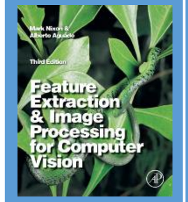
Lecture 7 Further Edge Detection

COMP3204 & COMP6223 Computer Vision

What better ways are there to detect edges?



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Department of
Electronics and
Computer Science

UNIVERSITY OF
Southampton
School of Electronics
and Computer Science

Applying Sobel operator

(a) original image (b) Sobel edge magnitude (c) thresholded magnitude

Stages in Canny edge detection operator

(a) Gaussian smoothing	(b) Sobel edge detection	(c) non-maximum suppression	(d) hysteresis thresholding

Stages in Canny Edge Detection

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.

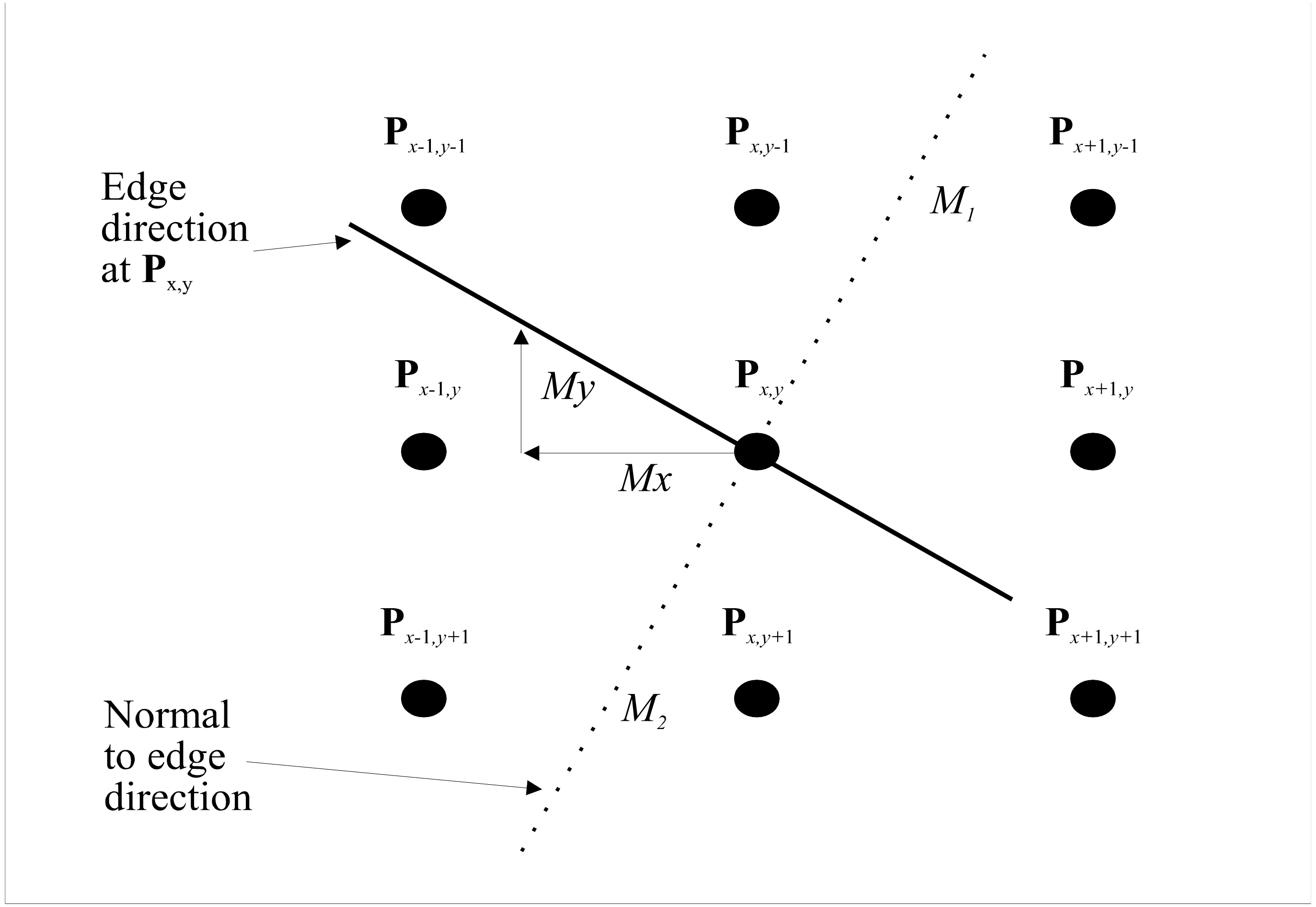
Approximation

1. use Gaussian smoothing;
2. use the Sobel operator;

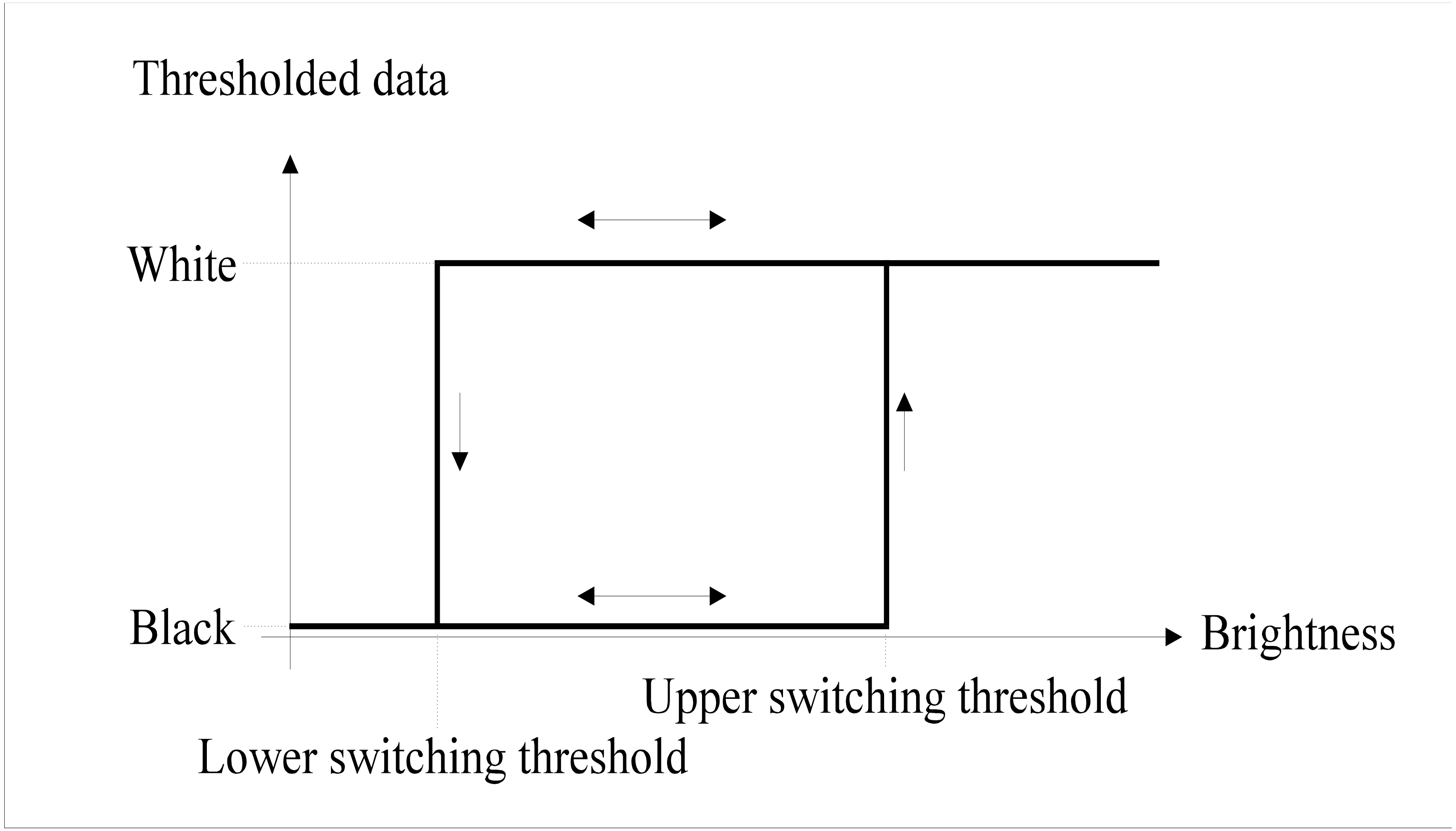
combine?

3. use non-maximal suppression; and
4. threshold with hysteresis to connect edge points.

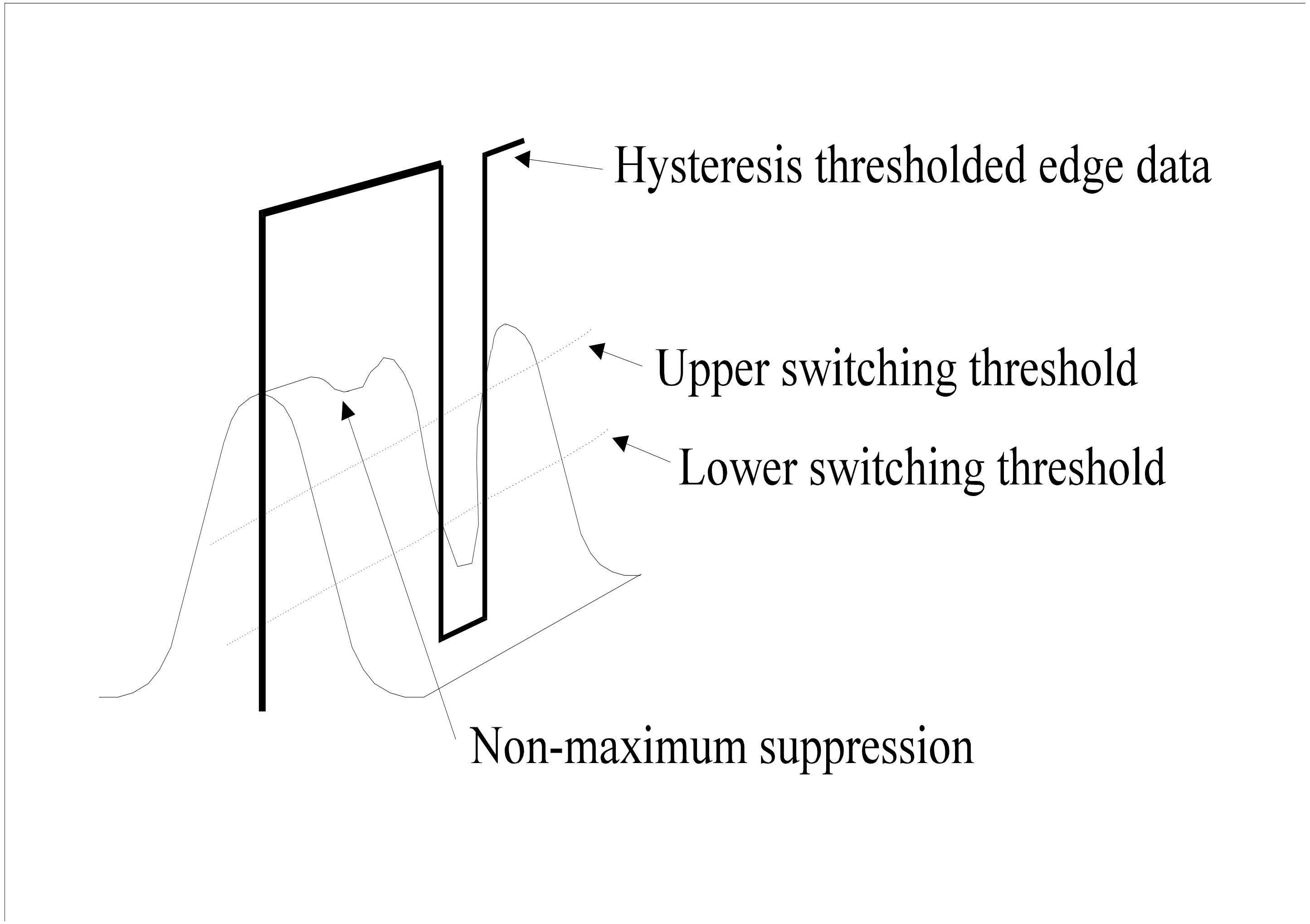
Interpolation in non-maximum suppression



Hysteresis thresholding transfer function



Action of non-maximum suppression and hysteresis thresholding



Comparing hysteresis thresholding with uniform thresholding

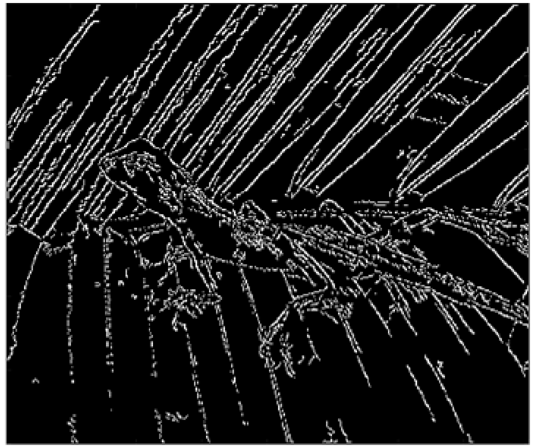
(a) hysteresis thresholding, upper level = 40, lower level = 10

(b) uniform thresholding, level = 40

(c) uniform thresholding, level = 10

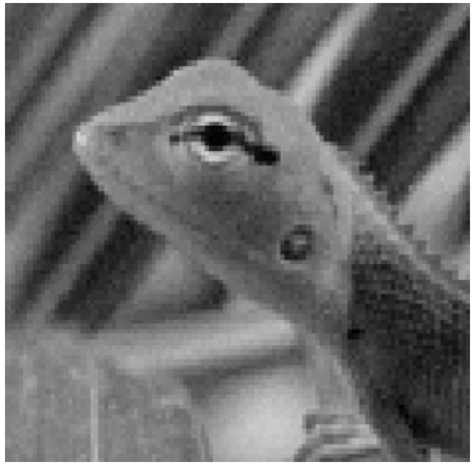
Comparing Canny with Sobel

(a) original image



(b) Canny

(c) Sobel

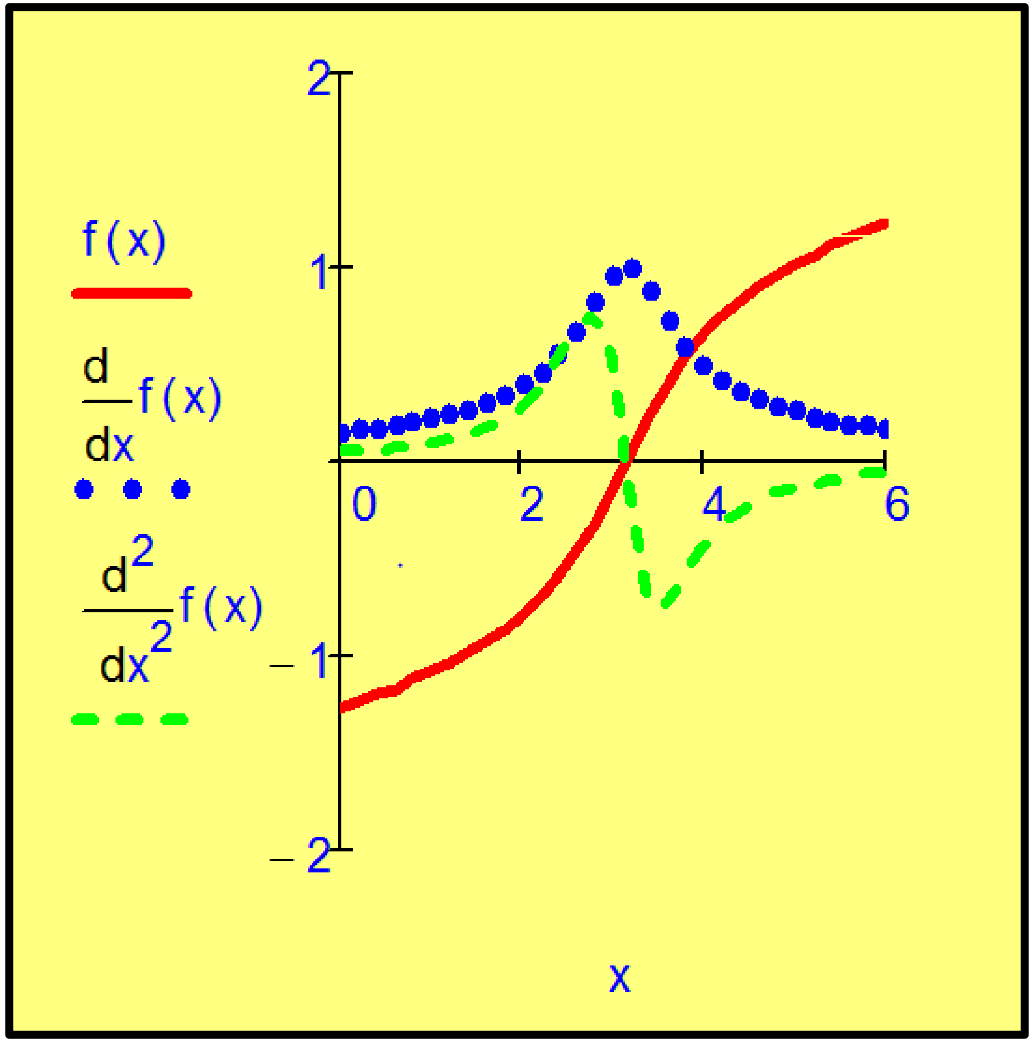


(d) detail of (a)

(e) detail of (b)

(f) detail of (c)

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
2	2	3	0	1	2	2	1
3	0	38	39	37	36	3	0
4	1	40	44	41	42	2	1
1	2	43	44	40	39	3	1
2	0	39	41	42	40	2	0
0	2	0	2	2	3	1	1
0	2	1	3	1	0	4	2

(a) image data

0	0	0	0	0	0	0	0
0	1	−31	−47	−36	−32	0	0
0	−44	70	37	31	60	−28	0
0	−42	34	12	1	50	−41	0
0	−37	47	8	−6	31	−32	0
0	−45	72	37	45	74	−36	0
0	6	−44	−38	−40	−31	−6	0
0	0	0	0	0	0	0	0

(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: “Lalpacian of Gaussian”

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

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

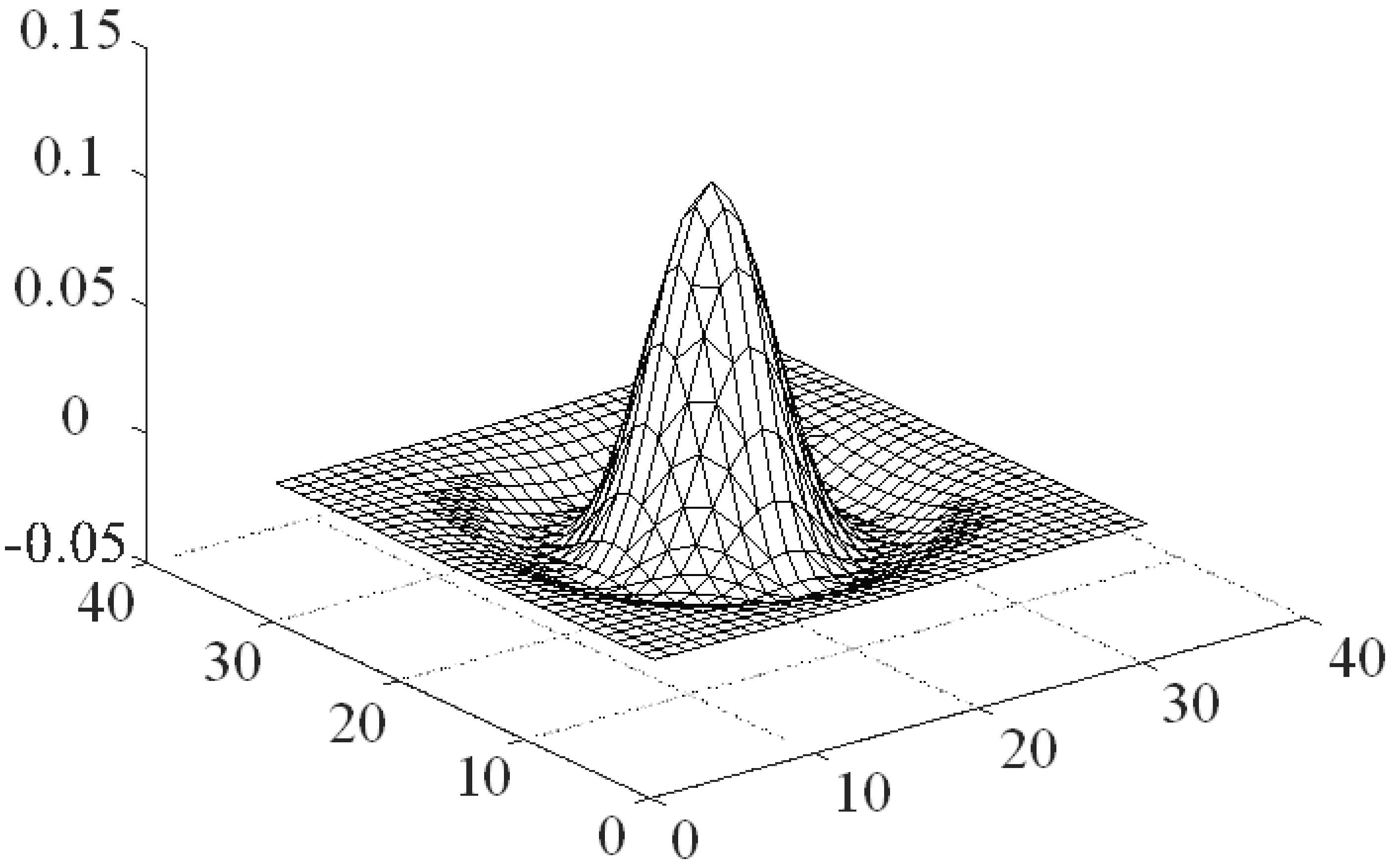
$$\mathrm{LoG}(x,y) = -\frac{1}{\pi\sigma^4}\left[1 - \frac{x^2+y^2}{2\sigma^2}\right] e^{-\frac{x^2+y^2}{2\sigma^2}}$$

- Two wrong, one right. Just one.....why?

    (and two of them don’t even work!!)

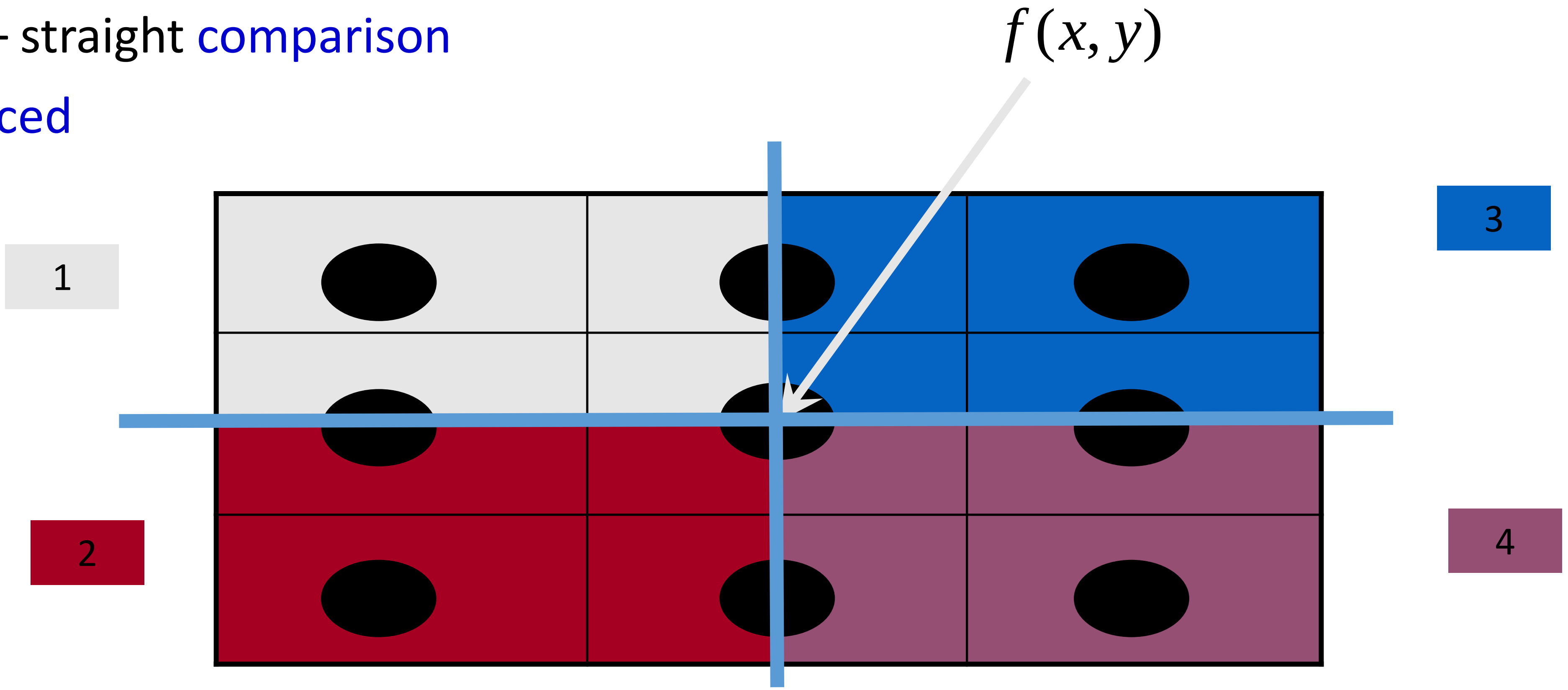
http://homepages.inf.ed.ac.uk/rbf/HIPR2/log.htm; http://fourier.eng.hmc.edu/e161/lectures/gradient/node8.html ; http://academic.mu.edu/phys/matthysd/web226/Lab02.htm

Shape of Laplacian of Gaussian operator



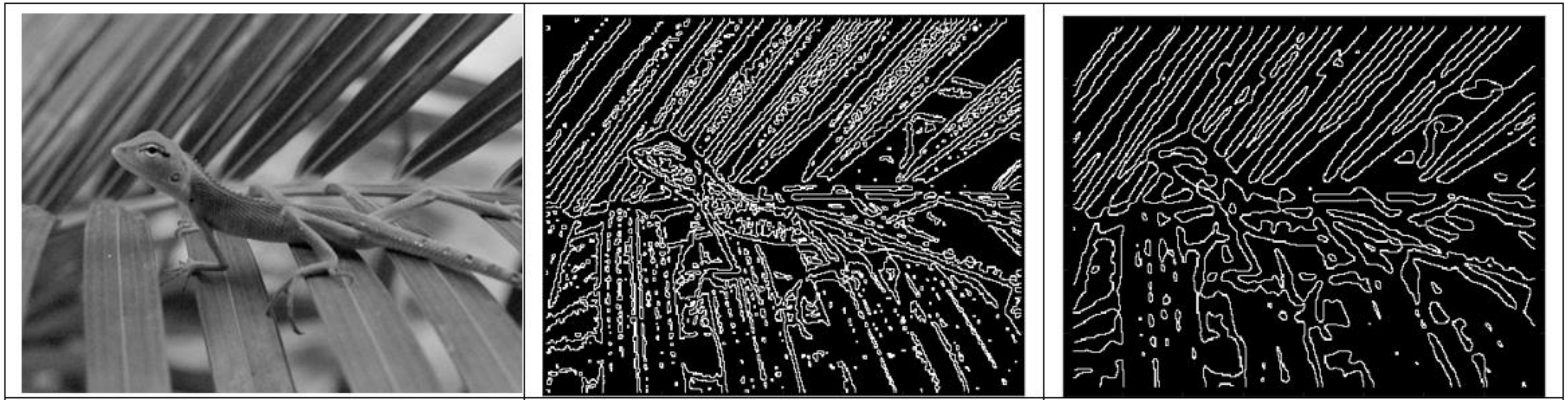
Zero crossing detection

- Basic – straight comparison
- Advanced



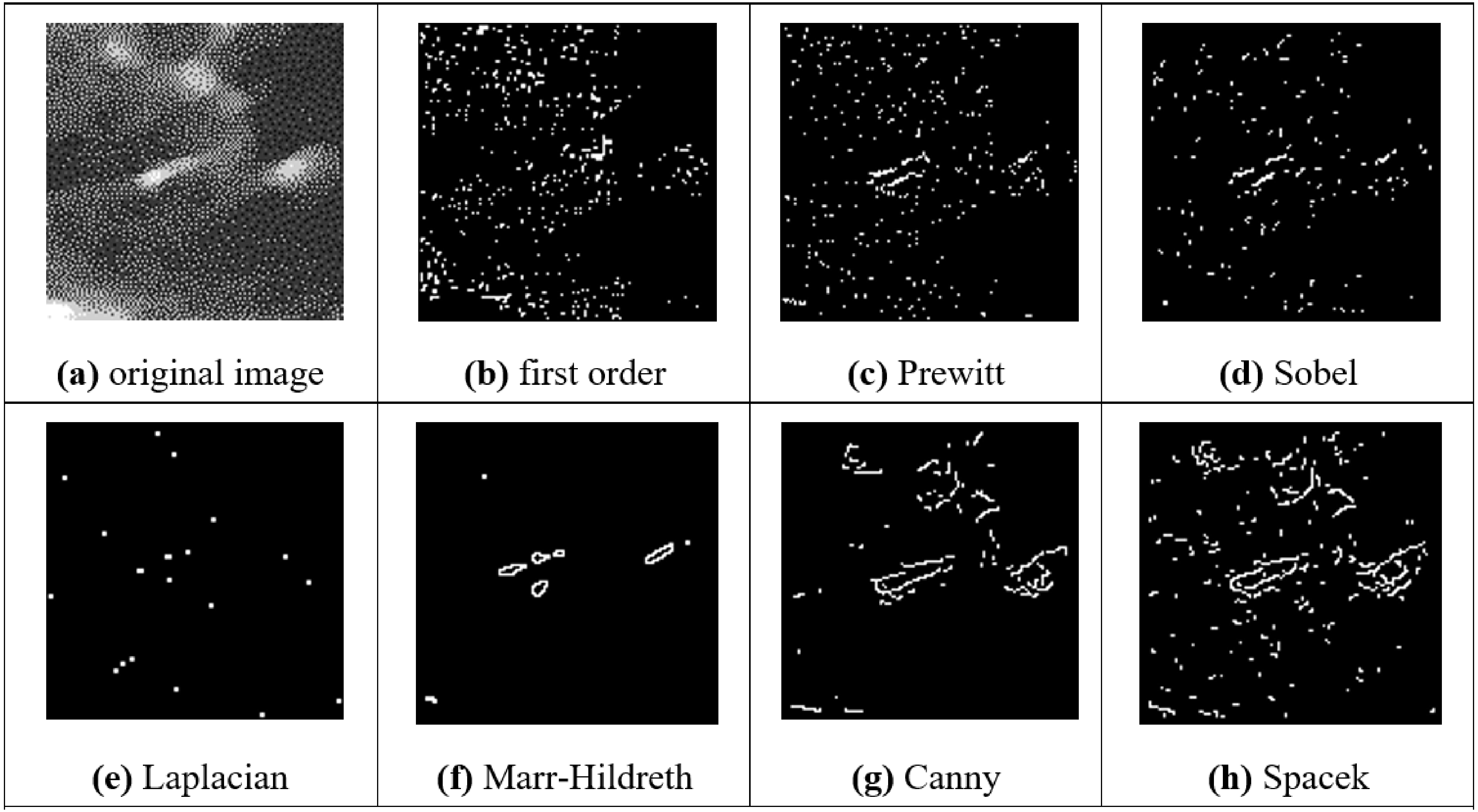
$$IF\left(\max(1,2,3,4)>0 \wedge \min(1,2,3,4)<0\right) \quad THEN \quad f(x,y)=\text{edge}$$

Marr-Hildreth edge detection



(a) image	(b) LoG $(9\times9;\sigma=1.4)$	(c) LoG $(19\times19;\sigma=3)$

Comparison of edge detection operators

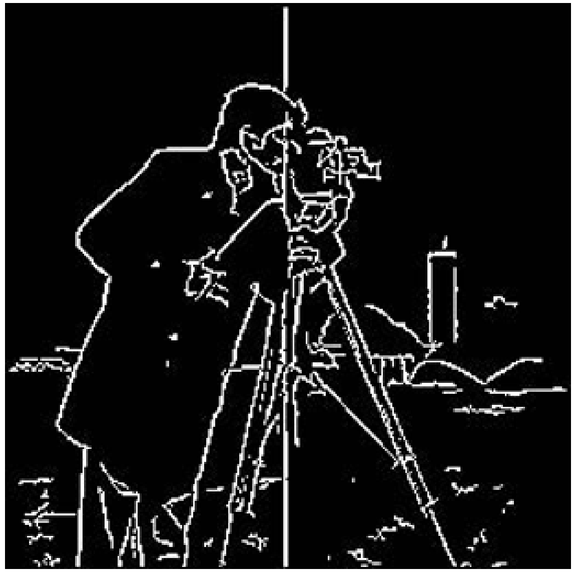


(a) original image (b) first order (c) Prewitt (d) Sobel

(e) Laplacian (f) Marr-Hildreth (g) Canny (h) Spacek

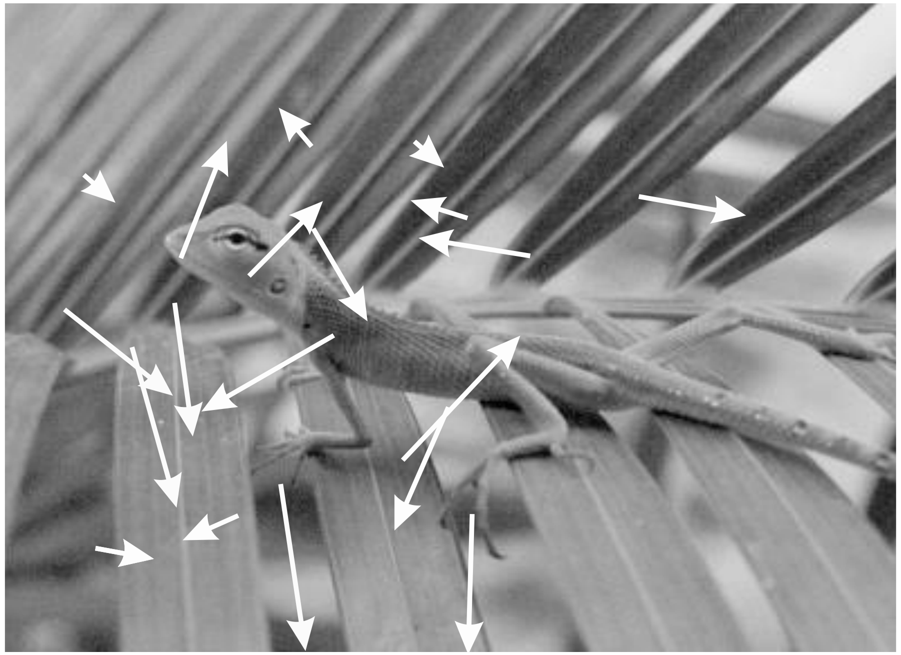
Newer stuff - phase congruency

- Immune to overall change in brightness (wow!!)

		
(a) modified cameraman image	**(b)** edges by the Canny operator	**(c)** phase congruency

Newer stuff – interest detections

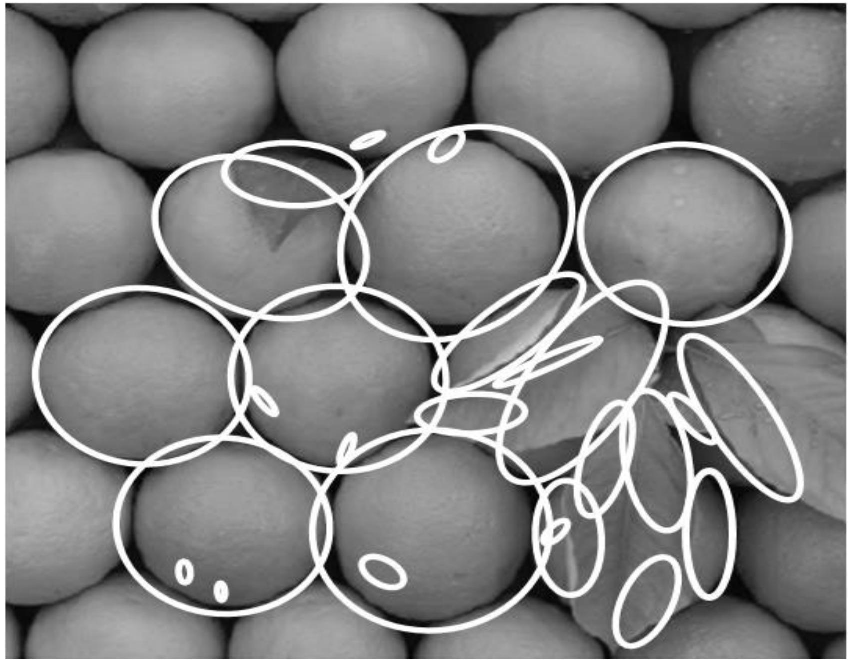
feature points



SIFT (mega famous)

(wait for Jon)

regions



brightness clustering

(excellent, but confess its ours)

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