String-like Occluding Region Extraction for Background Restoration

Toru Tamaki, Hiroshi Suzuki, Masanobu Yamamoto

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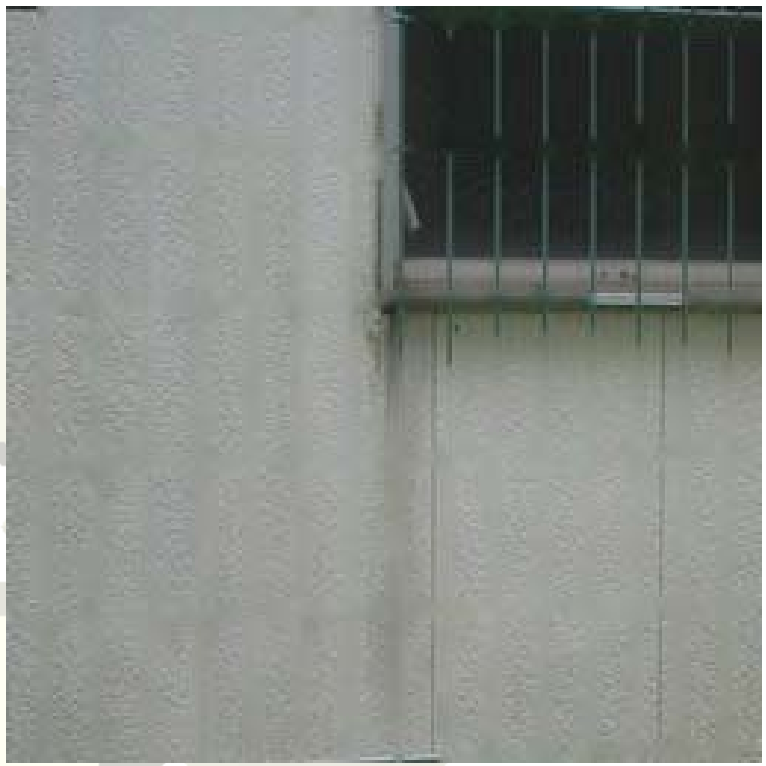

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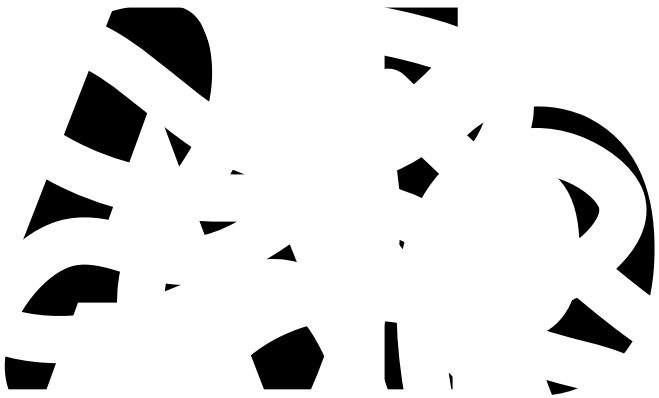
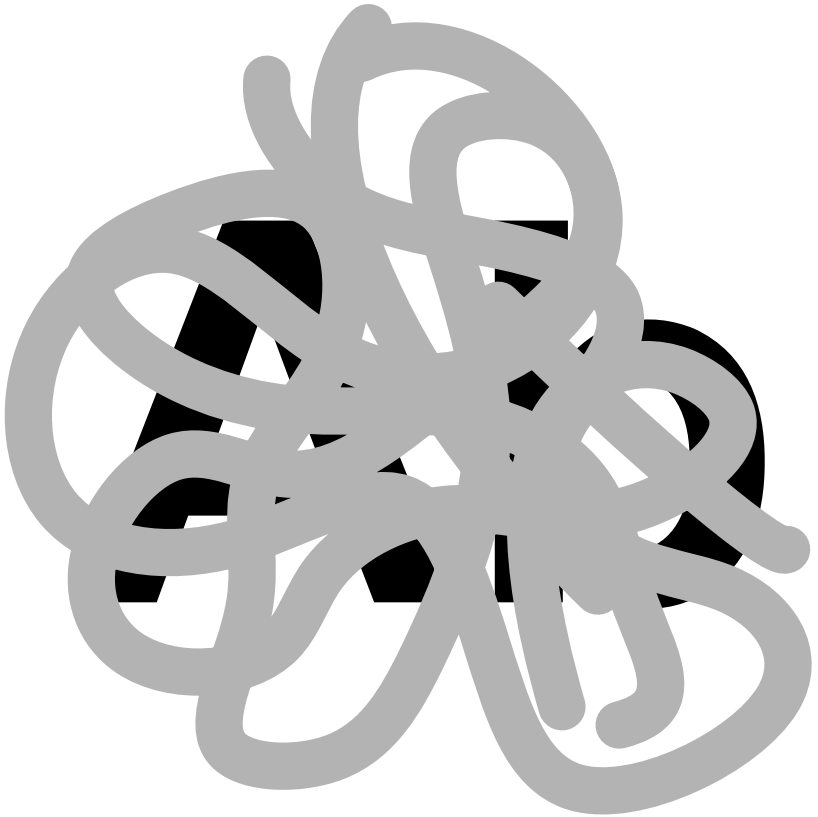
modal / amodal completion



modal
completion



amodal
completion

amodal completion in real scenes

Our Goal

- Objective
  - ***Find occluding regions: given an image only***
  - Recover the background scene
- What's "occlusion" ?
  - difficult to define…
- Related Researches
  - task-depend object detection
    - glasses
    - rain
    - fences
    - etc.

Our Goal

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- What's "occlusion" ?
  - difficult to define…
- Our Target
  - **string-like regions**
    - → strings, wires, fences, branches, etc.
  - properties
    - → long and narrow
    - → small, but not tiny
    - → contrast with background
    - → same background in both sides

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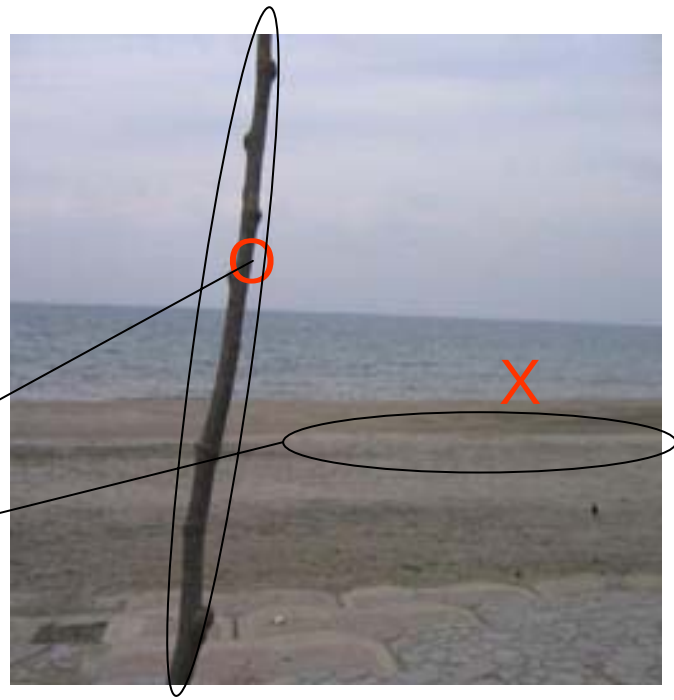

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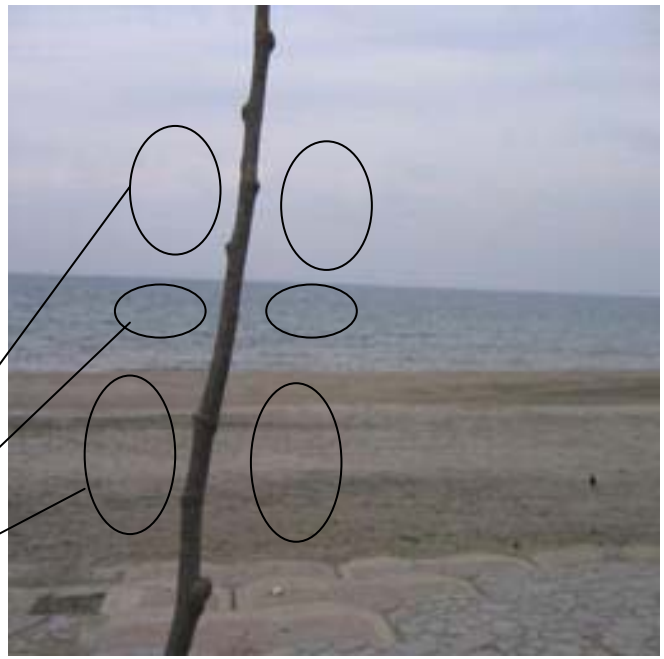
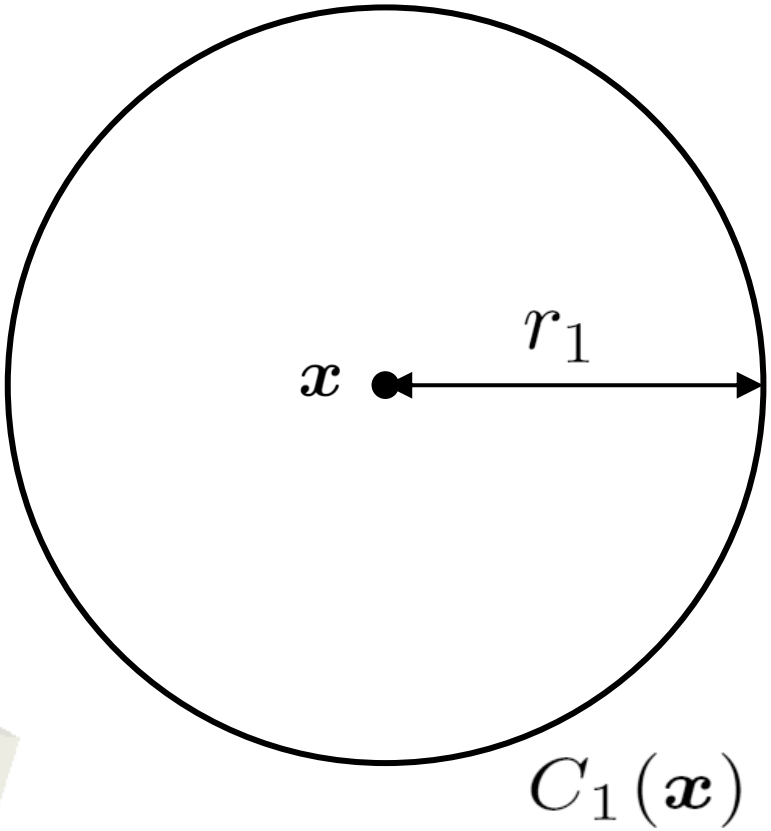


Circle Contrast: a proposed feature

Circle Contrast : $v(\boldsymbol{x}) = I(\boldsymbol{x}) - \frac{1}{2\pi r_1} \int_{C_1(\boldsymbol{x})} I(\boldsymbol{x}')\, d\boldsymbol{x}'$



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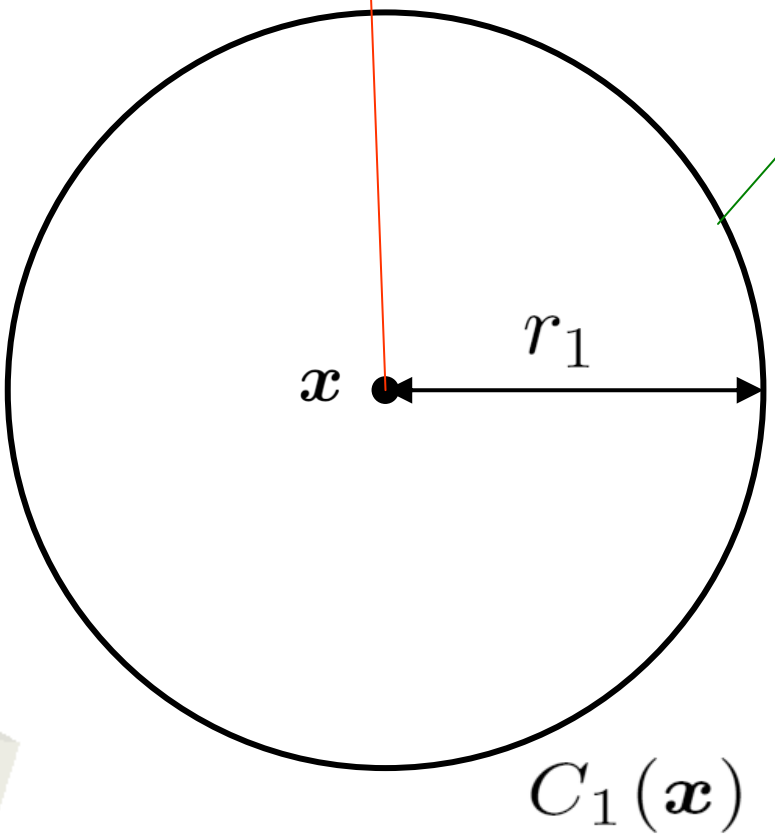
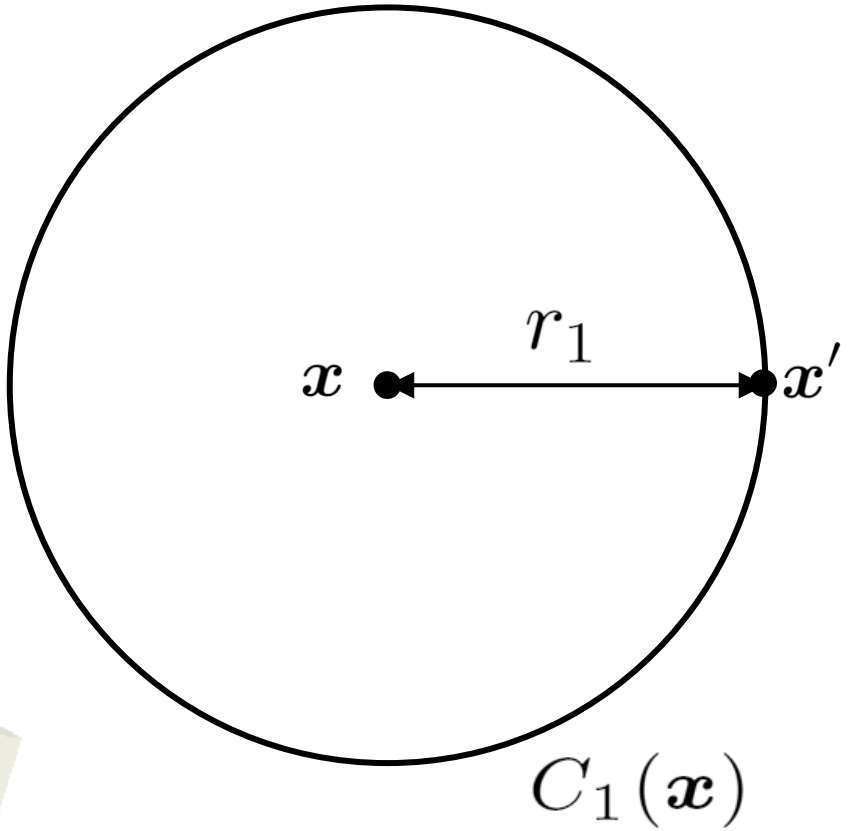


Circle Contrast: a proposed feature

Circle Contrast : $$v(\boldsymbol{x}) = \frac{1}{2\pi r_1} \int_{C_1(\boldsymbol{x})} I(\boldsymbol{x}) - I(\boldsymbol{x}')\, d\boldsymbol{x}'$$



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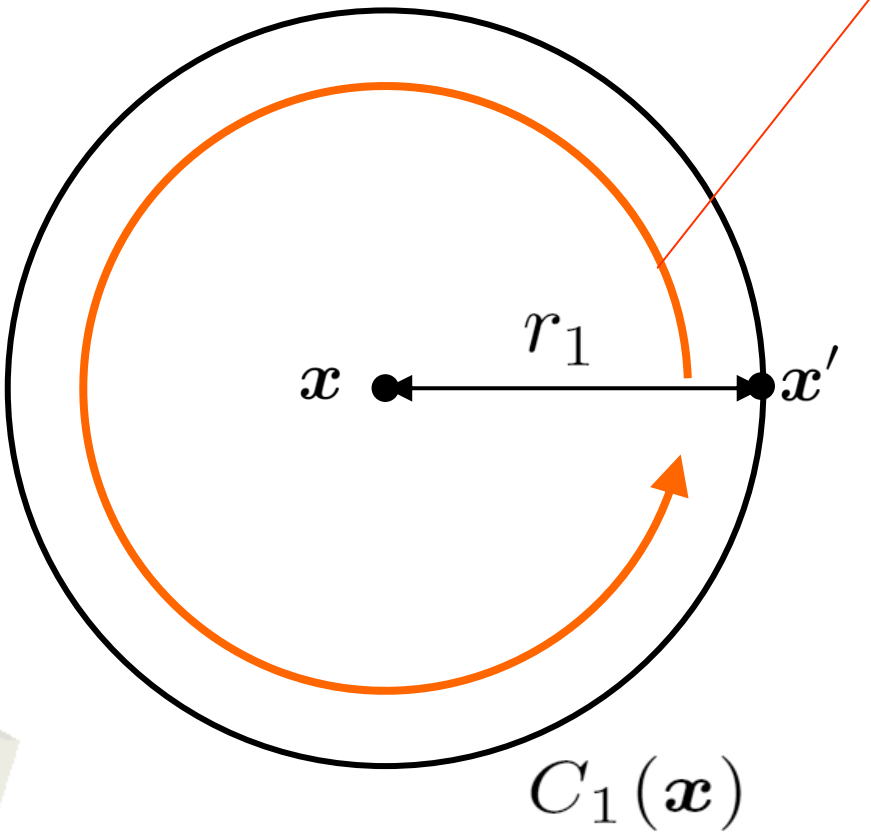
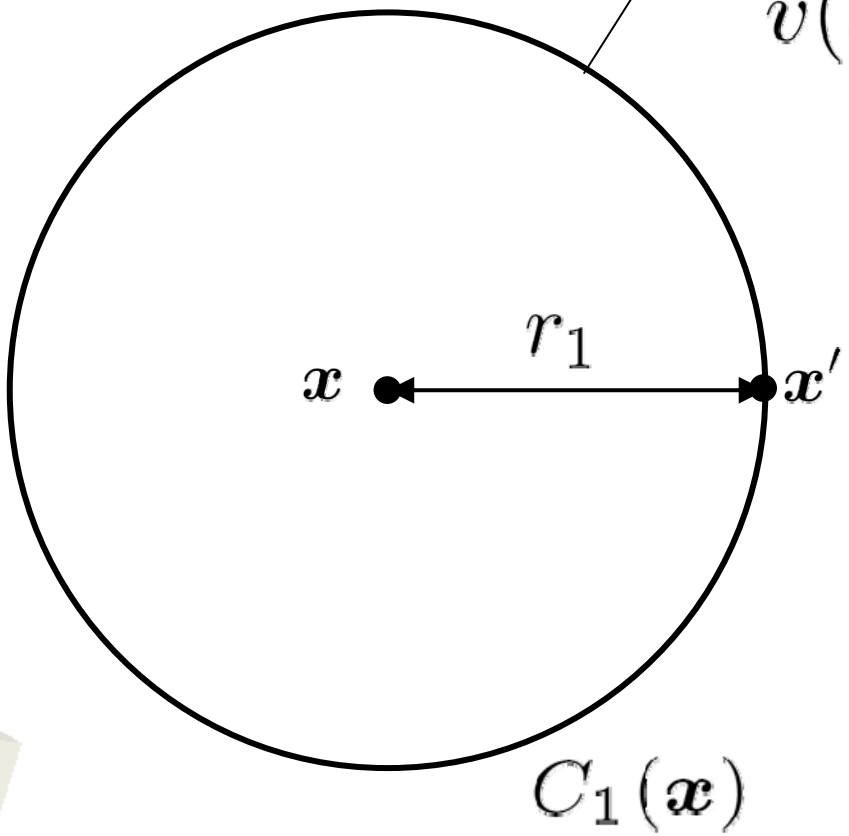


Circle Contrast in a flat region

$$I(\boldsymbol{x}) - I(\boldsymbol{x}') \cong 0$$

$$v(\boldsymbol{x}) \cong 0$$

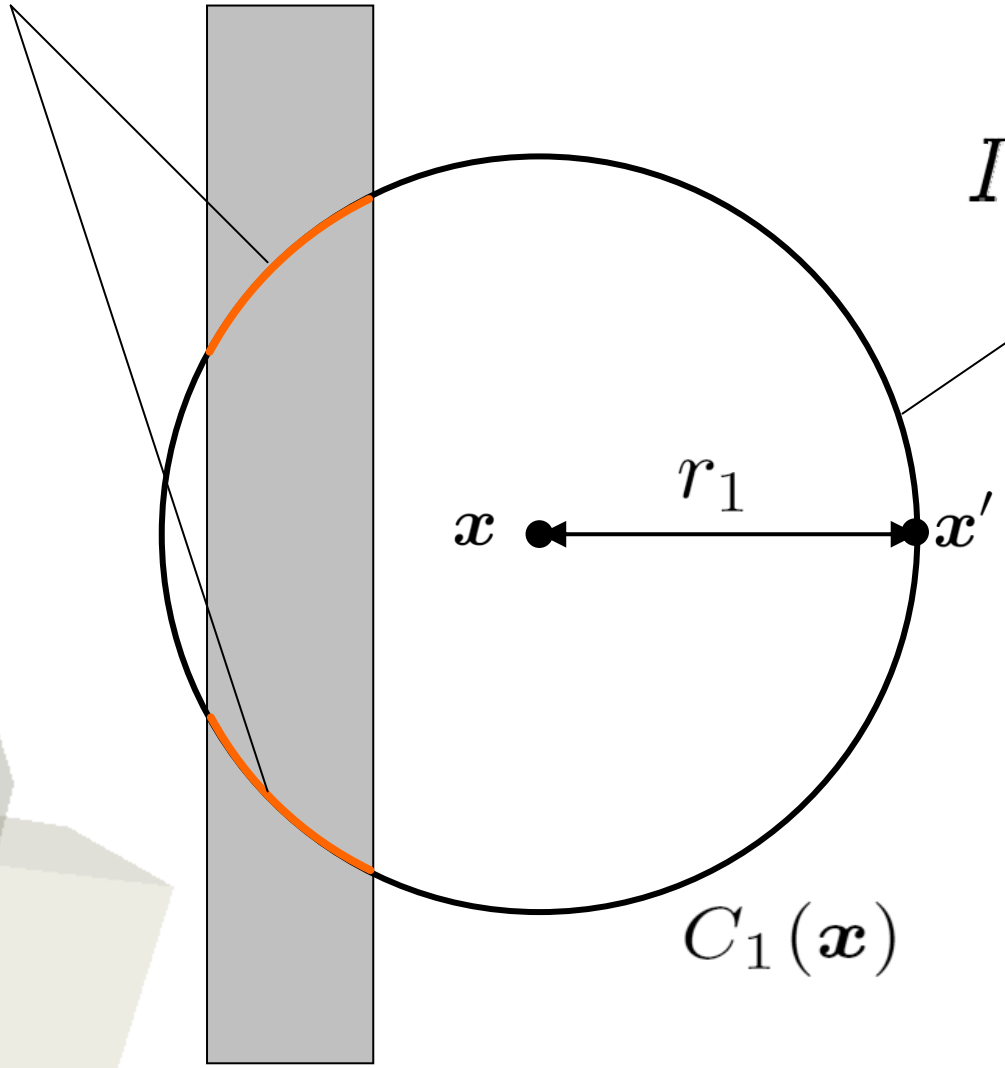


Circle Contrast at side of a string

$I(x) - I(x') \neq 0$

$v(x) \neq 0$, but small

$I(x) - I(x') = 0$



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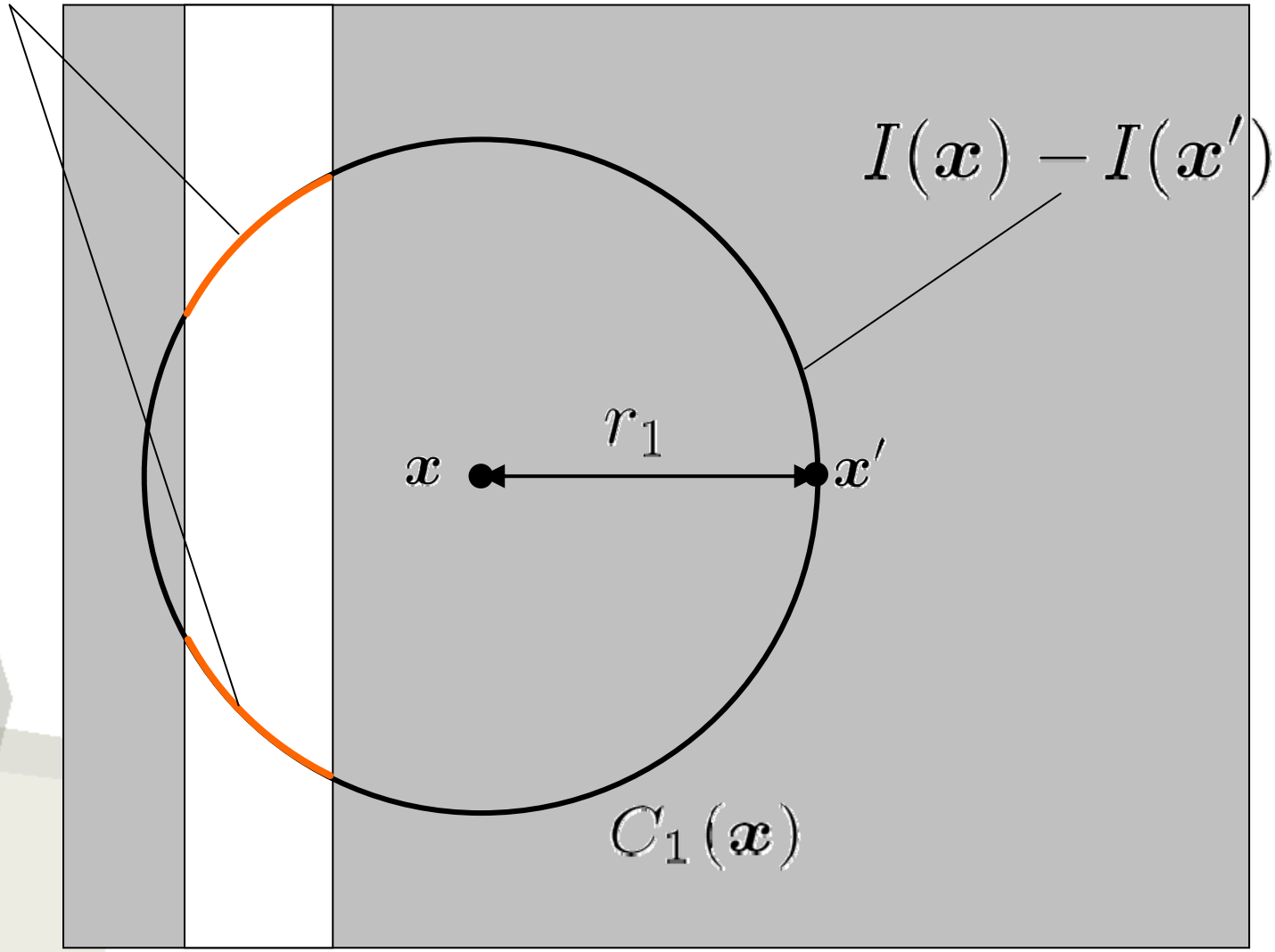
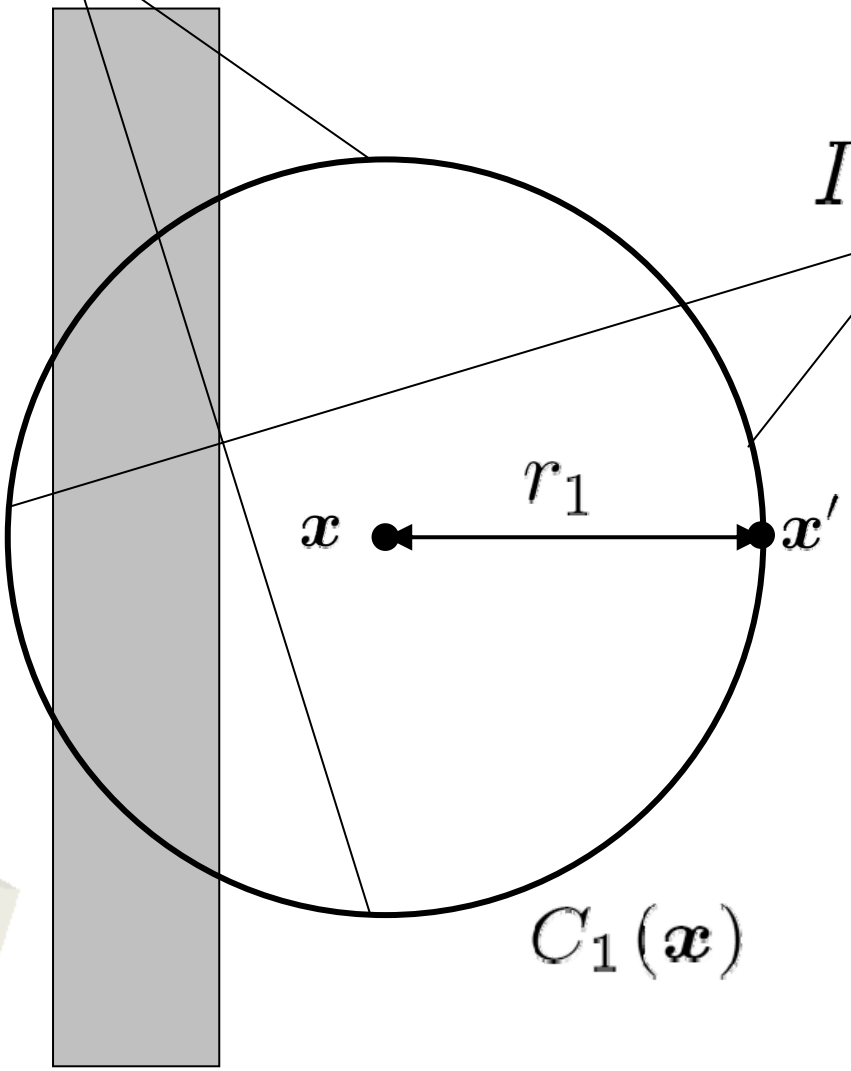


Circle Contrast on the string

$v(x) \neq 0$, but **LARGE**

$I(x) - I(x') = 0$

$I(x) - I(x') \neq 0$



Circle Contrast on the string

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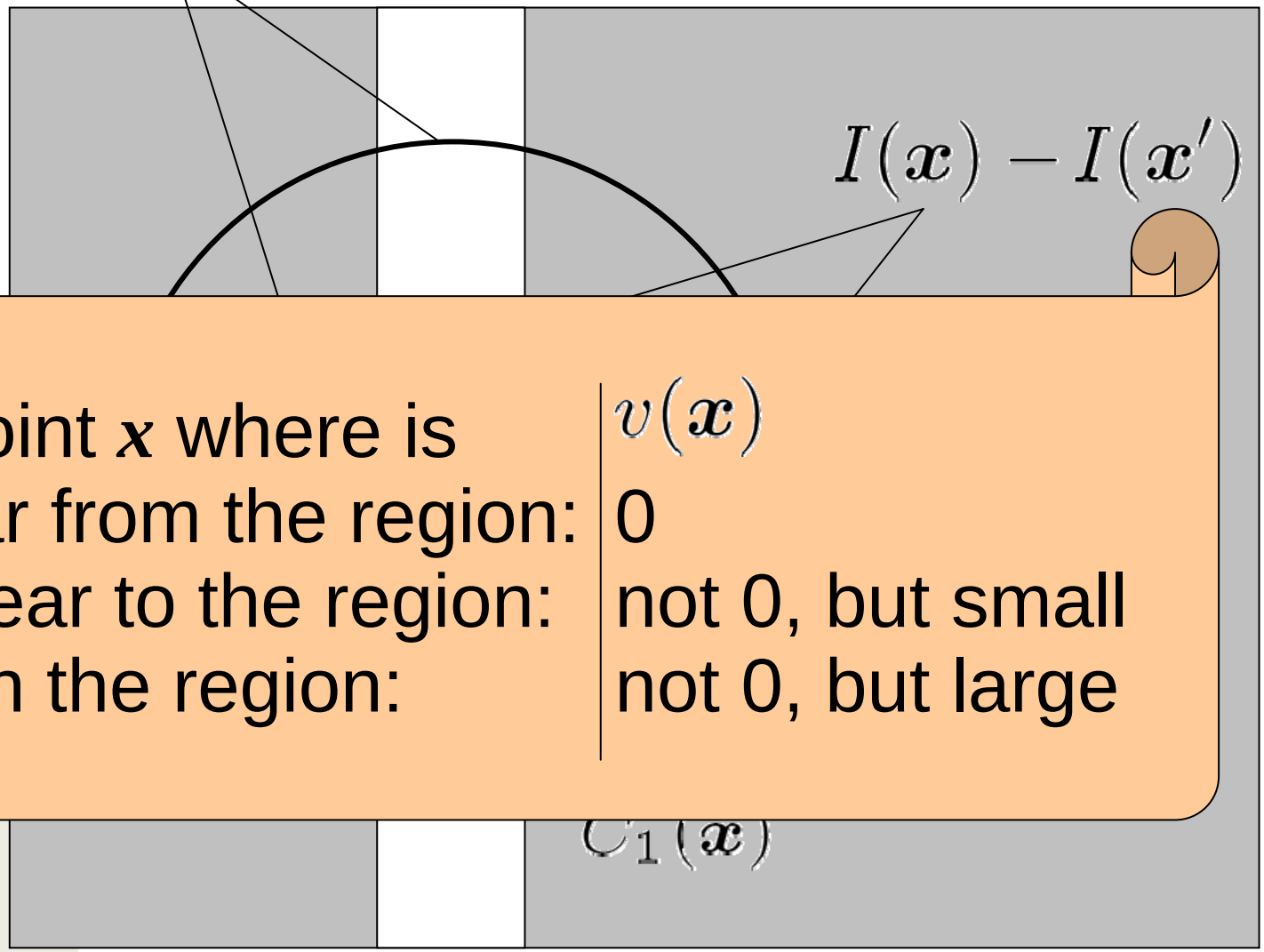
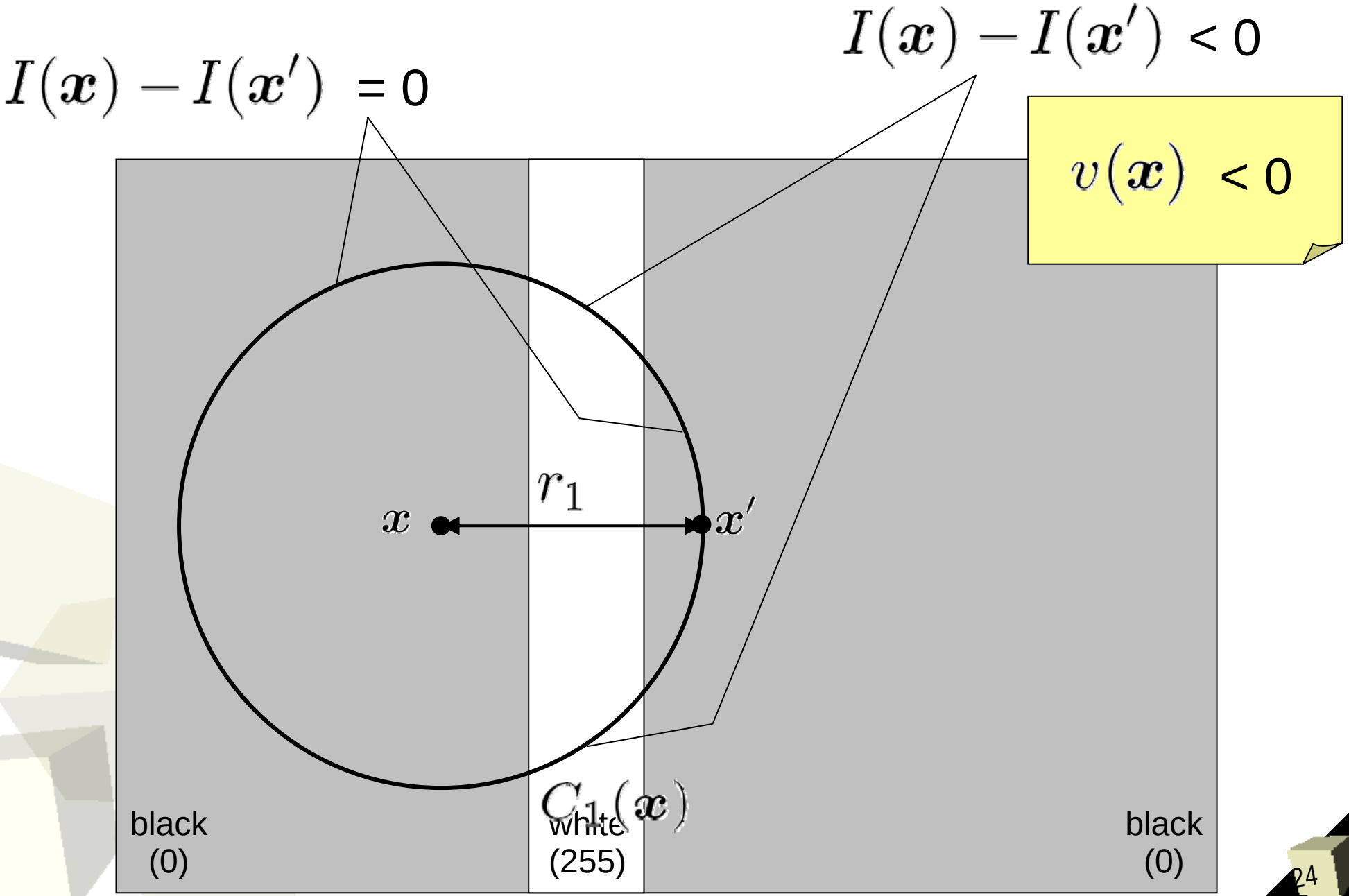


A point x where is

	$v(x)$
• far from the region:	0
• near to the region:	not 0, but small
• on the region:	not 0, but large

Circle Contrast across the string

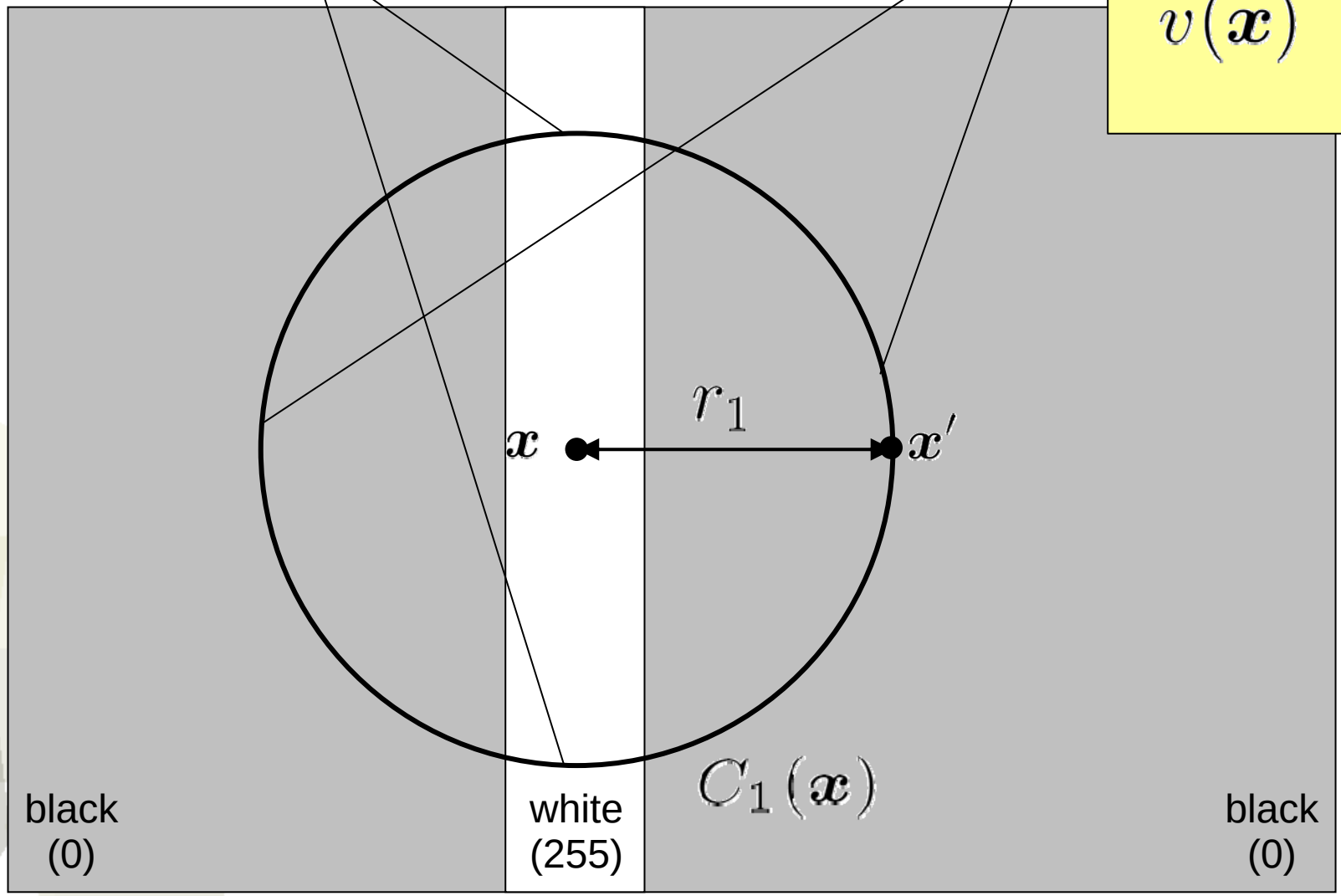


Circle Contrast across the string

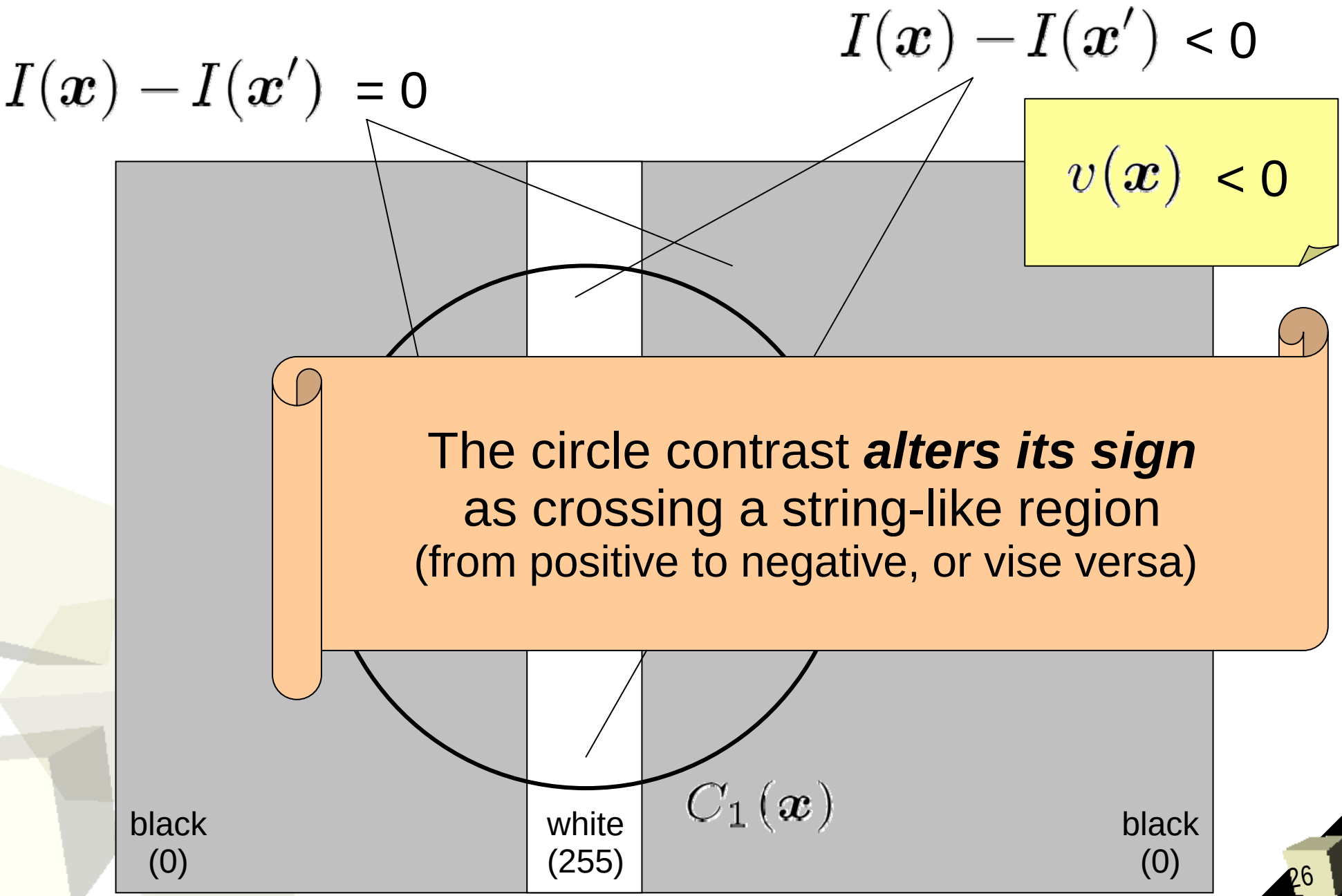
$I(x) - I(x') = 0$

$I(x) - I(x') > 0$

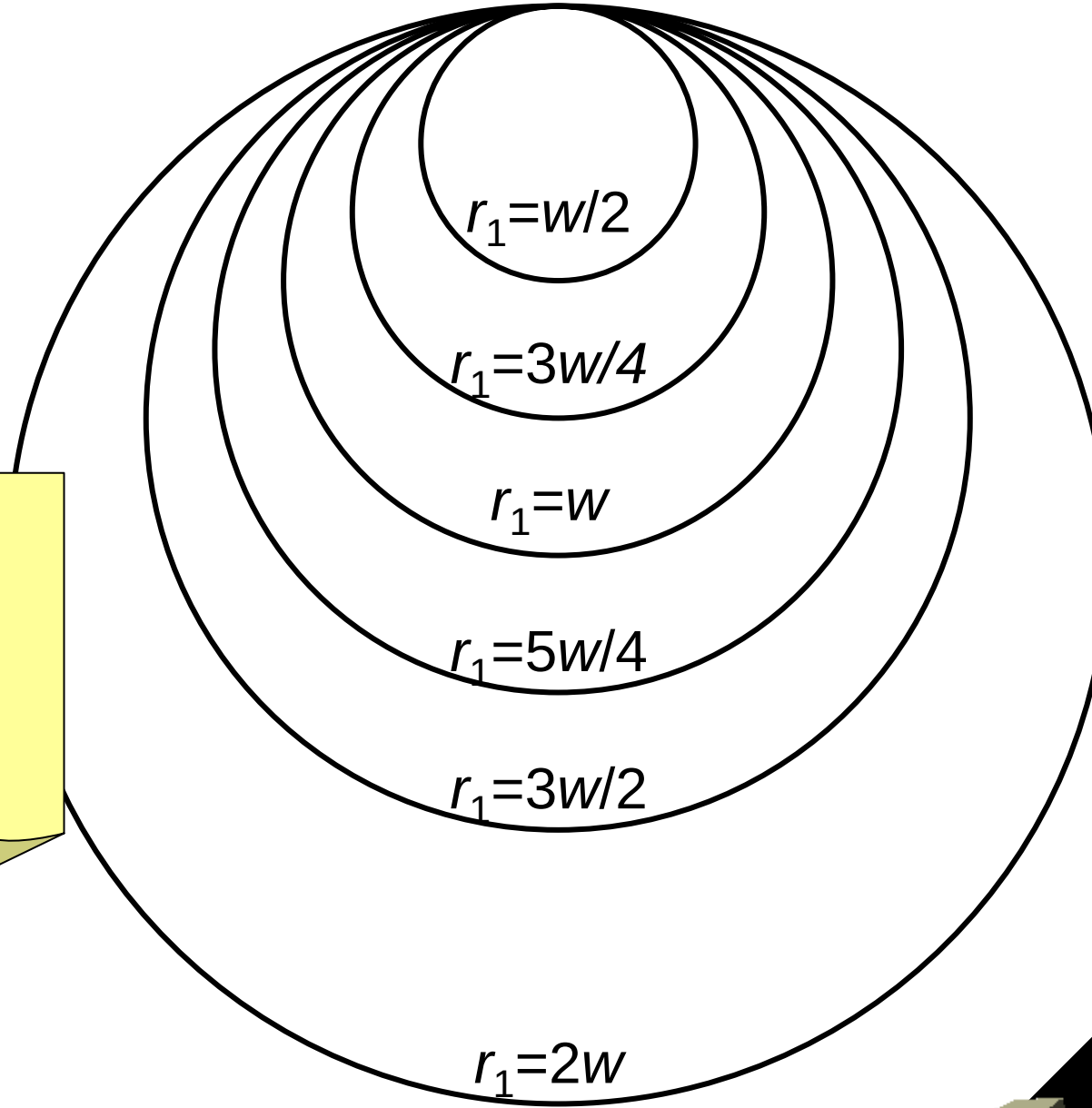
$v(x) > 0$



Circle Contrast across the string

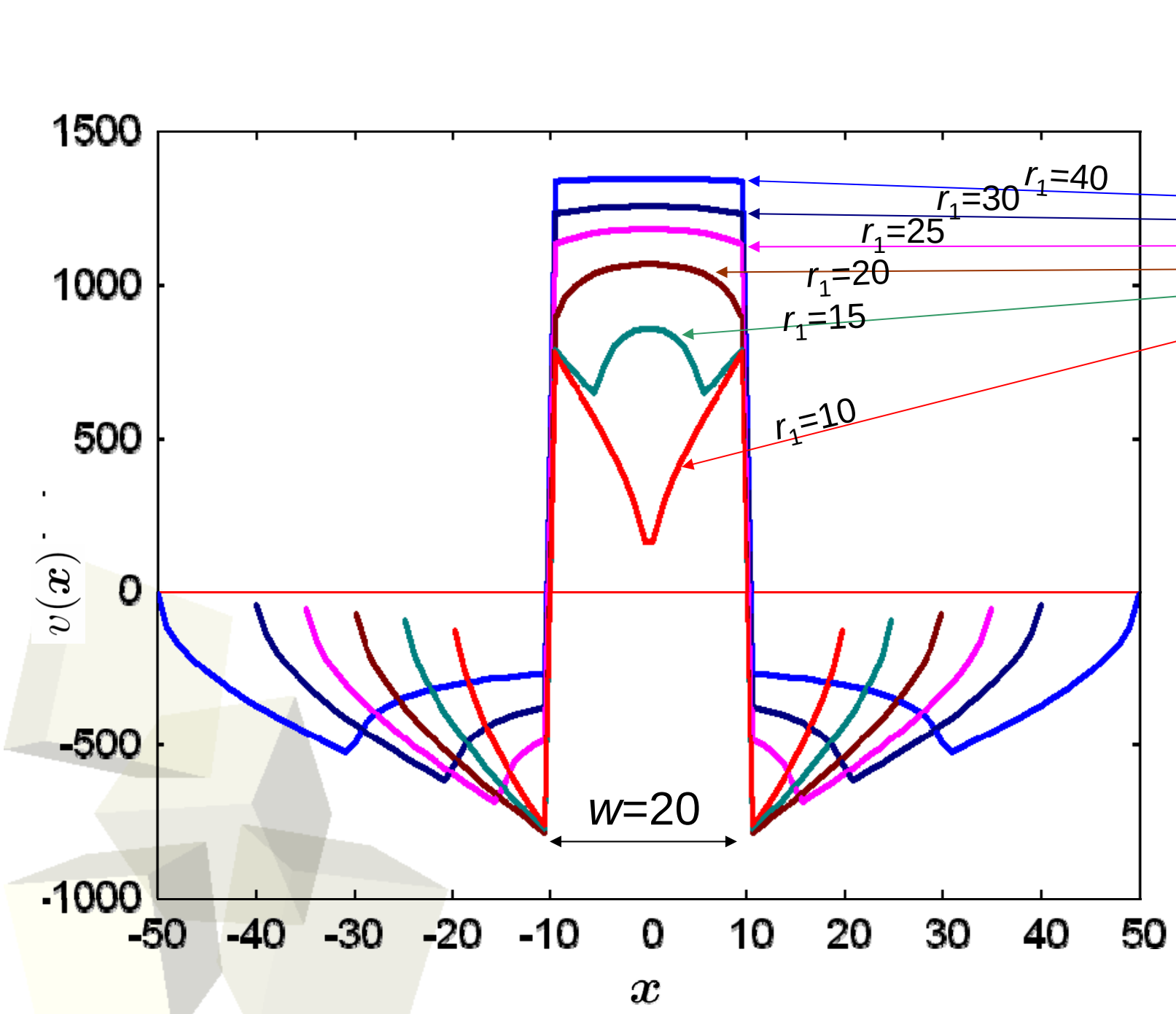


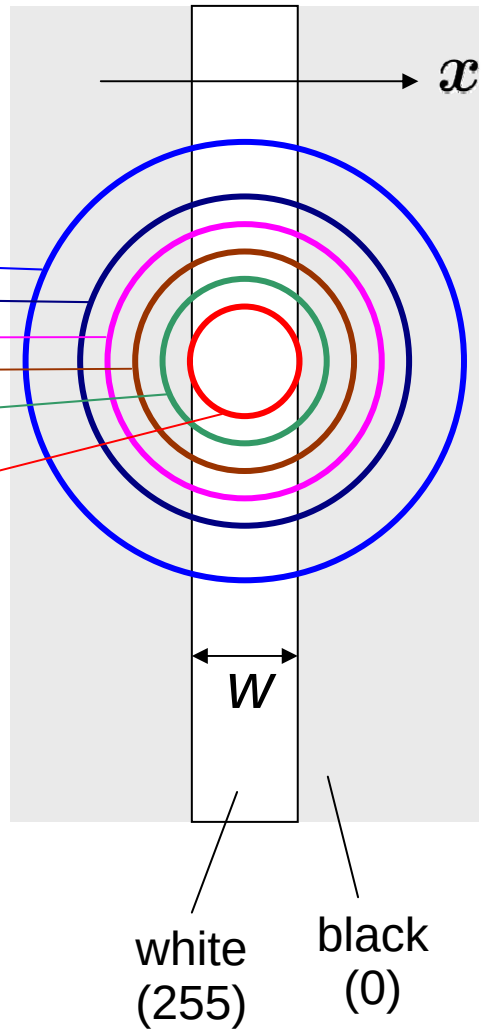
Circle Contrast as a spatial filter



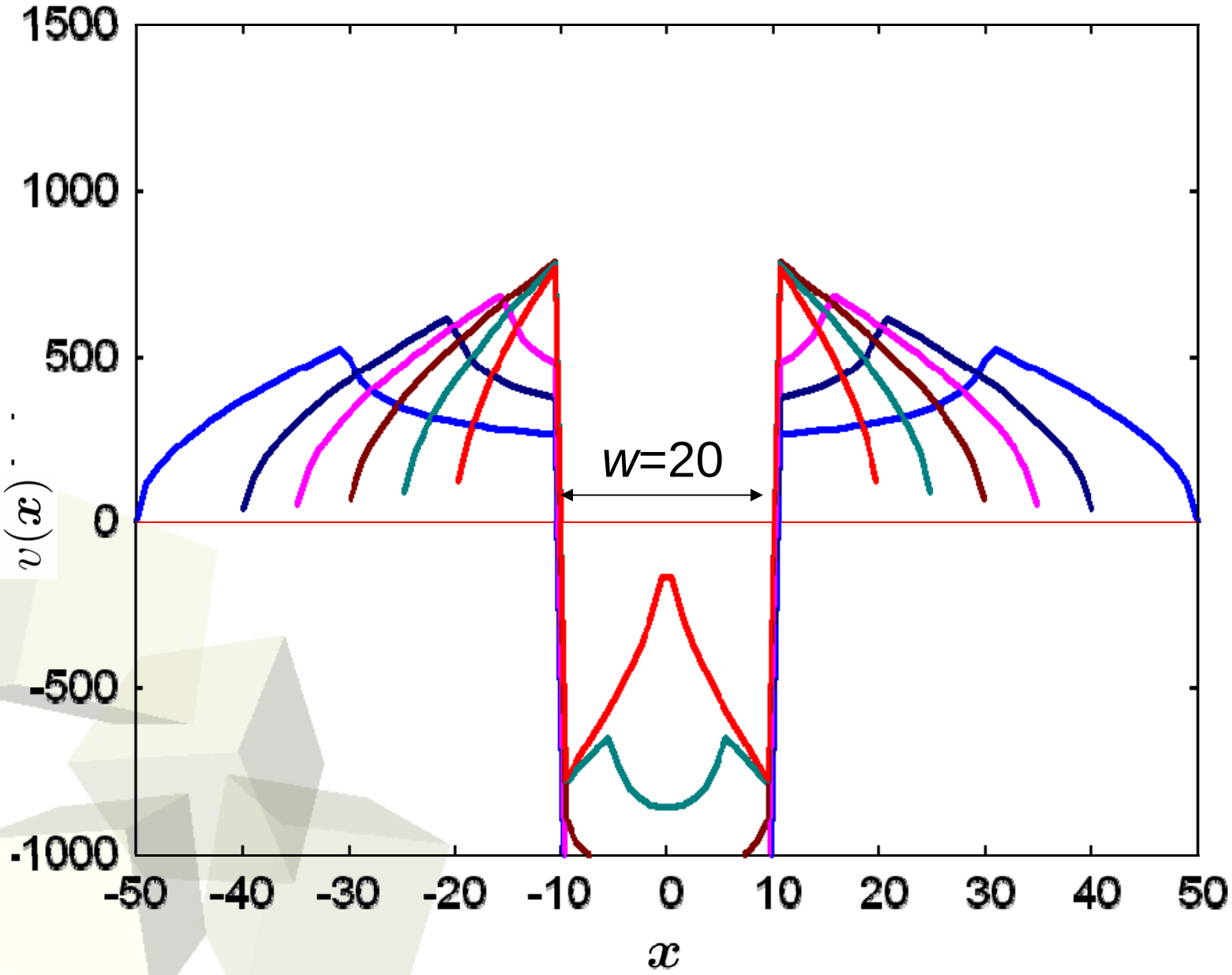
How large is
the circle enough?

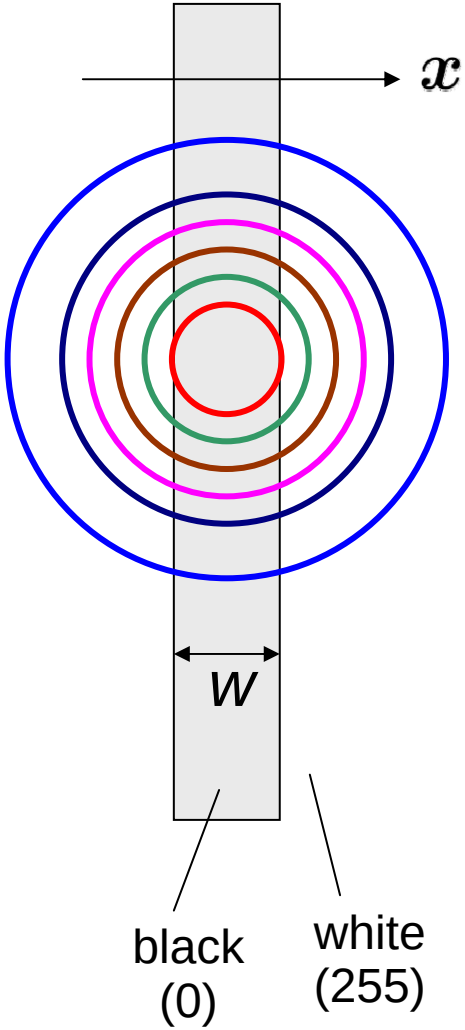
Response across the string



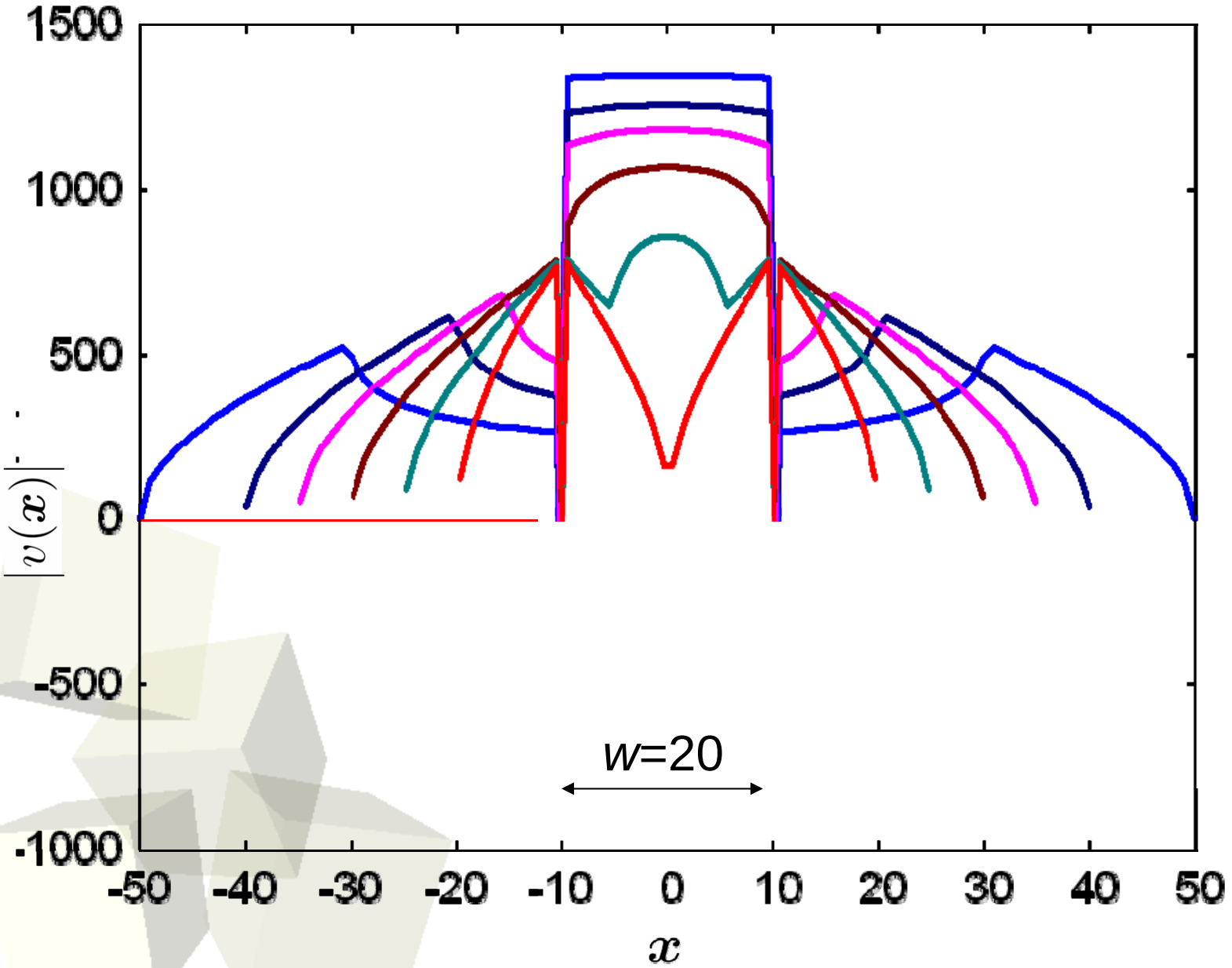


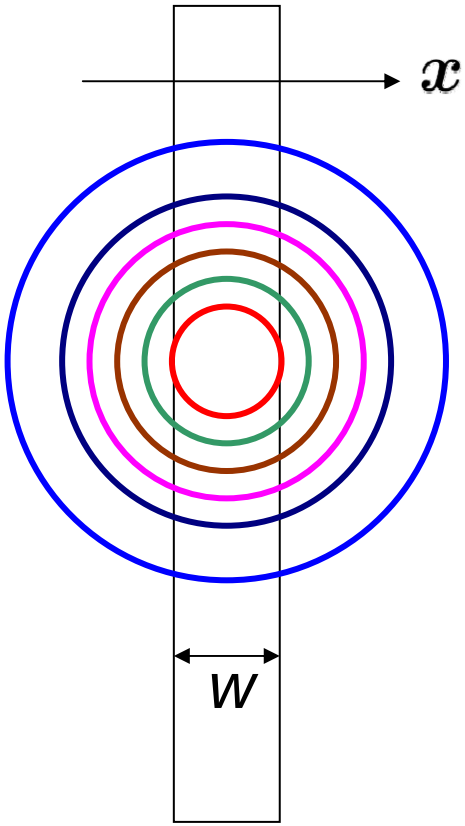
Response across the string



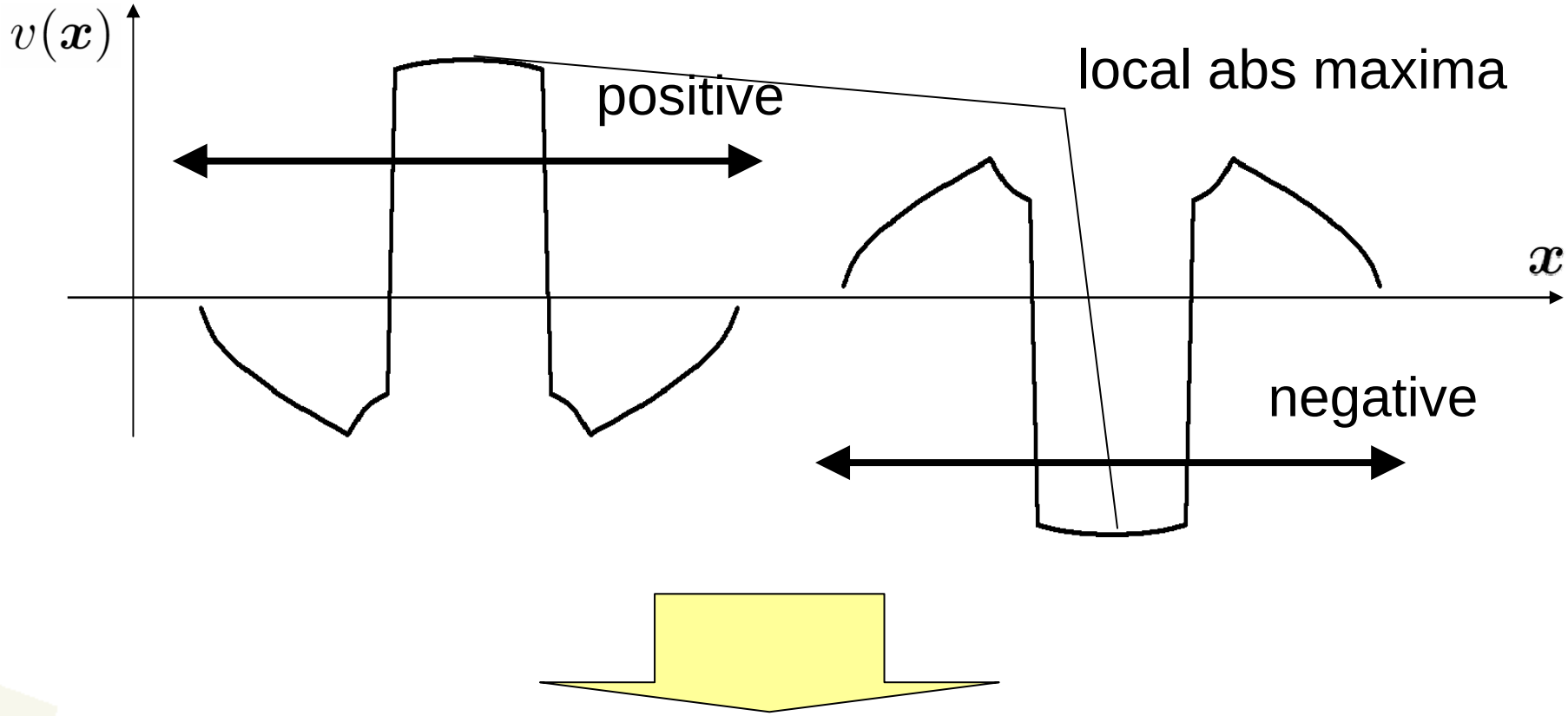


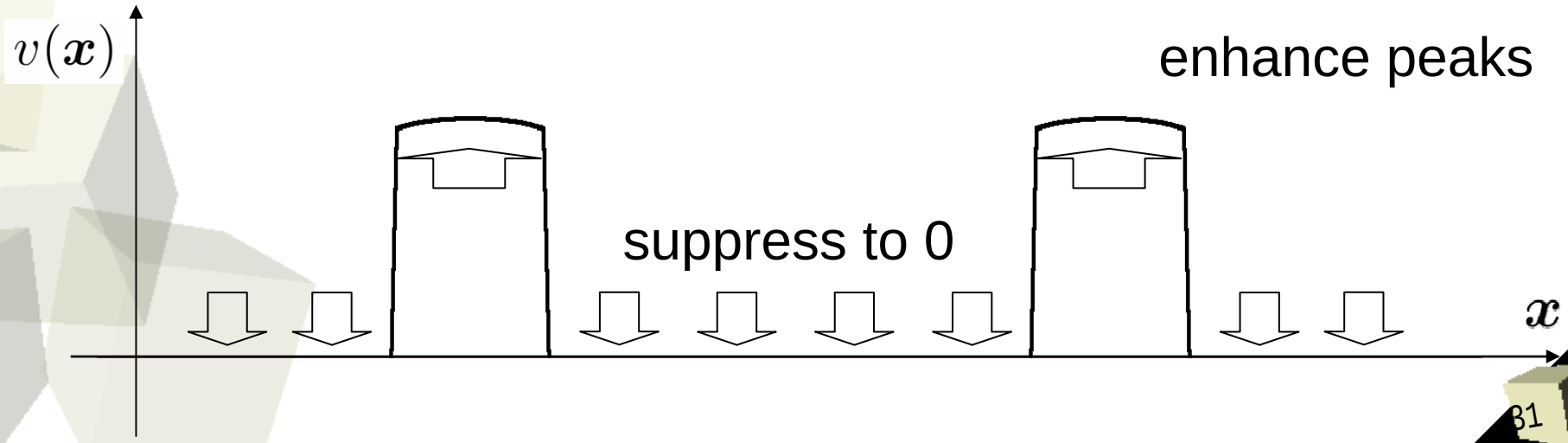
Response across the string





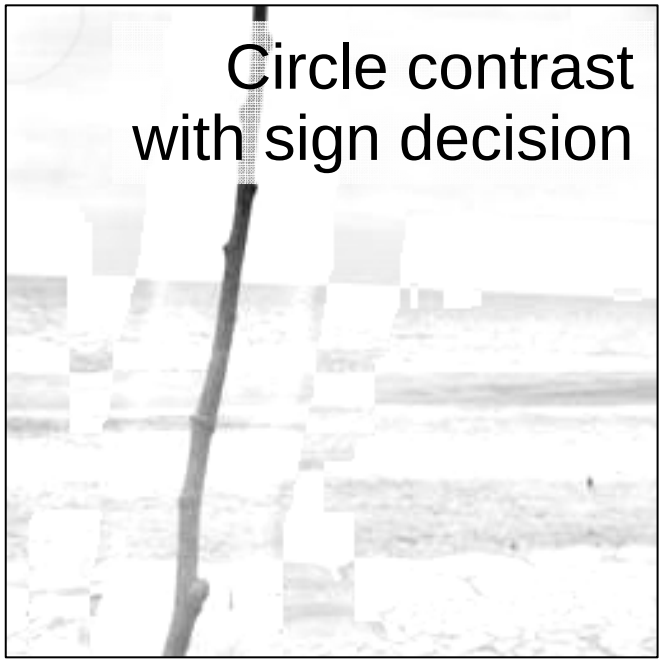
Absolute with locally largest value

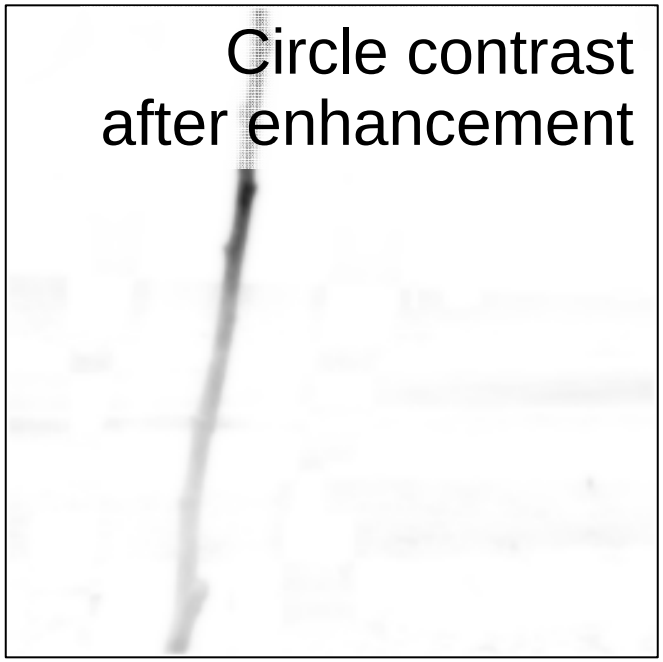


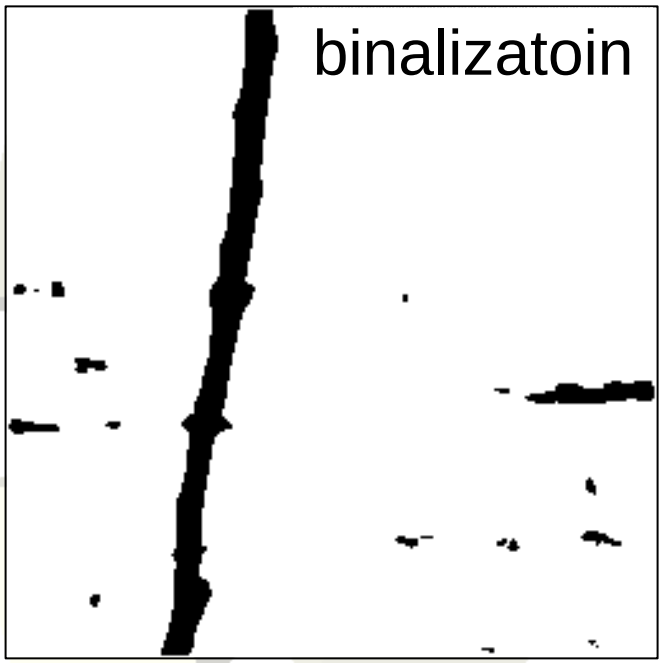


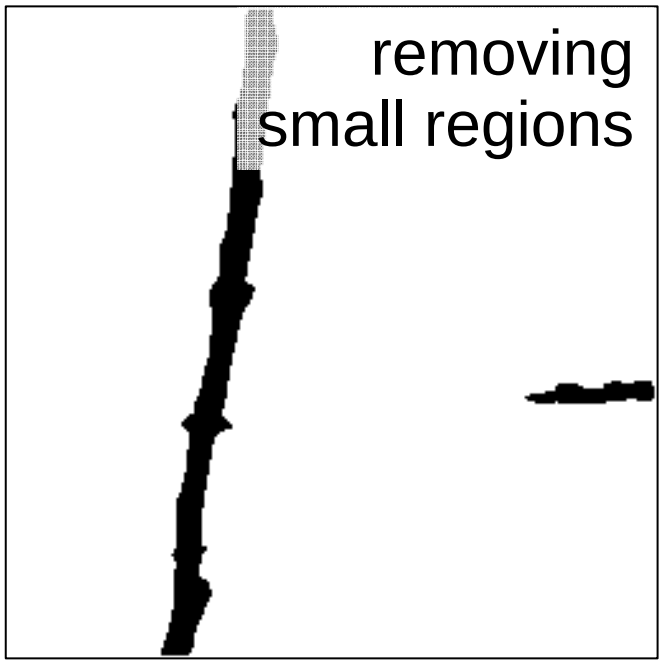
An example

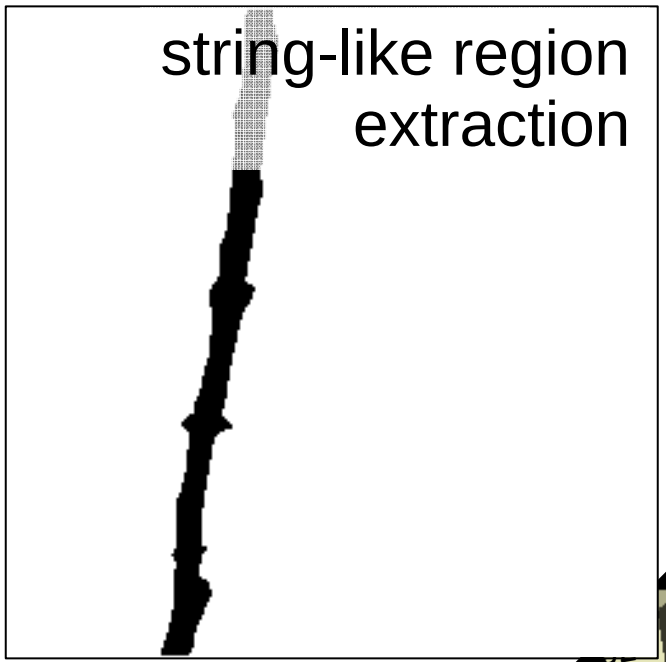

original image


Circle contrast
with sign decision


Circle contrast
after enhancement


binalizatoin

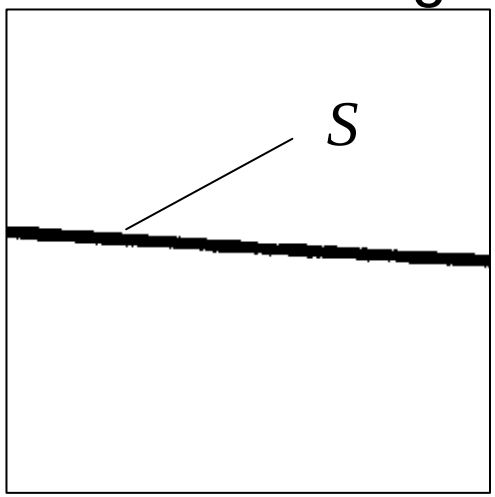

removing
small regions

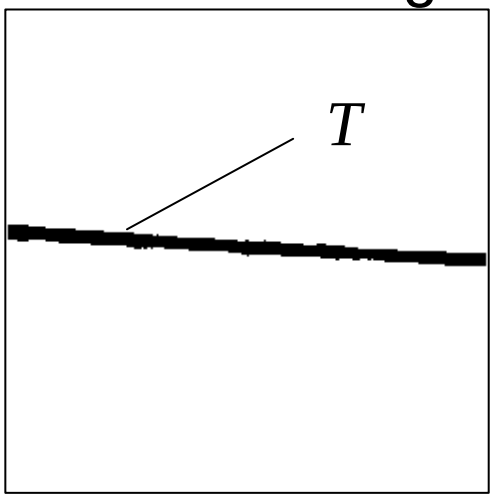

string-like region
extraction

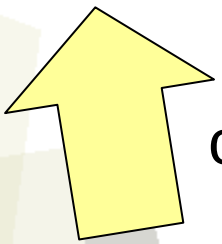
Evaluation for Extraction

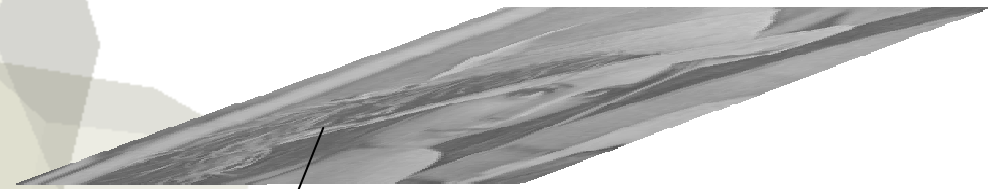
original image | occluded image | difference image | extracted image








capture


printed sheet

FN: $\frac{\#(S - T \cap S)}{\#(S)}$

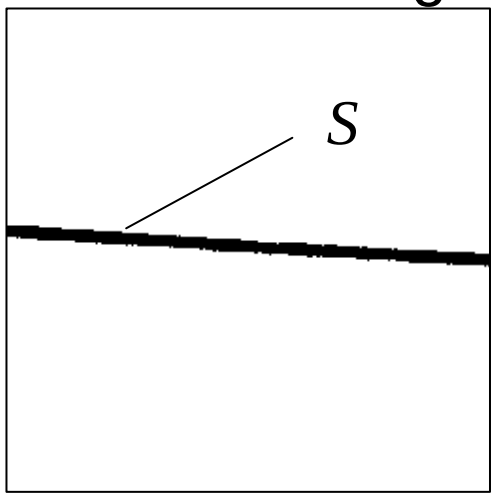
FP: $\frac{\#(T - T \cap S)}{\#(\bar{S})}$

Evaluation for Extraction

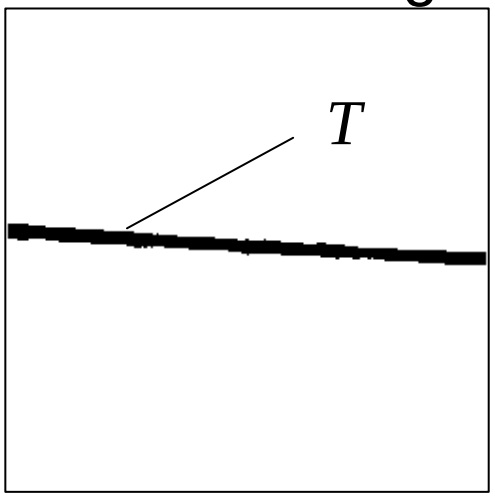
original image

occluded image

difference image



extracted image

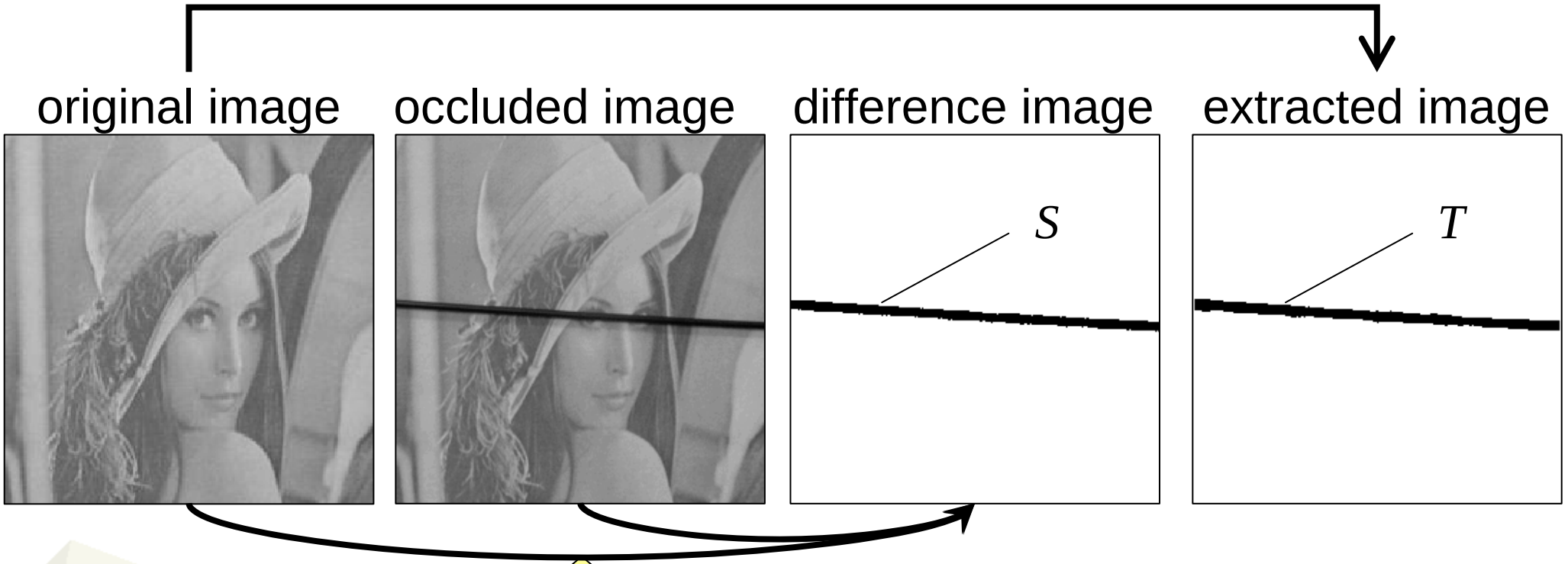


capture

FN: $\frac{\#(S - T \cap S)}{\#(S)}$

FP: $\frac{\#(T - T \cap S)}{\#(\bar{S})}$

Evaluation for Extraction

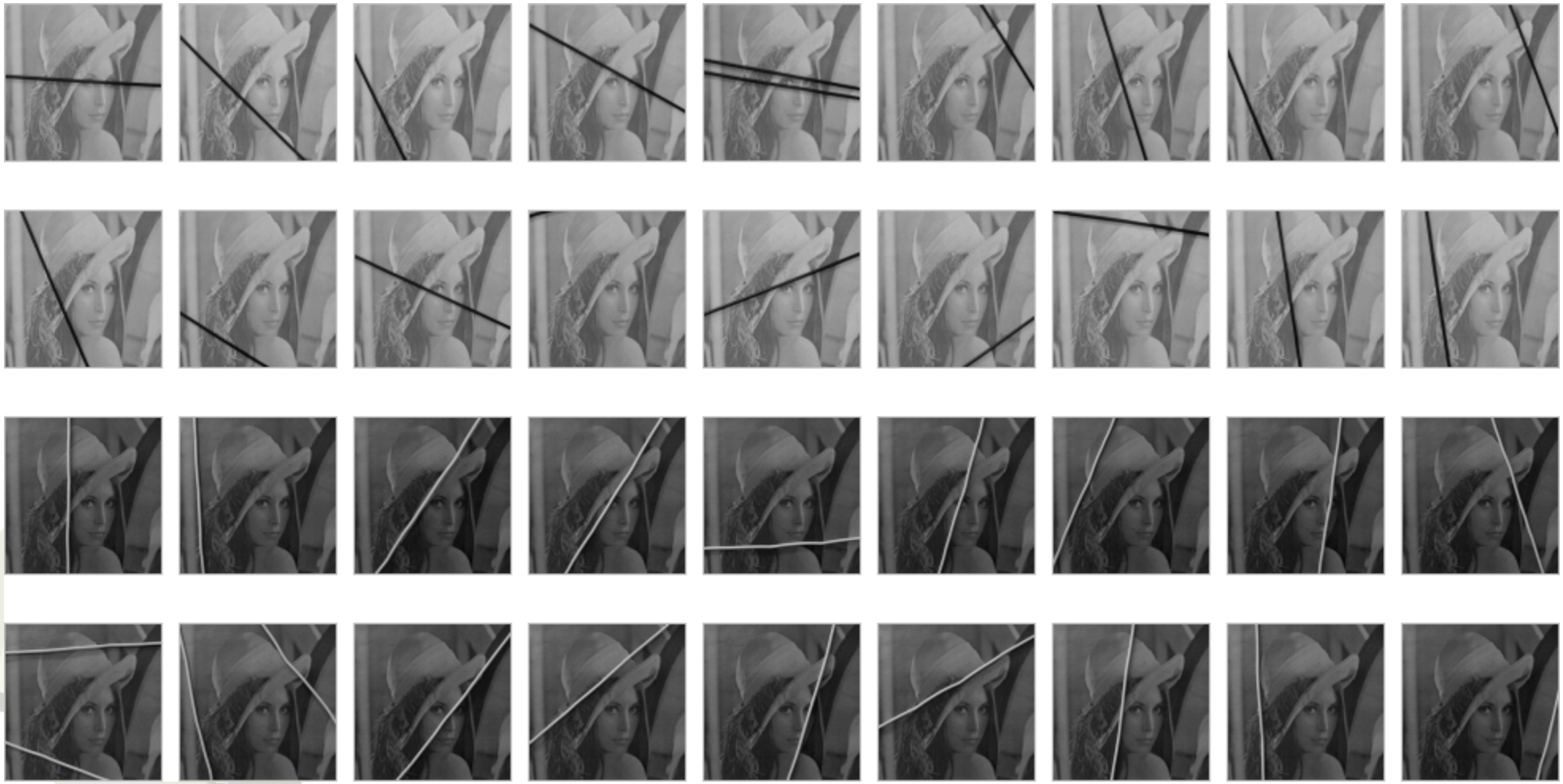


capture

FN: $\frac{\#(S - T \cap S)}{\#(S)}$

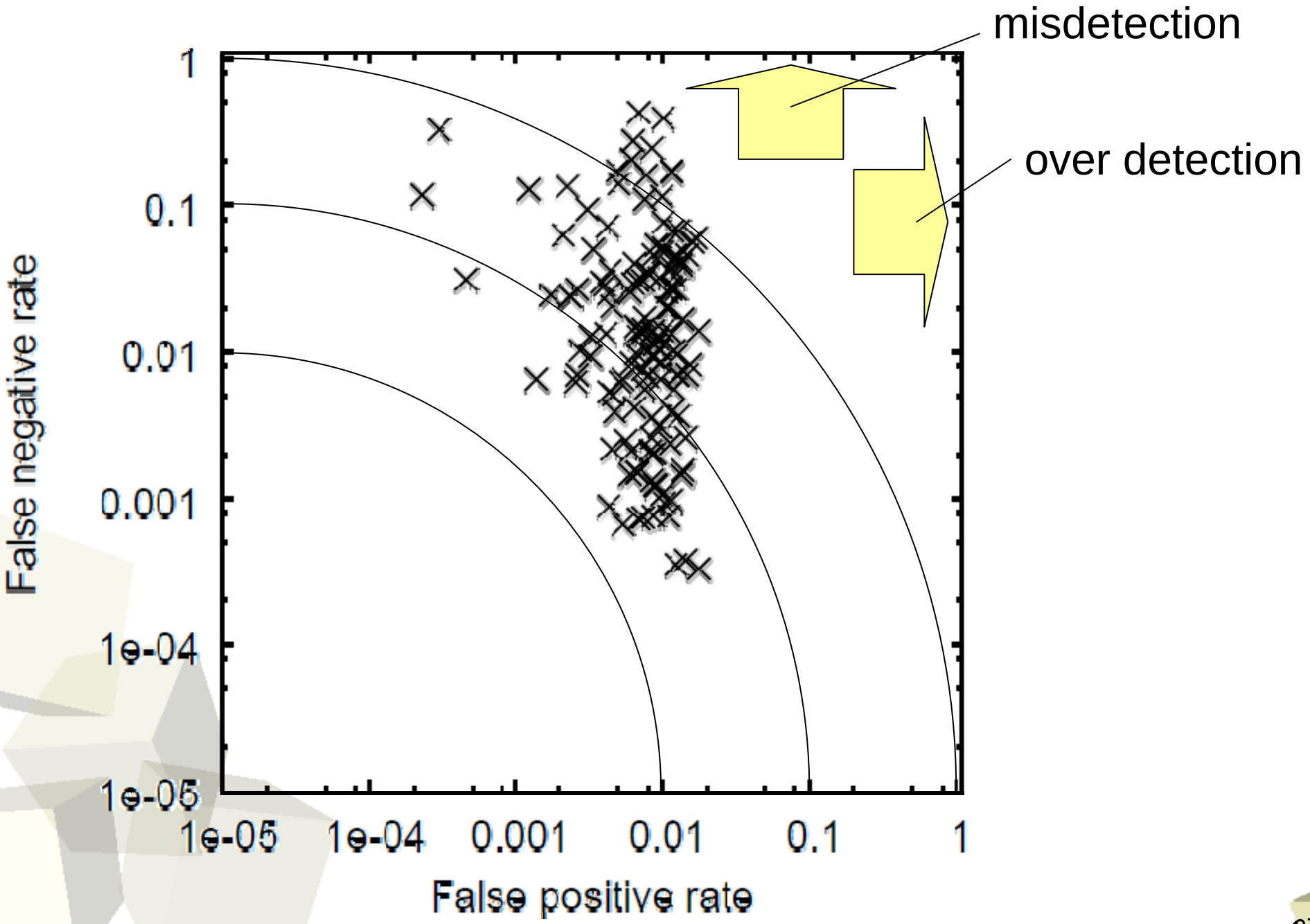
FP: $\frac{\#(T - T \cap S)}{\#(\bar{S})}$

Images for Evaluation



Total: over 180 images

ROC Curve


misdetection
over detection
False negative rate
1
0.1
0.01
0.001
1e-04
1e-05
1e-05
1e-04
0.001
0.01
0.1
1
False positive rate

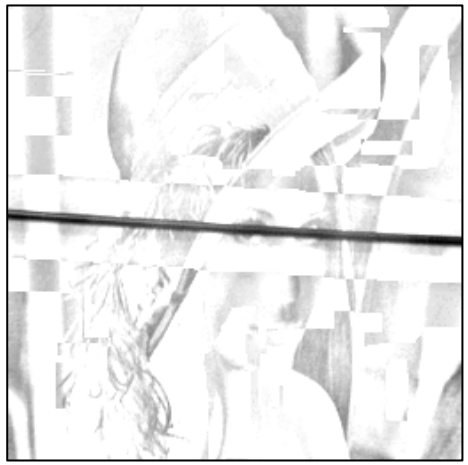
Circle contrast as the radius changes

$w = 5$

r_1=5

r_1=10

r_1=15



r_1=20

appropriate parameter value:

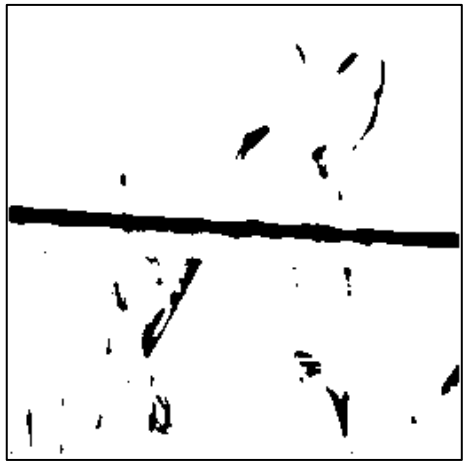
r_1=3w

Binarization threshold of circle contrast

Threshold range: [0, 1]

Results are very sensitive to threshold

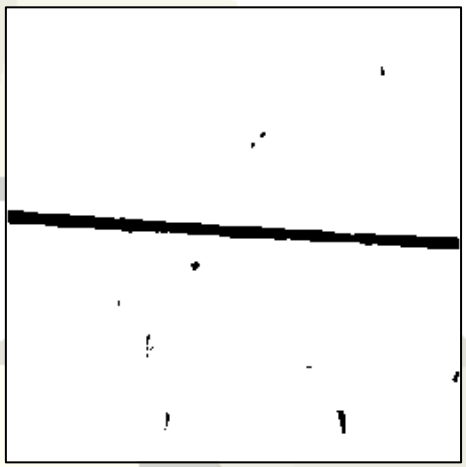
th=0.002



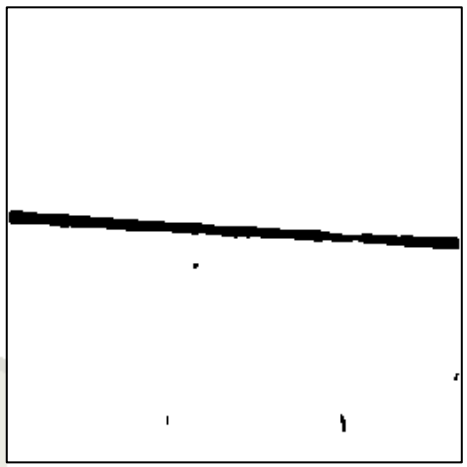
th=0.003

th=0.004

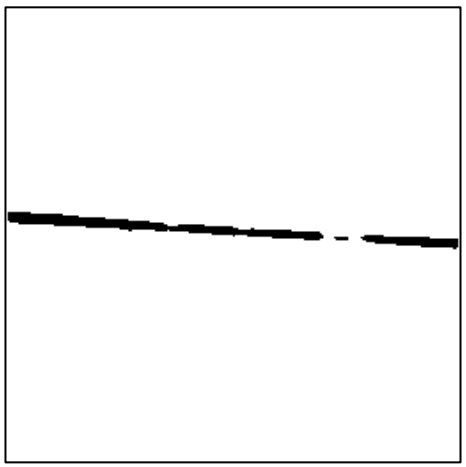
th=0.005



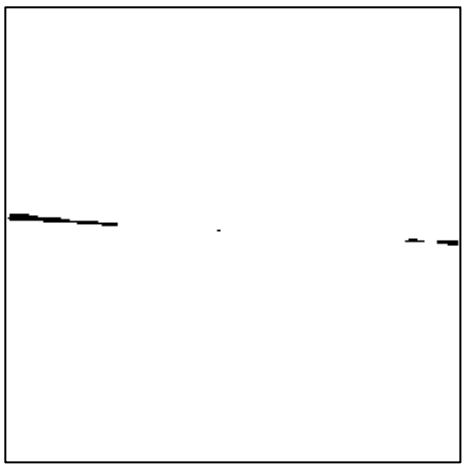
th=0.006



th=0.007

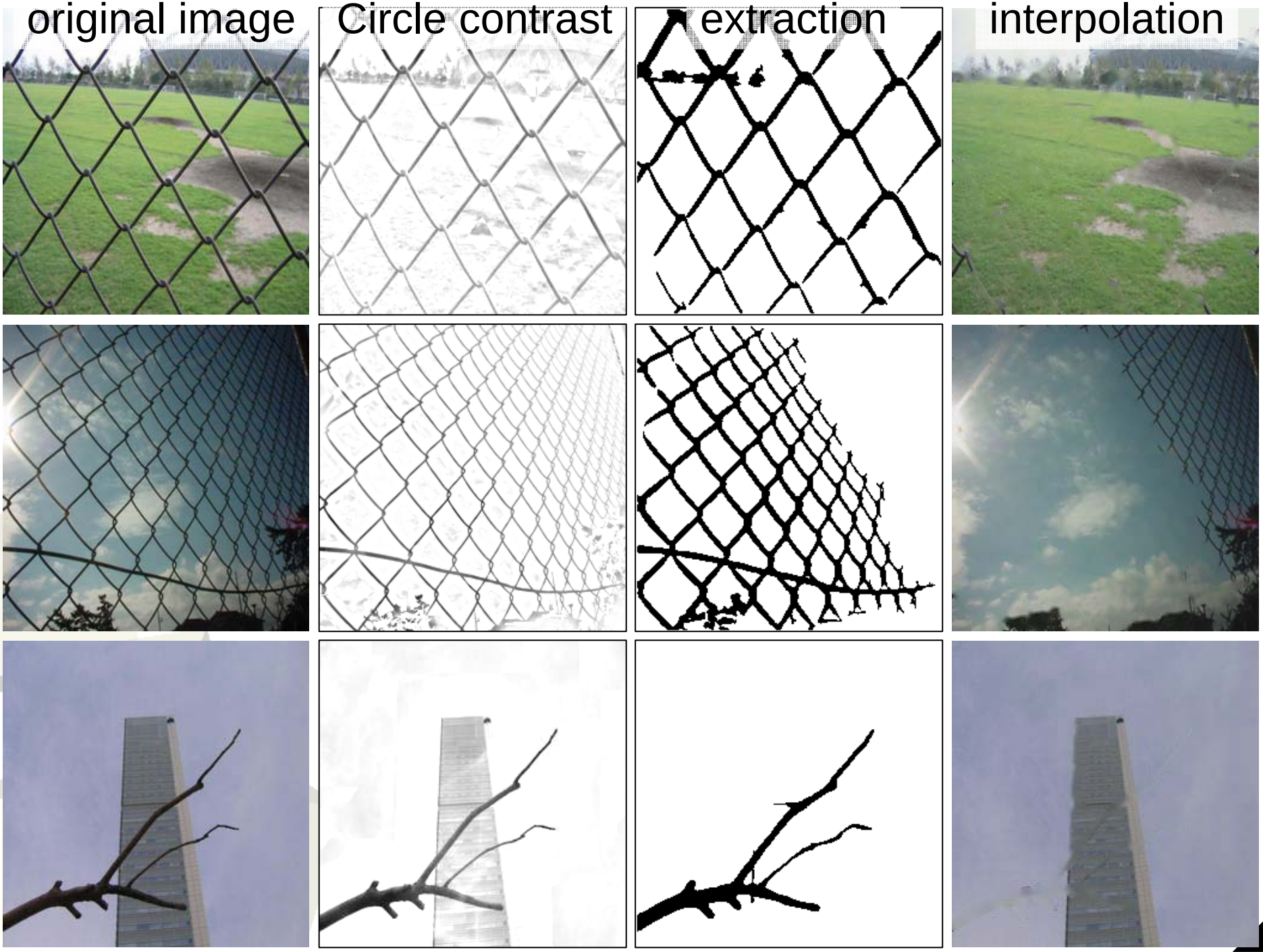


th=0.010



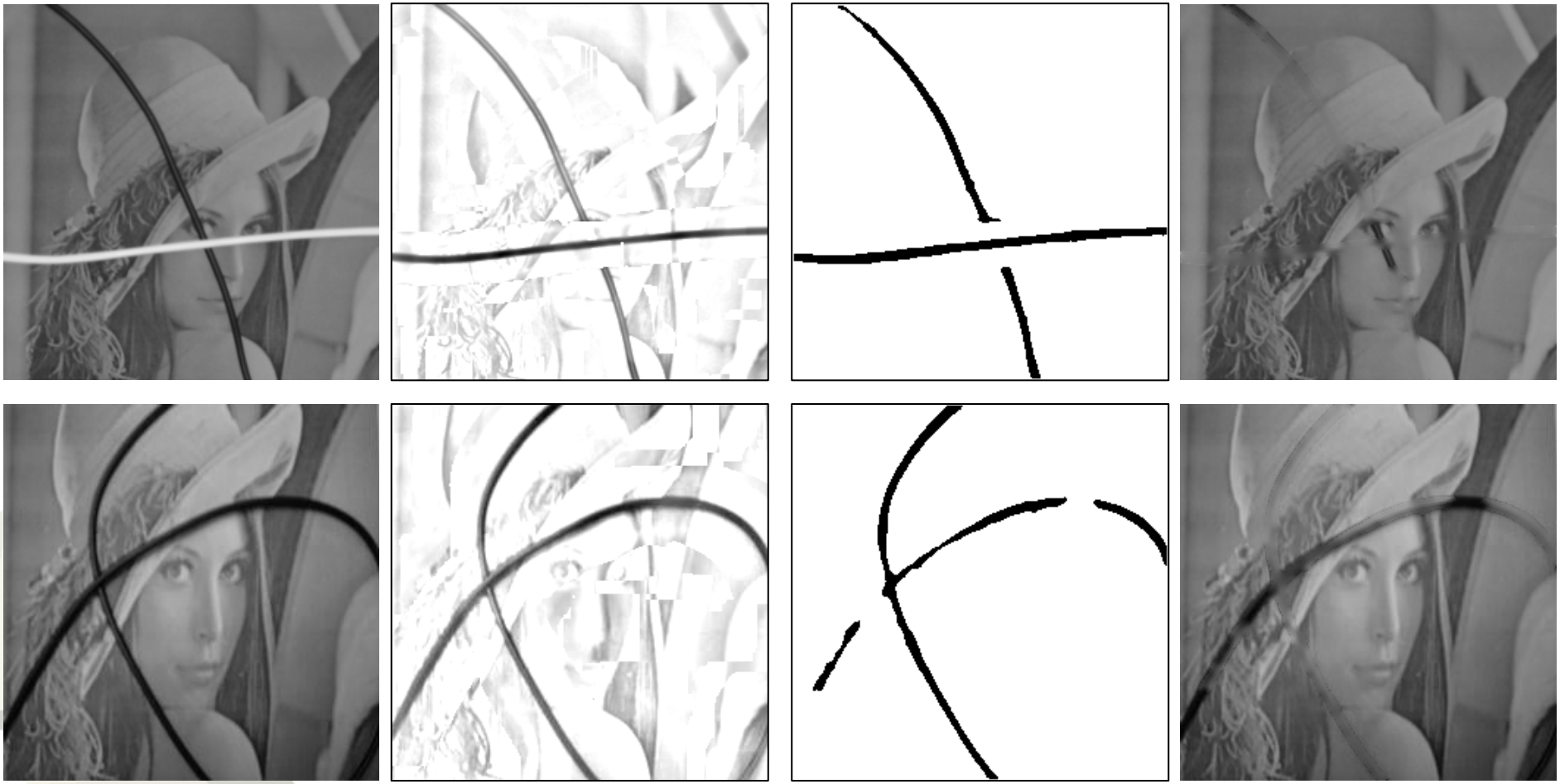
th=0.020

Experimental results



Experimental results

original image | Circle contrast | extraction | interpolation



Limitations

- Circle Contrast
  - the circle radius r_1 by user is requred
    - ➔ depends on images given
  - sign determination is not enough
    - ➔ many artifacts
    - ➔ inappropriate decision at cross sections
  - binarization threshold is the critical parameter

Conclusions

- String-like occluding object detection
  - proposed and analyzed the ***Circle Contrast***
    - simple model
    - good properties
    - needs parameter tuning
  - evaluated by experimental results with images
    - quantitatively with ROC curve
    - qualitatively as changing parameters
  - showed results images
    - with an simplest interpolation method
- Future works
  - make the circle contrast more robust
  - employ sophisticated binarization
  - consider color and texture