A Review: Human Finger Nail Image Analysis for Disease Diagnosis

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Abstract: Now days, non-invasive procedure for disease diagnosis is an important aspect in healthcare domain. There are various features of human body and mechanism which can be used for non-invasive procedure in disease diagnosis such as nail image, eye, breath etc. Human nail image analysis is one of the non-invasive procedure in which different image processing techniques such as image capturing, image pre-processing, image segmentation, feature extraction are used for nail image analysis. This survey paper presents various techniques used for nail image processing for different disease diagnosis. Different classification techniques such as SVM classifier, KNN classifier, ANN classification etc. used to classify nail database for disease prediction.

Index Terms **- nail image, disease diagnosis, classification, feature extraction**

I. INTRODUCTION

Innovation in modern health care is medical image processing. Medical image processing plays an important role in disease diagnosis. These medical images are processed and analyzed by applying different digital techniques such as fundamental algorithms for enhancements, segmentation, qualification, registration, visualization etc. To acquire visual information humans use visual system in which processing and understanding of the information happened to decide the related information. The focus of the image processing field is to automate the process of gathering and processing visual information. The process of receiving and analyzing visual information by digital computer is called digital image processing. There are different types of digital medical images based on how it is produced and how it looks such as X-Ray, CT scan, MRI, Ultrasound etc. [13].

Disease is disorder of function or structure of anatomy. Medical images plays very important role in human disease diagnosis. Disease affects human body or changes in human body can cause disease. Doctors examine the patient before prescribing any medicines and whenever necessary tells for laboratory tests. Based on these tests doctors will be able to decide the disease and accordingly giving the treatment. Modern diagnostic techniques require expensive equipment and highly-trained specialists. In the laboratory test there are various types of test considered such as blood test, urine test etc. [3] [9] and different types of scanning such as X-Ray, CT scan, MRI etc. In medical health care, the human nail is examined by doctors to get close information about the disease [5]. There are various parts of nail and features of the nail parts are examined by doctors such as nail plate color, texture of nail, nail shape, nail folds and many other. Symptoms of various diseases primarily affecting nails are the color, texture or shape changes in nails. Using digital image processing techniques we can detect such changes in the human nail to get more accurate results and to get more information about the disease easily [2]. Abnormal health condition can be indicated by transformation in nail color and texture [10][11]. The conditions like diabetes, iron deficiency, malnutrition, and diseases related to the organs like liver and heart can be diagnosed by observation of the change in the fingernails [5]. Nail is defined as the wrapper like structure which covers the tip of the fingers [8]. Nail unit has its own distinct class of diseases as these diseases have their own set of signs, symptoms, causes and effects that may or may not relate to other medical conditions [6]. Various research works has been done based on nail image processing and analysis for different disease diagnosis. In this paper we will be discussing the various image processing techniques used for nail image analysis and summarize related research work for disease detection using human finger nail image and will describe and compare different state-of-the-art techniques.

II. BACKGROUND

Why Nail Image for Disease Detection

There are various parts of human body analyzed for identifying the different effect in human body. Human finger nail analysis is one of the ways to identify disease in human body. Nails are the body part which are farthest from the heart and therefore are last to receive oxygen. As a result the nails are the first who shows the symptoms of disease in the human body [8]. Finger nails can be easily captured for diagnosis and there are no heavy equipments or conditions require for using nail image for disease diagnosis like in other tests and scanning process. Nail is one of the physical diagnostic tools which are commonly practiced in Ayurveda where nail can be a strong indicator of possible disorders occurring in the human body [14]. Human nails provide useful information about disorders or any nutritional imbalances depending upon their shape, texture and color [9].

Table 1: Nail Disorders and related diseases [2]

Nail Disorder	Diseases
Congenital	Anonychia, Nail Patella Syndrome, Pachyonychia congenital
Traumatic	Onychophagia, Hangnail, Onychog- ryphosis, Onychocryptosis
Infectious	Paronychia, Pseudomonas infection
Tumors	Glomus tumor, Melanocytic nevi

Abnormalities of the fingernail are few changes in human nails due to medical condition which require proper treatment. Nail abnormalities classified based on changes in shape, surface and color of the nail. Based on these categories few of the nail abnormalities are listed in table-2:

Table 2: Nail Abnormalities [2] [4]

Category	Nail Abnormalities
Dematosis (symptom of rash on the skin)	Onycholysis, Splinter Hemorrhage, Darier's Disease, Alopecia areata
Change in Shape	Clubbing, Koilonychia
Change in Surface	Beau‟s Lines, Meuhrcke‟s Line, Leukonychia
Change in Color	Terry's nails, Yellow nail syndrome, Lindsay‟s nails, Red Lunula, Splinter Hemorrhage

First effect of the most circulatory disorders symptoms is on the appearance of fingernails than before the rest of the body as a result abnormalities in the fingernail can be strong indication circulatory disorders [3].

Different Parts of Finger Nail:

The human finger nail is a part of human hand. The finger nail has different parts as shown in figure-1. The different parts of finger nails are nail plate (free edge, nail body, cuticle), lunula, nail folds, nail root and nail matrix [5][8][9].

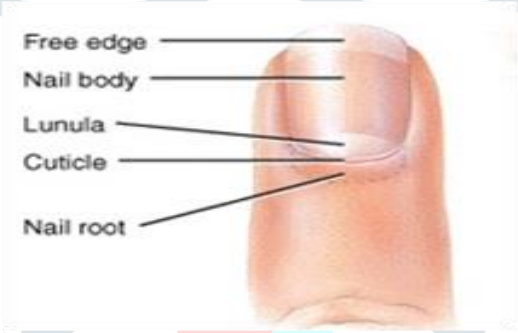


Figure 1: Different parts of Finger Nail [9]

Nail Plate: Nail plate is the observable part of the nail which is smooth, curved and light pink color. Free edge, nail body and cuticle are sub-parts of the nail plate.

Free edge: Free edge of nail is at end of the nail plate of the finger which function is to protect fingertip and the hyponychium [15]. Hyponychium is the thickened portion [8].

Cuticle: It is the flat of thin tissue available over the base of the nail plate.

Lunula: It is a visible part of the root of the nail which is crescent-moon contour seen at the plinth of the nail plate.

Nail folds: It is the thin skin line which holds the nail plate.

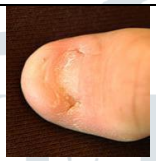
Nail root: It is the proximal end of the nail under a fold of skin [9].

Nail Matrix: nail growth occurs [5].

Diseases Based on Nail Features:

In Ayurveda, doctors observe the human nail to identify diseases which is the one of the indicator to conclude the disease. Basically we can classify diseases based on nail input as nail or skin diseases and other diseases. Following table-3 shows few of the nail type, nail image and related systematic illness:

Table 3: Nail Type based diseases

Nail Type	Nail Image	Systemic illness
White Nails / leukonychia (partial leukonychia) [4] [9]		iron deficiency (anemia), liver cirrhosis, kidney disease, heart failure, diabetes, psoriasis
Yellow Nails		thyroid disease, rheumatoid arthritis, certain forms of cancer
Bluish Nails		heart problems, emphysema [9]
Pale Nails		Anemia Congestive heart failure, Liver disease, Malnutrition [9]
Congenital Disorder [4]	 [4]	congenital ectodermal defect, severe exfoliative diseases, kidney issues, deficit hyperactivity disorder [4]
Traumatic Disorder [4]	 [4]	viral and microbial infections, Skin picking, skin biting [4]
Terry's Nails [16]		Hepatic failure, Cirrhosis, Diabetes, Mellitus, Congestive Heart failure and Hyperthyroidism [9]
Beau's Lines	 [9]	Pemphigus, Trauma, Raynaud's disease, Diabetes and Hypocalcaemia [4]

III. Literature Review

There are various systems proposed and implemented for diseases diagnosis using human nail image. In this, various features are extracted from human nail image and used for disease prediction. Here, we are discussing few systems implemented for disease diagnosis using human nail image.

Maniyan et. al proposed Nail Image Processing System (NIPS) for the prediction of various diseases and targeted 25 predicted disease classes. Three classifiers-SVM, Multi-class SVM and KNN used for disease prediction in which thirteen features of the human nail is used. These 13 features include nail color features, nail shape features and nail texture features. There is a system proposed by Tolentino et. al which target on detection of circulatory diseases by analyzing human fingernails. This system working includes image segmentation, color threshold, and shape analysis. Artificial Neural Network (ANN) is used here to classify the fingernail database to match the input data with the targeted circulatory disease such as Coronary Occlusion, Congestive Heart Failure, and Congenital Heart Disease. RGB color model is used. This system classifies the circulatory disease based on the values acquired from image segmentation, color threshold, and shape analysis.

Saranya et. al proposed a system in which nail image is segmented using Watershed, Thresholding and K-means segmentation Techniques to extract the infected nail regions. The shape features (area, perimeter, and diameter) of segmented nail region are extracted, calculated and analyzed for further diagnosis of nail diseases.

Indi et. al proposed disease diagnosis using nail image processing in which nail color RGB value used as feature for disease prediction where j48 classifier to classify and train the data. Here the limitation of the system is that it is using only one feature, nail color for disease prediction.

Gandhat et. al designed Disease Detection System uses DIP and analyzing techniques to identify nail colors where various similarity measures used to find similarity between two images.

Sharma et. al presented a system for disease detection by analyzing nail color and texture features. In this system, nail region is extracted by applying image segmentation. Then nail color RGB values and texture extracted and compared with the pre-defined value using knowledge base. Mannino et. al implemented a smartphone app which replaces common blood-based laboratory tests for detection of non-invasive anemia. This smartphone app estimates hemoglobin levels by analyzing color and metadata of fingernail bed photos and detects anemia.

IV. COMPARATIVE ANALYSIS

Pathology Laboratory tests are available to diagnose various diseases which will help doctor for further investigation. These tests are costly, time consuming and for these test presence of patient is required [11]. Nail image is used for disease diagnosis in which nail image is analyzed. There is limitation of human eye to recognize nail color and other features from nail but computer can identify more colors and able to detect every pixel precisely from nail image [11]. Since, we are using computer based analysis of human nail image for disease diagnosis.

There are various systems proposed by people for disease diagnosis using nail image. In the following table we are comparing various methodology implemented for different disease diagnosis using nail image features. In these systems, nail features considered are nail color, nail shape and nail texture, the details of nail features given in figure-3.

Table 4: Comparative Analysis of Nail Image Processing System for Disease Detection

System#	Target Diseases	Features	Methodology	Dataset	Results	Performance Evaluation Measures
System-1	24 diseases	Nail Color Nail Shape Texture (13 features)	SVM, Multiclass SVM, KNN classifier	Total 360 diseased images 5 images/ person Training 240 images Test Set 120 images	Models with two classifier combinations and all the three features produce the better results. Texture feature give better results than other features.	Performance Measures are - Accuracy, - Sensitivity and - Specificity using Confusion Matrix
System-2	Coronary Occlusion, Congestive Heart Failure, Congenital Heart Disease	Nail Color Nail Shape	Artificial Neural Network (ANN) for classification	Coronary Occlusion: 35 fingernail images from 4 patients CHF: 74 fingernail images from 10 patients CHD: 49 fingernail images from 6 patients	Artificial Neural Network classifier is successfully able to detect three Circulatory Diseases	Mean Squared Error (MSE), Gradient, Overall Regression Coefficient, and Best Validation Performance
System-3	24 diseases	Nail Color Nail Shape Texture	KNN Classification	483 image samples of palm of 40 persons, 5 images per person, 15 samples each of 24 diseases and 123 samples of healthy persons	Performance analysis is average 87.75% specificity, 99.51% sensitivity and 93.63% accuracy.	Performance Measures are - Accuracy, - Sensitivity and - Specificity
System-4	11 diseases (Nail diseases)	Shape and texture - Feature Vectors	Deep learning framework uses an ensemble of Convolutional Neural Nets	Dataset of 4190 images, 300 to 400 images belonging to different disease classes	Achieved accuracy of 80.45%.	Accuracy and kappa coefficients are computed along with ROC curves
System-5	heart disease, diabetic disease, Liver disease, anemia disease	Nail Color	j48 classifier	100 nail image samples of 20 persons, 5 images per person, 20 samples of each disease 20 samples of healthy person's nail image	Average matched 65%	Genuine Acceptance Rate (GAR), False Acceptance Rate (FAR) and Average Match

IV. DATASETS AND PERFORMANCE MEASURES

In system-1 & 3, total 360 diseased images and 123 images of healthy persons of 40 persons collected in which 5 images/ person has been captured. Out 483 images 240 used as Training set images and 120 as Test Set images. In system-2, total 158 fingernail images collected in which Congestive Heart Failure 10 patients - 74 nail images, Congenital Heart Disease 6 patients - 49 fingernail images and Coronary Occlusion 4 patients - 35 fingernail images were collected. In system-4, Dataset of 4190 images, 300 to 400 images belonging to different disease classes. In system-5, 100 nail image samples of 20 persons, 5 images per person, 20 samples of each disease 20 samples of healthy person's nail image.

In system-1 & 3 performance measures used are accuracy, sensitivity and specificity using Confusion Matrix. System-2 uses Mean Squared Error (MSE), Gradient, Overall Regression Coefficient, and Best Validation Performance as performance

evaluation measures. In system-4, accuracy and kappa coefficients are computed along with ROC curves where as in system-5 Genuine Acceptance Rate (GAR), False Acceptance Rate (FAR) and Average Match performance measures used.

V. CONCLUSION

Various diseases can be diagnosed using non-invasive approach, nail image analysis. The different nail features, nail color, nail shape & nail texture used to analyze nail image. The nail features are extracted and measured by deriving these features in certain values such as nail color extracted in terms of mean of color channels and pixels' RGB color value etc.; nail shape extracted in terms of area of nail shape, perimeter of nail shape etc. and nail texture extracted in terms of entropy, energy, compactness etc. The cutting edge classification technologies used in the nail image processing systems are deep neural network, artificial neural network classifier and SVM classifier. There are many other parts of nail which can be used for disease diagnosis.

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