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ISPRS WG V/6
MEDICAL IMAGE ANALYSIS, HUMAN MOTION AND BODY
MEASUREMENT

Hans-Peter Meinzer
German Cancer Research Center
Heidelberg, Germany




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The human visual system

- Cornea and lens focus light on the Retina
- Photoreceptors
 - Rods - brightness
 - Scotopic vision
 - Cones - color
 - Photopic vision
- Fovea
 - Area of sharpest viewing
 - Foveal vision
 - Only cones
- Blind spot
 - Point where axons converge to the optical nerve

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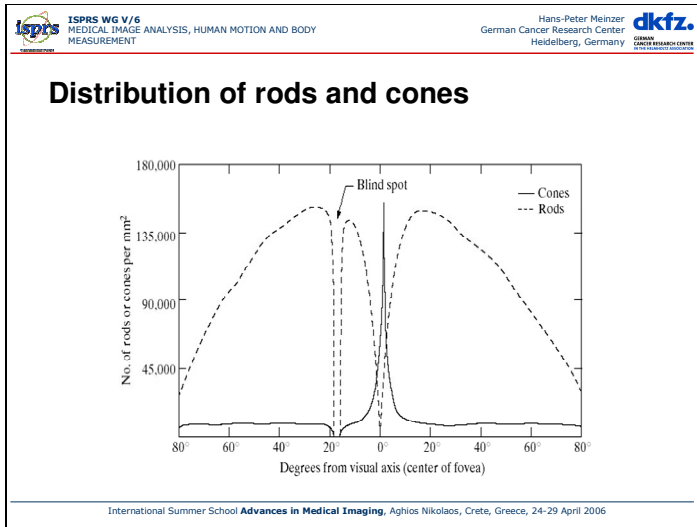
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Rods and cones

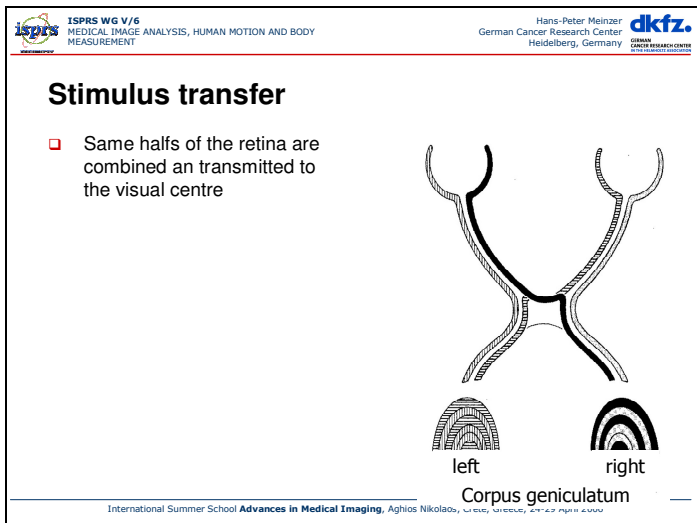
- Rods
 - 120 million rods
- Cones
 - 7 million cones
 - 150 hues
- Combined
 - 7 million shades

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Adjustment activities

- ☐ **Accomodation:** physical change to the lens thickness due to the tension by the ciliary muscle to focus an object


- ☐ **Adaption:** Adjusting the eye to brightness of light. Vision is possible in a range from 0,0001 lux to 10^9 lux.

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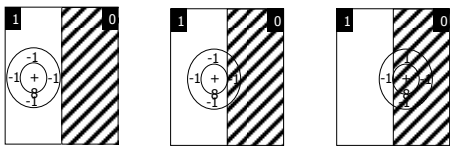

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Lateral inhibition

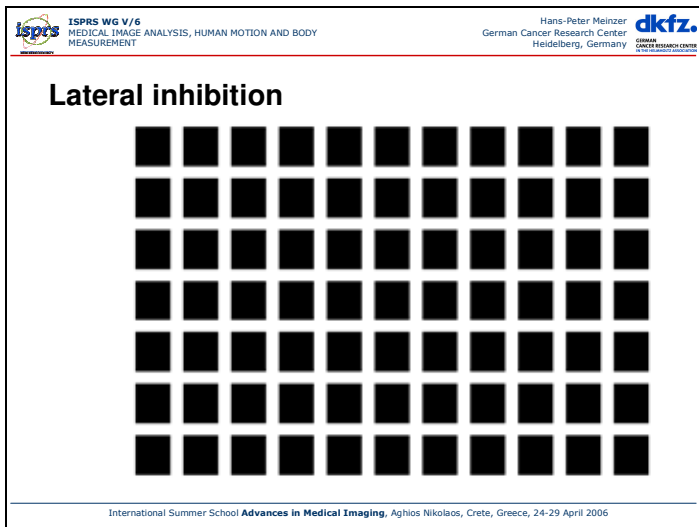
- ☐ Nerves attenuate an exaggerate differences
- ☐ Receptive fields: eye's internal real-time edge detectors



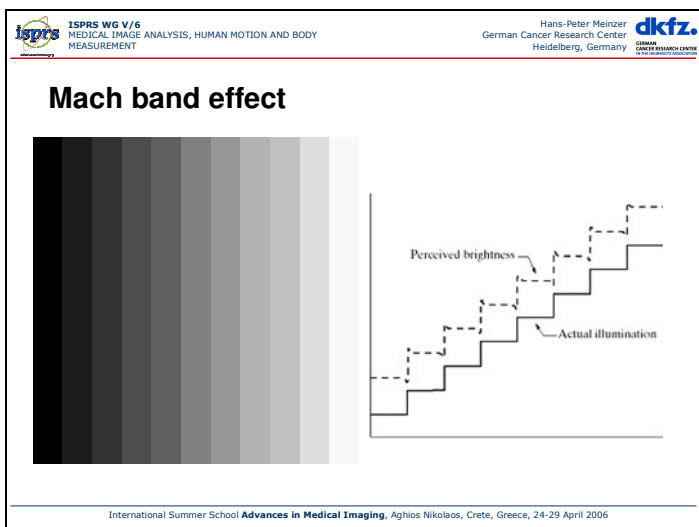
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Att.	-4	Att.	-3	Att.	-1
Rel.	4	Rel.	5	Rel.	-1

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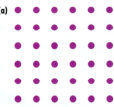
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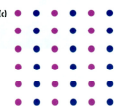

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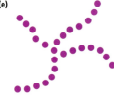
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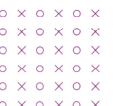
Recognition of structures


(a) 

(c) 

(e) 

(b) 

(d) 

(f) 

□ Gestalt laws of perceptual organization


□ Elements grouped by:

- (b) proximity
- (c),(d) similarity (here colour / shape)
- (e) good continuation
- (f) closure


□ i.e. elements grouped into coherent objects

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Ambiguities



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Ambiguities



Old woman / young woman

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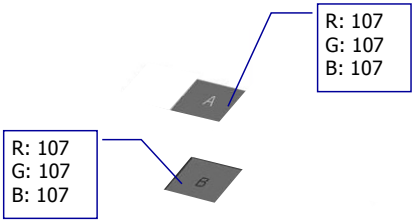
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Checkboard Illusion



R: 107
G: 107
B: 107

R: 107
G: 107
B: 107

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Features supporting 3D perception


- ☐ Perspective
- ☐ Colour
- ☐ Texture
- ☐ Opacity and occlusion
- ☐ Shadows
- ☐ Motion
- ☐ Knowledge

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We do it every day

- ☐ A photography is a perfect and realistic 2D representation of a 3D scenario
- ☐ That is why people can perceive (i.e. understand) it
- ☐ Why can one eyed persons drive a car?"




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 Benoit, Marie Guilhemine, 1800 AD

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Perspective

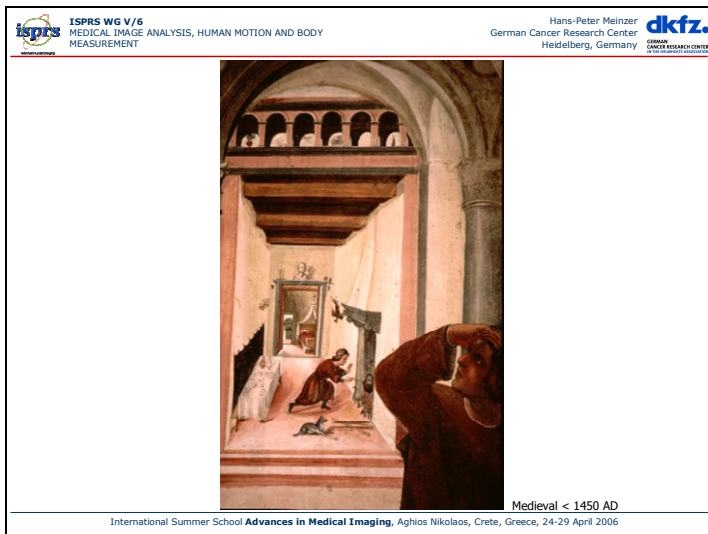
- ☐ There is only one primary horizon
- ☐ All edges parallel to the ground vanish to that horizon
- ☐ Object height is defined relative to the one horizon
- ☐ All visual objects are defined relative to the horizontal ground plate

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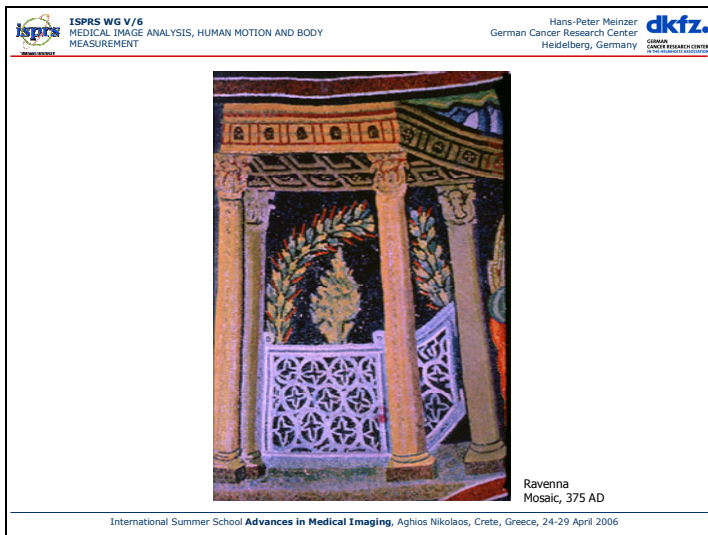
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"Artist painting a nude"
Durer, 1500 AD

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Leonardo, 1500 AD
Höhne, 1996 AD

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Colour and texture


- ☐ Different objects with different colours support perception
- ☐ Human perception appreciates realistic colours
- ☐ Texture of surfaces
- ☐ Texture of volumes


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"Ladies of Valencia"
Picasso, 1906 / 1907 AD

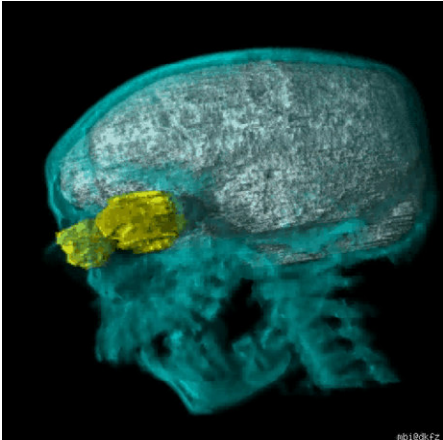
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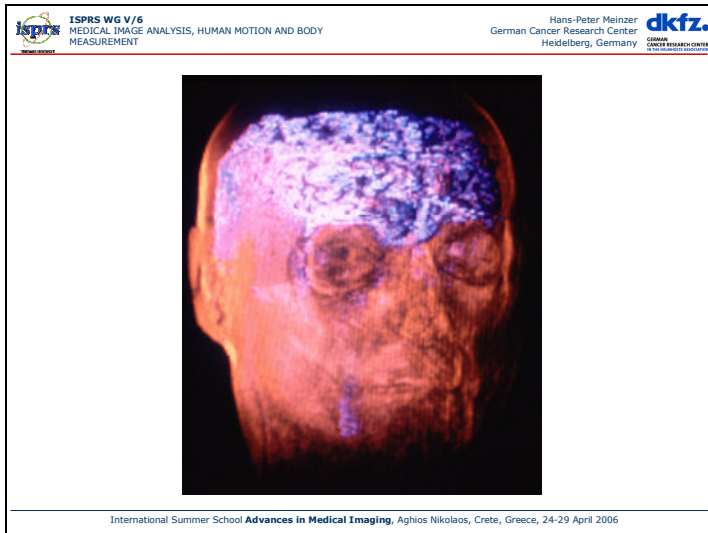
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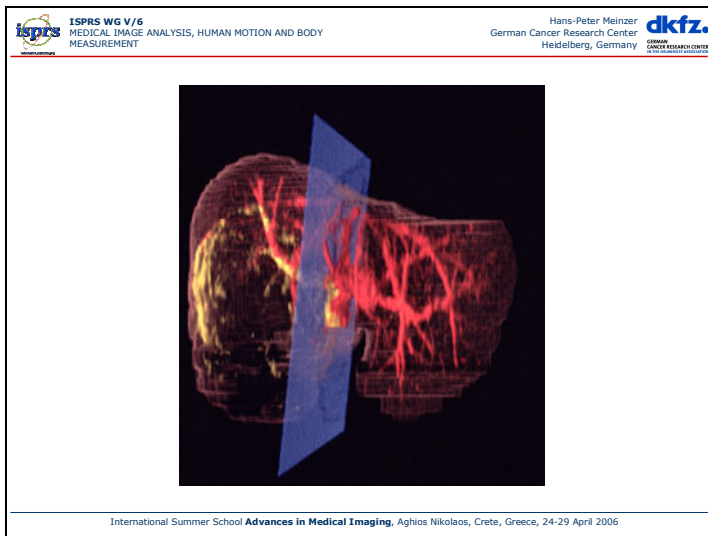


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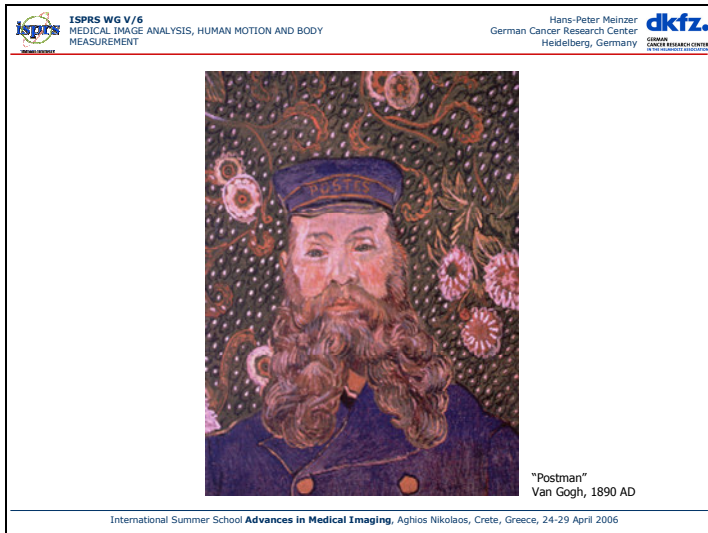
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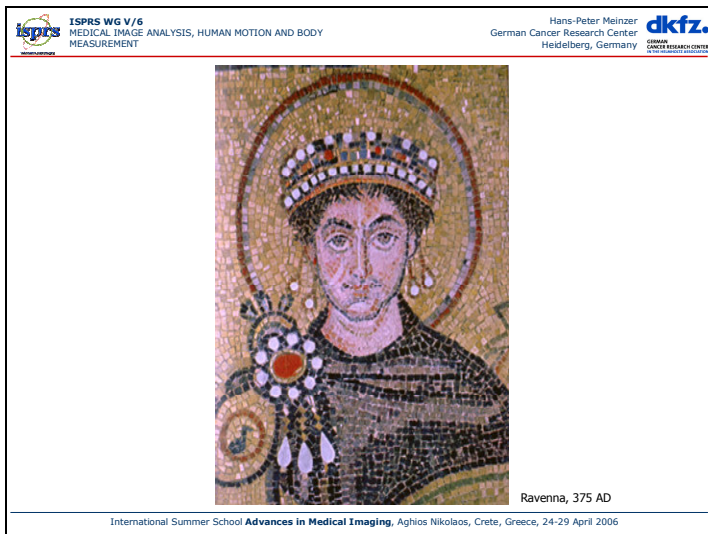
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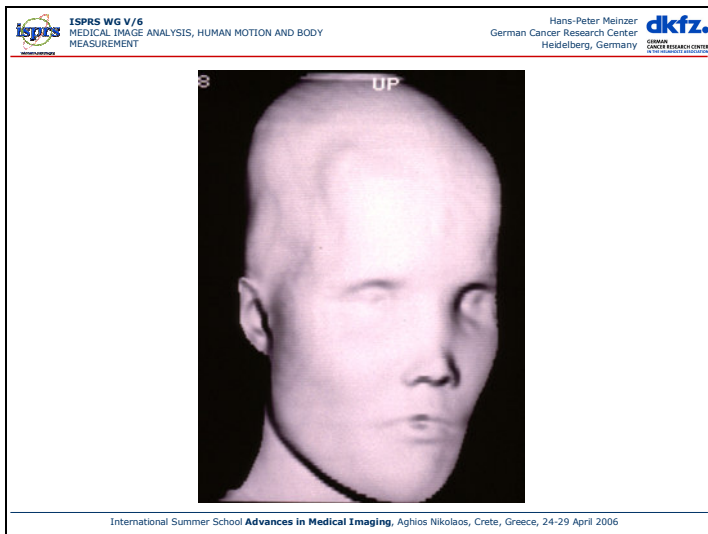
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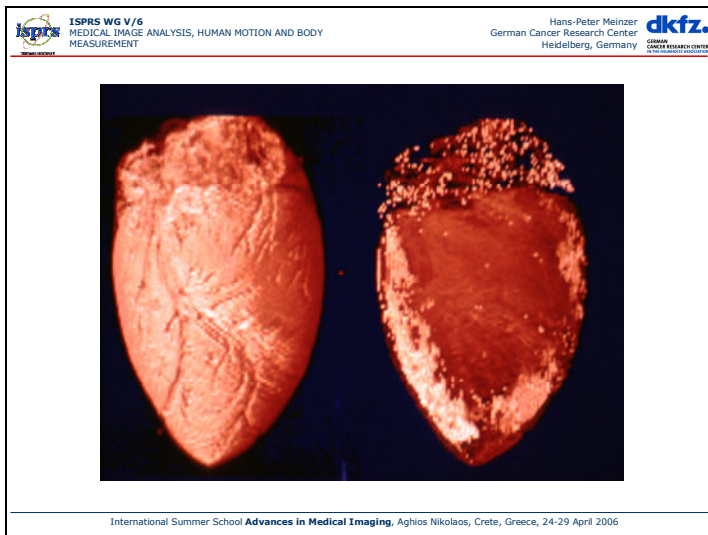
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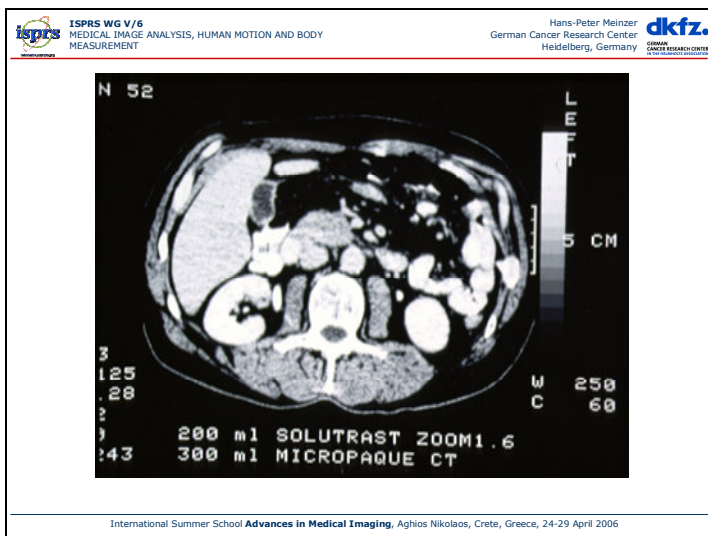
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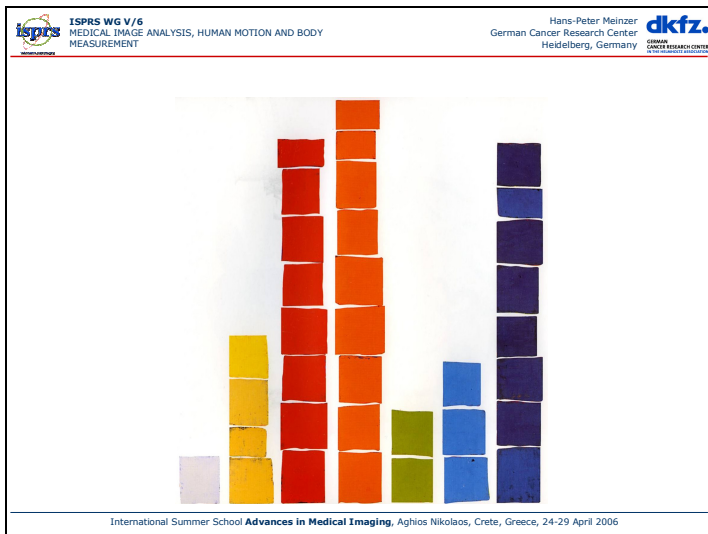
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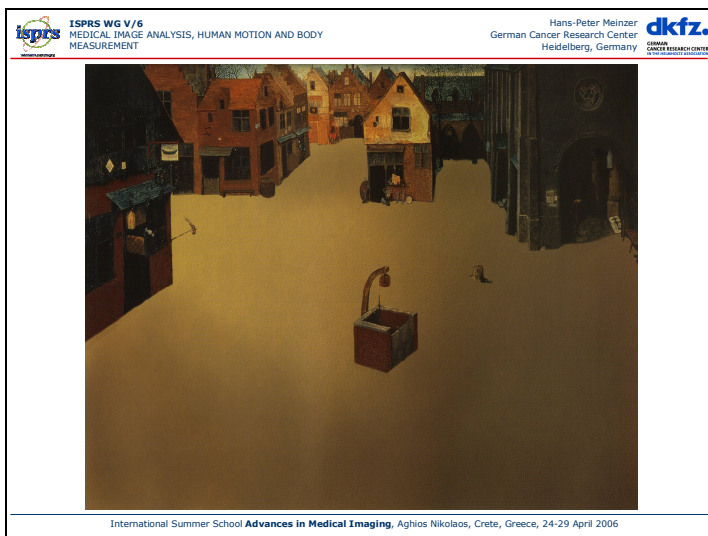
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Opacity and occlusion

- ☐ Surfaces primarily are visible by reflection
- ☐ Volumes primarily are visible by scattering
- ☐ Semi-transparent volumes scatter diffuse light and cast diffuse shadows
- ☐ Occlusion hinders light and causes shadow and semi-shadow
- ☐ Man can reconstruct partly invisible objects


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"Femina", Rose Descat, 1932 AD


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"Dance", Matisse, 1909 AD


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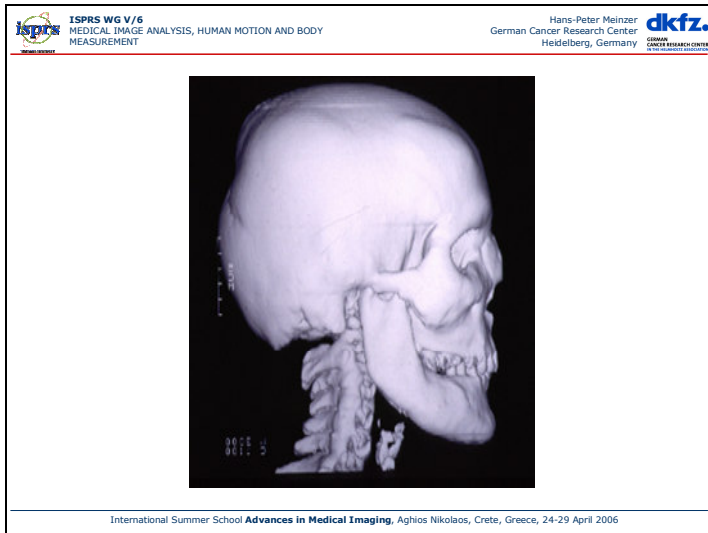
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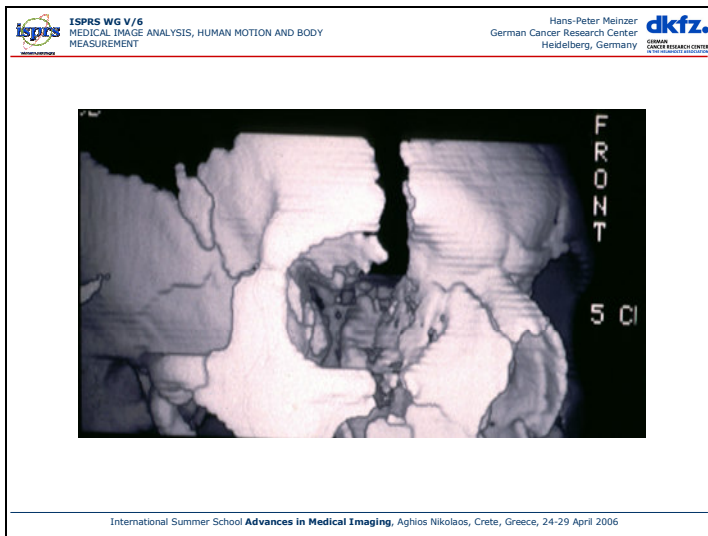
Ravenna
Mosaic, 375 AD

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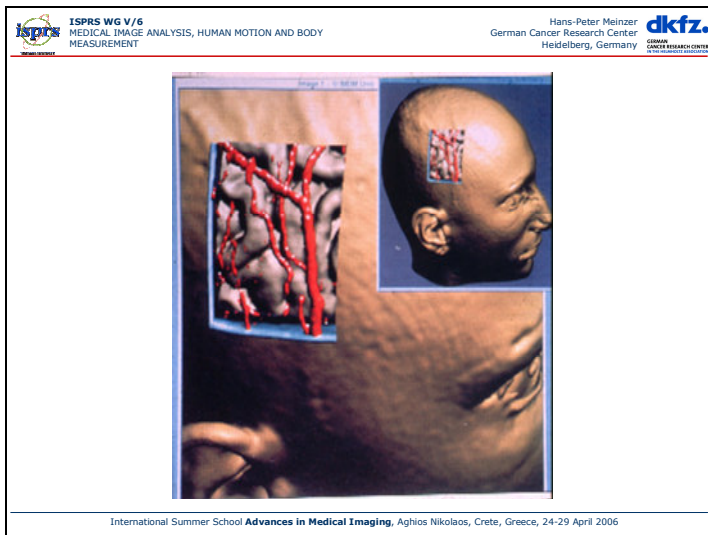
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Shadow

- ☐ Opacity and occlusion create shadow
- ☐ Shadow is (next to motion) the most important feature to our ability to perceive depth
- ☐ 3D illuminations needs (two) light sources, a balance of visibility and computational costs
- ☐ Secondary reflections (albedo) between objects are nice but not vital (in medical applications)

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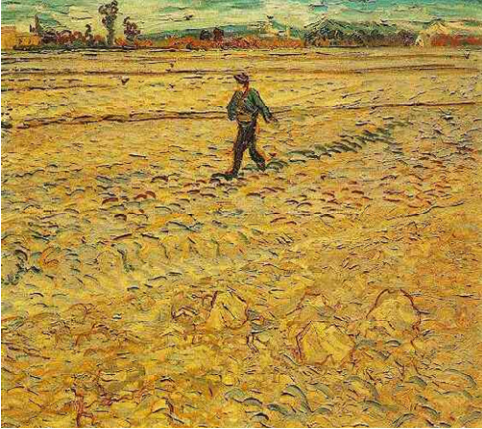


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"Sower"
Van Gogh, 1888

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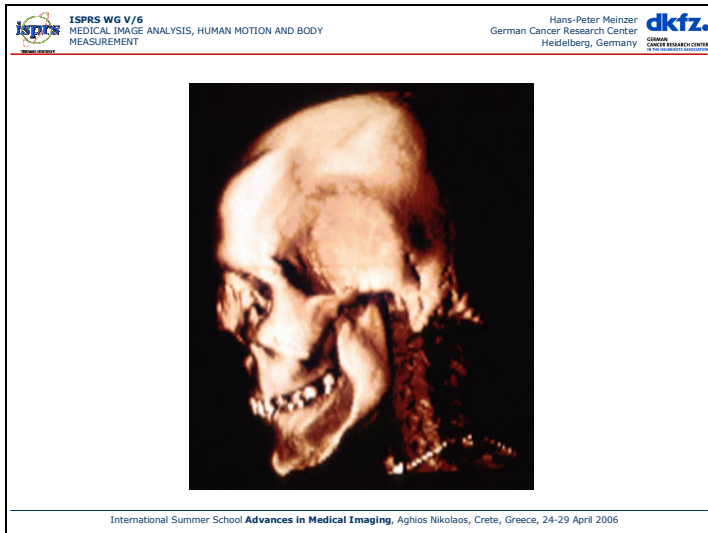
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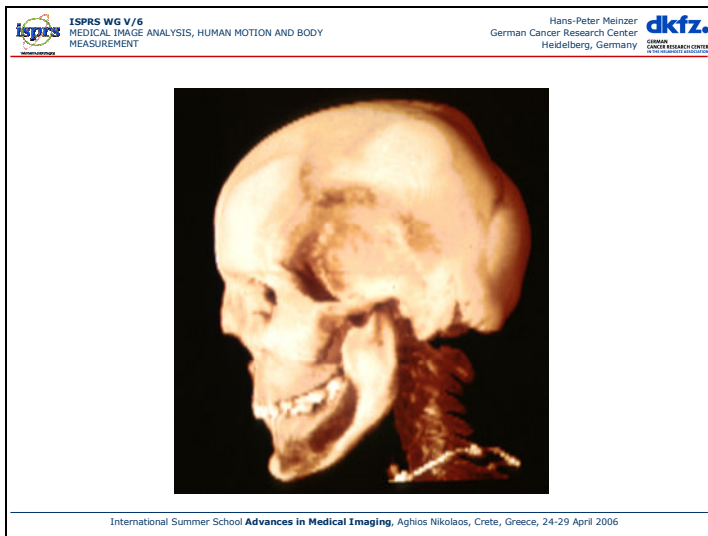
„Painter on His Way to Work“
Van Gogh, 1888 AD

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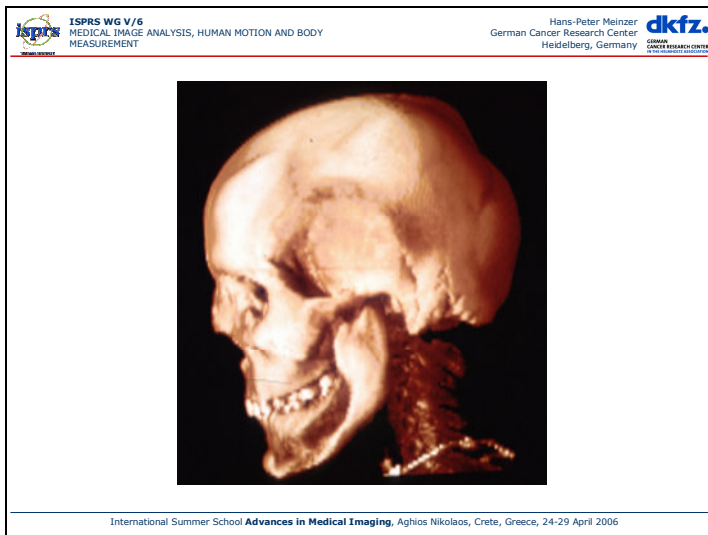
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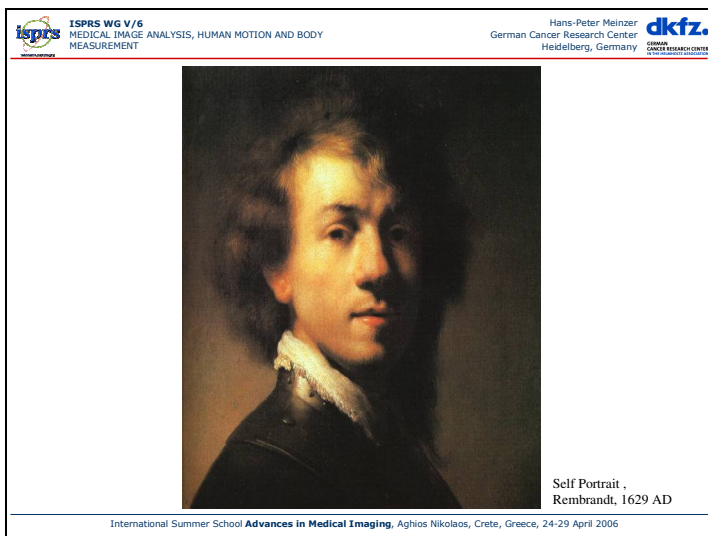
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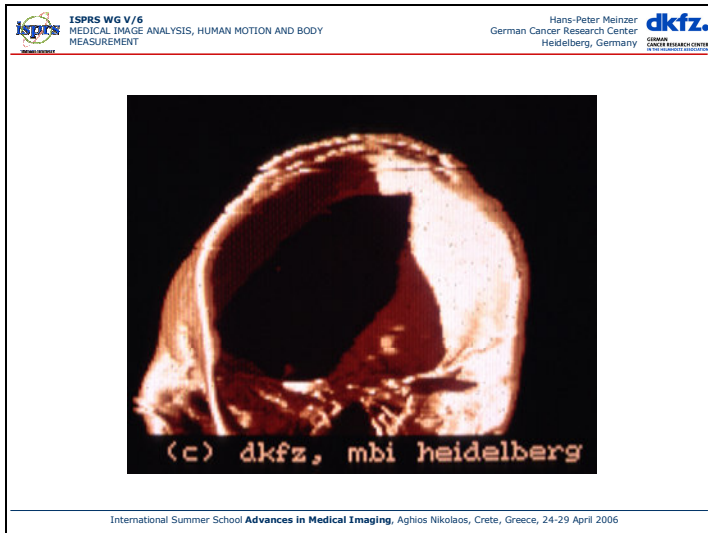
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"Enigma of a day",
de Chirico 1914 AD

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"Earl of Arundel"
Rubens, 1630 AD

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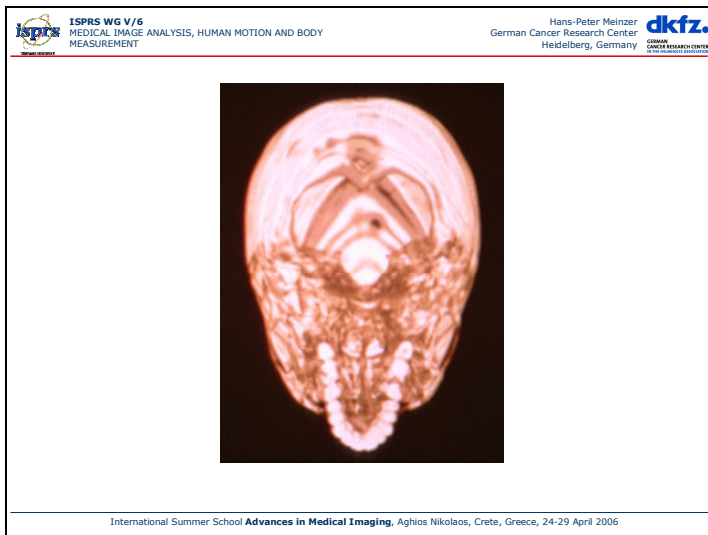
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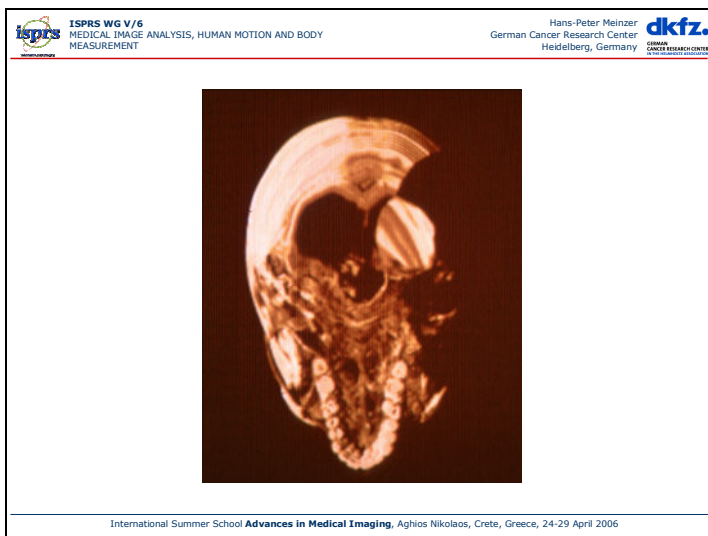
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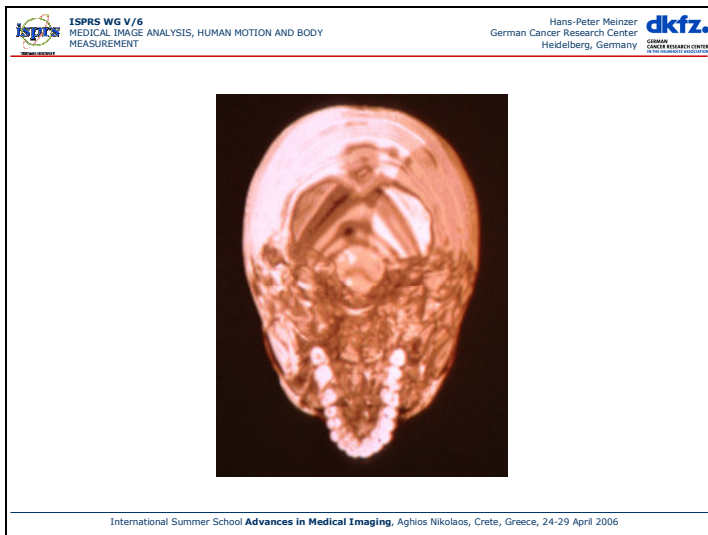
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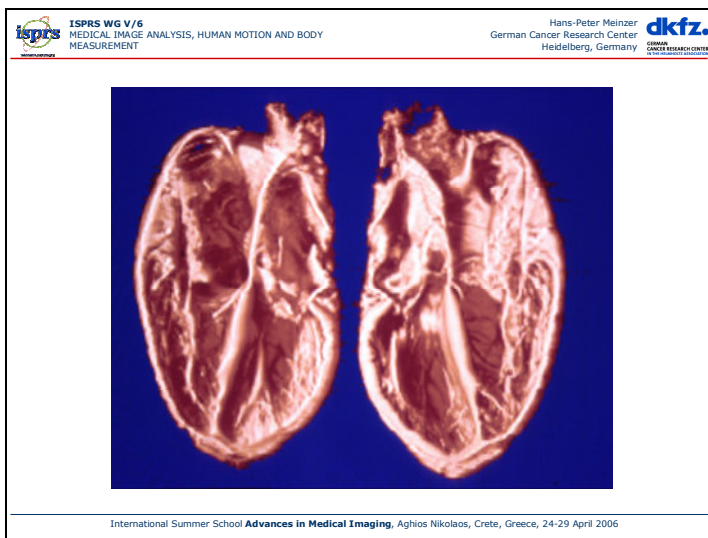
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"Snow white"
Disney, 1937

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"Robin Hood"
Disney, 19XX

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"Gerl's Game"
Pixar, 1997

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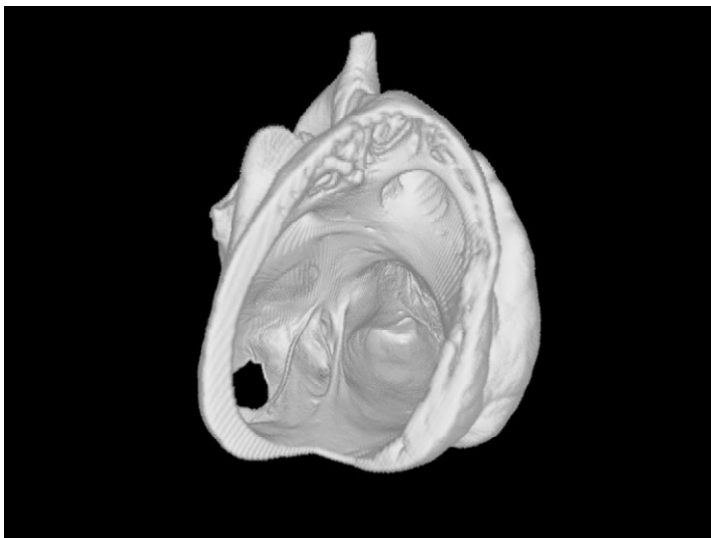

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Motion

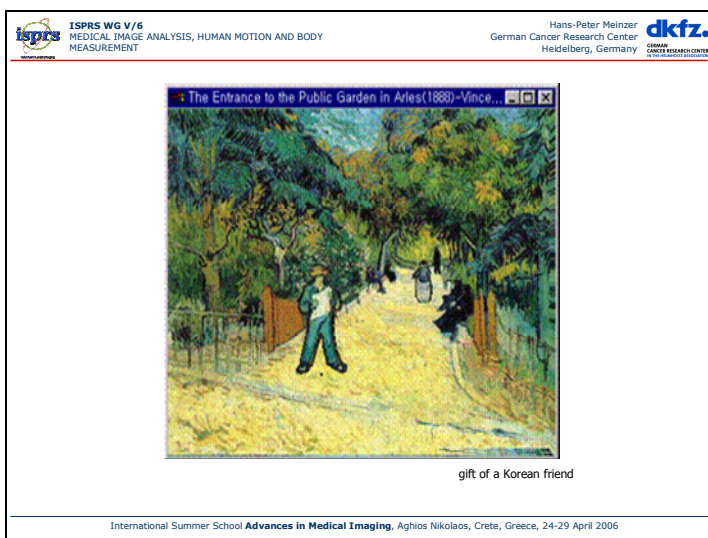
- ☐ The most vital impact on percetion on spatial depth is motion
- ☐ Shadows on objects caused by other objects support 3D perception
- ☐ This will be illustrated by a video

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gift of a Korean friend

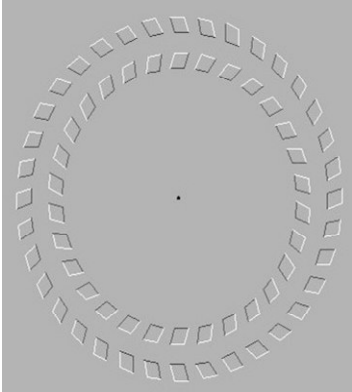
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Focus on the central dot and move your head back and forth !

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Herzfliegen


Zum Vorhof-Septum-Defekt bitte links...

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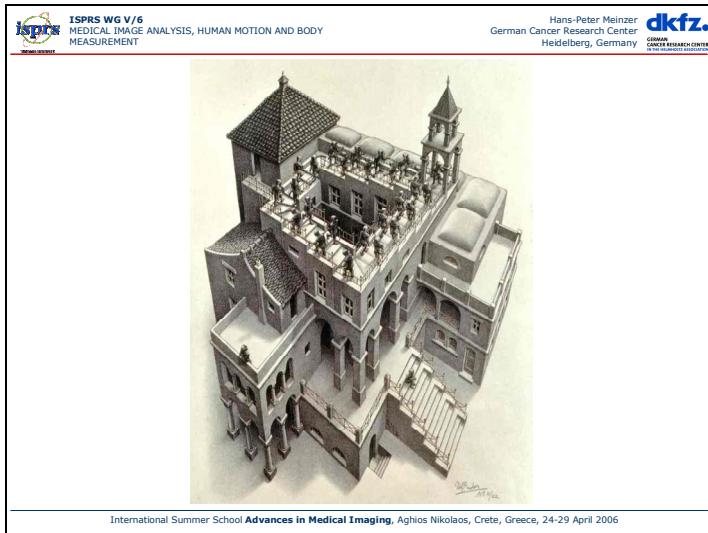


Knowledge

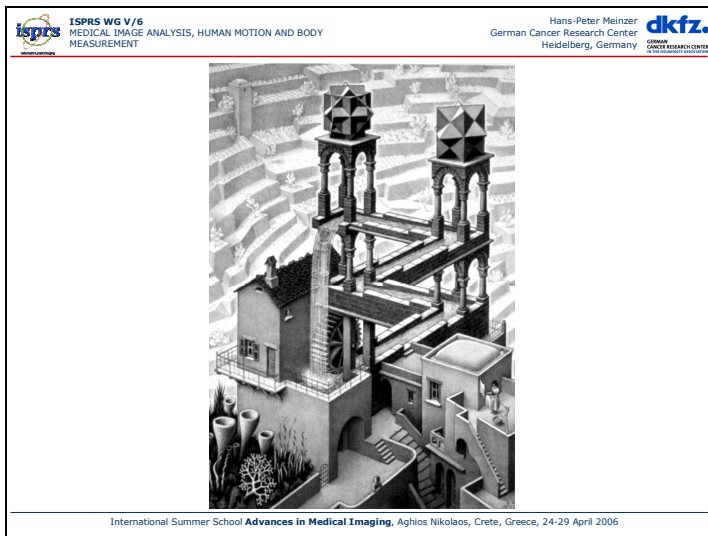
- ☐ The context of objects in time and space make them understandable
- ☐ Knowledge about features, shapes, behaviour help human perception
- ☐ Knowledge is not achieved in a few days
- ☐ Knowledge is difficult to store and retrieve in digital systems

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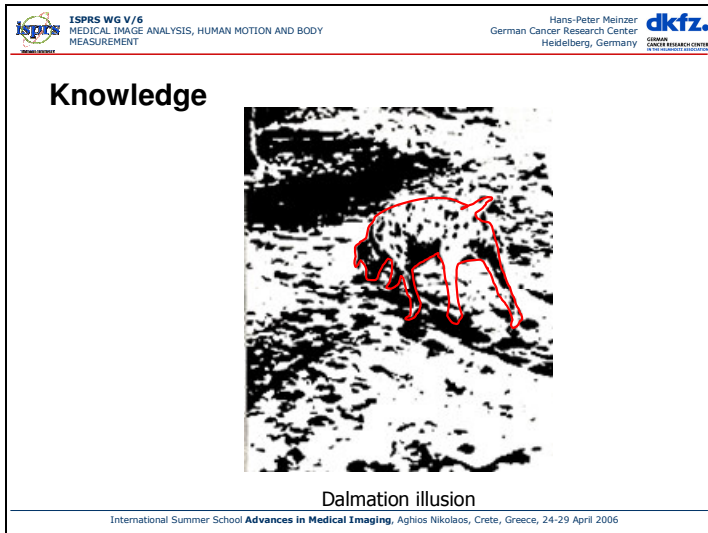
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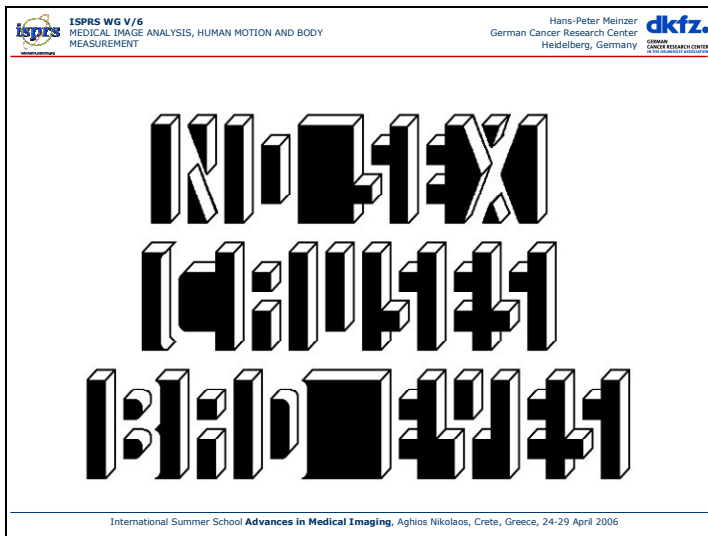
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81



82



83



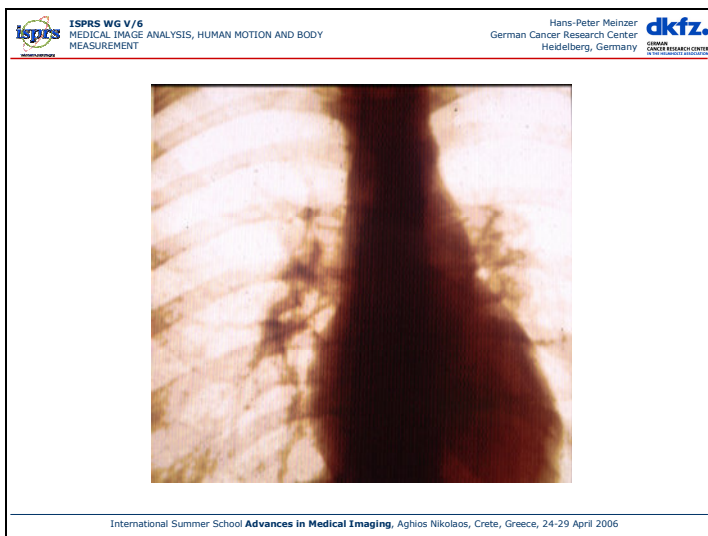
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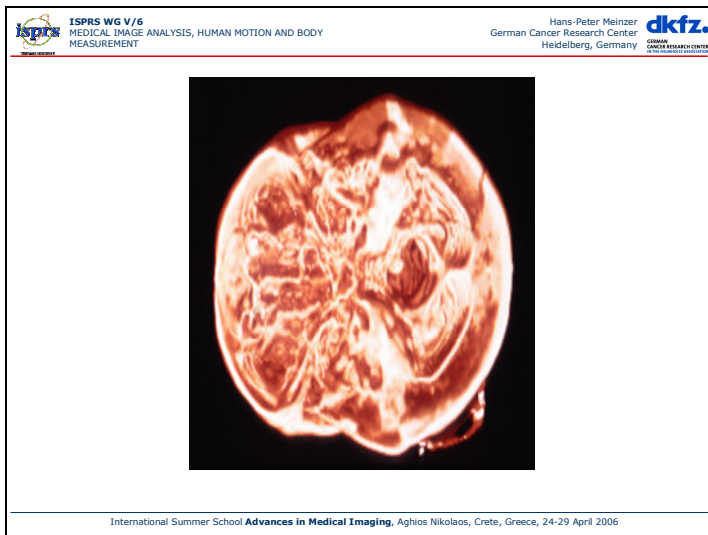
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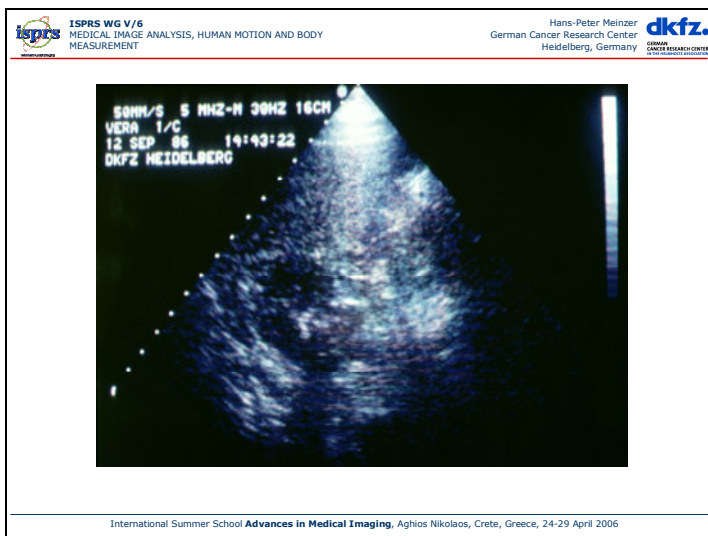
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87



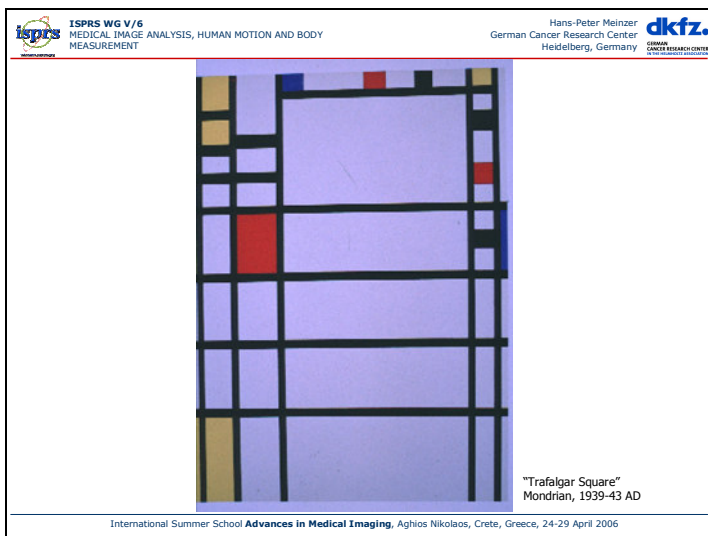
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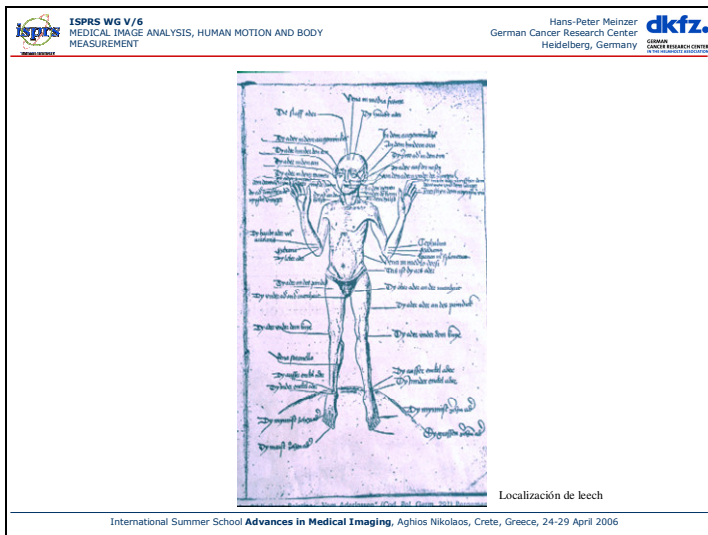
89



90



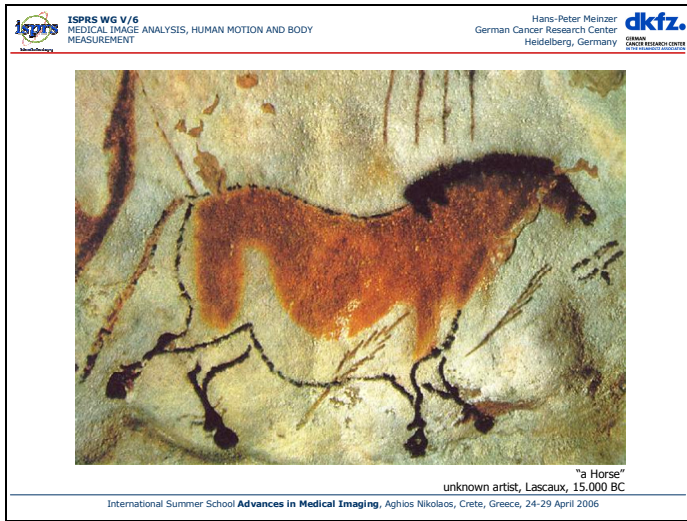
91



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94

ISPRS WG V/6
MEDICAL IMAGE ANALYSIS, HUMAN MOTION AND BODY MEASUREMENT

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Conclusions

- ☐ We must copy men's ability to understand topology and morphology
- ☐ The addition of knowledge to image understanding is indispensable
- ☐ If we can't make big steps we must make small steps


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**Thank you for your
attention!**

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