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Approach to Detect Diseases using Nail Image Processing

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Abstract
This paper surveys on the importance of human nail analysis through digital image processing for the prediction of various systemic and dermatological diseases. This paper covers the various diseases that can be predicted through nail analysis and on how a model for nail analysis can easily assist the medical practitioners in detecting various diseases

Keywords: Nail Analysis, disease prediction, digital image processing, colour image segmentation, edge detection, contour extraction

Introduction

Various underlying systemic and dermatological diseases in a human being can be easily understood through careful examination of visual appearance of fingernails and toenails. Clubbing is one example of a systemic disease, which was first described by Hippocrates in the fifth century B.C. Since then a lot of nail diseases have been found to be early signs of various underlying systemic diseases [1].

Color or shape changes in nails may be due to various diseases primarily affecting nails. But some of these nail changes are early symptoms of various systemic disease that clinically become evident [2].

Medical Practitioners usually observe the color, texture, shape of human nails (finger and toe) to get assistance in predicting various systemic diseases. And if the same job can be done automatically using a computer through digital image processing, then we would be able to get more accurate results and predict various diseases easily.

Nail Disorders

The primary use of a nail is protection. A nail disorder is a condition caused by injury to the nail or due to some diseases or imbalances in the body. A medical practitioner or a nail technician should be able to easily recognize the normal and abnormal conditions and understand why they occur.

Nail Disorders can be classified into four categories. They are:

A. Congenital
B. Traumatic
C. Infectious
D. Tumors

A.Congenital

Congenital disorder or birth defect is a condition existing at or before birth. The various related diseases are given in Table I

B.Traumatic

Trauma refers to the damage to the nails caused by physical harm from external sources (Table I).

C.Infectious

An infectious disorder refers to the communicable diseases that can passed by infections from one person to another or from one part of the body to another (Table I).

D.Tumors

An infectious disorder refers to the communicable diseases that can passed by infections from one person to another or from one part of the body to another (Table IV).

Dermatosis Affecting the Nail

Dermatosis is a condition that affects the skin, nails, hair, glands, etc. The various types of diseases affecting the nails are:

A.Psoriasis

Psoriasis is the most common skin disease which affects the fingernails. Associated nail changes include:

(i) Onycholysis : The nail is separated from the nail bed. (Fig 1)
(ii) Splinter hemorrhage: Here we can see a prominence in the dermis of nail-bed. (Fig 2)

Fig 1: Onycholysis

Fig 2:Splinter hemorrhage

B.Darier's Disease

In Darier's disease [7] red and white colored lines start appearing on the nails. People with Darier disease normally suffer from various neurological disorders such as epilepsy, mild intellectual disability and depression. (Fig 3)

Fig 3: Darier's Disease

C.Alopecia areata

Alopecia areata is a type of disease which most often affects the scalp and beard, but it can also occur on any part of the body which has hair. We can see hair loss and regrowth at the same time on different skin areas. The nail plate is usually rough with a brass like appearance.(Fig 4)

Fig 4: Alopecia areata

C.Eczema

Eczema causes the skin to be inflamed or irritated. And it also causes itching. Severe pompholyx around the nail folds causes nail dystrophy, resulting in irregular ridges. (Fig 5)

Fig 5:Eczema

Nail Abnormalities in Systemic Diseases

Nail Abnormalities can also be classified into following three categories based on changes in shape[1][8],surface[14] and color of the nails. They are:

A.Changes in Nail Shape

Table I: Nail Findings due to nail shape changes

Si. No	Nail Findings	Nail Indication	Associated Systemic Conditions
1	Clubbing(Fig 6)	The Lovibond's angle can be seen to be greater than 180 degrees.The window between the back surfaces of the index fingers seems to disappear.	Pulmonary malignancy, Inflammatory bowel disease, chronic bronchitis, cirrhosis, congenital heart disease, atrioventricular malformations
2	Koilonyc-hia (Fig 7)	The nails are concave and the nail edges are everted and shaped like spoon such that they can retain a drop of water. This disease is most commonly found in fingernails, but also occasionally in toenails also.	Anaemic, trauma,nail-patella syndrome, hemochromatosis, Raynaud's disease,
3	Onycho-lysis (Fig 8)	The nail plate is separated from the underlying nail bed. Nails are usually smooth and without any nail bed inflammation	Psoriasis, amyloidosis, hyperthyroidism, sarcoidosis, infection, trauma, connective tissue disorders

Fig 6:Clubbing

Fig 7:Koilonychia

Fig 8:Onycholysis

B.Changes in Nail Surface

Table II: Nail Findings due to nail surface changes

Si. No	Nail Findings	Nail Indication	Associated Systemic Conditions
1	Beau's Lines (Fig 9)	Due to a temporary stop in the division of cells in the nail matrix, deep lines run from one side to another side on the fingernail.	Any severe systemic illness that disrupts nail growth, pemphigus, trauma, Raynaud's disease, diabetes, hypocalcaemia
2	Muehrck-e's Lines (Fig 10)	These are white colored lines which run all the way across the nail and is parallel to lunula	Liver disease,hypoalbuminemia (nephrotic syndrome), malnutrition
3	Leukony-chia (Fig 11)	Small white spots starts appearing on one or two nails of the fingers	Random and minor trauma to the proximal region of the nail bed

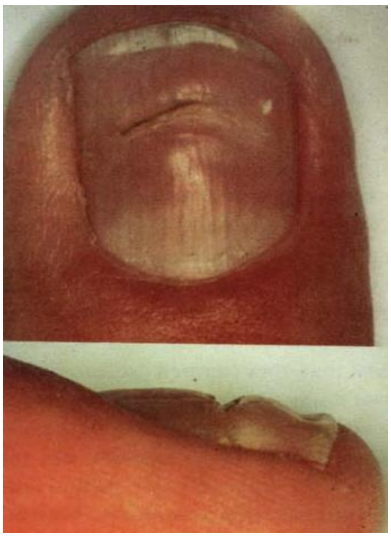


Fig 9:Beau's Lines

Fig 10:Muehrcke's Lines

Fig 11: Leukonychia

C.Changes in Nail Color

Table III : Nail Findings due to nail color changes

Si. No	Nail Findings	Nail Indication	Associated Systemic Conditions
1	Terry's nails (Fig 12)	Nails are normally white in color proximal region of nail bed and normal in other regions.	Hepatic failure, diabetes mellitus, CHF, cirrhosis hyperthyroidism, malnutrition
2	Yellow Nail Syndrome (Fig 13)	Nails are usually yellow in color and sometimes with a slight green color.	Rheumatoid arthritis, Lymphedema, immunodeficiency, bronchiectasis, pleural effusion, sinusitis,,nephrotic syndrome, thyroiditis, tuberculosis
3	Half and Half Nails (Lindsay's nails) [16] (Fig 14)	Proximal region on the nail bed is usually white in color but the distal region is pink or reddish brown.	Specific for renal failure. Also found in renal transplant recipients, hemodialysis and HIV patients.
4	Red Lunula (Fig 15)	Lunula is red in color	Collagen vascular disease and alopecia areata. It is also found in patients suffering from rheumatoid arthritis, cardiac failure, COPD, cirrhosis,chronic urticaria, psoriasis.
5	Splinter hemorr-hage (Fig 16)	We can see leaking of blood from the blood vessels of the nail bed	It is seen in patients suffering from ulcer, oral contraceptive use, endocarditis, SLE, rheumatoid arthritis, malignancies,pregnancy, psoriasis, trauma

Fig 12:Terry's nails

Fig 13:Yellow nail syndrome

Fig 14: Lindsay's nails

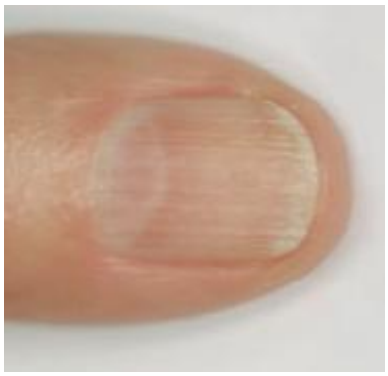
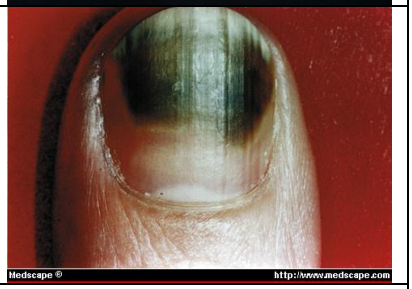


Fig 15:Red Lunula

Fig 16:Splinter hemorrhage

Table IV : Nail Disorders[4][6][14]

Si.No	Disease Name	Changes in Nail	Associated Systemic Conditions	Figure
	A. Congenital Disorders			
1	**Anonychia[15]**	A portion or all of the fingernails and toenails are absent without much bone problems.	Severe congenital ectodermal defect, ichthyosis, trauma, Raynaud phenomenon, epidermolysis bullosa, lichen planus or severe exfoliative diseases	
2	**Nail patella syndrome**	There is fingernail dysplasia with the third lunula absent, appearance of horns and deformation of the radial heads is also seen.	Kidney issues may arise such as proteinuria and nephritis. Hypothyroidism,irritable bowel syndrome, attention deficit hyperactivity disorder (ADHD), and thin tooth enamel	
3	**Pachyonychia congenita**	Overgrowth of the nails in the nail bed and hyperkeratosis is also seen. Excess keratin is seen in nail beds and hence thickening of the nails	Hyperhidrosis hyperkeratosis,warts, skin lesions on the limbs, and lustreless and kinky scalp hair is also seen.	
	B. Traumatic Disorders			
4	Onychophagia	The skin is broken skin on the cuticle region. Fingernails become severely disfigured due to nail biting for years and which in turn leads to the destruction of the nail bed.	Various types of viral and microbial infections are seen. It is very common among children and adolescents with skin picking, skin biting, and urge to pull out hair disorders.	
5	Hangnail	The skin of epidermis seems to break away from the lateral side of nail folds	Paronchyia	

6	Onychogryphosis	The great toenail appears yellow in color, thickened and slightly twisted towards one side.	Most commonly seen in the older people. Later on it becomes necessary to remove the nail and matrix surgically.	
7	Onychocryptosis	The nail fold of the great toe penetrates through the edge of the nail plate which results in severe pain.	Bacterial Infection	
	C. Infectious			
8	**Paronychia**	Soft tissue infection around a fingernail	The affected area often appears erythematous and swollen. Pus collects under the skin of the nail. The nail plates discolored and thickened. The cuticles and nail folds start to separate from the nail plate and thus microorganisms start invading at that portion.	
9	**Pseudomonas infection[3]**	The nail plate is bluish-black or green in color due to the collection of the pigment called pyocyanin below the nail.	Onycholysis, nail psoriasis and fungal nail infections.	
	D. Tumors			

10	**Glomus tumour [15]**	Splitting and malformation of the nail plate	Usually associated with severe pain, which may be spontaneous or resulting due to mild trauma or changes in temperature	
11	**Melanocy-tic nevi**	It is present as longitudinal melanonychia	Abnormal skin pigmentation in some areas of the body	

Survey of the Model for Nail Analysis

In this section a survey of the existing model for nail analysis that has been applied is presented.

Medical Practitioners usually observe the color, texture, shape of human nails (finger and toe) to get assistance in predicting various systemic diseases as mentioned above. If an efficient model for doing the analysis of nail using Digital Image Processing is developed, then it would be a big boon for the Medical Practitioners to predict the diseases more accurately and easily. In recent years, various number of research work has been carried out for predicting diseases using Nail Analysis. A model[9] proposed by Hardik Pandit et. al is illustrated in Fig 17.

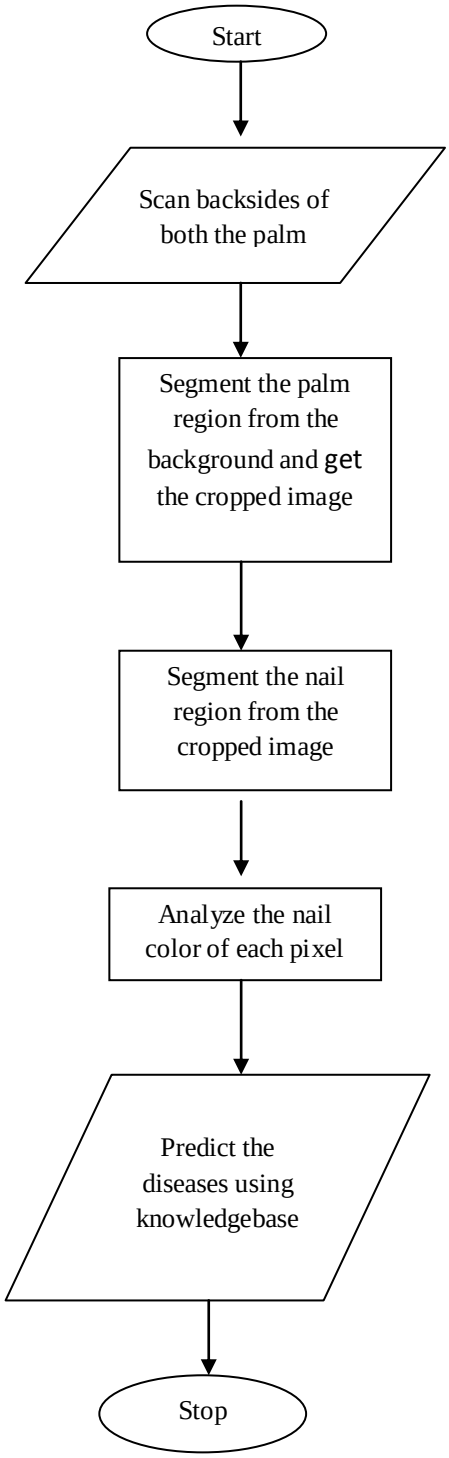


Fig 17: A Model for Nail Analysis

Working of the model

(i) Scanning back sides of both the palms

The back sides of both the left and right palms are scanned using a good scanner so that there is minimum impact of lighting conditions on the background.

(ii) Extract the palm region from the background

The palm is segmented from the background image using a model which extracts the palm region based on the RGB color of the skin using Color Image segmentation method. As this method makes use of the skin color, it is invariant to scaling or rotation. And then after the palm region is segmented, all the other pixels of the background is set to the same color, so that it does not cause any confusions for further processing and finally the palm is cropped.

Extracting the Nail region and Analyzing Nail Color

The Nail regions are also extracted using segmentation, contour extraction and edge detection methods and the nail color is analyzed and recorded.

Predicting the diseases

The recorded nail color is compared with the abnormal nail colors stored in the database and the diseases are predicted. While predicting the diseases, the recorded nail color may not have the exact match with the nail color stored in databases. Then, in such cases the maximum and minimum values of samples is compared and the deviation percentage amount helps in predicting the disease.

Advantages of the model

The mentioned model aids in easily and accurately predicting various diseases. The main advantages of the model are as follows:

(i) Eyes of human are very much influenced by colors, that is, the same color will be understood differently by different people. And hence this can lead to prediction of wrong results. But as the computer observes only RGB color space of pixel, the color prediction will be unique on all machines.

(ii) Human vision also has some limitation on understanding resolution. Difference in color of the nearby pixels cannot be easily identified by human eye, but computer vision can easily differentiate between the colors of each and every pixel accurately.

(iii) Color changes in some pixels of the nail cannot be easily understood by the human eyes, because of mixing of the background color of some pixels with those of the nails. And computer vision have an added advantage over here and is able to accurately identify the smallest changes in color of the nails.

Disadvantages of the model

The few disadvantages of the model are as follows:

(i) Only eight fingers of left and right hands are considered for examination. But the thumbs of both hands are not considered and hence thumbs have to be scanned separately.

(ii) For Disease Prediction only the eight fingers of hands have been considered. In some cases of diseases, the toenail also gets affected. And hence we also need to consider the toenails for disease prediction

(iii) Only six nail colors have been examined. We need to consider other nail colors like green, white stripes appearing horizontally and vertically, etc

(iv) For Disease prediction we need to consider not only the color of nails, but also the shape and texture or surfaces of the nails

Conclusion and Future work

The models available in literature were able to predict only eight fingers of left and right hand. Detailed research has not been carried out in analyzing the thumb nail and toenail colors for predicting various diseases.

As nails show the early symptoms of various underlying systemic diseases and if all the disadvantages of the models available in the literature are overcome and are carried out as future work, then we would be able to develop a fully automated system which will surely be able to predict various diseases that can affect a human being, in its earlier stages itself.

References

[1] Fawcett RS, Linford S, Stulberg DL. Nail Abnormalities: Clues to Systemic Disease. Am Fam Physician March 15, 2004; 69(6):p 1417-24

[2] Motswaledi MH, Mayayise MC. Nail changes in systemic diseases, SA Fam Pract 2010; 52 (5): p 409-413.

[3] http://www.aocd.org/?page=GreenNailSyndrome

[4] http://www.wikipedia.org/wiki/

[5] http://www.healthline.com/health/dermatoses

[6] dr-suzan.com/ihab/wp-content/

[7] http://ghr.nlm.nih.gov/condition/darier-disease

[8] Gregoriou, MD,George Argyriou, MD,George Larios, MD, and Dimitris Rigopoulos, MD,PhD, "Nail Disorders and disease:What the nails tell us", The Journal of Family Practice, VOL 57, NO 8 / AUGUST 2008

[9] Hardik Pandit and D M Shah, "The Model of Nail Color Analysis : An Application of Digital Image Processing", International Journal of Advanced Research in Computer Science and Software Engineering (IJARCSSE) ISSN: 2277 128X Vol 3, Issue 5, May 2013.

[10] Hardik Pandit and D M Shah, "The Model for Extracting a Portion of a Given Image Using Color Processing", International Journal of Engineering Research & Technology (IJERT) ISSN: 2278-0181 Vol. 1 Issue 10, December- 2012.

[11] Sung Kwan Kang, Mi Young Nam, Phill Kyu Rhee, "Color Based Hand and Finger Detection Technology for User Interaction", International Conference on Convergence and Hybrid Information Technology 2008

[12] R. C. Gonzalez and R. E. Woods, "Digital Image Processing", 2nd edition, Pearson Education, 2004

[13] Philip Fleckman, M.D., Jennifer Lee, Michael L. Astion M.D. Ph.D, Nail-Tutor™: an image-based personal computer program that teaches the anatomy, patterns of pathology, and disorders of the nails, Dermatology Online Journal 3(2): 2

[14] dr-suzan.com/ihab/wp-content/uploads/2010/11/Nails-handout.doc

[15] D. A. R. De Berker, "Disorders of Nails", Textbook of Dermatology, 01/01/2004

[16] Ramos-e-Silva, M, "Hair, nail, and pigment changes in major systemic disease", Clinics in Dermatology, 200805/06

[17] www.patient.co.uk