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Design of a decision support system, trained on GPU, for assisting melanoma diagnosis in dermatoscopy images

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Abstract. The purpose of this study was to design a decision support system for assisting the diagnosis of melanoma in dermatoscopy images. Clinical material comprised images of 44 dysplastic (clark's nevi) and 44 malignant melanoma lesions, obtained from the dermatology database Dermnet. Initially, images were processed for hair removal and background correction using the Dull Razor algorithm. Processed images were segmented to isolate moles from surrounding background, using a combination of level sets and an automated thresholding approach. Morphological (area, size, shape) and textural features (first and second order) were calculated from each one of the segmented moles. Extracted features were fed to a pattern recognition system assembled with the Probabilistic Neural Network Classifier, which was trained to distinguish between benign and malignant cases, using the exhaustive search and the leave one out method. The system was designed on the GPU card (GeForce 580GTX) using CUDA programming framework and C++ programming language. Results showed that the designed system discriminated benign from malignant moles with 88.6 % accuracy employing morphological and textural features. The proposed system could be used for analysing moles depicted on smart phone images after appropriate training with smartphone images cases. This could assist towards early detection of melanoma cases, if suspicious moles were to be captured on smartphone by patients and be transferred to the physician together with an assessment of the mole's nature.

1. Introduction

Melanoma comprises one of the most lethal and difficult to treat forms of cancer with more than 100 000 cases worldwide each year [1]. The annual incidence rate of the disease has an increasing tendency, which is attributed to modern lifestyle and long exposure to ultraviolet radiation that has been identified as among the most influential factors for triggering the disease. Early stage detection of melanoma has been shown as the most crucial step for treating the disease, since at early phases melanoma seems to be more vulnerable to available treatments [2, 3].

Diagnosis of melanoma is done using special observation instruments called dermoscopes. Dermoscopes use polarized light in order to enhance the visibility of pigmented lesions [4]. The

accuracy in melanoma detection using dermoscopes has been shown significantly higher (>90%) as compared to conventional visual clinical examination (approximately 65%) [5], rendering dermoscopy the standard every day clinical tool of dermatologists. The evaluation of suspected skin lesions follows various guidelines, among which the ABCD rule is probably the most popular [6]. According to the ABCD guidelines the diagnostic conclusion is derived based on estimations regarding the suspected lesion's asymmetry (A), border irregularity (B), color (C) and diameter (D). Although dermoscopy has improved melanoma detection rates, it requires training and experience for seizing the benefits that this technology may offer to the dermatologist [6]. Moreover, even with experienced dermatologists, difficulties may arise due to differential diagnosis issues, since melanoma may be mixed with other skin lesion types, such as seborrheic keratosis [7, 8]. The above factors may comprise potential sources of diagnostic misleads that might guide inappropriate treatments with controversial efficacy [9-11]. The purpose of this study was to design a decision support system to be used as a second opinion tool available to the dermatologist in order to safeguard from potential sources diagnostic misleads in melanoma detection.

2. Material and Methods

Clinical material comprised images of 44 dysplastic (clark's nevi) and 44 malignant melanoma lesions, obtained from the dermatology database Dermnet [12]. Initially, images were processed for hair removal and background correction using the Dull Razor algorithm [13]. This method consists of three phases: hair are identified using an operation of closure over each of the color segments, hair pixels are then replaced by interpolation with neighbourhooding tissue pixels and finally, a median filter with a 7×7 kernel is applied in order to eliminate the impulse noise. Processed images were segmented to isolate moles from surrounding background, using a combination of level sets/gradient flow vector snakes and an automated thresholding approach [14].

Morphological and textural features were calculated from each segmented mole. Morphological features comprised measurements of the area, perimeter, roundness and eccentricity [15] describing the size, the shape and asymmetry of segmented moles. Textural features consisted of measurements regarding the mole's gray-level histogram by means of the mean value, standard deviation, skeweness and kurtosis. Moreover, the spatial distribution of the mole's illumination was investigated with the aid of the co-occurrence matrix and run-length matrixes [16, 17]. The co-occurrence matrix encodes the frequency of appearance of the same pairs of pixel intensities, whereas the run-length matrix describes the frequency of appearance of a set of consecutive pixel- intensities having the same grey value. In total, twenty (20) textural features were computed (4 histogram-based, 11 co-occurrence matrix-based and 5 run-length matrix-based). Thus, each case was represented by 24 features, 4 morphological and 20 textural. Extracted features were fed into a pattern recognition system, assembled with the Probabilistic Neural Network (PNN) classifier [18], which was trained to distinguish between benign and malignant cases, using the exhaustive search and the leave one out method.

The exhaustive search generates all possible combinations of available features. Each feature combination is then evaluated by the classifier using the leave-one-out method that constructs the model using all cases but one. The left-one-out case is considered as an unknown case. The classifier is then asked to classify the left-one-out case to either the benign or malignant class. If the classifier decides that the left-one-out case belongs, for example, to the benign class and the left-one-out case comes from the benign class, then the classifier has a successful/correct classification result, else an unsuccessful/error classification result. By measuring the correct and error classifications then it is possible to determine the prediction accuracy of the model for each feature combination. Then, the feature combination, which provides the highest classification result, is selected as the most informative one [19]. The system was designed on the GPU card (GeForce 580GTX) using CUDA programming framework and C++ programming language.

3. Results and Discussion

Figure 1 illustrates an example of the application of the proposed image processing strategy for segmentation of melanoma mole. Figure 1(a) is the original color dermoscopy image. Figure 1(b) is image following the application of the DullRazor hari removal algorithm,. It is clear that the effect of darker hairs covering the mole has been greatly reduced. Figure 1(c) is the gray scale transformed image with corrected background. Figure 1(d) is the thresholded image that separated brighter from darker pixels based on automated threshold calculation based on the Otsu's method [20]. Figure 1(e) illustrates the elimination of stray pixels outside and inside the mole's region. Figure 1(f) depicts the result following the application of morphological opening and closing filters for smoothing of boundaries. Figure 1(g) shows the border of the mole, which was obtained following the application of an edge-detection Roberts filter. The result of Figure 1(g) was considered as the initialization for the level set method that converged to the final boundaries of the mole using the gradient flow vector approach (Figure 1(h)).

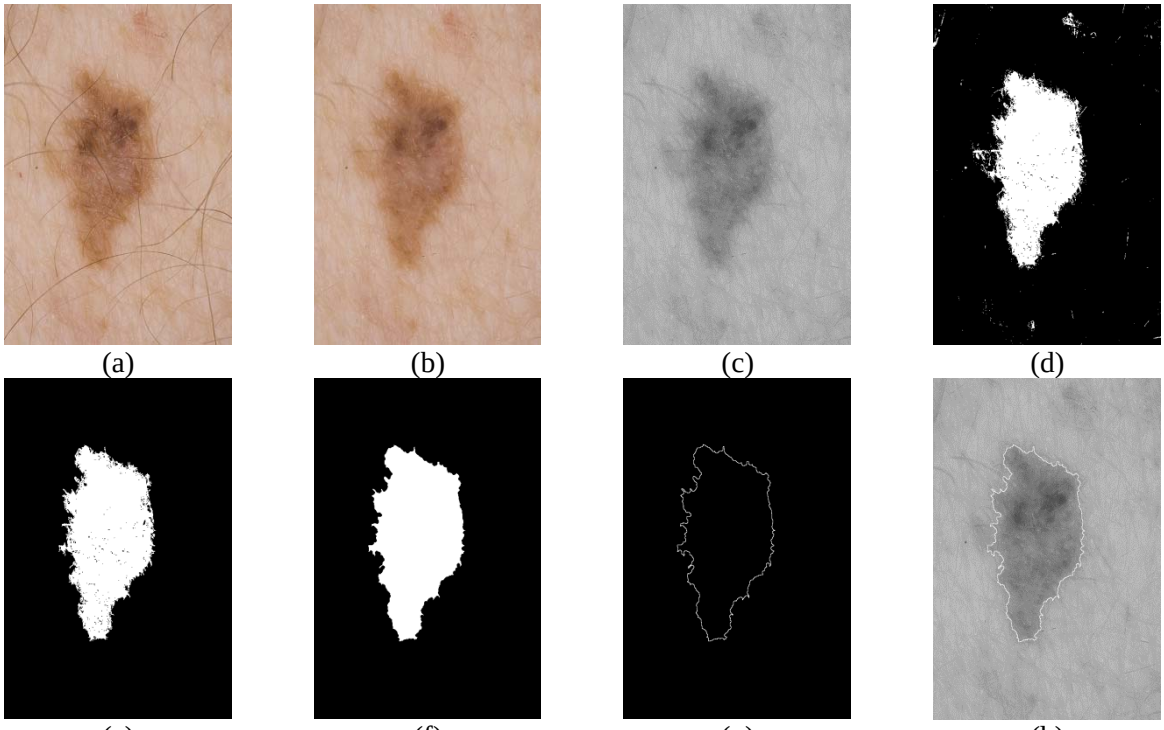

Figure 1. (a) Original Image, (b) Application of the DullRazor algorithm for hair removal, (c) Background corrected grey scale image, (d) Thesholded Image, (e) Elimination of stray objects outside and inside the mole's region, (f) Morphological closing and opening, (g) retaining of the mole's boundary using Roberts edge detection filter, (h) Final delineation of mole's boundary following the application of the gradient flow vector algorithm

Results showed that the designed system discriminated benign from malignant moles with accuracy higher than 88.6% employing three (3) morphological features (perimeter, roundness and eccentricity) and six (6) textural features extracted from the co-occurrence matrix according to the leave-one-out method. This particular feature combination was also tested on an external cross validation scheme to investigate the generalization of the model to new cases [21]. According to this set-up, the performance of the system was estimated 84%±5%. The proposed system could be used for analysing moles depicted on smart phone images after appropriate training with smartphone images cases. This

could assist towards early detection of melanoma cases, if suspicious moles were to be captured on smartphone by patients and be transferred to the physician together with an assessment of the mole's nature.

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