



**EDGE**

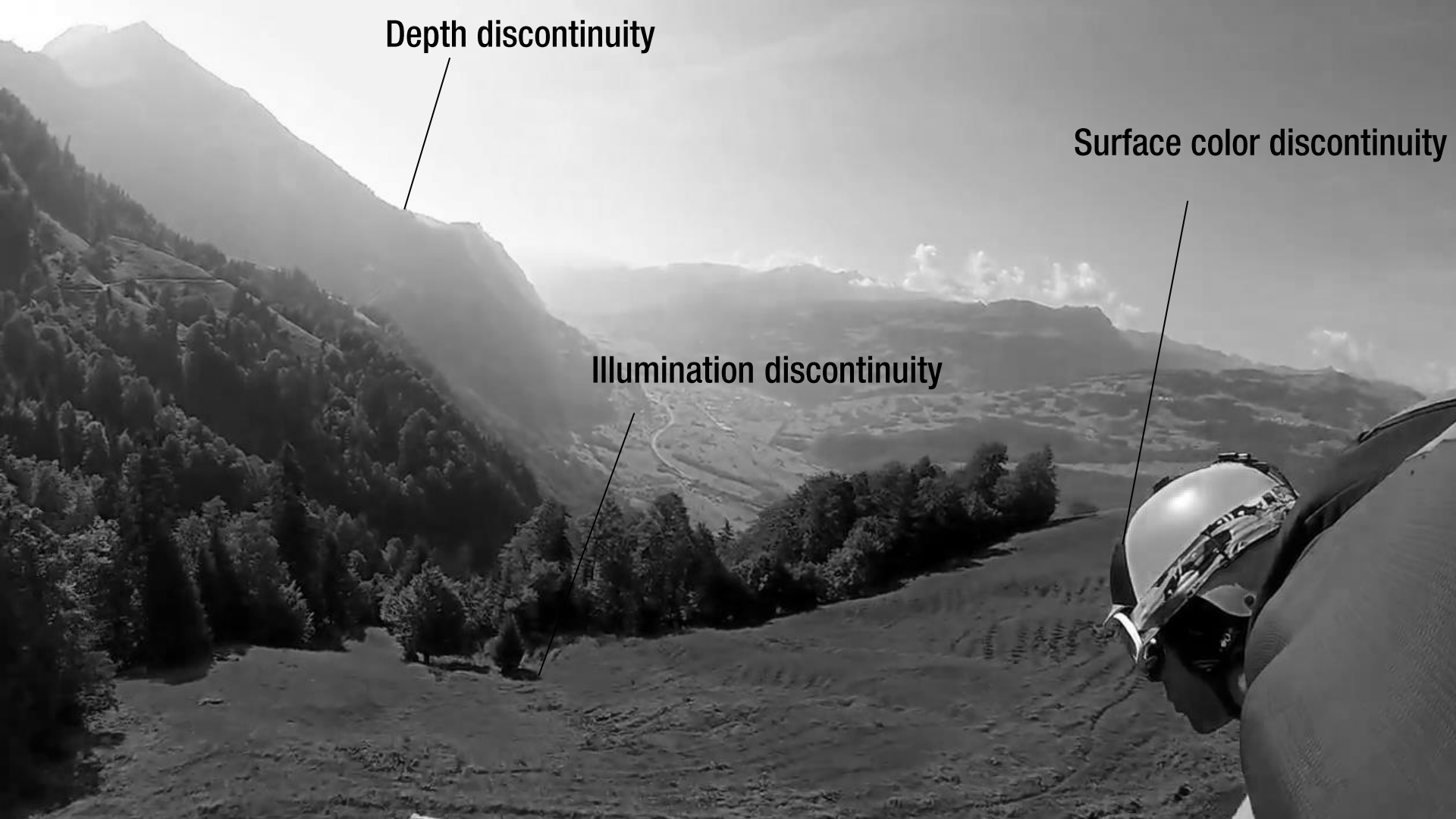
**HYUN SOO PARK**

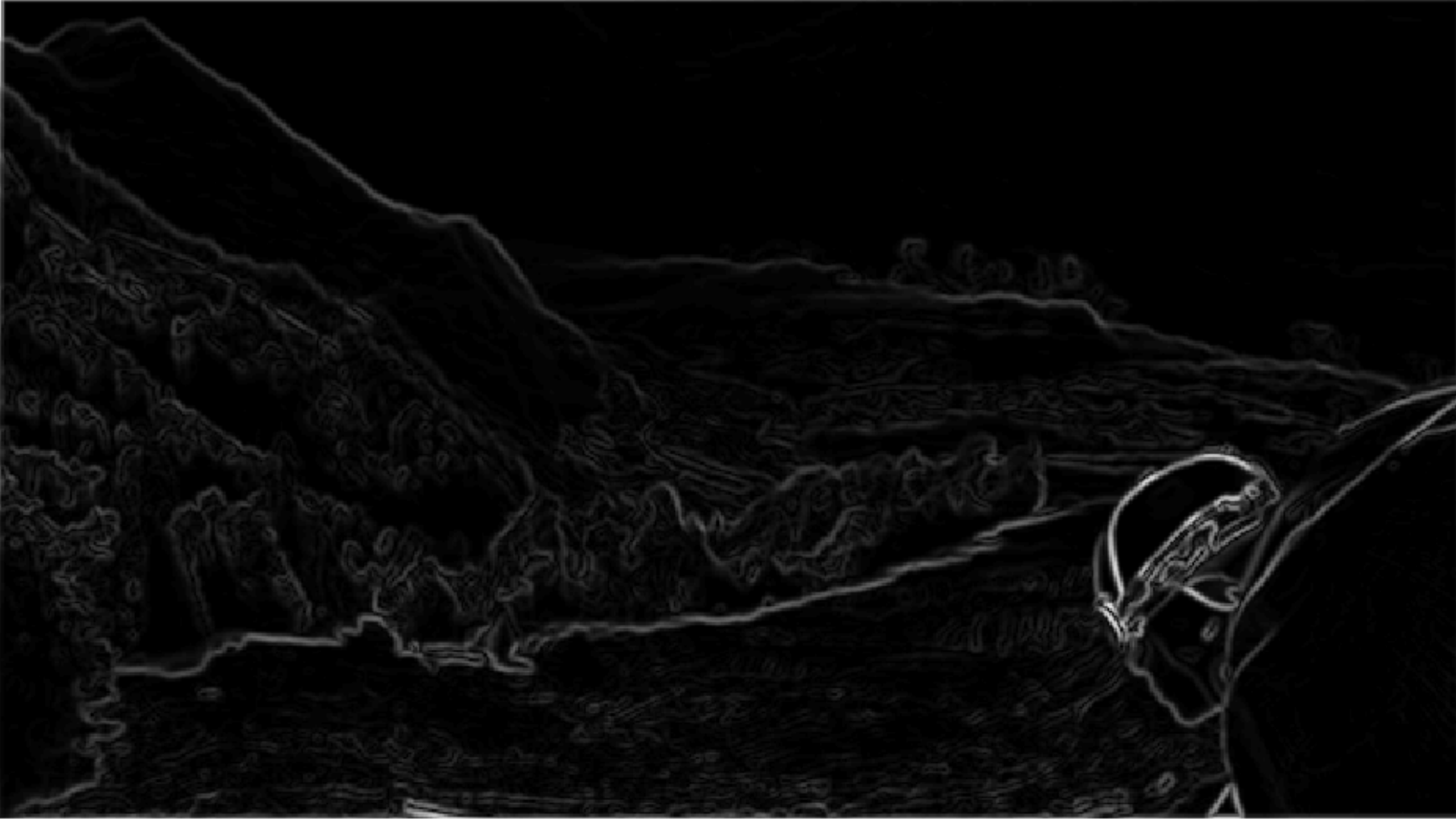


**Depth discontinuity**

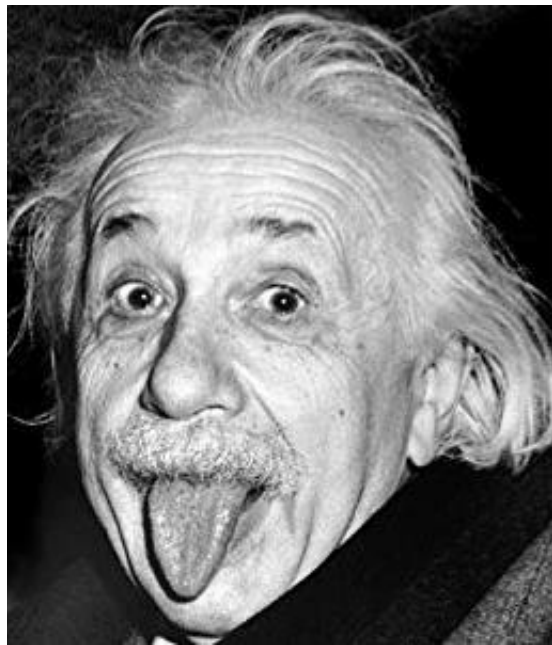
**Surface color discontinuity**

**Illumination discontinuity**

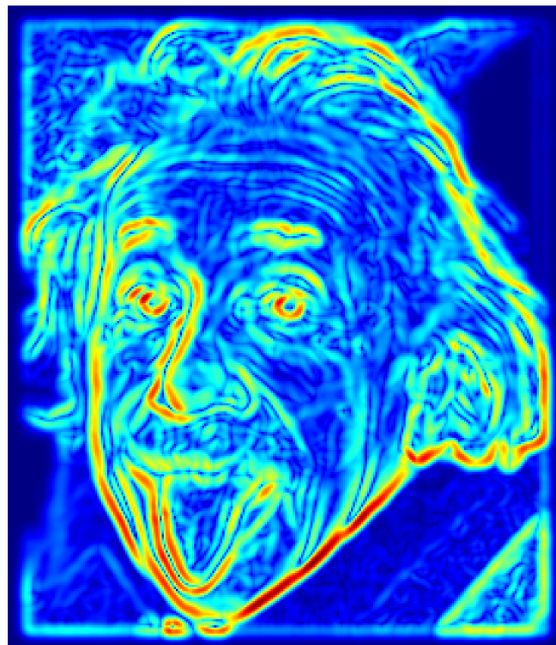




# *EDGE DETECTION: WOULD MAGNITUDE THRESHOLDING WORK?*

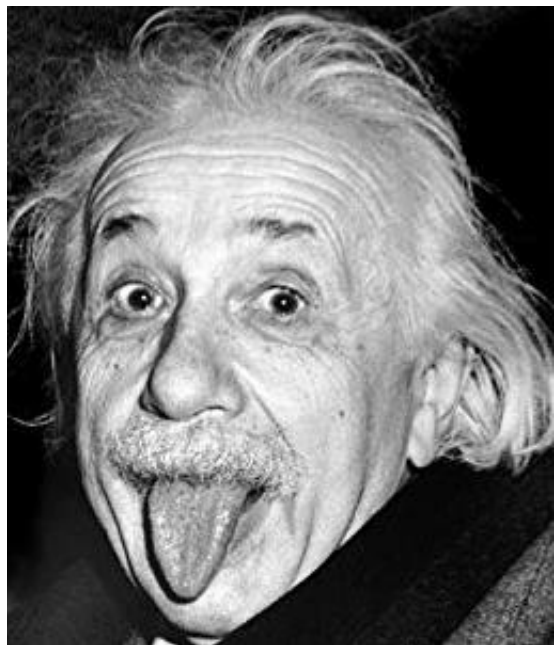


$I$



$$\|\nabla I\| > \varepsilon$$

# *EDGE DETECTION: WOULD MAGNITUDE THRESHOLDING WORK?*

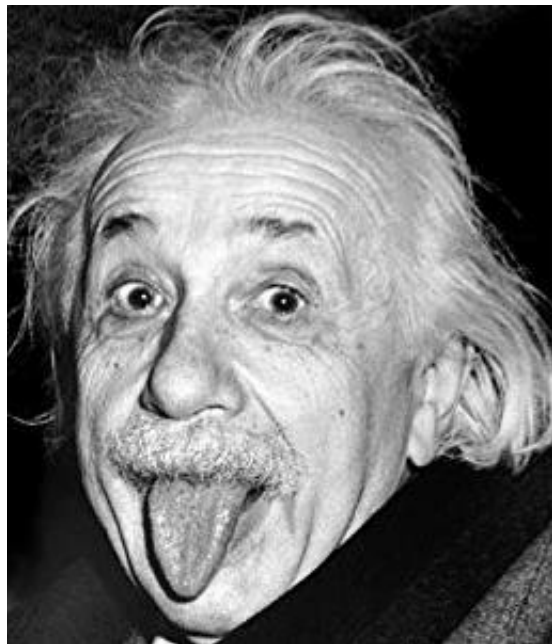


$I$



$\|\nabla I\| > \varepsilon$

# EDGE DETECTION: WOULD MAGNITUDE THRESHOLDING WORK?

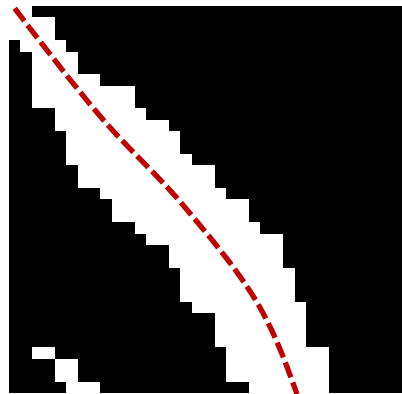


$I$

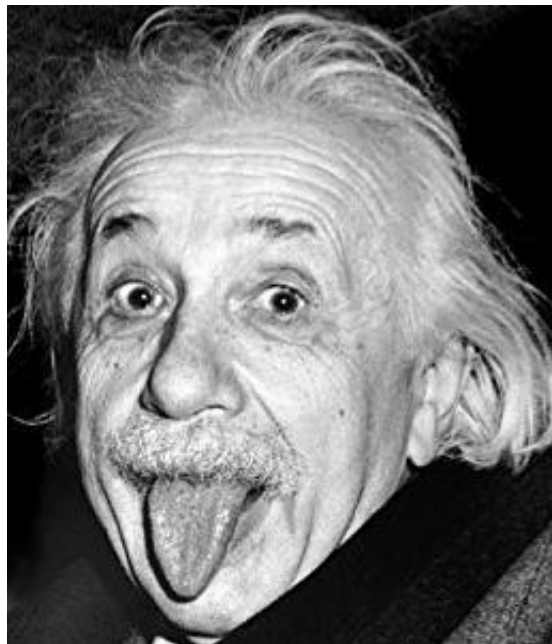


$$\|\nabla I\| > \varepsilon$$

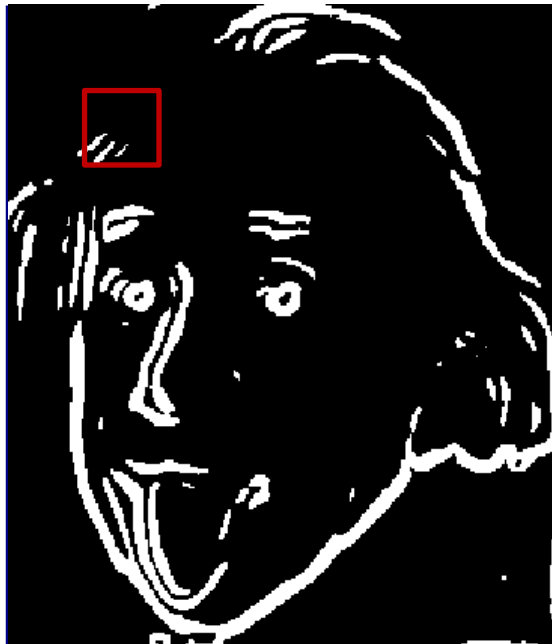
Non-locality



# EDGE DETECTION: WOULD MAGNITUDE THRESHOLDING WORK?



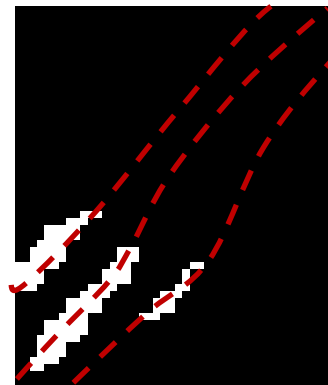
$I$



$$\|\nabla I\| > \epsilon$$

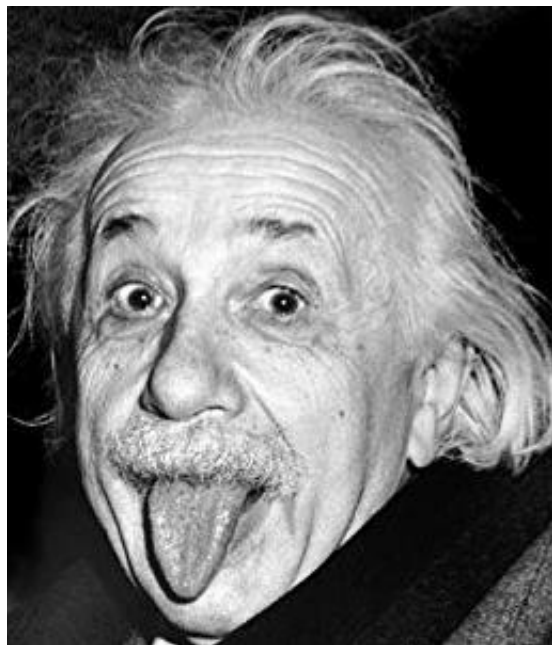
Non-locality

Discontinuity





# EDGE DETECTION: WOULD MAGNITUDE THRESHOLDING WORK?



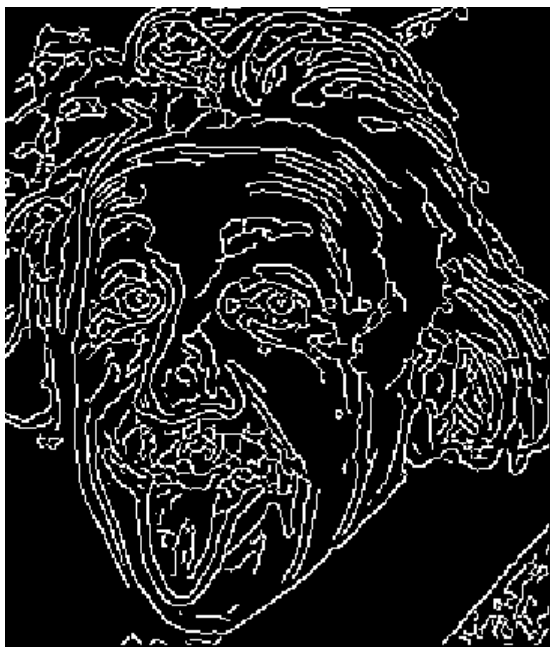
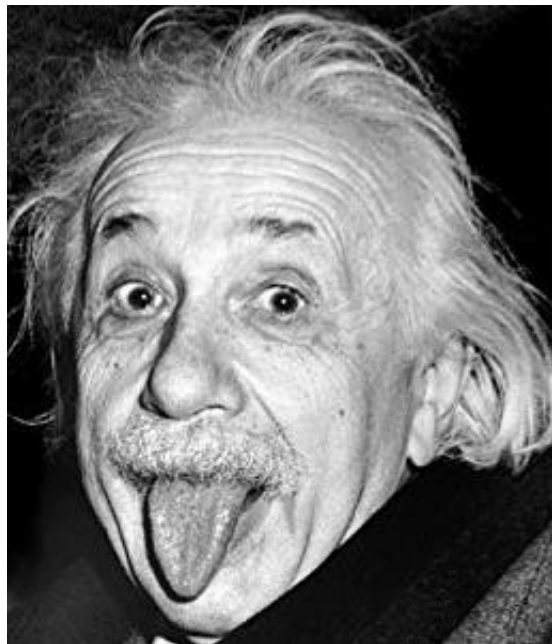
$I$



$$\|\nabla I\| > \varepsilon$$

Non-locality  
Discontinuity  
Threshold?

# *CANNY EDGE DETECTOR*

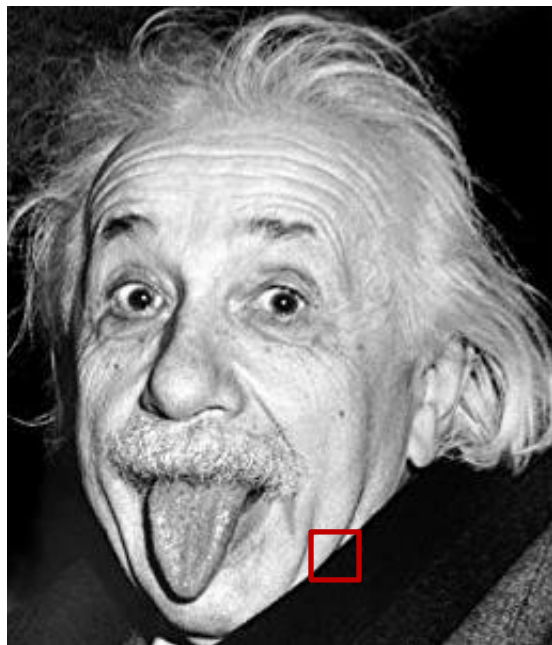


John F. Canny, UC Berkely

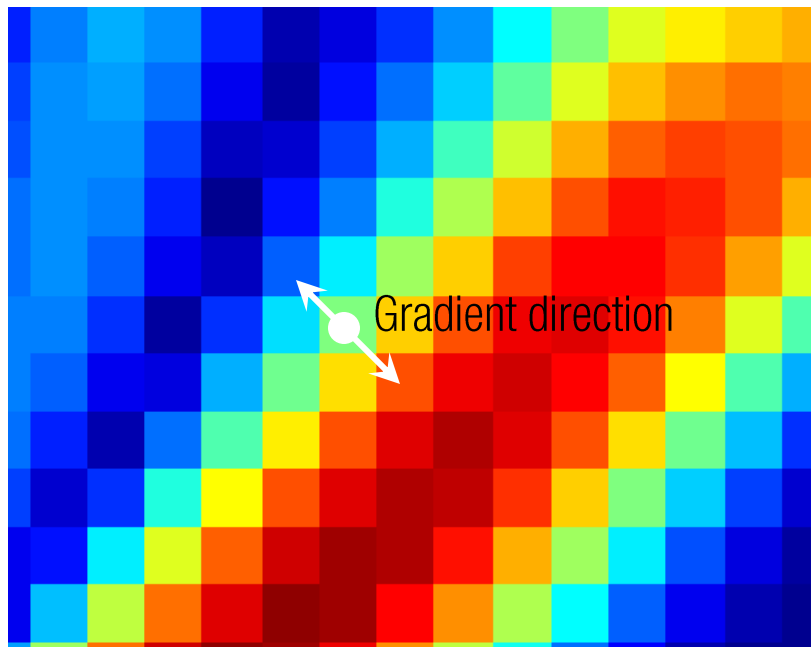
*I*

*Canny, A Computational Approach to Edge Detection, TPAMI (1986)*

# EDGE LOCALIZATION: NON-MAXIMUM SUPPRESSION



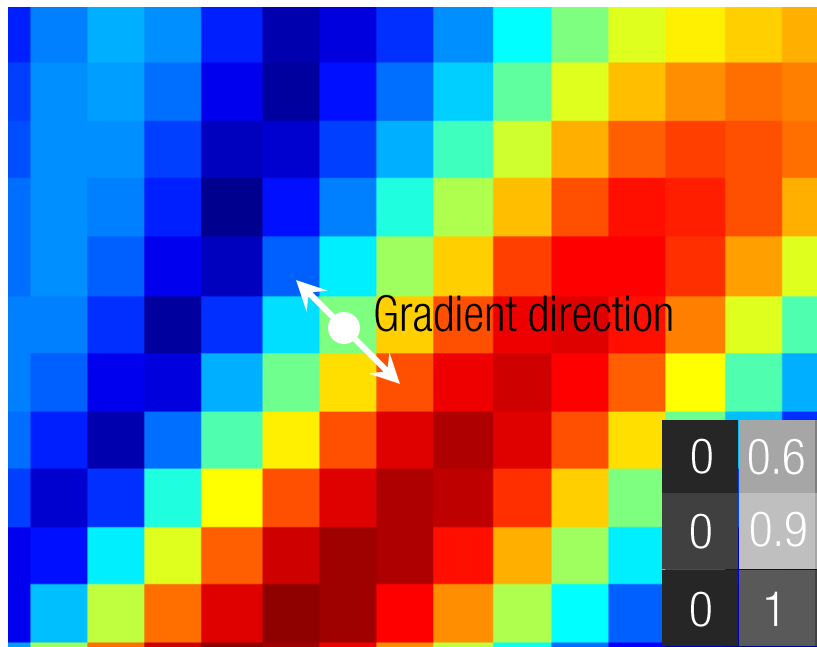
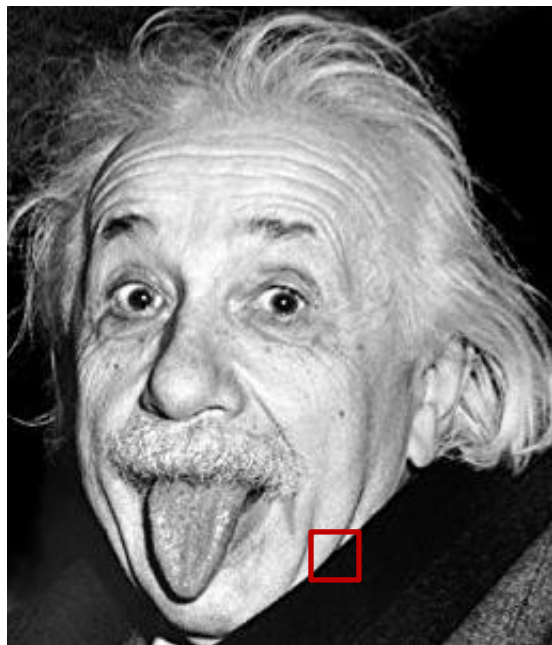
$I$



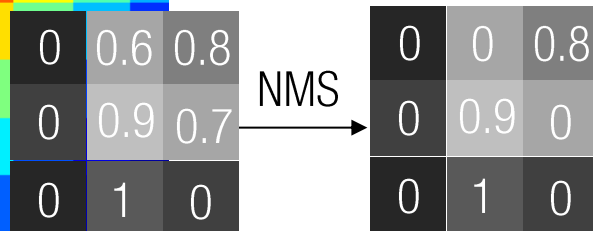
Edge response

Check if the pixel is local maximum along the gradient direction

# EDGE LOCALIZATION: NON-MAXIMUM SUPPRESSION

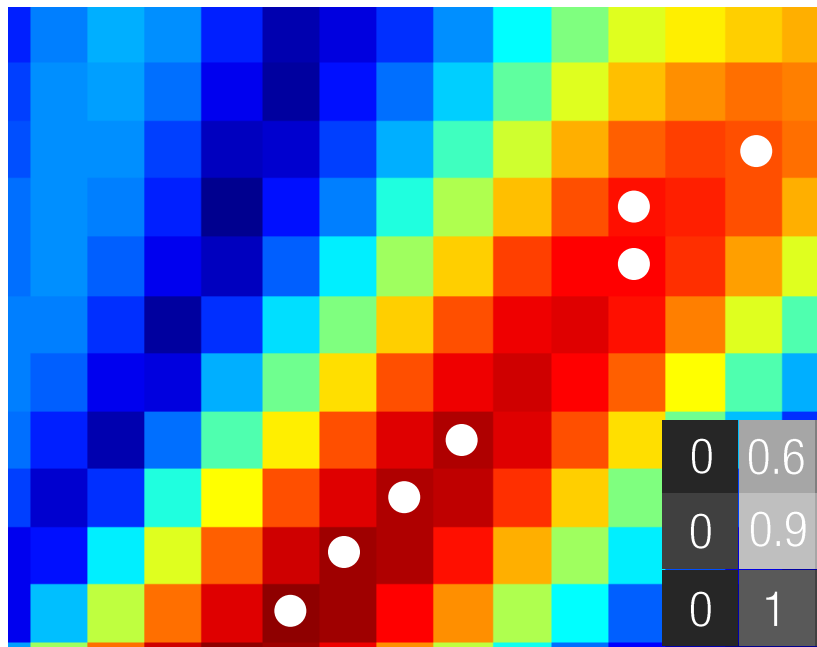
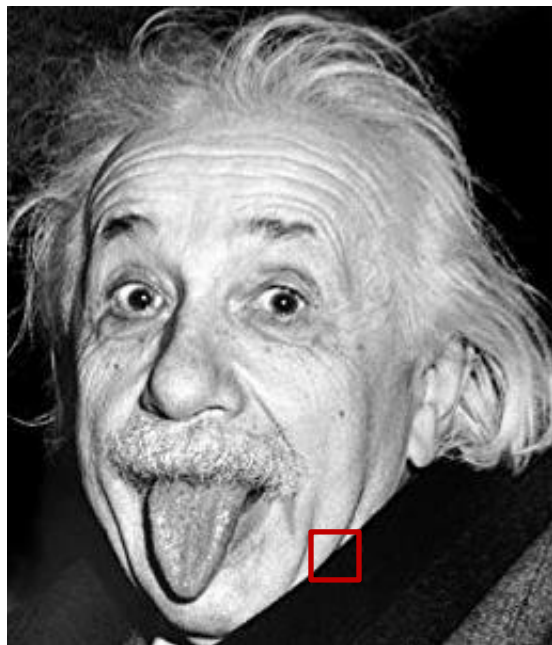


Check if the pixel is local maximum along the gradient direction

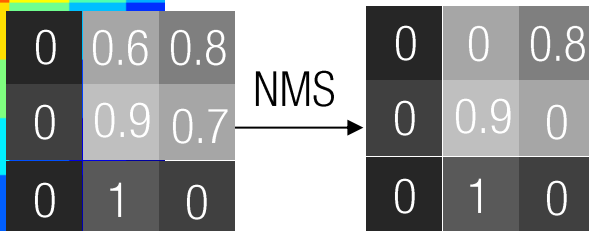


Edge response

# EDGE LOCALIZATION: NON-MAXIMUM SUPPRESSION



Check if the pixel is local maximum along the gradient direction



Edge response

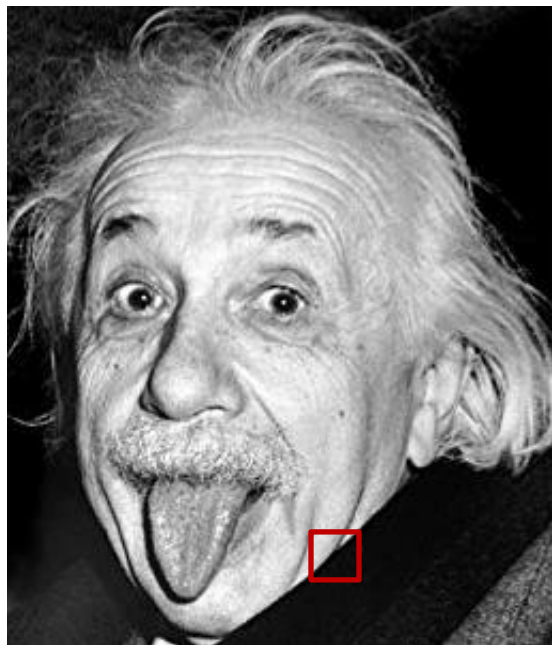


Thresholding

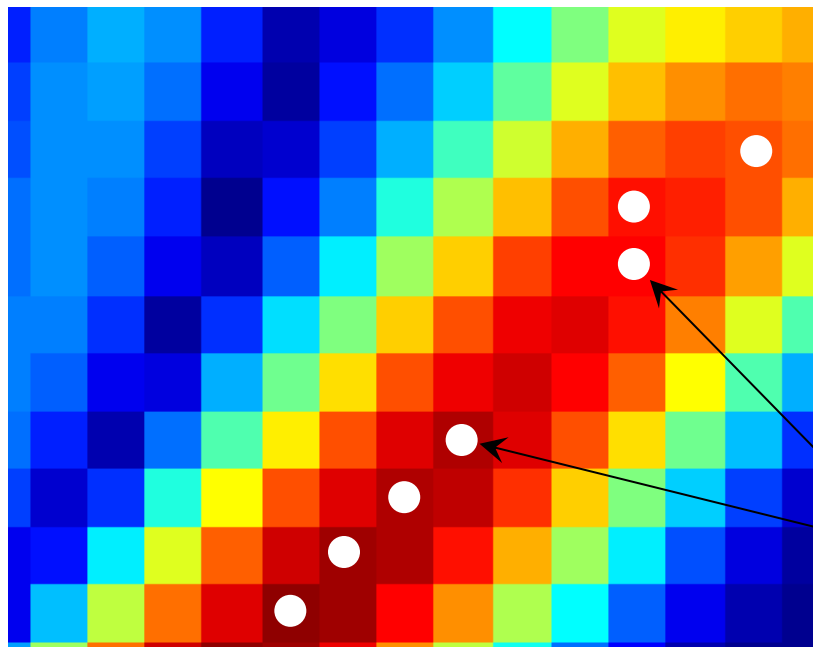


Localized edge

# EDGE LINKING



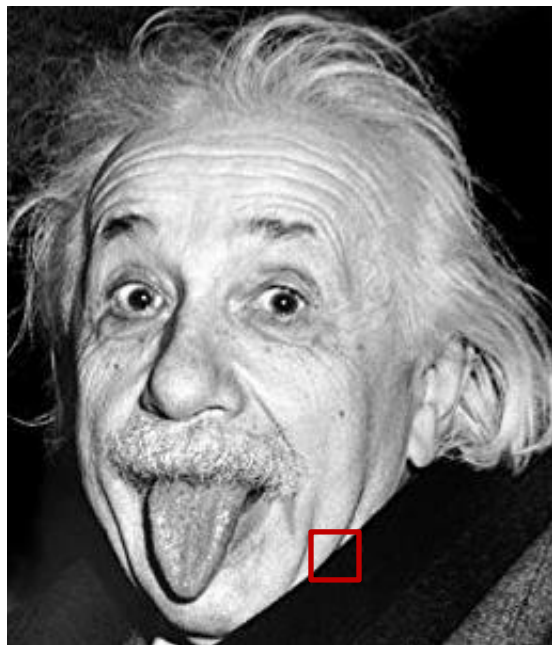
*I*



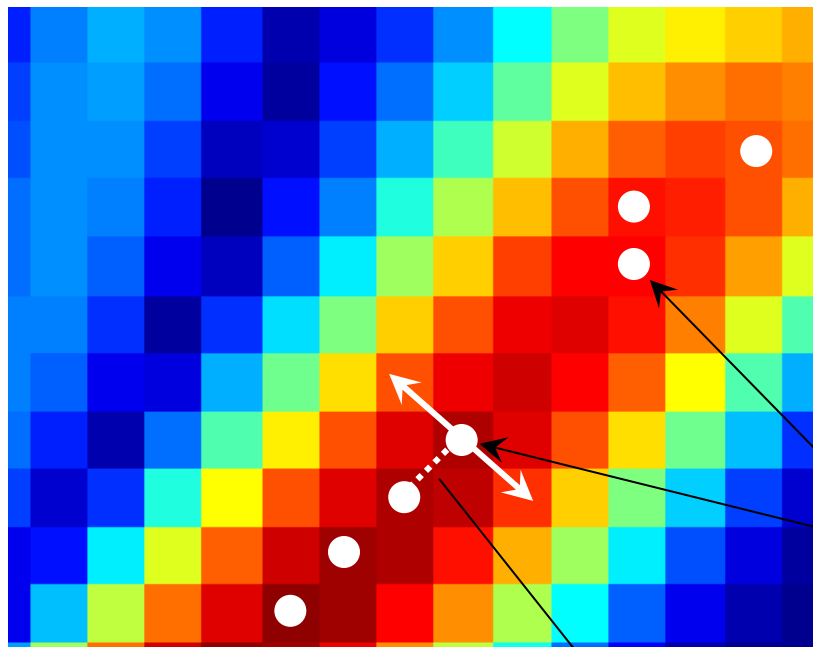
Edge response

Edge discontinuity

# EDGE LINKING



*I*



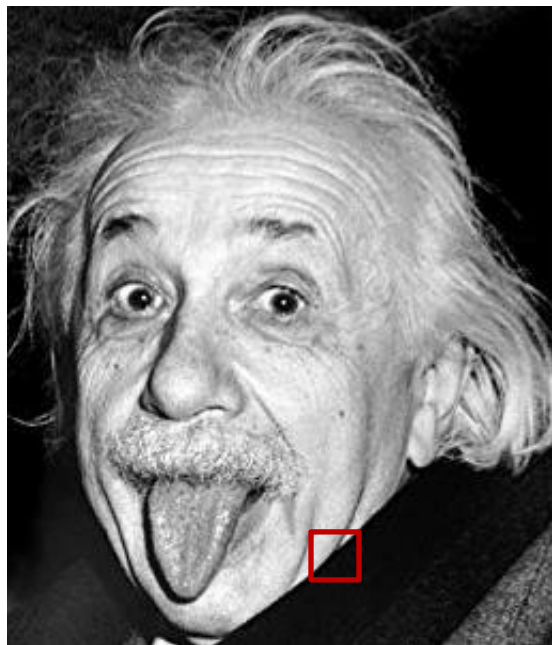
Edge response

Edge linking

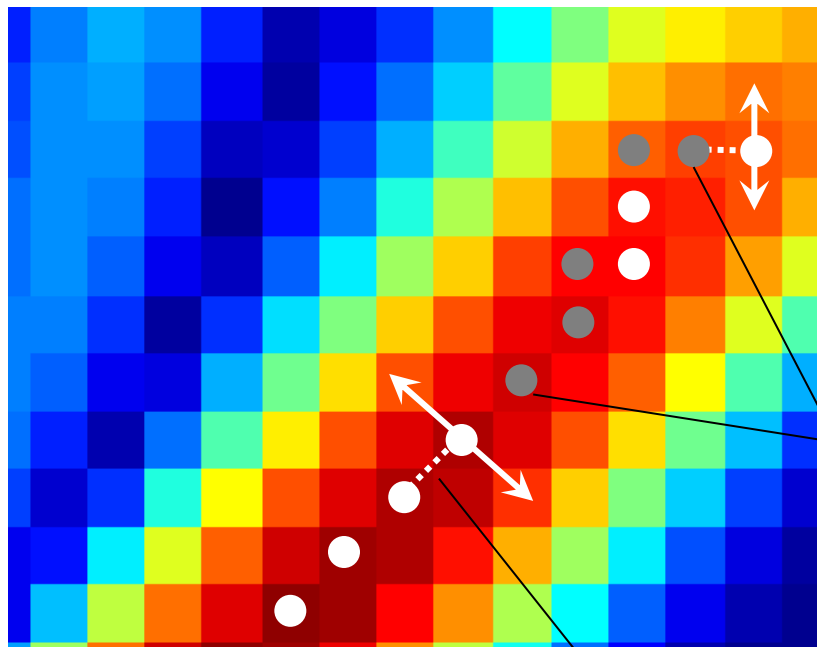
Edge discontinuity



# EDGE PREDICTION



*I*

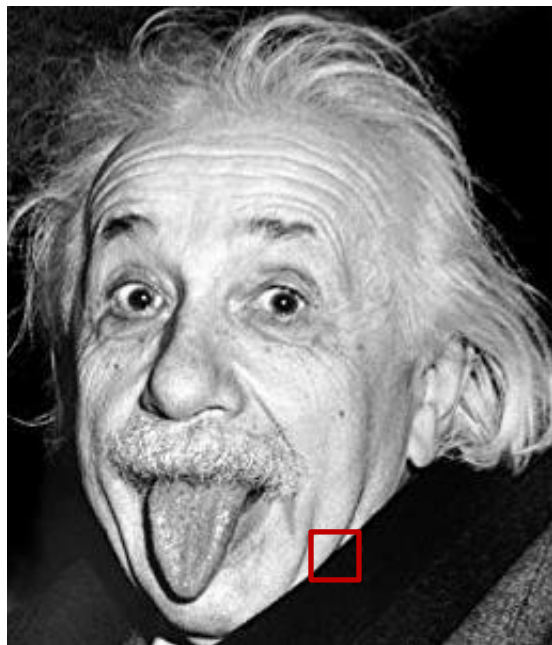


Edge response

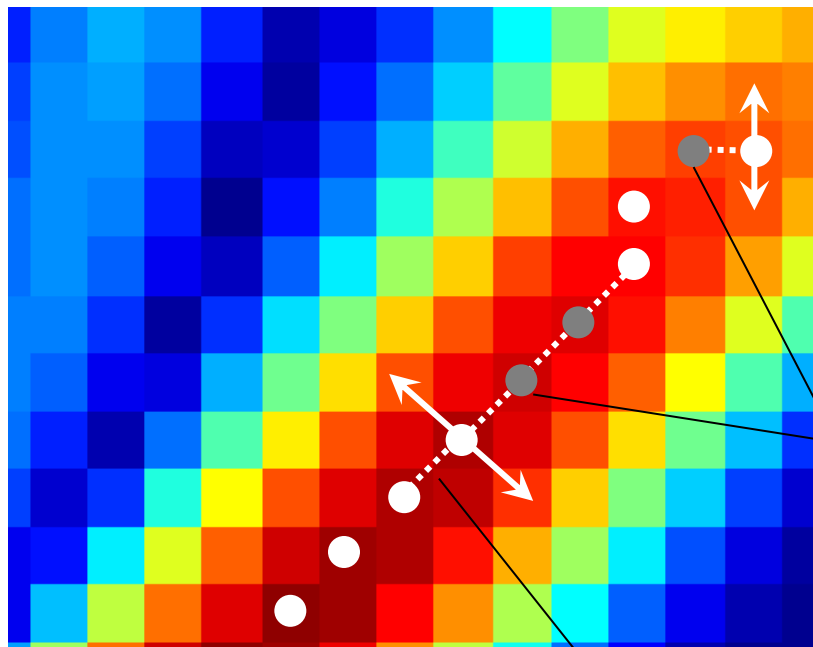
Edge linking

Next edge pixel prediction  
→ Tangent to the edge

# EDGE PREDICTION: HYSTERESIS



*I*

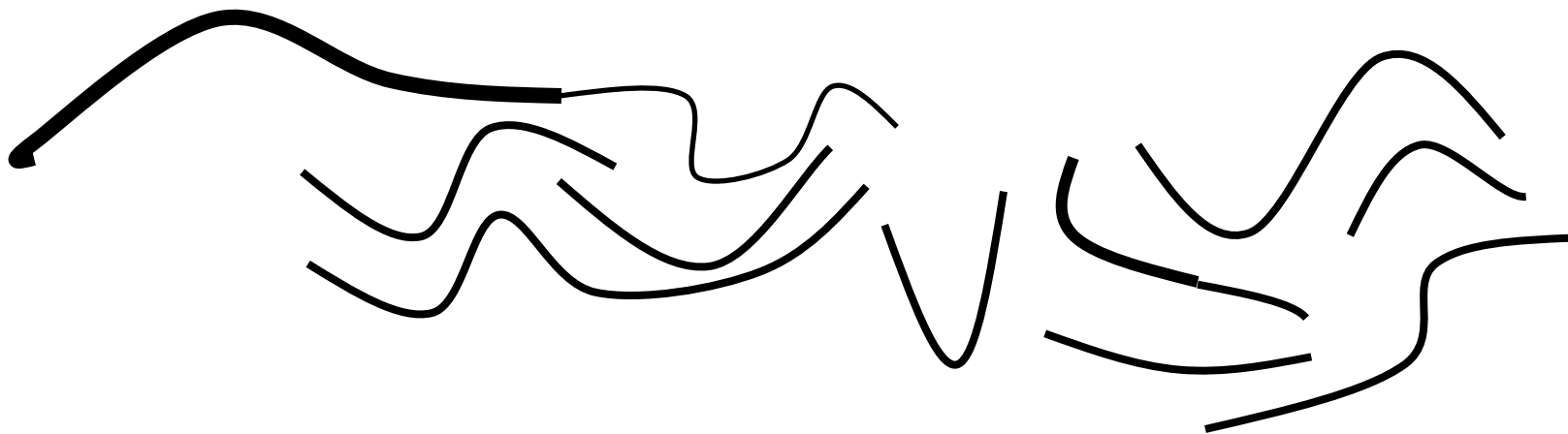


Edge response

Edge linking

Next edge pixel prediction  
→ Tangent to the edge  
Check if edge response  
is sufficiently large

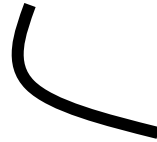
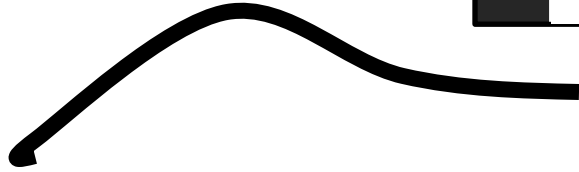
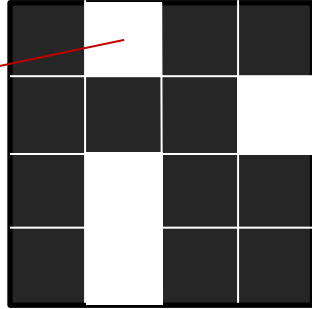
# *EDGE FILTERING: HYSTERESIS*



# *EDGE FILTERING : HYSTERESIS*

High thresholding

Edge indicator

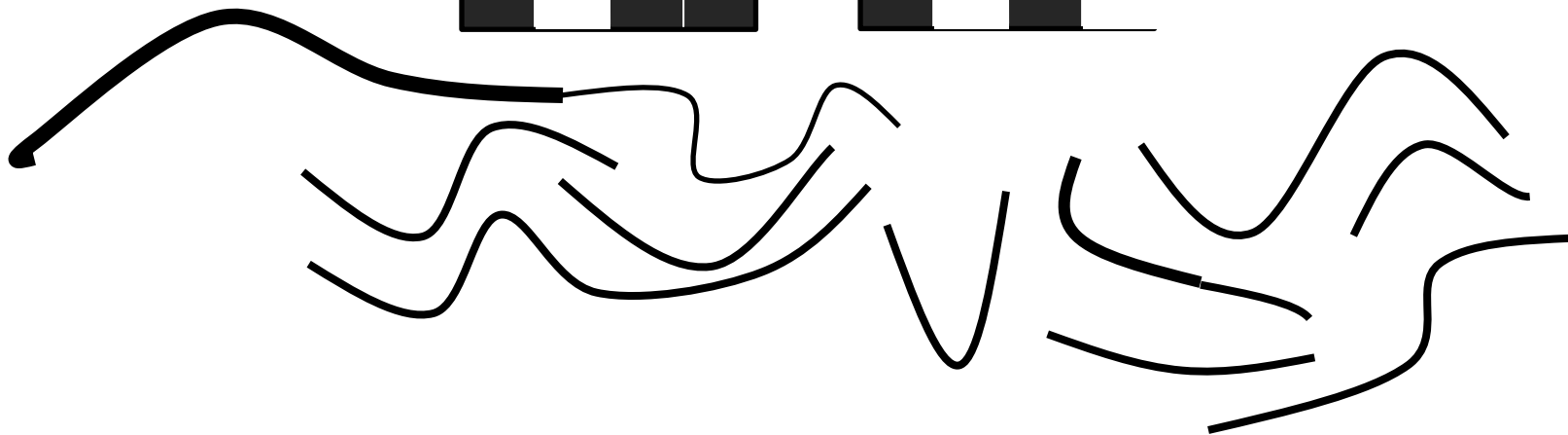
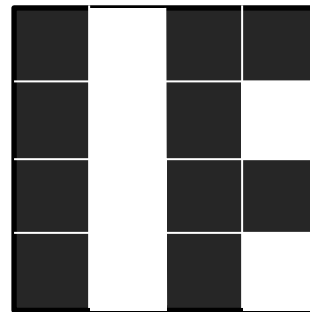
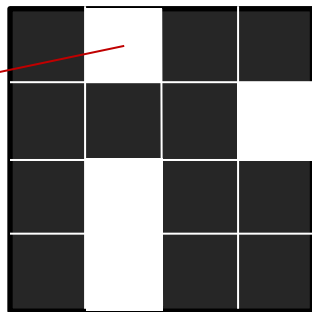


# EDGE FILTERING : HYSTERESIS

High thresholding

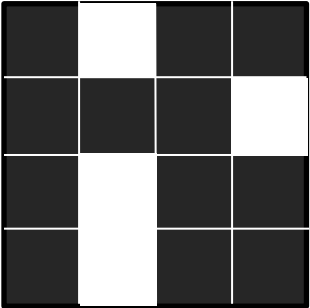
Low thresholding

Edge indicator

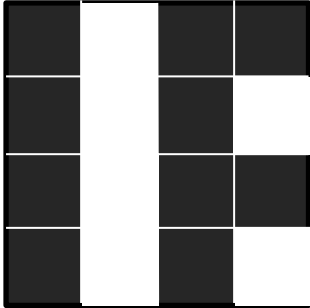


# EDGE FILTERING : HYSTERESIS

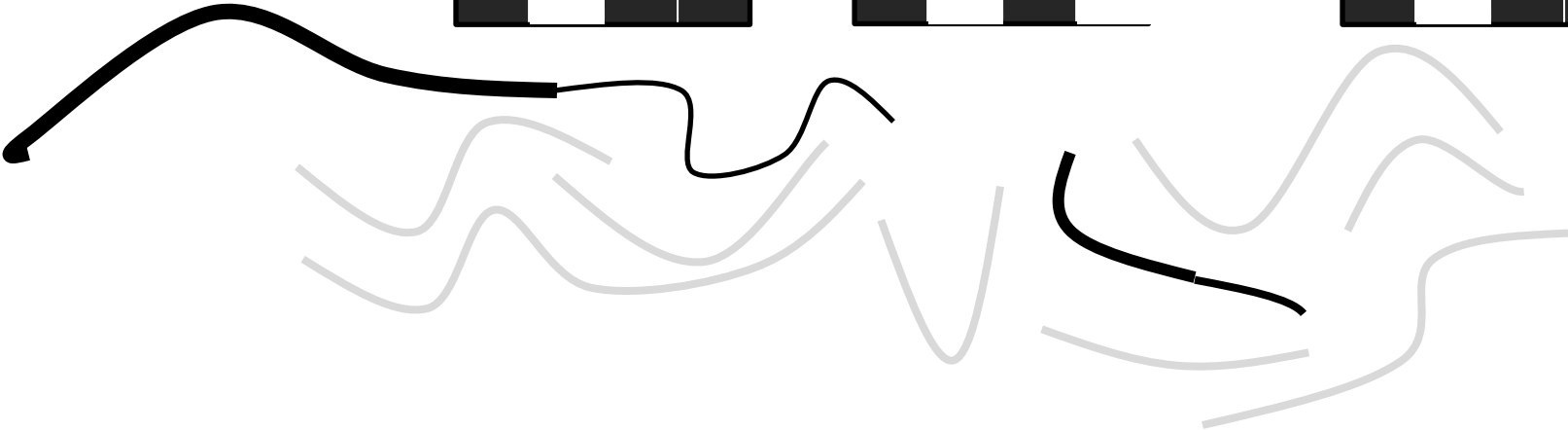
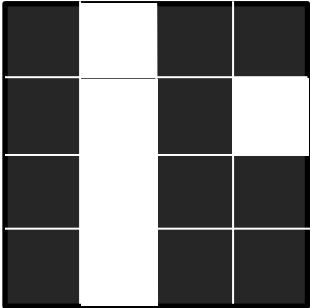
High thresholding



Low thresholding



Hysteresis





Localized edge



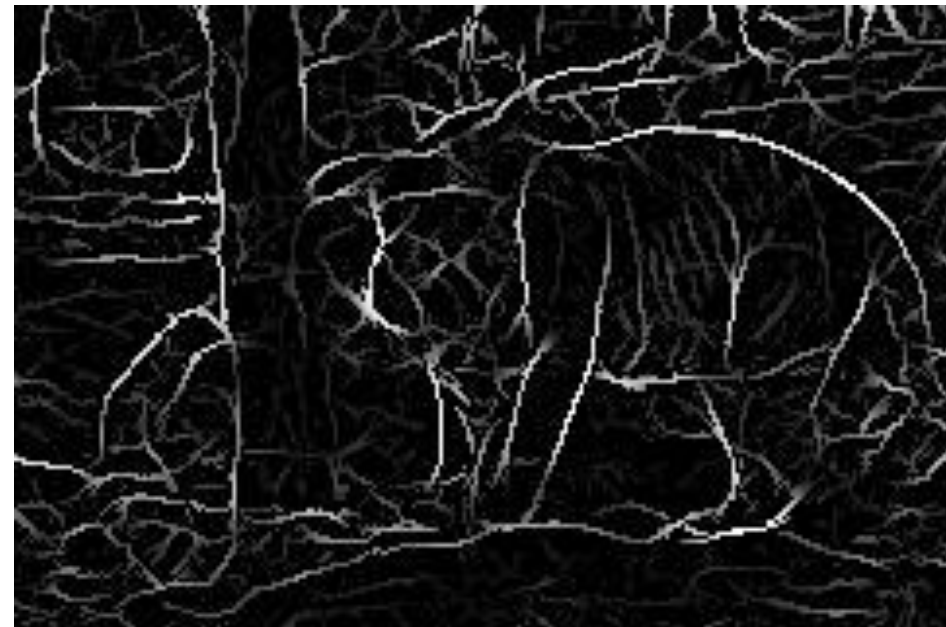
Edge linking

# *Is EDGE DETECTOR SOLVED?*



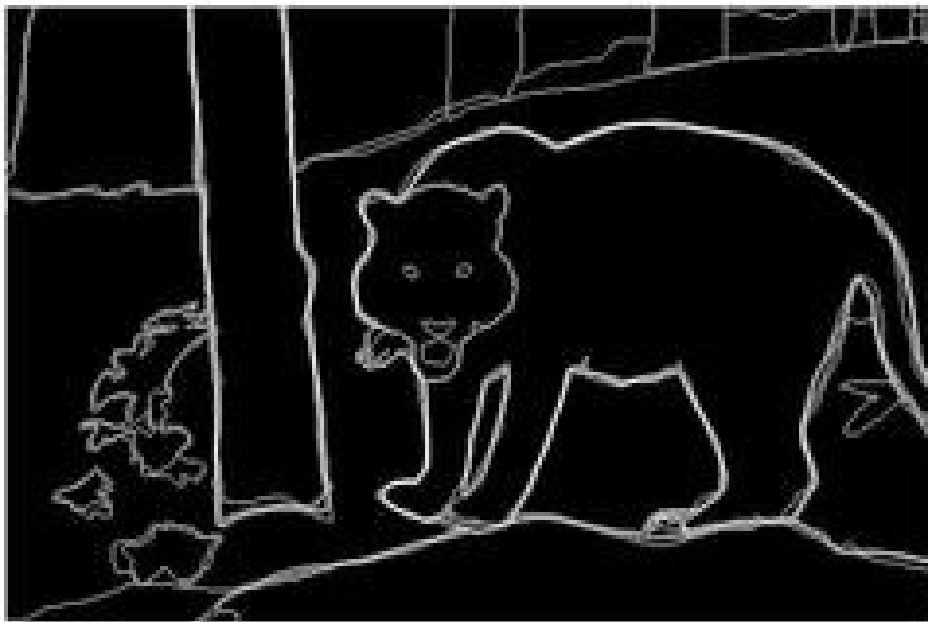


# *Is EDGE DETECTOR SOLVED?*



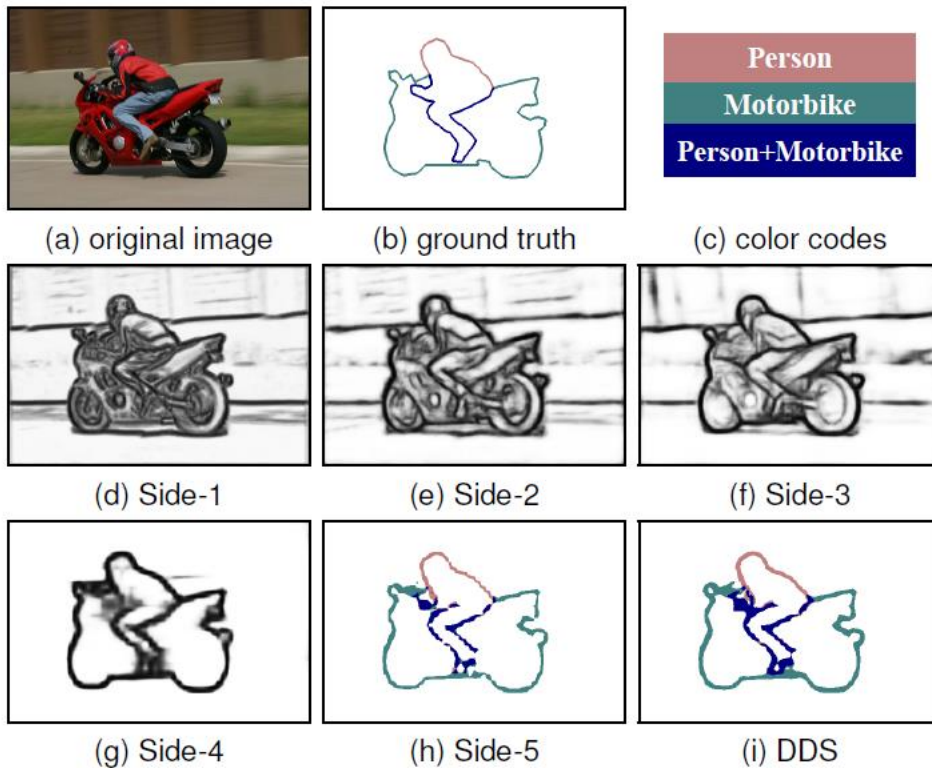
Canny edges

# *Is EDGE DETECTOR SOLVED?*



Human perceived edges

# SEMANTIC EDGES

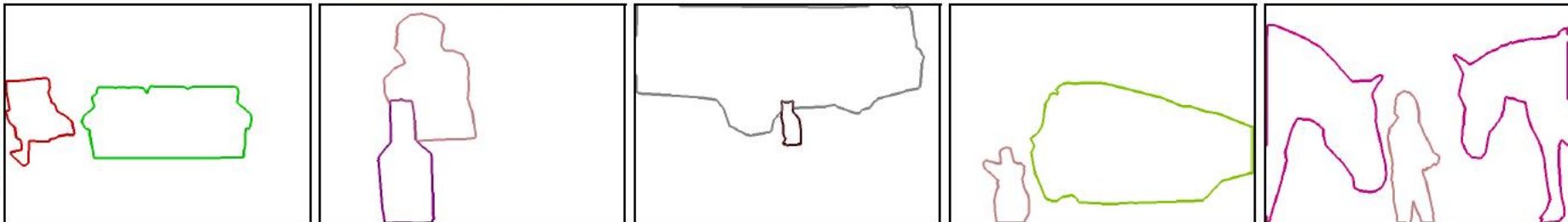


aeroplane	bicycle	bird	boat	bottle	bus	car	cat	chair	cow
dining table	dog	horse	motorbike	person	potted plant	sheep	sofa	train	tv monitor

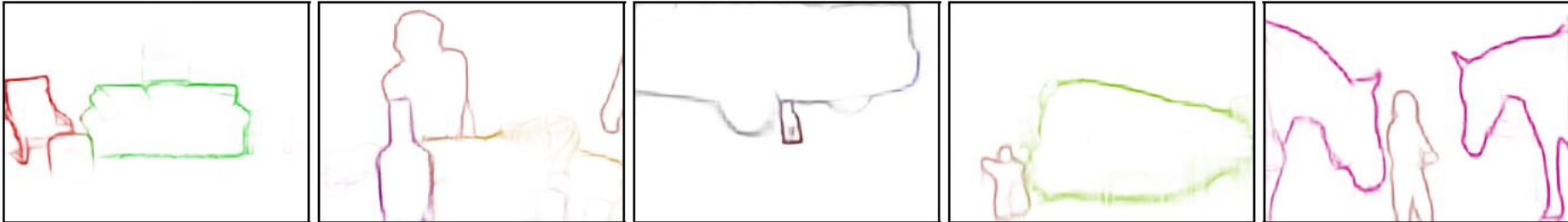
Original Images



Ground Truth



DDS-U



Liu et al., "Semantic Edge Detection with Diverse Deep Supervision", TPAMI (2018)



Shai Avidan

Mitsubishi Electric Research Lab

Ariel Shamir

The interdisciplinary Center & MERL



# ShadowDraw

Real-Time User Guidance for Freehand Drawing

Yong Jae Lee

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C. Lawrence Zitnick

Microsoft Research

Michael F. Cohen

Microsoft Research

SIGGRAPH 2011

