Chapter 4
Image Processing
Point Processing
Lecture *Digital Image Processing, Oct*. 18th, 2010

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Topics: Point Processing

1. What is point processing?
2. Grey level mapping
3. Histograms
4. Segmentation using thresholding

What is Point Processing

Under the term **Point Processing** we summarize all processing that can be done based on a single image pixel. The output of the process is a single value. Usually, this output value replaces the input pixel in the image. The process is carried out *pixel-wise*.

Examples: A number of examples are given in this lecture. Grey level mapping, histograms, segmentation using thresholding.

Images can be Added

- Image computation, like the mapping, is pixel-wise.
- Also possible: -, , , AND, OR

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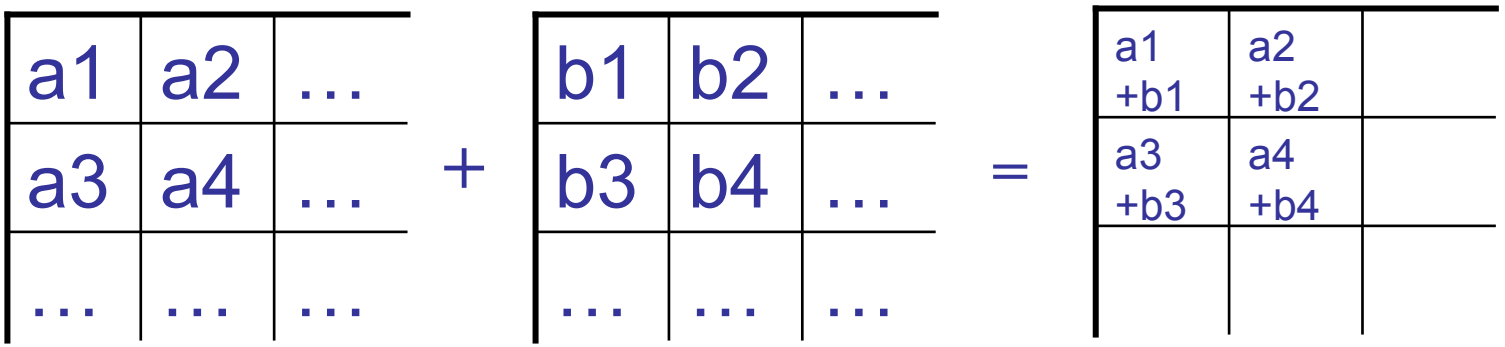
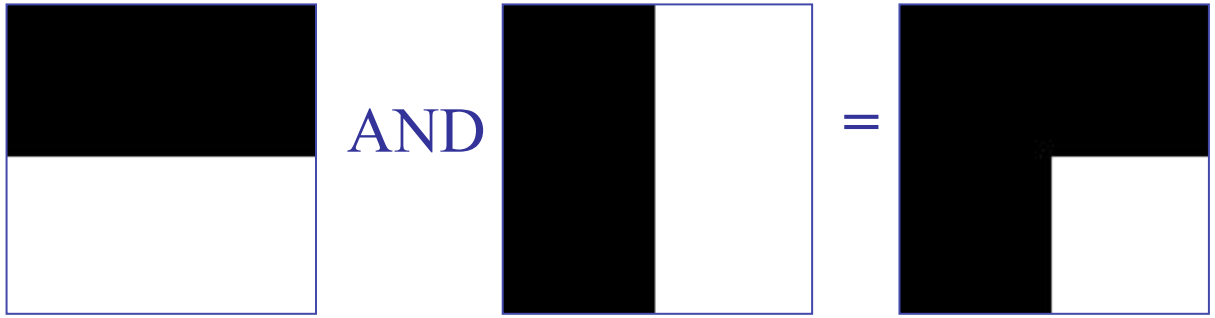
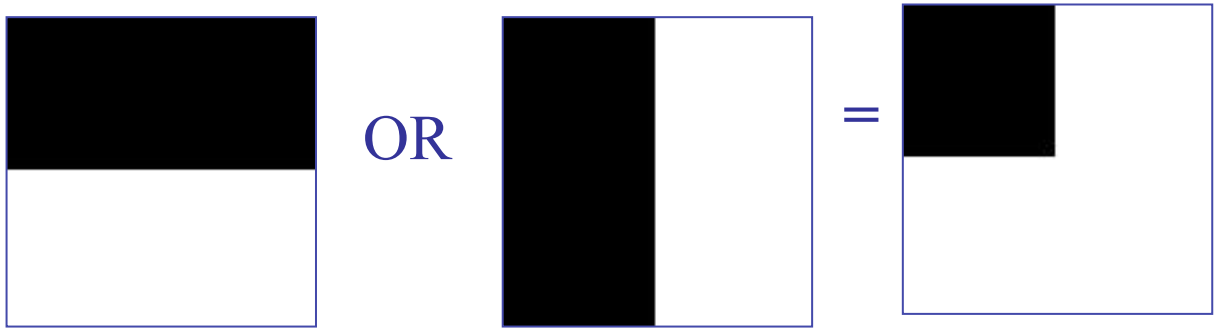


AND-, OR-Operations

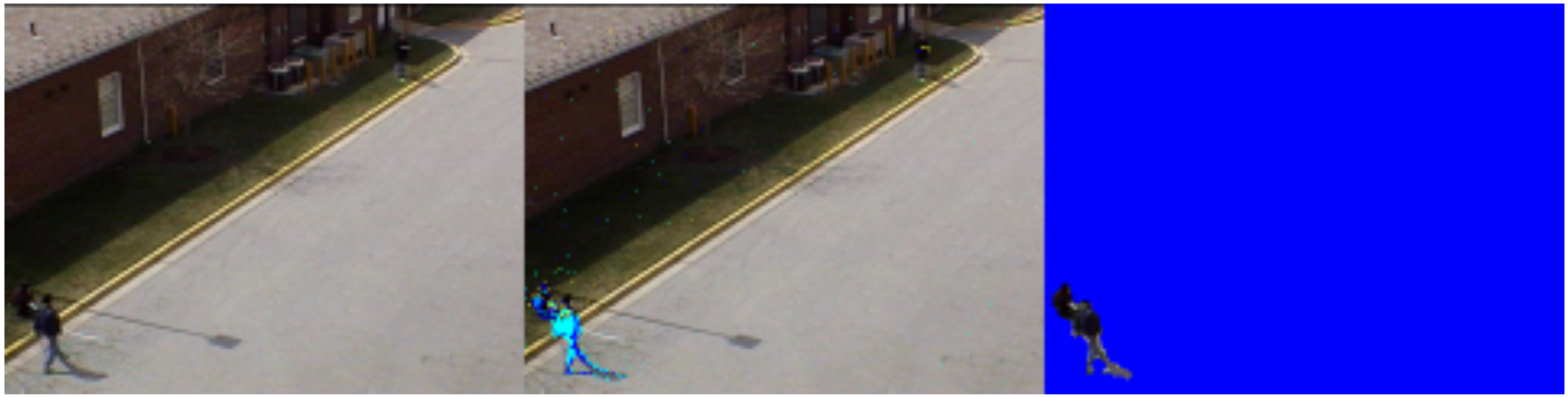
AND	0	1
0	0	0
1	0	1



OR	0	1
0	0	1
1	1	1



Example: Image Subtraction, Background Subtraction



Caution!!

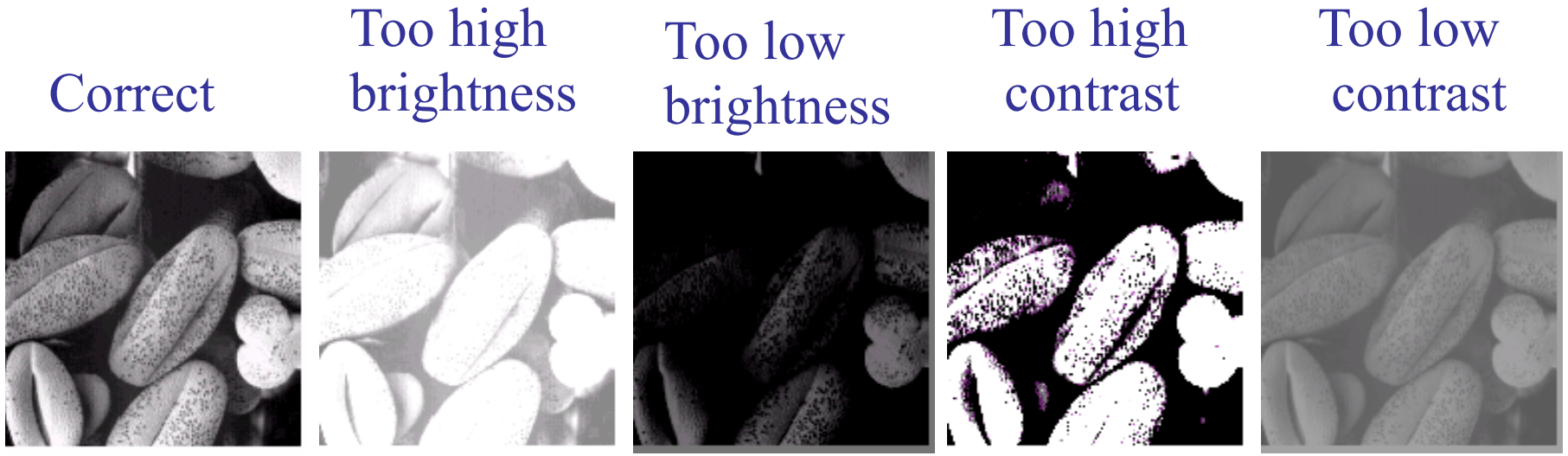
- Undesired effects may happen, when computing with images:

Overflow / Underflow

Example: Two Gray value images I_1, I_2 ,
Pixel range: 0..255! Their Pixel sum (multipl.) may be larger than 255!!
Subtraction results may be smaller than 0!!

Gray Level Ehancement?

- Process one pixel at a time independent of all other pixels
- For example used to correct Brightness and Contrast (remote control)



Brightness

- The brightness is the intensity
- Change brightness:
- To each pixel is added the value *b*

$$g(x,y) = f(x,y) + b$$

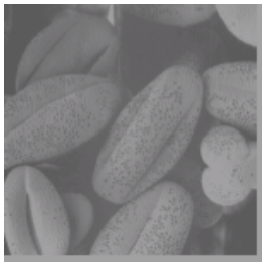
- *f(x,y)* is the input image
- *g(x,y)* is the (enhanced) output image
- If *b*>0 => brighter image
- If *b*<0 => less bright image

Example Program Code for Brightness Change

```
Int x,y,helpVal;
int a=10;
for (y=1; y<height; y++)      %run the loop. To run the y-loop
   for (x=1; x<width; x++)    %first is faster!!
        helpVal=pixel(x,y)+a;          %compute the new val
        if (helpVal>255)               %check for overflow
                pixel(x,y)=255         %if overflow, save max value 255
        else                           %if not overflow, save helpVal
                pixel(x,y)=helpVal;
        end
   end
end
```

Contrast

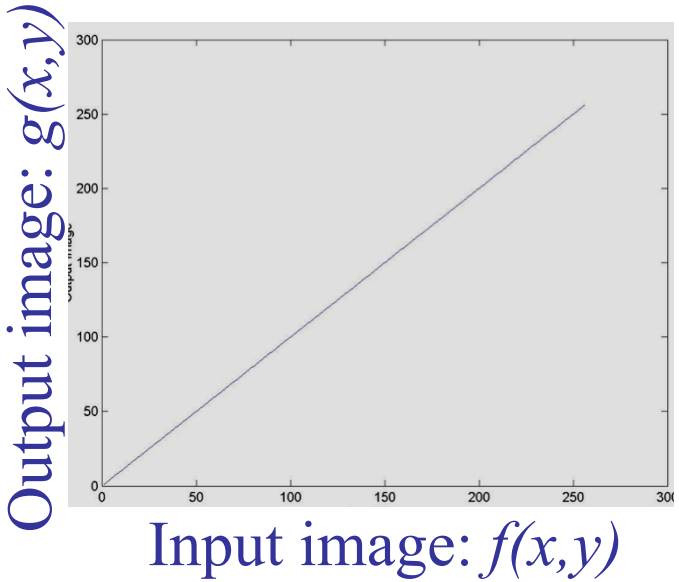
- The contrast describes the level of details we can see
- Change contrast: $g(x,y) = a * f(x,y)$
- Each pixel is multiplied by *a*
- *f(x,y)* is the input image
- *g(x,y)* is the (enhanced) output image
- If *a*>1 => more contrast
- If *a*<1 => less contrast



Combining brightness and contrast

- Both: $g(x,y) = a * f(x,y) + b$
- Greylevel mapping
- X-Axis: Input Value
- Y-Axis: Output Value
- This plot: **Identity**
  - Output equals Input
- Apply to each pixel!
- To save time the greylevel mapping can be written as a **Lookup-Table:**

Input	0	2	…	255
Output	0	2	…	255



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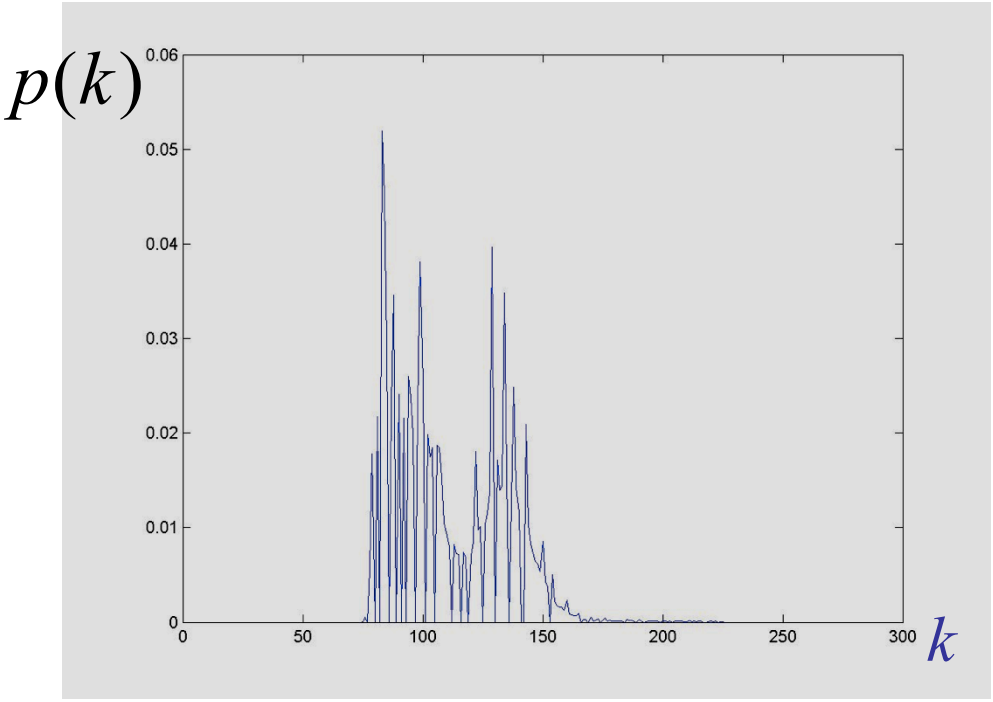
Histogram

How to set the greylevel mapping

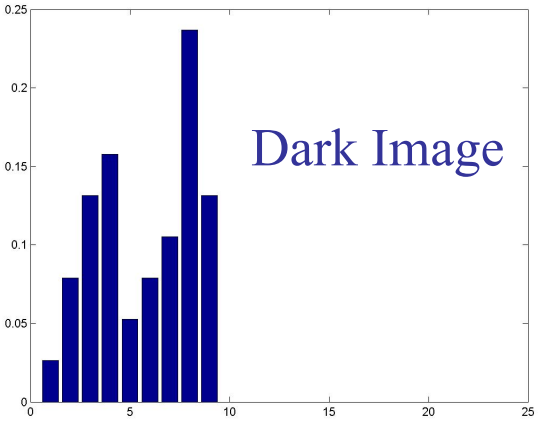


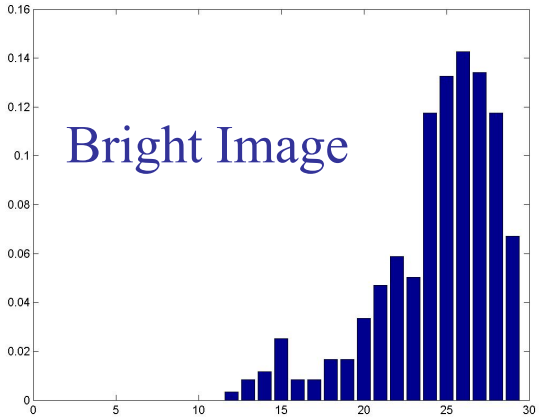
- **Histogram processing** – a powerfull tool!

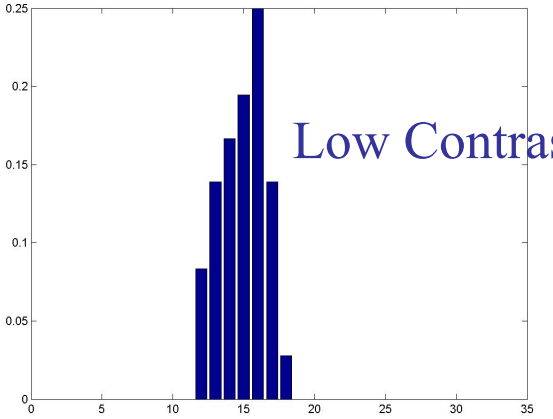
A Histogram is a discrete function $p(k) = n_k / n$,

- n_k is the number of pixels with the k-th gray level
- n is the total number of pixels
- Histogram entry $p(k)$ gives the probability of gray value k of appearing in the image.

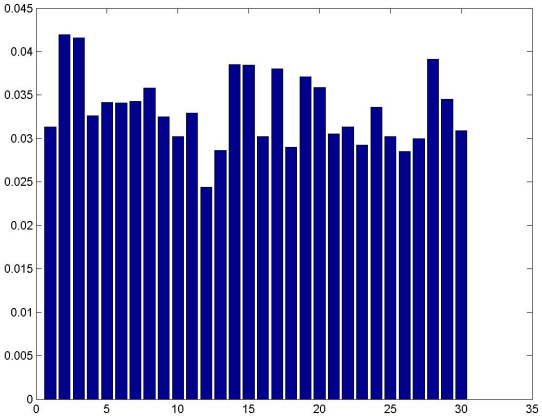
Histogram Types



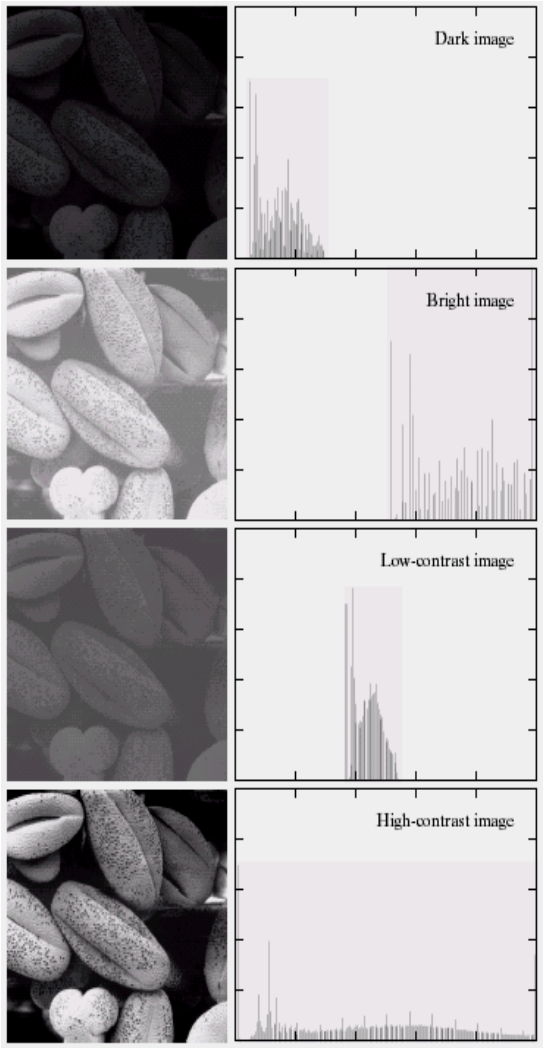




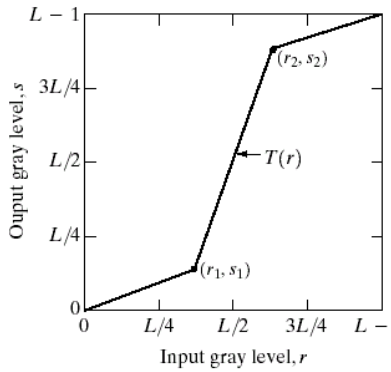
High Contrast

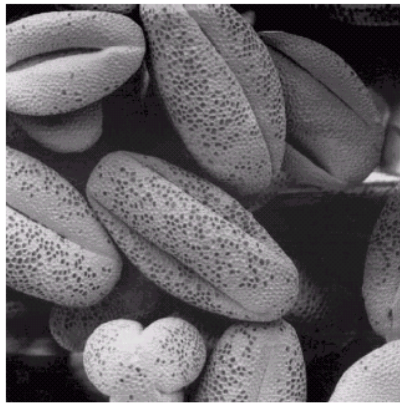


Histogram processing

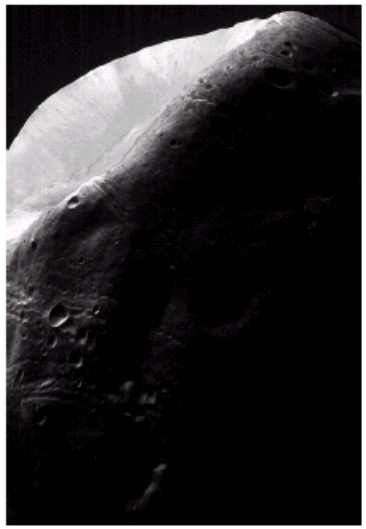


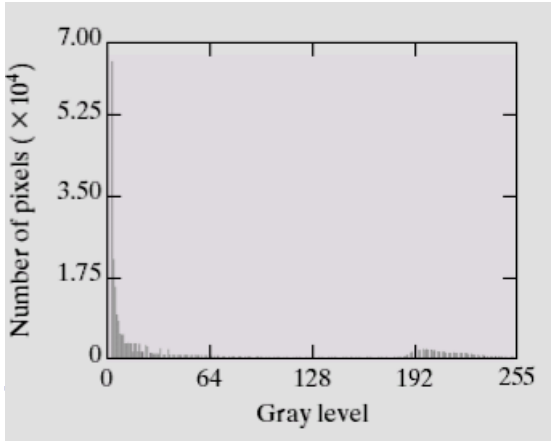
- Different types of mapping
  - Piecewise linear



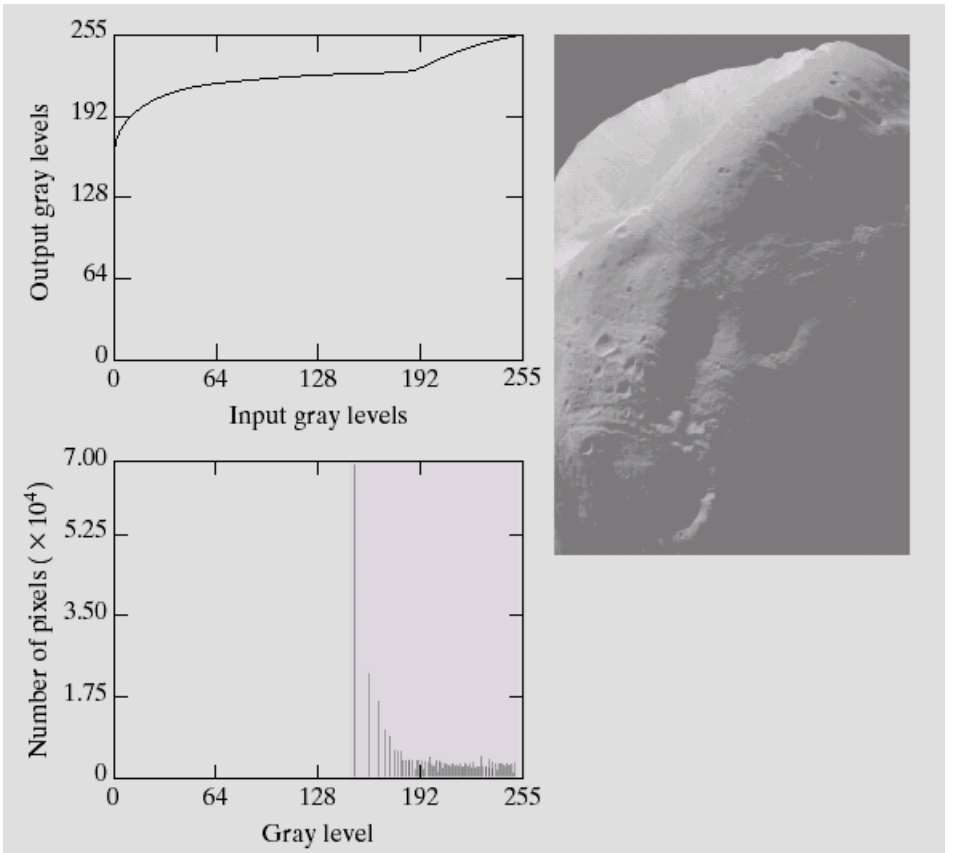


Histogram processing

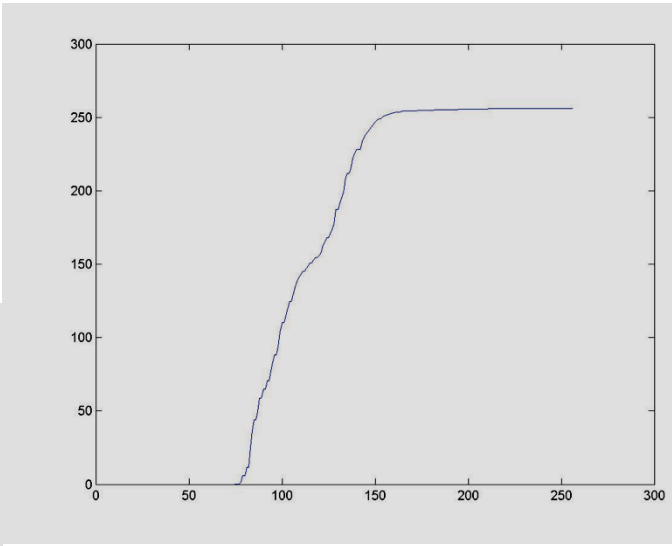


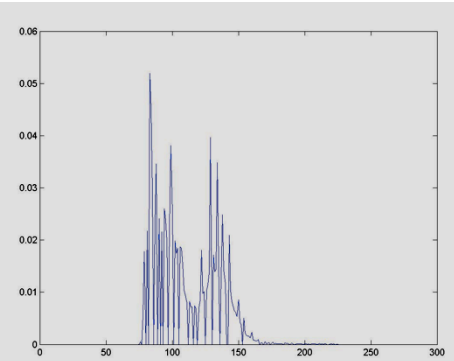


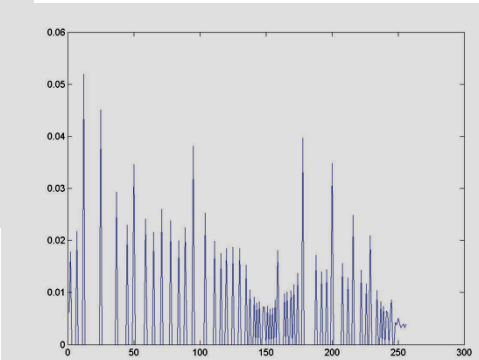
- Non-linear, e.g., Logarithmic
- Arbitrary



Histogram Equalization

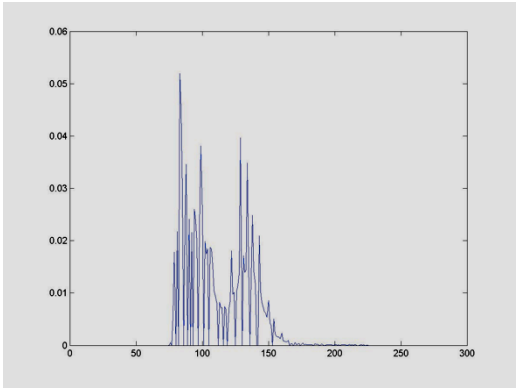


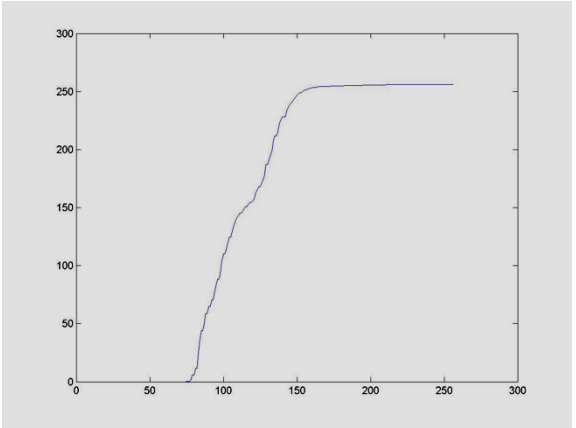




In Statistical Terms

- The Histogram is given by the probabilistic density function (pdf) of the pixel gray values *p(x)*.
- The mapping *g* for a gray value *k* is defined by the probability distribution of the pdf *p(x)*:

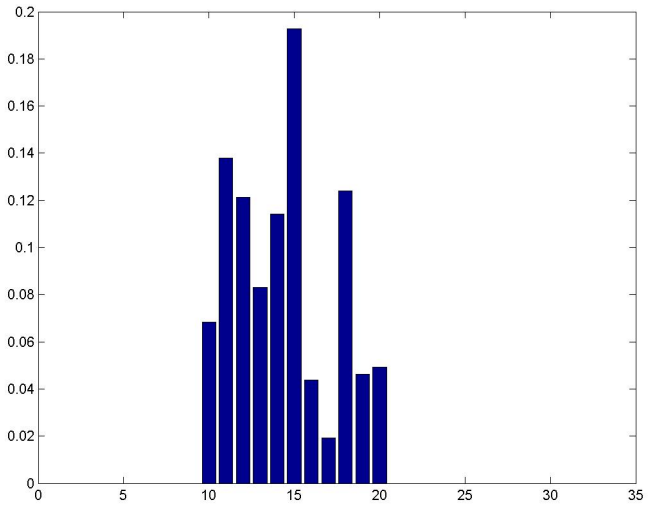


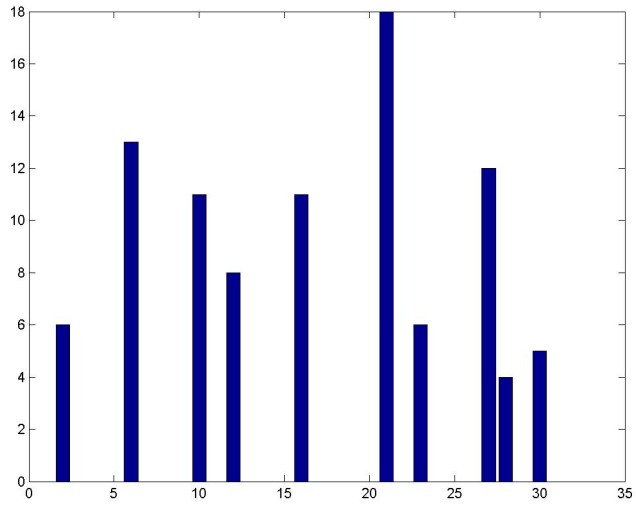


$$g(k) = 255 \cdot \sum_{i=1}^{k} p(i)$$

Improving contrast

- Humans cannot tell the difference between greylevel values that are too close to each other
- So: spread out the greylevel values
- This is called histogram stretching





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Histogram stretching

- Algorithm:

1. Find maximum:

```
max=0;
//Check each pixel:
if f(x,y)>max
        max=f(x,y);
```

2. Find minimum…
3. **Shift** values so that minimum is 0:

```
//For each pixel:
g(x,y)=f(x,y)-min;
```

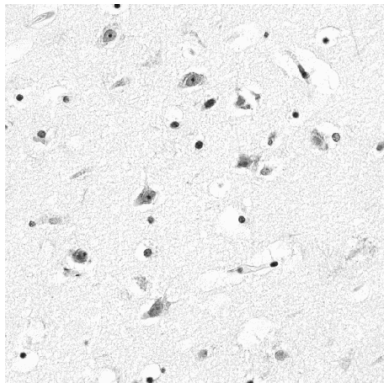
4. **Scale** values so that maximum is 255 and write into output image `g(x,y)`:

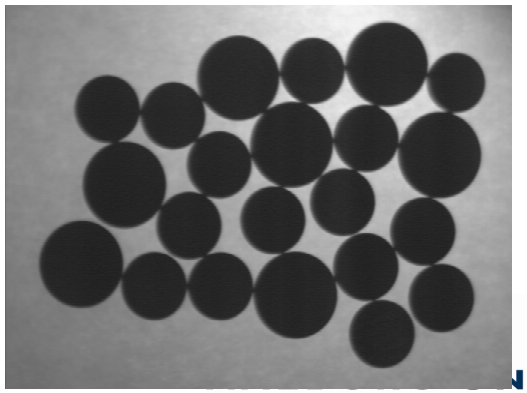
```
c=255/(max-min);
//For each pixel:
g(x,y)=round(g(x,y)*c);
```

Something really different…

Segmentation

- Until now: Image processing (manipulation)
- Image analysis: segmentation
- The task:
  - Information versus noise
  - Foreground (object) versus background





Segmentation

- Use greylevel mapping and the histogram
- When two peaks (modes) of a histogram correspond to object and noise
- Find a THRESHOLD value, *T*, that separates the two peaks. This process is called THRESHOLDING
- Algorithm:
  - If $f(x,y) > T$ then $g(x,y) = 1$, else $g(x,y) = 0$
  - If $f(x,y) < T$ then $g(x,y) = 1$, else $g(x,y) = 0$
- Result: a binary image where

  object pixels = 1 and noise = 0

What to remember

- Point processing
- Brightness and contrast
- Greylevel mapping
- Histogram
- Thresholding (segmentation)

Amazing Computer Vision

Play Automatic Movie Summary

Exercises

- Questions to the lecture?
- What was good about the lecture and what could have been better?
- Discuss the questions
- Generate a simple c-program for changing the image contrast and/or the image brightness. For this: Load “Lenna” into the memory and show her on the screen. Then, apply the today's techniques and generate a new image.
- Write a program to Histogram-Equalize the image!!
- Finish the exercises from last time

Questions

- What does Point Processing mean?
- Describe Brightness and Contrast
- Describe greylevel mapping and how it relates to Brightness and Contrast
- What is a histogram?
- How can a histogram be used to choose the greylevel mapping?
- What is histogram stretching?
- What is thresholding and how is it related to a histogram and to segmentation?