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Survey On Detection Of Disease Using Tongue Diagnosis System

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***Abstract*—In recent years, the diseases are dominant more and more as per the diagnosing techniques are newly introduced. Various methods are used to cure a disease but the efficient and easy interpretation for diagnosing the disease is less in use. Considering the human tongue which acts as a gateway for the digestion tract and internal organs, can be treated as a diagnosing agent for a resourceful analyse of some diseases. The tongue diagnosis system acts as an effective non-intrusion method for detection of disease. This structure mainly focuses on key factors of tongue and evolution of various algorithms to produce an optimized result over the data. The main aim of this article is to provide an easy analysis of some of the features of the tongue like the colour of the tongue, shape of the tongue, colour correction over various light estimation, edge detection, water content in tongue, segmentation of tongue and coating of tongue based on fissure and fur deposits. All these components are taken into consideration by many scholars and the various data mining based algorithms are used to predict the symptoms of the disease. The regions of the tongue work as a route map for the internal organs like liver and gall bladder, the digestive system inside stomach, kidney, heart, etc. thus the analogy of all the major diseases can be predicted by the use of tongue diagnosis system.**

***Index Terms*—Tongue Diagnosis, colour correction, segmentation, image acquisition, contour shape, classification.**

I. INTRODUCTION

The most vital organ that articulates speech and helps in determining the taste of food is the tongue. It consists of many muscles that help in swallowing and digestion of food. Taste buds occupy the upper portion of the tongue that builds a primary organ of taste. Multiple lingual papillae [1] also surround the upper bound of the tongue. The tongue must be moist and sensitive so that it controls the nerves and blood vessels. Saliva is the source of tongue moisturizing. The tongue helps in cleaning the teeth. Thus tongue which serves as the mirror in visualizing the digestive tract helps in diagnosing the human condition by the outlook determined. It also reflects the complete metabolic and nutritive survey over the body.

A healthy tongue is free form pain and it is generally moisture in nature and evenly coloured as pink over pale red. On the early day's Greek physician Hippocrates and Galen [2] found that tongue is a basic and vital indicator of diseased and healthy being. The tongue diagnosis system plays an important factor in both Ayurveda and Siddha medicines. The tongue of the person is treated as a map to locate the performance of the digestive system in the human body.

II. ZONES OF TONGUE

The tongue is segmented into five regions or zones. The tip of the tongue corresponds to the heart and lungs. The left and right part of the tongue carries the functioning of the liver and gall bladder of both left and right respectively. The innermost tongue helps in the prediction of diseases over kidneys and urinary bladder. The central part of the tongue helps in the determination of the stomach and spleen where the upper region of the central part takes care of large and small intestine. The Chinese medicine map of the tongue is demonstrated in Fig.1. It signals the digestive system of the body when it acquires a particular taste to make sure the digestive system or liver that secretes particular bile juice to dissolve the food. It acts as an alert message to the digestive tract that particular food ison its way to get digested. Hence tongue is the external projection of one's interior or internal organs.

Reflex zones play a major role in the diagnosis of the tongue since it provides basic information about which organ gets internally affected through its exterior visualization of tongue zone.

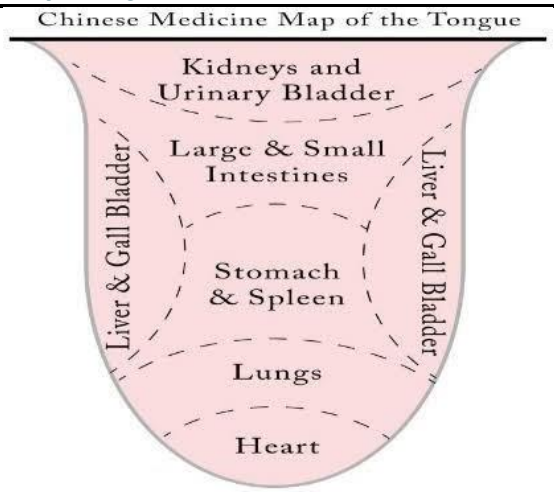

Fig.1 Chinese medicine map of the tongue.

It can be verified over two ways: if there is an abnormality in tongue coat then it ensures there to present trouble over digestive enzymes. If there is a discoloration of tongue body then it corresponds to nutritive defect over the internal organ of the human body. Tongue diagnosis can be made easy over conscious patients but on the unconscious and the non-cooperative patient is more difficult. The abnormal tongue provides a hint over the therapeutic or diagnosis of internal organs.

III. EXAMINING THE TONGUE

Examining the tongue includes a complete history of a person over alcohol and tobacco usage. Keen assessment over lymph-adenopathy [8] is a major importance. The examining process includes two ways: an examination of the tongue body and examination of the tongue coat (moss). The former method gains information about nutritive content and structural form over internal organs. It also ensures the blood and bloodstreams which carry essential needs for the internal organs. The latter method finds out any imbalance over the digestive tract. It also keeps track of metabolisms and the presence of any toxins or metabolic wastes if any. Some of the important constituents over tongue examination are tongue texture, shape, colour, moisture, size, coating and nature of papillae [9][10].

A. Tongue body texture

The tongue body's general structure may be smooth or rough, flat or rumpled. A dry tongue indicates the internal organisms are dry in condition. A rumpled tongue indicates ineffective digestion by the digestive systems. Its appearance will be like thick and greasy coated that representing the existence of toxins due to deficient digestive enzymes. A rough tongue indicates the deficiency of moisture over organs. A raw tongue implicates dark red and it acts as a sign of heat deficiency and depletion of important fluids in our body. A cracked tongue is a significant portrayal of stress and tension where the crack occurs in the middle of the tongue which represents the spinal column. The body texture of the tongue holds a major role in the tongue diagnosis system. The body of the tongue is the main source of detection of various colour factors. The texture of the tongue is the basic validation of the tongue diagnosing system. Thus the tongue texture should be checked up mainly.

B. Size

A healthy tongue appears ample and full-bodied but neither too obese and nor too skinny. The enlargement of the tongue indicates the greatness of disease and contrariwise the thin structure of tongue implies the deficiency or depletion of nourishment over organs.

C. *Colour*

The normal healthy tongue looks like sanguine pink which is a balanced proportion of red and white. The overall colour of the tongue portrays the balance of blood and bloodstream with the proportion of nutrients in our body. Any deviation from this colour proportion will lead to severe imbalance over health conditions. The tongue with white and pale colour indicates coldness whereas red colour indicates the excess of heat in the human body. The purple colour of tongue indicates the blood immobility or any deficiency in the vital force. Yellow indicates jaundice and brown indicates an excess of black bile.

D. Wetness

It determines the state of hydration of the human body. Depletion in water level increases the thirst and results in nausea and vomiting of a person. Tongue dryness is examined in diarrhoea and heat exhaustion.

E. The tongue Coat

The present state of the patient's metabolism and digestion can be determined using tongue coating or moss. It also extracts any settlement of toxins in the digestive tract. A healthy tongue doesn't build up any coat over it. The coating of tongue differs in four different ways namely, colour, thickness or heaviness, size and moisture.

F. Nature of papillae

The tongue which is black hairy is a harmless and momentary condition that gives the tongue a dark appearance. It is formed based on numerous tiny projections of dead cells (papillae) on the tongue surface.

It doesn't cause any problem over organs and it is painless. It was stain by any tobacco or any food materials that settle down over tongue surface that act as a factor of tongue diagnosis.

G. Movements

The tongue that deviates indicates paralysis or palsy over the face. It gets deviated in the paralyzedside which proves as a symptom of stroke.

H. Tongue Ulcers

The appearance of the tongue looks like sore or cut over its surface which becomes painful and irritatedduring drinking and eating. The most common type of tongue ulcer is canker sore [11], which irritates even for an unknown reason. Infection over viral diseases, oral cancer and tongue injury are different scenario for arise of tongue ulcer**.** Even the ulcers vary on the directions of its appearance over tongue surface. Example: syphilitic ulcer which is the longitudinal direction in nature.

IV. LITERATURE REVIEW

Some of the previous articles over tongue diagnosis include various methods of analysing a tongue. Tongue can be analysed based on its characteristics that differ for each of the person. Thus examining the features of tongue is very much challenging in real time process.

The previously calculated methods and algorithms carry a little advantage as well as disadvantage on comparing to one another. The below table Table.I., describes the factors included for tongue diagnosis and the researches over those characteristics of tongue with the result depicted, which can be improved for the future use of advanced diagnosis system.

TABLE. I LIST OF PREVIOUS METHODS USED FOR PROCESSING TONGUE FEATURE

S.No.	Feature of the tongue	Algorithm / Material used	Result	Accuracy	Reference
1.	Colour Correction	Digital camera with CCD	Results in a beginner level of colour correction	70%	[4]
		Hyperspectral imaging	Improved result over RGB	77%	[22]
		Hyperspectral imaging with sublingual vein extraction algorithm	More prominent result	>86.74%	[28]
		Pixel Based Sublingual Vein Segmentation	Works well even in the presence of noise	85%	[24]
		Spectral Angle Mapper (SAM) algorithm	Good performance even in noise	88%	[24]
2.	Feature Extraction	K- means clustering	Not reliable over unhealthy patients	79%	[25]
3.	Segmentation and edge detection	Agglomerative clustering algorithm with J-measure	Multiple scale segmentation	77%	[31]
4.	Contour Shape	Dual snake model	Not feasible over initial contours	92.89%	[32]
		Geodesic flow	Shape and location of tongue is determined	98%	[33]

V. MATERIALS AND METHODS

The tongue diagnosis system is mainly based on diagnosing the tongue with the help of tongue colour, segments in the tongue and contour shape. The first and foremost process is image segmentation and colour correction of the tongue. The various methods of colour correction include different algorithms that expose natural light emission over the tongue with some of the advantages and disadvantages.

A. Colour Correction

The beginner level of colour correction is done by a digital camera with the help of a charge-coupled device (CCD) [4][12][15][17] as an image sensing module. The procedure for tongue diagnosis system is represented in Fig.2. After the process of colour correction, the image segmentation [13][14][16][18 - 21] is done based on 2 Dimensional or 3 Dimensional image processing. Colour correction is the essential term over tongue diagnosis because the tongue appears to be varying based on the different light source. The inclusion of colour checker for Spectral Angle Mapper algorithm as mentioned in literature review is represented in Fig.3.

The hardware-based implementation of colour correction is done by image acquisition device by Zhang et al [14] and colour checker by McCamy[25] . Jang et al [20] and Zhang et al [14] made use of Halogen Tungsten Lamp as a device to identify the colour of the tongue. Both used colour with low temperatures. As another method of examining the tongue, Hu et al [26] diagnosed the tongue based on different light conditions namely halogen, fluorescent, incandescent. They made the system to be independent of the lightning environment with the help of Support Vector Machine (SVM). This reports the accuracy of the colour of the tongue at the level of 94% with colours like red, deep red and light red. The process includes k-means, unsupervised machine learning on the first stage with the background separation. Later it was analyzed by SVM within the time stamp of 48 seconds. This improves the classification of colours by 41.2%. Hence this method proves the higher accuracy than other analyzing algorithms.

B. Feature Extraction

Multiple algorithms are used in feature extraction of the tongue. Various colour representations are used in MATLAB like HSI (Hue, Saturation, and Intensity) and HSV (Hue, Saturation Value or brightness) in which HSI is relevant to the normal vision of human. Some researchers have found LAB, where L stands for Lightness of colour and “a” and “b”, stands for the dimension of colour opponents.

C. Segmentation and Edge Detection

The process of segmentation is demonstrated in Fig.4.The implementation of J measure based segmentation was done by Deng and Manjunath which was visualized with an input image of tongue occurring multiple-scale segmentation. Thus the shape of the tongue helps in edge detection and determining the contour shape over Automated Tongue Diagnosis system (ATD) [3-7].

Some of the filters like Prewitt, Laplacian filters and sobel are general edge detectors used in image processing. To differentiate between face and mouth separate canny filters are used and based on feature extraction, different diseases are diagnosed. Another algorithm like Principal Component Analysis (PCA) based tongue detection algorithm is used to provoke an edge detection of input tongue but it is incompetent over small data sets. Thus Yan et al proposed a model for segmentation based on sublingual image acquisition with the help of infrared light. So the proposed model consists of radial projection over the watershed algorithm which produces an output of tongue segmentation for accuracy of 82.0% in analyzing 105 subjects.

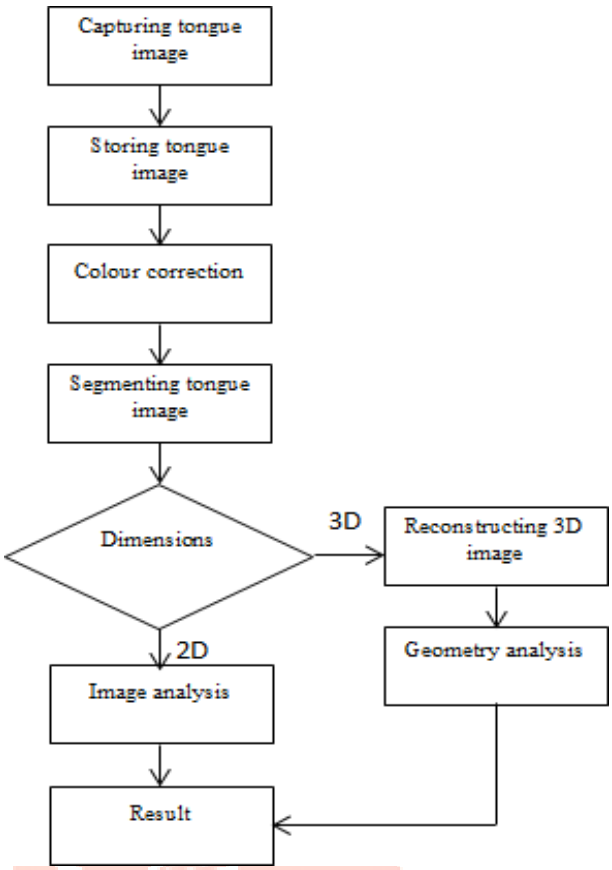

Fig.2.Procedure for tongue diagnosis system

D. Shape of Contour

Shi et al [33] made a database of colours of the tongue and applied geodesic flow twice so that the tongue shape and location is determined. This produces a result of 98% accuracy over other works. The placement of the tongue is demonstrated in Fig.5.

Zhang et al used a decision tree to predict the shape of the tongue with five different types of study with the help of 130 healthy and 542 diseased people. It includes 13 geometric features of the tongue and provides a promising result over tongue diagnosis. It also makes a better option over other analysis techniques. It overcomes the defect over other analyze methods.

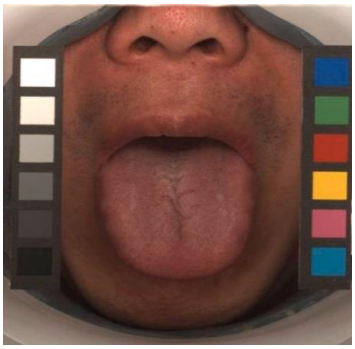

Fig.3 Tongue image in colour checker

Fig.4. J-measure segmentation process

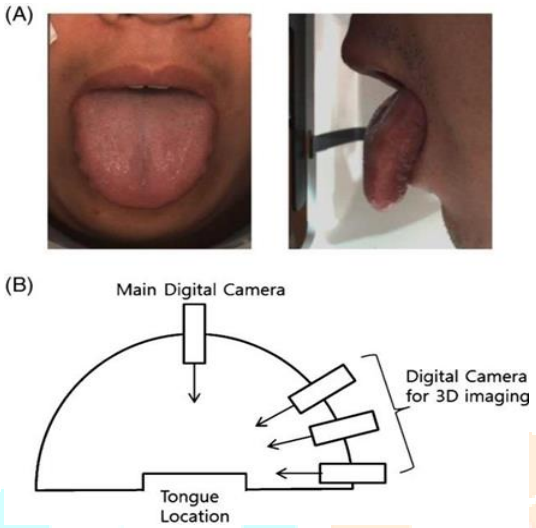

Fig.5 A) 3D image construction B) Tongue location

VI. DISCUSSION

The various diseases can be classified based on multiple algorithms used on features of the tongue like colour, shape and fissure of the tongue. Xu et al [35] examined various symptoms by the classification technique. Zhang et al [4] verified the Bayesian network classifier- based system to find symptoms of pulmonary heart disease, gastritis, bronchitis, appendicitis, pancreatitis, and with 75% accuracy. It results in a quantitative analysis with the help of Support Vector Regression for colour correction and Bayesian classifier for measuring. They considered 540+ patients and 56 healthy persons to build a model which results in highest accuracy on healthy people but this algorithm doesn't work on diseases like abdominal tuberculosis. Abe et al [36] determined a model to find the presence of oral bacteria in saliva and coating of the tongue. It finds the indication of pneumonia as well. In this research, he used tongue data of elderly persons above the age of 60+, where the tongue coating is taken into account for detection of pneumonia. Han et al [37] found the presence of colorectal cancer diagnosis based on tongue analysis where cancer affected patients have abundance lack in tongues of bacterial microorganisms such as Neisseria, Porphyromonas, Haemophilus and Fusobacterium.He also states that the colour of tongue for the cancer patients turn purple while the healthy ones remains reddish. He considered the presence of microbial particle in the thickness coating of a tongue. Zhang et al [15] help in diagnosing different diseases like kidney diagnose, hypertension, circulation insufficiency, upper respiratory tract infection, verrucous, coronary heart disease, bronchitis and other chronic diseases based on k- NN and another algorithm like SVM to find whether the person is healthy or not. It brings out the accuracy of 91.99%. SVM works well over k-NN algorithm but in case of disease like hypertension and diabetes, both the algorithms results very poor.Statistical analysis was used by Kim et al [38] to prove redness in tongue and low coating in tongue for the Yin deficient persons. It also predicts the comparison between ischemic strokes based on retroflex tongue for more than 300 patients. More in advance, some secondary outcomes has been predicted to track the functional dyspepsia.

An advanced tool called Diagnosis Decision Support System (DDSS) has been developed to diagnose the disease in the early stage by collecting information from the patients through images of medical records, questionnaires and by capturing the real time image of the patient for their illness. It predicts the disease based on the input given by the patients and it displays the risk factor of the disease and a proper diagnosis for the disease to be cured [39-40]. Zhang and Zhang [41] used a sample of 600+ images of healthy tongue and diseased tongue to classify five different tongue shapes using decision tree. Based on 13 features of tongue like colour, fissure and fur, they classified diseases like heart disease, gastritis and diabetes with the help of SVM classifier. It shows the result of 76.42% of accuracy over k-NN. Zhang et al [42] used 800+ images of tongue to equalize and normalize those tongue features and examined the diabetes with an accuracy of 78.77% by providing 23 input parameters like colour, texture, etc. into SVM classifier. It brings out the valid result on diabetes detection using tongue diagnosis.Han et al [37] proposed a model for cancer prediction based on tongue diagnosing and the characteristics of subject analyzed. Thus the result of tongue colour for cancer patients is determined by Han et al with the help of Bayes probability formula. Hence the colour of tongue for cancer patients is represented in Fig.6. The overall process of tongue diagnosis system is demonstrated in Fig.7.

An advanced technique of using Deep Convolutional Neural Network [43] was carried out to extract the features of tongue over 315 images and the weighted liblinear SVM model was trained to differentiate between healthy and sick persons, that rapidly works faster than CNN and it was claimed to be implemented in real time, which benefits by producing an accuracy of 91.14%. The main risk factor on building a classification model depends upon the task of extracting features of the tongue. Some other researches [44] is based on detection of Breast Cancer with the help of tongue diagnosis by using tongue features like tongue colour, shape of the tongue, fur, saliva , teeth marks over the tongue, fissure and quality of the tongue. It works better on detection of early stage of the disease to provide an immediate treatment to cure. Tongue data of 60 patients and healthy ones are taken into account for training the model and 10 images are taken for testing which renders accuracy of 80 to 90%.

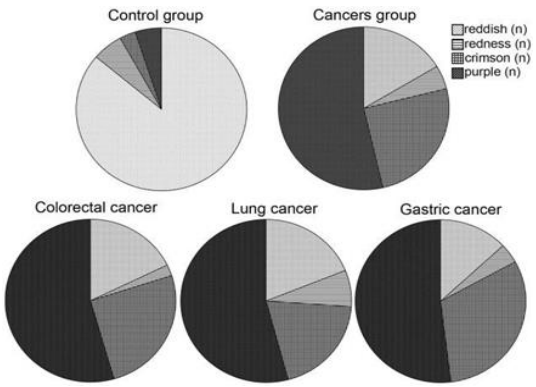

Fig.6 Appearance of tongue colour for cancer patients

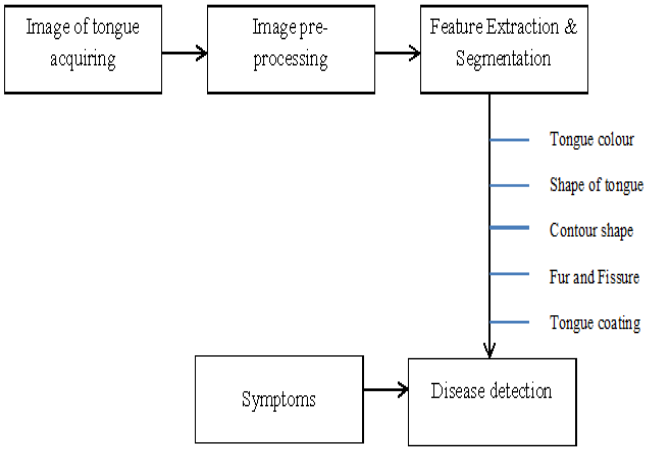

Fig.7. Process of tongue diagnosis

TABLE. II VARIOUS DISEASE PREDICTION BASED ON DIFFERENT ALGORITHMS

Algorithm Used	*Feature of tongue taken into account*	*Disease Predicted*	*Accuracy*	*Ref. No.*
Classification	colour	Viral hepatitis	75%	[35]
Statistical analyse	tongue coating	Ischemic stroke	83.3%	[32]
Bayesian network	chromatic and textural measuring	pulmonary heart disease	75%	[15]
Tongue plaque index	tongue coating	pneumonia	71%	[36]
Image acquisition	tongue coating	colorectal cancer	90%	[37]
KNN & SVM	tongue colour gamut	verrucus, hypertension	91.99%	[16]
CNN	colour and coating	gastrtitis	91.14%	[19]

VII. CONCLUSION AND FUTURESCOPE

The tongue diagnosis system was developed by many scholars following various components into consideration like image segmentation, healthy and unhealthy tongue classification and tongue colour correction. This work mainly enhances the technique of diagnosing the disease on the basic level. Thus various diseases that are known by the symptom of tongue diagnosis are listed out in Table.II

The literature work is obtained thus it needs to be invoked as a work of automated tongue diagnosis in the future handheld devices like mobile phones. This brings out an enhanced and easy way of tongue diagnosis in which anyone can diagnose themselves carrying an application in a portable device like mobile phones.

The future model builds up an easy access to the diagnosing system. So people from any location can find an easy approach of diagnose the disease with the help of mobile application. This work portrays the major use of algorithms on tongue diagnosis which produces accurate result over symptoms of several diseases. Thus this also proceeds with other diagnosing factors (rather than colour, tongue shape, features like fissure or fur, light estimation, watershed terminology and contour shape with edge detection) to be surveyed for the betterment of algorithm analysis and better optimization of the result.

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