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Dynamic infrared thermography for skin lesion screening

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Abstract

Infrared thermography technology has improved dramatically in recent years and is gaining renewed interest in medicine for applications such as skin tissue identification, breast reconstruction using DIEP flaps, psoriasis etc. However, there is still a need for an optimized measurement setup and protocol to acquire the most appropriate images for decision making and further processing. Nowadays, different cooling methods are used, but a general optimized cooling protocol has not been defined yet. In this manuscript, a standardized cooling technique and measurement setup, are reviewed and optimized. It is possible to improve the thermal images by choosing an appropriate cooling method, cooling and optimized measurement setup.

1. Introduction

In 2020, more than 19 million new cases of cancer were diagnosed, with an estimation of around 10 million deaths. Non-melanoma of the skin accounts for 6.2% of the total amount of new cases, while melanoma of the skin accounts for 1.7% of new cases. Early detection of the cancer increases survival rates and leads to less expensive, more effective treatments that often have less impact on patients' quality of life [1]. Infrared thermography (IRT) can make the difference in the early detection of skin cancer. The diagnosis of skin lesions consists of measuring the thermal response of the skin and skin lesion to thermal stress (cold provocation). Cooling the surface of the skin increases the thermal contrast. During rewarming, a different thermal behaviour can be displayed because of the difference in the thermophysical properties of the lesion and the healthy tissue. In literature, different cooling techniques were considered; cooled gel pack, aluminum medal, immersion in water, alcohol spray, vortex tube an a commercially available AC unit [2, 3]. During measurements for skin cancer identification, the IR camera is mostly mounted on a tripod. Involuntary body movements are difficult to suppress while having a complex body position or while standing straight. This leads to degrading imaging quality.

2. Materials and Methods

A FLIR A700 long-wave infrared camera (7,5-14 μm) equipped with a macro lens is used to capture 16-bit thermal image sequences in 640 $\times$ 480 resolution at a frame rate of 30 Hz. The cooling device used to cool the skin lesion is a Cryo 6 cold air unit from Zimmer MedizinSysteme GmbH. The Cryo 6 cooling system cools the skin in a non-contact, rapid and reproducible manner without affecting the infrared camera's field of view. The camera is mounted in a customized measuring head (figure 1a) which rests on the skin and that allows the camera to be kept at a fixed focal distance from the skin. The measurement head cools the lesion and surrounding skin while the infrared camera captures thermographic images of the cooling and reheating cycle.

The temperature of the examination room is kept constant at 21 ± 1 °C and humidity $\leq 50\%$. The patient must acclimate for at least 10 minutes to reach a stable temperature. An examination table on which the patients can position themselves comfortably is foreseen so that unintentional movements can be excluded. First, a visible light (RGB) image is taken of the patient's skin lesion. Then, 100 steady-state images of the affected skin area are taken to serve as a baseline. The skin lesion is cooled for 10 to 30 seconds and the cooling and rewarming of the skin lesion and healthy skin is recorded. The cycle of cooling and rewarming lasts from 2 to 4 minutes, depending on applied the cooling load. The use of the measurement head is illustrated in figure 1b

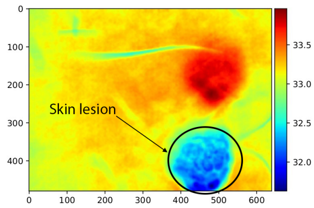
3. Results

The preliminary results of the applied imaging procedure can be found in figure 2. The lesion in steady state has a temperature of around 32 °C. After the cooling load, the temperature of the lesion decreased to around 4 °C. The 20, 60 and 120 second rewarming frames are also displayed. The skin lesion is clearly visible in the infrared images.

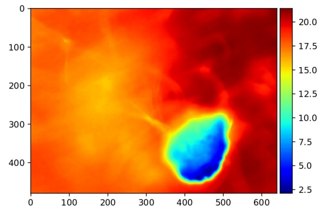
(a) *Cryo cooling unit and measurement head*

(b) *Close up of measurement system while capturing data*

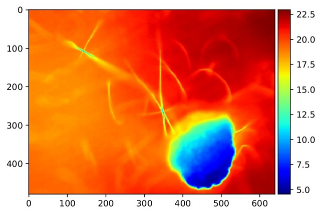
(a) *RGB image lesion*



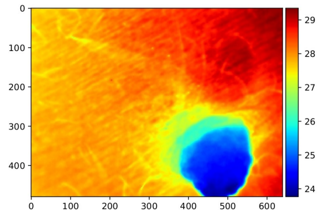
(b) *Steady state image*



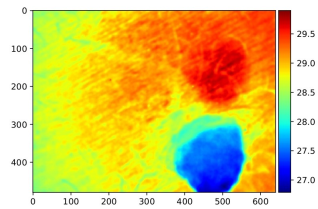
(c) *After 20 sec of cooling*



(d) *20 sec rewarming*



(e) *60 sec rewarming*



(f) *120 sec rewarming*

Fig. 2. *RGB image and macro infrared thermography on skin lesion (20 sec of cooling, 120 sec rewarming)*

4. Conclusions

In order to compare measurements taken at different times, a general measurement setup and protocol are required. Comparison of different cooling techniques and cooling times led to finding the most appropriate cooling protocol for thermal measurements to identify skin tissue. The measurement hardware was reviewed and optimized to increase the accuracy and repeatability of the measurements. This proof of concept for the measurement head was successful, but adjustments still need to be made to the instrument. Centering the instrument over the region to be measured needs to be facilitated by implementing a real-time RGB camera and laser pointer. Future research will include a system to avoid uncontrolled movements of the measurement head and the patient, as well as thermographic data processing such as motion tracking, image processing, segmentation, and classification of the lesions.

References

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