Advances in Pain Assessment by using Thermography: FITI- PAIN Project

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Abstract

This paper reports the advances concerning an instrumental technique used to assess pain. Pain is a debilitating condition affecting about 20% of the adult population worldwide. It has important physical, psychological, and social consequences and can affect quality of life. Today, pain assessment mainly relies on patients' self-reports describing their pain perception. Consequently, its evaluation is highly subjective. In specific cases, for example, when the patient is unable to communicate his/her sensation due to disability, the algologist assesses pain by observing the patient's face or behaviour. For these reasons, the development of objective tools for pain assessment remains a major challenge.

The authors aim to address the lack of objective pain assessment tools by proposing an instrumental technique. In detail, the Research Team has developed an innovative thermographic technique, named functional Infrared Thermal Imaging (fITI). It has been applied to study the pain mechanism in both healthy volunteers and patients with chronic pain by investigating the role of microvascular perfusion in pain sensation.

Cold pressor test and painful stimuli obtained by using a Wartenberg pinwheel have been used as pain triggering events in volunteers. Data related to the perfusion signal have allowed us to extract information on the sympathetic nervous system involvement in the pain mechanism. The study has shown clear alterations of microvascular perfusion during pain sensation. Such alterations are strictly related to physiological processes such as: the constriction or relaxation of vascular smooth cells, the involvement of the sympathetic nervous system, the shape changes of endothelial cells in the vessel wall as a response to haemodynamic cues, and the respiratory and cardiac activities. The strict relation between the pain mechanism and the above processes could provide significant information to measure pain in the next future.

1. Methodology

The main achievements of the project include the development of two thermography-based prototypes and a mathematical model that converts thermal signal into perfusion signal in both the time and frequency domains. Perfusion signal has been investigated in both healthy subjects and patients with pain-related disorders. Pain was experimentally induced in healthy volunteers through standardized stimuli, while a high-performance thermal camera was used to observe the body areas affected by pain. The experimental study carried out on the blood flow dynamics in the presence of pain has shown a direct alteration of the perfusion signal. Whereas microvascular perfusion is, at rest, characterized by periodical changes, the signal has shown evident alterations at the moment at which the pain is evoked. In detail, the Cold Pressor Test and a Wartenberg pinwheel have been used as standardized tools to evoke pain in the hands of volunteers. Both hands have been observed for 20 minutes to analyse such oscillatory components of blood flow. Results show that the perfusion component in specific Regions Of Interest (ROIs) directly correlates with pain sensation. The wrist shows a greater sensitivity than the other hand regions. Blood flow components show noticeable alterations when the subject experiences high-intensity pain.

In Figure 1, the thermographic image of the volunteer's hands is shown. Sixteen ROIs have been investigated. In the fifteenth minute, the right forearm was stimulated by using the Wartenberg pinwheel. The pain sensation reported by volunteer was 7 on a scale from 0 to 10.

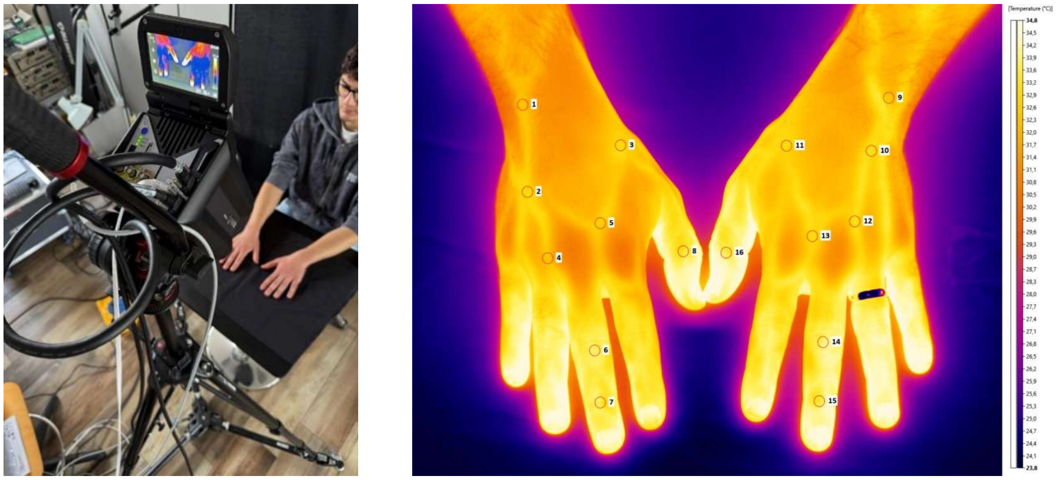

Figure 1. Thermographic image of the volunteers' hands.

Figure 2 reports the spectrogram of the perfusion signal of the wrist of the right hand. It is possible to observe the response, highlighted in yellow, to the painful stimulus.

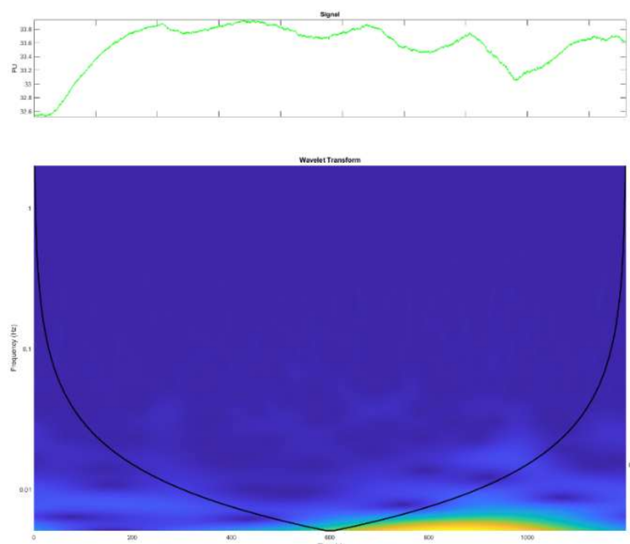

Figure 2. Spectrogram of the response to pain of the right hand wrist (ROI #1).

Overall, the experimental activities confirmed the effectiveness of the developed technique as a promising instrumental-based tool for pain assessment. The research team expects the proposed approach to have a significant scientific impact in both academic and clinical contexts, thanks to its innovative contribution to pain evaluation.

2. Acknowledgment

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