

Thermography

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Motivation

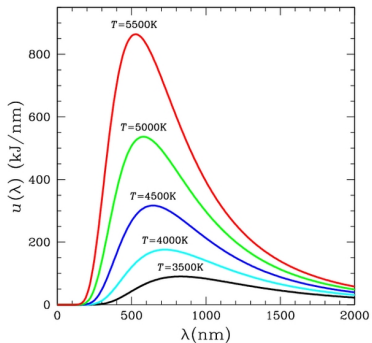
Principal features

- ▶ Measure infrared radiation
- ▶ Temperature estimation
- ▶ Contact-free

Application

- ▶ Night vision
- ▶ See through smoke
- ▶ Locate overheated parts
- ▶ Locate bad contacts (electric power lines)
- ▶ Detect heat leaks (buildings)
- ▶ Astronomy
- ▶ Medical imaging

Black body radiation



► Planck's law

Stefan-Boltzmann law

Energy flux density per unit surface is proportional to T^4 :

$$E = \sigma T^4$$

$$\sigma = \frac{2\pi^5 k^4}{15c^2 h^3} \approx 5.67 \cdot 10^{-8} \text{ J s}^{-1} \text{ m}^{-2} \text{ K}^{-4}$$

At 100 K energy flux density E is 5.67 W/m^2 ,

at 273 K $\approx 0^\circ\text{C}$ it is 1098 W/m^2 .

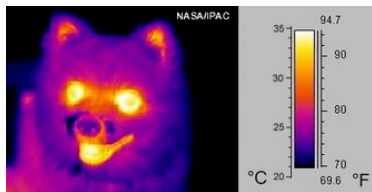
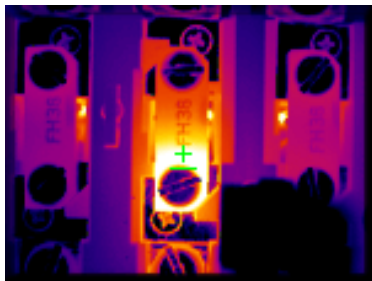
Temperature estimation

- ▶ Measurement at single wavelength
- ▶ Black body / known reflectivity assumption
- ▶ Calibration (objects) needed

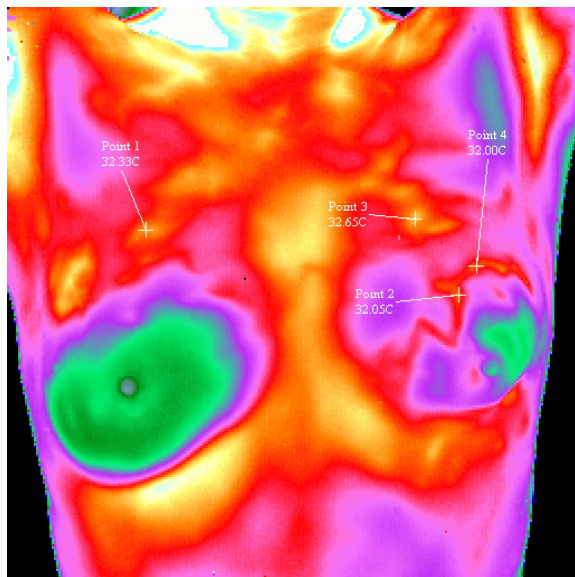
Detector types

- ▶ Cooled
 - ▶ Cooled to 4 ~ 110 K, typically 80 K
 - ▶ To avoid blinding by own thermal noise
 - ▶ Same principle as visible-light cameras, different materials
 - ▶ Superior quality
 - ▶ narrow-gap semiconductors (indium antimonide/arsenide, lead selenide/sulfide, HgCdTe)
 - ▶ photon-counting superconducting tunnel junction
- ▶ Uncooled
 - ▶ Change of resistance, voltage, or current when heated
 - ▶ pyroelectric materials
 - ▶ microbolometer (vanadium oxide changes R when heated)

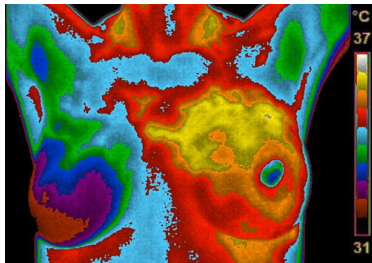
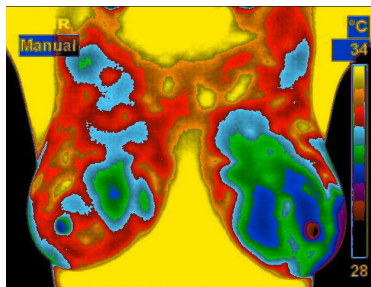
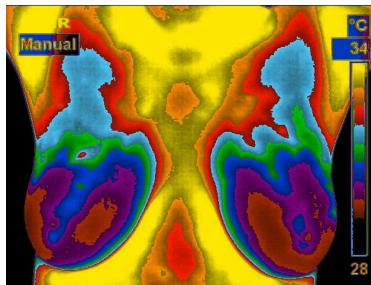
Examples



Breast Thermography



Breast Thermography (2)



Other medical thermography applications

- ▶ Visualising vessels, vessel diseases
- ▶ Angiogenesis — cancer detection
- ▶ Dermatology
- ▶ Stomatology
- ▶ Headaches, facial nerve injury
- ▶ Neuro-musculo-skeletal diagnostics

Conclusions

- ▶ Imaging IR radiations
- ▶ New information, imaging without visible light
- ▶ Temperature measurements with limited accuracy, reproducibility
- ▶ Noninvasive medical diagnostics
- ▶ Limited reliability (too many influencing factors)