Factorization Based Segmentation and Machine Learning Approach for Infection-based Classification in Chronic Wound Assessment

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Introduction
The essential component in an optimal wound care is an accurate and thorough assessment of wound status. The wound healing status needs to be monitored and analyzed for proper treatment plans. Chronic wounds are difficult to heal fast and hence, the treatment lasts for long duration. Non-healing wound results in infection and leads to high risk of inflammation. The objective of this work is to develop an efficient approach for classifying infected and non-infected wound in chronic wound assessment using wound photographs.

Hypothesis
The proposed method will be helpful in infection based chronic wound classification, which can assist healthcare professionals for more accurate diagnosis and treatment of wound.

Methods
Total 102 wound images are considered in this study and are obtained from an open source database Medetec. It includes 56 infected and 46 non-infected wounds. These images are observed to be suffering from reflection due to blood stains, shadows, clinicians’ fingers, and illumination problem. Hence, the quality of image is improved by proper preprocessing methods. It consists of gaussian filtering followed by color correction by automatic white balance and image guided filtering. Secondly, individual color channel is extracted and factorization based segmentation is performed. Segmentation result is compared with ground truth and validated using performance measures such as accuracy, sensitivity and dice coefficient. Color, texture and geometrical features are extracted from the segmented wound bed. Finally, a binary classification is performed in order to classify infected and non-infected wound. Classifiers considered in this work are Multi-Layer Perceptron (MLP), Support Vector Machine (SVM), Random Forest (RF) and Naive Bayes.

Results
The obtained result shows that gaussian filter is able to remove illumination present in the image. Automatic white balance provided appropriate color correction in all three color channels. Also, it helped to improve the contrast and brightness of image. The image is smoothened using image guided filter while preserving the edges of wound. Fig.1 shows the preprocessed result for representative wound images. Proper segmentation is achieved using the selected preprocessing methods followed by factorization based segmentation. It has been found that segmentation performed in color channel obtained by subtracting green and blue components from red gives better result. Fig. 2 shows the result of wound area segmentation by factorization method. Segmentation evaluation shows that performance measure obtained is more than 95% for all the validation metrics. Statistical analysis performed on extracted features shows that color and texture features are critical in differentiating infected and non-infected wound. Classifier performance is compared in Fig.3. Obtained results show that the highest performance is achieved with SVM followed by MLP, RF and Naive Bayes.
**Figure 1**

(a) Raw image, (b) Gaussian filtered, (c) Color corrected and (d) Image guided filtered

**Fig 1.** Preprocessing of representative chronic wound images

(i) Non-infected Wound

(ii) Infected Wound

**Figure 2**

(a) Raw image, (b) Preprocessed image in selected color channel, (c) Segmented mask and (d) Ground truth

**Fig 2.** Result of factorization based segmentation method

(i) Non-infected Wound

(ii) Infected Wound

**Figure 3**

**Fig. 3** Comparison of classifier performance
Conclusion
This work demonstrates that factorization-based segmentation method is able to extract clinically significant wound area which has irregular boundary and complex tissue distribution. Further, it is observed that color and texture features are able to differentiate infected and non-infected wound. Hence, possible to aid in wound diagnosis and treatment.

Statement of Impact
Since infected wound leads to inflammation and severe health issues, identifying infected wound might be helpful, in order to provide better therapeutic treatment in medical community.

Keywords
chronic wound, wound infection, factorization-based segmentation, features, classifiers