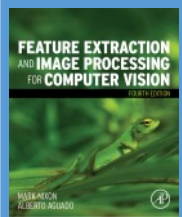


Lecture 4 Point Operators

COMP3204 Computer Vision

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



Book
pp
72-83

Department of
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Computer Science

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Southampton
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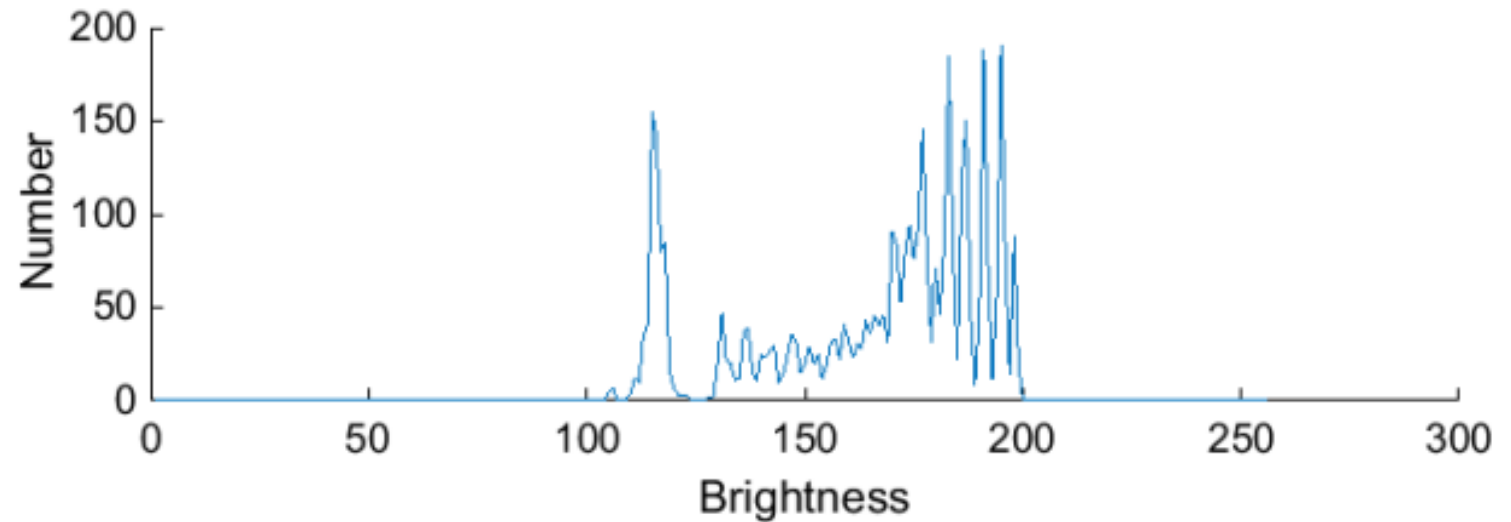
Content

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

An image and its histogram

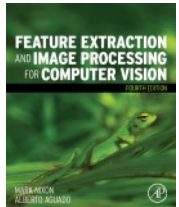


(a) image of an eye



(b) histogram of eye image

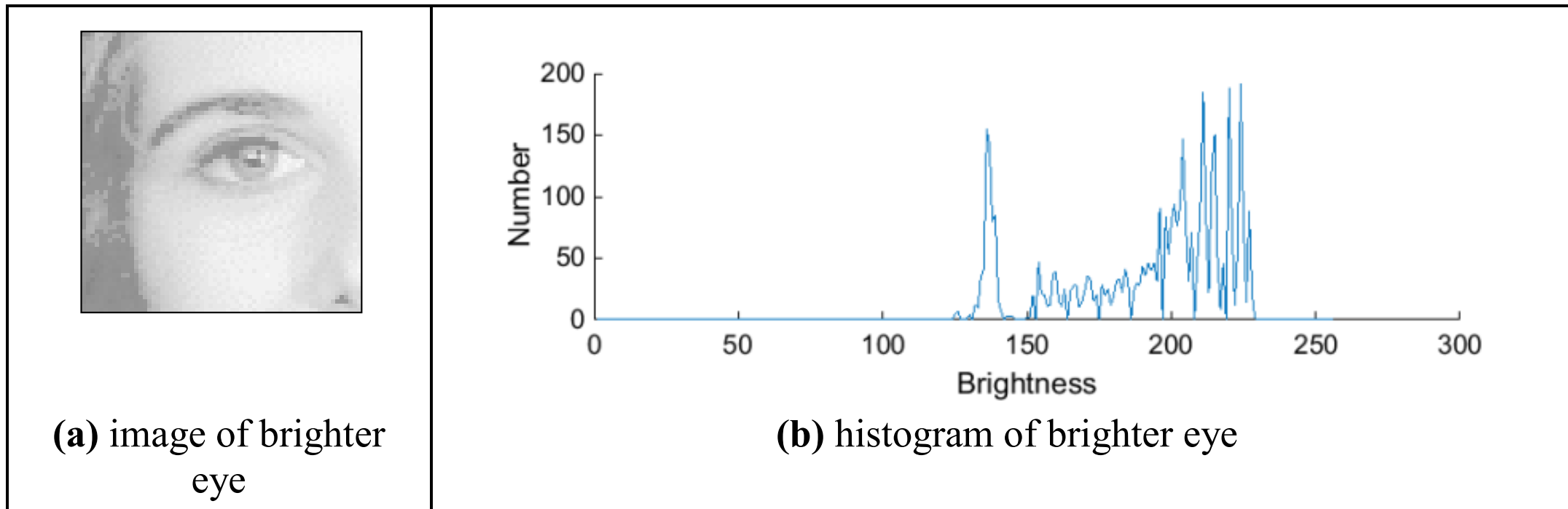
The histogram shows **contrast**



Brightening an image

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

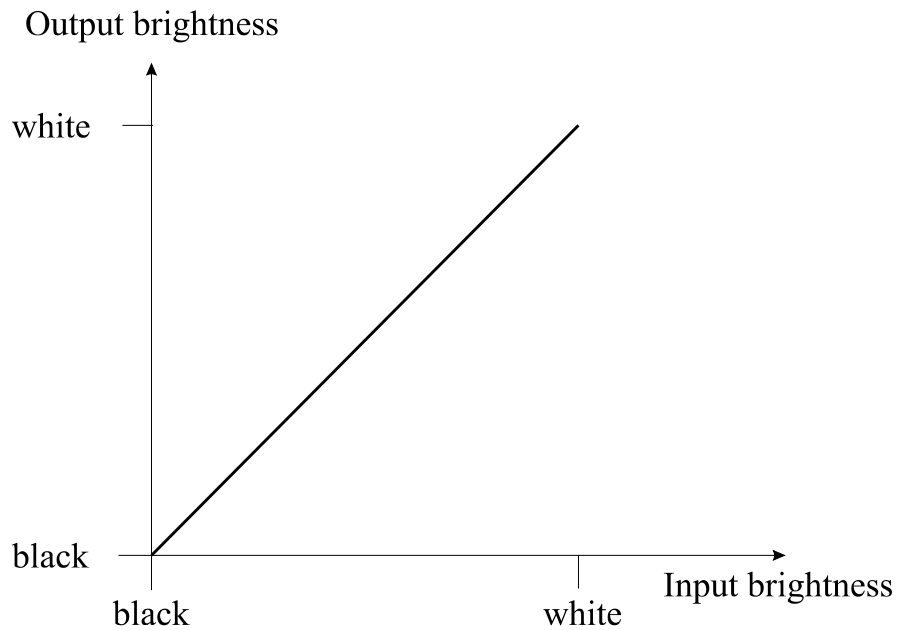
new image \mathbf{N} ; old image \mathbf{O} ; gain k ; level l ; co-ordinates x, y



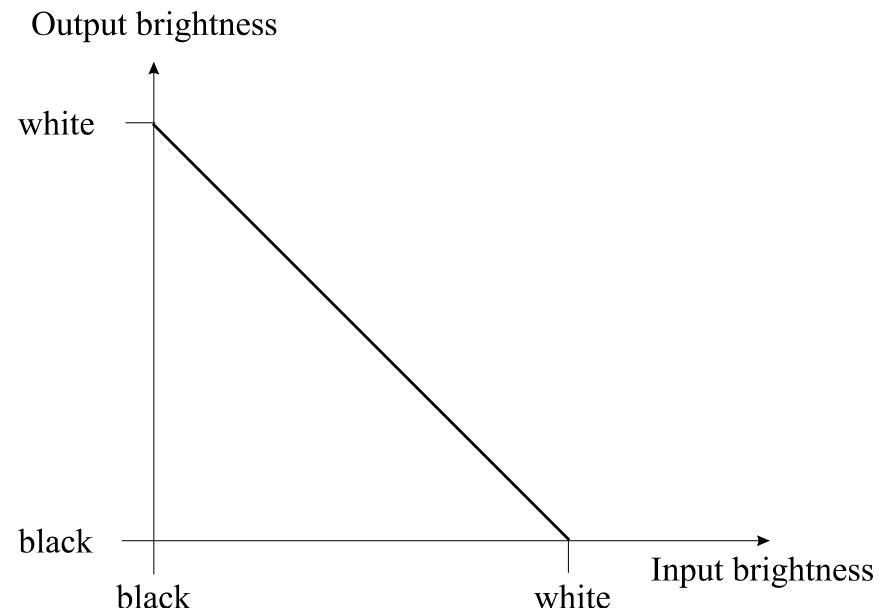
Then **choose** values for k and l



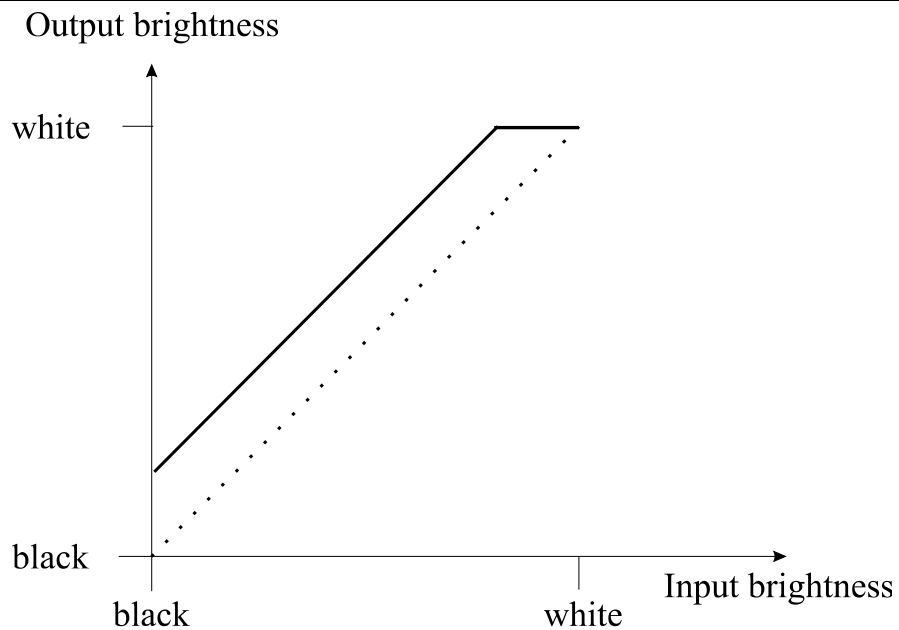
Intensity mappings



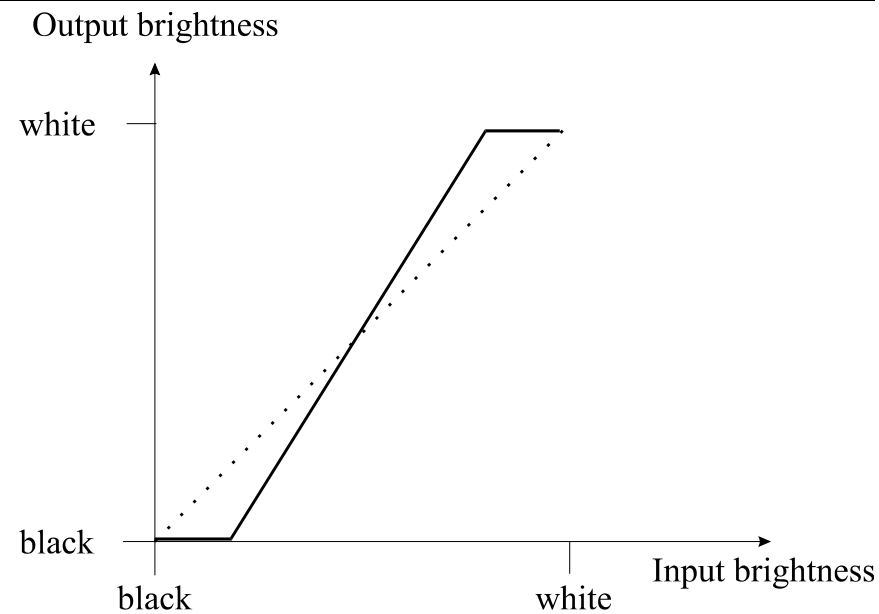
(a) copy



(b) brightness inversion



(c) brightness addition



(d) brightness scaling by multiplication



Applying exponential and logarithmic point operators



(a) logarithmic compression



(b) exponential expansion

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

Brightness compression

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

Brightness expansion

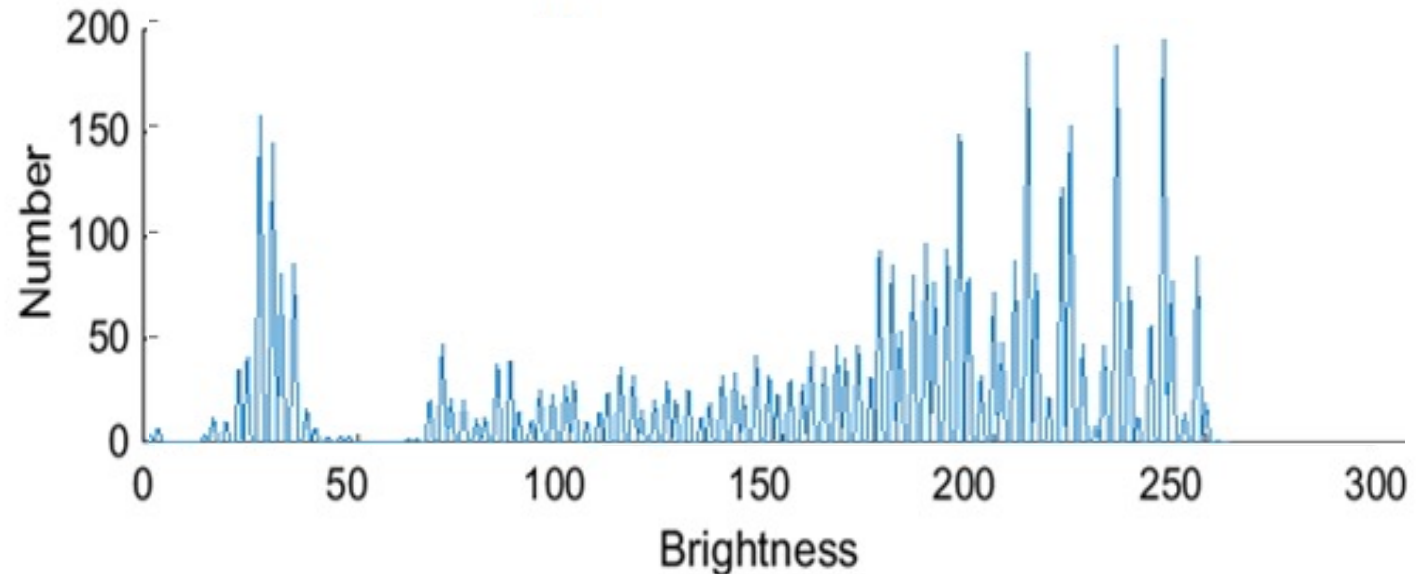
Intensity normalisation - function

Aim is to use **all** available grey levels for display

Original histogram

Shift origin to zero

Scale brightness to use whole range



Intensity normalisation

$$\mathbf{N}_{x,y} = \frac{\mathbf{Nmax} - \mathbf{Nmin}}{\mathbf{Omax} - \mathbf{Omin}} \times (\mathbf{O}_{x,y} - \mathbf{Omin}) + \mathbf{Nmin}$$

new image **N**; old image **O**; co-ordinates x, y

minimum new **Nmin**

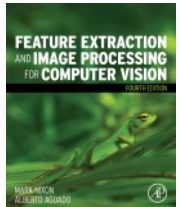
maximum new **Nmax**

minimum original **Omin**

maximum original **Omax**

$$\mathbf{N}_{x,y} = \frac{255}{\mathbf{Omax} - \mathbf{Omin}} \times (\mathbf{O}_{x,y} - \mathbf{Omin})$$

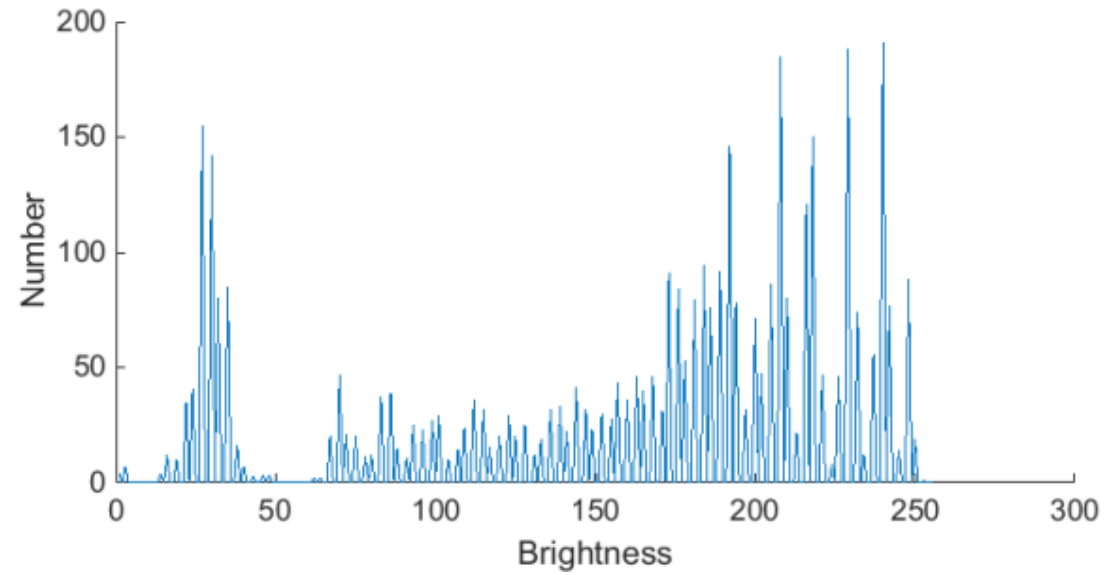
Avoids need for parameter choice



Intensity normalisation and histogram equalisation



(a) intensity normalised eye



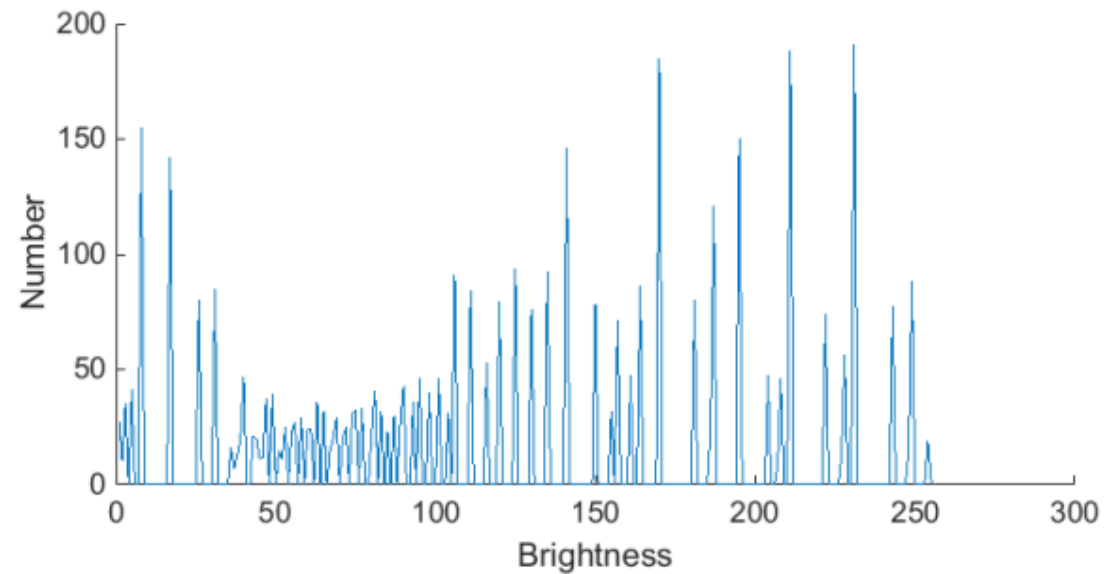
(b) histogram of intensity normalised eye

Grey levels all
'weigh' the
same

Used in
Matlab's
imagesc



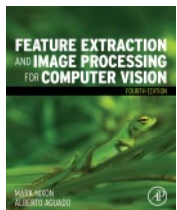
(c) histogram equalised eye



(d) histogram of histogram equalised eye

Grey levels
have different
weights

Aimed for
human vision



Histogram Equalisation – aim is a flat histogram

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

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

number of points per level in the output picture

cumulative histogram of the output picture

mapping for the output pixels at level q

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

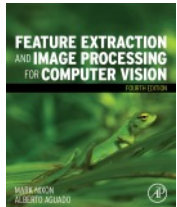
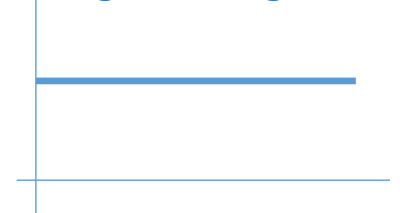
$$\sum_{l=0}^p \mathbf{O}(l) = \sum_{l=0}^q \mathbf{N}(l)$$

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

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

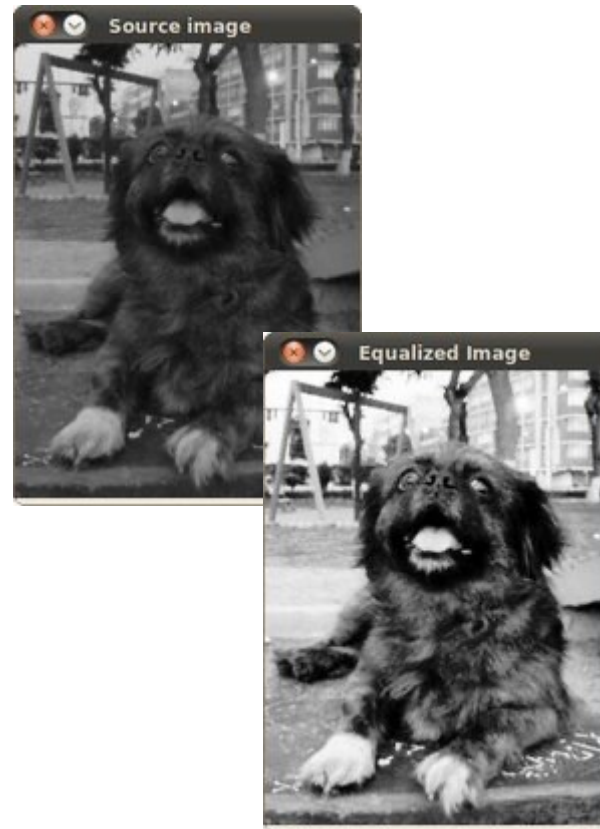
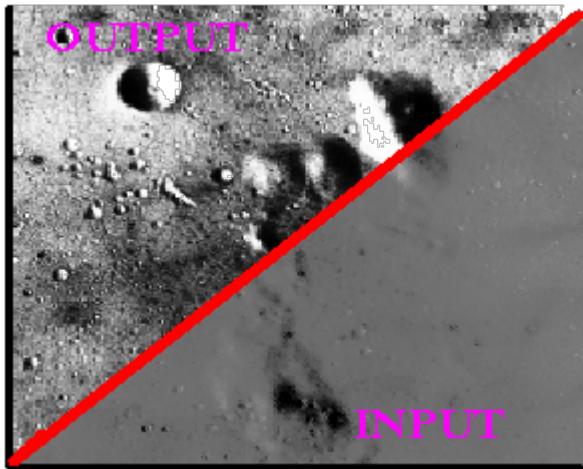
$$q = \frac{\mathbf{N}_{max} - \mathbf{N}_{min}}{N^2} \times \sum_{l=0}^p \mathbf{O}(l)$$

Target histogram



Often used in **medical image analysis**
Effective ... but ... **nonlinear** and major problems with noise

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>

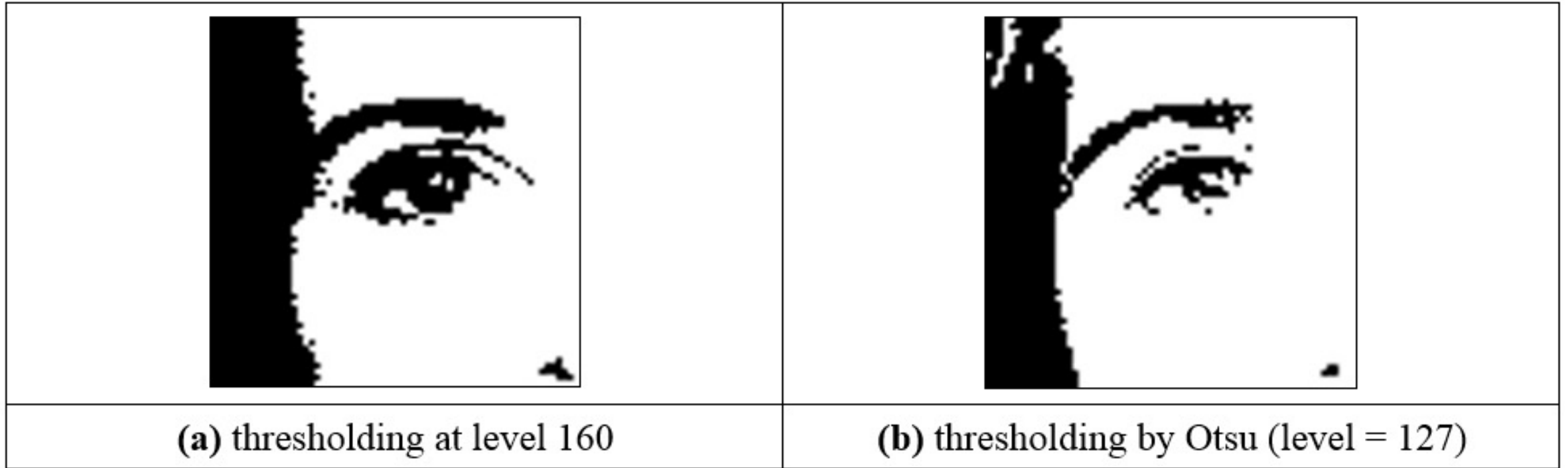
Thresholding an eye image

Thresholding selects points that **exceed** a chosen threshold

$$N_{x,y} = \begin{cases} 255 & \text{if } N_{x,y} > \text{threshold} \\ 0 & \text{otherwise} \end{cases}$$



Thresholding an eye image: manual vs automatic



Is optimal thresholding a **myth**??

Thresholding an image of a walking subject



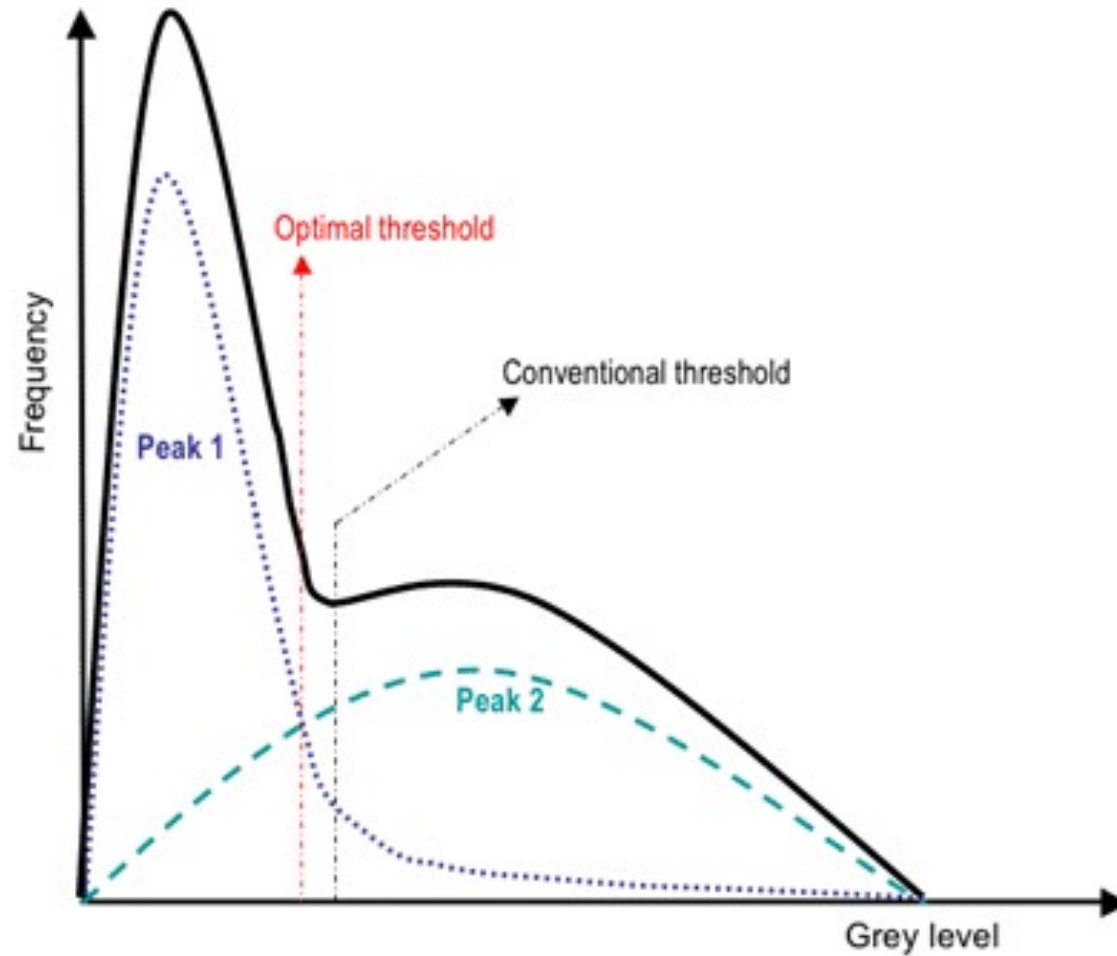
(a) walking subject



(b) automatic thresholding by Otsu

Many consider that **shape** concerns a **higher** level

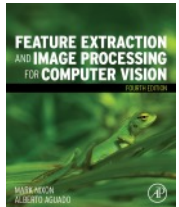
Advanced thresholding



Main points so far

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.



Other thresholding techniques...

