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The Model of nail color analysis – An application of Digital Image Processing

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Abstract - This paper discusses a model of nail color analysis for prediction of diseases using digital image processing. The model is a prototype which observes the color of nails of human palm on the basis of the principles of medical science, and predicts probable diseases, if any. Medical practitioners often observe nails of human palms to get assistance in prediction of diseases. The proposed model does the same job without any human intervention. The model gives more accurate results than human vision, because it overcomes the limitations of human eye like subjectivity and resolution power. As on now, the model is limited to identification of seven different colors of nails. In future it can be enhanced for more colors to predict more diseases.

Key words - Computer vision; Digital Image Processing; Nail color and Diseases; Color Segmentation; Edge Detection; Image Recognition

I. Introduction

Medical science follows different ways to diagnose the diseases in human body. One of the ways to identify or ensure the existence of disease is analysis of the color of nails of human palm. Like other test methods for diagnosis of disease, this one is also followed by medical practitioners. Usually, pink nails are indicators of good health. But, certain color of nails indicates certain diseases, for example: (i) a faded pink color of the nails can be an indicator of anemia, heart failure, malnutrition, and liver disease. (ii) Conditions of white nail with dark edges can be a sign of serious problems with the liver, such as hepatitis. (iii) The yellow color indicates a fungus infection. If the infection is worse, the nail becomes thicker and brittle. Sometimes, yellow nails indicate a serious condition such as thyroid disease, lung, diabetes, or psoriasis. (iv) Lack of oxygen can cause the nails turn blue. However, infection of the lungs such as pneumonia or heart abnormalities may also be the cause. (v) Corrugated nails surface is the early signs of psoriasis or arthritis, and is usually accompanied by a waning of nail color. Nail conditions that change color to red brown are also commonly encountered. (vi) If longitudinal black stripe is found in the middle of the nail. That could be an early symptom of melanoma, the most severe type of skin cancer. [5]

II. Need of the system

There are three main reasons why the system is needed to analyze nails for accurate prediction of diseases. (i) Human eye is having subjectivity about colors. i.e. the same color could be named differently by different people, which may lead to wrong result. Since computer observes only RGB color value of pixel, it would be unique on all the machines. (ii) Human eye is having limitation in resolution. If nearby pixels are having difference in color, human eye cannot identify it, but computer vision would resolve each and every pixel accurately. (iii) Small amount of color change in few pixels on nail would not be highlighted to human eyes, because of background color of other pixels. Computer vision again wins here and identifies smallest color changes on nails.

III. Proposed Model

To automate the manual process of analysis of nail color, a model is developed as shown in fig. 1.

Fig. 1 Model for disease prediction based on digital image processing and medical palmistry

The developed model has five main components as below:
(i) Input to the model: Scanned back sides of human palm.
(ii) Extraction of palm region from background: It includes four major sub-components namely RGB component analysis, Image rotation (if needed), Setting common background, and cropping.
(iii) Extraction of nail region from cropped image: The nail region is further separated from cropped image of palm.
(iv)Analysis of nail region for color of each pixel: The extracted nail region is analyzed on the principles of digital image processing.
(v) Disease prediction: From the knowledge gathered from medical literature, nail color is matched with certain range of RGB component values and diseases are predicted if found.
Working of model is explained in next section of this paper.
Since this is a prototype, only a subset of diseases is considered for predictions. Diseases related to liver like Hepatitis and Jaundice, lung disease like Cyanosis, Antimalarials, and Haematoma, heart diseases like heart disfunctions , and some miscellaneous other disease like Psoriasis, Fungal Infection, Tetracycline, Diabetes, Thyroid disease, Anemia, Malnutrition [4] are also covered in this model.

IV. Working of Model

(i) Input to the prototype
Both right and left palms are scanned one by one, from their back side, so that the nails could be captured entirely. Of course, nails of thumbs are not clearly visible in scanned image, so nails of two thumbs are not considered for further processing. Palms are scanned through the flat bed scanner "HP ScanJet 4670" because it was having minimum impact of background lighting of the room on the image as compared to other flat bed scanners. Minimum impact of background lighting is very important for input image to get accurate result.

(ii) Extraction of palm region from background
To separate the palm from rest of the image, a model is created which extracts the portion of interest in the given image on the basis of color processing. The model works is three steps. (a) RGB component analysis for human palm: Careful observations of RGB color values of different skin tones of human show that, in the image of human skin, red component is having higher value than green and blue components. This observation sets logic behind this step. (b) Image rotation (if needed) to keep nails on top in image: As far as color processing of palm is concerned, any inclination of palm gives same result. For nail's color processing vertical position of palm in image is needed. User can scan his/her palms either horizontally or vertically. Horizontally scanned palm is automatically rotated and made vertical by the prototype. The logic behind this step is that, any human palm will have length greater than breadth. (c) Setting common color value background: After selecting pixels of palm, all the remaining pixels are set with common new color value, so it would be easy to eliminate them in further processing of color of palm. (d) The image is cropped according to the end coordinates of the palms in the image
In this way both the palms in the image are separated from background. [3]

(iii) And (iv) Processing palm region for extraction of region of nails and analysis of color of pixels of this region:
To process further and to analyze color of nails one more algorithm is developed, which forms a subsystem of nail color analysis. By using the distinguished characteristics of human palm regarding to the nails, the algorithm is designed and implemented, which successfully gives average as well as pixel by pixel color of nail of each finger [4].

(v) Disease recognition:
As mentioned in introduction section, different colors of nails indicate certain disease. To implement this model, computer should have reference color value of ill nails to compare user's nail. That is, when user uploads his/her palm images, color values of nails in those images would be compared with these reference colors. If the case matches with any of reference color values, user would be victim of that disease. For reference color values of ill nails, 50 samples are taken per color. That is, for example, for yellow nails, 50 different yellow nails color values are considered, and then their arithmetic mean is considered as a reference color value for yellow nails. While execution of this model, it is possible, that user may have certain disease, but the nail color value may not be exactly equal to the RGB color components of reference color for that disease. To overcome, this problem, variation in RGB components according to the highest and lowest value of samples is considered and that much percentage of deviation is allowed to get disease. For example, reference RGB component values for light yellow nails is (213,169,98). Now by observing samples carefully, it is found that, minimum value of red component in samples was 196 and maximum value of red component was 230. Therefore, if the user's nail having pixels with red component within this range, they are considered for further analysis of disease. Same logic is used for green and blue components, and deviations from reference values are considered. Logical AND is performed to verify whether user is victim of respective disease or not. If all three components are lying within the range, user would be a suspect of that disease. Sample IF condition for this is shown below:


```
if ((current_redtf <= (213 + (10 * 213 / 100)) && current_redtf >= 213 - ((8 * 213 / 100))) && (current_greentf <= ((169 + (15 * 169 / 100))) && current_greentf >= (169 - (20 * 169 / 100))) && (current_bluetf <= ((98 + (25 * 98 / 100))) && current_bluetf >= (98 - (25 * 98) / 100)))
 {
  LSFlight_yelloNailcount++; // Calculating number of pixels of this color
  oimgL.SetPixel(Ls.X, Ls.Y, Color.Black); // Highlighting the pixels
 }
```

(vi) Identification of stage of disease:

If the model finds nail color of user, lying in suspicious illness category, number of pixels with this color is counted. In above code segment it is shown by using counter variable "LSFlight_yelloNailcount". Every time when new pixel within this color range is found, the counter is increased by one. In this way, this variable will give total number of pixels of given color. The stage of disease is decided in this model as following table:

TABLE I
Decision Parameters to Decide Stage of Disease

Percentage of pixels with given color in all nails	Stage of disease
Between 5% to 10%	Strong Probability of disease
Between 11% to 30%	Initial stage of disease
Above 30%	Advanced stage of disease

After getting percentage of pixels with given color model generates the output as shown in resulting figures Fig. 2(part I) and Fig. 2(part II). They are two parts of same web page which can be scrolled.

V. Results

The prototype works successfully for above mentioned color values of nails. In result, three major things are displayed. Input and output images of palm, a table which shows nail color analysis of nails of both the palms except thumbs, and prediction based on this analysis.

(i) Input and Output images of palm: For both, left and right palms output images are shown. In these output images, nail region is painted with different colors, according to their original pixel color value. The actual color which is represented by such color is mentioned in nearby table. Reason behind painting nail regions with different colors is that, the minor color difference between nearby pixels may not be visible in image we display as output. Therefore, we selected some contrast colors to highlight such color change in nearby regions.

(ii) Nail color analysis table: As shown in Fig. 2, this table is at right side of output image. It is common for all nails. That is, in this table analysis of all eight fingers is collectively shown. Each entry in the table is made per color. For example, total red pixels found in all eight fingers. Since the focus is on all the finger nails, total pixels for each color are important for us. In the table, there are four columns. First color of region in processed image, which displays color of respective regions, in box to understand the result image. Second, actual color of nail in the region, which shows actual color of pixels of nails, highlighted by respective color in the same row. Third, number of pixels found with this color. This value shows total number of pixels found of actual color of nail region. And lastly, percentage of total nails pixels with this color. If all the rows have value zero for this field, it means that, there is no pixel on nail found which indicates any disease that we have considered in this model. This parameter is used for further prediction.

(iii) Prediction of disease: as mentioned earlier, the percentage of pixels are considered to predict disease. This prediction is displayed in Fig. 2, below the analysis table. In the resulting figure below, prediction is shown for a person who is suspect of the diseases related to heart or lungs, and liver, based on knowledge base created by medical science. The person is known and under observation.

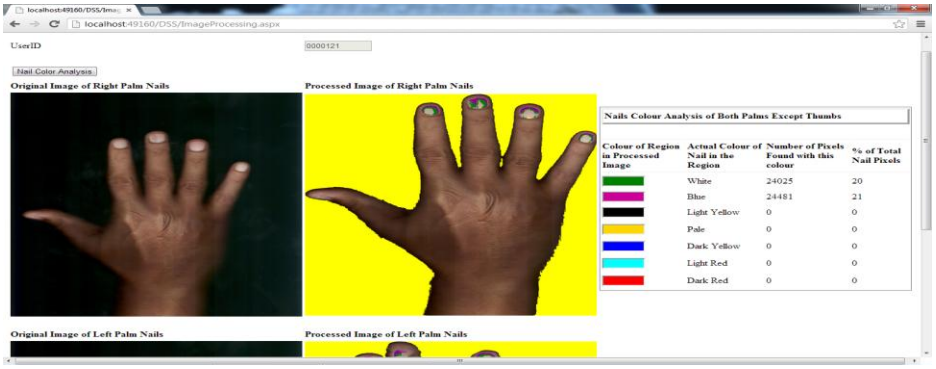

Fig. 2 (part I) Web page which shows prediction of disease according to analysis

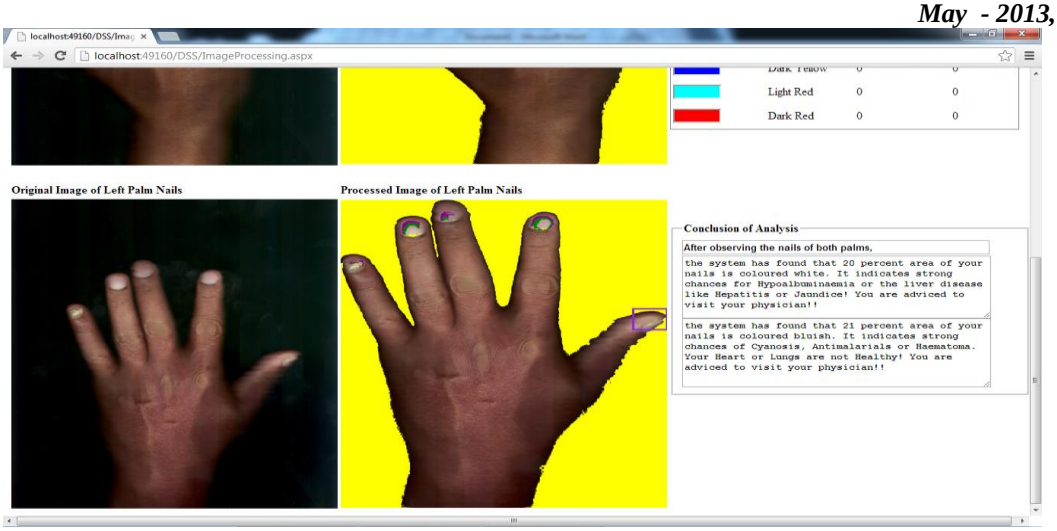

Fig. 2 (part II) Web page which shows prediction of disease according to analysis

VI. Conclusion

Thus, the paper demonstrates the model developed for nail color analysis. This fully computerized model works successfully as shown in result figure. It is quite useful to avoid human eye limitation as mentioned earlier for analyzing color of nails of human palm. Doctors can use this model to have assistance in disease identification. Other users can also get advantage of this model as a type of routine checkup.

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