Zurich University of Applied Sciences

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On the potential of active thermal imaging for skin cancer diagnostic

DERMOLOCKIN

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Introduction

Thermal imaging or thermography consists in measuring and imaging the thermal radiation emitted from every object with a temperature above the absolute zero point. Thermography is a widely used method in engineering, presenting undisputed advantages such as being **sensitive, fast, non-contact and non-invasive**. Since first disappointing studies devoted to skin cancer diagnostic, thermal imaging dramatically evolved. Current affordable IR cameras feature excellent thermal and spatial resolution, and are not more difficult to use than a standard webcam. In addition, new active measurement procedures in combination with numerical models demonstrated that quantitative physiological information could be retrieved.

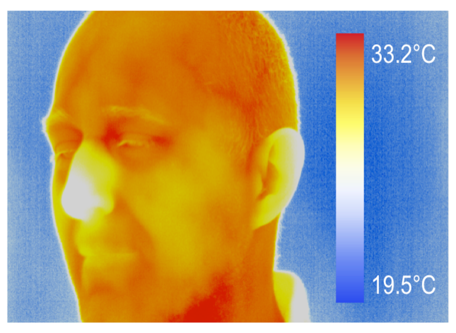
We believe that the time has come to re-examine the potential of thermal imaging for skin cancer diagnostic.

1980

First generation of IR camera

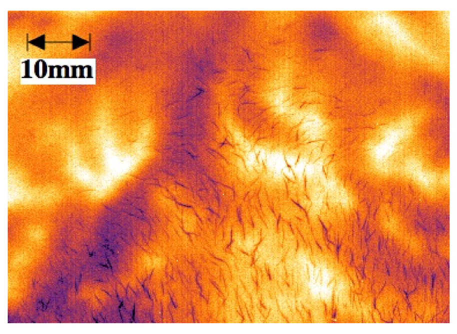
2015

Lepton® core from FLIR



IR image taken with an uncooled microbolometer core from Xenics

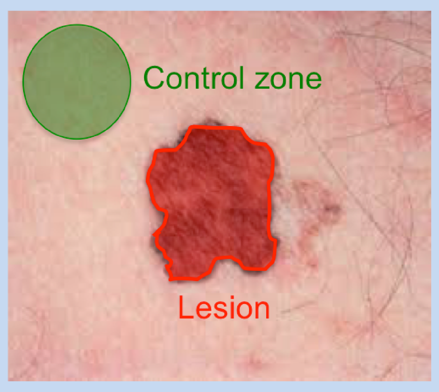
State of the art

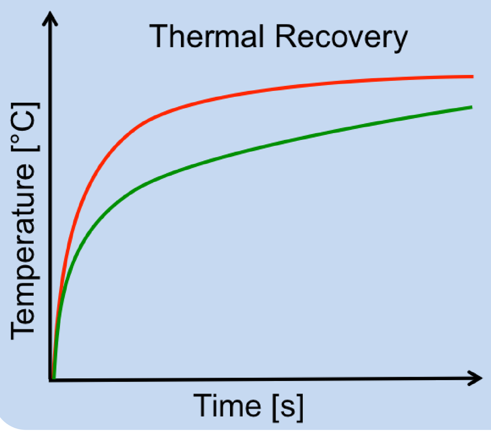


IR image of a male chest showing o mosaic of hyper- and hypothermal areas.

Several studies tried to detect early-stage melanomas with thermography based on the assumption that malignant lesions should exhibit a different temperature pattern compared to surrounding healthy skin. Results showed a high percentage of false negatives. This is due to the fact that small hot or cold spots are often "buried" in sub-cutaneous thermal signals and difficult to identify (see left image).

Active thermal imaging





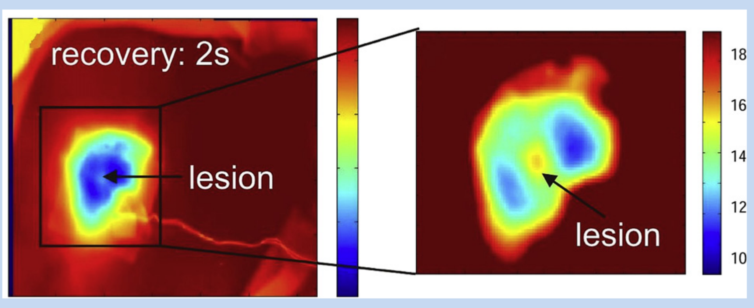
Active thermal imaging (or dynamic thermography) allows to retrieve more information than standard thermal imaging (passive thermography).

<u>Active thermography works the following:</u>

- The skin surface is subject to an external thermal stimulation (cold or hot).
- The way the skin retrieves its equilibrium is monitored (thermal recovery).
- The thermal recovery is different between the different types of lesions and healthy skin.
- The technique is successfully used in engineering

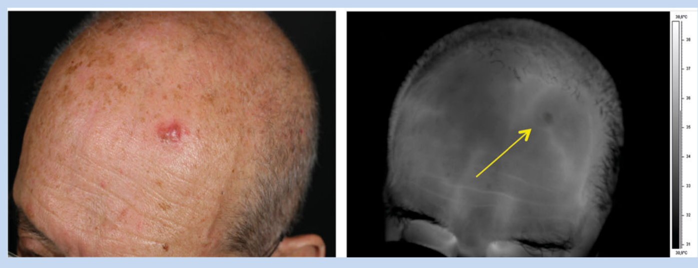
Previous clinical outcomes

Çetingül and Hermann at Johns Hopkins compared the thermal recovery of early-stage melanoma with healthy surrounding tissue[3,4].



IR image of a stage II melanoma lesion taken after cooling (2s into the thermal recovery)[3].

They demonstrated that melanoma exhibit a faster thermal recovery time in comparison to healthy skin.



BCC exhibit a cold at the location of the tumour[2].

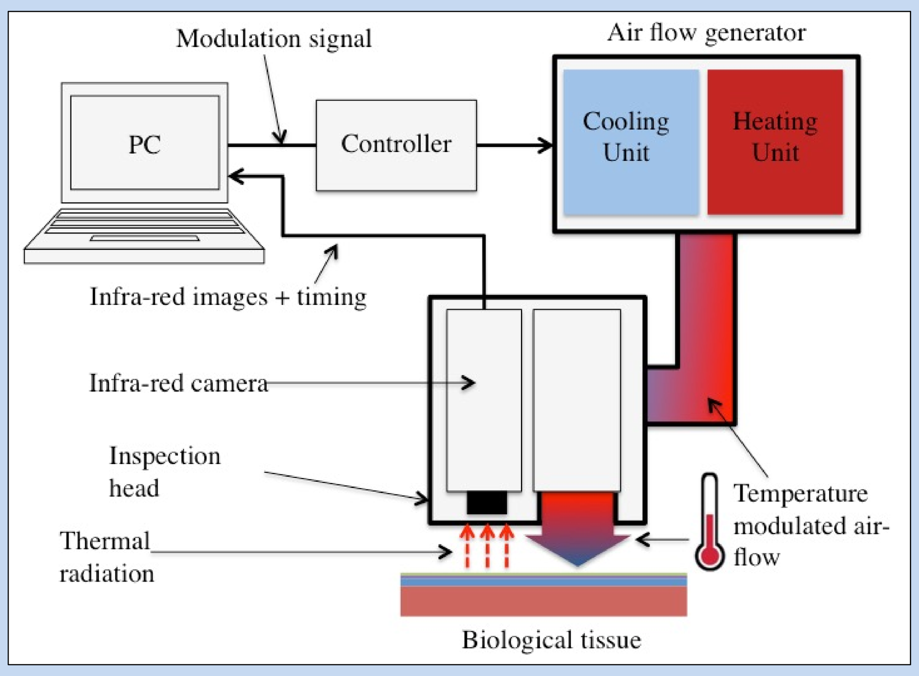
Di Carlo has been a pioneer using active thermography for skin cancer diagnostic[1]. He noticed that melanomas (except *in situ*) develop hyperthermic signatures. Recently, a study carried out on 36 patients demonstrated that BCC and AK exhibit clear different thermal recovery times[2] even when dermoscopy is not conclusive.

Our technology

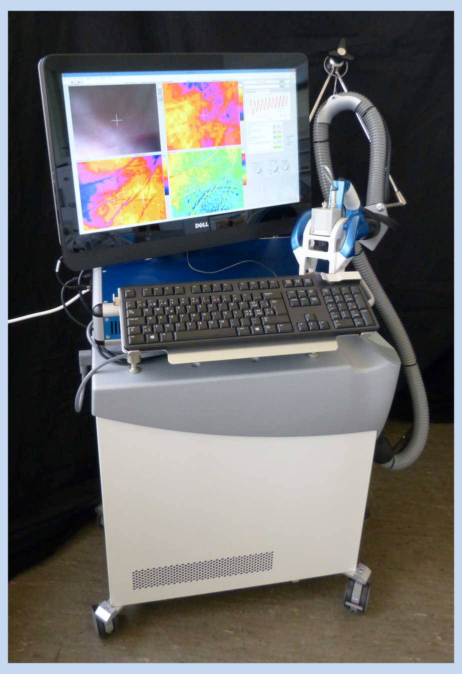
Despite interesting preliminary results, more clinical data should be acquired to assess the potential of active thermal imaging in skin cancer diagnostic. One of the current problem is the **lack of standardization of measurement procedures** obtained with the different setups.

To solve this problem, we developed a compact and versatile apparatus capable of delivering reproducible cold and hot thermal stimulations. In addition, specific image analysis tools have been implemented to extend the device capabilities.

The Dermolockin prototype



Pictorial description of the Dermolockin setup

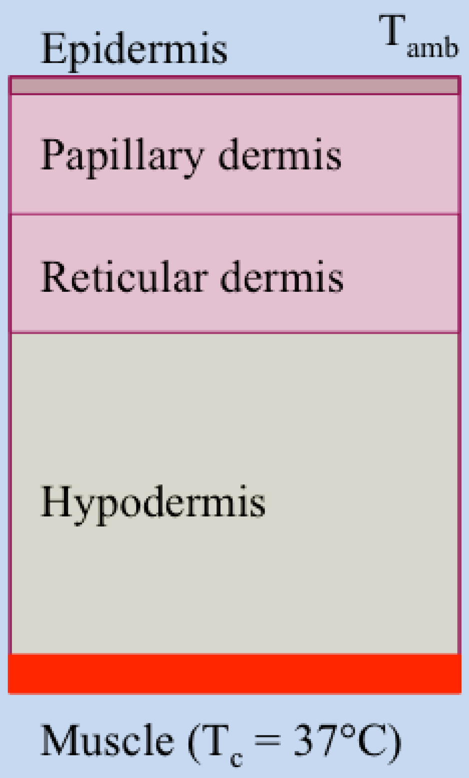


Current prototype

<u>Set-up features:</u>

- Different thermal modulations possible (cooling + warming). Reproducible measurements.
- Non-contact, based on a temperature-modulated air-flow.
- Outstanding IR images quality (high resolution camera from Xenics), specifically developed image analysis tools to process and display the results.
- Clinical images available (under polarized illumination).
- Compact, easy-to-use and safe (no radiation, no LASER).

3D heat transfer skin model

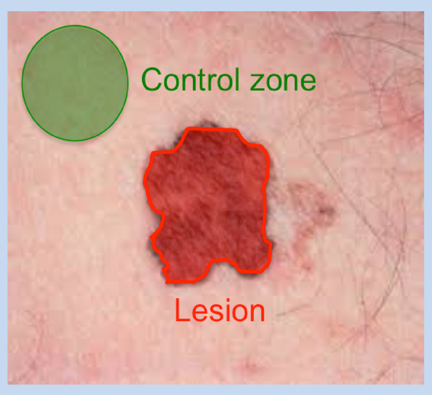


To analyze the thermal images and to retrieve quantitative information, we developed a 3D numerical skin model. The model aims to reproduce heat transfer processes happening in the different skin layers. It takes into account the skin density, heat capacity and conductivity, perfusion and metabolism.

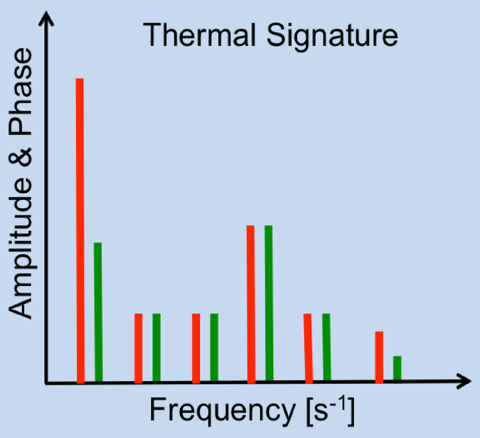
<u>The model allows to:</u>

- Analyze the thermal images to extract physiological skin parameters.
- Select the measurement procedures for an optimal contrast lesion/healthy skin.

Data analysis



The acquired infrared images are first pre-processed with standard image analysis tools to improve quality (background correction, small movement compensation, cropping, etc.)



In a second step, we analyse the thermal signatures and the associated frequency responses for each pixel. Different characteristics can be plotted (phase, amplitude, real or imaginary part). This allows to distinguish between domains with lesion and healthy skin. In our example, a significant contrast between lesion and healthy skin is obtained in the low frequency range

Bibliography

[1] Di Carlo (1995) *Clinics in Dermatology* **13**:329-336.
[2] Di Carlo et al. (2014) *Dermatologic Therapy* **27**:290-297.
[3] Çetingül & Herman (2011) *International Journal of Thermal Sciences* **50**:421-431.
[4] Çetingül & Herman (2013) *Expert Review of Dermatology* **2**:177-184
[5] Bonmarin & Le Gal (2014) *Computers in Biology and Medicine* **47**:36-43.
[6] Bonmarin & Le Gal (2015) *Skin Research and Technology* **21**:284-290

Conclusion

- Thermal imaging dramatically evolved during the last decades.
- Preliminary clinical results using active methods are promising.
- Procedures should be standardized and more data are needed to evaluate the potential of the method for different applications.
- Possibility to use numerical modelling and image processing tools developed in engineering to improve the method accuracy.