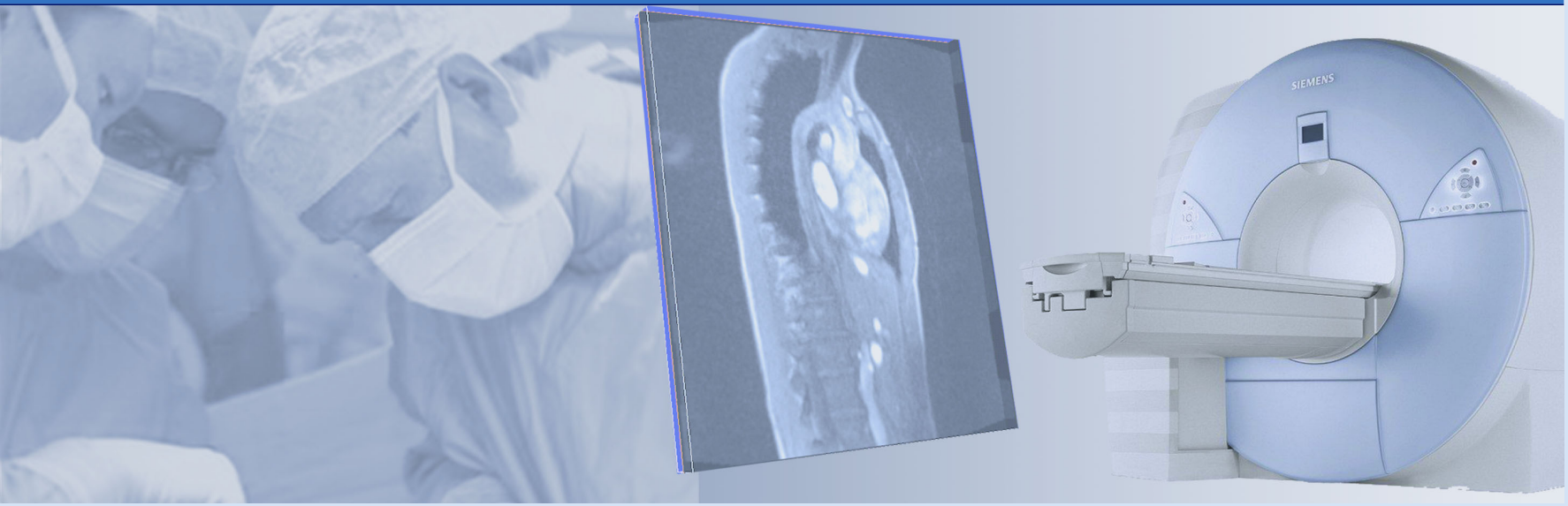
Tutorial computer- and robot-assisted surgery



NCT

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getragen von:
Deutsches Krebsforschungszentrum
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Medizinische Fakultät Carl Gustav Carus, TU Dresden
Helmholtz-Zentrum Dresden-Rossendorf

Sebastian Bodenstedt
Translational Surgical Oncology

Questions from the lecture?

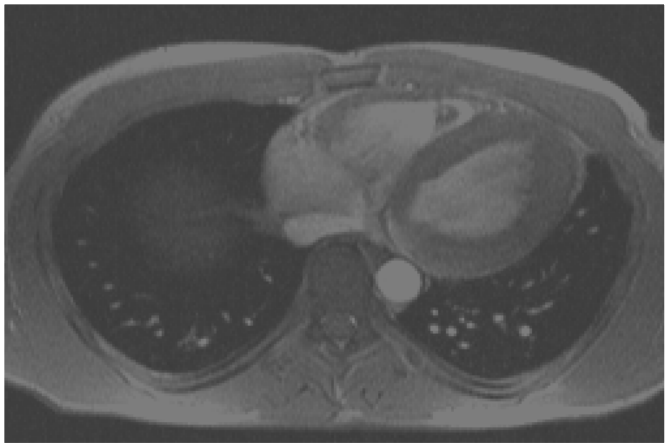
Reminder: Convolution & Filters

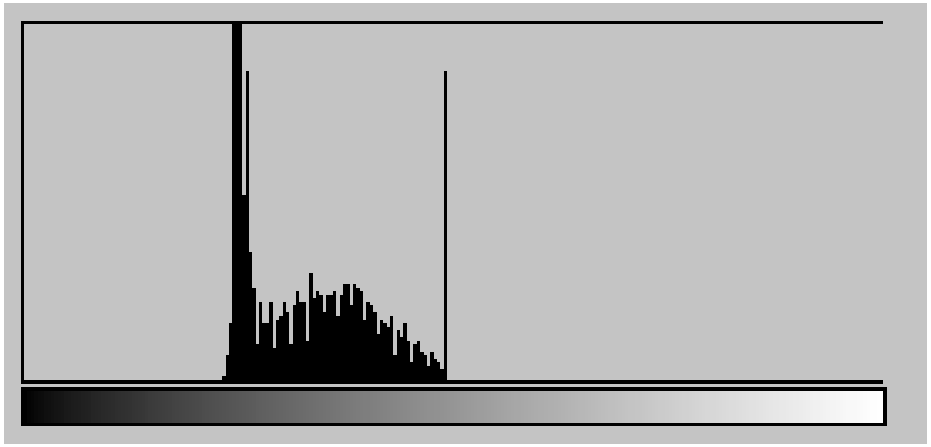
Characteristics of images

- Histogram: occurrence rate of features

$$h(g) = \#(x, y) : \mathrm{G}(x, y) = g, g \in [0..q]$$

$$p(g) = \frac{h(g)}{mn}$$ = Relative frequency: $$\sum_{g=0}^{255} p(g) = 1$$





Operations on images

- Point operation

  Results of transform f is only influenced by a single pixel

- Local operation

  Results of transform f is only influenced by the surroundings of a pixel

- Global operation

  Results of transform f is influenced by the entire image

Point operation

- Modification of a single pixel through operations that are only depend on value and position of that pixel

$$g'_{xy} = P_{xy}(g_{xy})$$

  - Indices x, y of function P describe possible dependency of the function to the position of the pixel

Example: $$g'_{xy} = \begin{cases} 2g_x, if\ (xy)\ mod\ 2 \equiv 0 \\ 4g_x, if\ (xy)\ mod\ 2 \equiv 1 \end{cases}$$

Homogenous point operations

- Independent from position of the position of image point, only dependent on value

$$g'_{xy} = P(g_{xy})$$

Generally not invertible operation (compare threshold segmentation)

=> affine homogenous point operations

=> non-affine homogenous point operations

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Affine point operations

- Definition:

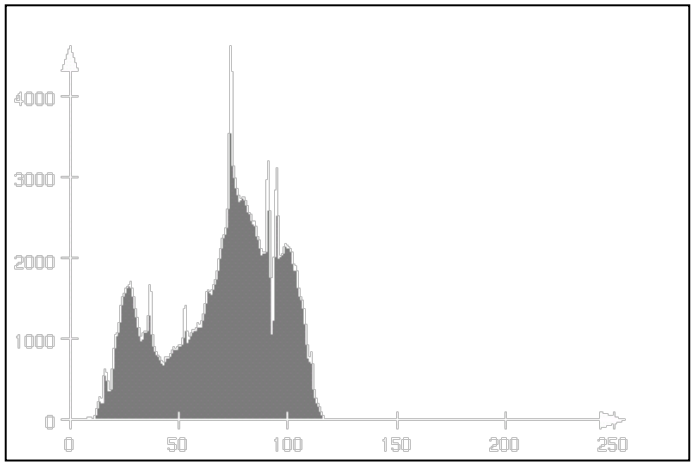
$$P : \lfloor 0..q \rfloor \rightarrow \lfloor 0..q \rfloor$$
$$g' = ag + b$$

- Parameters a, b define function:

$a > 1, b = 0$	Contrast increase
$0 < a < 1, b = 0$	Contrast reduction
$a = 1, b > 0$	Brightness increase
$a = 1, b < 0$	Brightness reduction

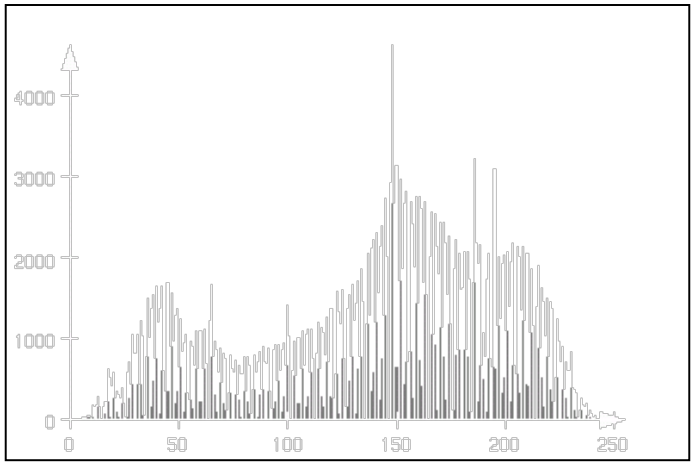
Increase contrast

- Histogram only has spikes in a small area of possible grayscale values



- By increasing contrast, the small area is spread onto a larger area

- Characteristics
  - Usage of the entire grayscale spectrum
  - Visual effect is improved



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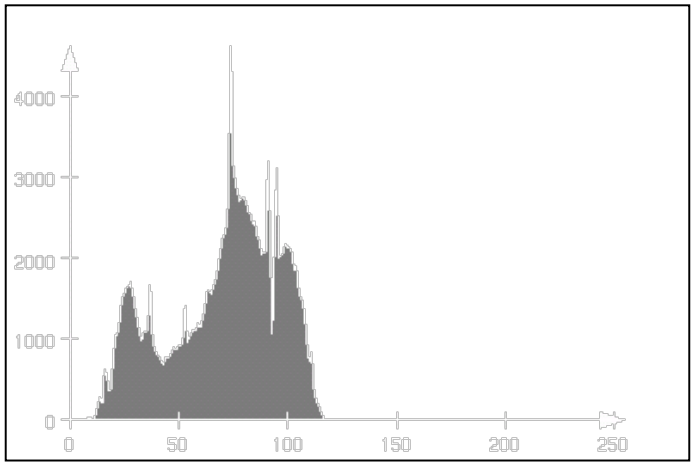
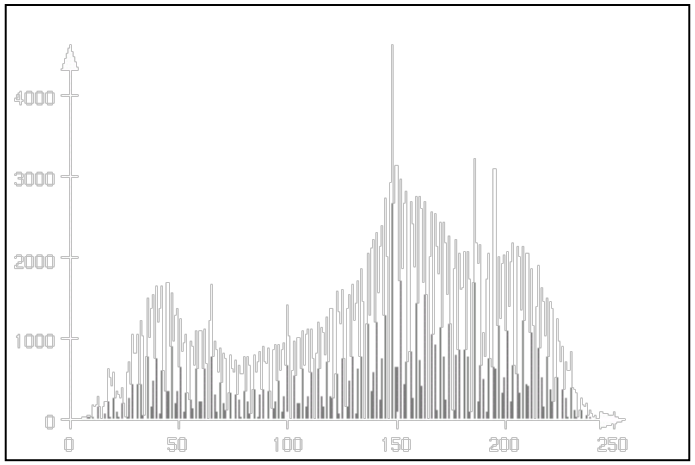
Histogram spread

- First, the minimum and maximum intensities (*min* and *max*) of a given image are located
- Then the interval [*min, max*] is mapped onto [0, 255]

- Affine point operation:

$$a \Leftarrow \frac{255}{max - min} \qquad b \Leftarrow min * a$$





Histogram stretch

- Improvement of histogram spread
- Instead of the minimum and maximum intensities of a given image, quantiles are used
- For this, we compute an accumulated histogram:

$$h_a(g) = \sum_{k=0}^{g} h(k)$$

- We define a quantile-function:

$$h_q(p) = argmin_x\, h_a(x) \geq p \cdot h_a(255),\ p \in [0,1]$$

- We then define two quantiles, e.g.

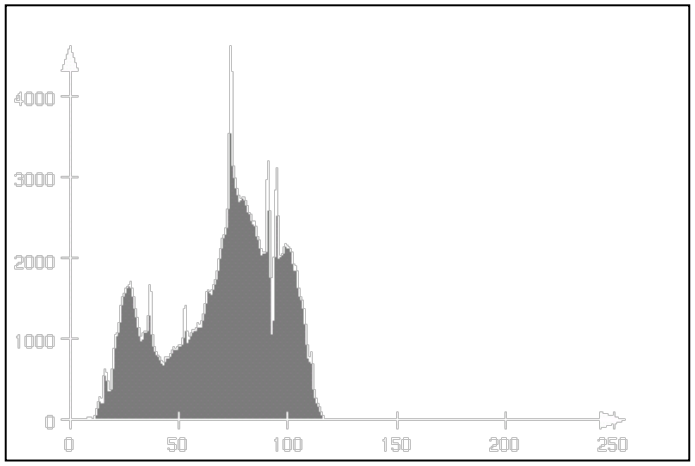
$$p_{min} = 0.1,\ p_{max} = 0.9$$

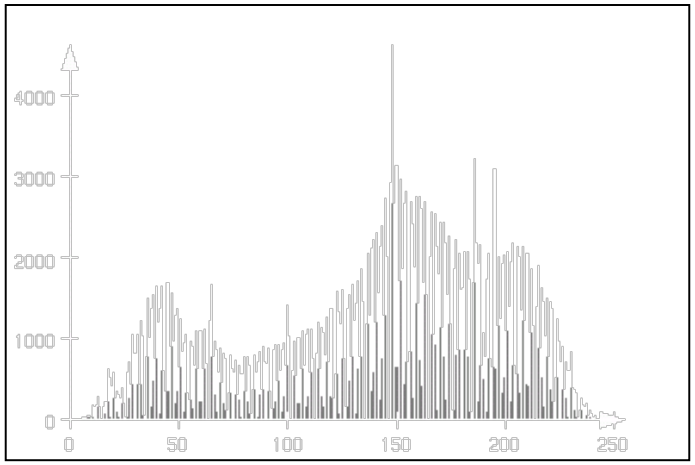
- And plug them into the quantile-function

$$min = h_q(p_{min}),\ max = h_q(p_{max})$$

- And define an affine transform

$$a \Leftarrow \frac{255}{max - min} \qquad b \Leftarrow min * a$$





Histogram equalization

- Improvement of histogram stretch
- Increases contrast in areas with many hits in histogram
- For this, we again compute an accumulated histogram:

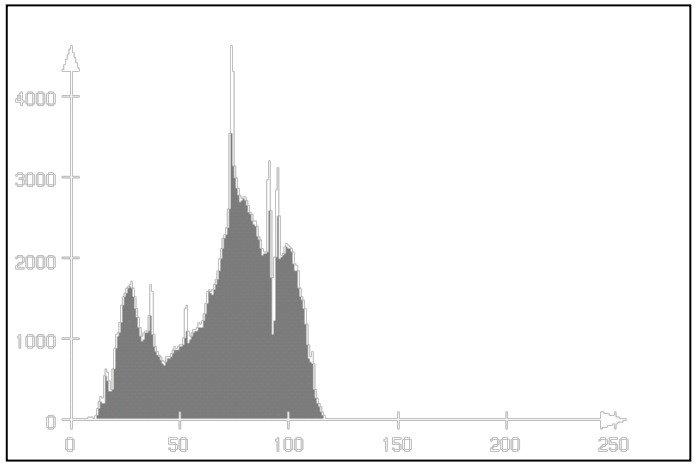
$$h_a(g) = \sum_{k=0}^{g} h(k)$$

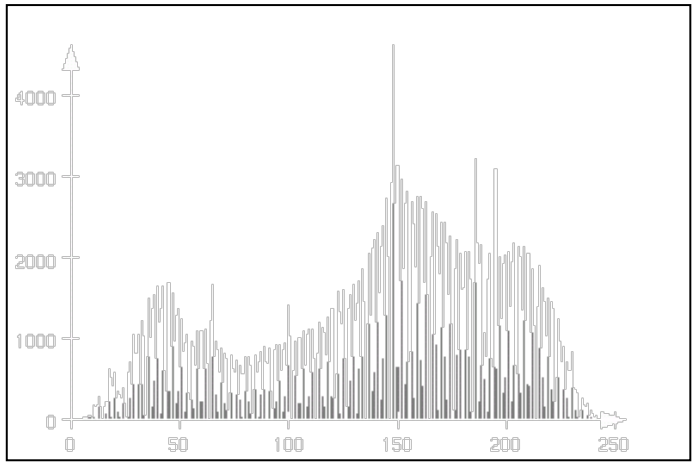
- We then re-distribute the range:

$$h_n(x) = \frac{255 \cdot h_a(x)}{h_a(255)}$$

- We then assign each pixel its new value:

$$g' = h_n(g)$$





Any questions?