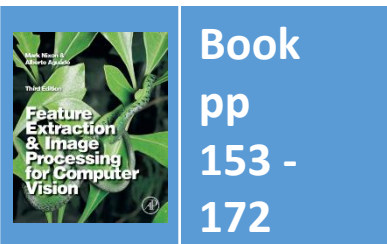


Lecture 7 Further Edge Detection

COMP3204 & COMP6223 Computer Vision

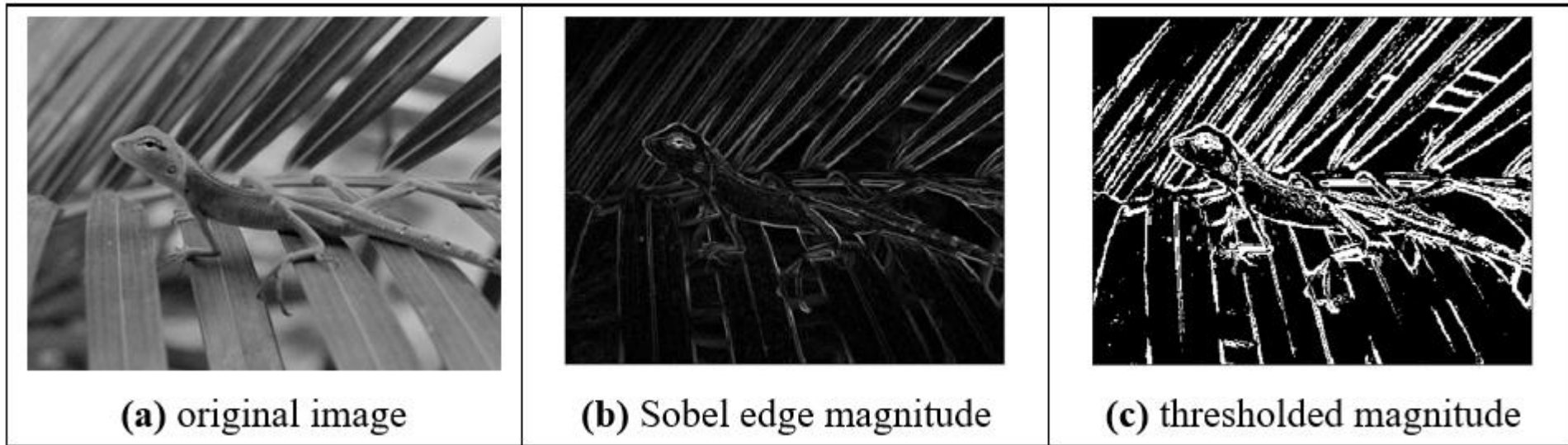
What better ways are there to detect edges?



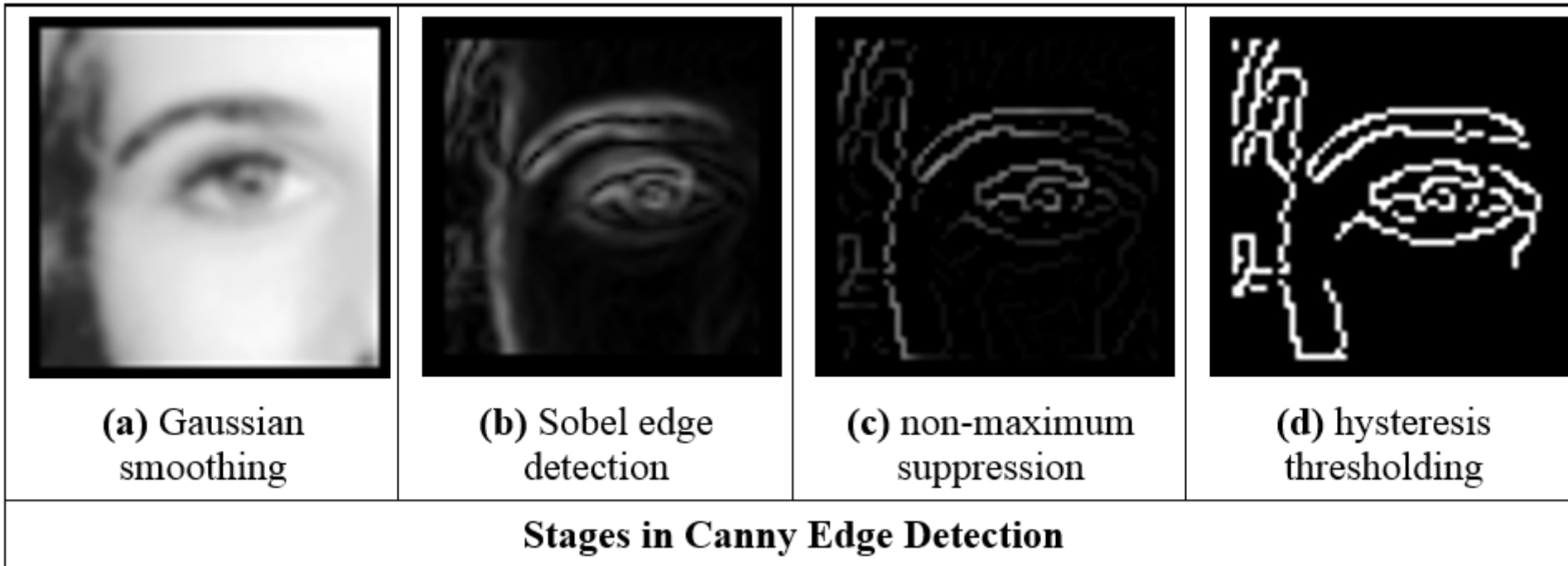
Department of
Electronics and
Computer Science

UNIVERSITY OF
Southampton
School of Electronics
and Computer Science

Applying Sobel operator



Stages in Canny edge detection operator



Canny edge detection operator

Formulated with three main objectives:

- **optimal** detection with no spurious responses;
- **good** localisation with minimal distance between detected and true edge position; and
- **single** response to eliminate multiple responses to a single edge.

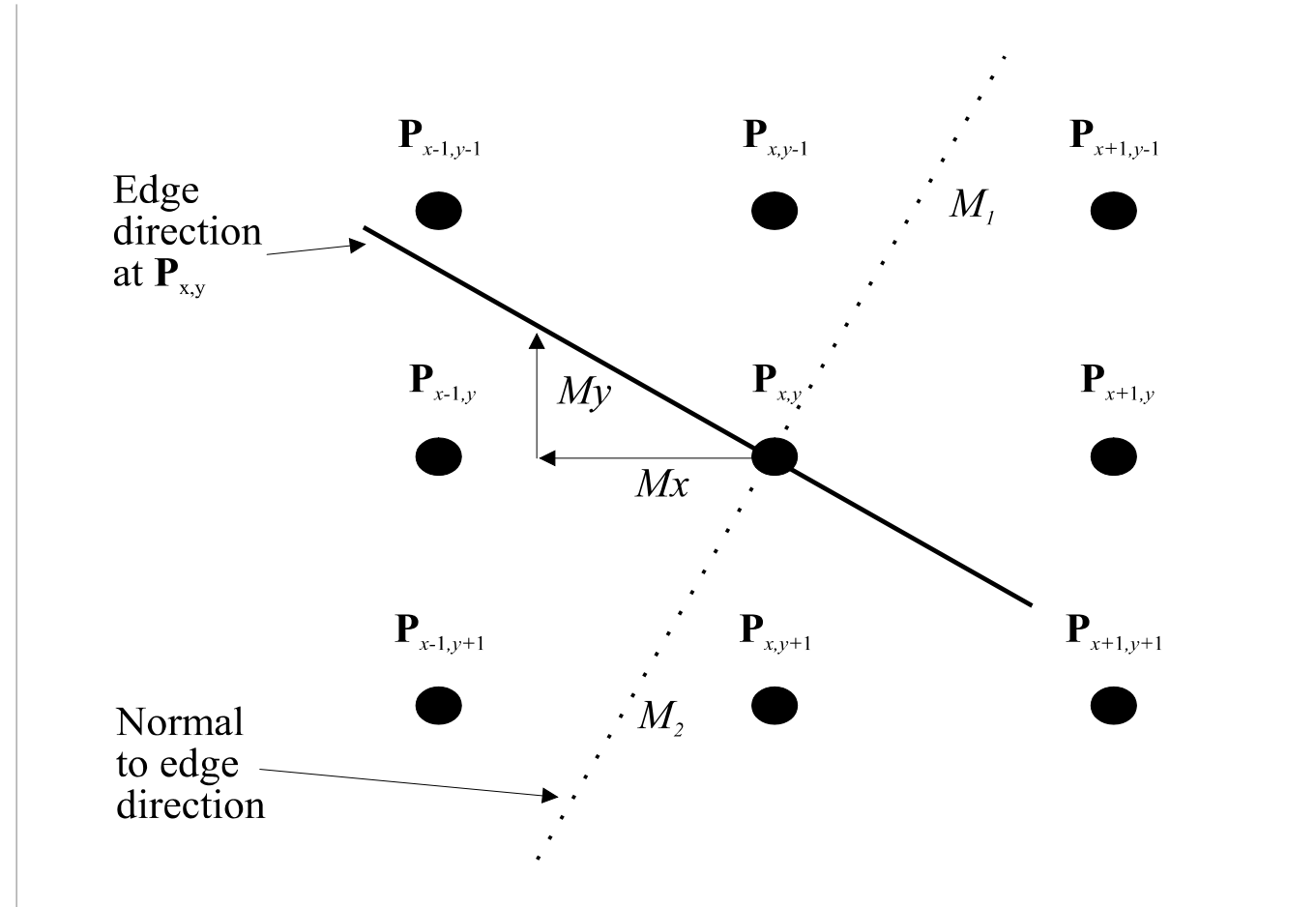
Approximation

1. use **Gaussian smoothing**;
2. use the **Sobel** operator;
3. use **non-maximal suppression**; and
4. **threshold** with hysteresis to connect edge points.

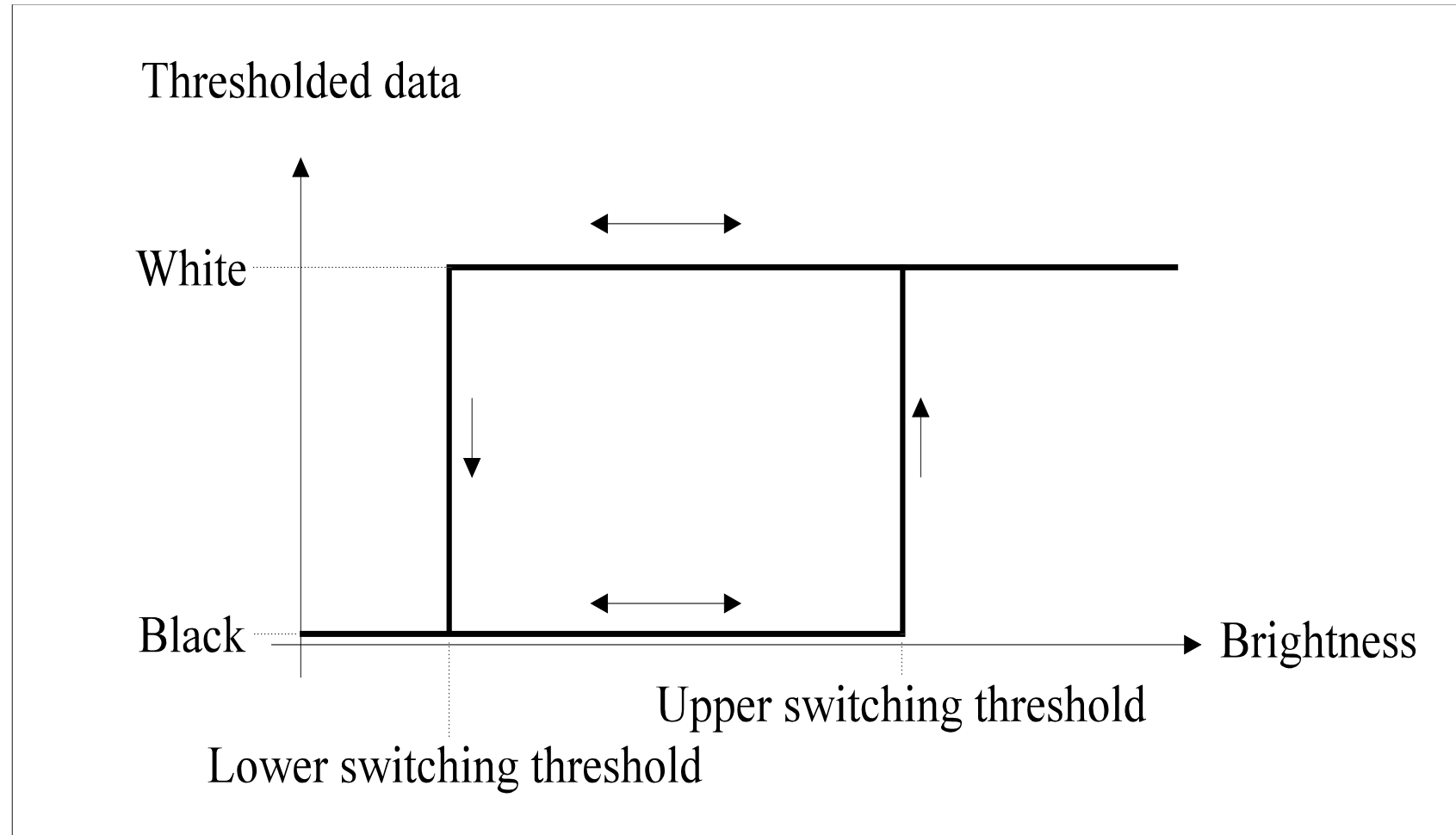
) combine?



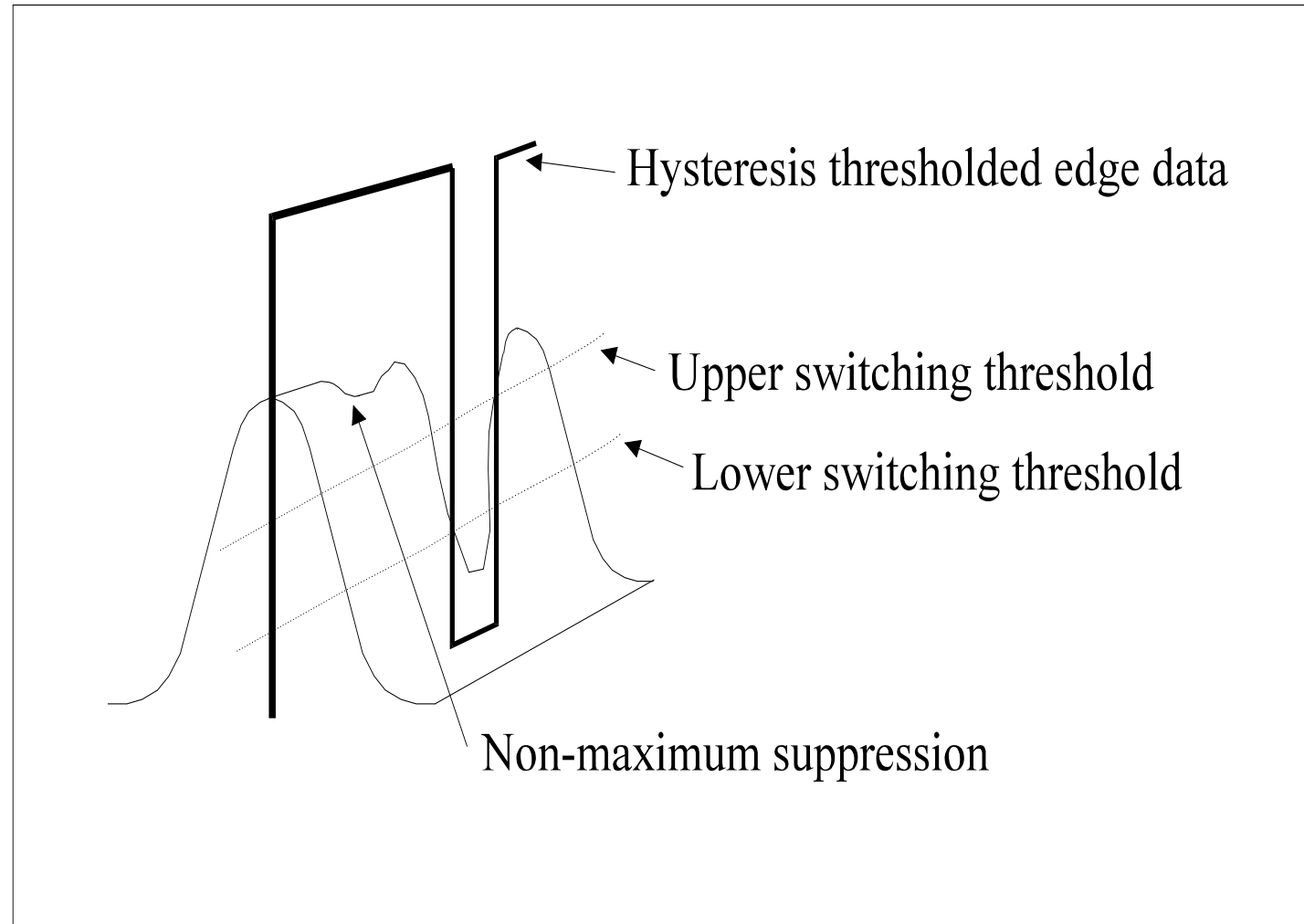
Interpolation in non-maximum suppression



Hysteresis thresholding transfer function



Action of non-maximum suppression and hysteresis thresholding



Comparing hysteresis thresholding with uniform thresholding



(a) hysteresis thresholding,
upper level = 40,
lower level = 10



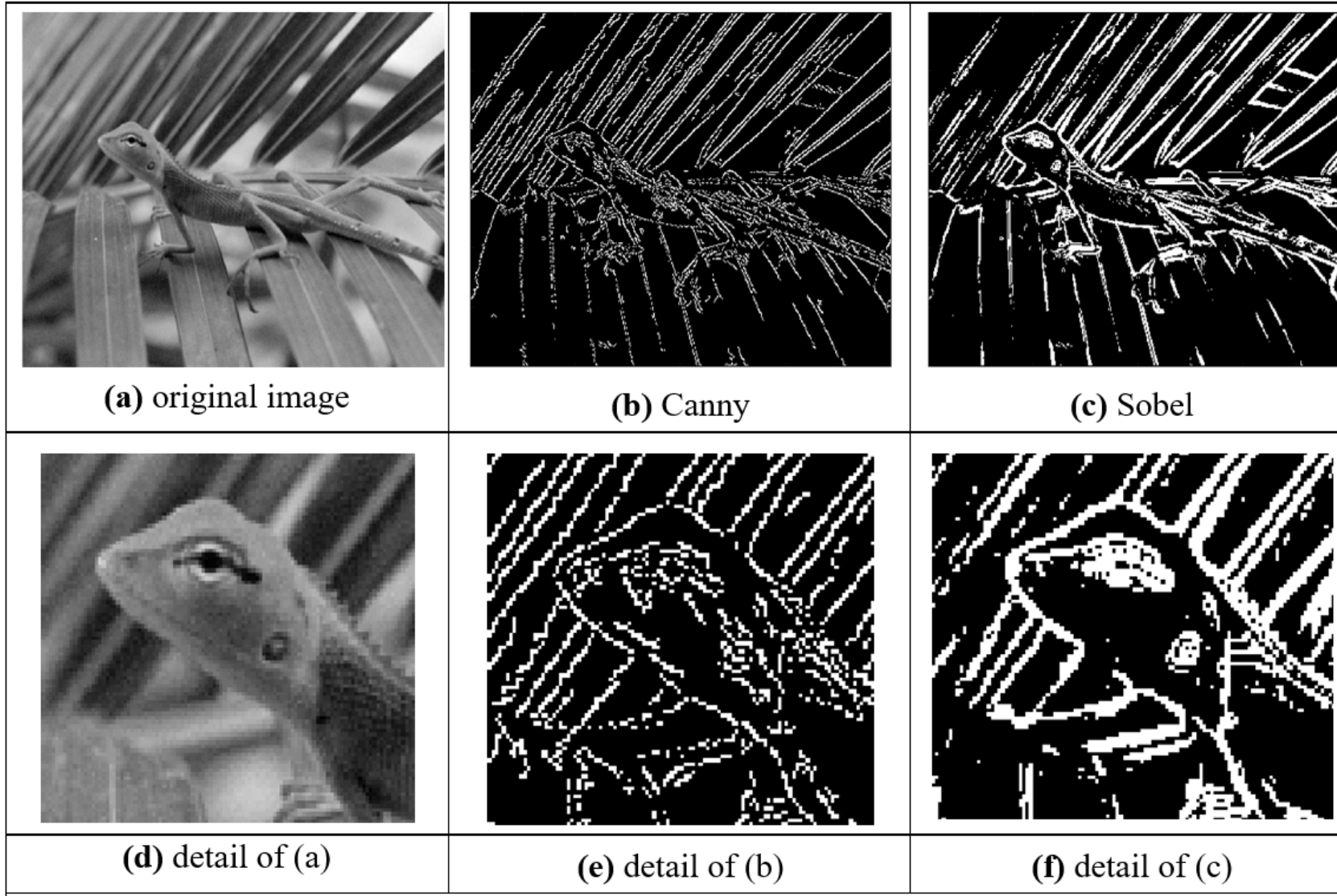
(b) uniform thresholding,
level = 40



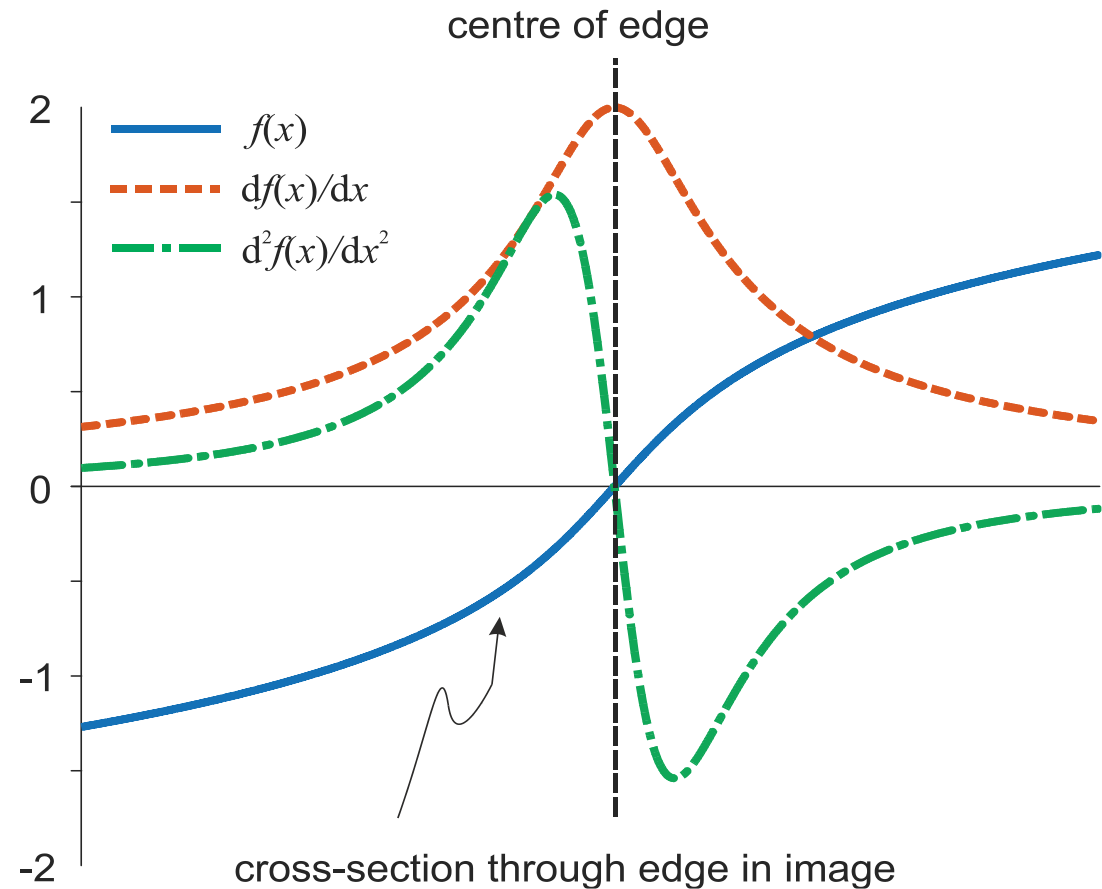
(c) uniform thresholding,
level = 10



Comparing Canny with Sobel



First and second order edge detection



Edge detection via the Laplacian operator

0	-1	0
-1	4	-1
0	-1	0

1	2	3	4	1	1	2	1	0	0	0	0	0	0	0	0	0
2	2	3	0	1	2	2	1	0	1	-31	-47	-36	-32	0	0	0
3	0	38	39	37	36	3	0	0	-44	70	37	31	60	-28	0	0
4	1	40	44	41	42	2	1	0	-42	34	12	1	50	-41	0	0
1	2	43	44	40	39	3	1	0	-37	47	8	-6	31	-32	0	0
2	0	39	41	42	40	2	0	0	-45	72	37	45	74	-36	0	0
0	2	0	2	2	3	1	1	0	6	-44	-38	-40	-31	-6	0	0
0	2	1	3	1	0	4	2	0	0	0	0	0	0	0	0	0
(a) image data								(b) result of the Laplacian operator								



Mathbelts on...

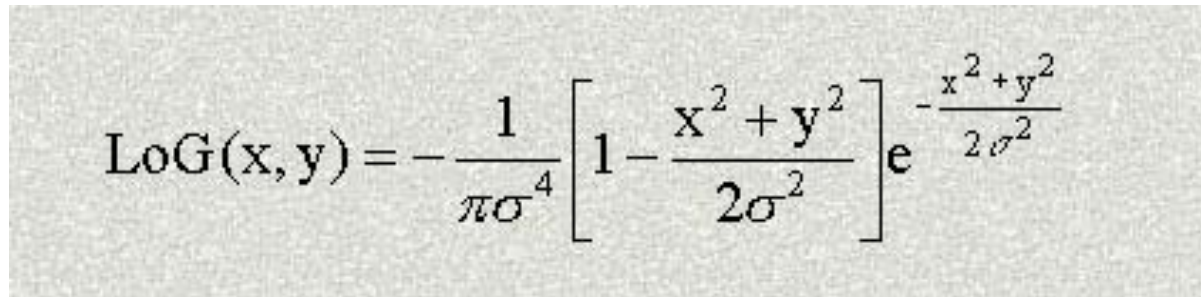
$$\begin{aligned}\nabla^2 g(x, y) &= \frac{\partial^2 g(x, y, \sigma)}{\partial x^2} U_x + \frac{\partial^2 g(x, y, \sigma)}{\partial y^2} U_y \\&= \frac{\partial \nabla g(x, y, \sigma)}{\partial x} U_x + \frac{\partial \nabla g(x, y, \sigma)}{\partial y} U_y \\&= \left(\frac{x^2}{\sigma^2} - 1 \right) \frac{e^{\frac{-(x^2+y^2)}{2\sigma^2}}}{\sigma^2} + \left(\frac{y^2}{\sigma^2} - 1 \right) \frac{e^{\frac{-(x^2+y^2)}{2\sigma^2}}}{\sigma^2} \\&= \frac{1}{\sigma^2} \left(\frac{(x^2 + y^2)}{\sigma^2} - 2 \right) e^{\frac{-(x^2+y^2)}{2\sigma^2}}\end{aligned}$$



Top 3 hits Google: “Laplacian of Gaussian”

$$LoG(x, y) = -\frac{1}{\pi\sigma^4} \left[1 - \frac{x^2 + y^2}{2\sigma^2} \right] e^{-\frac{x^2 + y^2}{2\sigma^2}}$$

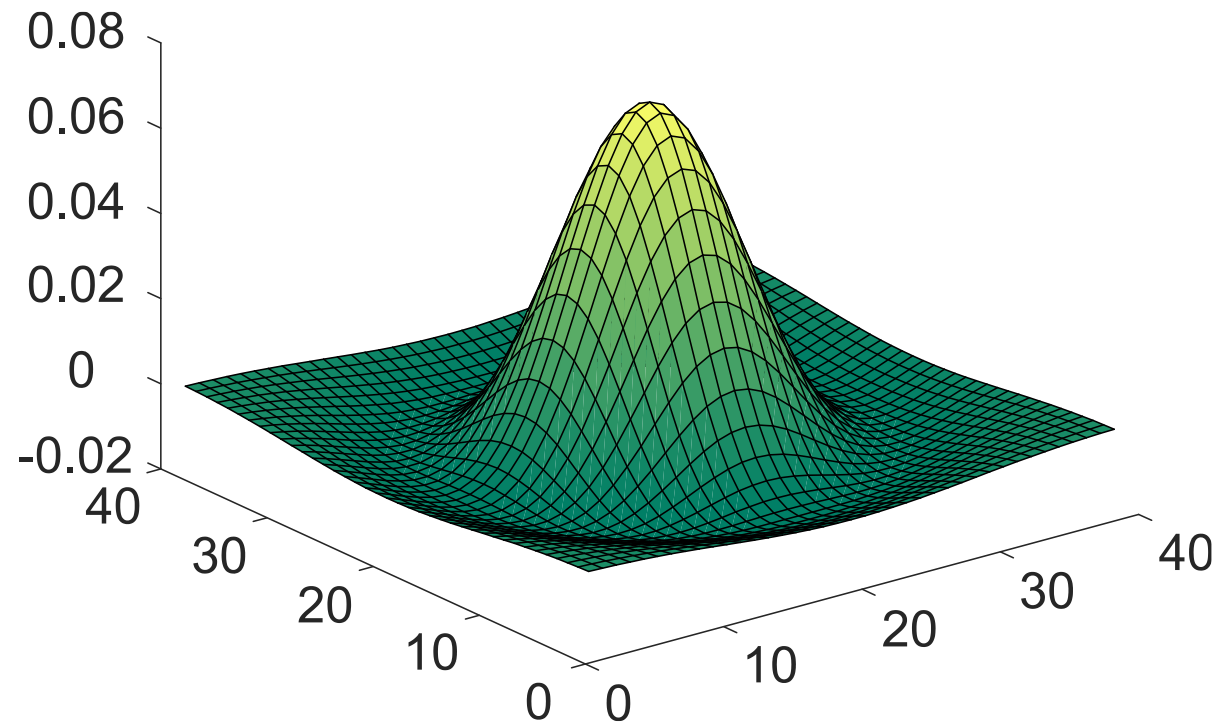
$$LoG \triangleq \Delta G_\sigma(x, y) = \frac{\partial^2}{\partial x^2} G_\sigma(x, y) + \frac{\partial^2}{\partial y^2} G_\sigma(x, y) = \frac{x^2 + y^2 - 2\sigma^2}{\sigma^4} e^{-(x^2 + y^2)/2\sigma^2}$$


$$LoG(x, y) = -\frac{1}{\pi\sigma^4} \left[1 - \frac{x^2 + y^2}{2\sigma^2} \right] e^{-\frac{x^2 + y^2}{2\sigma^2}}$$

- **Two** wrong, **one** right. Just one.....why?
(and two of them don't even work!!)

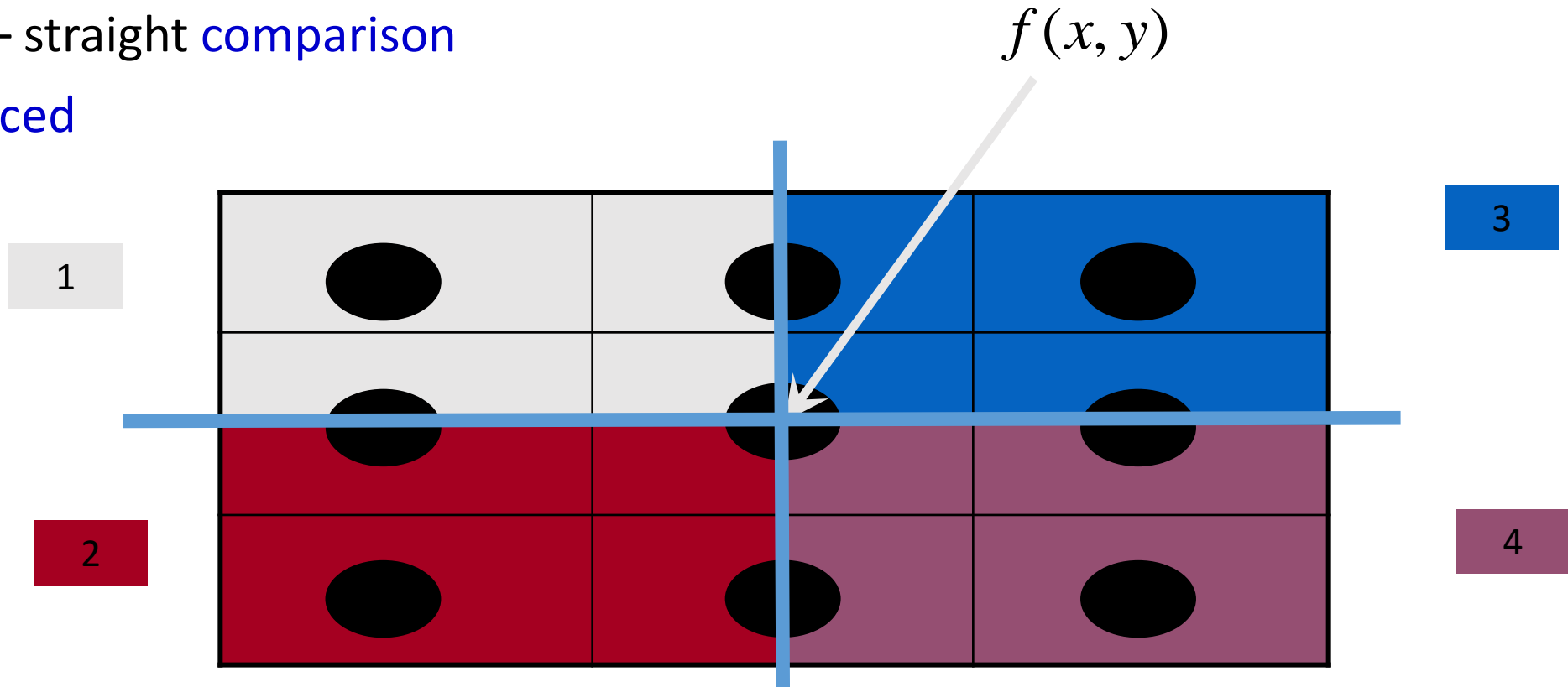
<http://homepages.inf.ed.ac.uk/rbf/HIPR2/log.htm>; <http://fourier.eng.hmc.edu/e161/lectures/gradient/node8.html> ;
<http://academic.mu.edu/phys/matthysd/web226/Lab02.htm>

Shape of Laplacian of Gaussian operator



Zero crossing detection

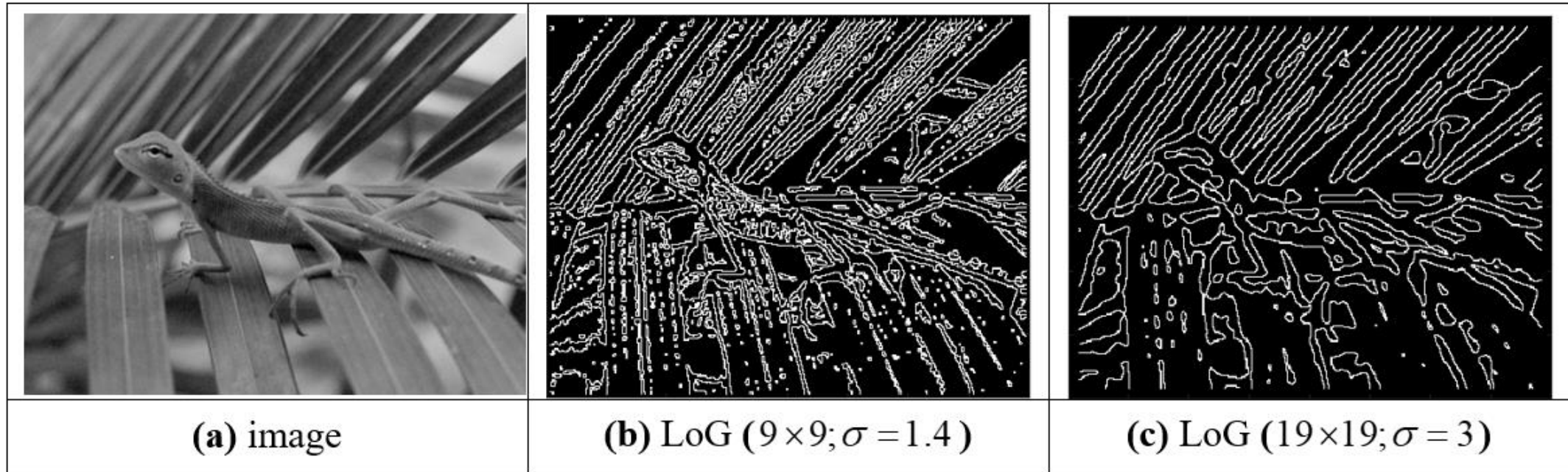
- Basic – straight comparison
- Advanced



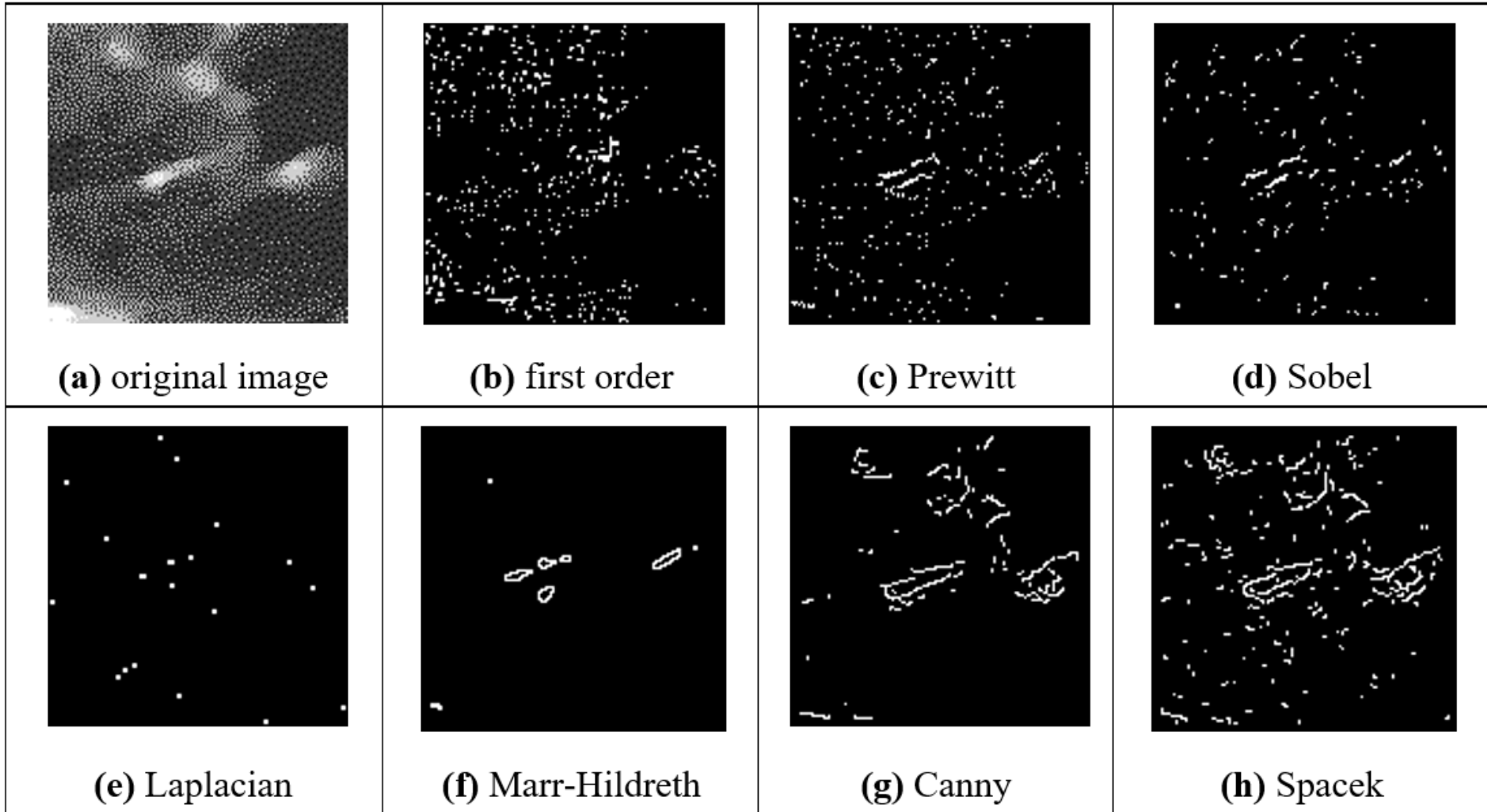
$IF (\max(1, 2, 3, 4) > 0 \wedge \min(1, 2, 3, 4) < 0) \quad THEN \quad f(x, y) = \text{edge}$



Marr-Hildreth edge detection

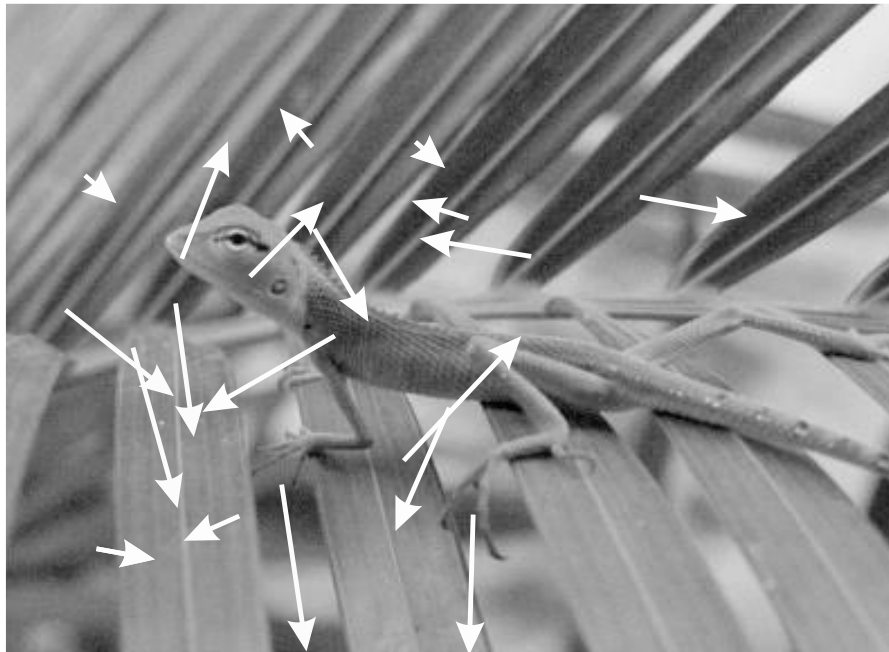


Comparison of edge detection operators



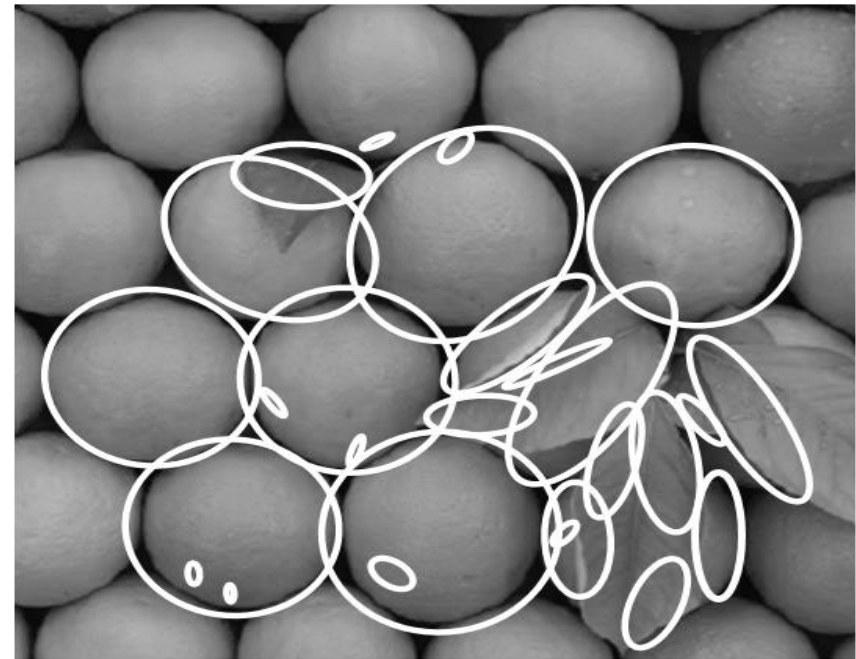
Newer stuff – interest detections

feature points



SIFT (mega famous)
(wait for Jon)

regions



brightness clustering
(excellent, but confess it's ours)

Lomeli-R. and Nixon and Carter, *Mach Vis Apps* 2016

Newer stuff – saliency

