Burn Image Classification Using One-Class Support Vector Machine

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Abstract. Burn image classification is critical and attempted problems in medical image processing. This paper proposes the image classification model applied for burn images. The proposal model use one-class Support Vector Machine with color features for burn image classification. The aim of this model is to identify automatically the degrees of burns in three levels: II, III, and IV. The skin burn color images are used as inputs to the model. Then, we apply the multi-color channels extraction and binary based on adaptive threshold for Support Vector Machine classifier. The proposal model uses One- class Support Vector Machine instead of kernel Support Vector Machine because of unbalance degrees of burns images database. The experiments are conducted with the real-life image provided by Cho Ray hospital with the precision 77.78 %. The validation process shows that our main results and the feasibility of our proposal model are stated (Fig. 1) .

Keywords: Burn image classification · Support Vector Machine (SVM) · Multi- color channels

1 Introduction

Medical image processing has a variety of potential applications in the recent years. There were many research results applying image processing for medical in both general applicable theory and specific applications. Computer-aided diagnostic processing has already become a significant part of clinical routine. The aim of this research is to develop the computer-aided system for burn image classification.

Burns, commonly caused by fire, can also result from chemicals, electricity, and other heat accidents. Burns are classified based on how much of the skin's thickness is involved [1]. The purpose of burn image classification is to identify automatically the burning degree of patients based on the color images of burning regions.

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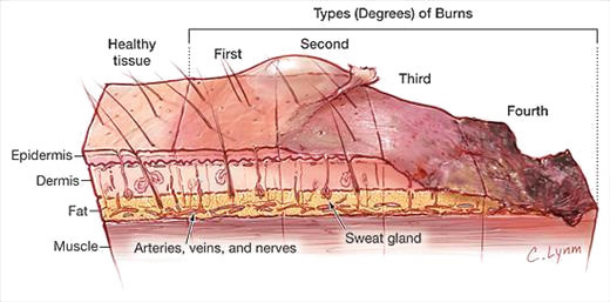

Fig. 1. Degrees of burn [1]. This shows a figure consisting of four types of burns relating to the depths of skin. The more into the depths, higher degree of burn, for example, as the fourth degree, the burn wounds are into the muscle depth.

1.1 Medical Image Processing

The historical study of medical imaging has been very long. This is an interesting research problem [2]. In recent years, the more developing of computer vision, the more integration of computer vision system and medical image process system:

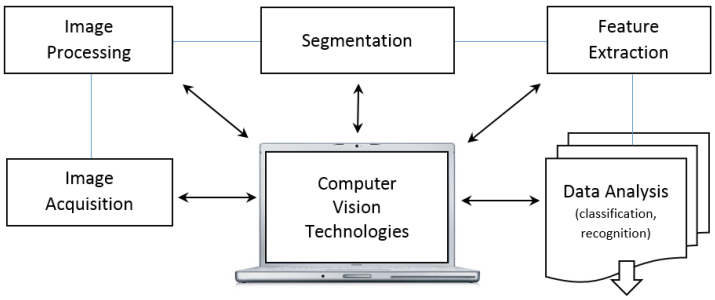

Fig. 2. Computer vision applies for medical image processing in almost phase such as image acquisition, segmentation extraction, processing and classification or recognition.

In the above Fig. 2, the computer vision technology can apply for almost phases in the medical imaging system, especially, some artificial intelligent tools are very useful for data analysis such as pattern recognition, classification.

In the medical imaging topic, automatic burn image classification is the open problem. In this research, we try to apply computer vision processing and machine learning for identifying the degrees of burns. In the clinical burning patient diagnosing code, the doctor need to identify the degrees of burn: Degrees I, Degrees II, Degrees III, and Degrees IV based on the depth of levels of burns and scalds and some clinical diagnosis and diagnosis related groups. Degree I of burns involves only the top layer of the skin. Degree II of burns injures deeper into the skin and cause blistering.

Degree III of burns involves all the layers of the skin, including the nerves. Degree IV of burns extends into the muscle.

1.2 Medical Image Classification

The medical test in the medical diagnosis often uses laboratory analysis, bio signal analysis (ECG, EEEG…) and image analysis. Burn image classification is a kind of image classification with the lower number classes in the medical imaging focusing on the image analysis. Thus, we must use the image processing techniques for image feature extraction. The feature extraction techniques common used for medical imaging is Fourier transform, 2D function for monochrome image, image brightness profiles, or RGB color component profiles.

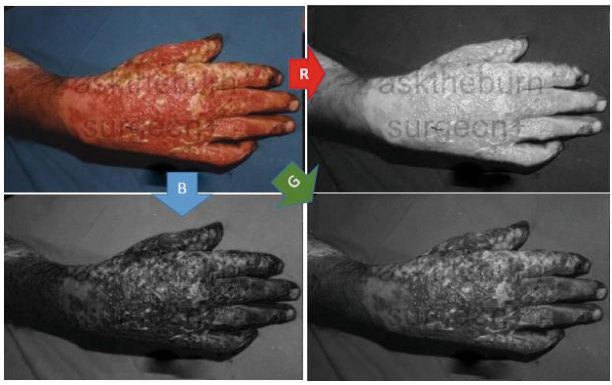

Fig. 3. An example of multi-color channels. The top-left is the original burn image. The top-right is the red channel extracting from the original image. The bottom-left is the blue channel extracting from the original image. The bottom-right is the green channel extracting from the original image.

In the burn images process, the Red channel is the most significant channel. There is a little difference between the Blue and the Green channel. For the above burn image example in Fig. 3, Degree II and Degree IV have the same form in the Blue and the Green channel, but the Red channel of Degree II and Degree IV are not the same.

1.3 Classifier Based on Machine Learning

The image classification model using machine-learning technique often has two phases: training phase and classifying phase. In the training phase, the system uses machine-learning algorithm to update the parameter of classifier model. For example, SVM computes the coefficient of hyperplanes in the training. After that, SVM uses the hyperplanes to classify the image in the testing phase. The common architecture of image classification using machine-learning system is below:

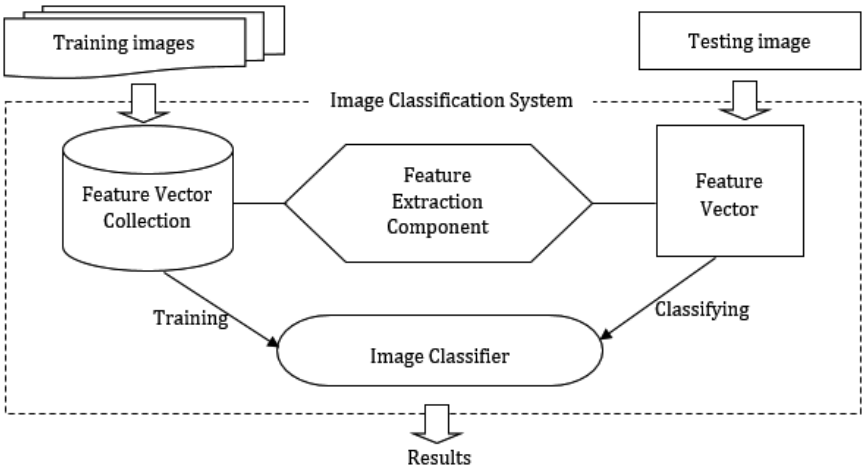

Fig. 4. Image classification architecture using machine learning. The feature extraction component is used in both training and classifying phases. The feature vectors of images are used as inputs to the image classifier.

There are many kinds of classifiers applied for medical classification: some use expert system and some use learning from data. They often use machine learning Neural Network, Support Vector Machine… with the suitable learning algorithm (Fig. 4).

Some popular learning algorithms are unsupervised learning, supervised learning, semi-supervisor learning, or active learning. In the burn image classification, most of burn image data from the hospital labeled. Given the data with annotation by the doctors, either supervised or unsupervised learning approaches could apply for burn image classification. The burn images dataset is small and pre-labeled. Thus, we uses supervised learning approaches.

There is very little burn image classification systems suggested by some researchers. For example, M. Survana [3] has applied Template Matching, k-NN and SVM classification methods for skin burn images with their own collection dataset with only 120 images in 3 types of burns (superficial dermal, partial thickness and full thickness). This experimental results show that SVM is more suitable classifier for burn images than k-NN and Template Matching. Besides, B. Acha [4] also proposed the classification of burn wounds using SVM by color and texture information of burn images. That is the reason why we suggest using SVM for burn images of classification. To the best of our knowledge, there is not any image classification model for identifying the degrees of burns based on machine learning in Vietnam. The aim of this paper is to build a burning classification system for Vietnamese patients (Fig. 5).

The digital color burn image will be drop and segmentation before it is extracted color feature. The color features of burn images are used as inputs to the SVM classifier. The out of SVM classifier are the degrees of burn. The remainder of this paper is organized as follows. Section 2 deals with the preprocessing and feature extraction from burn images. Section 3 provides a detailed exposition of the proposal model

Fig. 5. SVM classifier applies for burn image. This figure shows diagram of SVM burn image classification from the burn image input to the degrees of burn output.

applying for burn image classification. Section 4 is devoted to the study and discussion of the experimental results. Conclusion and future works are mentioned in the Sect. 5.

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2 Burn Image Feature Extraction

Firstly, we normalize the burn images in a standard size with the rate 4:3 for removing un-burned region of images. The dropped images will be segmented based on color information by B. Acha [4].

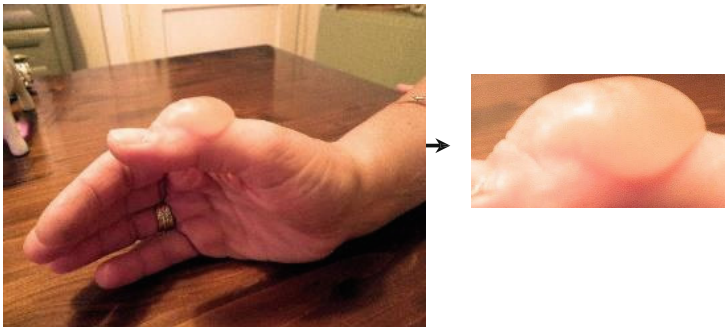

Fig. 6. Burn image size standardization for segmentation. The original burn image is on the left and the dropped image removing some unrelated burning background objects is on the right.

Due to the requirement of the processing speed is real time, this paper suggested to use the fast feature extraction based on multi-color channels Red, Green, Blue and Gray. In order to improve the performance of machine learning, the multi-color channels will be binary to 0 or 1 (Fig. 7).

3 Burn Image Classification Model

The overview of burn image classification model includes four stages: image acquisition, image pre-processing, feature extraction and classification. It is presented in the below diagram:

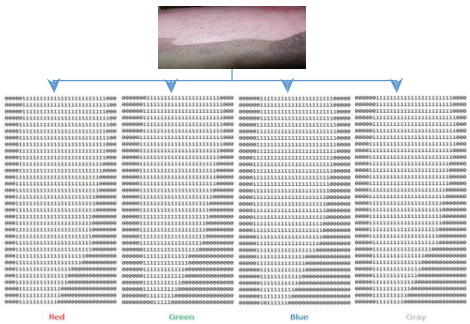

Fig. 7. Multi-color channels extraction. The burn image is extracted into Red, Green, Blue and Gray color channels (color figure online).

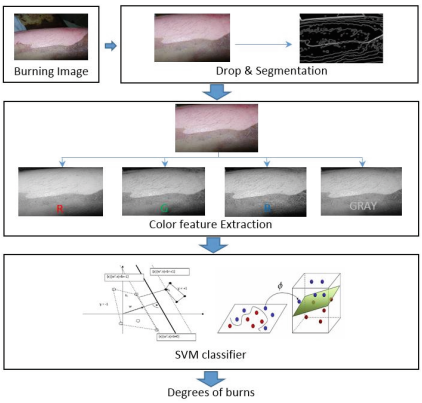

Fig. 8. Burn image classification model. The figure shows the overview of our burn image classification using SVM.

The burn images have been collected and supplied from the Cho Ray hospital, Vietnam and published in http://fit.hcmup.edu.vn/medical_image_project/. The burn image will be standardize and segmentation before inputting the feature extraction component. The output burn image features are the multi-color binary channels, which are used as inputs to the SVM classifier (Fig. 8).

4 Experimental Results

We have built images databases from Cho Ray hospital consisting 396 burn images in the 4 degrees of burn II, III and IV. We do not classify the degrees I of burn because it is minor level and might cause from the sun sight. This is also the reason why many Vietnamese people do not care about the degrees I of burns at this time. The degree II of burns has 180 images, the degree III of burns has 192 and the degree IV of burns has

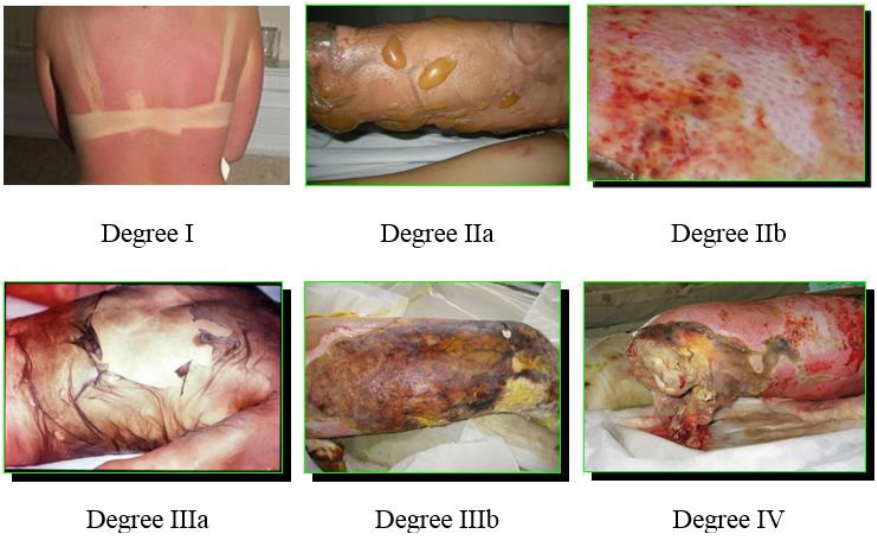

Fig. 9. Illustration for degrees of burn images. The degrees from I to IV display from top-left to bottom-right.

24 images. There are very little images of the degrees IV of burns because this is high level of burn and the patients maybe die before inpatient entrance (Fig. 9).

We create two folders: a half images in training and a half images in testing like two-folded cross validation scheme to divide the database. Some images in training folder and in testing folder are below:

The precision, false acceptance rate (FAR) and false reject rate is the common criterion to evaluate the classification rate, simplify given by:

$$\begin{aligned} \text{Precision} &= \frac{\#\text{correctly classified images}}{\#\text{ total images}} \\ FAR &= \frac{\#\text{False classified images}}{\text{classified images}} \\ \text{FRR} &= \frac{\#\text{False classified images}}{\text{rejected images}} \end{aligned} \tag{1}$$

The experimental results in the precision, FAR and FRR will help us to analysis the root cause of classification errors and improve the suggested model. The experimental results with multiple SVM kernels are presented in the below Table 1 in order to identify the suitable SVM kernel for burn image classification (Fig. 10).

The results show that the One-Class SVM (OC-SVM) [5] is suitable in this classification problem because of the unbalance data. It shows that our main aims are stated and proved. OC-SVM if compared to SVM has the higher accuracy of burn image classification. However, OC-SVM required the trade of computing time to the accuracy in the case using the simple binary features (Table 2).

Table 1. Burn image classification detail results using SVM

Degrees	#image for training	#image for testing	#image classified correctly using Gauss kernel	Precision classification using Gauss kernel	#image classified correctly using Polynomial	Precision classification using Polynomial
II	90	90	63	70 %	68	76 %
III	96	96	72	75 %	72	75 %
IV	12	12	7	58 %	6	50 %

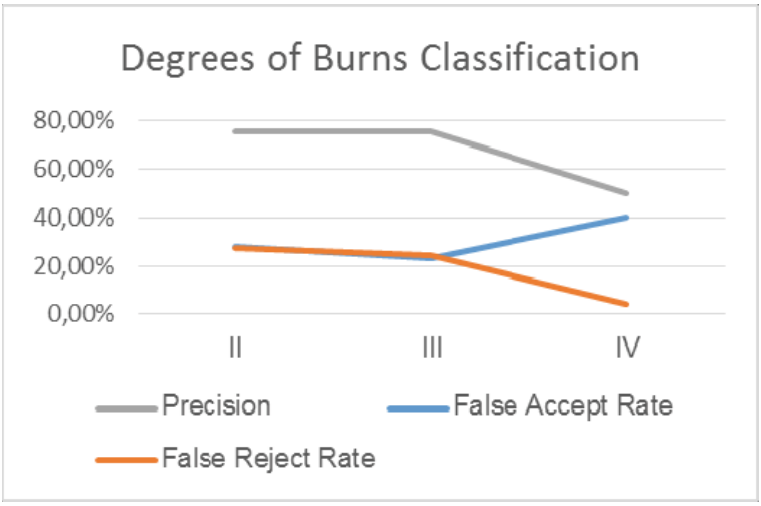

Fig. 10. Precision and FAR- FRR on Degrees of Burn Identification results. the FAR of Degrees IV is high and the FRR of Degrees IV is low because of unbalance burn image of Degrees IV image is too low due to the number of burn inpatient in this level. To improve upon this unbalance data shortcoming, we suggest using One Class SVM instead of traditional SVM.

Table 2. Classification results using one-class SVM vs. traditional SVM

Methods	#training images	#testing images	Precision classification using Gauss kernel	Precision classification using Polynomial
SVM	198	198	71.71 %	73.73 %
One-class SVMIV	198	198	73.23 %	77.78 %

From experimental results of SVM classification method using Polynomial kernel is more accuracy than Gauss kernel. It maybe cause from the distributed of burn image data is 48 % in the degrees II of burn and 47 % in the degrees III of burns. The rest distributes under 5 %. The wrong classification is focus on the Degrees IV of burn.

The number of images of this degree is too lower than the Degrees II and III. Due to this unbalance in the training, we try to use one-class SVM instead of traditional SVM. It has been improve the accuracy of classification.

The overall precision is less than 80 % because we have not yet combined local feature extraction method, for example, Local Binary Pattern (LBP) with multi-color channels feature. Besides, the training and testing images are very difference in the same Degree. For example, the burning Degree II patient is on the hand used for training and another one is on the leg used for testing. These burn images are only similar in some local features, but they are very difference in general view.

5 Conclusion and Future Works

This paper introduces an approach using one-class SVM with color feature for burn image classification. This paper proposes the classification model for burn image to identify automatically the degrees of burns in three levels for Vietnamese patients. The proposal model uses the multi-color channels extraction and binary based on adaptive threshold. Because of the unbalance degrees of burns data, we suggest use one-class SVM instead of traditional SVM. The experiments were conducted with the real-life image provided by Cho Ray hospital with the precision 77.78 %. The experimental results show the feasibility of the proposal model in the starting researching phase.

The expectation of improving the accuracy and the real time processing are opening challenges of this problem. We cannot trade off the classification time because its requirement is real time in the diagnosis degrees of burns phase of treatment process. However, we can trade off the training time to improve the precision of classification. So that in the future work, we can use a big data for training phase and use some improved SVM such Fuzzy SVM or another complex training model in order to increase the classifying accuracy.

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