Identifying black dots in dermatoscopic images using template matching.

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Introduction

One of the dermatoscopic features for identifying malignant melanoma that have been defined by medical doctors are black dots [3]. Black dots are heavily pigmented melanocytic cells with a diameter of less than 0.1mm. If they are located near the perimeter it indicates an atypical lesion or a melanoma.

The method presented here for identifying black dots uses template matching by area correlation to identify the shape of the black dots. The color information is then used to distinguish between similar shaped dots with different colors.

Template matching

The presence of a known object in an image can be detected by searching for a match between a object template $u(m,n)$ and the image $v(m,n)$. One way of doing this is by computing the cross-correlation between the template and image. The cross-correlation for a displacement (p,q) is given by

$$c_{vu}(p,q) = \sum_m \sum_n v(m,n)u(m-p,n-q). \tag{1}$$

If there is a close match between the unknown image and template, the correlation amplitude is high. A given object can be located by searching for peaks in the cross-correlation function. The dermatoscopic images used here are RGB color images which makes is possible to search for black dots in all color dimension. The object can be located by finding the peaks in the summed cross-correlation functions for all color dimensions. Here we will use a simple threshold instead, as we focus on the possibility of using template matching for detecting black dots.

The template is acquired by computing the mean of a few predefined black dots. The average pixel value in the template is subtracted from the pixels. Having a template with average pixel value of zero, removes the influence of the mean in the correlation evaluation.

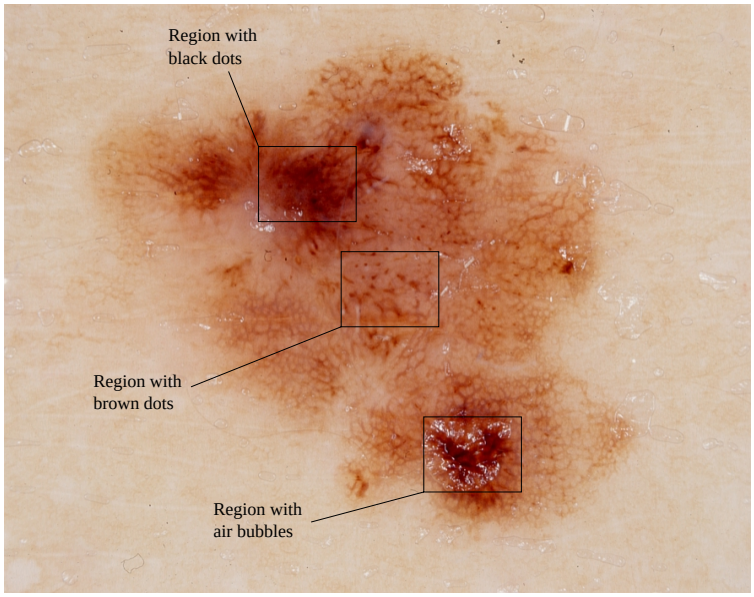

Figure 1 The skin lesion used for experiments holds 3 regions of interest, region with black dots, region with brown dots and region with air bubbles and pigmented network.

The color of the black dots is determined by examining the predefined black dots. As the RGB color space is used, the integer pixel values range from 0 to 255 for all color dimensions. In RGB color space, the true black color is defined as zero in all color dimensions. The black color of the black dots is not as restrictive, it just has to be very dark. This makes it possible to define some maximum value for all the color dimensions, where the color accepted as black will lie below these values.

Results

The skin lesion which holds the black dots and will be used for experiments, is shown in Figure 1. The images has 3 regions that are of interest, all marked with squares in the image. The top region has black dots, where some of them will be used for generating the template. The middle region has dots which have the same size and shape as the black dots, but the color is not as dark as in the black dots. These dots may not be detected as black dots. The bottom region has dark pigmented network and some air bubbles, which the template matching could easily detect as black dots. These air bubbles occur in the oil layer on a glass plate on the camera and could obscure the detection of black dots.

First the template has to be generated. A blow up of the region with black dots is shown in Figure 2. There are 6 black dots selected to generate the template, marked with numbers from 1 to 6. These 6 black dots are shown in Figure 3 where the intensity for

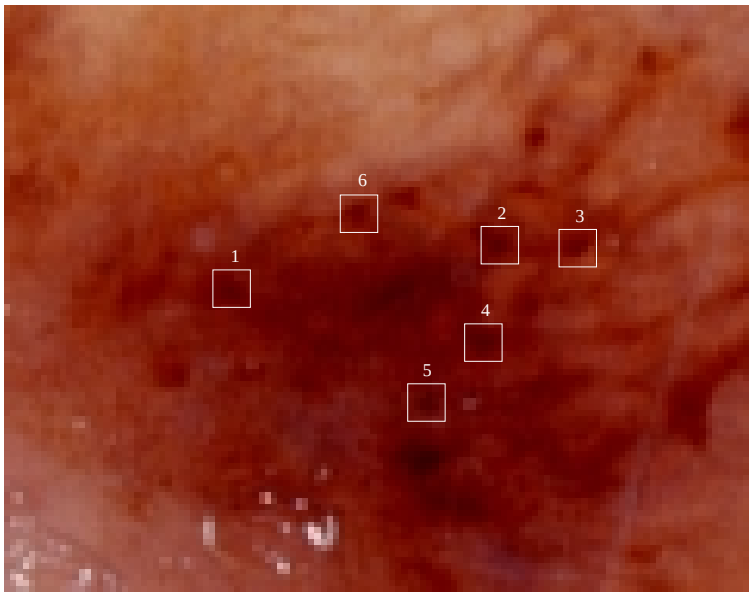

Figure 2 A blow up of the region with black dots. The squares show the black dots used for making the template.

each of the three color dimension is shown separately. The size used for the template is 11×11, which covers the black dots and the surrounding pixels to clearly mark the shape of the black dots. The figure shows that only the red color dimension can be used for

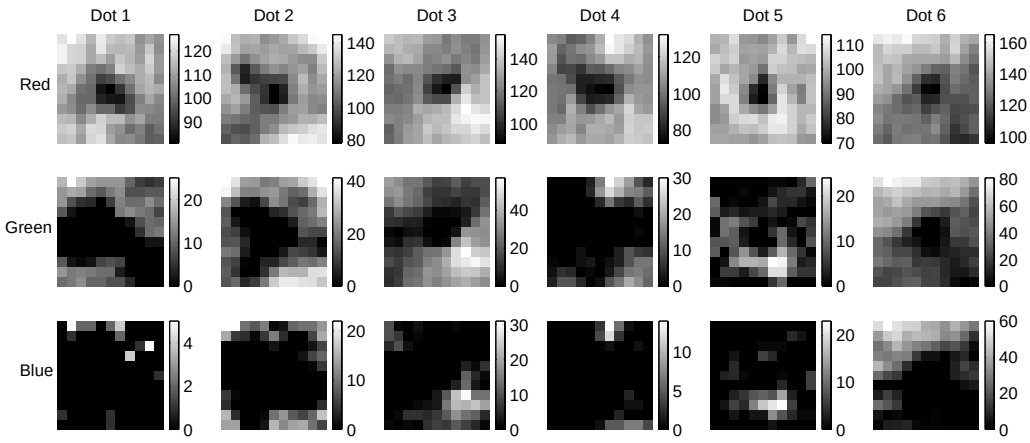

Figure 3 The red green and blue pixel values for the 6 predefined black dots.

template matching, as the other color dimensions, green and blue, do not look anything

like dots. The red color shows clearly the shape of the black dots.

The next step is to determine the black color from Figure 3. The color values for the green and blue colors have the value 0, and therefore selected as maximum values. The red color maximum value is selected to 100.

The template generated from the 6 black dots is shown in Figure 4. The average pixel

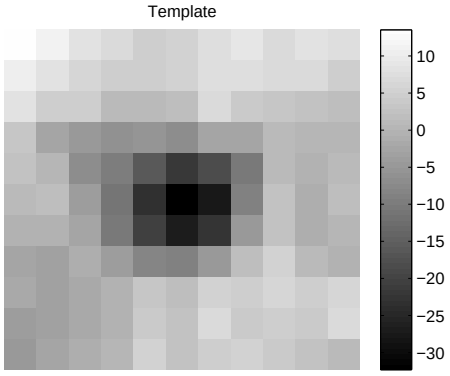

Figure 4 The template for the red color image.

value has been subtracted from the pixels, thus making the pixel values negative in the middle of the template.

The threshold value to find the peaks for the correlation is determined from the correlation values of the predefined black dots. The correlation values are shown in figure 5. The lowest value is observed in black dot 4, around 4500. The threshold value is selected

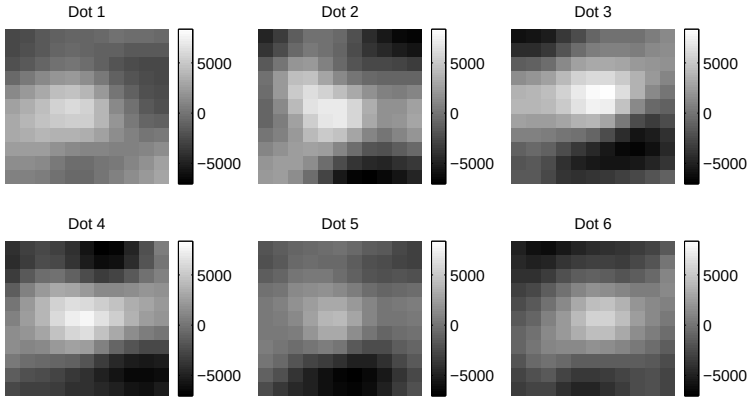

Figure 5 The result of convolution of the red image and the template of the 6 predefined black dots.

a little bit lower or to 4000. The template matching method is now tested on the three

regions shown in Figure 1.

First the results from the region with the black dots is shown in Figure 6. Not sur-

Figure 6 A region of the dermatoscopic image (left) and the detected black dots by template matching (right).

prisingly, the predefined black dots are easily found, but there are also some other dots detected. The two large dots in the middle at the bottom, and two at the bottom right are not black dots, as they are too large. This indicates that the template matching does not work in all cases, and it does not detect the shape of the dots well enough.

The result from the region with the brown dots is shown in Figure 7. No black dots

Figure 7 A region of the dermatoscopic image (left) and the detected black dots by template matching (right).

are detected here as the color is not dark enough to classify the dots as black. This shows the importance of have color detection combined with template matching.

The results from the region with air bubbles and dark pigmented network is shown in Figure 8. There is clearly misclassification in the detection of black dots. Much larger black areas, originating from dark pigmented network, is detected as black dots. The template matching does not work well here. The detected object is much larger than the black dot in the template. The convolution values for the region in Figure 8 is shown in Figure 9. This shows that much larger object then the black dots are highly correlated with the template. This mean that template is not very selective in finding black dots.

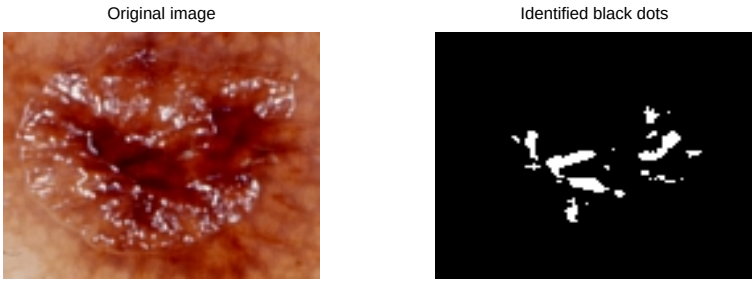

Figure 8 A region of the dermatoscopic image (left) and the detected black dots by template matching (right).

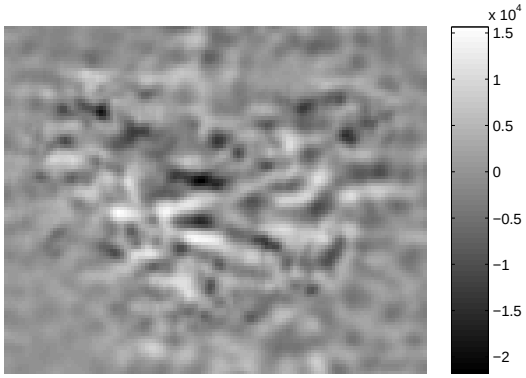

Figure 9 The correlation values for image region shown in figure 8.

The problem with using template matching is that many objects are falsely classified as black dots, as seen in Figure 6 and 8. This could be solved with some post-processing method, where the size and shape of the dots found with template matching, could be evaluated. Objects that have a certain size and circular shape would be classified as black dots.

Conclusion

The result from using template matching by area correlation is not satisfactory, despite that the problem of finding black dots is rather well defined, i.e. the size, shape and color is known. Many objects in the image are classified as black dots, even though they are too large and are not circular in shape. There are at least two things that could be the reason for the poor results. Firstly, the template is very small compared to the size of the image. This mean that there are few pixels in template compared to hundreds of possible object in the image. Template matching has been used with success in face recognition

where the template has the same size as the image. Secondly, using a template made from predefined black dots can be questioned, as the background can vary in color and intensity. The background is not supposed to have any influence on the classification of black dots, but by using the background of the predefined black dots in the template, a certain restriction is made.

Nevertheless, this method can possibly be used with some post-processing method. By evaluating the size and shape of the dots from the template matching, dots that have a certain size and circular shape could be recognized as black dots and thus give better results.

References

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