Lecture 4 Point Operators

COMP3204 Computer Vision

How many different operators are there which operate on image points?

Book
pp
84-95

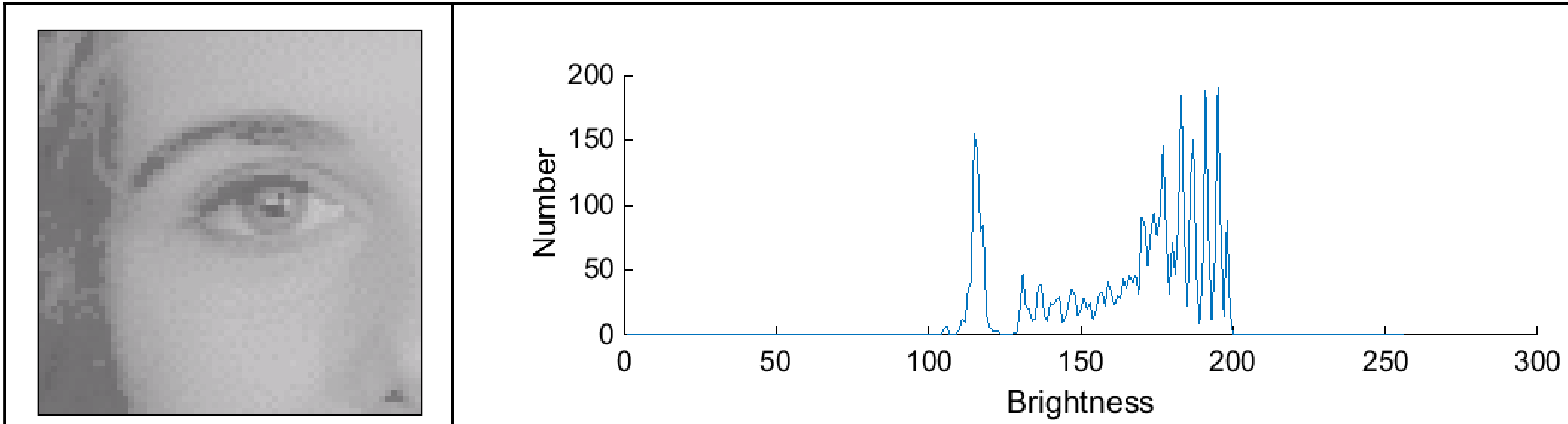
Department of
Electronics and
Computer Science

UNIVERSITY OF
Southampton
School of Electronics
and Computer Science

Content

1. How do we best display images?
2. What operators are available which work solely on image points?

An image and its histogram



(a) image of an eye

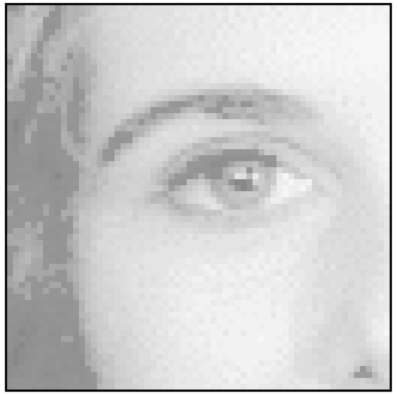
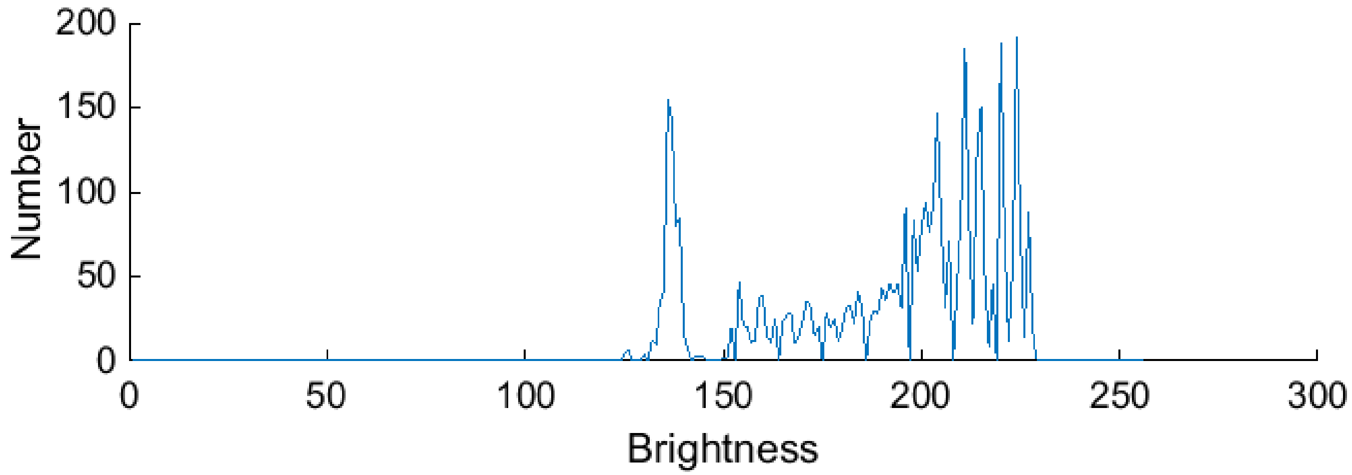
(b) histogram of eye image

The histogram shows contrast

Brightening an image

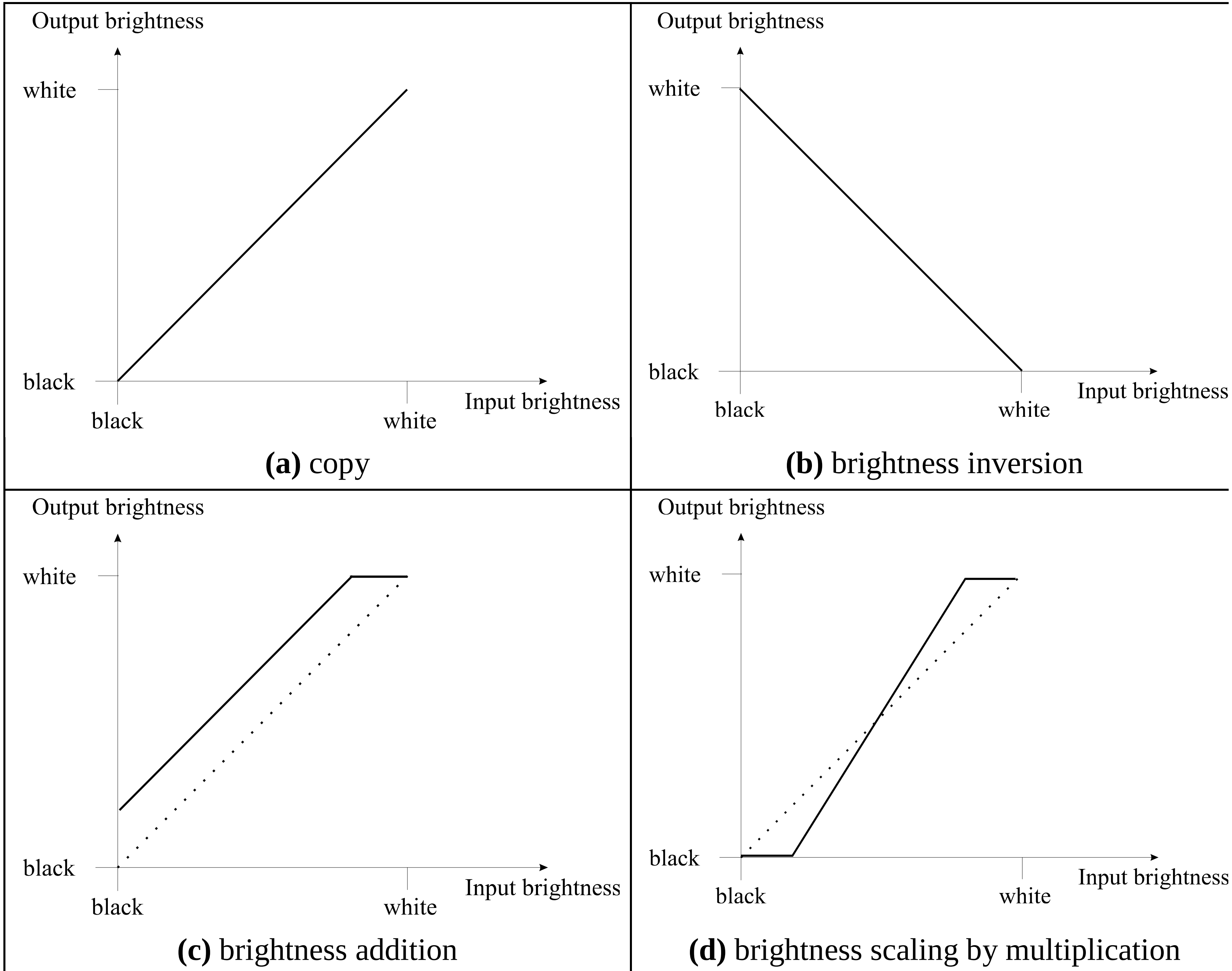
$$\mathbf{N}_{x,y} = k \times \mathbf{O}_{x,y} + l$$

new image **N**; old image **O**; gain *k*; level *l*; co-ordinates *x*,*y*

 **(a)** image of brighter eye	 **(b)** histogram of brighter eye

Then choose values for *k* and *l*

Intensity mappings



(a) copy

(b) brightness inversion

(c) brightness addition

(d) brightness scaling by multiplication

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FOURTH EDITION

MARK NIXON

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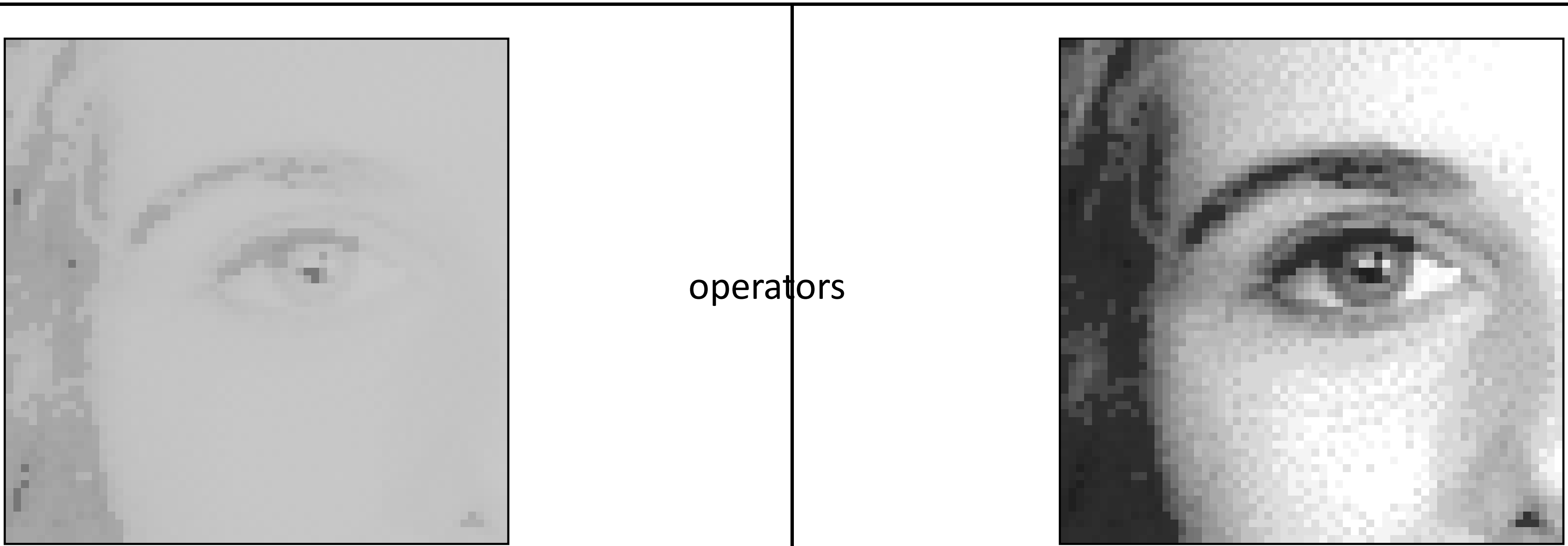
Applying exponential and logarithmic point operators



operators

(a) logarithmic compression

(b) exponential expansion

$$\mathbf{N}_{x,y} = \log\left(\mathbf{O}_{x,y}\right)$$

Brightness compression

$$\mathbf{N}_{x,y} = \exp\left(\mathbf{O}_{x,y}\right).$$

Brightness expansion

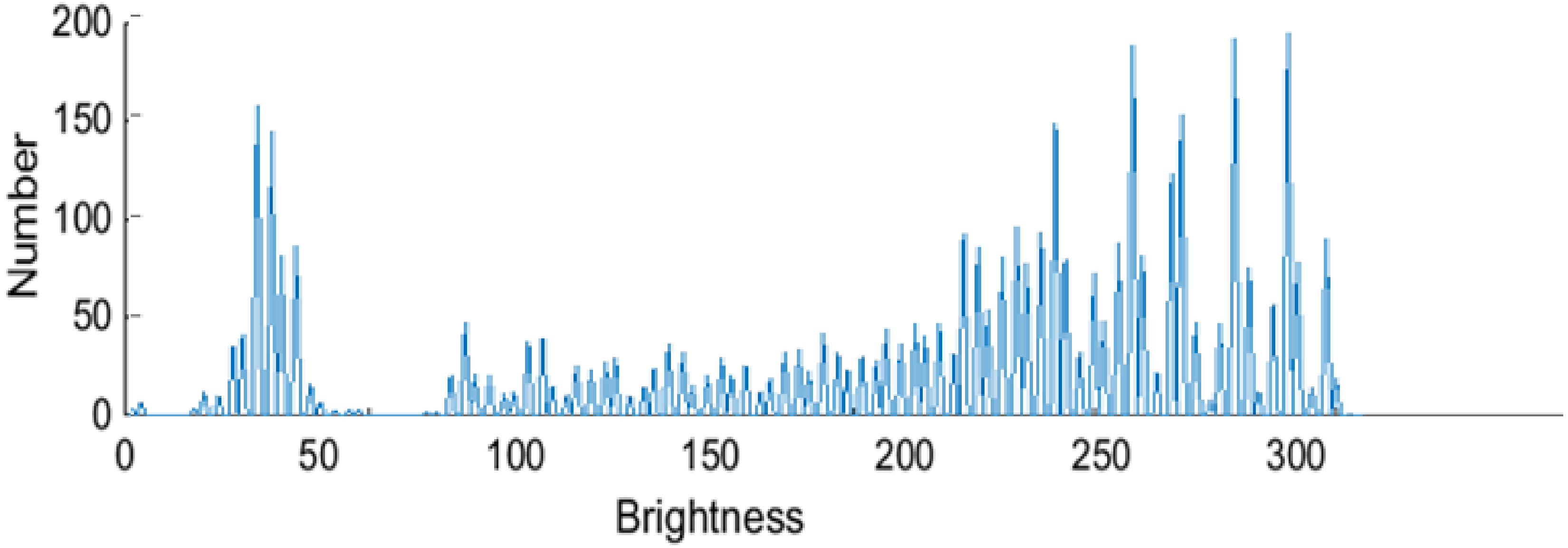
Intensity normalisation - function

Aim is to use all available grey levels for display

Original histogram

Shift origin to zero

Scale brightness to use whole range



Intensity normalisation

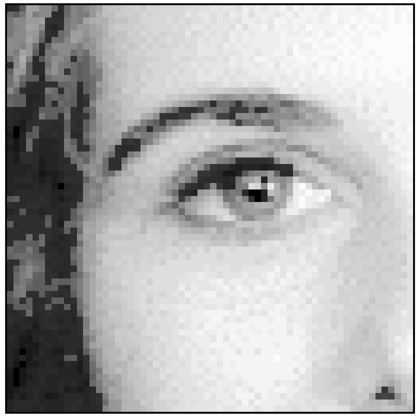
$$\mathbf{N}_{x,y} = \frac{\mathbf{N}max - \mathbf{N}min}{\mathbf{O}max - \mathbf{O}min} \times \left(\mathbf{O}_{x,y} - \mathbf{O}min\right) + \mathbf{N}min \qquad \forall x, y \in 1, N$$

new image **N**; old image **O**; co-ordinates *x,y*
minimum input **N***min*
maximum input **N***max*
minimum output **O***min*
maximum output **O***max*

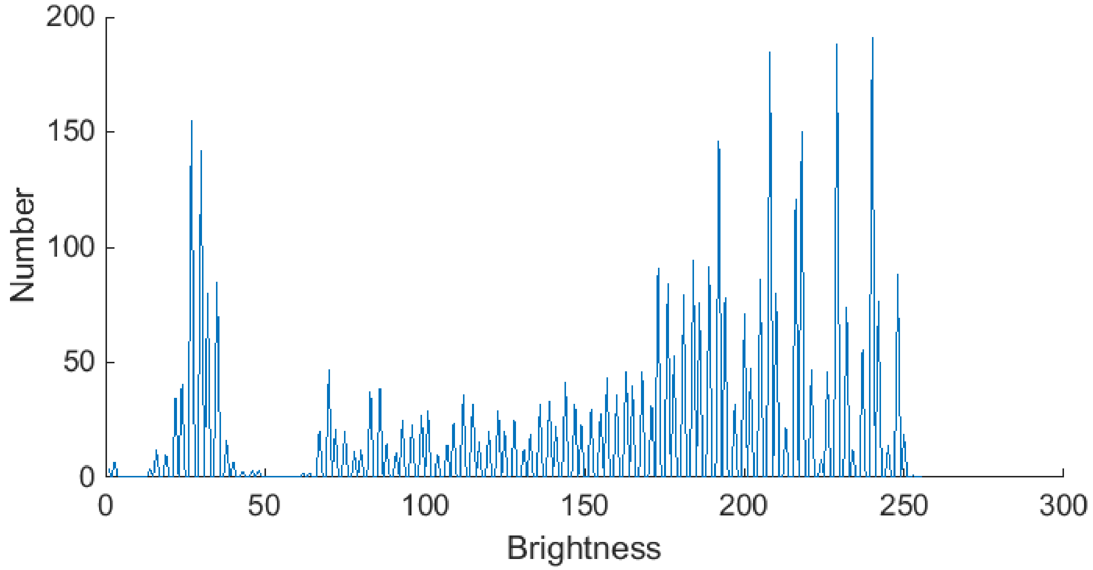
$$\mathbf{N}_{x,y} = \frac{256}{\mathbf{O}max - \mathbf{O}min} \times \left(\mathbf{O}_{x,y} - \mathbf{O}min\right)$$

Avoids need for parameter choice

Intensity normalisation and histogram equalisation



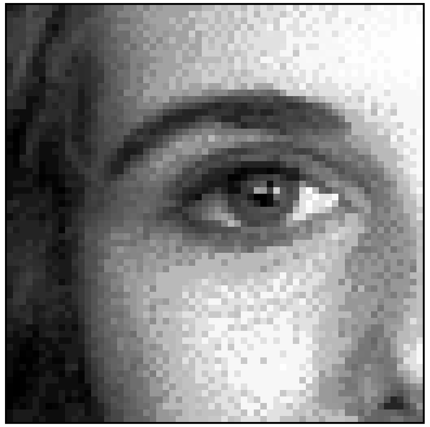
(a) intensity normalised eye



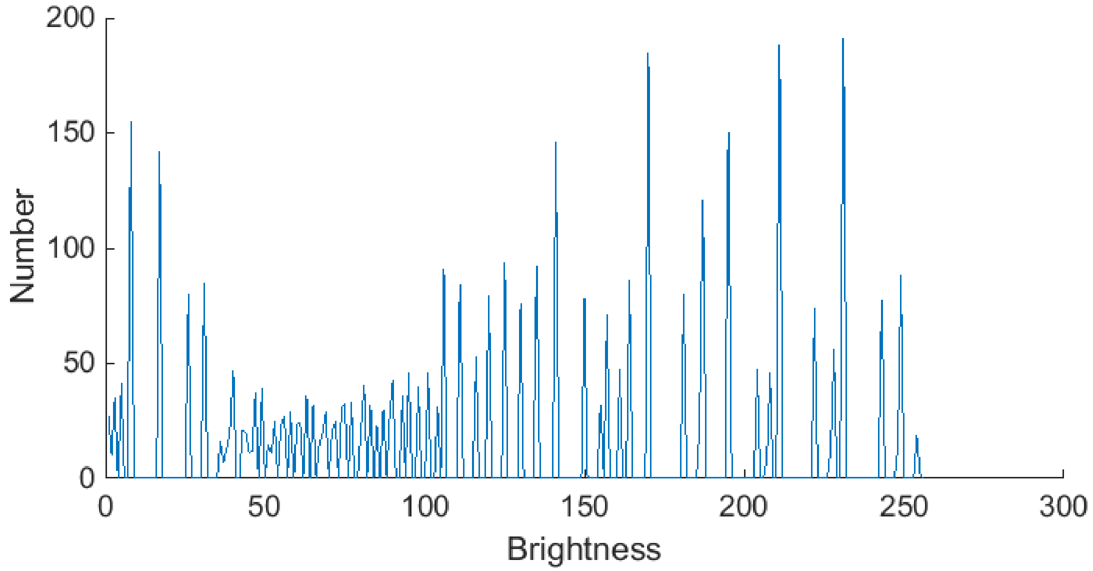
(b) histogram of intensity normalised eye

Grey levels all 'weigh' the same

Used in Matlab's `imagesc`



(c) histogram equalised eye



(d) histogram of histogram equalised eye

Grey levels have different weights

Aimed for human vision

Histogram Equalisation – aim is a flat histpgram

*N*² points in the image; the sum of points per level is equal in equalised and original image

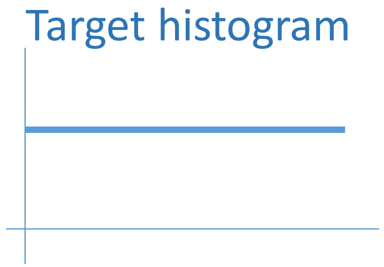
$$\sum_{l=0}^{M}\mathbf{O}(l)=\sum_{l=0}^{M}\mathbf{N}(l)$$

cumulative histogram up to level *p* should be transformed to cover up to the level *q*

$$\sum_{l=0}^{p}\mathbf{O}(l)=\sum_{l=0}^{q}\mathbf{N}(l)$$

number of points per level in the output picture

$$\mathbf{N}(l)=\frac{N^2}{\mathbf{N}max-\mathbf{N}min}$$



cumulative histogram of the output picture

$$\sum_{l=0}^{q}\mathbf{N}(l)=q\times\frac{N^2}{\mathbf{N}max-\mathbf{N}min}$$

mapping for the output pixels at level *q*

$$q=\frac{\mathbf{N}max-\mathbf{N}min}{N^2}\times\sum_{l=0}^{p}\mathbf{O}(l)$$

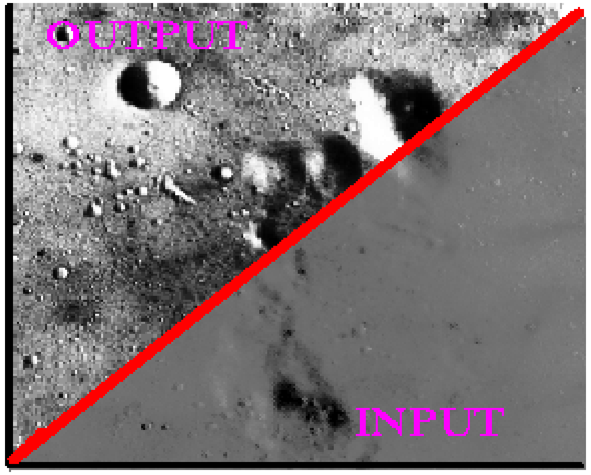
Often used in medical image analysis

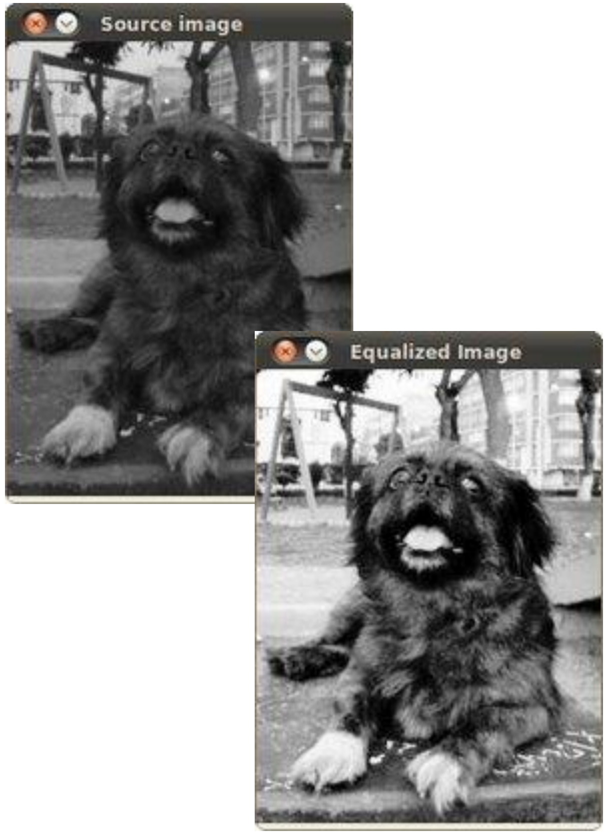
Effective ... but ... nonlinear and major problems with noise

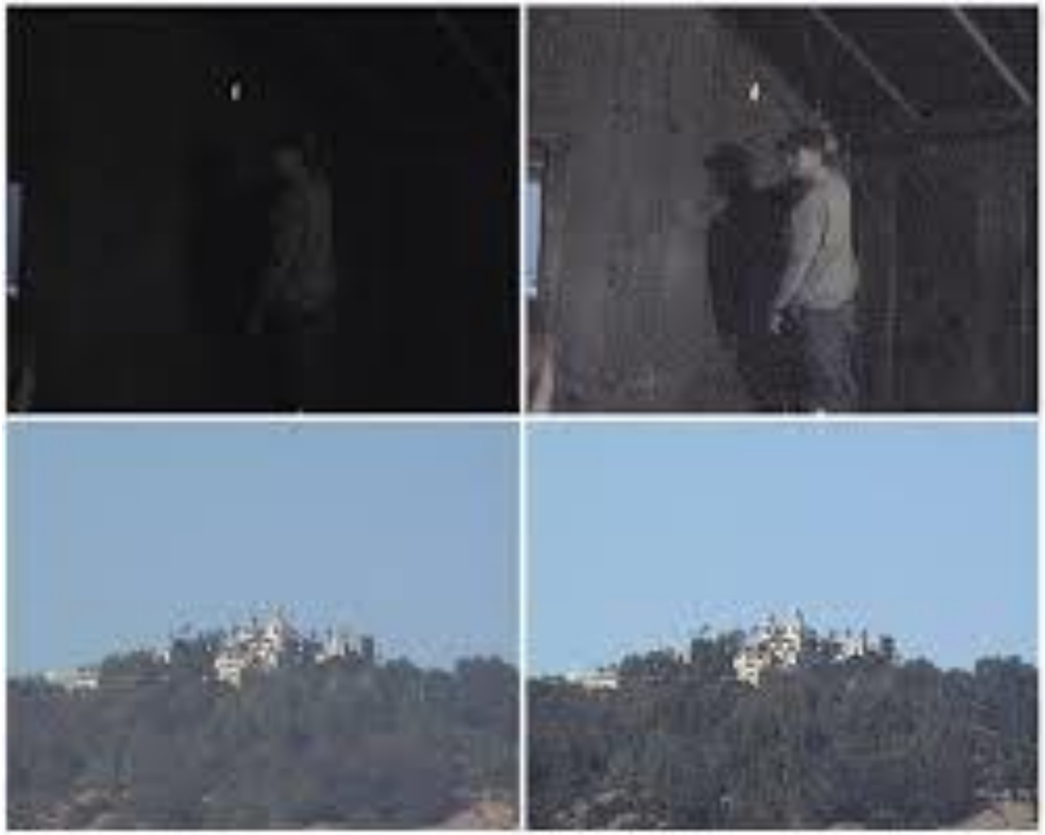
Fireside time

All this maths is a bit of a d’oh. Do we need it with deep learning?

Applying intensity normalisation and histogram equalisation





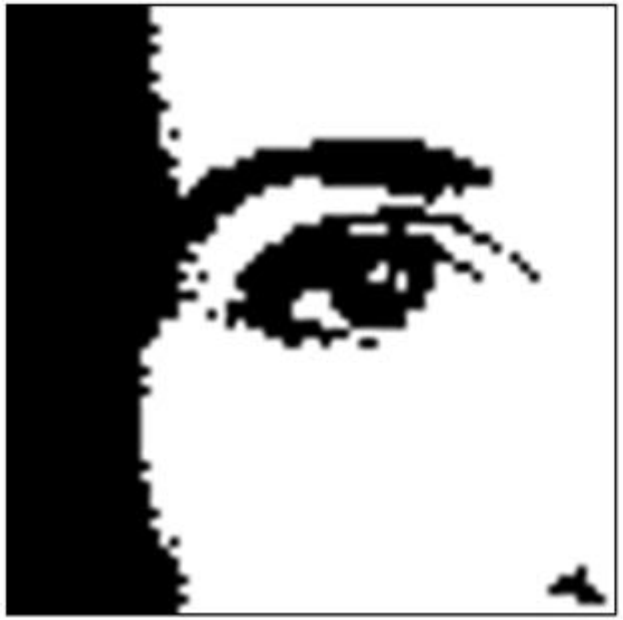


http://homepages.inf.ed.ac.uk/rbf/HIPR2/histeq.htm;
http://docs.opencv.org/doc/tutorials/imgproc/histograms/histogram_equalization/histogram_equalization.html ;
http://www.softpedia.com/get/Multimedia/Video/Other-VIDEO-Tools/Easy-Histogram-Equalization.shtml

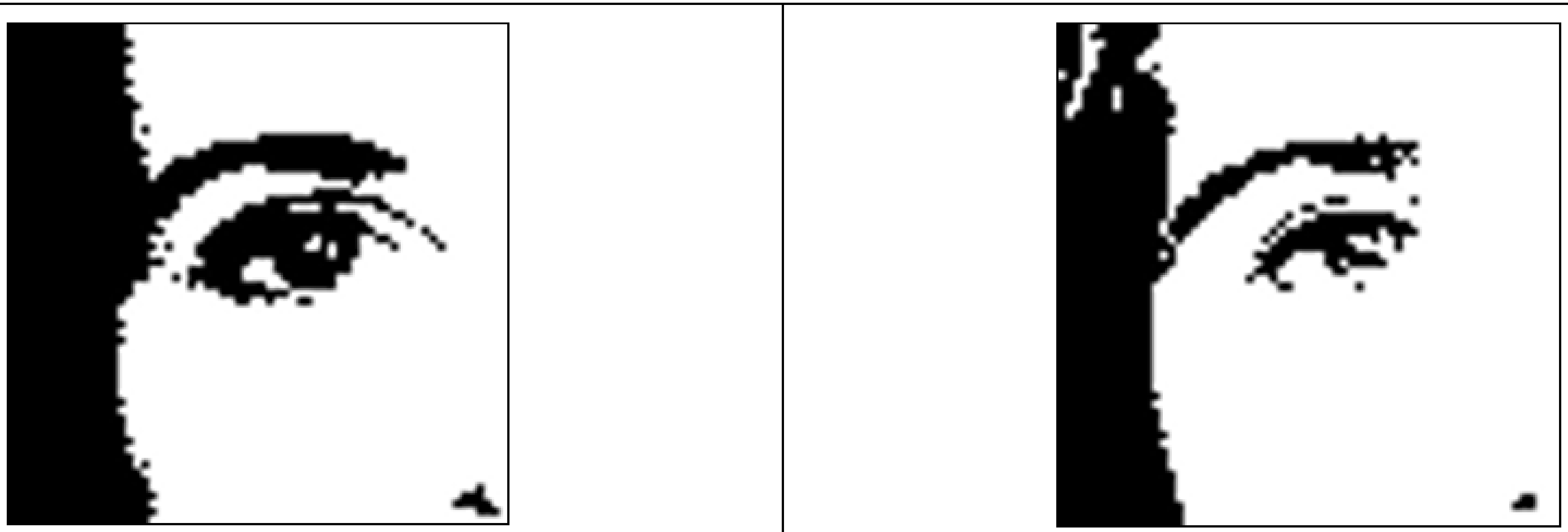
Thresholding an eye image

Thresholding selects points that exceed a chosen threshold

$$\mathbf{N}_{x,y} = \begin{cases} 255 & \text{if} \quad \mathbf{N}_{x,y} > \textit{threshold} \\ 0 & \textit{otherwise} \end{cases}$$



Thresholding an eye image: manual vs automatic



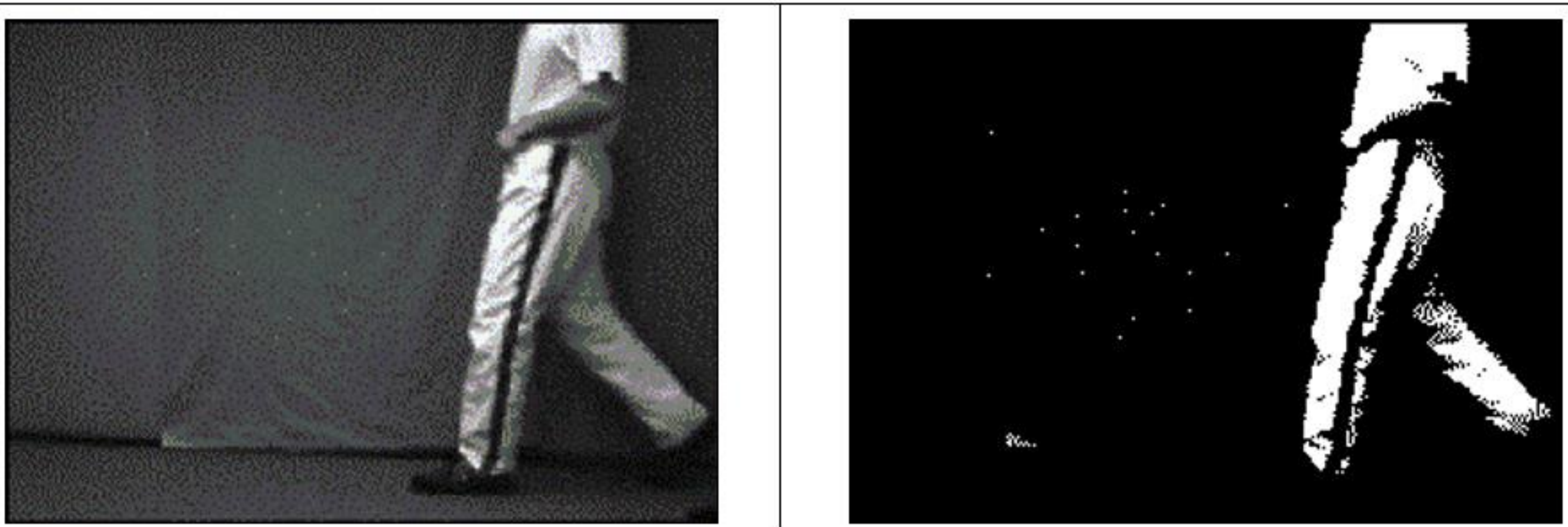
(a) thresholding at level 160

(b) thresholding by Otsu (level = 127)

Mark Nixon & Alberto Aguado
Third Edition
Feature Extraction & Image Processing for Computer Vision

Is optimal thresholding a myth??

Thresholding an image of a walking subject



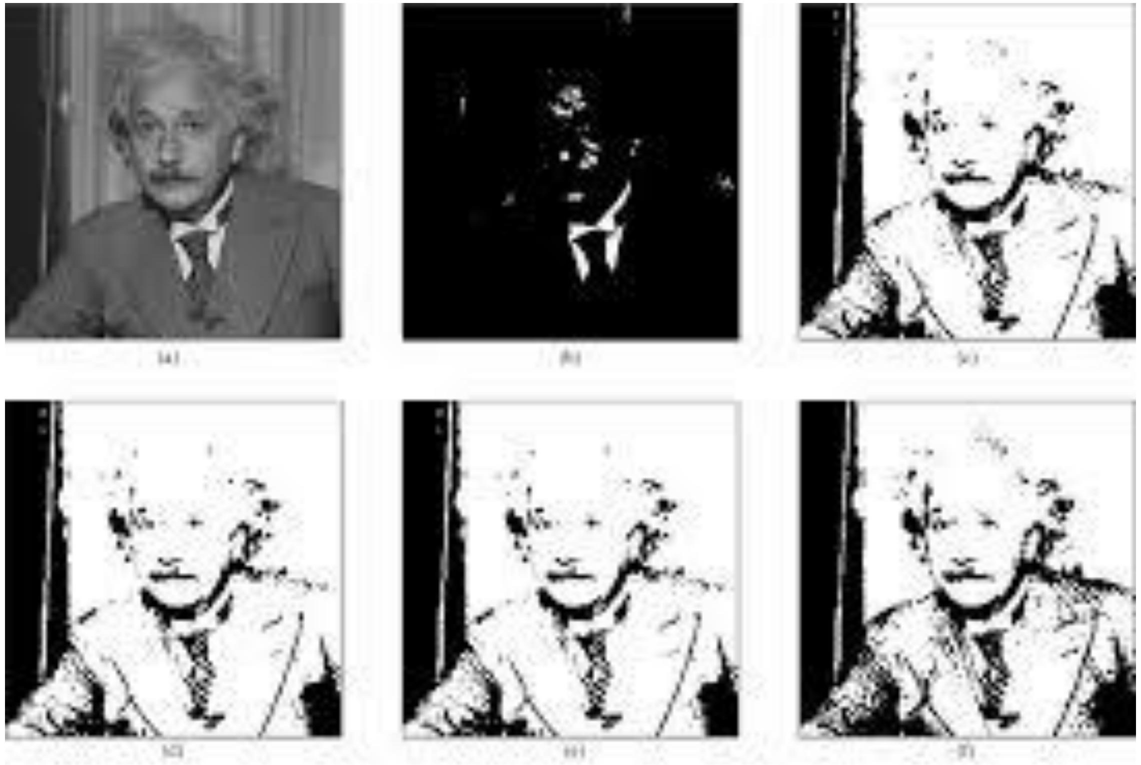
(a) walking subject

(b) automatic thresholding by Otsu

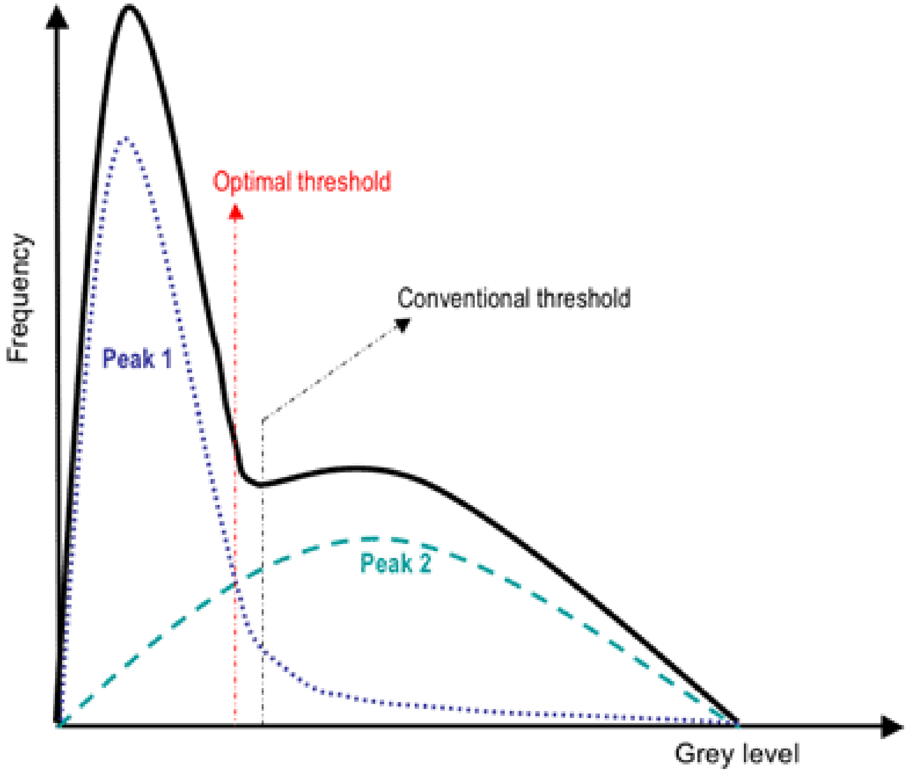
Many consider that shape concerns a higher level

Advanced thresholding

Entropic thresholding (2010)



Optimal thresholding



http://opticalengineering.spiedigitallibrary.org/article.aspx?articleid=1096546;
https://www.cs.auckland.ac.nz/courses/compsci773s1c/lectures/ImageProcessing-html/topic3.htm

Takeaway time

1. point operators are largely about image display
2. concern histogram manipulation
3. thresholding used a lot
4. intensity normalisation used for display

Need sets of points. That’s group operators, coming next.

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