Tongue Image Analysis for Prediction of Health Quality

[1]Sonali J. Mane, [2]Aishwarya Sawant, [3]Ashish Limje

[1]Assistant Professor, [2]Student, [3]Student
[1]Department of Information Technology,
[1]Bharati Vidyapeeth College of Engineering, Navi Mumbai, India.

Abstract: Using Tongue diagnosis, different diseases that a person carry can be identified. It is one of the methods that is used in Traditional Chinese Medicine (TCM) to diagnose diseases. In addition, being used as a traditional tongue diagnosis method, the model derived by using certain techniques can be used for different purposes such as early disease detection. Therefore, we believe that using the collection of the dataset of different people having diseases as well as persons who are healthy can be very beneficial for analyzing whether a person is healthy or unhealthy. Using methods such as capturing images, extracting features from it can be used to prepare a fulfilled model which will be able to function as we want. A smartphone-based image acquisition device can be proved to be user friendly in terms of simplicity and ease of using the application. Tongue image diagnostic model can identify whether a person is healthy, unhealthy or diabetic based on feature extraction such as texture and color of tongue. The results shows that the system can properly identify three groups of categories such as healthy, unhealthy and diabetic. In this paper we proposed a model based on Convolutional Neural Network and also performed a comparison between Support Vector Machine (SVM) algorithm and Convolutional Neural Network.

Index Terms **- Tongue Diagnosis, Machine learning, SVM, Convolutional neural network.**

I. INTRODUCTION

TCM believes that our tongue has many relationships with different human body parts, and the internal organs. Thus, it is very important aspect to determine a person's health condition by using tongue as a medium [8]. In Traditional Chinese method, our tongue is divided into sections related to a particular body organ. If anything is wrong with that particular body organ, tongue is affected by it, that is why doctors believes in diagnosis of tongue while inspecting an illness. According to TCM, tongue tip is related to heart and lungs while the root of tongue is associated with kidney and intestines, left and right sides of the tongue is related to liver and gallbladder of the body and the middle part of the tongue is related to the stomach area. Dermatoglyphics as a diagnostic aid used from ancient eras and now it is well established in number of diseases which have strong hereditary basis and is employed as a method for screening for abnormal anomalies [9]. The goal of this is to examine how this particular method works for this particular problem given a manually labelled dataset and to support the idea of using Machine learning

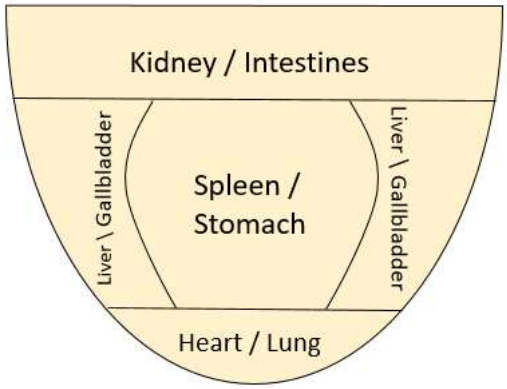

Figure 1: Organs Associated with Tongue

II. LITERATURE SURVEY

G. Uma Devi et. al. [1] examined the tongue shape and its relation to the human being's health condition by using geometry features of tongue. They captured a tongue image with a specially designed iPhone device. From the captured image, features are extracted and are further provided to the appropriate SVM classifier. SVM classifier compares it with the trained data and produces the output as normal or abnormal. Square shaped tongue images are an indication of viral infections. They used GV and NS classifiers for square images and achieved an accuracy of 84.07%. Circle shaped tongue images are an indication of diabetes and heart disease. They used DM and EG classifiers for circle images and achieved an accuracy of 88.65%. Triangle shaped tongue images are an indication of blood related diseases. They used NR and CG classifiers for triangle images and achieved an accuracy of 75.00%.

Tina Lidia et. al. [2] proposed a user-friendly way of detecting whether the person is suffering from diabetes or not by analyzing the tongue images. Firstly, the tongue images were captured and then the images are analyzed based on color, texture, and geometric feature. Then the tongue images that are captured are image wrapped and a tongue color spectrum is established with 12 colors (cyan, red, blue, purple, deep red, light red, light purple, light blue, black, gray, white, yellow) which could be

present on tongue. At last, the geometric details are calculated based on 13 geometric features (width, length, length width ratio, smaller half distance, center distance, center distance ratio, area, circle area, circle area ratio, square area, square area ratio, triangle area, triangle area ratio) that are extracted from tongue images based on distance, measurement, area, and their ratio. Decision tree is used for classification of tongue shapes (rectangle, acute triangle, obtuse triangle, square, circle) using 13 geometrical features.

H. Z. Zhang et. al. [3] presented a novel computer-aided tongue diagnosis system. In this system, they used a standard acquisition device to capture the image and a novel color correction model based on Support Vector Regression to correct the color distortions as the colors of the image may vary under different lighting conditions. The complete system comprises five components: User interface module, Acquisition module, Tongue image database, Image processing module and Diagnosis engine. For Diagnosis engine they used Bayesian network classifiers. The test was carried out on a dataset of 544 patients having 9 diseases (Leukemia, Pulmonary Heart disease, Abdominal Tuberculosis, Appendicitis, Nephritis, Gastro duodenal perforation, Gastritis, Pancreatitis, Bronchitis) and 56 healthy peoples. The system was able to identify six groups: Healthy, Pulmonary Heart disease, Appendicitis, Gastritis, Pancreatitis, and Bronchitis with accuracy over 75%. And also, the execution time is 5 seconds for the complete diagnosis process (Image preprocessing + diagnosis).

Zhong Gao et. al. [4] presented a computerized tongue inspection method based on SVM. Two kinds of quantitative features were extracted from the images of tongues that are color feature and texture feature using Gray Level Co-occurrence Matrices (GLCM). Then, Support Vector Machine and Bayesian Network are employed to build the mapping relationship between chromatic features, textural features and diseases. The experiment was carried out on a total of 768 volunteers, which includes 665 patients affected by 6 common diseases and 103 healthy volunteers. They achieved an accuracy of 86.6% of the Multi-class SVM classification and 75.5% accuracy of Joint Bayesian Network classifier. So, they concluded that the SVM can be used to classify tongue images more accurately than Bayesian Network.

Jie Ding et. al. [5] presented a simple approach for classification of tongue images based on Doublet SVM. Their method comprises three major steps: (1) extraction of HOG features based on local object appearance and shape, which will be the input of the combined classifier in the preprocessing of the tongue image; (2) the most similar tongue images are found that belongs to the same label and different label which are then used to build a new sample for Doublet; (3) calculation of distance metric M by the SVM classifier and doublets. The experiment was carried out on a total of 326 samples (78 positive samples and 278 negative samples). They achieved the prediction accuracy of 89.1% (Random Forest), sensitivity of 95.8% (SVM) and specificity of 61.3% (Random Forest).

III. METHODOLOGY

This paper explains the system developed in parts. The first part is image processing part wherein different images are pre-processed and features are extracted. Second part is training the model to predict an output, for it we used two different algorithms and based on the performance we choose to go with higher accuracy classifier for best results. The third part provides the output to the user either by taking live input through camera or by uploading image. We have used various libraries for implementing the project which includes Sci-kit Learn, OpenCV, TensorFlow, NumPy, SciPy, Matplotlib. Apart from it we have used Android studio for building mobile application and MySQL for saving the data of the user.

Figure 2: Tongue image sample of Healthy person (left) and Unhealthy person (right).

3.1 System Design

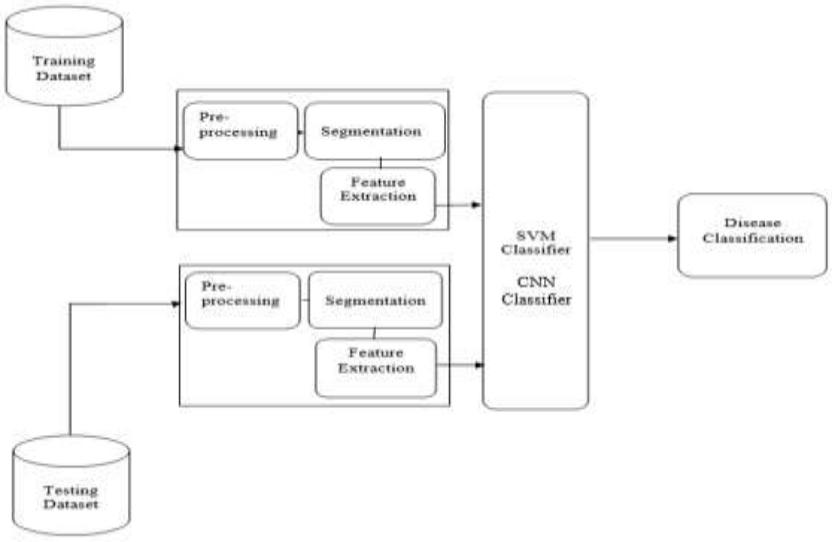

Figure 3: System Design

3.2 System Architecture

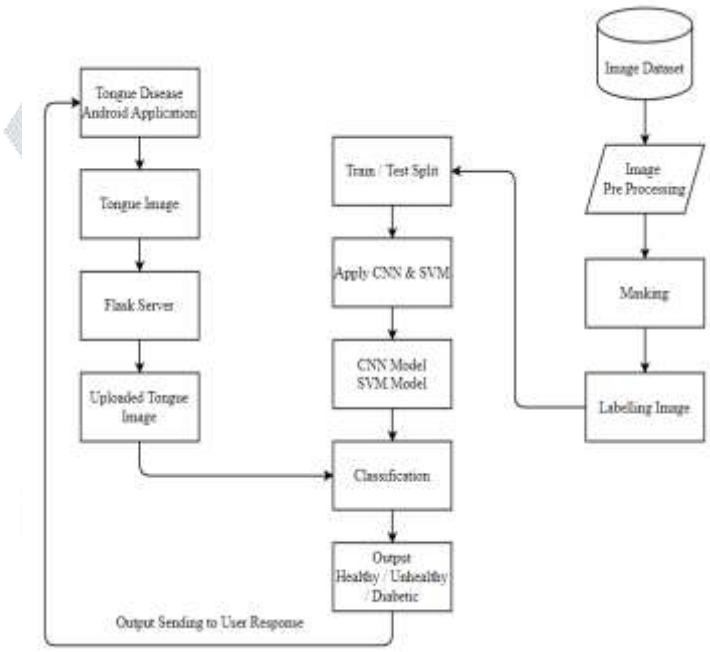

Figure 4: System Architecture

IV. IMPLEMENTATION

4.1 Image Processing Steps

A. Trimming of image:

Image is trimmed using the selection option and the part that is to be processed is extracted from the image. Trimming is carried out to remove unwanted object or irrelevant noise.

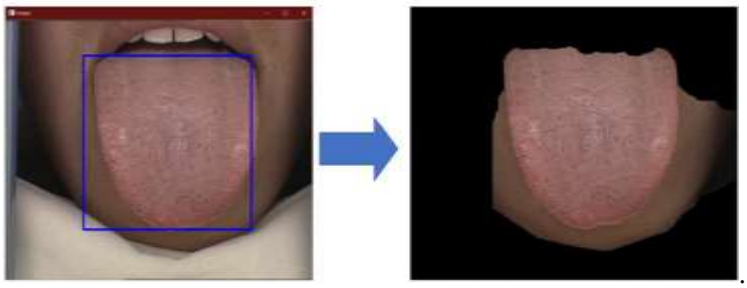

Figure 5: Trimmed Image

B. Color Masking

The trimmed image is passed into color masking step where image is masked based on the specific color of the image. The basic idea is given below: 1. Capture and store the background frame. 2. Detect the colored part of image using color detection algorithm

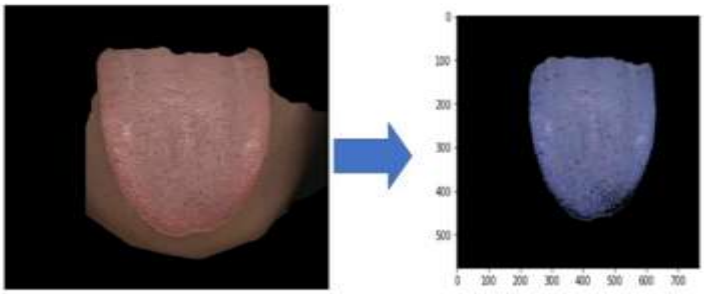

Figure 6: Color Masked Image

C. HSV Extraction

- Hue: Color information of image is depicted through it.
- Saturation: Intensity of image is depicted through it.
- Value: Brightness of image is depicted through it.

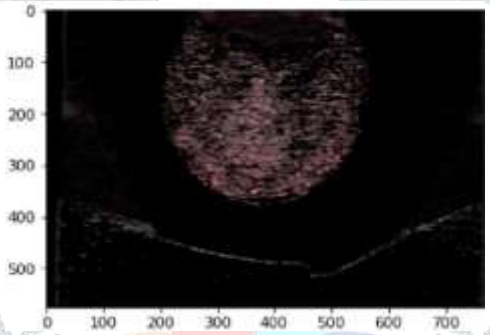

Figure 7: HSV Color Extraction

4.2 Algorithms Used

1. Support Vector Machine (SVM)

The objective of the support vector machine algorithm is to find a hyperplane in an N-dimensional space (N — the number of features) that distinctly classifies the data points. Support vectors are data points that are closer to the hyperplane and influence the position and orientation of the hyperplane. Deleting the support vectors will change the position of the hyperplane. These are the points that help us build our SVM [7].

2. Convolutional Neural Network (CNN)

A Convolutional Neural Network (CNN) is a Deep Learning algorithm which can take in an input image, assign importance to various objects in the image and be able to differentiate one from the other. The pre-processing required in a ConvNet is much lower as compared to other classification algorithms. While in primitive methods filters are hand-engineered, with enough training, ConvNets have the ability to learn these filters/characteristics [6].

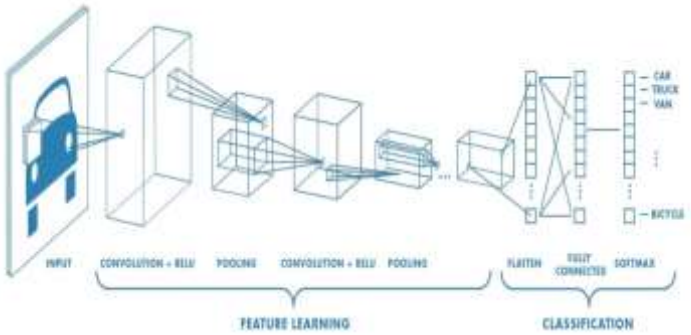

Figure 8: Fully Connected Convolutional Layers

4.3 Implementation Steps

We have performed classification using two classifiers namely convolutional neural network (CNN) and support vector machine (SVM) and out of two we have trained the final model using CNN rather than SVM based on their accuracy.

Step 1: In first step, we have extracted features from the dataset by performing image processing techniques for proper feature extraction. Extracted features are color and texture from tongue image.

Step 2: In next step, we used both the classifiers for predicting which person lies into which category i.e. healthy, unhealthy or diabetic.

Step 3: Once fitting the model, we compared the accuracy score and performance measures of both the classifiers.

Step 4: After fitting all the classifiers, best performing model was selected as candidate model for tongue disease detection system.

Step 5: We have performed ReLU **(**Rectified linear activation unit) and pooling operations in convolution to introduce non linearity in the model for faster computation and applied convo+Pooling that gives location invariant feature detection. Pooling also reduces dimension and computation. We have used Max pooling which makes model tolerant towards small distortions and variations.

Step 6: Our finally selected and best performing classifier is Convolutional Neural Network which is then saved on disk. It will be used to classify whether a person is healthy or diseased.

Working

Proposed system will be an android application programmed in java. It will accept tongue image as an input from the user. The image would be then sent to the classification model. Based upon the classifiers, output would be generated.

Input from the user can be taken using two different ways, they are as follows:

1) Using Camera for capturing image.

2) Uploading image from mobile gallery.

Using the input, system can successfully classify the image. After classification output is generated, this output is sent to tongue diagnosis android application where the output is displayed.

4.4 Snapshots of System Working

V. RESULTS AND DISCUSSION

A total of 297 subjects, including 124 patients, 101 healthy volunteers and 72 Diabetic patients, are used in the following experiments. The dataset is split in a 7:3 ratio where we use 70% of the data samples as a part of our training data and 30% samples as a part of our test set.

The features extracted from the tongue images are used to build two different classification models, Support Vector Classifier (SVC) and CNN.

For detection of Diabetic Person, we get the best results with SVM model, as seen in Figure 5.1, giving us an accuracy of 96% followed by CNN model which gives an accuracy of 78%.

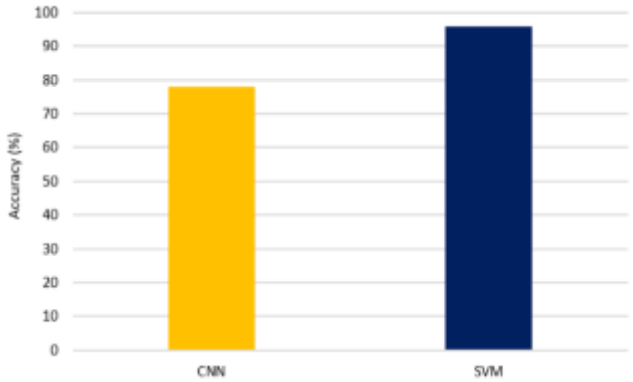

Figure 9: Comparison between CNN and SVM to determine accuracy for detection of Diabetic person.

For detection of Healthy Person, we get the best results with CNN model, as shown in Figure 5.2, giving us an accuracy of 100% followed by SVM model which gives an accuracy of 90%.

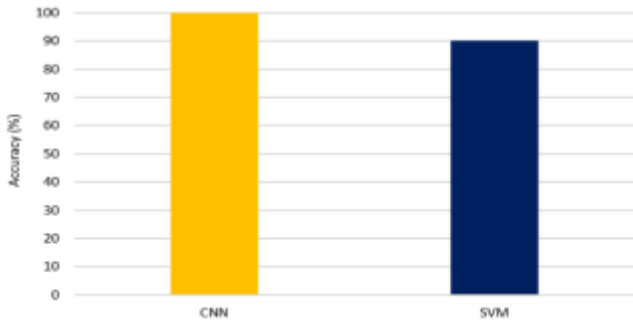

Figure 10: Comparison between CNN and SVM to determine accuracy for detection of Healthy Person.

For detection of Unhealthy Person, we get the best results with CNN model, as shown in Figure 5.3, giving us an accuracy of 93% followed by SVM model which gives an accuracy of 77%.

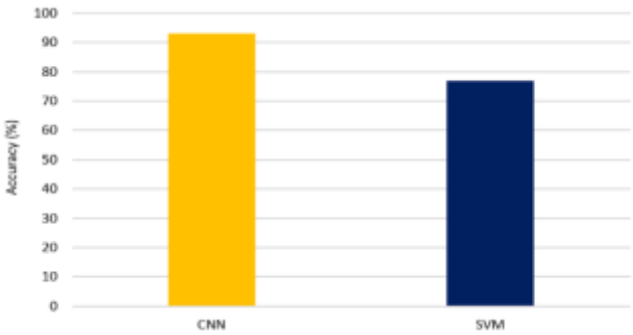

Figure 11: Comparison between CNN and SVM to determine accuracy for detection of Unhealthy Person.

Table 1: Comparison of Precision, Recall, F1-Score and Accuracy for both the classifiers.

Classifier	Precision	Recall	F1-Score	Accuracy
CNN	0.92	0.90	0.90	0.947
SVM	0.89	0.88	0.88	0.878

VI. CONCLUSION

Developed Tongue diagnosis system is a smart-phone based system which helps users to operate and handle it easily. Tongue diagnosis application will help to diagnose the health condition of the person using the classifiers that helps to predict the output. We implemented image processing techniques for extracting features from the image. We performed training on 70% of data and testing on 30% of data. Accuracy score of CNN is 94.7% and that of SVM is 87.78% from which we concluded that Convolutional Neural Network (CNN) helps to classify the images more accurately than Support Vector Machine (SVM) classifier. Lastly, we conclude that we successfully performed comparison between two machine learning algorithms.

REFERENCES

[1] G. Uma Devi, Research Scholar, Dr. E.A. Mary Anita, Professor, "An analysis of tongue shape to identify diseases by using supervised learning techniques" 978-1-5090-6135-8/17/$31.00 ©2017 IEEE

[2] Tina Lidia J, Hussain Ahmed, "Tongue Image Analysis for Medical Diagnosis".

[3] H. Z. Zhang, K.Q. Wang, Member, IEEE, D. Zhang, Senior Member, IEEE, B. Pang and B. Huang, "Computer Aided Tongue Diagnosis System".

[4] Zhong Gao1, Laiman Po3, Wu Jiang2, Xin Zhao1 and Hao Dong, "A Novel Computerized Method Based on Support Vector Machine for Tongue Diagnosis."

[5] Jie Ding1, Guitao Cao,1,2, Dan Meng 3 "Classification of Tongue Images Based on Doublet SVM."

[6] Sumit Shah, "A Comprehensive Guide to Convolutional Neural Networks — the ELI5 way" at towardsdatascience, Medium.

[7] Rohith Gandhi, "Support Vector Machine — Introduction to Machine Learning Algorithms" at towardsdatascience, Medium.

[8] Ratchadaporn Kanawong, Tayo Obafemi-Ajayi, Tao Ma, Dong Xu, Shao Li, and Ye Duan, "Automated Tongue Feature Extraction for ZHENG Classification in Traditional Chinese Medicine."

[9] Zhong Gao1, Laiman Po3, Wu Jiang2, Xin Zhao1 and Hao Dong, "A Novel Computerized Method Based on Support Vector Machine for Tongue Diagnosis."

[10] Zuoyong Li1, Zhaochai Yu1, Weixia Liu2, Zuchang Zhang1, "Tongue image segmentation via color decomposition and thresholding."

[11] Robert Parcus, Kin Long Chow, Hai Long Zhu, Qin Yu and Shi Ping Zhang, "Development of a Mobile Phone Based Tongue Image Acquisition System " School of Chinese Medicine Hong Kong Baptist University.

[12] Lun-chien Lo, Mark Chun-cheng Hou, Ying-ling Chen, 2,+John Y. Chiang, Cheng-chun Hsu, "Automatic Tongue Diagnosis System" Department of Traditional Chinese Medicine, Changhua Christian Hospital, Changhua, Taiwan

[13] Cristian José López Del Alamo, Lizeth Joseline Fuentes Pérez, Luciano Arnaldo Romero Calla, Wilber Roberto Ramos Lovón, "A novel approach for image feature extraction using HSV model color and filters wavelets"

[14] Naoya Ikeda1, Yoshitaka Fujiwara2 and Hideki Yoshida3,"Tongue diagnosis support system", Satellite Venture Business Laboratory, Kitami Institute of Technology, Japan

[15] Marzia Hoque Tania, K. T. Lwin, M. A. Hossain, "Computational Complexity of Image Processing Algorithms for an Intelligent Mobile Enabled Tongue Diagnosis Scheme", Anglia Ruskin IT Research Institute, Anglia Ruskin University Chelmsford, United Kingdom.

[16] Patil, V., Ingle, D.R. An association between fingerprint patterns with blood group and lifestyle based diseases: a review. Artif Intell Rev 54, 1803–1839 (2021). https://doi.org/10.1007/s10462-020-09891-w