Dynamic Laser Speckle in Medical Imaging: On the quantification of skin patterns

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Abstract

The objective examination of the skin is performed through qualitative or semi-quantitative observation, and in some cases, it is complemented with digital imaging by dermoscopy [1]. However, skin assessment using Digital Imaging Processing (DIP) techniques that lead to the extraction of quantitative features is a central process in Dermatology, being translated by state markers (in terms of physiopathology and morphology). These features, together with a large set of techniques can be used by healthcare professionals as an aid to diagnosis and therapeutic [2, 3]. In this work, the skin pattern is assessed by means of dynamic speckle, a technique based on the analysis of the interference pattern created when a surface is illuminated with a coherent light source (e.g. laser). This pattern, consisting of small light and dark spots, exhibits a grainy effect that varies in shape and intensity over time reflecting the dynamic processes that lead to microscopic changes of the surface shape itself.

The interference pattern obtained might not have obvious relation to the macroscopic properties of the surface, however, it has been used to characterize dynamic processes at the microscopic level.

This project aims (i) to characterize the speckle patterns of healthy skin and (ii) use these quantitative standards to evaluate some skin diseases (e.g. psoriasis, melanocytic lesions, ...) as well as healing processes (e.g. diabetic foot wounds).

Given the experimental nature of this project, the first step is the definition of specific protocols in terms of video sequencing and dynamic states to each of the identified conditions. At a second stage, a comprehensive image processing task will be carried out, mainly by using Machine Learning and Pattern Recognition tools, to define quantitative metrics for each dynamic state/condition.

The instrumentation to obtain the speckle image will be adequate to be used in the skin, meeting the thermal conditions to avoid local homeostasis. In the proof of concept (in the second part of the project) this study will follow all the legal requirements and will be submitted to an ethical committee.

The characterization of the activity patterns (i.e., microcirculation) associated with cutaneous lesions through the definition of quantitative markers will facilitate to have a more objective knowledge of the physiological processes and to monitor in this way treatments and their evolution.

Keywords: dynamic speckle, digital imaging processing, texture analysis, skin diseases assessment

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