What is thermal imaging

Thermal imaging is the technology dedicated to form images through the acquisition and processing of thermal signals, using thermographic cameras. Unlike normal cameras which detect visible light, thermographic cameras detect infrared radiation, so they are also called IR cameras. With IR sensing cameras, we are able to measure temperature accurately simply by looking at an object. This is called a non-contact method for temperature measurement. Besides, the ability to form pictures and see things in darkness makes thermal imaging extremely powerful.

How thermal imaging works

Image 3 shows the typical structure of an IR camera. This structure is similar to that of a normal camera, except that the optical system focuses infrared light. Infrared is a form of light that has longer wavelength than visible light in the spectrum. Infrared is used to infer temperature because it usually carries a lot more thermal energy than visible light. After an image is formed on the plane of IR detectors (Focal Plane Array), each detector would tell the light intensity at a specific pixel. There are two types of IR sensors: thermal sensors that react to temperature change and photon sensors that directly count incoming photons (Image 4). Combining the measurements from thousands of IR detectors, we can analyze them and present an interpretable image.

Emissivity Calibration

Emissivity is an extremely important input parameter in the thermal imaging process. It indicates how well a surface absorbs and emits radiation energy compared to a blackbody. A blackbody would absorb all the radiation energy that falls upon it and radiate it away, so a blackbody has an emissivity of 1. Image 6 shows the emissivity effect: although the ring has the same temperature as the hand, it appears to be colder in the image. This “error” is caused by the fact that the ring has lower emissivity than the hand.

Blackbody Radiation

Anything with a temperature above zero Kelvin emits blackbody radiation, which is electromagnetic radiation across all wavelengths. IR cameras use Stephan-Boltzmann law to calculate temperature from radiation intensity (Image 5). In this equation, I is radiation intensity in Watts per unit area, \( T \) is temperature in Kelvin, and \( \varepsilon \) is emissivity. Stephan-Boltzmann law states that the total blackbody radiation emitted from an object is proportional to the fourth power of its temperature.

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I = \varepsilon \cdot \sigma T^4
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Stephan-Boltzmann law

Image references