A Review on Segmentation of Vitiligo image

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Abstract. Digital image processing is playing a vital role in medical science. Segmentation is a very important and critical step of image processing to analyse the image. Segmentation has become an eminent objective in image analysis and computer vision algorithms. Vitiligo is a very common skin disease that causes depression for the patient suffering from it. In current work, several segmentation techniques like thresholding, watershed, Region-based RAG, Felzenszwalb Segmentation, SLIC - K-Means based image segmentation, and Quickshift image segmentation were analysed along with their experimental results on vitiligo image. The execution time of different algorithms was also measured and analysed. Some of the advantages and disadvantages of applied techniques were discussed.

Keywords: Vitiligo, Segmentation, Image Processing, Thresholding, Watershed

1. Introduction

Skin disease is a very common problem faced by many people in the world. There is a fatal and non-fatal skin disease. Vitiligo is a very common skin disease and does not lead to death. In this disease white patches appear on the skin. These patches are caused by lack of a cell melanin which is responsible for skin color. Melanin is produced by melanocytes cell. It is an autoimmune disease where melanocytes cell is mistakenly killed by the immune system. However, it is not harmful but it affects the mental state of humans. They lose confidence to go in public. Vitiligo treatment is time-consuming. It takes several visits for a patient to get it diagnosed, and also accurate identification of disease depends on the year of experience of the doctor.

The influence of digital image processing in the modern world is enormous. Digital image processing plays an important role in the diagnosis of various diseases in the medical field. Digital image processing consists of different steps to process the image. These steps include image procurement, pre-processing, segmentation, and classification. Every step in image processing is important, but image segmentation is a very critical step. The good quality segmented image leads to better classification accuracy. Digital image processing steps are shown in Figure 1.
Image segmentation is the process of partitioning the image into various segments to analyze the different parts of the image. Each segment shares the same characteristics. Later interested segments can be extracted from an image for further analysis. There are several techniques available for image segmentation. In this work, we will discuss different segmentation techniques which can be applied to vitiligo image.

2. Related work

Liu used CNN in HSV and YCrCb for lesion detection which was an effective mechanism [1]. The author used MFCC and i-vectors to extract characteristics of images [2]. ASLM techniques consist of 4 steps for the segmentation of melanoma images [3]. In another work Gradient and feature, the adaptive contour was used for identification of melanoma image [4]. Segmentation was inbuilt in the LVQ neural network for vitiligo images [5]. Various segmentation techniques review was presented by Gurusamy [6]. In another work, CNN with U Net architecture and watershed algorithm was used for automatic segmentation of vitiligo images [7]. The graphical interface was developed and face contouring, patched ROIs definition, image filtering selection, and global threshold setting were used [8]. Local binary pattern, GLCM, DCT, and DFT is one of the techniques for extracting features of images [9]. In another work, WLD was used along with GLCM, DCT, DFT, and LBP for feature extraction of vitiligo images. Density-based and active contour approaches were used to detect the border of skin lesions [12]. GLCM was used for feature extraction [13]. In other work image inpainting, canny based edge detection, the morphological operation was used for image segmentation [14].

3. Segmentation techniques

3.1: Thresholding: Thresholding can be used as an image segmentation technique, where pixels of the image can be changed to easily analyze the image. In thresholding, a grayscale image is converted into a binary image.

(i) Normal Thresholding:
Otsu’s segmentation: Global Otsu’s segmentation works on the bimodal histogram of the image. The bimodal histogram is the histogram of the frequency of the pixel intensity of the image. Here threshold will be calculated automatically from the histogram. This works on the concept of minimizing the intraclass intensity variance and maximizing the inter-class intensity variance.
If the background of the image is relatively uniform, then the global threshold gives good results. However, if there is more change in the background intensity, adaptive thresholding (a.k.a. local or dynamic thresholding) may give better results. However local is much slower than global thresholding.
(ii) Multi-Otsu Thresholding. The multi-Otsu threshold is a thresholding algorithm that is used to separate the pixels of an input image into several different classes, each one obtained according to the intensity of the gray levels within the image.

3.2: Watershed segmentation. The watershed algorithm works on grayscale image boundary between two regions are calculated based on the brightness of pixels. The image is viewed as a landscape where bright pixels formed a high peak. With the help of markers, this landscape is flooded until different flood basins meet at peaks. Each different basin is considered as different regions. Compactness feature can be added for the region with regular shape.

3.3 Region-based RAG. This algorithm works on a region adjacency graph which represents the adjacency of regions with a graph. Each region is considered as a node in the graph. The edge between the two regions will be given weight which can be defined based on the difference in average color between the two regions.

3.4 Felzenszwalb Segmentation. It uses a minimum spanning tree-based clustering for image segmentation of multichannel image (RGB image). The image can be smoothened before segmentation with the help of the Gaussian kernel. Several segments can be decided by the user. The algorithm uses Euclidean distance between pixels in color space.

3.5 SLIC - K-Means based image segmentation. It is similar to the quickshift algorithm where it uses the K-means algorithm in the 5d space of color information and image location. It is very simple and efficient. Several segments can be provided by the user.

3.6 Quickshift image segmentation. This algorithm is a 2D image segmentation algorithm and represents the family of the local mode-seeking algorithm. It simultaneously computes hierarchical segmentation on multiple scales. This scale shows the local density approximation. Also, the level can be selected to produce hierarchical segmentation.

4. Experimental Results

Image for vitiligo was collected from kaggle.com which is the online repository of the dataset used for the machine learning algorithm. We have used python with Jupiter notebook to implement the different algorithms. Color image of vitiligo as shown in Figure 2 was converted into a grayscale image. Then normal thresholding was applied to the image.

![Figure 2. Color Images of Vitiligo.](image)

First, we have applied regular thresholding and inverted thresholding to the image where pixels were converted to either black or white color depends on the threshold value. This thresholding works well with the binary image. We have set the value of the threshold to 127. The result is shown in figure 3. As can be seen from the result that this algorithm did not work well with our data set.
The next threshold method used was global otsu’s thresholding which is based on the bimodal histogram. Here the value of the threshold was calculated automatically based on the histogram. Then the threshold was applied to the image. This calculated threshold can be seen as a red line in the histogram of the figure. As it can be seen from figure 4 that otsu’s thresholding gives a better result than manual thresholding, however, the result is not promising still.

![Figure 3: Result of Manual Threshold and Inverted Threshold.](image)

Next local thresholding was applied on the vitiligo image. For each pixel, an optimal threshold was defined by maximizing the variance between two classes of pixels of the local neighborhood. This color image of vitiligo was converted into a grayscale image. Then the image was converted into an 8-bit unsigned integer format. The value of the radius was taken as 15. Figure 5 shows the comparison of local threshold and global threshold on the vitiligo image.

![Figure 4: Result of Global Threshold.](image)
Multi-Otsu calculates several thresholds, determined by the number of desired classes. The number of classes taken here is 3: for obtaining three classes, the algorithm returned two threshold values. They are denoted by a red line in the histogram given below in Figure 6.

![Figure 5: Comparison of Local Threshold & Global Threshold.](image)

![Figure 6: Result of Multi-Otsu.](image)

The next watershed algorithm was used to segment the vitiligo image. The first color image was converted into a grayscale image. The image was de-noised and the local gradient was calculated with the value of radius taken as 5 to get the smoother image. Then a marker image was constructed from the region of the low gradient within the image with the condition gradient less than 10. In a gradient image, the areas of high values provide a blockade that helps to segment the image. Using markers on the lower values will ensure that the segmented objects are found.
In this method, the color image was converted into a grayscale image. The color image was segmented using the k means clustering algorithm, whereas the grayscale image was used to calculate the edges from the image. Then with the help of the initial segmented image and edge map, Region Adjacency Graph (RAG) was created. Value of connectivity was taken as 2. The result is shown in Figure 8.

**Figure 7:** Steps of Watershed Algorithm.

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In the next figure, the result of 4 segmentation techniques was shown. Felzenszwalb Segmentation was used with a value of sigma of 0.5. The number of segments decided here was 100. In Slic number of segments was taken as 250 and the value of sigma was taken as 1. Quickshift algorithm takes two important parameters kernel size which was taken as 3 and the maximum distance was taken as 6. In the watershed algorithm, a compactness feature was added for a more regularly shaped region. Finally, the result of applying all these four algorithms is shown in Figure 9.

![Figure 8: Result of Region Boundary Based RAG Segmentation.](image)

![Figure 9: Comparison of Different Segmentation.](image)

The execution time of each algorithm was measured and shown in table 1.

| SN | Name of the algorithm   | Execution time (In Millisecond) |
|----|-------------------------|---------------------------------|
| 1  | Local otsu              | 48.7ms                          |
| 2  | Multi otsu              | 6.51 ms                         |
| 3  | RAG                     | 461ms                           |
| 4  | Watershed               | 11.1ms                          |
| 5  | Felzenszwalb            | 27.9 ms                         |
| 6  | Slic                    | 40.8 ms                         |
| 7  | Quickshift              | 284 ms                          |
| 8  | Compact Watershed       | 28.74 ms                        |

5. **Analysis & Discussion**
As can be seen from the result and Figure 10 the normal threshold with a manual threshold is a simple and very popular technique for image segmentation but it did not work well with vitiligo images. However Otsu’s thresholding gives a better result than the manual threshold but the result is still not convincing. Multi Otsu’s thresholding gives the best result among all thresholding techniques. Compact watershed gives a better result than the normal watershed method. Out of Felzenszwalb, SLIC, Quickshift, and compact Watershed, Felzenszwalb, and SLIC give a promising result.

Thus by analysing results it can be seen that Felzenszwalb, SLIC, and multi Otsu’s thresholding gives a better result than other techniques like Quickshift and compact watershed. In terms of performance multi Otsu thresholding gives optimal results however other overheads time (digitization) were not included in the performance. The watershed algorithm also can be considered in terms of optimal performance whereas again time is taken for denoising the image and gradient calculation was not taken into account. Felzenszwalb and compact watershed also give a comparative performance.

6. Conclusion & Future scope

This paper briefly discusses some of the segmentation techniques for vitiligo images. Image segmentation is an important step of image processing which is affected by so many features like texture, content, and various other characteristics. In this work different image segmentation techniques have been discussed and also the result of each technique on the vitiligo image has been shown. Some of the techniques which work well with other medical images do not work well with vitiligo image whereas some of the techniques give the convincing result. In the future, more research can be conducted to improve the computational speed and accuracy, as good segmentation leads to good classification accuracy.

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