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BIOMICROSCOPY OF THE SKIN UTILIZING HIGH FREQUENCY ULTRASOUND IN A MULTI MODAL APPROACH

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Abstract - The general aim of medical imaging is to collect spatially distributed information of a medical object with respect to its morphology, its function and its histology for diagnostic purposes. Skin imaging modalities include high frequency ultrasound (HFUS), optical dermatoscopy and epiluminescence microscopy (ELM) as well as optical coherence tomography (OCT). In dermatology, morphology is the most interesting information, requiring high resolution imaging capabilities. Additionally, functional information (e.g. transflux activitý, perfusion) and histological information of tissue (malignancy, skin aging effects) are of increasing interest. Functional and histological imaging approaches can be understood as quantitative modalities as they are based on a quantitative analysis. The combination of different imaging modalities in a multi modal approach allows to collect non-redundant manifold information and to take advantage of the different kind of information. In this paper, the potential of multi modal skin imaging combining ELM, HFUS and OCT is explored.
Keywords: Multi modal imaging, dermatoscopy, epiluminescence microscopy, high frequency ultrasound, optical coherence tomography, OCT, skin imaging, dermatology

1. Introduction

In dermatology, ELM is the conventional approach for analyzing suspicious skin lesions. The diagnostic output depends significantly on the individual experience of the physician. For this reason systems performing a computerized image analysis and classification of skin lesions have been developed. Depth information of skin lesions is included, however, to a very limited extend only in ELM. On the other hand, HFUS and OCT allow to image skin structures and tissues non-invasively with high resolution over depth [1-5]. In a multi modal approach, we combine images obtained with these techniques and take advantage of the different kinds of information. Each imaging modality has its limitations, and, therefore, the motivation of multi modality is to increase the completeness by combining information from different modalities [4-7].

2. Imaging Systems

We have made the below described skin imaging techniques available at the Bioengineering Lab of the Dermatological University Hospital (Prof. Dr. med. P. Altmeyer, Dr. K. Hoffmann) of the Ruhr-University Bochum, Germany. Our goal is to combine these modalities to assist in the early diagnosis of skin cancer and therapy planning.

Epiluminescence Microscopy (ELM):

ELM images are acquired with the 'microDERM' video dermatoscopy system (Visiomed AG, Bochum, Germany). In this system skin surface is imaged with a CCD camera under standardized conditions (illumination, calibrated colors) and stored electronically in a patient data base. This enables to perform follow-up examinations and documentation of suspicious skin lesions very easily. Furthermore, acquired images can be analyzed automatically by the computer. In a first step, the imaged lesion is segmented and features (shape, color, size, etc.) with relevance to the ABCD-rule of dermatology are analyzed. Extracted features are used as input for a neural network classifier for the discrimination of benign and malignant skin lesions. This classifier is integrated in the computer of the 'mircoDerm' system. In a European multi center study skin lesions were imaged and excised afterwards. Based on histopathological findings as 'gold standard', excised lesions were classified. Features extracted from the images together with the histopathological classification were then used as database for the training of the neural network classifier.

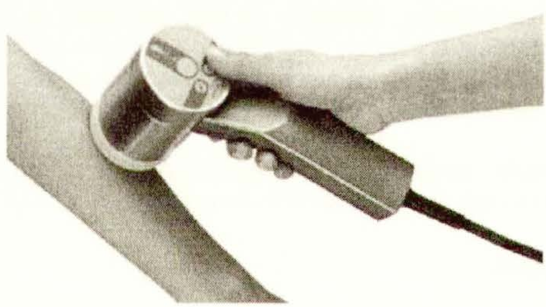

Fig. 1. 'microDerm' video dermatoscopy system (www.vsiomed.de)

High Frequency Ultrasound (HFUS):

HFUS can be utilized for imaging skin structures and skin lesions over depth non invasively [1-3], and additional information to ELM is obtained. Systems utilizing ultrasound in the 20 MHz range are already well established in dermatology, but spatial resolution is limited. Increasing the frequency and bandwidth, on the other hand, allows to improve the resolution. We make use of HFUS in the range up to 100 MHz, enabling skin imaging at microscopic resolution down to 10 µm. We have developed a HFUS skin imaging system with a mechanical scanned single element transducer. During the measurement, ultrasound waves are coupled to the skin through a water path. Images are acquired over an axial / lateral field of view of 1.6 mm / 12 mm.

Optical Coherence Tomography (OCT):

Similar to ultrasound, skin can be imaged non invasively over depth with OCT, utilizing broadband infrared light instead of sound waves. Because of the different underlying physics, contrast mechanisms in OCT are different compared to HFUS. Light, which is backscattered inside the tissue is interfered with light reflected in an optical reference path. Images depicting the optical backscattering properties of the skin are obtained detecting the interfered light with a photo diode. The optical path length in the measurement arm determines the axial measurement position, and lateral scans are performed with a mechanical scanning optics. For our measurements, a 'SkinDex 300' OCT scanner (ISIS optronics Gmbh, Mannheim, Germany) working at 1300 nm wavelength is used. Images are acquired over a limited axial / lateral field of view of 0.9 mm / 1 mm with a 5 μm minimum axial and 3 μm minimum lateral resolution.

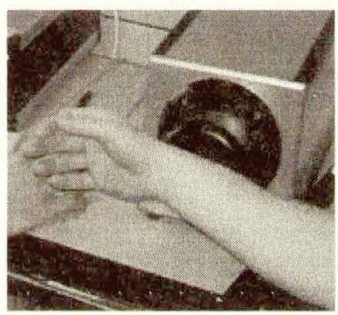

Fig. 2. OCT-scanner (www.isis-optronics.de)

3. Image Fusion

The goal of image fusion is to represent images, which are acquired with different imaging modalities, in the same coordinate system, i.e. in the same spatial arrangement. To achieve this goal, images objects have to be segmented in a first processing step in each data set. Established digital image processing methods can be utilized for this purpose. Afterwards, imaged objects can be spatially aligned to each other utilizing a non-rigid or rigid registration, accounting for object deformations or neglecting them.

4. Results

In Fig. 3 a) a melanocytic nevus, imaged with HFUS is shown. B-mode images covering a three dimensional (3D) volume were acquired. In a first step, the skin surface was automatically segmented applying a threshold segmentation. Afterwards, HFUS images were aligned to acquired ELM surface images, based on manually selected landmarks with a non-rigid registration approach. In Fig. 3 b) HFUS and ELM data are shown in the same coordinate system after registration. Further investigations were aimed at the comparison of HFUS and OCT as non invasive modalities for skin imaging [5].

a) b)

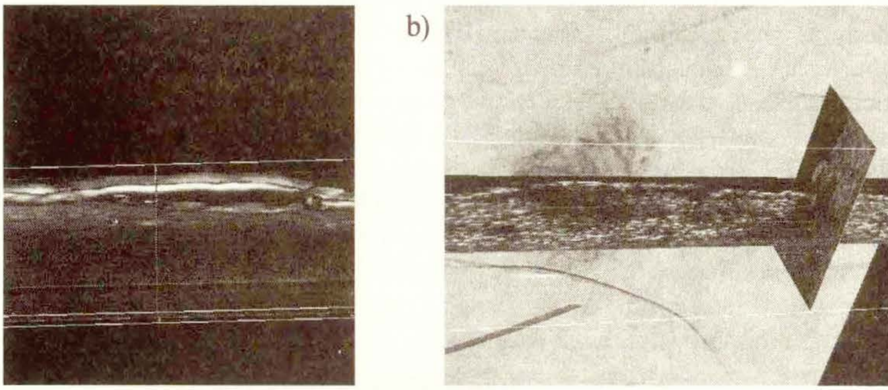

Fig. 3. a) HFUS image of melanocytic nevus, segmented skin surface and nevus; b) Registered HFUS and ELM data sets in the same coordinate system

Results indicate that OCT has a more limited penetration depth compared to HFUS, but a more isotropic resolution. OCT is very well suited for high resolution imaging of the uppermost skin layers, i.e. the epidermis. HFUS, on the other hand, offers a larger field of view, which enables imaging of the epidermis as well as the subjacent dermis.

5. Conclusions

HFUS and OCT are imaging modalities enabling non invasive and high resolution skin imaging over depth in addition to ELM. Utilizing image processing concepts for the registration of acquired data sets allows the representation of imaged skin structures in the same coordinate system. Additional information about skin lesion structure and morphology is gained.

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