A DEVICE SUPPORTING SKIN TISSUE ANALYSIS AND ANOMALY DETECTION USING TRANSDERMAL LIGHT

ABSTRACT

A device is described to support the analysis of skin tissue and anomaly detection using transdermal light. The handheld device operates in contact with the skin's surface. It contains light sources that emit light directed into the skin of suitable intensity and wavelengths such that the light penetrates into the epidermis and dermis. A set of photodetectors contained in the device detect returning light that is reflected from and scattered by various types and shapes of tissues on and within the skin. The detected light provides three dimensional information about the skin under the device. This information is subsequently available for analysis and anomaly and lesion detection by various means, such as tomographic reconstruction and deep learning. A sequence of patterns can be produced by scanning the device across the surface of the skin, creating tissue baselines and body maps. Subsequent scans would allow changes to be detected.

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CLAIMS

1. A handheld device equipped with light sources and photodetectors that operates in contact with and spanning an area of the skin. The light sources emit light of suitable intensity and wavelengths depending on the embodiment that penetrate into the epidermis and dermis. The photodetectors are positioned to detect returning light that is reflected from and scattered by various types and shapes of tissues on and within the skin, thus capturing three dimensional information about the composition of the skin beneath the device. The photodetector output is subsequently available for analysis by various means, such as tomographic reconstruction and deep learning.

BACKGROUND OF THE INVENTION

Melanoma is a type of skin cancer that develops from skin cells called melanocytes. The estimated five-year survival rate for patients whose melanoma is detected early is 99%. The survival rate falls dramatically to 63% when the disease reaches the lymph nodes, and 20% when the disease metastasizes to other organs. In its early highly curable stages, melanoma is confined to the surface and upper portions of the epidermis. In its later more deadly stages it penetrates deeper into the epidermis and dermis. The diagnosis of melanoma is typically done via a biopsy when recommended by a dermatologist after a visual skin inspection. A device that can provide a reliable diagnosis without special medical training and which can be kept in the home for convenient use would greatly reduce the rate of serious outcomes of this disease.

FIELD OF THE INVENTION

The current invention relates to medical analysis of skin tissues for the purpose of detecting melanomas and other anomalies. Specifically, the use of subcutaneous light to distinguish melanoma from other skin tissues, as in:

Rey-Barroso, Laura et al. (2018). Visible and extended near-infrared multispectral imaging for skin cancer diagnosis. *Sensors*.

DESCRIPTION OF THE RELATED ART

1. US 2017/0172487 A1. Publication Date: Jun. 22, 2017. The invention relates to medical analysis of skin basal-cell carcinoma and melanoma by sub skin imaging. Light sources illuminate both the surface and subsurface of the skin. Reflected light is recorded by a camera for later analysis. This differs from the present invention in that in the latter the returning light is captured by photodetectors at the surface without the use of camera optics, such as lenses. https://patents.google.com/patent/US20170172487A1/en
2. The *sKan* is a handheld device that uses thermal signatures to detect melanomas. This differs from the present invention in that in the latter light rather than thermal energy is used. https://medium.com/dyson/the-skan-a-low-cost-skin-cancer-detection-device-engineered-to-end-misdiagnosis-c9a6beff3546

3. *DermaSensor* is a handheld pen-shaped device that uses elastic scattering spectroscopy. A user evaluates lesions by running the tip of the device over the skin. The differs from the present invention in that in the latter light is transmitted and received rather than bombarding the skin with free electrons to trigger transitional molecular energy states within skin.
   https://www.curetoday.com/articles/pen-like-device-may-help-detect-melanoma
4. The *Verisante Aura* non-invasively analyzes a lesion/mole by scanning 21 different cancer biomarkers at the cellular level. It uses Raman spectroscopy which is a noninvasive optical technique capable of measuring vibrational modes of biomolecules within skin tissues. This differs from the present invention in that in the latter reflected and scattered light is used rather that molecular energy emissions.
   See: Lui, H., Zhao, J., McLean, D., Zeng, H. (2012). Real-time Raman spectroscopy for in vivo skin cancer diagnosis. *Cancer Research*. 15;72(10):2491-500. doi: 10.1158/0008-5472.CAN-11-4061
   https://www.forbes.com/sites/johnnosta/2013/03/14/simply-amazing-instantly-diagnosis-melanoma-with-the-flash-of-a-light/#3e2f66ce3cf9

SUMMARY OF THE DISCLOSURE

The device comprises one or more light sources of various intensities and wavelengths, arranged in a configuration spanning an area on the surface of the skin, depending on the embodiment. It also comprises a set of photodetectors of varying quantities, sensitivities, and arrangement relative to the light sources, depending on the embodiment. The operation of the device consists of sequentially activating the light sources by embodiment-specific means to emit light on to and into the skin and to cumulatively detect light reflected and scattered by tissues in the skin by use of the photodetectors, providing three dimensional information about the composition of the skin beneath the device. The photodetector output is then used for further analysis.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is side view showing the device in operation as light penetrates the skin and is reflected or scattered by tissues within the skin back to a set of photodetectors.

DETAILED DESCRIPTION

For illustration purposes, four sample light photons from a single light source are shown. In the actual device the light sources will bombard the skin with a huge amount of harmless ballistic photons emitted at essentially every angle. The two oblong structures within the skin are nevi (singular nevus), which are discolored lesions that are commonly found in skin ("beauty marks"). As the light source is activated the photons are emitted. From left to right, the first ballistic photon is shown as it penetrates into deeper layers beneath the skin and is thus undetected. The second photon is reflected at a deep skin level and returns to the photodetectors where it is sensed by a specific detector. The third photon strikes the left nevus and is absorbed and thus undetected. The fourth photon is scattered by the right nevus and is sensed by a detector. It should be noted that information about the skin is not only provided by patterns of detected photons, but also by the absence of them. The photodetector array can be one or two dimensional.

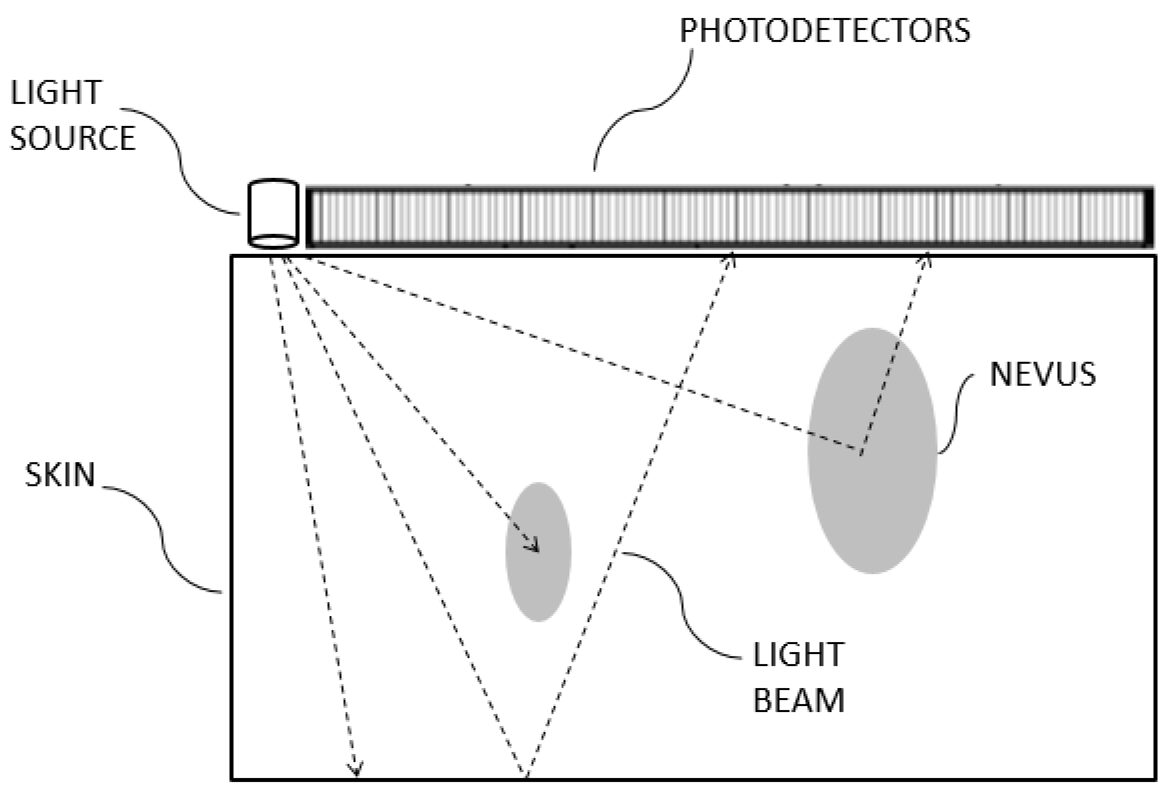

FIG. 1 – SIDE VIEW OF DEVICE OPERATION