Infrared Thermography

Nikon Laird-S270 Infrared camera

Temperature resolution 0.1°C
Thermal interaction
Thermograms of a healthy 52 year old male subject in a cold environment (ca. 15°C; upper panel) and in a warm environment (ca. 25°C; lower panel). In the cold environment arteriovenous anastomoses in the nose and the auricle region of the ears are closed, resulting in low skin temperatures at these sites. Also note reduced blood flow in the cheeks but not on the forehead, where the blood vessels in the skin are unable to vasoconstrict.
Especially designed image analysis software* allows one to superimpose an IR-thermal images onto a normal digital photograph. The degree of superimposition can be varied from 0-100%. This technique allows one to more easily relate an IR-image with surface anatomy. The image shows the abdominal region of a patient prior to autologous breast reconstruction surgery (1 day pre-operative).

Medical Computing Research Group, University of Glamorgan, Wales, UK.
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Efficiency of skin blood flow as a heat transporter. The photograph in the upper left panel shows a rubber mat being heated with a water filtered infrared-A irradiator at high intensity (400 mW/cm²) for a period of 20 minutes. In the lower panel the time course of surface temperature of the mat at 5 selected spots as measured by an IR-camera is given. During the last 10 minutes of the 20-minute heating period the left hand of a healthy 54 year old male subject was placed on the mat. Note that skin surface temperature of the hand remains below 39°C.
Panel A. The distribution of cutaneous nerves of the hand.

Panel B. IR-thermogram (palmar view) of a 40 year old female patient following a successful nerve block of the left median nerve. Note the strong vasodilatory response (area of highest temperature) due to suppression of autonomic input and how the affected area nicely coincides with the predicted distribution of this nerve.

Panel C (palmar) & D (dorsal) IR-thermograms of the hands of a 36 year old female patient whose left wrist (middle of the red circle) was punctured with a sharp object resulting in partial nerve damage (motor and sensory loss). The strong vasodilatory (increased skin temperature) response resulting from partially severed nerves can easily be seen.

Panel D. IR-thermogram (dorsal view) of the same patient, showing similar vasodilatory response.
Infrared thermograms, temperature profiles, scanning laser Doppler scans (SLD), and blood flow profiles (perfusion units PU) of the abdominal area of a 44-year-old healthy female subject before (A), immediately after (B) and 5 minutes (C), 10 minutes (D) and 20 minutes (E) after a 20-minute heating of the right side of the abdomen with a water-filtered infrared-A irradiation lamp. The blue horizontal lines in the IR-thermograms indicate the position of the temperature profiles. The red horizontal lines in the SLD scans indicate the position of the blood flow profiles. In IR-thermogram B, the white colour indicates skin temperatures greater than 36°C.
Visualization of perforating blood vessels with dynamic IR-thermography

Visualization of perforating blood vessels in the abdominal area with the use of dynamic IR-thermography. The IR-thermograms show skin temperatures before and at various times after a mild skin cooling (2 minute fan cooling) in a 32 year old female subject. To help highlight the perforating vessels an outline function has been employed in which all skin areas having a temperature greater than 32.5°C are enclosed in solid lines.
Infrared thermal imaging and autologous breast reconstruction surgery

Infrared thermal images of an abdominal skin flap during breast reconstruction surgery. The sequence of IR-thermal images demonstrates the return of heat to the excised skin flap following re-establishing its blood supply (anastomising of a mammary artery and vein to a single branch of the deep inferior epigastric artery and a concomitant vein). Prior to this procedure the excised skin flap had been without a blood supply for about 50 minutes and consequently cooled down. The photograph in the upper left panel shows the skin flap in position on the chest wall prior to being shaped into a new breast.
Infrared thermograms of a patient 6 days after autologous breast reconstruction surgery. The new breast was constructed using skin and fat tissue excised from the lower abdomen - a so called DIEP (deep inferior epigastric perforating artery) flap. The thermal images give information about circulation in the new breast, which depends on the patency of the anastomoses between the vessels of the transplant and the recipient vessels on the thoracic wall.
The hot spots were later confirmed as lymphomas.

Example of IR-thermography as a tool in cancer diagnostics.

22 year old female patient
ØNH avd, UNN. 13.09.04
Frey's Syndrome is a rare neurological disorder that results from injury or surgery near the parotid salivary glands, damaging the facial nerve. The parotid salivary glands are located on the side of the face below and in front of the ear. This syndrome is characterized by flushing or sweating on one side of the face when eating. IR-thermography provides a convenient non-invasive method for localizing the affected area for treatment with botox.
Visualization of sweat glands on fingertip (each dark spot in the IR-thermogram shows the opening of a sweat gland. The openings show up as dark (cold) spots due to evaporation of sweat).
Drainage of blood in hand via superficial veins is influenced by finger temperature.
Non-freezing cold injury (NFCI) in left foot of 26 year old male subject following cold exposure during military exercise

Affected area (cold skin due to reduced circulation)
Visualizing pain and inflammation

Corn

Inflammation in foot and lower leg caused by corn
IR thermography and cancer diagnosis

Intra-oral soft tissue cancer with infiltration into jaw bone. Increased blood circulation in the affected area shows up on the IR-thermogram as a warm area.
Non-specific muscle pain in upper right arm. The area of discomfort closely matched the area of cooler skin (blue coloured area inside black circles).
Occlusion of left internal carotid artery.
Total right side hemiparesis.
Infarction of left hemisphere
Visualizing blood flow varicose veins

IR-image taken 5 seconds after leg elevation to drain the damaged veins

IR-image taken 16 seconds later

Retrograde re-filling of left saphenous vein following leg elevation
Chronic venous ulcer

Temperature profile across ulcer

3-D visualization of infrared image
Subclavian steal syndrome is caused by occlusion of the proximal subclavian artery with subsequent retrograde filling of the subclavian artery via the vertebral artery. Note thermal asymmetry between right and left side of body.

60 year male
Discomfort in left arm with periodic loss of manual dexterity.
BP: right over arm 124/82 mm Hg
left over arm 90/80 mm Hg
Dynamic IR-thermography can be used to examine circulatory responses in the skin during recovery from a cold provocation test (the hands were covered with thin plastic bags before being immersed in cold water for 2 min at 10°C).
Asymmetrical re-warming of fingers following cold provocation test in 69-year old female patient with Raynauds Syndrome.

"white" fingers

Cold water test

Finger-tip temperatures

Vertical line indicates time point at which IR-thermogram was taken. Note thermal asymmetry in fingers.
Normal and 3D-infrared thermograms of venous leg ulcers (inside of r. leg)

Note "inflammed" right leg.
Circulatory loss in injured fingers
Image inversion

Comparison of left and right side using inversion of one image

Upper - normal view with left breast directed towards camera
Lower - inverted view with right breast is directed towards camera