Edge:
Canny

Dr. Tushar Sandhan

Introduction

- Single point thick edges

input

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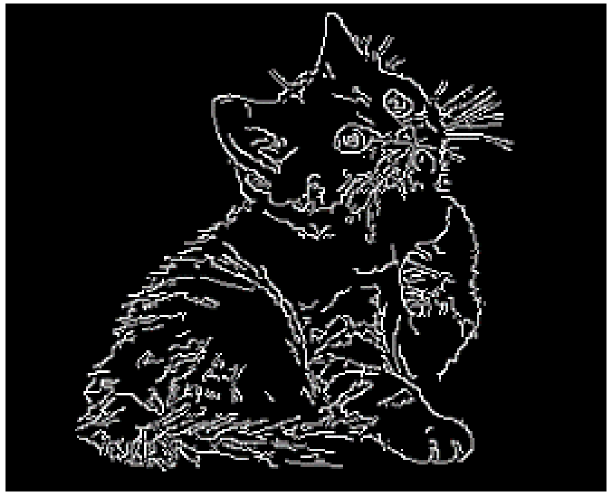

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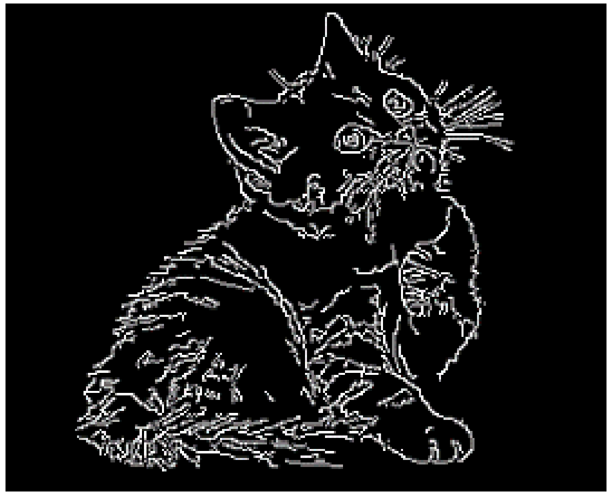

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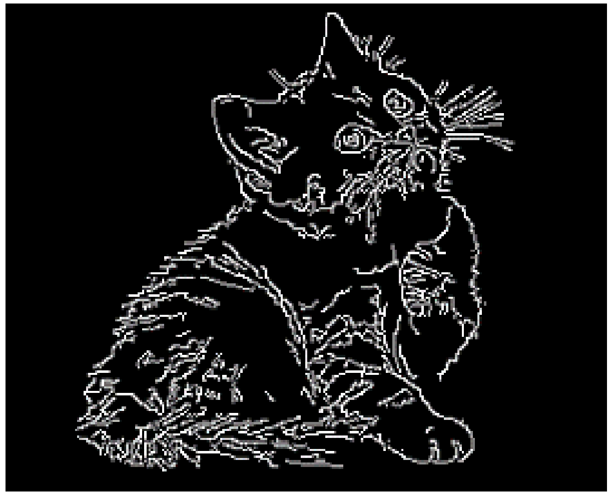

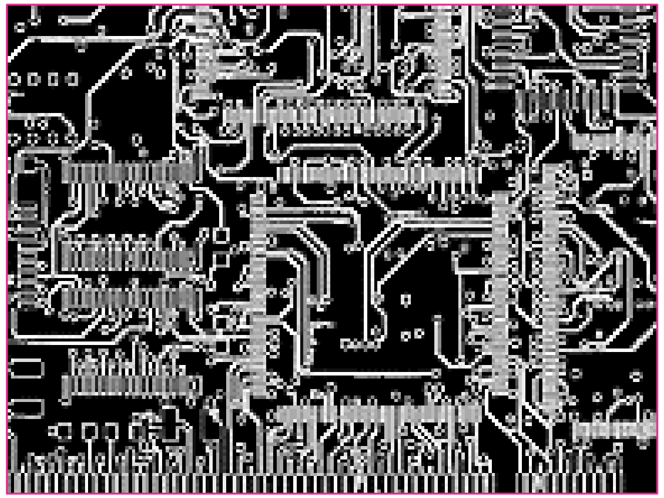

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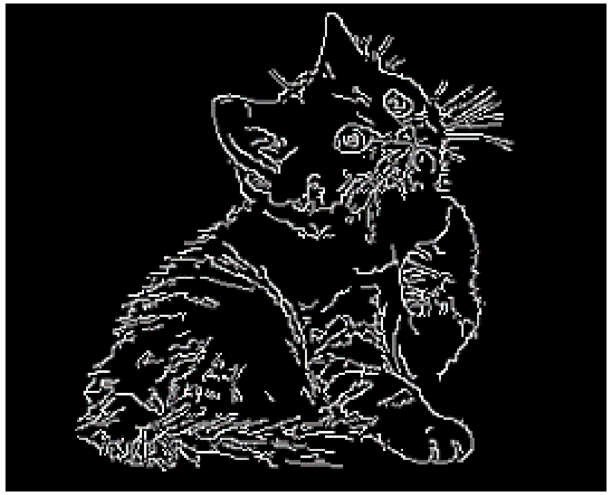

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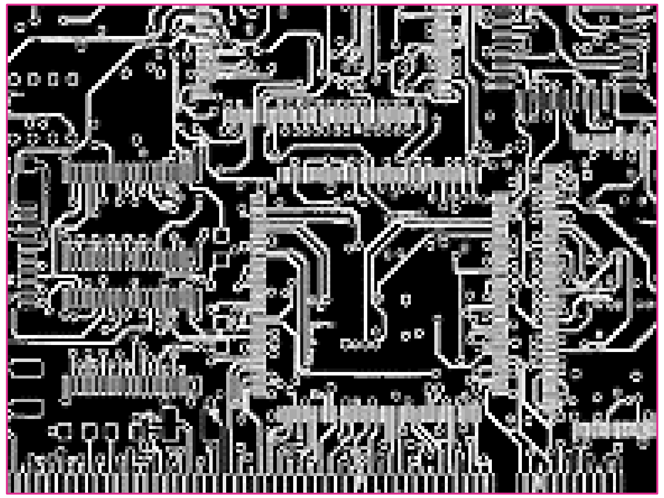

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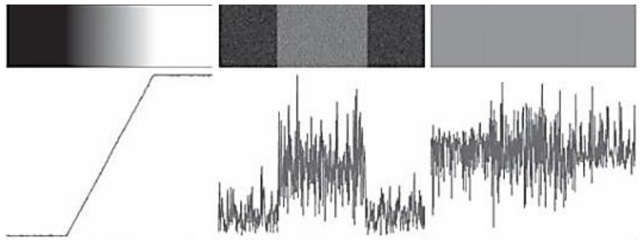

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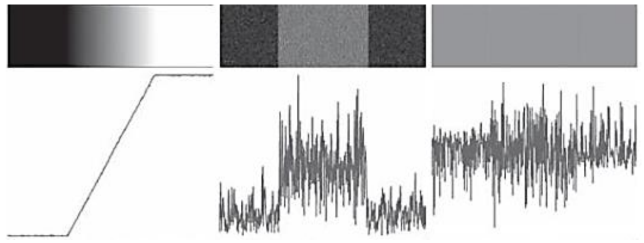

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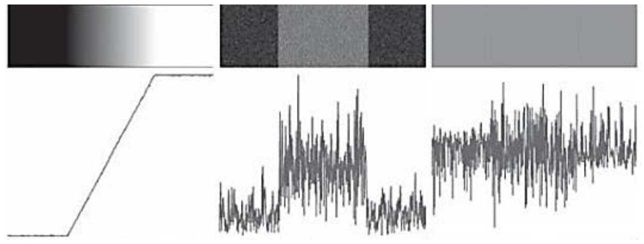

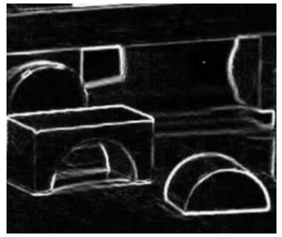

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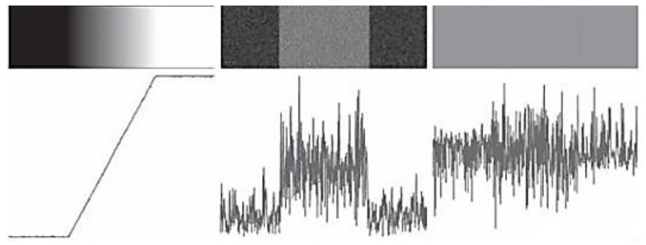

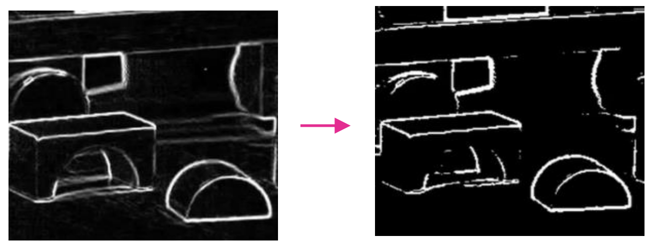

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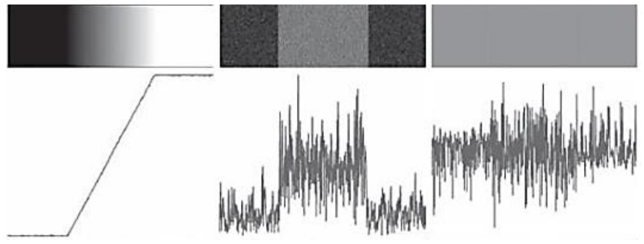

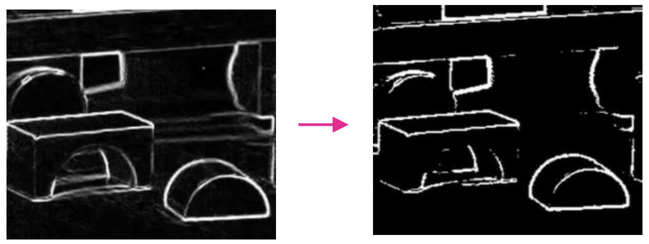

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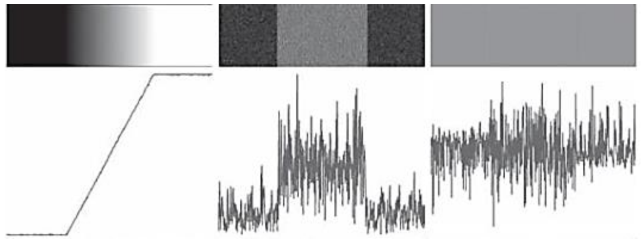

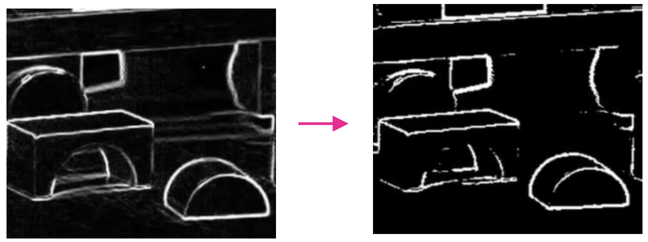

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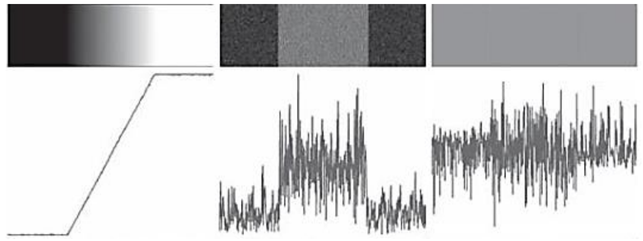

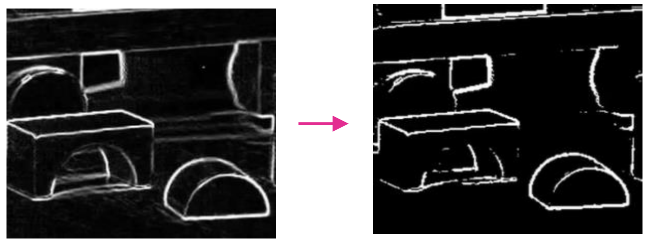

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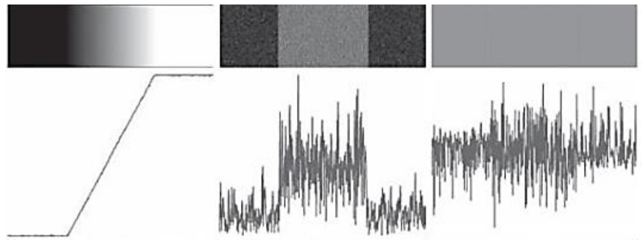

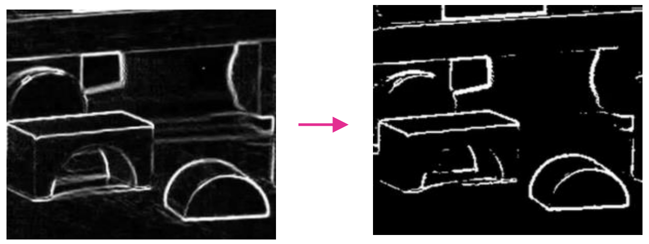

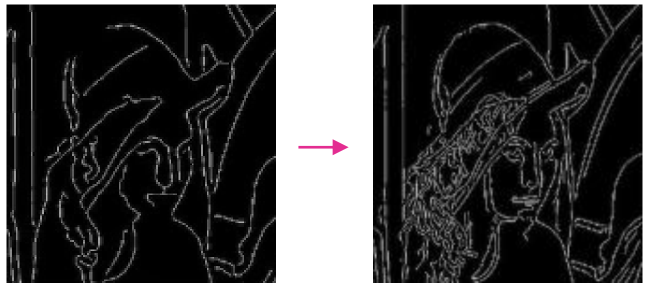

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  - single point edge response
    - 1 point for each true edge point

Canny edge detector

- Image derivatives
  - input image $f(x,y)$
  - smoothed $f_s(x,y)$
  - any operator can be used to get $g_x(x,y)$, $g_y(x,y)$

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  - ridges thinning is needed
  - non-max suppression
    - suppress where?

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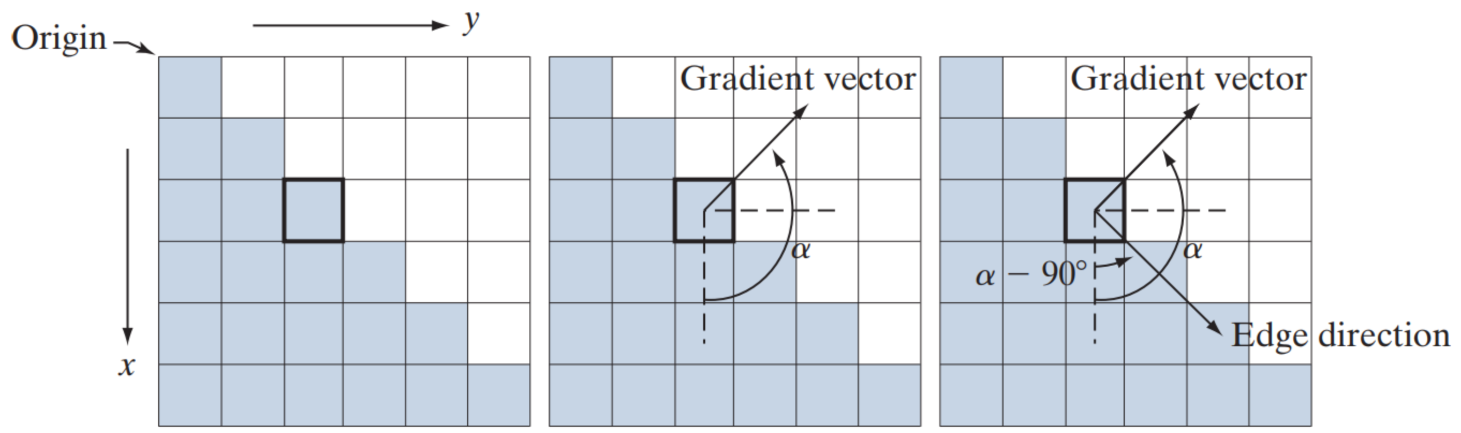

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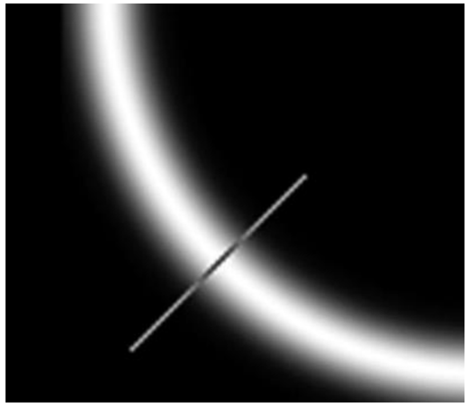

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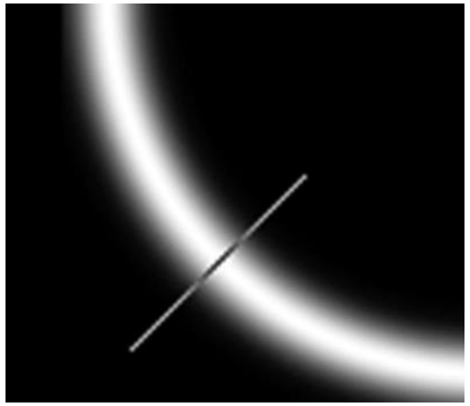

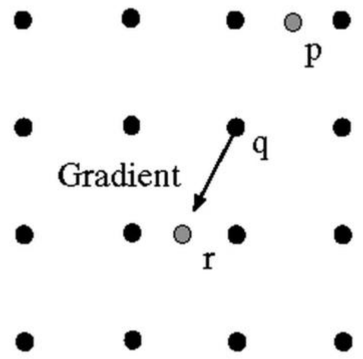

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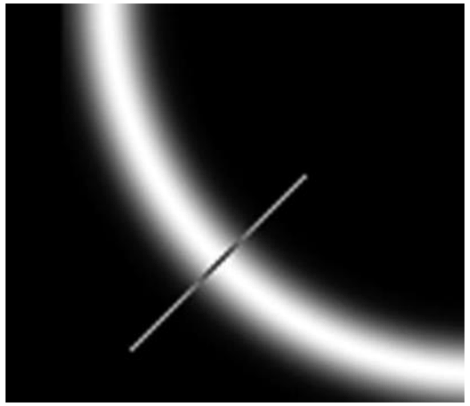

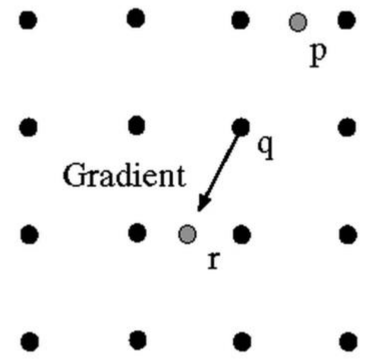

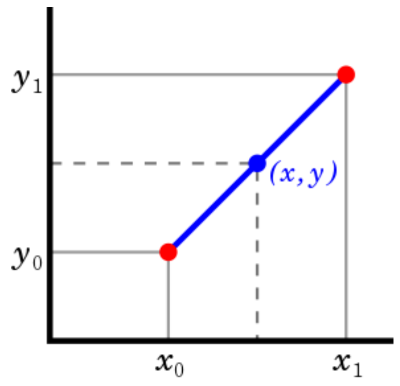

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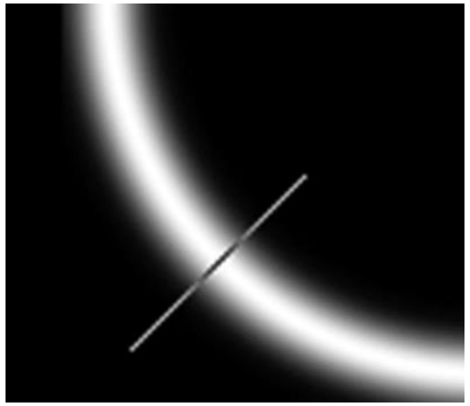
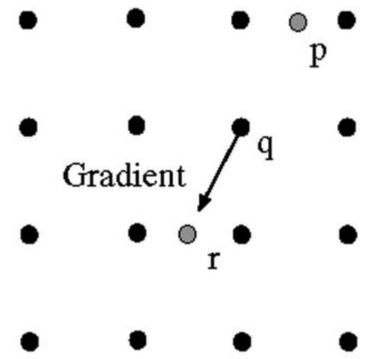
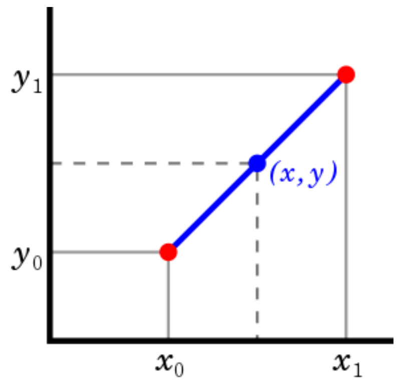




$$\frac{y - y_0}{x - x_0} = \frac{y_1 - y_0}{x_1 - x_0}$$



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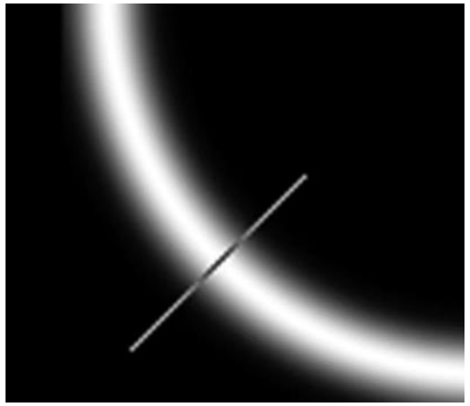

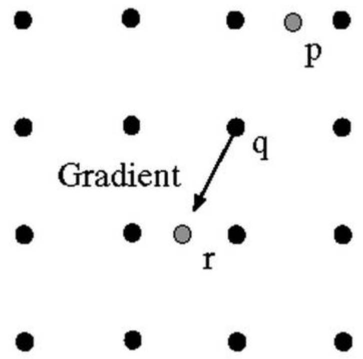

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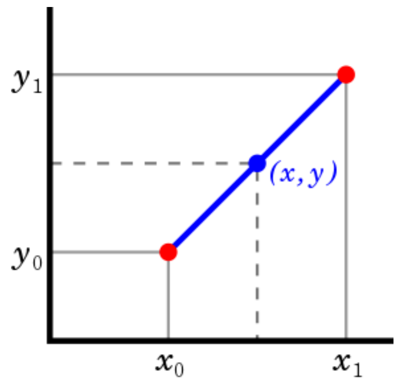

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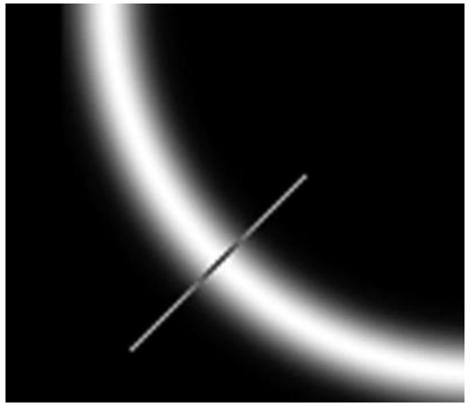

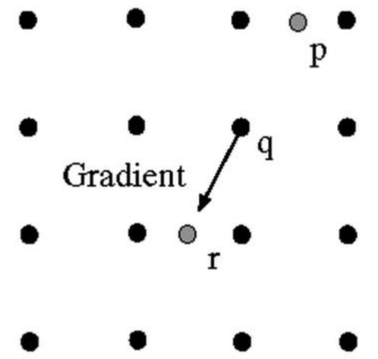

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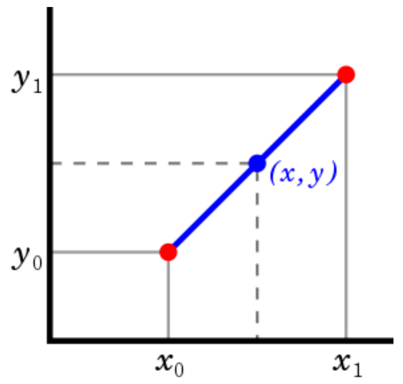

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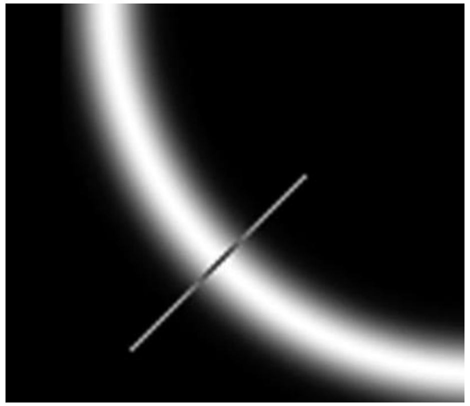
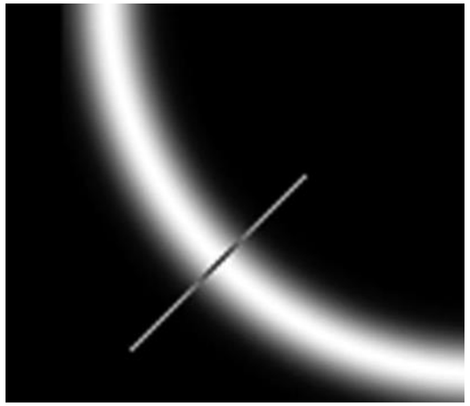


Canny edge detector

- LINKINg Points
  - Canny edge detector
    - It starts with one thing: gradients
    - In the end, it doesn't even matter: which operators have been used
  - at last we have to link the non-suppressed ones!



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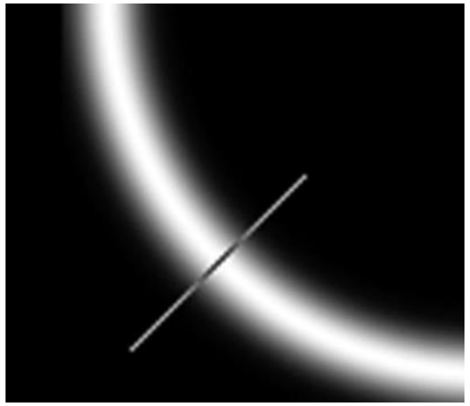

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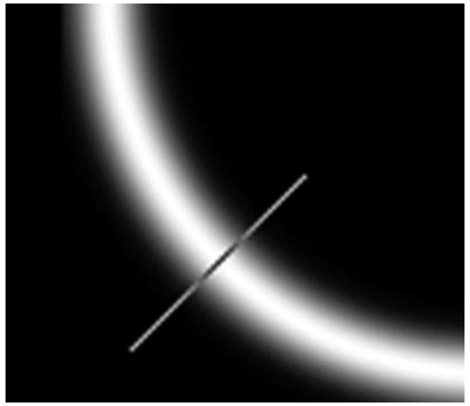

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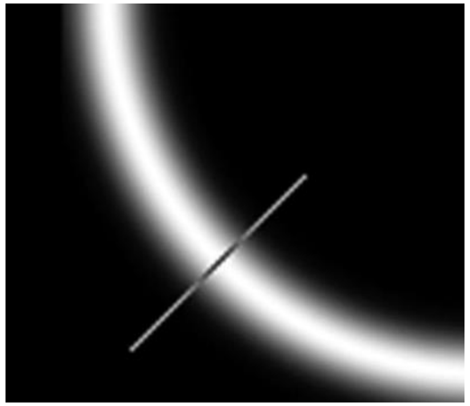

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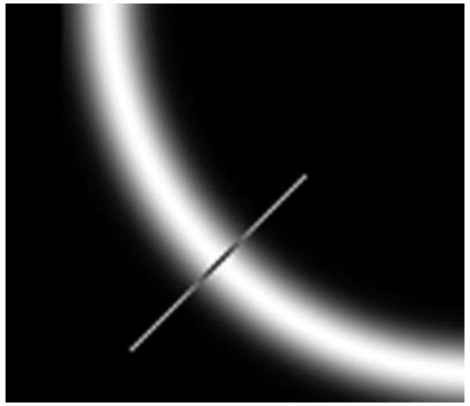
  - two instruments of thresholds: Hysteresis

    a. find all edge points using TH^{high}
    b. from each strong point follow the both side direction ⊥ to the edge normal
    c. in that directions, construct the contours of connected edge points
    d. mark all points greater than TH_{low}



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- Entire algorithm composition:

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1. Filter image with derivatives of Gaussian
2. Get M, α
3. Non-max suppression
   - thin multi-pixel wide edges to a single pixel widths
4. Linking: the hysteresis
   - 2 thresholds: TH_{low} , TH^{high}
   - TH^{high}: to start an edge
   - TH_{low} : continue started edge

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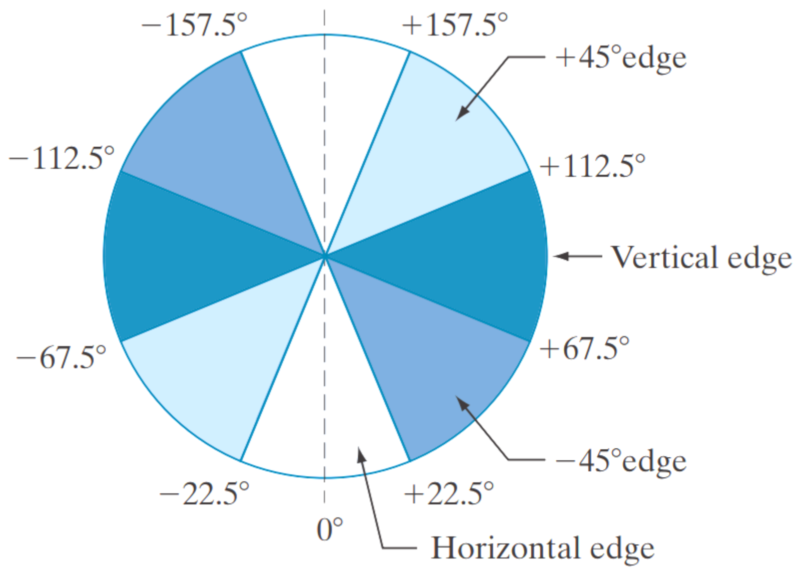

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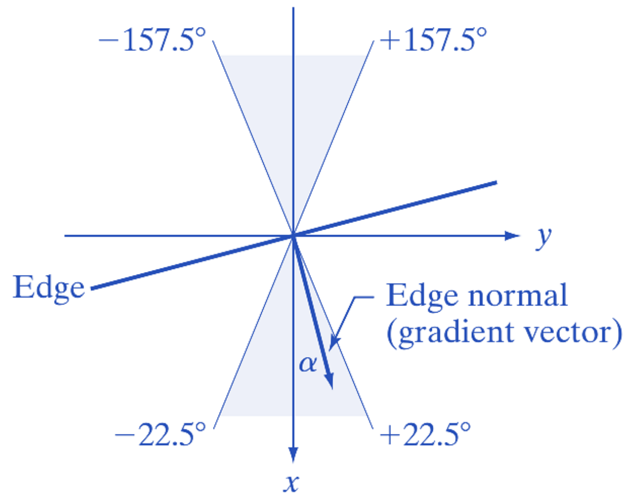
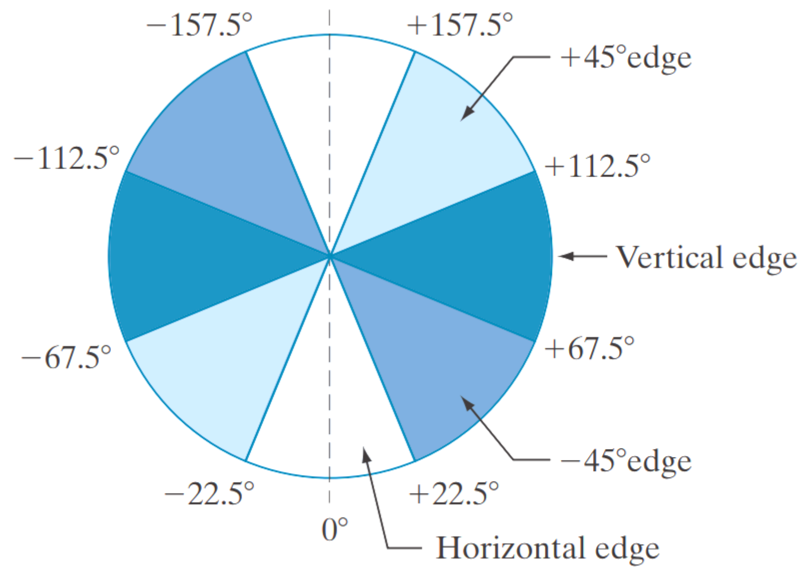
Vertical

-45 degrees

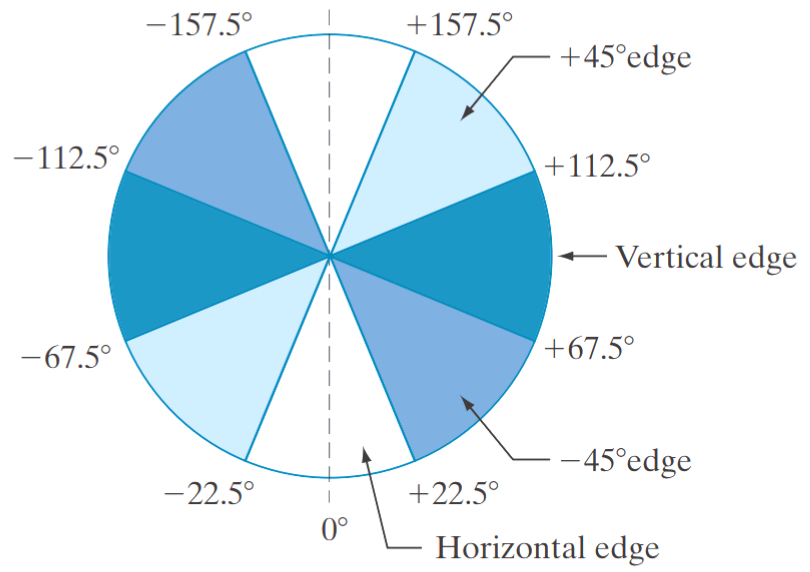




Canny edge detector

- Speeding up the beats of operations
  - binning the α (angles)
    - get the directional bin $Bin()$ closest to α
    - from previous operations edge: $M(x,y)$
    - suppression
      - If $M(x',y') > M(x,y)$ then

        $M(x,y) \rightarrow 0$
      - where neighbors $x',y' \leftarrow Bin(x,y)$



Canny edge detector

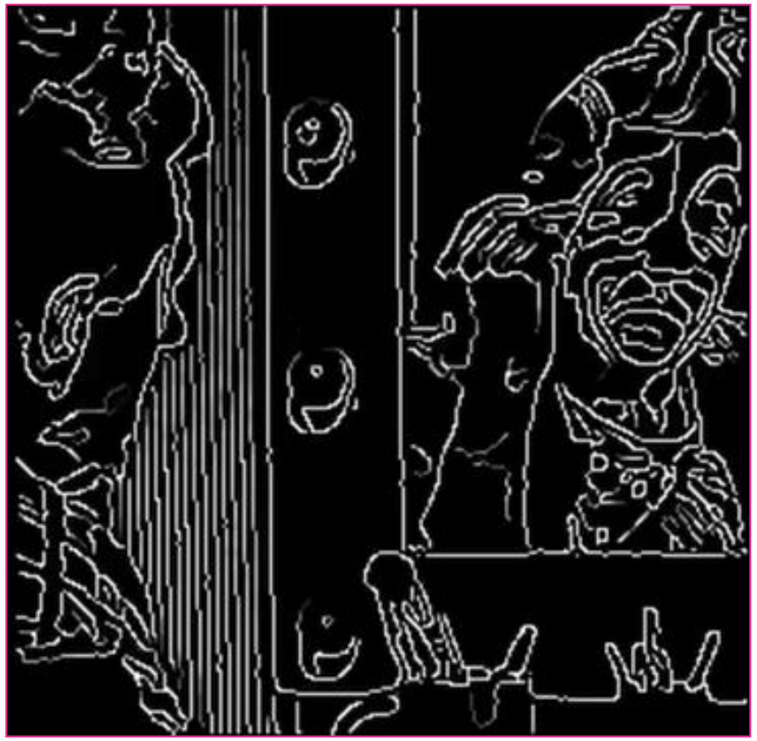
- Varying σ

input

Canny edge detector

- Varying σ

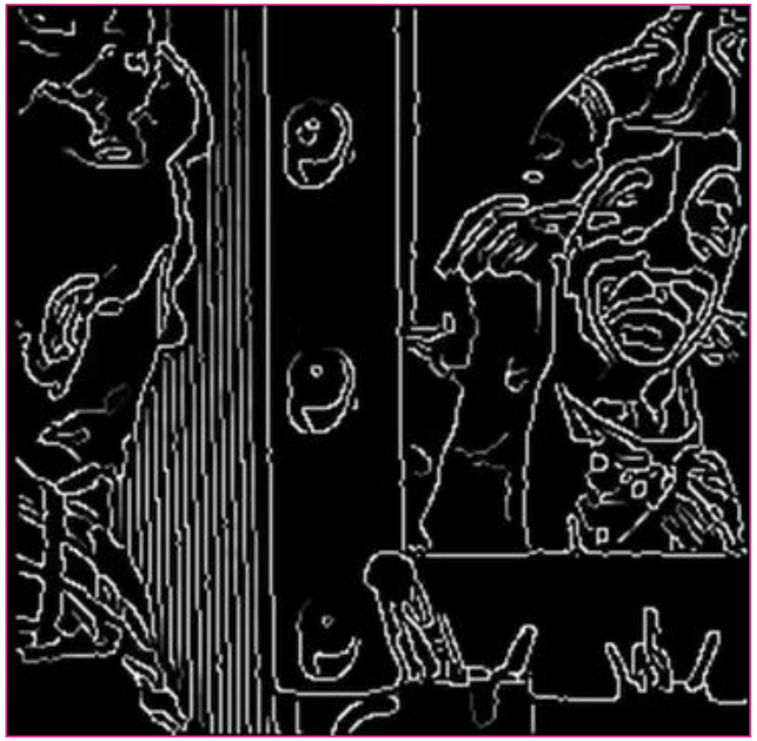
input

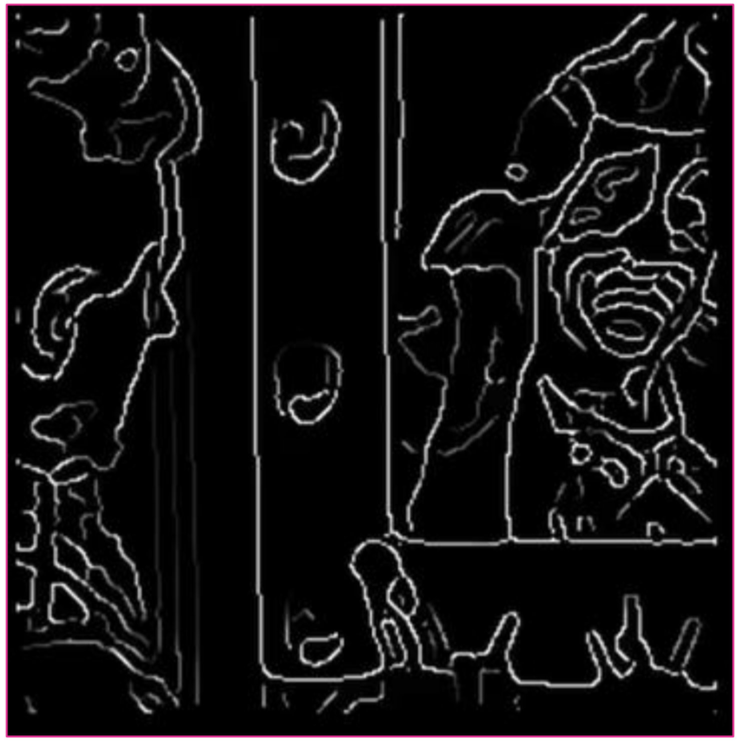


Canny edge detector

- Varying σ

input



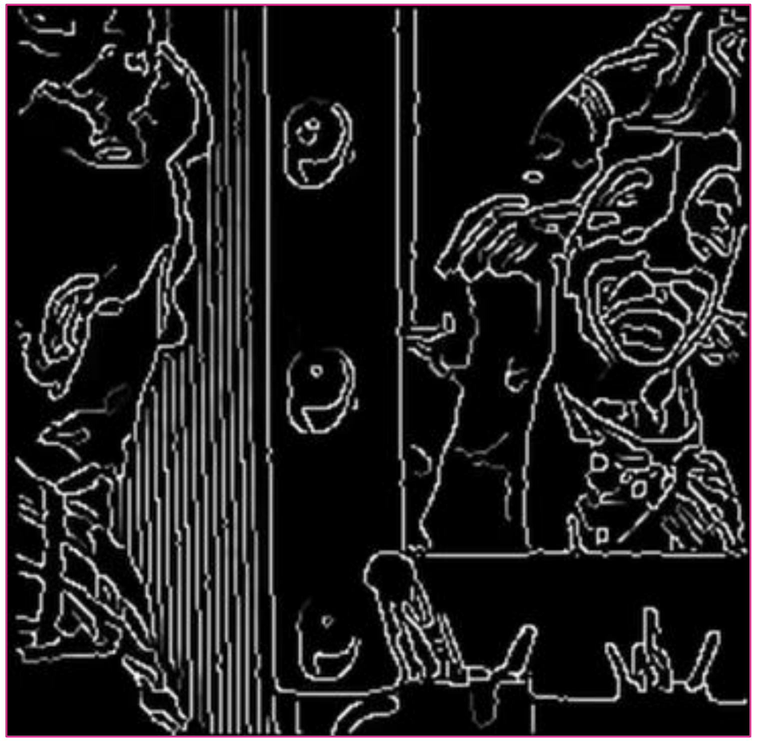


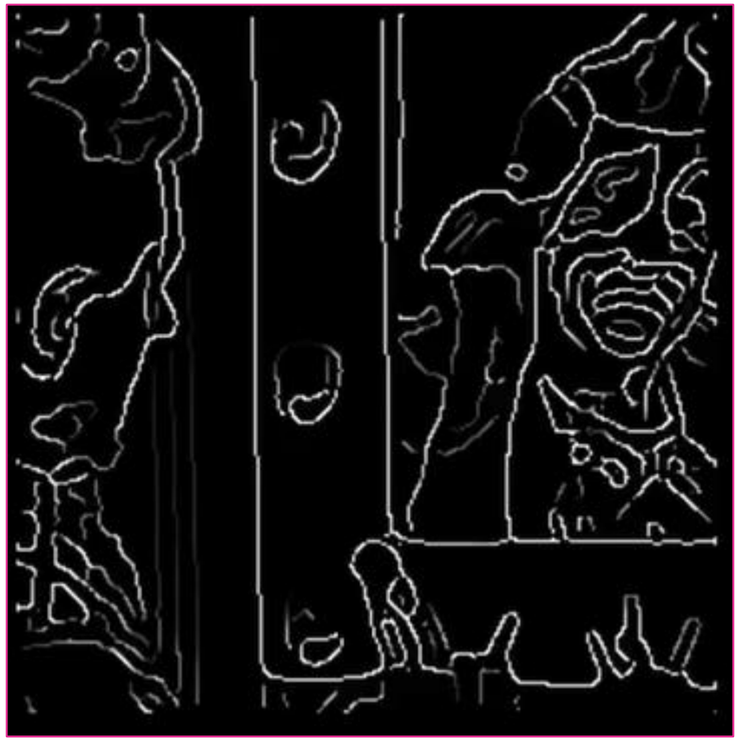
Canny edge detector

- Varying σ

input

σ small





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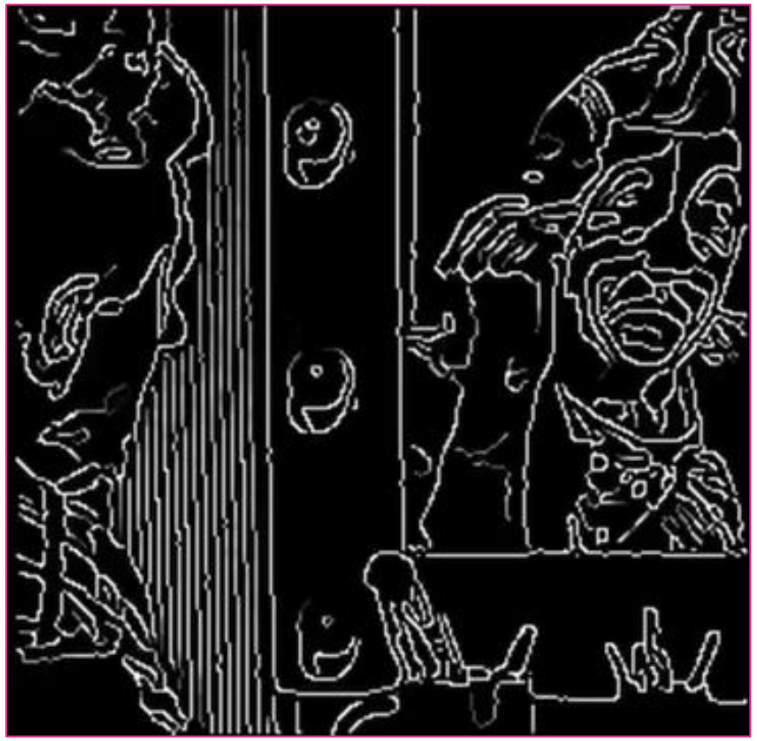
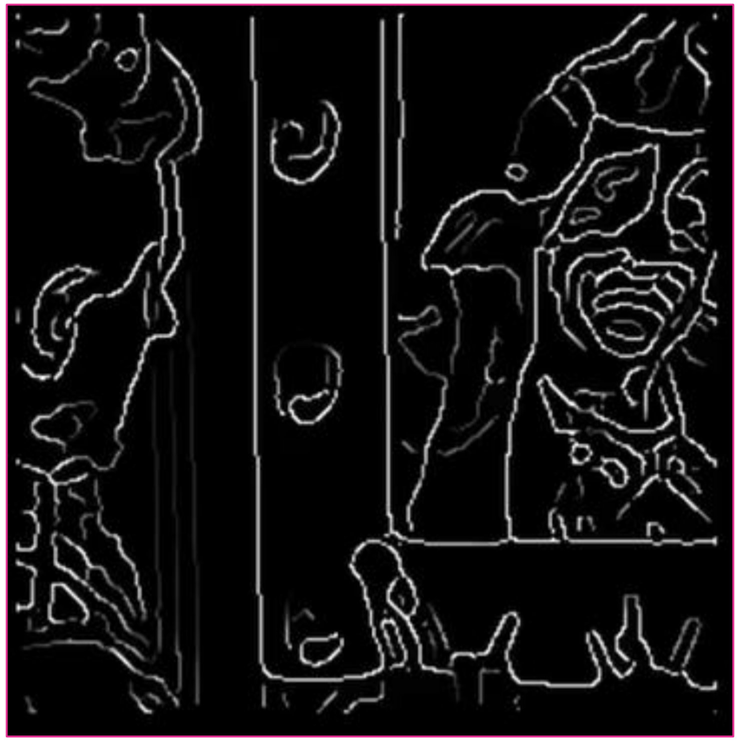


σ large



Canny edge detector

- Comparing other edge detectors

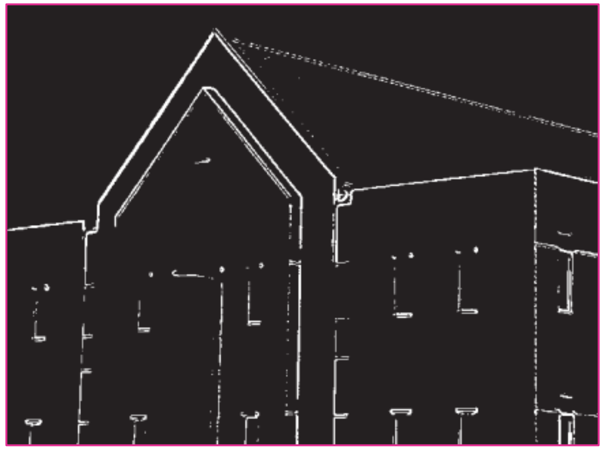
input

Canny edge detector

- Comparing other edge detectors

input

Sobel with TH



Canny edge detector

- Comparing other edge detectors

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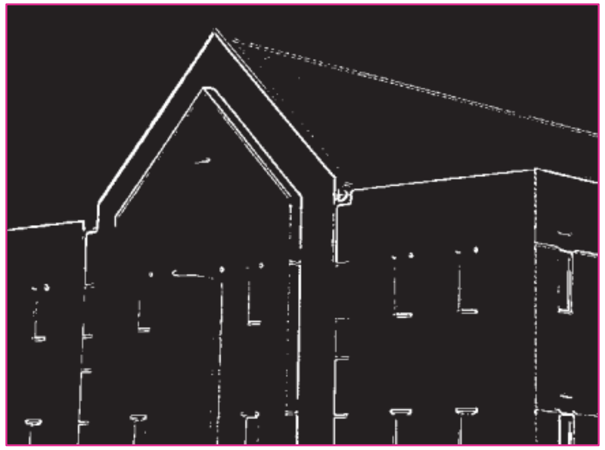
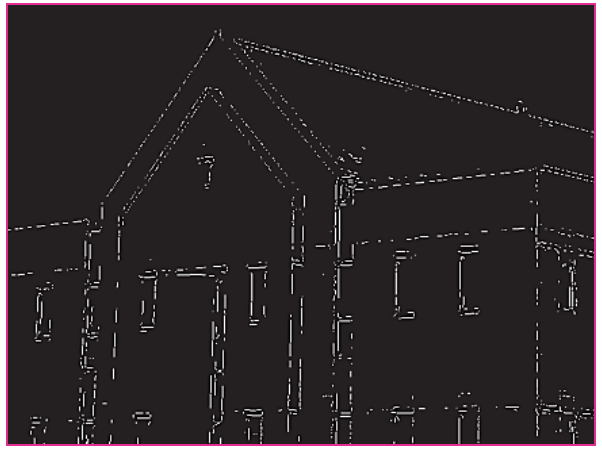


LoG zero crossings



Canny edge detector

- Comparing other edge detectors

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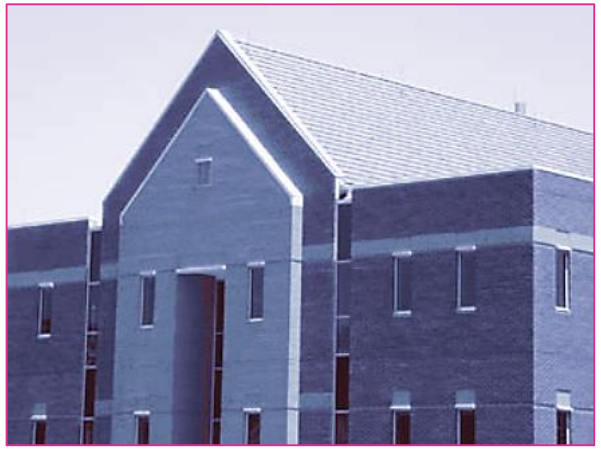

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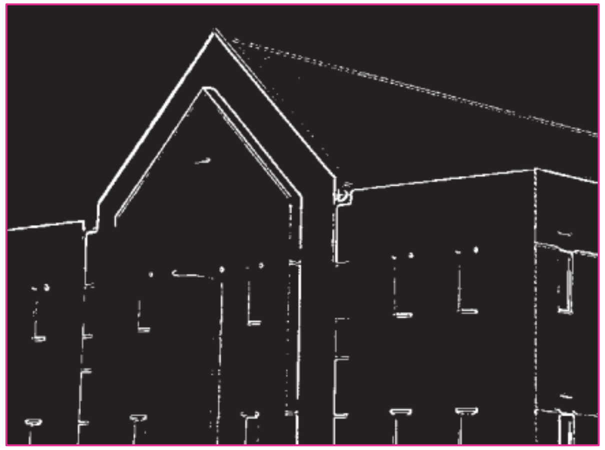

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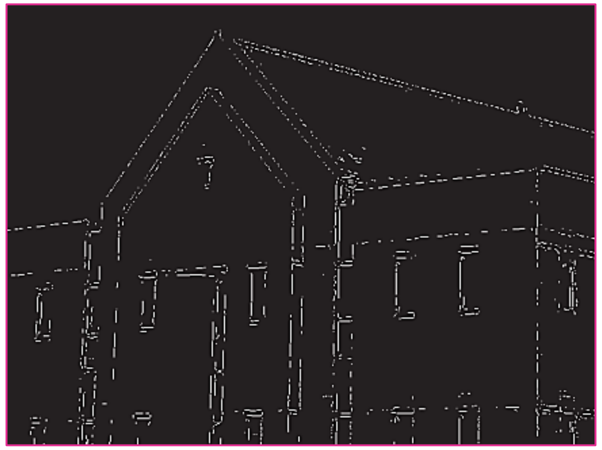
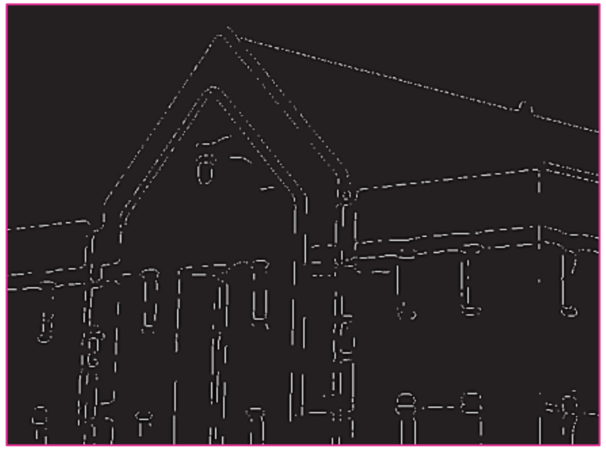


Canny



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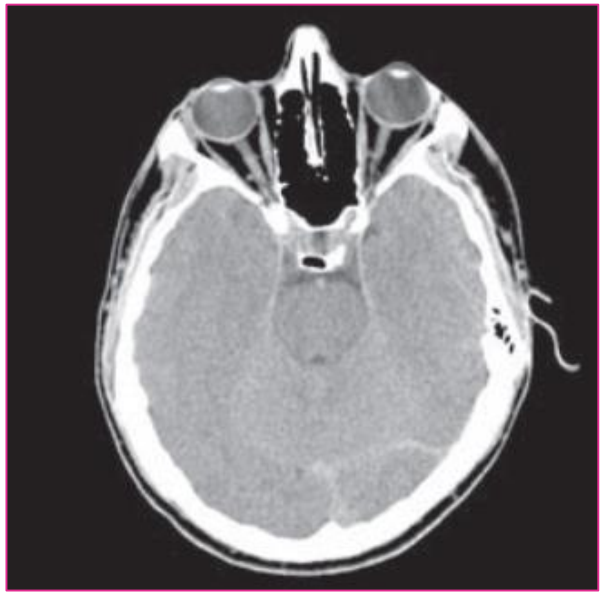

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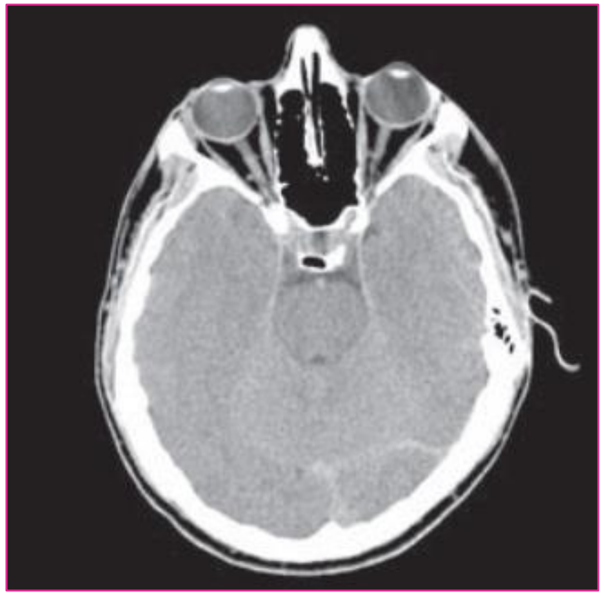

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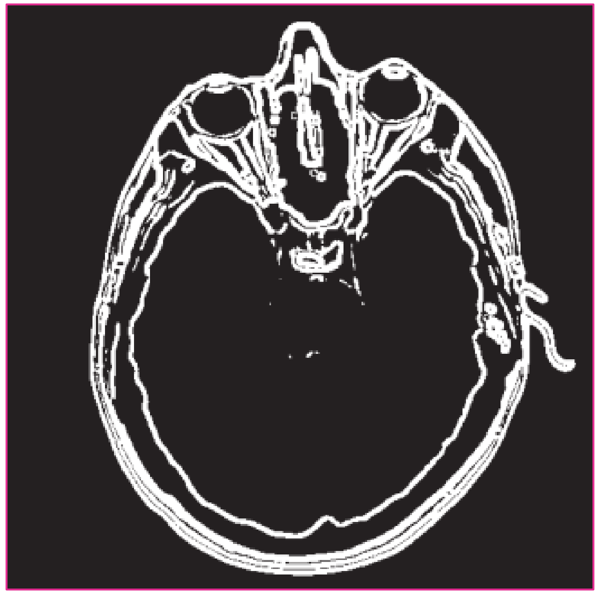

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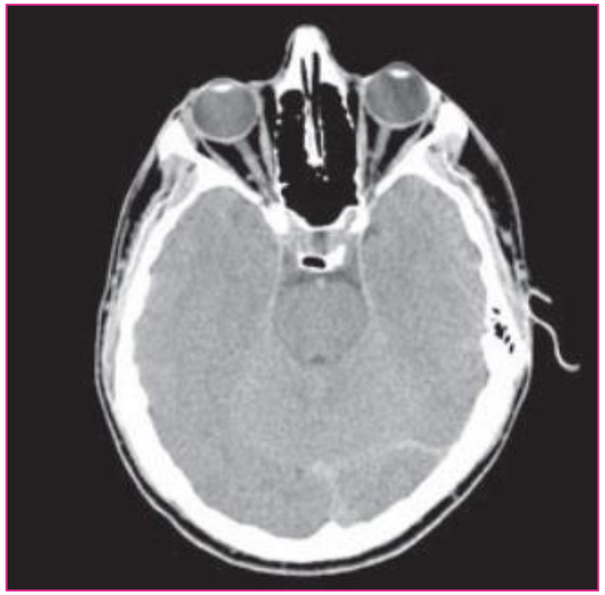

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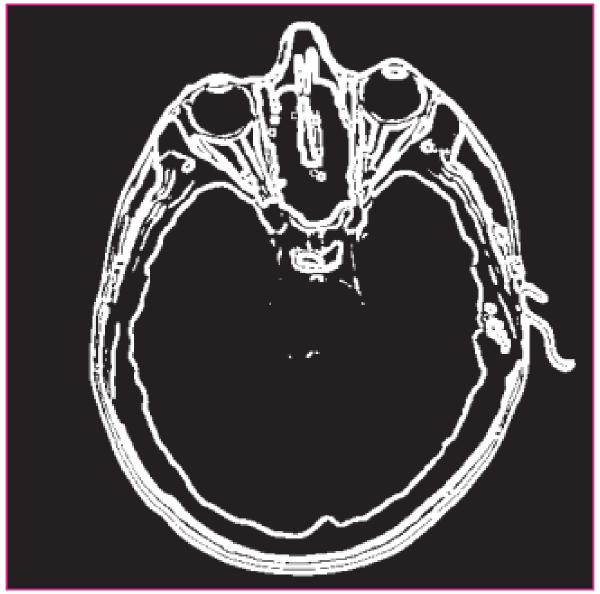

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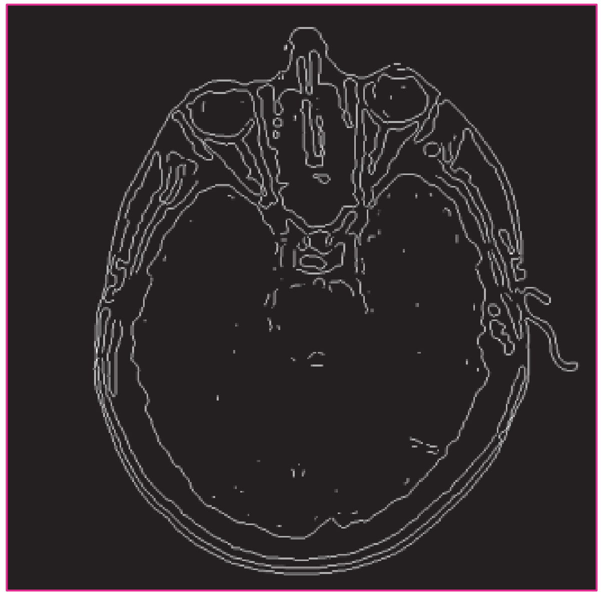

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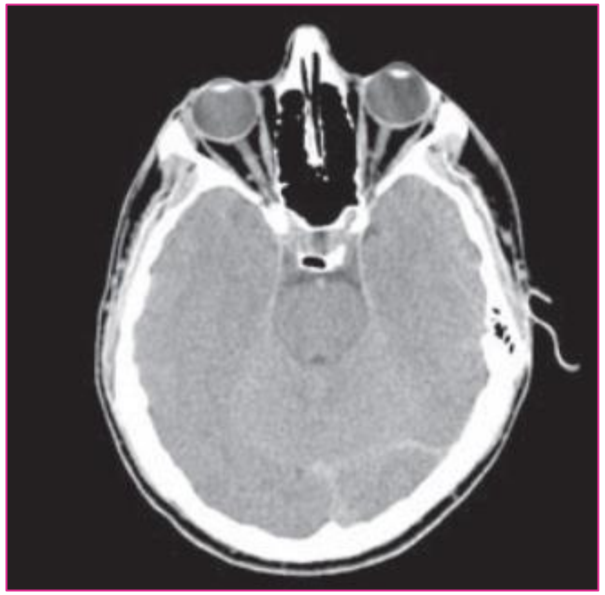

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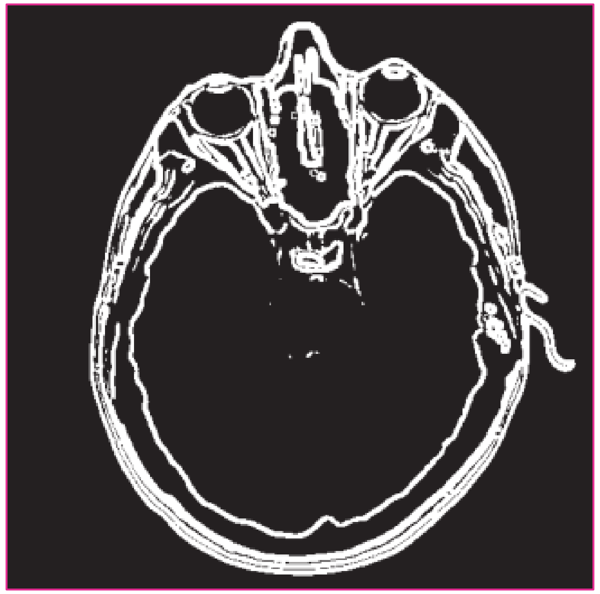

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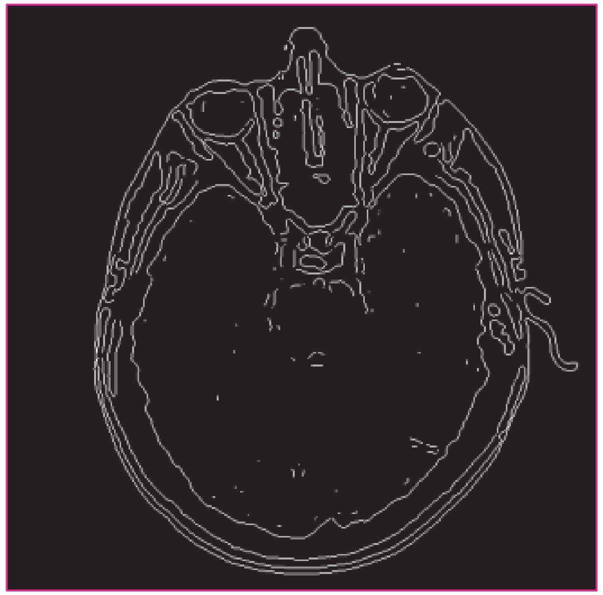
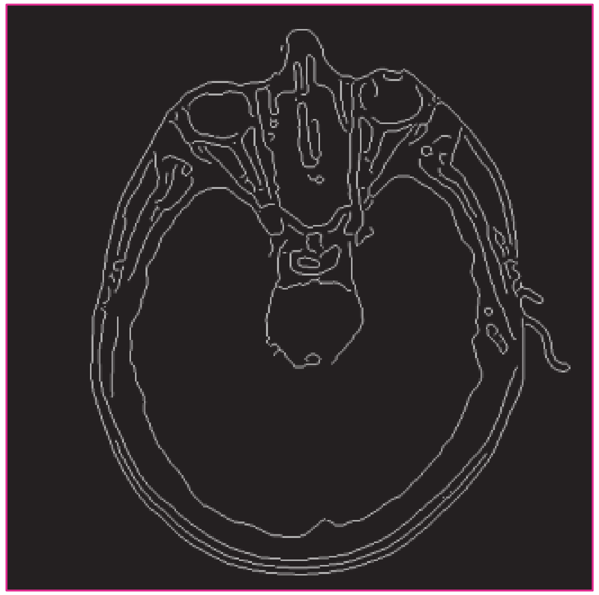


Canny



A canny player with a Canny edge!

A canny player with a Canny edge!

Messi

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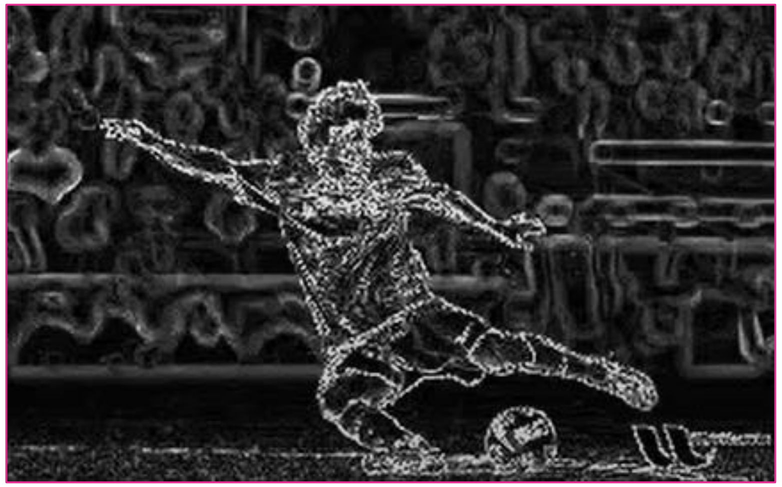
Messi



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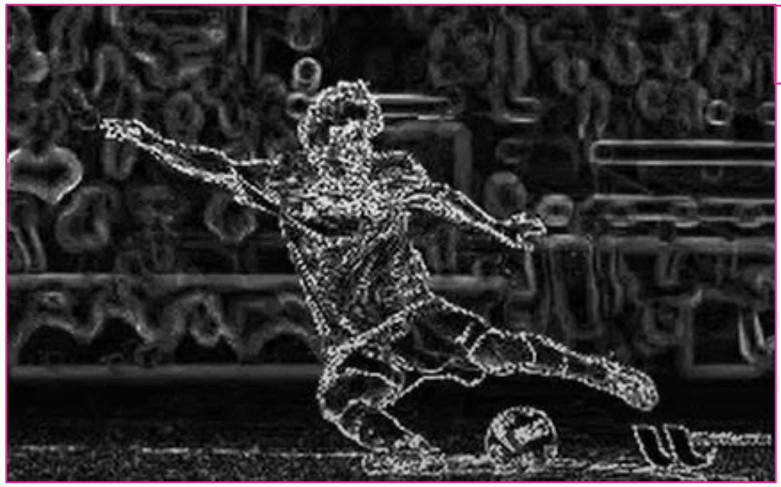
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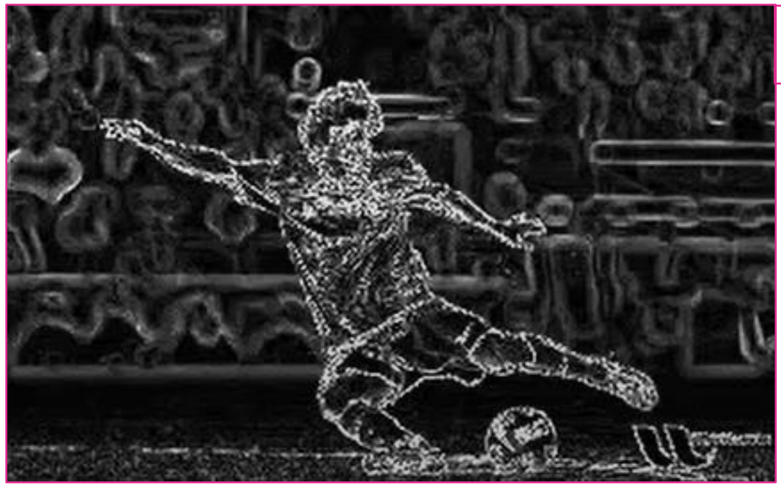

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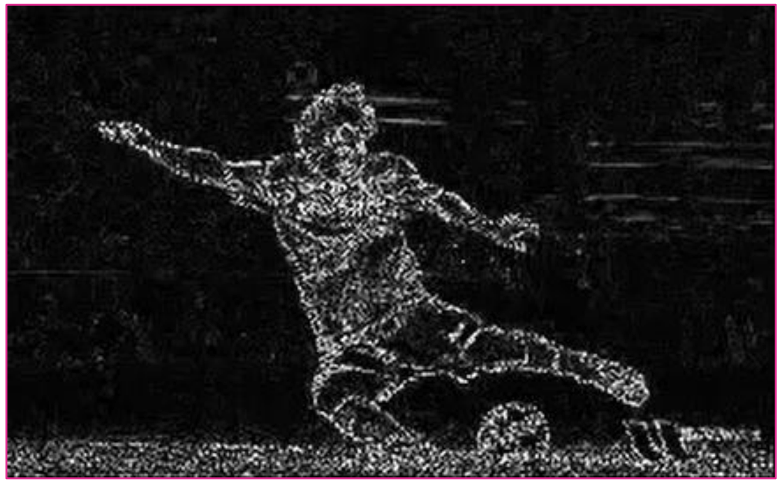

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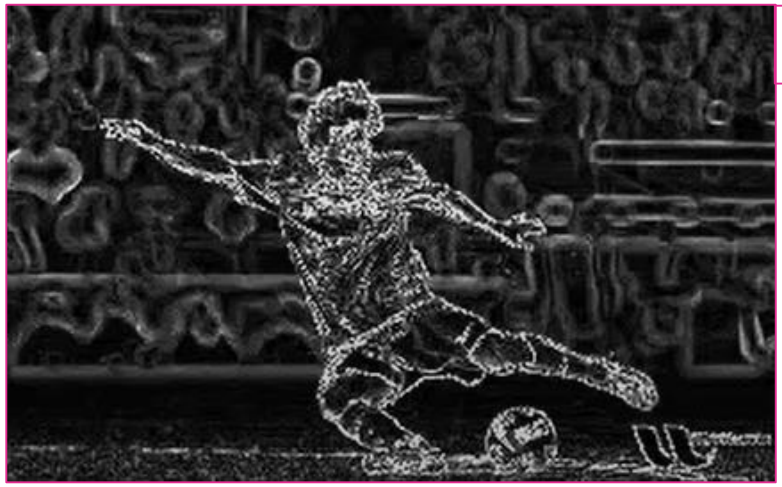
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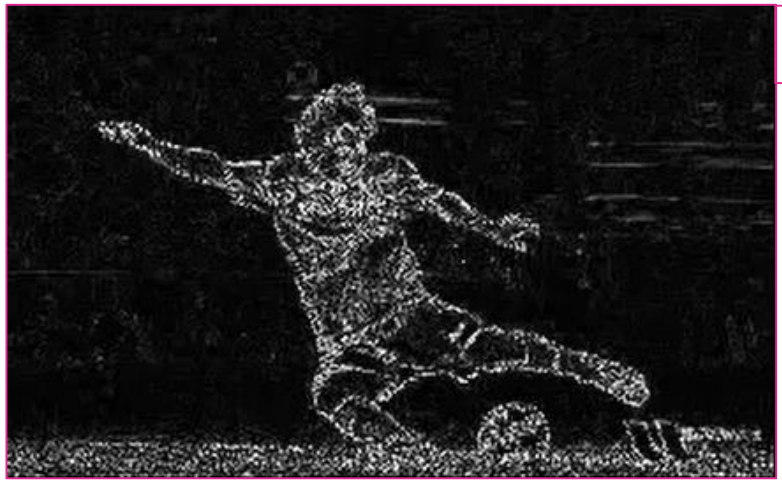
Laplacian

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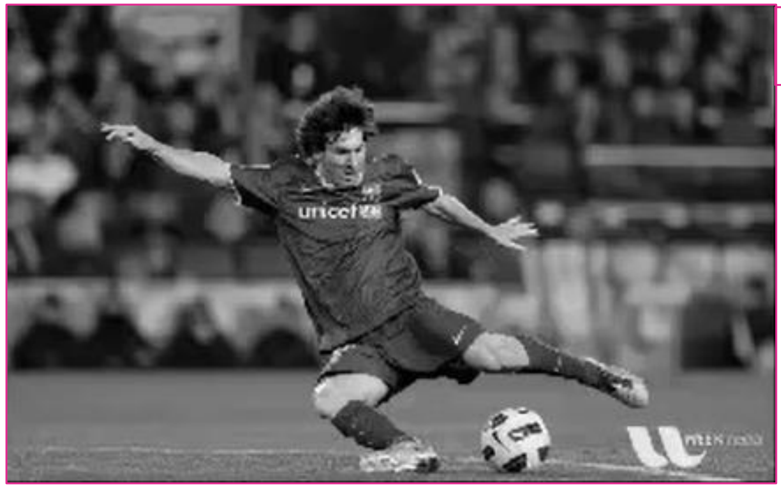
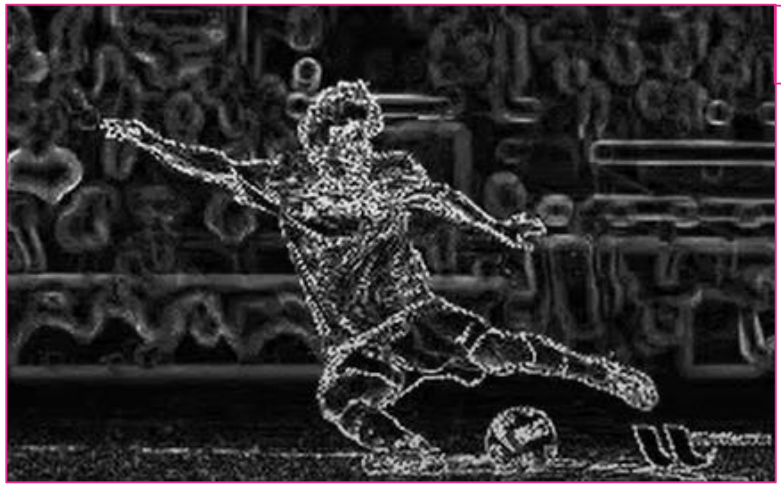


Messi



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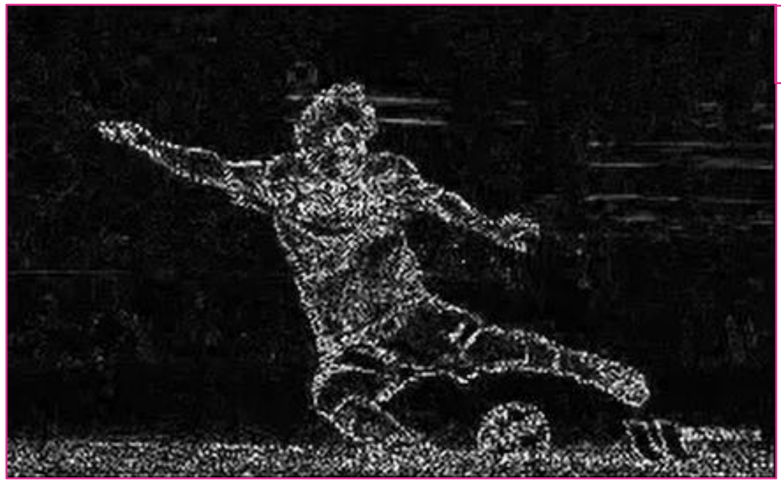

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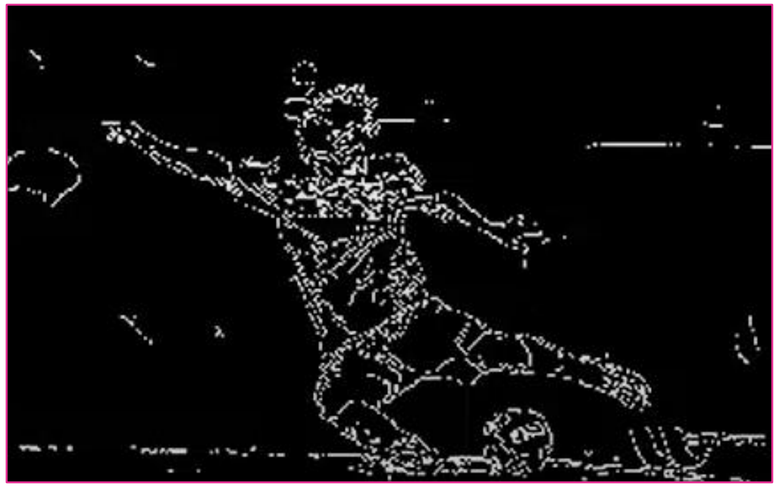

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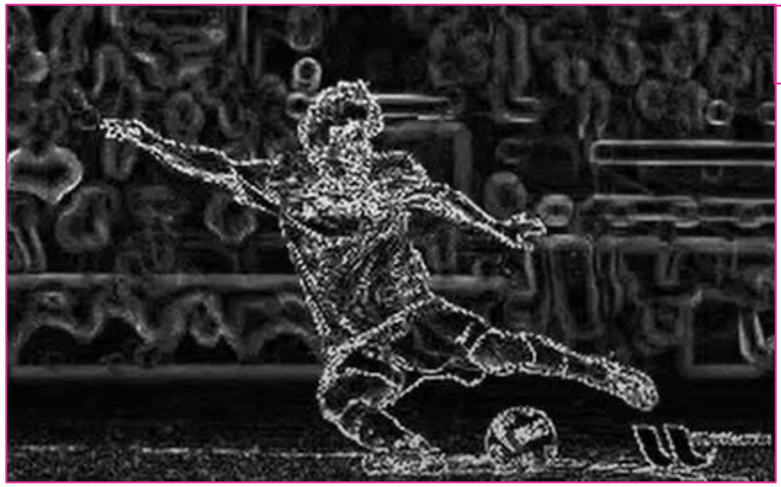
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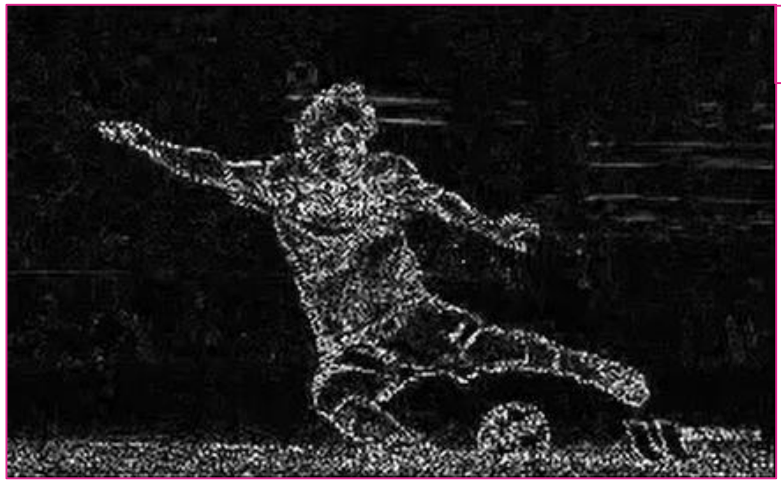
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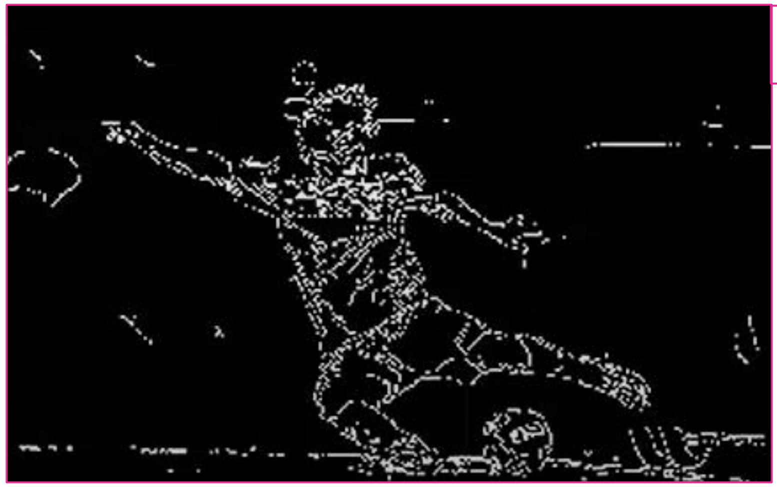
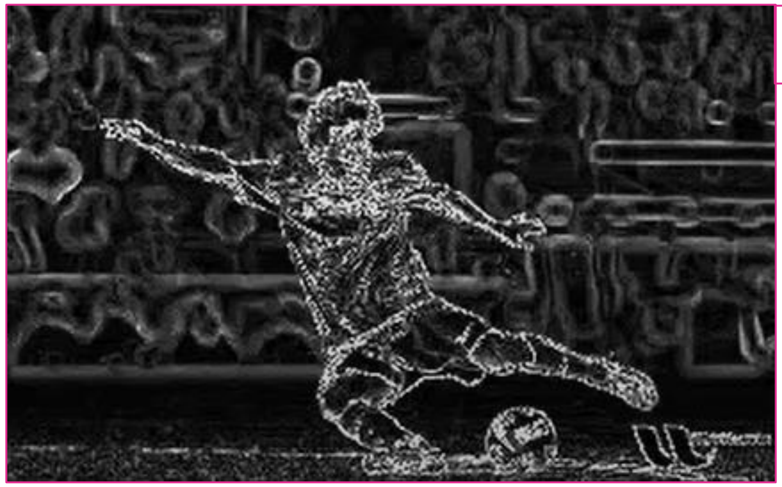

Canny

A canny player with a Canny edge!

Messi

who will you go with?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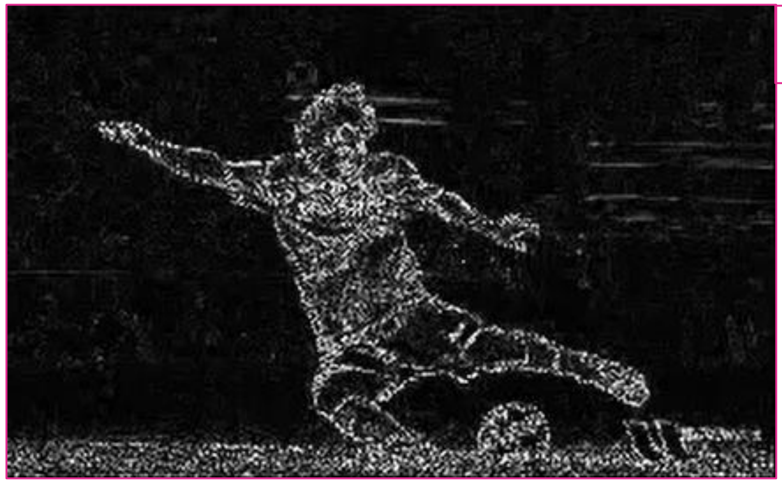
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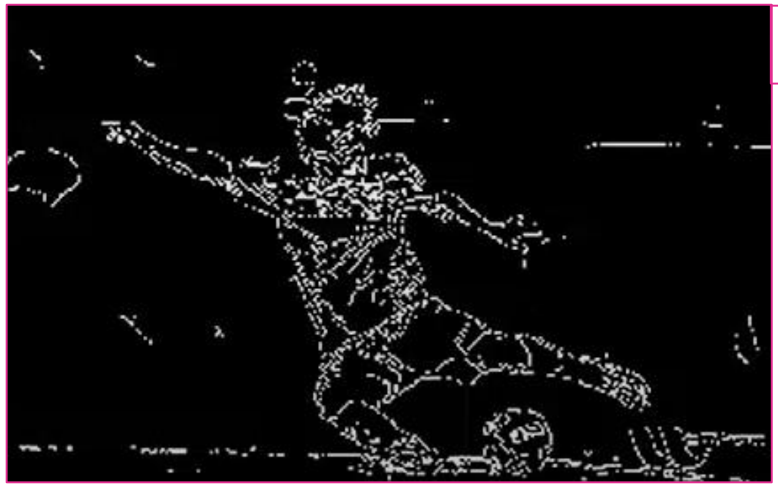
Canny

Conclusion

- Canny edge detector

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❑ Single point thick edges

❑ Canny operations

- Thinning: non-max suppression
- Linking: double TH hysteresis
- High accuracy is paid via computational expenses

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Go with a 'canny' player, for accuracy

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And with uSΘin BΘLt, for speed!

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