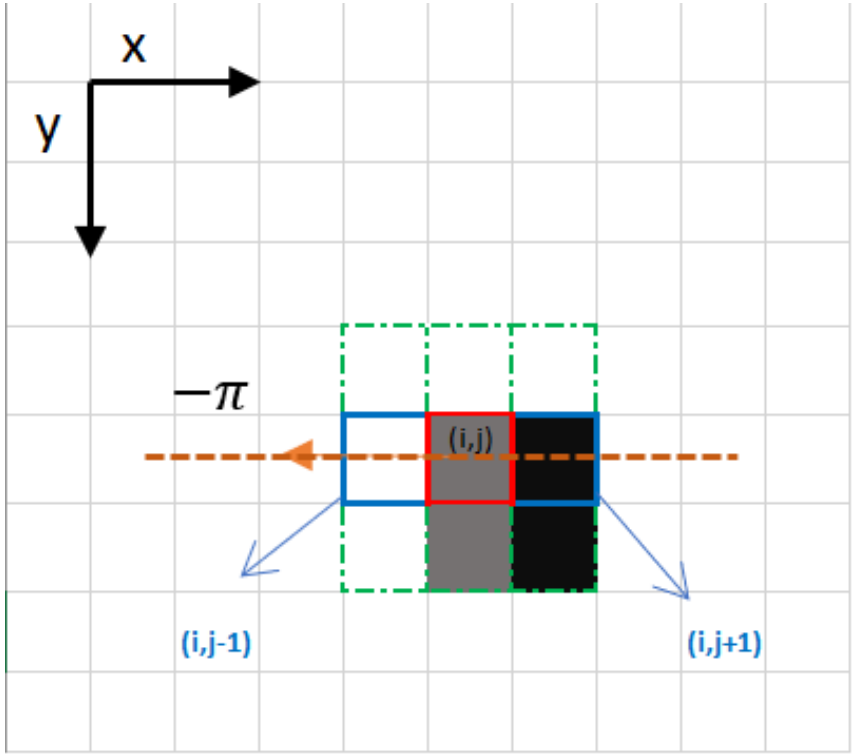




- Il gradiente punta a valori alti di intensità

Non maximal suppression

- Sopprimiamo il pixel se lungo la direzione del gradiente i pixel adiacenti hanno un valore più alto



Non maximal suppression

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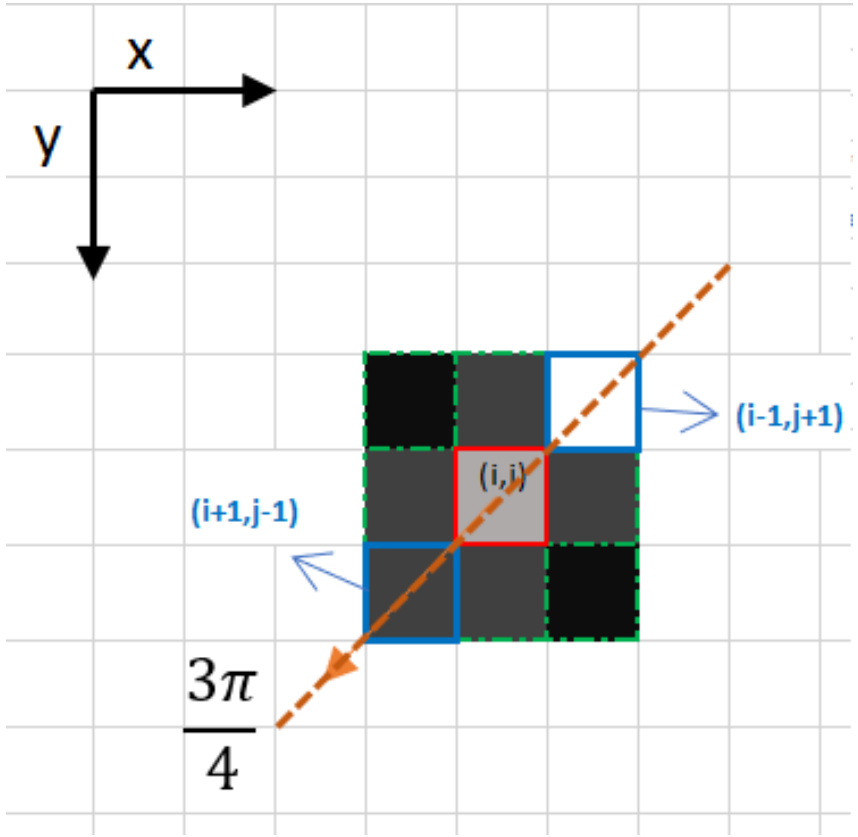
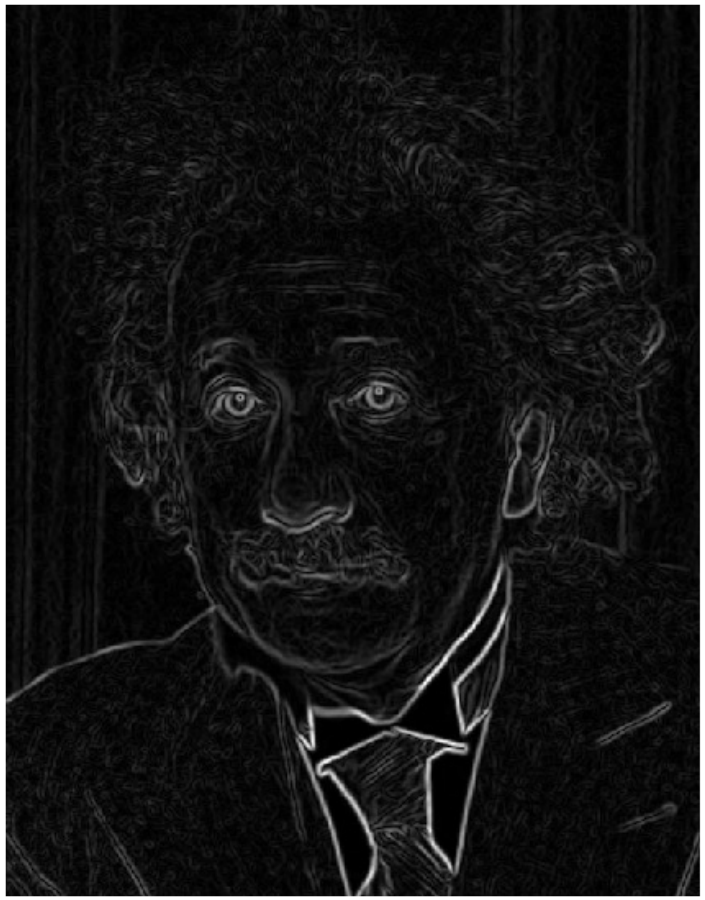
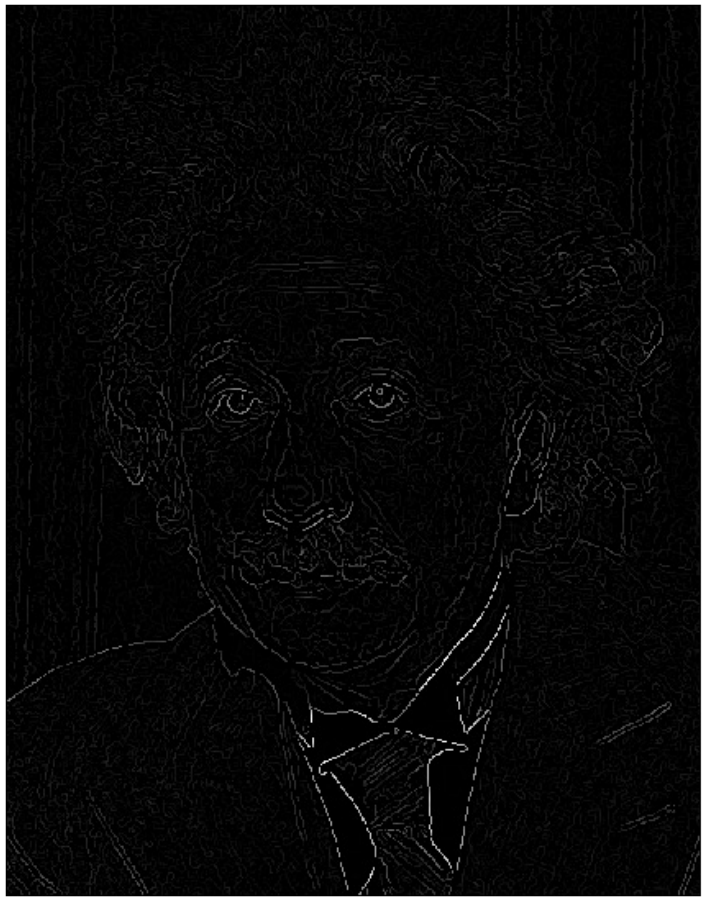


Non-Maximal Suppression

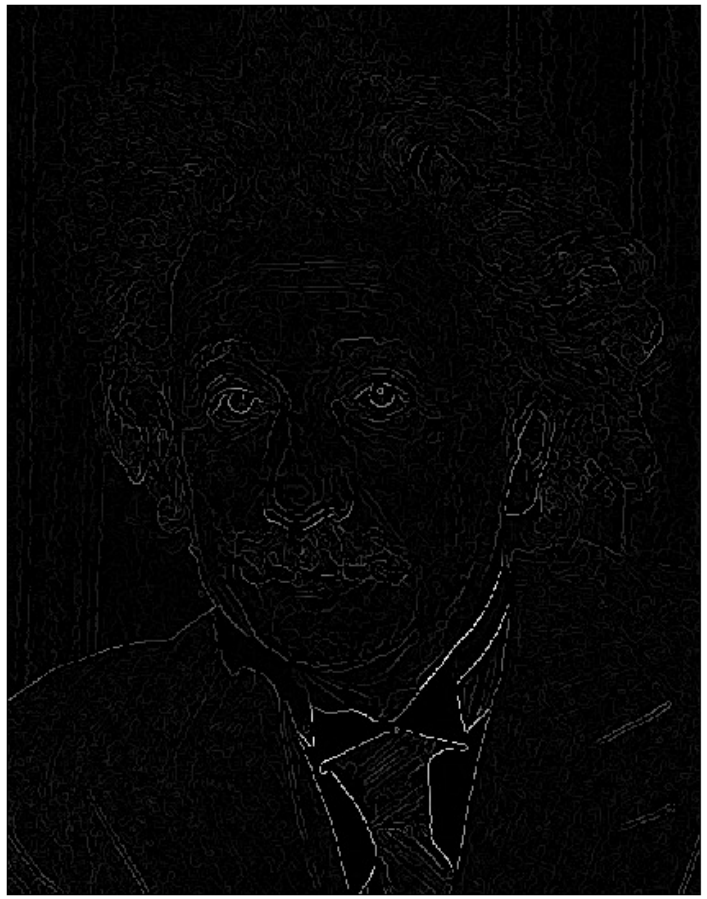




Level-wise thresholding, hysteresis

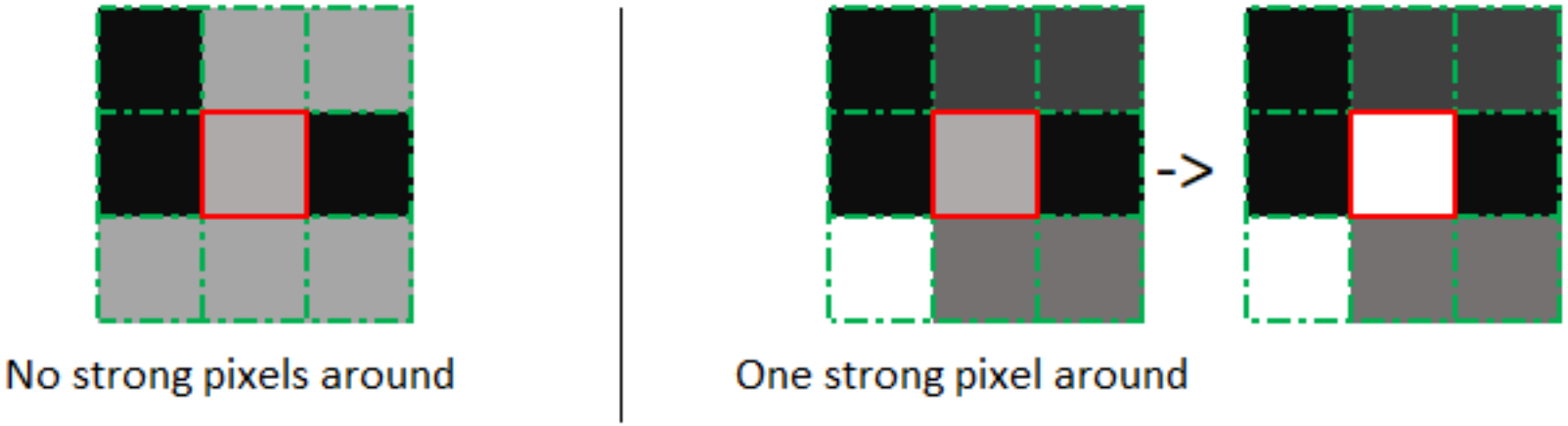
- Strong/Weak/irrelevant pixels
  - Strong pixels: intensità alta (contribuiscono sicuramente ai bordi)
  - Weak pixels: intensità non alta, ma neanche bassa
    - Li teniamo da parte
  - Irrelevant pixels: intensità bassa, da rimuovere
- Usiamo due soglie
  - High threshold per identificare strong pixels
  - Low threshold per identificare irrelevant pixels
- Tutti i pixel nel mezzo delle due soglie sono weak e verranno gestiti dal meccanismo dell'isteresi

Level-wise thresholding



Hysteresis

- «Attrazione gravitazionale»
  - Se un weak Pixel ha uno strong pixel nel vicinato, diventa anch’esso uno strong pixel, altrimenti diventa irrelevant e viene soppresso



Hysteresis