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Department of Electrical & Computer Engineering

PhD Dissertation Announcement

Automatic Recognition of Buruli Ulcer Images on Smart Handheld Devices

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Buruli ulcer (BU) disease is a devastating flesh eating bacterial infection that each year affects thousands of people in tropical and subtropical regions. Clinically, BU usually starts as a painless subcutaneous nodule, or other pre-ulcer forms including papule, plaque, and edema, then it evolves into a painless ulcer with undermined edges, and finally leads to extensive scarring, contractures, and deformations with possible total loss of articulation function. However, treatment with antibiotics at an early stage has been very successful in preventing irreversible deformity and long-term functional disability. Therefore, an easily implemented and rapid diagnostic test that can detect the early stages of BU is of high research priority.

In this dissertation, a multistage computerized image-analysis system is proposed that can automatically detect BU in multispectral dermoscopic images. The specific contributions of this work focus on the development of techniques for precise lesion segmentation, efficient image sampling for feature extraction, and skin image modeling for accurate lesion classification. For lesion segmentation, a new method is proposed based on fusion of the partial masks derived from separate segmentations of the color and luminance channels of BU images. This procedure outperformed other techniques when tested on a subset of 26 BU images where the ground truth of manual segmentation by domain expert physicians was known. Internally the system represents BU lesions using the Bag-of-Features methodology, where image features are extracted from image patches. A new strategy for nonuniform image sampling was developed based on occurrence of contextual pixel saliency, whereby patches from dermoscopically interesting regions are sampled more densely. Experiments on a set of 197 images demonstrated an advantage of this method compared to classical grid or random sampling. To obtain more accurate statistics and address the problem of class imbalance due to the small number of BU images compared to non-BU controls in the dataset, a new resampling technique was developed, which increased the sample size of the minority class by splitting lesions in the data space, rather than synthesizing new samples in the feature space. Combined with the feature selection metric of Pearson correlation coefficient, this method resulted in a classifier with more discriminative power. Additionally, a new feature representation of the multispectral images based on optical skin modeling was proposed. In this method, the distribution of physiological characteristics of a lesion, such as melanin, blood volume, and blood oxygenation were estimated for all image pixels, and features were extracted from these reconstructed maps. Experimental results with a set of 197 multispectral images showed that the use of multispectral images provided a significant improvement in classification performance compared to classification based on single white light images. Finally, a modular stand-alone application that includes all system stages has been developed in Matlab that can be further implemented on smart handheld devices.

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