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A novel approach to multiclass psoriasis disease risk stratification: Machine learning paradigm

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ABSTRACT

The stage and grade of psoriasis severity is clinically relevant and important for dermatologists as it aids them lead to a reliable and an accurate decision making process for better therapy. This paper proposes a novel psoriasis risk assessment system (pRAS) for stratification of psoriasis severity from colored psoriasis skin images having Asian Indian ethnicity. Machine learning paradigm is adapted for risk stratification of psoriasis disease grades utilizing offline training and online testing images. We design four kinds of pRAS systems. It uses two kinds of classifiers (support vector machines (SVM) and decision tree (DT)) during training and testing phases and two kinds of feature selection criteria (Principal Component Analysis (PCA) and Fisher Discriminant Ratio (FDR)), thus, leading to an exhaustive comparison between these four systems.

Our database consisted of 848 psoriasis images with five severity grades: healthy, mild, moderate, severe and very severe, consisting of 383, 47, 245, 145, and 28 images respectively. The pRAS system computes 859 colored and grayscale image features. Using cross-validation protocol with *K*-fold procedure, the pRAS system utilizing the SVM with FDR combination with combined color and grayscale feature set gives an accuracy of 99.92%. Several performance evaluation parameters such as: feature retaining power, aggregated feature effect and system reliability is computed meeting our assumptions and hypothesis. Our results demonstrate promising results and pRAS system is able to stratify the psoriasis disease.

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1. Introduction

Psoriasis is a chronic skin disease and characterized as a reddish and scaly lesion on the skin surface [1]. Statistics show that it affects 125 million people worldwide [2], but its prevalence differs depending on the geographical regions. The prevalence of psoriasis in Europe, USA, Malaysia and India is about 0.6–6.5% [2], 3.15% [2], 3% [3] and 1.02% [4], respectively. It may also affect the quality of life due to its discomforting social appearance [5]. Its consequences is increased risk of suicidal attempts (about 30%) making this disease an equally dangerous, at par with depression, heart disease, and diabetes [6]. The cause of psoriasis is still unknown but most researchers agree that the prime reason for this disease is genetics [7]. It is incurable disease but can be controlled by long and careful treatment. Among the various types of psoriasis namely plaque, guttate, inverse, pustular, and erythrodermic, plaque psoriasis is most commonly found in 80% of all psoriasis cases [8]. Thus, this study is focused on plaque psoriasis. An example of plaque psoriasis lesions on several regions of the human body is shown in Fig. 1.

Dermatologists are mainly interested in monitoring a stage and grade of psoriasis disease for betterment of patient's therapy. The current most widely used standard for measurement of psoriasis severity is "psoriasis area and severity index" (PASI) score [9]. This computation is based on the area, erythema, scaling and thickness of the lesion. This score is derived subjectively from the visual and haptic inspection of the dermatologist. This is critically based on the acquired expertise by the dermatologist. Both inspections suffer from inter- and intra-observer variability in severity scores. Hence, this process is very subjective, laborious, time consuming and brings unreliability to the process of decision making, leading to inaccurate. So, we here propose an objective computer-aided assessment system.

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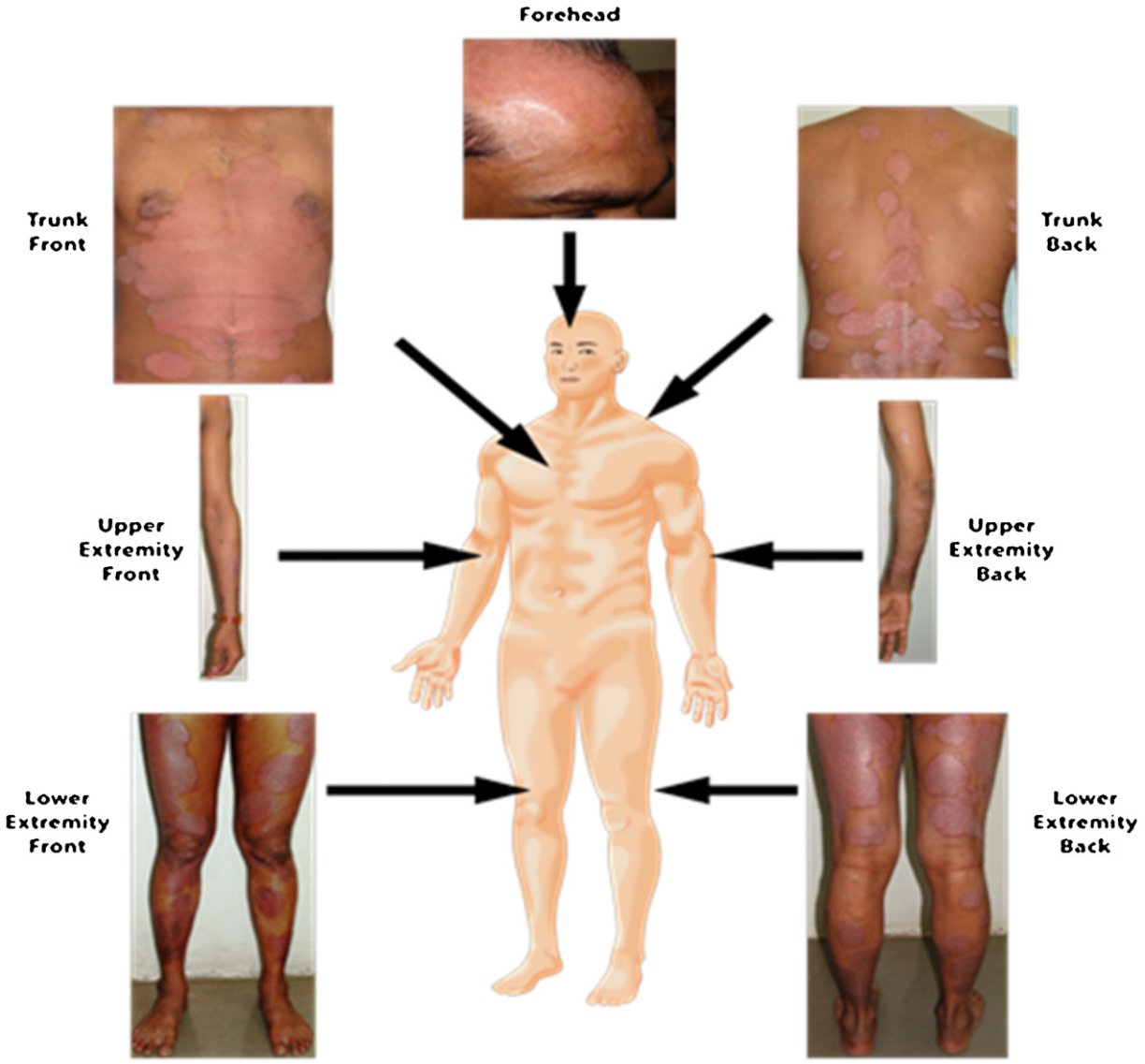

Fig. 1. Examples of plaque psoriasis disease on several body regions (psoriasis images—Courtesy of Psoriasis Clinic and Research Centre, Psoriatreat, Pune, Maharashtra, India; center body image copyright but courtsey from Global Biomedical Technologies, Inc., Roseville, CA, USA).

Biomedical computer-based methods have shown a promising sign in diagnosis and monitoring of diseases and in general healthcare. The current challenge lies under the same paradigm which can help dermatologists as a second guess for the disease severity evaluation and improving the work flow leading to better therapy. We thus propose a machine learning-based solution for severity risk assessment and stratification. To understand the severity of the psoriasis disease, dermatologists preferably analysis the lesion by its color, scales on the lesion surface and the lesion size or regional area spread by the lesion. The color of lesion varies from light red to dark red (purplish). The light red indicates improved condition of the disease while dark red indicates lesion severity [10]. So, hypothetically, color strength and its variations in a lesion are mainly adapted as a criterion for classification of psoriasis disease. Our first hypothesis is that there is strong color information in psoriasis images and machine learning model would be able to stratify the psoriasis disease by learning different color features.

Further, from the genetic nature of the disease, the severity starts to develop gradually by changing the lesion characteristics from grayscale to light red color to dark brown color (see Fig. 2). Such a skin characteristics can be reverse engineering modeled by converting the color lesions back to grayscale space and understanding their characteristics. Thus we hypothesis, that the psoriasis grayscale images have valuable lesion severity information helpful in risk stratification. Based on the hypothesis one and two, we further assume that the features of the psoriasis lesions by combining the grayscale features and color features can further lead to better decision making and risk assessment process. We therefore pose the third hypothesis that combined color and grayscale information can further improve the risk stratification. If our methods prove to be stratifying different grades of the lesions correctly, then the pRAS system can be proven to be reliable. We thus hypothesize if the reliability of the pRAS system is above a certain threshold, then; the pRAS system is able to correctly stratify the lesion grades.

The application of machine learning in skin cancer images has recently dominated. This comes from the spirit and initiatives of Suri and his team where machine learning was adapted dating back to early 90's [11–14]. The fundamental challenge in current psoriasis disease risk assessment systems is the lack of availability of risk stratification with varying degree of severity. Second serious issue is the lack of adaptation of risk assessment systems on

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