

# Einführung in die Farbwissenschaft

## Alien Vision

### Multispectral Imaging ("Alien Vision")

- a short tour that demonstrates a different "visual" world
- modern imaging devices permit us to „see“ in areas of the electromagnetic spectrum for which humans do not have sensory organs
- most animals see different!
- everyday objects sometimes exhibit strange appearance attributes when viewed in non-visible wavebands

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### Light – Basic Properties

- visible light is electromagnetic radiation in a particular region of the entire spectrum
- distinguishing criterion: its frequency

~380 – 780 nm ≈ 780 – 380 GHz

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### Ultraviolet (UV) & Infrared (IR) Taxonomy

- 1–30 nm **EUV** (extreme UV)
- 30–200 nm **FUV** (far UV)
- 200–400 nm **NUV** (near UV)
- 400–750 nm **visible** light
- 750–1100nm **NIR** (near IR)
- 1.1–2.5 μm **SWIR** (short wave IR)
- 2.5–7 μm **MWIR** (medium wave IR)
- 7–15 μm **LWIR** (long wave IR)
- 15–1000 μm **SMMIR** (sub-millimeter IR/wave)
- 1–3 mm **MMW** (Millimeter wave)

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### Animals in Near-UV

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### Photos with UV Light

scorpions in daylight      scorpions in UV light

Werner Purgathofer 5 source: John Bokma

### Insect Vision: Near-UV

This slide illustrates how insects perceive the world in the near-ultraviolet spectrum. It shows two butterflies: a bright yellow one and a black and white one. Below them are several flowers: yellow daisies, blue and purple flowers, and a white calla lily. The flowers are shown in their natural colors and in near-UV light, where they appear in shades of blue, purple, and red. The TU Vienna logo is in the top right corner.

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### Testing Money with UV Light

This slide demonstrates how UV light is used to test the authenticity of Euro banknotes. It shows a 5 Euro banknote in daylight and in UV light. In daylight, the banknote is normal. In UV light, it glows with bright blue and red colors. A small device is shown testing the banknote. The TU Vienna logo is in the top right corner.

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### Near-UV Medical Imaging

This slide shows near-UV medical imaging of a human face. The left image is a grayscale image of a face in visible light. The right image is a grayscale image of the same face in near-UV light, showing different skin textures and features. The TU Vienna logo is in the top right corner.

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### Person in IR – Visible – UV (and LWIR)

This slide shows four grayscale images of a person's face in different spectral bands: IR, visible, UV, and LWIR. The images show how the person's face appears in each band. The TU Vienna logo is in the top right corner.

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### Near-IR and Near-UV Imaging

This slide shows near-IR and near-UV imaging of a kitchen stove. The left image is a grayscale image of a stove in visible light. The right image is a grayscale image of the same stove in near-UV light, showing different textures and features. The TU Vienna logo is in the top right corner.

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### „Anomalous“ Near-IR Image

This slide shows an „Anomalous“ near-IR image of a glass of water. The left image is a grayscale image of a glass of water in visible light. The right image is a grayscale image of the same glass in near-IR light, showing a dark, almost black appearance. The TU Vienna logo is in the top right corner.

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### Medium and Long Wave IR

- non-standard imaging equipment needed
- MWIR / LWIR video equipment is comparatively recent technology
- MWIR cameras have **metal lenses** which are totally opaque to visible light!
- cooling is necessary for their CCD elements




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### SWIR Night View



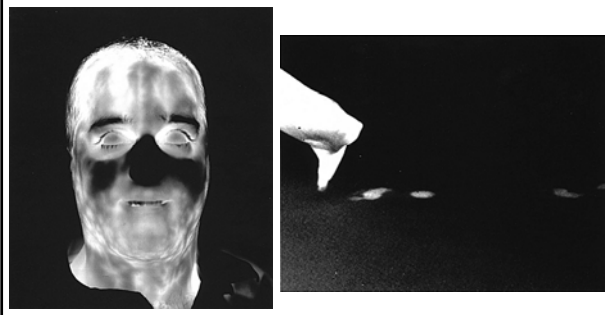
© Goodrich

### MWIR Examples



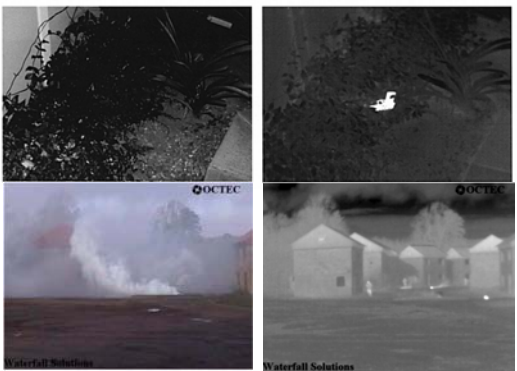
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### MWIR Examples



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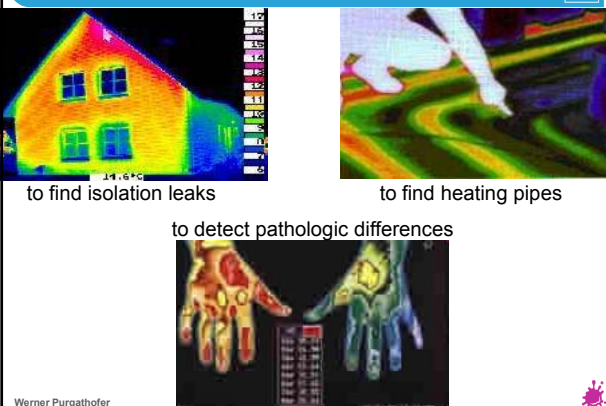
### LWIR Examples



Waterfall Solutions

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### IR Images



to find isolation leaks

to find heating pipes

to detect pathologic differences

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### LWIR Examples

to see through smoke and clouds

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### IR Photography Example

normal RGB image      monochrome photo with IR filter

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### IR Satellite Composite Images

R = 0.81 $\mu\text{m}$	R = 1.65 $\mu\text{m}$	R = 10.6 $\mu\text{m}$
G = 0.76 $\mu\text{m}$	G = 2.20 $\mu\text{m}$	G = 9.1 $\mu\text{m}$
B = 0.61 $\mu\text{m}$	B = 2.23 $\mu\text{m}$	B = 8.3 $\mu\text{m}$

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### Millimeter Wave Imaging

- recent development
- penetrates clothing and fog
- passive, not harmful
- emitted by the human skin
- current problems:
  - ◆ low resolution
  - ◆ low frame-rate
- plastic lenses used in production cameras

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### MMW Application: "Blind" Landing

view out of window

mm-wave image

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### MMW Security: Principle

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### MMW Images for Security Control

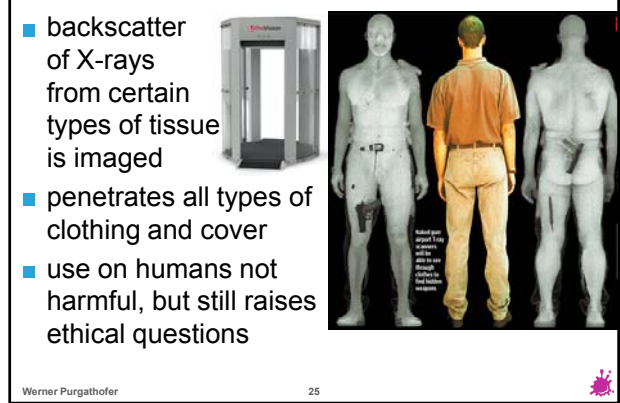


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This slide shows four images related to Millimeter Wave (MMW) security scanning. On the left, a man in a blue sweater is shown in a normal photograph and next to his corresponding MMW scan, which highlights his body shape and clothing. On the right, a man in a light blue shirt and dark pants is shown in a normal photograph and next to his MMW scan, which shows his body and the papers he is holding.

### X-Ray Backscatter


- backscatter of X-rays from certain types of tissue is imaged
- penetrates all types of clothing and cover
- use on humans not harmful, but still raises ethical questions



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This slide illustrates X-ray backscatter technology. It includes a photograph of a person walking through a backscatter scanner. To the right, three human figures are shown: a normal photograph of a person in an orange shirt and yellow pants, and two corresponding backscatter images. The backscatter images show the body's outline and internal structures, with one image highlighting a specific area. A small text box next to the backscatter images reads: "Backscatter images are not X-ray images. They are not harmful and do not penetrate the body. They only show the body's outline and internal structures." The TU Vienna logo is in the top right corner.

### X-Ray Backscatter



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This slide shows four backscatter images of a person. The first two images are labeled 'L' and 'R' and show the person's body with arms raised. The last two images are labeled 'R' and 'L' and show the person's body with arms raised, with red boxes highlighting specific areas on the chest and lower back.