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A Novel Hbnk based Metastasis and Acrometastasis Disease Prediction for Lung Cancer

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ABSTRACT

Lung cancer is a major cause of morbidity and mortality worldwide. Lung cancers may present with metastases in various locations of the body. The main metastasis areas of lung cancers are liver, adrenal glands, brain and skeletal system. This paper presents lung cancer detection using the symptoms occur in tongue and hand. Metastasis and Acrometastasis diseases were presented as the tumor in the tongue and hands of the human body. Acrometastasis to the hand is an unusual presentation which might mimic an infectious, inflammatory, or a metabolic pathology. Tongue metastasis is extremely rare as an initial manifestation of the disease. This work proposes Hybrid Bayesian nearest neighbor model classifier(HBNK) to predict the lung cancer using tongue and hand images. Tongue segmentation is performed using Morphological based random walker segmentation and the hand segmentation is performed using sobel edge detection method. To train the classifier ORB features, color diversity features and the chromatic features are extracted. The experimental results shows that the performance of the proposed method. Putting HBNK on IoT Thingspeak platform will help doctors to diagnose tongue and hand images that are received from computerized system online. The obtained results of proposed method are compared with KNN algorithm.

Keywords
Metastasis; Acrometastasis; HBNK;Tongue segmentation;IoT Thingspeak.

Introduction

Lung carcinoma is one of the leading cancer-related causes of death worldwide.[1] In Serbia, according to the data from the National Institute of Public Health "Dr. Milan Jovanović Batut," Belgrade, lung carcinoma dominates and accounts for 25.8% of deaths due to malignant tumors in men and 7.9% (after breast and colorectal cancers) in women.[2] Heavy smokers have even 20-fold higher risk of lung cancer due to benzopyrene from tobacco and accumulated numerous genetic mutations in reserve cells.

Metastatic proclamation is termed as a feature of high risky malignant process, which is leads to poor prediction of people who has affected by the disease, even this cause the patient's death. The molecular and cellular methods essential for the various proclivities of metastatic circulation are the concept of static debate and deep research efforts because of implication importance for prediction ability and identification of disease in advanced manner with efficiency. However diagnosis of cancer is most often made, if the multiple lesions have already spread from

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the site of primary tumor. The modulation of organ-seeking vesicles and pro-inflammatory cytokines reveals the evidence when the colonization is done by cancer cells which can remotely prepare distant sites for subsequent. In the other way, the analysis of phylogenetic application to cancer metastatic subclones could be more useful in dissecting evolutionary history of cancer lineages [3]. In the increasing demand metastatic growth from extra-thoracic malignancies are the 2nd most frequent site lungs with with pulmonary secondary lesions being predicted in 20–54% of cases.

Reported incidence of metastases from NSCLC to the tongue varies between 0.2% and 1.6%.Primary NSCLC spreads to distant organs by 3 routes: systemic, venous, or lymphatic circulation.[4] Lingual metastases occur mostly in patients whose primary lung cancers are generally disseminated; their prognoses tend to be rather poor . This patient's rare tongue metastasis likely occurred through lymphatic circulation rather than systemic or venous dissemination. As with primary tumors of the tongue, metastatic lesions to the tongue may be ulcerated or polypoid. Tongue metastasis can also cause pain, bleeding, discomfort, difficulty in swallowing, or dyspnea. Although rare, tongue metastasis should be considered under these circumstances, especially in cases with nonulcerated masses on the base of the tongue; appropriate investigation should be undertaken.

As in this case, hand acrometastasis is very rare in cancer patients and accounts for approximately 0.1% of all bone metastases . Hand metastasis was first described in 1906 in a case of breast cancer presenting with multiple metastases to metacarpal bones . However 47% of acral metastases occurring in the hand are caused by lung cancer . Hand metastases of lung cancer are mainly in male patients with smoking history. Therefore, it suggests that acral metastases may be related to smoking. Interestingly, acral metastases are two times more common in dominant hand, this may be due to more blood supply and susceptible to trauma of dominant hand [5]. Thus, it is logic that the trauma predisposes tissue more vulnerable so tumor cells can settle and grow in the skeletal system easily. Patients with acrometastasis have a worse prognosis, in one case report patient with acral metastasis has 6-months survival [6]. Although worse prognosis lead doctors to palliative treatment, the localization of the primary disease and extention of the disease should be major factor of treatment decisions.

Related work

Terashima T et.al [7] In the case of tongue cancers, tongue metastasizing are relatively rare which is lying between only 0.2 - 1.6% .If the primary tumor is already metastasized then the diagnosis will become poor. The most general cancers which metastasis to the tongue is breast, gastrointestinal tract ,lung, skin, and liver. To identify the cancer, the base of the tongue acts as a common site related to the anterior tongue. Rarely the tongue metastasis can be the initial presentation of an occult primary cancer.

Liu, S et.al [8] The lung nodule prediction system is developed using add adversarial synthetic nodules and adversarial attack samples. The training data utilizes theses two techniques to enhance the accuracy and robustness of the systems. To reduce the detector response projected gradient descent (PGD) is used to find out the latent code to produce the nodules which are bounded to the neighborhood. To create a most robust network PGD is be used

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and also it find out the pattern of noise which are act as network trigger to make a mistakes. This work is implemented two different benchmark datasets which is obtained from three radiologists. The results show that the proposed method increases the performance on real time CT data.

LIU CHENYANG et.al [9] proposes a joint lung nodule detection and classification model for simultaneous lung nodule detection. Segmentation and classification subject to possible label uncertainty in the training set. This method operates like end to end scheme which outputs the both classification and prediction nodules simultaneously with a predicted nodule segmentation. A 3-D encoder decoder architecture is utilized by both detection and classification sub networks of the proposed joint network for better exploration of the 3-D data. Moreover, the extracted features from the subnetwork and multiscale nodule-specific features are used by the classification subnetwork in order to improve the performance of the classifier.

Mohd Firdaus Abdullah et.al [10] presents the k-Nearest Neighbours method to categorize the stages of lung cancer using CT Scan Images. The main objective of this work is to execute the image processing techniques to extract the unique features from the lung CT images. To detect the cancer inside the lung CT image, the features are extracted from the segmented images are used. The proposed model utilizes the modules such as data collection, data pre-processing, features selection and classification using image processing methodologies to improve the results.

YUYUN YE et.al [11] proposes a novel automated pulmonary nodule detection model using the modified V-Nets and a high-level descriptor based support vector machine (SVM) classifier. The former is for nodule candidate detection and the latter is for false positive (FP) reduction. To decrease the performance of FP a hard mining method is given for retraining the network. The more critical features from the CT images are employed by the proposed SVM classifier, which performs better in FP reduction comparing with SVM based classifiers and CNN classifiers.

IMDAD ALI et.al [12] improves the classification rate of CT scan images in pulmonary nodules by presenting transferable texture Convolutional Neural Networks (CNN) .To extract the features from the convolutional layer, a scheme called an Energy Layer (EL) is employed. The space complexity and time complexity can be reduced by including EL with learning parameters of the network. The designed model has one EL and three convolutional layers. Instead of pooling layer, EL layer is used. Totally the proposed method includes 9 layers CNN architecture to extract the features automatically and classify the pulmonary nodule candidates as malignant or benign.

Popper H. H [13] Metastasis in lung cancer is a multifaceted process. The author reviews the different procedures with multiple isolated steps like hypoxia, angiogenesis, circulation, and establishment of a metastatic focus. In real time, more number of these processes overlap and occur even simultaneously, but such a presentation would be unreadable. Metastasis needs cell migration toward higher oxygen tension, which can be done by modifying the cell's structure (epithelial-mesenchymal transition), orientation inside the stroma and stroma interaction, and communication with the immune system to avoid attack.

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IoT Thingspeak platform

Thingspeak is one of the open source software in IoT cloud platform.The firm ioBridge is launched the Thingspeak in the year 2010 for supporting service in the field of IoT applications. Thingspeak is generally referred as a an IoT analytics platform service which helps people to data aggregation, data analyze and visualization with live data streams in cloud. The best of Thingspeak is an instant data visualization, which is utilized by the IoT with demand analytics for prototyping and proofing concept. There are so many capabilities are in Thingspeak, among them some of the features are listed below.

- Easy configuration:Device configuration transmit the data to Thingspeak by using some IoT protocols.
- Visualization: Real time visualization of collected sensor data.
- Aggregation: Data aggregation based on the third party request.
- Analysis: According to the schedules and events, run the automatic IoT analytics.
- Prototyping: Prototype creation of IoT systems setting up or web software developing without servers.
- Automation:Automatic Data manipulation and communication used by third party services .

Methodology

In the following subsections, the background of the proposed method is discussed in detail. Fig 1 shows that the architecture diagram of the proposed method.

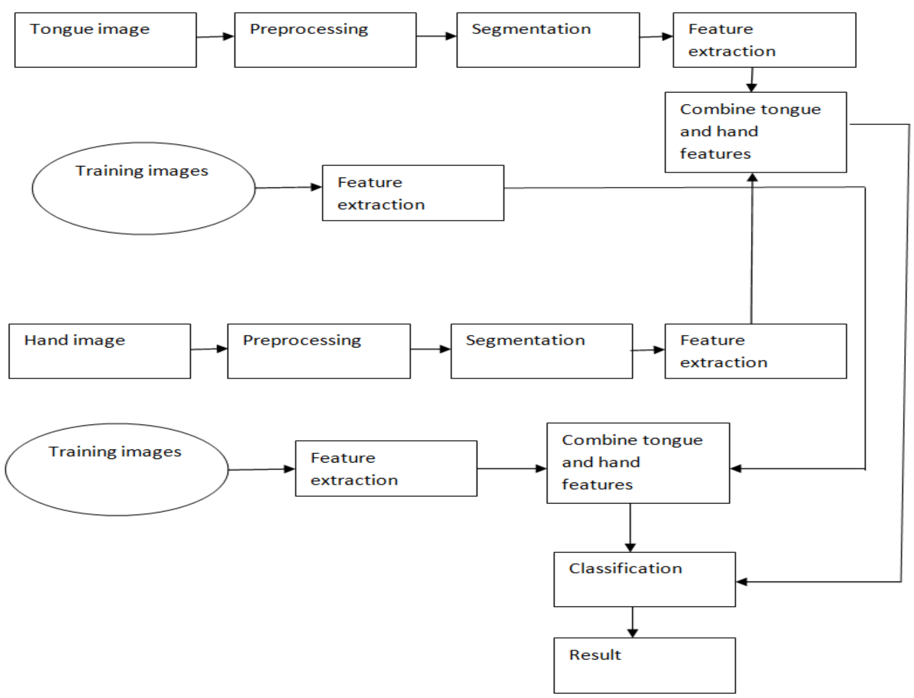

Fig 1 Architecture diagram of proposed method

Dataset Preprocessing

Data preprocessing is the necessary part before applying the machine learning algorithm for classification problems. The pre processed data reduces the noise of the images and enhances the images using CLAHE equalization

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algorithm. Hybrid Weiner-bilateral filter is applied to remove the noise present in the image. The low contrast medical images has been effectively improved using CLAHE algorithm. Histogram clip cap and area scale for background are the factors to be used in CLAHE which can simultaneously affects the algorithms efficiency. It redistributes the used grayscale value in order to make the image more clarity with the help of makes the secret characteristics. There are different types of transformations can be evaluated with CLAHE algorithm by considering the frequency. Let 'Q' be an image with N×N pixel of range P (i, j). Then R be the output image with same N×N pixel which is produced by the input image 'Q'. The equation for equalization is

$$P_n = 255\left(\frac{|\varphi w(P) - \varphi w(\min)|}{|\varphi w(max) - \varphi w(\min)|}\right) \quad (1)$$

$$\varphi_w(P) = \left[1 + exp\left(\frac{\mu w - P}{\sigma w}\right)\right]^{-1} \quad (2)$$

Hybrid Weiner-bilateral filter

Let consider the image is evaluated with the Gaussian function with kernel's convolution. The equation of convolution in discrete case is formed by,

$$f * g[n] = \sum_{l=-\infty}^{\infty} f(l).\, g[n-l] \quad (3)$$

Here the kernel is build using the 2-D Gaussian function. Let consider K be the amplitude, (m,n) be the center, σx, σy the standard deviations in the x and y directions. Let take the size of kernel as 3x3.

$$f(x,y) = K.\, e^{-\left(\left(\frac{(x-m)^2}{2\sigma x^2}\right)+\left(\frac{(x-n)^2}{2\sigma y^2}\right)\right)} \quad (4)$$

Weiner filter is most commonly used because of its simplicity. A weights of optimum filter is measured using the linear system which decreases the noise level of the received signal. Bend-correlation and covariance matrices are utilized to compute the weights of noisy signals.In order to assess the optimum filter weight, noise numbers are calculated. The array obtained in f(x,y) is given into the input of BF(bilateral filter). BF reduces the noise by incorporating the edge preservation. The signal convolution often outputs a loss of edge information, because of the blurriness with irrespective to the edge or noise. A non linear bilateral filter is used to overcome this kind of problems. The bilateral filter can be expressed as

$$B_{filt}[I]_p = \frac{1}{W_p} \sum_{q \in S} G_{\sigma s}\left(\|p-q\|\right) G_{\sigma r}\left(I_p - I_q\right) I_q \quad (4a)$$

σ_s is the spatial extent of the kernel.

σ_r is the minimum amplitude of an edge. The sharper edge can be obtained by having smaller value for σ_r. If the value of σ_r tends to infinity, then the equation tends to a Gaussian blur.

Morphological operation with Random walker segmentation

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Initially morphological dilation and erosion is applied to create the mask of the image. Let consider the given filtered image is segmented into k objects with the seed information provided by the user, which is in the form of l= 1 to k where l stands for label. For each l=1 to k .Then the following steps are proceeded.

Step 1:

Initially the graph is constructed by taking the image pixels as vertices, and it is denoted by H. If the pixels are said to be 4- connected then the edge should be connected with two vertices .

Step 2

Let G_l be the graph on the color space which uses set Ai to construct G_l. $d_{ij,l}$ is the distance between colors Ai and Aj in graph G_l .

Step 3

If the two vertices of H, vi and vj are connected and have color values Ai and Aj, then the weight of the edge connecting them is given as

$$\omega_{ij,l} = e^{-\beta \mathrm{dij,l}^2}$$

Step 4

Construct the Laplacian L^l whose ijth element is given as follows

$$L_{ij} = \{\partial_{i,l} \quad if\ i = j;\ -\omega_{ij,l} \quad if\ i\ and\ j\ are\ adjacent;0 \quad O.W \qquad (5)$$

Step 5

As in case of ordinary Random Walker we solve the system

$$L_u P^l = -B^T m^t \quad (6)$$

Where P^l is the probability that vertex vi belongs to the vertex set with the label l.

Feature Extraction

ORB Algorithm

The proposed ORB algorithm [14], is a combined form of FAST and BRIEF method, in which feature points are described using binary string. Initially improved FAST algorithm is used to extract the feature point of ORB and then BRIEF algorithm is utilized to describe those features The speed of ORB is very fast because of FAST and BRIEF ,which are absolute advantage in speed. ORB is very sensitive to noise and fast which is also having rotational invariance feature.

The problem occurred in rotational invariance can easily solved by ORB which is not possible in BRIEF. The moments of plaque (circular neighborhood) is defined by

$$m_{pq} = \sum_{x,y} x^p y^q I(x,y) \qquad (7)$$

Where x, y -The position of the FAST feature point

Circular neighborhood radius r, x, y ∈ [-r, r].

Then equation (8) shows that the formula for center of gravity of the plaque calculation

$$C = \left(\frac{m_{10}}{m_{00}}, \frac{m_{01}}{m_{00}}\right) \quad (8)$$

The Angle which is formed by feature point and the center of gravity has been defined as for the FAST feature point direction:

$$\theta = arctan\left(\frac{m_{01}}{m_{10}}\right) = \arctan\left(\frac{\left(\sum_{x,y} yI(x,y)\right)}{\sum_{x,y} xI(x,y)}\right) (9)$$

Based on the equation given in (9), the BRIEF descriptors are extracted by the ORB algorithm, since because of noise and environmental factors can change the feature points direction and random pixel blocks of correlation which is comparatively high, thus reduces the discrimination of descriptors.

Steps of chromatic feature extraction

- Convert RGB image into HSV
- Find variance for Hue plane
- Find standard deviation for hue plane
- Find skewness for hue plane
- Repeat this process for Saturation and value.
- Combine all these features

Steps of color diversity feature extraction

- Convert RGB image into HSV
- Extraction of hue features
- Extraction of Saturation features
- Extraction of value features

HBNK Classification

HBNK is a classification model which is based on the combination of Bayes theorem and KNN. Let consider the proposed algorithm is independent among predictors. Simply, Naive Bayes classifier assumes that the existence of a specific feature in a class is varies to the existence of any other feature.

The bayes theorem can be written by

$$P(b|A) = \left(\frac{P(A|b)P(b)}{P(A)}\right) \quad (10)$$

Where b is the class variable of lung cancer, which indicates the patient affected by the lung cancer or not based on the given hand and tongue images with the given the conditions. The variable A represents the features of the images.

The variable A can be written as,

$$A = (a1, a2, a3, \dots\dots\dots.., an)$$

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Where a1,a2,…..an, are features of the images i.e ORB, chromatic and color diversity features. The chain rule can be expanded by applying the features of A.

$$P(b|a1, a2, a3, \dots \dots, an) = \left(\frac{P(a1|b)P(a2|b) \dots P(an|b)P(b)}{P(a1)P(a2) \dots P(an)} \right) \quad (11)$$

Now, values for each can get by looking at the dataset and applying them into the equation. The values of denominator will not change, for all images in the dataset, then it remains constant. So that the denominator can be removed and a proportionality can be introduced.

$$P(b|a1, a2, a3, \dots \dots, an) \; \alpha \; P(b) \prod_{i=1}^{n} P(Ai|b) \qquad (12)$$

Here the class variable outputs two types of outcomes, which are Normal patient and the cancer affected patient. Therefore, we need to search the class **b** with maximum probability.

$$b = argmax(b)P(b) \prod_{i=1}^{n} P(Ai|b) \qquad (13)$$

By using equ(13), the class of image can be identified with the given predictors and the class outputs can be used as a key values for KNN algorithm. The KNN classifier, uses the simplified incarnation of KNN model in order to diagnosis the target class label as the class label that is most often represented among the k most similar training examples for a given query point.

Let consider the target function f(a)=b which assigns a class label

More formally, assume we have a target function f(a) = b that assigns a class label $b \in \{1,2, \dots \dots t\}$ to training

$$f: R \to \{1,2, \dots t\} \; (14)$$

Assuming we identified the k nearest neighbors (Dk ⊆ D) of a query point b [q]

$$D_k = \left\{ \left(a^{[1]}, f\left(a^{[1]}\right) \right), \dots \dots, \left(a^{[k]}, f\left(a^{[k]}\right) \right) \right\} \quad (15)$$

The hypothesis of KNN is defined by

$$h(a^{[q]}) = \arg max_{b \in \{1, \dots t\}} \sum_{i=1}^{k} \delta(y, f\left(a^{[1]}\right) \; (16)$$

Wher, δ indicates the Kronecker Delta function

$$\delta(x, y) = \{1 \quad if \; x = y; \quad 0 \; if \; x \neq y \quad (17)$$

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Or, in simpler notation, if you remember the “mode” from introductory statistics classes

$h(a^{[t]}) = mode(\{f(a^{[1]}), \ldots\ldots, f(a^{[k]}))$ (18)

Where $h(a^{[t]})$ is the predicted output classes using the proposed HBNK classifier.

The distance of KNN is calculated using equation(19)

$$d(x^{[a]}, x^{[b]}) = \sqrt{\sum_{j=1}^{m} \left(x_j^{[a]} - x_j^{[b]}\right)} \quad (19)$$

Pseudo code of proposed algorithm

Input: Image

Output: Lung cancer Prediction

1. Read an image
2. Convert the image into a grayscale image
3. Apply CLAHE equalization by using equation (1)
4. Calculate Gaussian kernel using equation (4)
5. Perform wiener filter using equations (5) and (6)
6. Apply morphological operation with random walker segmentation to segment the image.
7. ORB feature extraction using equation(9)
8. chromatic and color diversity feature extraction
9. Repeat steps 1 to 8 for hand images with sobel edge detection based segmentation
10. club the hand and tongue features and compute features for all of the images in the dataset
11.Split training data features and testing data features
12. Apply bayes theorem to predict the class labels using equation (13)
13.Use class labels as a key values for K-nearest neighbors
14. Next, we need to choose the value of K i.e. the nearest data points. K can be any integer in our case it is 5.
15. For each test data do the following
16. Calculate the distance between test data and each row of training data using equation(19)
17. Chosen of top K rows from the sorted array
18. Predicted result of patient.

Experimental results

In this section, the results of proposed work is demonstrated and the values are tabulated. This work is carried out with 64 bit operating system and Intel core I5 processor with 8 GB RAM respectively. Fig 2 shows that the processed results for tongue images. Fig 2(a) shows that gray scale tongue images. Fig 2(b) shows Equalized images

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using CLACHE technique. Fig 2(c) shows Filtered tongue image using Weiner filter. Fig 2(d) shows Contrast enhanced tongue image and Fig 2(e) displays the output of segmented tongue image using morphological operation with random walker segmentation.

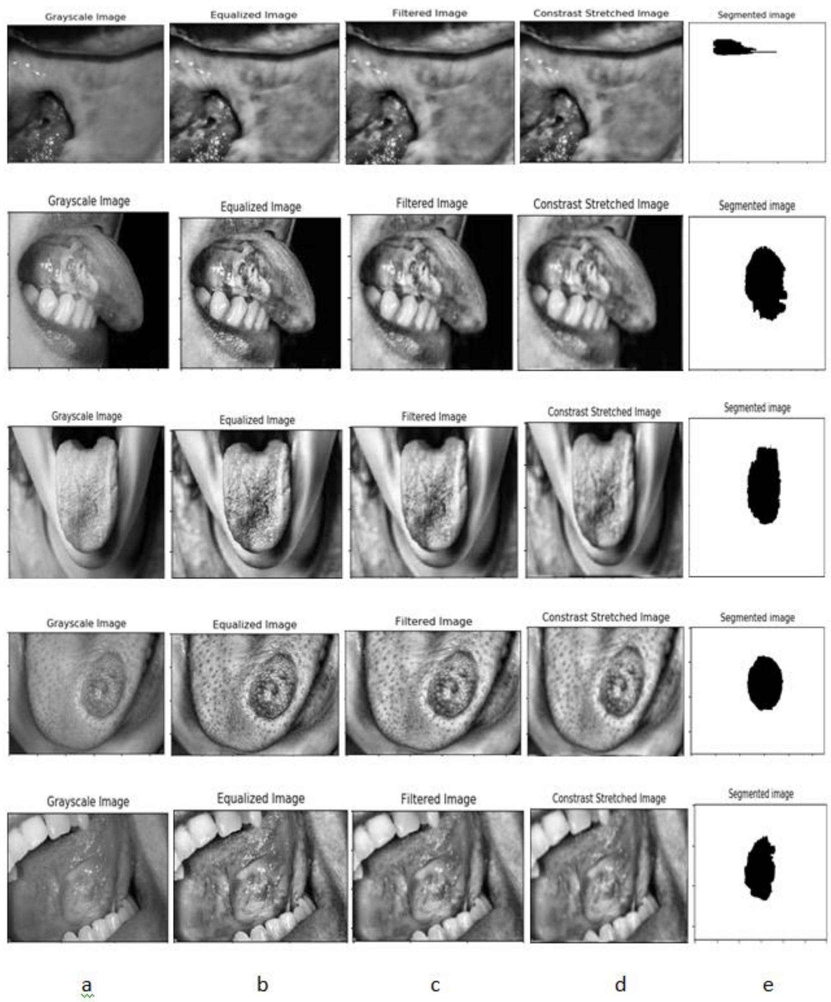

Fig 2 Results of Tongue images

Fig 3 shows that the processed results for hand images. Fig 3(a) shows that gray scale hand images. Fig 3(b) shows Equalized images using CLACHE technique. Fig 3(c) shows Filtered tongue image using Weiner filter. Fig 3(d) shows Contrast enhanced tongue image and Fig 3(e) displays the output of segmented tongue image using sobel edge detection method.

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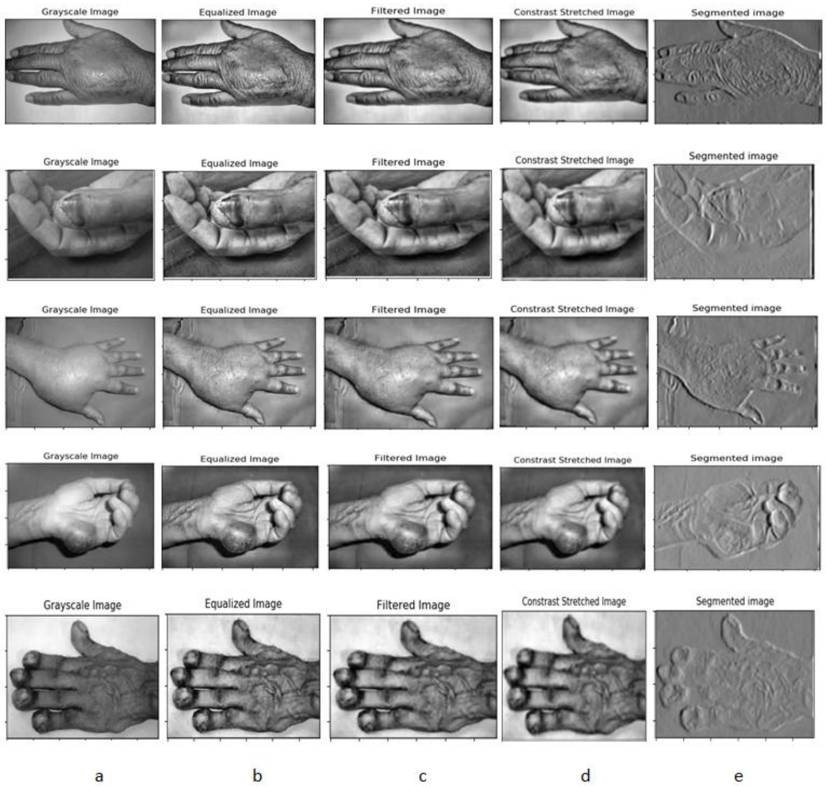

Fig 3 Results of hand images

Performance metrics

Performance of anticipated lung cancer diagnosis system is computed with metrics like accuracy, PSNR,MSR and MSE. To evaluate these parameters, True negative (TN), False Negative (FN) True positive (TP), and False positive (FP) should be calculated. The patients whose are having cancer is termed as TP ,The probability of healthy patients are identified as cancer is referred as FP, The probability of cancer patients are identified as healthy is referred as TN, and the patients without cancer is determined with cancer is termed as FN.

Accuracy

Accuracy depicted as overall measure of effectiveness of classification. It is evaluated as in Equation (20)

$$Accuracy = \frac{TP+TN}{TP+FP+TN+FN} \qquad (20)$$

It is necessary to equate the enhanced image with the original image. Improved color reproduction was evaluated by various means in this paper. The parameters for assessment are as follows.

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Mean to norm ratio of deviation

Mean to standard deviation ratio (MSR) is calculated using mean and standard deviation of the image. MSR should be high.

Mean Square Error

MSE is referred as a mean square cumulative error between the original image and the filtered image. MSE can be computed using the equation given in (21)

$$MSE(x,y) = \frac{1}{N}\sum_{j=1}^{N}\left(x_j - y_j\right)^2 \quad (21)$$

Where x is an input image and y is a filtered image.

Peak signal-to-noise ratio

PSNR cannot determine image similarity across contrast-enhanced forms. PSNR is measured using decibels (dB) .PSNR is defined as

$$PSNR = 10\ log10\left(\frac{R^2}{sqrt(MSE)}\right) \quad (22)$$

The higher PSNR indicates that, the filtered image is in good quality. It is the ratio of the signal's maximum power to the power of perverting noise that affects its representation's fidelity. Table 1 displays the output calculation of the MSR, PSNR, and MSE values for the experimented image filtering process.

Thing speak's analytics

In IOT platform the analytic power of Matlab functions are adopted by using Thing-speak . To upload the tongue and hand images to the secured website, Thingspeak in MATLAB is very useful. Lung cancer detection was done using HBNK algorithm. Accordingly, the doctor can access the graphs or images via Thingspeak platform with support of automatic cloud based diagnosing for the patient status by categorizing the hand and tongue images.

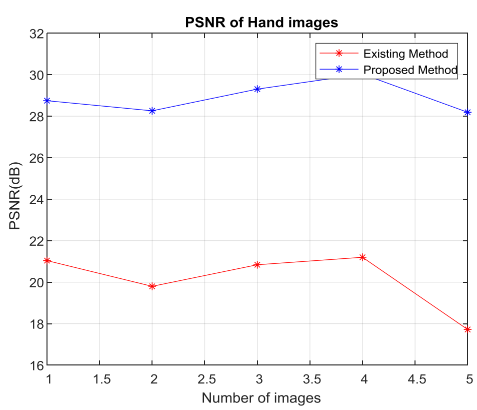

Fig. 4. PSNR representation of hand images

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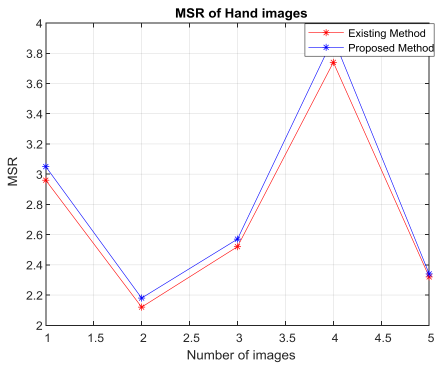

Fig. 5. MSR representation of hand images

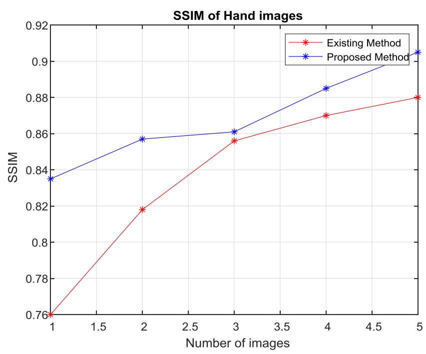

Fig. 6. SSIM representation of hand images

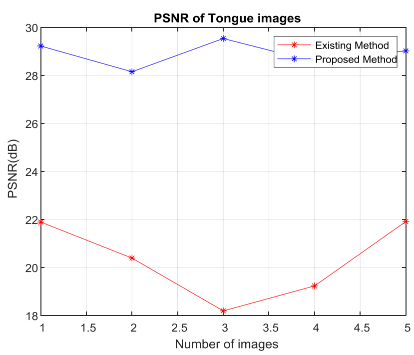

Fig. 7. PSNR representation of tongue images

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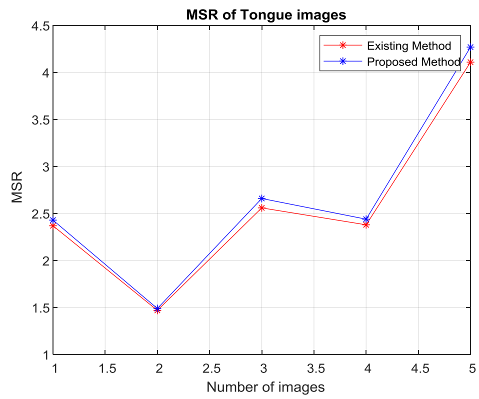

Fig. 8. MSR representation of tongue images

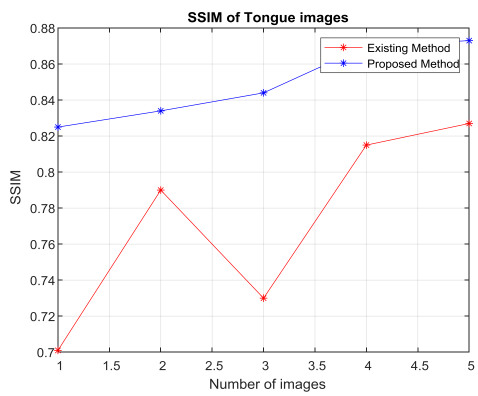

Fig. 9. SSIM representation of tongue images

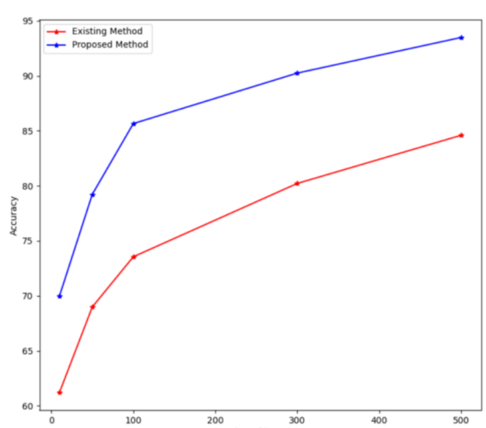

Fig 10 Accuracy of KNN Vs HBNK

TABLE I.

PERFORMANCE COMPARISON FOR HAND IMAGES

Performance metrics	Median filter	Hybrid Weiner-bilateral filter
MSR	2.7320	2.8080

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SSIM	0.8368	0.8686
PSNR	20.1200	28.9066

TABLE II.

PERFORMANCE COMPARISON FOR TONGUE IMAGES

Performance metrics	Median filter	Hybrid Weiner-bilateral filter
MSR	2.5780	2.6580
SSIM	0.7726	0.8492
PSNR	20.3320	28.9086

TABLE III

ACCURACY COMPARISON OF KNN AND HBNK

Number of Iterations	10	50	100	300	500
KNN	61.23	68.99	73.55	80.22	84.6
HBNK	70	79.23	85.66	90.25	93.49

Conclusion

Here, effectual lung cancer diagnosis system is modeled known as HBNK. Here, an effectual segmentation is utilized to segment hand and tongue images with a algorithm called Morphological with random walker segmentation for accurate lung cancer diagnosis using HBNK classifier. From the experimental results it can be seen that the proposed method identifies images of various sizes and shapes accurately. More appropriate features are needed for classification from extracted segmented images. The features like ORB, color diversity and chromatic features are extracted. After extracting the features the network is trained using HBNK classifier. The designed model is build with huge successive stages that commonly produced final output of prediction. All the process utilized in various stages are easy to implement and simple. The proposed HBNK classifier yields the accuracy of 93.49% .The proposed method attains a good accuracy to classify lung cancer using hand and tongue images.

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