Quantitative Assessment of Varicella Stages in Severe Dermatologic Manifestations

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Assessment and Classification of Varicella Images

Varicella-zoster virus causes chickenpox, a very contagious disease manifested by rash, itching, tiredness, and fever.

The affected individual gets stomach, back and face covered with blister-like rash that often spreads over the entire body resulting in 250 or even 500 itchy blisters.

Babies, adults, and people with weakened immune systems can be seriously affected by chickenpox.

In the United States, about 11,000 people were hospitalized for chickenpox each year and about 100 people died each year as a result of chickenpox before the varicella vaccine started to be applied in 1995.

Assessment and Classification of Varicella Images

Also, until varicella vaccination became widespread in the United States, this disease affected approximately 4 million children per year, and was responsible for an estimated $400 million in medical costs and lost wages each year.

Still today worldwide it represents a serious problem especially in places where there are no vaccination programs.

There are a few papers in the literature that treat this interesting and important topic.

Assessment and Classification of Varicella Images

Algorithm for the automated autonomous varicella detection has been developed and tested on various images of individuals affected by this disease.

Related images were taken under different conditions which permitted to test the degree of recognition and its robustness.

This technique allows to assess quantitatively any changes in the process of treatment and response to available medications used to remedy or minimize the symptoms of this disease.

Assessment and Classification of Varicella Images

Clinically applicable, a cost-effective algorithm for automated varicella detection is proposed with the goal of assisting medical doctors in diagnostic procedures.

This algorithm was tested using an independent database of 20 real images with variable intrinsic and extrinsic features.

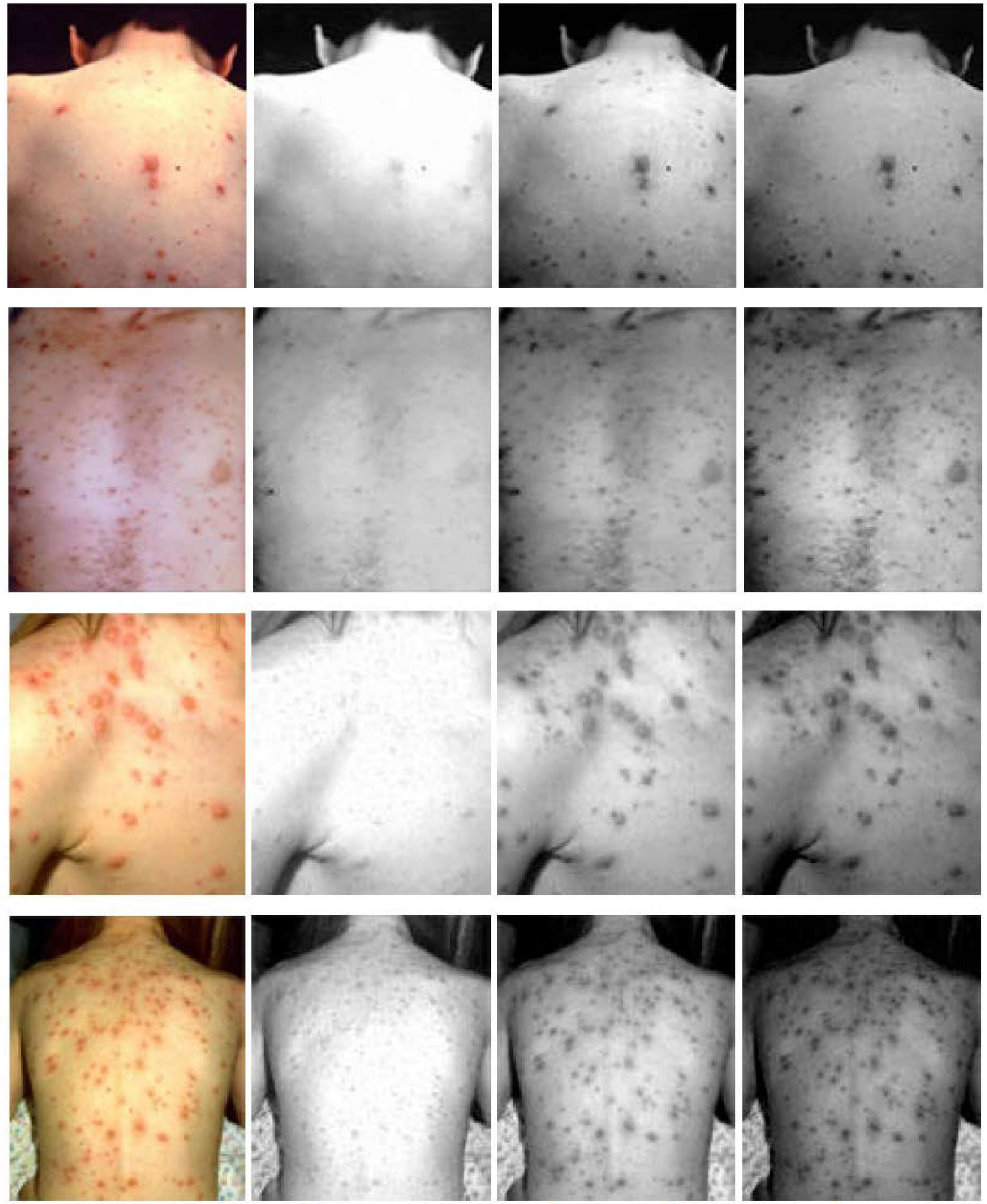
Assessment and Classification of Varicella Images

Considering the fact that these images are taken under different clinical conditions and at different stages of illness development, and their complexity imply challenges related to:

1) Changes in their appearance due to various stages of rush by which it is manifested;
2) The unique skin color for every patient;
3) Different image resolutions;
4) Various illumination conditions and uneven illumination under which images are taken;
5) Poor contrast;
6) Varying size and
7) Intensity level of blisters.

Assessment and Classification of Varicella Images

Taking all of this into account, we observed red, green and blue component of the images and concluded that the blue one offers the best contrast and inherent emphasis of the targeted blisters



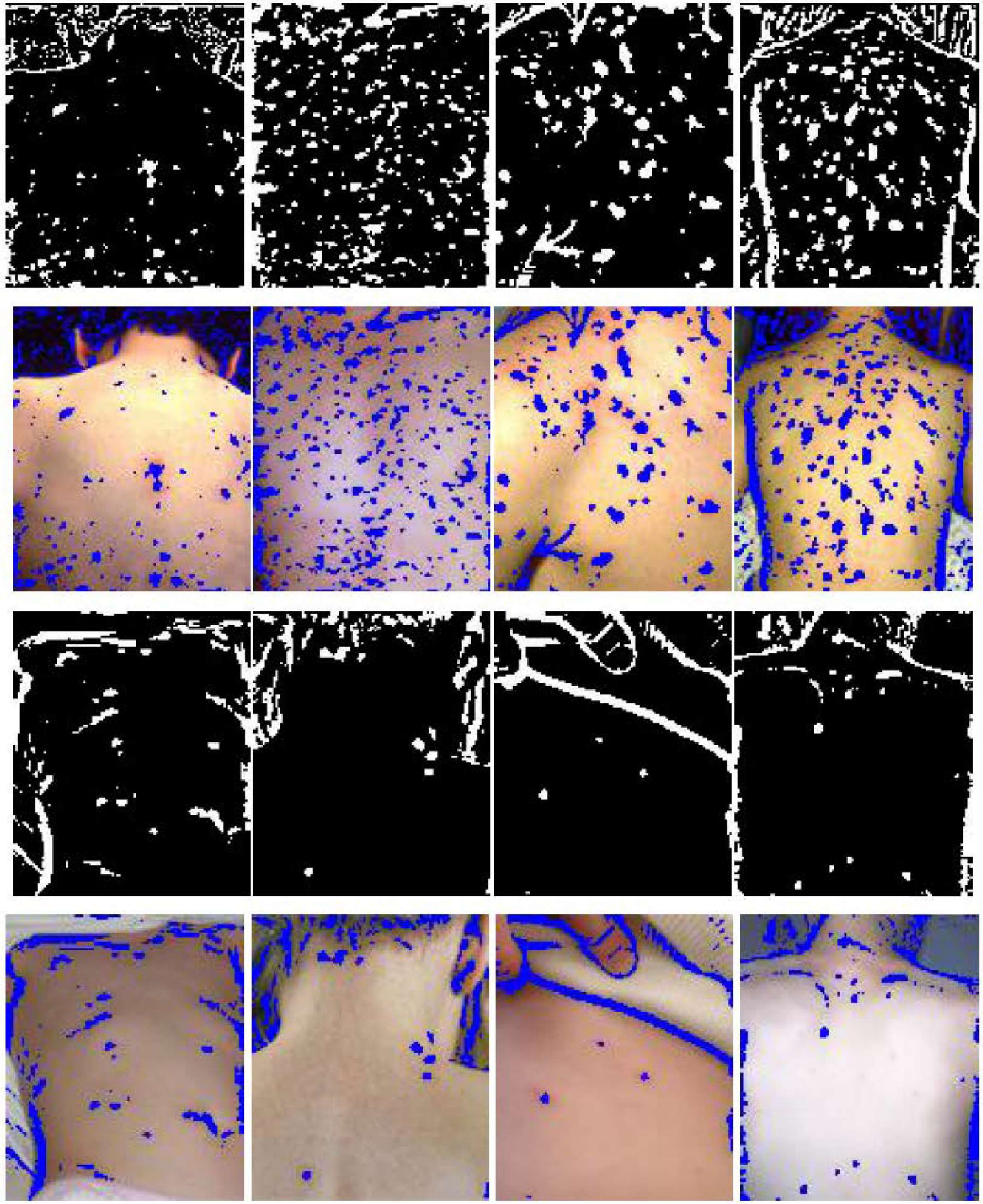
Method I

First, we applied the sliding window where minimum and maximum values were calculated, where central pixel was selected as potential varicella blister if two criteria were satisfied according to the equation (1)

$$(Max - Min) > 10\% \text{ of } 255 \text{ and } Current\ Pixel < Median \quad (1)$$

If the difference between maximum and minimum value of the pixels encompassed by the window surrounding analyzed pixel was higher than 10% of the maximum pixel intensity 255 and if the analyzed pixel’s intensity was smaller than the median value of the pixels surrounding it, then that pixel is selected as belonging to the targeted blisters.

Method I



Method II

Considering that this method did not give fully satisfying results, we applied color methods which implied three criteria expressed in the equation (2)

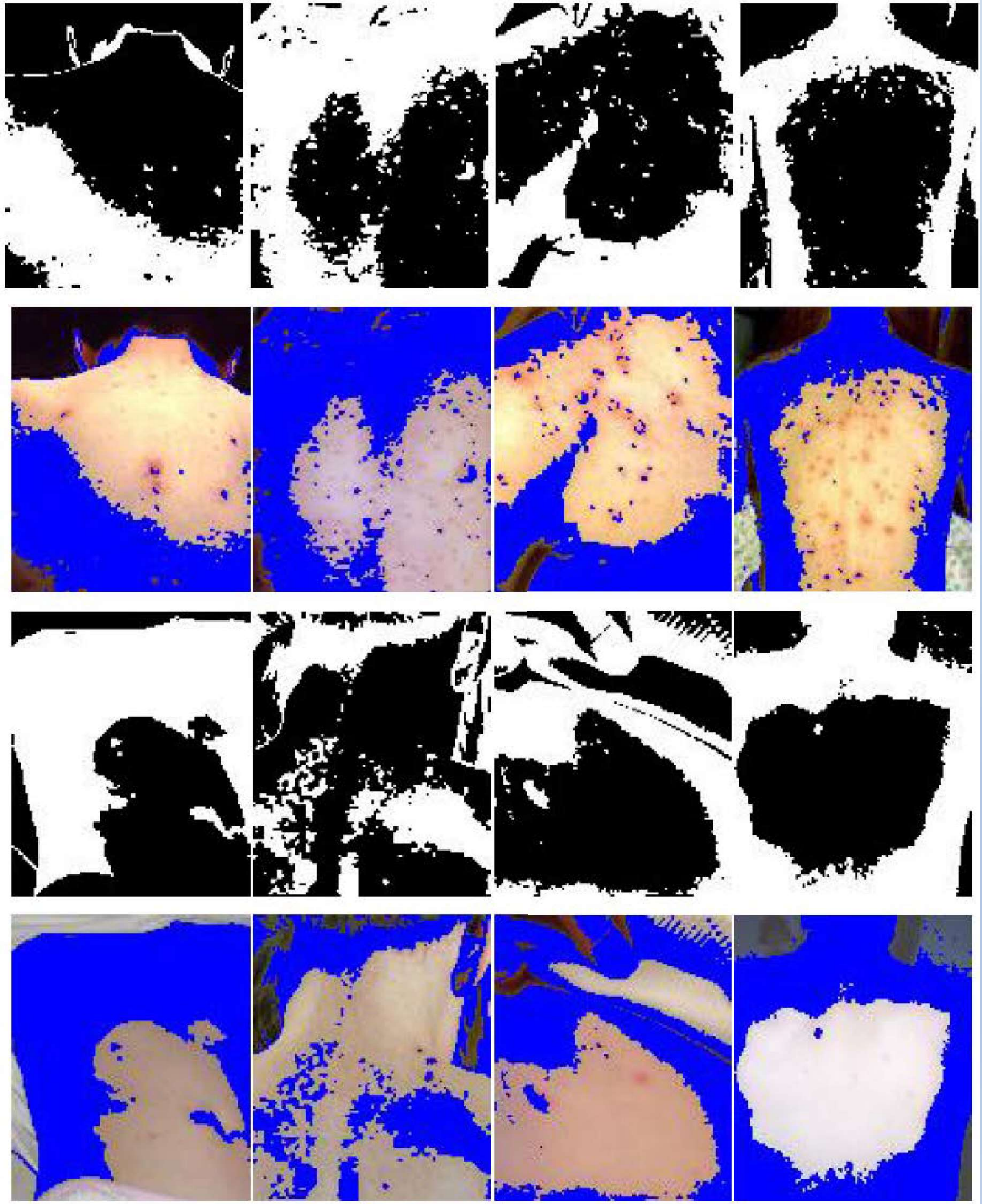
$$Red > \frac{MedianR}{2} \text{ and } Red < MedianR \text{ and}$$
$$Green > \frac{MedianG}{3} \text{ and } Green < MedianG \text{ and} \quad (2)$$
$$Blue > \frac{MedianB}{3} \text{ and } Blue < MedianB$$

Considering that red plane pixels had the poorest contrast in reference to the targeted rush i.e. blisters regions, we assessed gray level plane instead.

Gray, green and blue corresponding pixel's intensity values were checked within boundaries determined by median values of the respected color planes and assigned as belonging to targeted region if the conditions were met.

Due to changes in analyzed images' appearance caused by various rush stages, unique skin color, various illumination conditions and uneven illumination under which images are taken as well as poor contrast, the obtained results were even less satisfactory than the ones generated by the previously described method

Method II



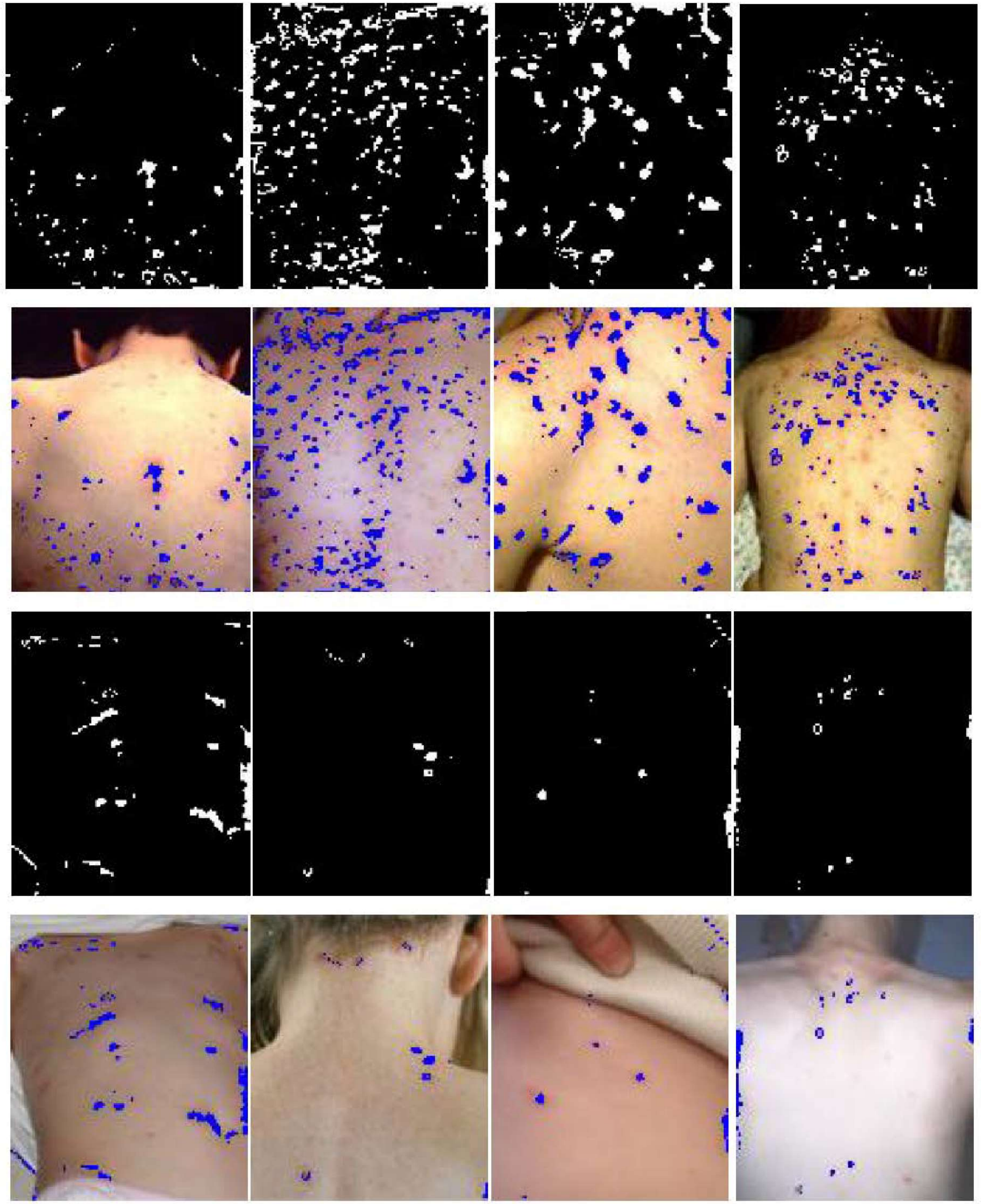
Method III

We fused previously described two techniques and propose new method which incorporates the advantages of both and we used the sliding window where the central pixel was selected as potential varicella blister if five combined criteria from two previous methods were satisfied

$$(Max - Min) > 10\%\ of\ 255\ and\ Current\ Pixel\ <\ Median\ and$$
$$Red > \frac{MedianR}{2}\ and\ Red < MedianR\ \ and$$
$$Green > \frac{MedianG}{3}\ and\ Green < MedianG\ and$$
$$Blue > \frac{MedianB}{3}\ and\ Blue < MedianB$$

It can be observed that body edges and background areas are omitted while the targeted varicella blisters are successfully detected in all images.

Method III



Conclusion

Varicella, also called as chicken pox, is an extremely contagious disease that is characterized by a blistery rash which manifests itself through various stages of appearance.

This is why, the proposed combined min-max-median window and color algorithm, applied on varicella affected patients' images taken under various clinic environment conditions, represents unique attempt to develop an automated mathematical and simulation technique capable of automatically detecting targeted varicella affected skin areas.

The algorithm shows to be robust to various appearance changes of varicella images processed in clinical environments due to various stages of rush, unique patient's skin color, different image resolutions, various illumination conditions, poor contrast and varying size and intensity level of blisters.

The simulation results were performed using MATLAB and tested on the varicella images provided by the governmental Centers for Disease Control and Prevention, showing to be successful in differentiating and detecting varicella rush affected skin areas in the images taken under various environmental clinical conditions.