DETECTION AND CLASSIFICATION OF TUMORS IN CT IMAGES

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Abstract

Image segmentation is the process of partitioning a digital image into multiple segments or set of pixels. The objective of image segmentation is to group pixels into a prominent image region. In this paper, segmentation of Gray level images is used to provide information such as anatomical structure and identifying the Region of Interest i.e. locate tumor, lesion and other abnormalities. The image segmentation methods may be classified into several types: image-based, model-based and hybrid methods. Purely image-based methods perform segmentation based only on information available within the image. These include thresholding, region growing, morphological operations, active contours level sets, watershed, fuzzy connectedness, and graph cuts (Gcs).Image based methods perform well on high-quality images. However, the results are not as good when the image quality is inferior or boundary information is missing .One advantage of model based methods is that, even when some object information is missing, such gaps can be filled by drawing upon the prior information present in the model .In this paper a semi automated segmentation method is implemented for medical image segmentation. Tumor detection is one of the major applications of medical image segmentation .A tumor detection algorithm using fuzzy c means clustering is also implemented in this paper.

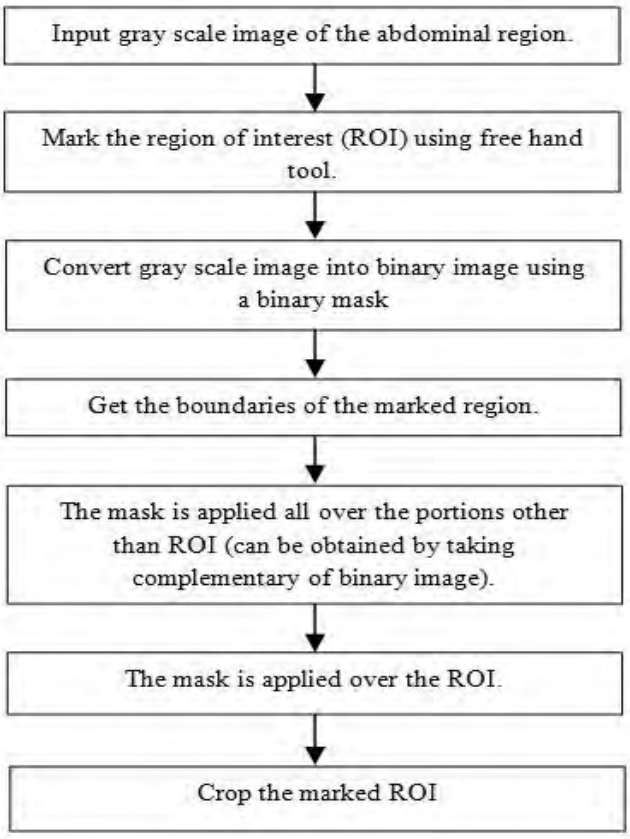
Keywords: fuzzy c-means clustering, thresholding, region growing, morphological operations, active contours level sets, watershed, fuzzy connectedness, and graph cuts (GCs)

1. Introduction

The segmentation of organs like the liver, pancreas, and kidneys on abdominal computed tomography (CT) scans can form an input to computer aided diagnosis (CAD) systems and laproscopic surgery assistance [1]. Further applications include radiotherapy planning [6] as well as cancer detection and staging [6]. Most previous work on auto-mated abdominal segmentation is based on statistical shape models or Semi automated segmentation involves the following two steps: 1) manually marking the region of interest; 2) automated calculation and segmentation of the marked ROI .Usually, statistical models are learned on a training set and applied in combination with post processing steps that are often specialized to a particular organ. CT images [1] [2] are often preferred by diagnosticians since they have high Signal-to-Noise ratio and good spatial resolution, thus providing accurate anatomical information about the visualized structures. These good image qualities, and the advances in the digital image processing techniques, motivate the great deal of research work aimed at the development of computerized methods[5] [7] [9]for the automatic abdominal organ analysis[14]

1.1. *SEMI AUTOMATED SEGMENTATION*

For many years, one of the most important tasks in image processing has been to perform automatic image segmentation. Many types of methods have been developed: edge detection and following, region growing, snakes, region modeling and separation, mathematical morphology, etc . However, in some fields of application, such as medical or biomedical imaging, objects of interest (OOIs) are often badly defined and even sophisticated automatic segmentation algorithms often fail. For these situations, the only possibility until recently was to replace automatic methods[8] by interactive (or manual) ones, where a lot of interaction between the user and the image is necessary, This type of interaction is always very tedious and possibility of occur-ring fatigue errors are high since every stage of segmentation is done manually . Some years ago, a third possibility was suggested by researchers in the field of medical image processing: it consists in renouncing fully automatic image segmentation in favor of semi-automatic image segmentation, with a very limited amount of user interaction, in contrast to intensely interactive approaches. In this paper we tried to implement a semi automated segmentation method in which the first stage of segmentation is done manually, and rest of the calculations are done automatically. Following is a flowchart showing steps involved in semi automated segmentation.[15]



In this method manual intervention is very little when com-pared with other methods. Only the first step in segmentation, that is marking the region of interest is done manually. Since manual calculations are less, possibilities of occurring fatigue errors are found to be less in this method.

The semi automated segmentation method is implemented using Matlab . For this an image free hand tool is designed. Using the free hand tool the required region which is to be segmented is marked .The gray scale image is converted into binary image by applying a binary mask. The results obtained are shown below.

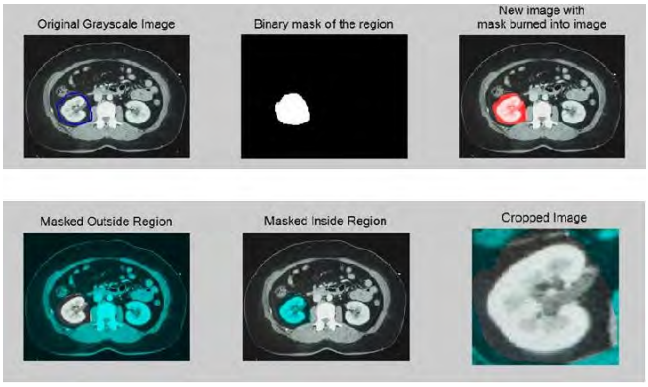


Figure 1: results of semi automatic segmentation.(a)input gray scale image where the blue line shows the marked ROI(b)binary image of marked gray scale image(c)masked burned into ROI(d)masked applied over regions other than ROI(e)masked applied over ROI(f)final cropped out image.

1.2. *Fuzzy C means*

The idea of fuzzy connectedness goes back to the work of Rosenfeld [10]. Dellepiane et al. [3] and Udupa and Samarasekara [4] were the first authors to incorporate the fuzzy nature of images into a segmentation algorithm through the concept of fuzzy connectedness, which is supposed to capture efficiently fuzzy “hanging togetherness. In practice, the idea is to compute a map of the connectedness of every pixel in the original image,

in relation with one specific (designated) pixel belonging to the object of interest (OOI).Although the practical results of segmentation obtained by this method are often good, we can easily identify some weaknesses such as the segmentation results heavily depend upon threshold used. Thus improvement in segmentation and tumor detection can be done with fuzzy c means clustering method.

Fuzzy c-means (FCM) clustering is an unsupervised technique that has been successfully applied to feature analysis, clustering, and classifier designs in fields such as astronomy, geology, medical imaging, target recognition, and image segmentation.[11-13] An image can be represented in various feature spaces, and the FCM algorithm classifies the image by grouping similar data points in the feature space into clusters. This clustering is achieved by iteratively minimizing a cost function that is dependent on the distance of the pixels to the cluster centers in the feature domain. The pixels on an image are highly correlated, i.e. the pixels in the immediate neighbourhood possess nearly the same feature data. Therefore, the spatial relationship of neighbouring pixels is an important characteristic that can be of great aid in imaging segmentation. General boundary detection techniques have taken advantage of this spatial information for image segmentation. However, the conventional FCM algorithm does not fully utilize this spatial information. So improvement in conventional method can be done by incorporating noise reduction method also.

The FCM algorithm assigns pixels to each category by using fuzzy memberships. Let $X = (X_1\ X_2 \ldots X_n)$ denotes an image with N pixels to be partitioned into C clusters, where X_i represents multispectral (features) data. The algorithm is an iterative optimization that minimizes the cost function defined as follows:

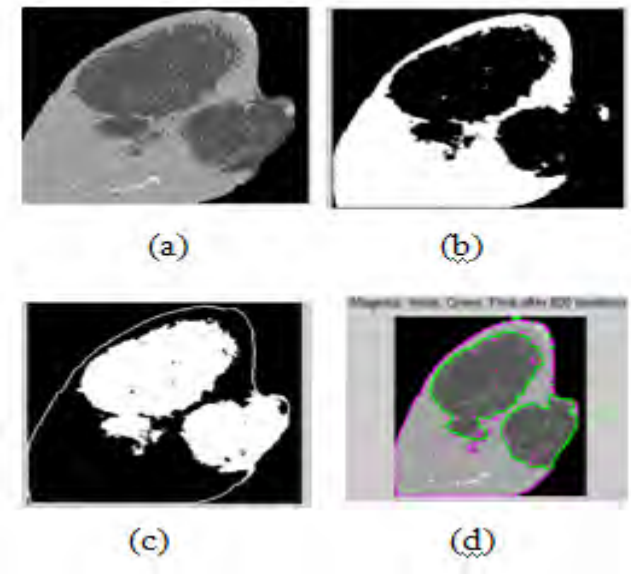


Figure 2 (a)original grayscale image(b),(c)converted images(d)tumor detected final output.

1.3. *Subtractive Method*

Image subtraction or pixel subtraction is a process whereby the digital numeric value of one pixel or whole image is subtracted from another image. This is primarily done for detecting changes between two images. In subtractive method we are converting the colour CT image into gray scale and then into binary format for the ease of processing in Matlab. In photography and computing, a grayscale or greyscale digital image is an image in which the value of each pixel is a single sample, that is, it carries only intensity information. Images of this sort, also known as black-and-white, are composed exclusively of shades of gray, varying from black at the weakest intensity to white at the strongest,[0-255].

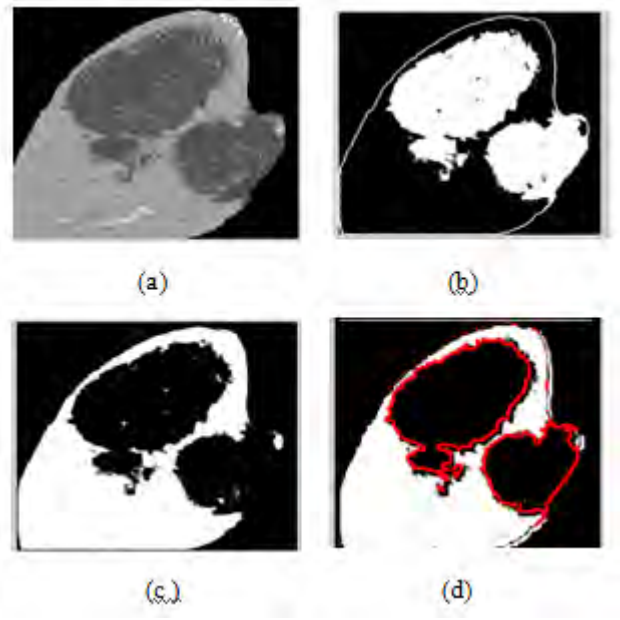


Figure 3 (a)Original image (b) Binary image (c)complemented image (d) detected tumor Region marked as red

1.4. *Morphological method*

We use mathematical morphology as a tool for extracting image components that are useful in the representation and description of region shape, such as boundaries, skeletons.The morphological method includes operations such as dilation and erosion by using simple matlab commands such as imerode and imdilate we can perform morphological operations.

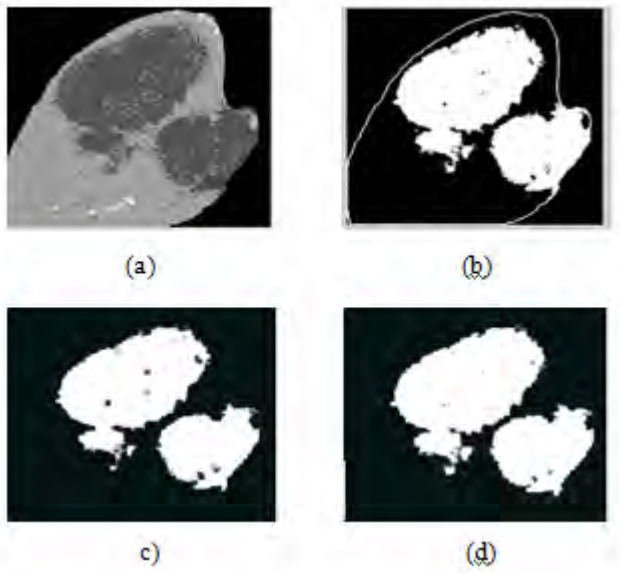


Figure 4 (a).Original image (b) converted images (c) tumor detected using erosion (d) holes filled using dilation and imfill

2. Tumor Classifier Using Artificial Neural Network :

Tumor classsification was done with the help of neural networks and the results obtained was in accordance with the input image. The classifier gave the result as what kind of tumor is the input image of the three. In tumour classification we have first created a database containing the three types of kidney tumors. Then for training the network we need to extract the image features of each image in the database. The database consists of 28 images of various kidney tumor category, of which 25 images are used for training purpose. The input can be either the trained image or the untrained image in the database. If input is provided as any one of the trained image the neural network will give perfect output. For that the given input image is convereted into RGB, CIE lab HSV and HLS colour space. Then the colour moments of each image is calculated. A fitting net-work is designed for giving all these extracted features as input. A gabor filter is also incorporated with this classifier for texture analysis. In image processing, a Gabor filter, named after Dennis Gabor, is a linear filter used for

edge detection. Frequency and orientation representations of Gabor filters are similar to those of the human visual system, and they have been found to be particularly appropriate for texture representation and discrimination. The neural network here uses supervised learning. Another case is that the input we are providing is any one of the untrained image then the neural network uses associative neural network and compares the input to the trained images to find similarity and give outputs correspondingly.[16][17]

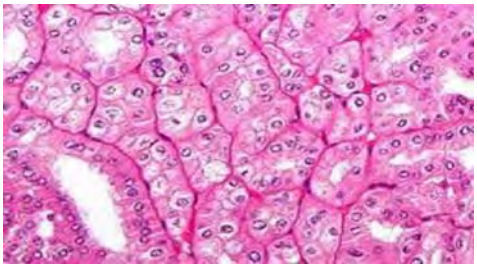
The associative neural network (ASNN)[18] is an extension of the committee of machines that goes beyond a simple/weighted average of different models. ASNN represents a combination of an ensemble of feedforward neural net-works and the k-nearest neighbour technique(kNN). It uses the correlation between ensemble responses as a measure of distance amid the analyzed cases for the kNN. This corrects the bias of the neural network ensemble. An associative neural network has a memory that can coincide with the training set. If new data become available, the network instantly improves its predictive ability and provides data approximation (self-learn the data) without a need to retrain the ensemble. Another important feature of ASNN is the possibility to interpret neural network results by analysis of correlations between data cases in the space of models. Finally the neural network will give the output as what kind of tumor it is.

2.1. *Types Of Kidney Tumors*

Both benign and malignant tumors occur in the kidney. With the exception of oncocytoma, the benign tumors rarely cause clinical problems. Malignant tumors on the other hand, are of great importance clinically and deserve considerable emphasis.[8][19]By far the most common of these malignant tumors is renal cell carcinoma, followed by Wilms tumor, which is found in children and finally urothelial tumors of the calyces and pelves. Kidney tumors are known as renal cell carcinoma which includes three main classification.

2.1.1 Chromophobe Renal Cell Carcinoma

Thick cell walls which will be visible, solid light brown cut surfaces ,large polygonal cells.



2.1. 2 .Renal Cell Clear Cell Carcinoma

The microscopic appearance of renal clear cell carcinoma may present reddened areas where blood vessels may bleed ,large blood vessels, black scarring ,large tubules shown as white.

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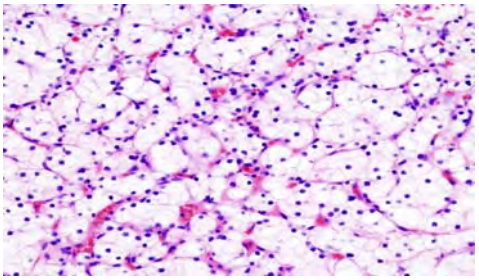
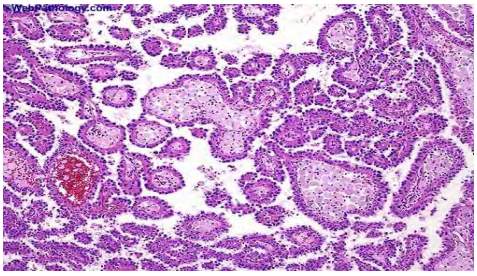
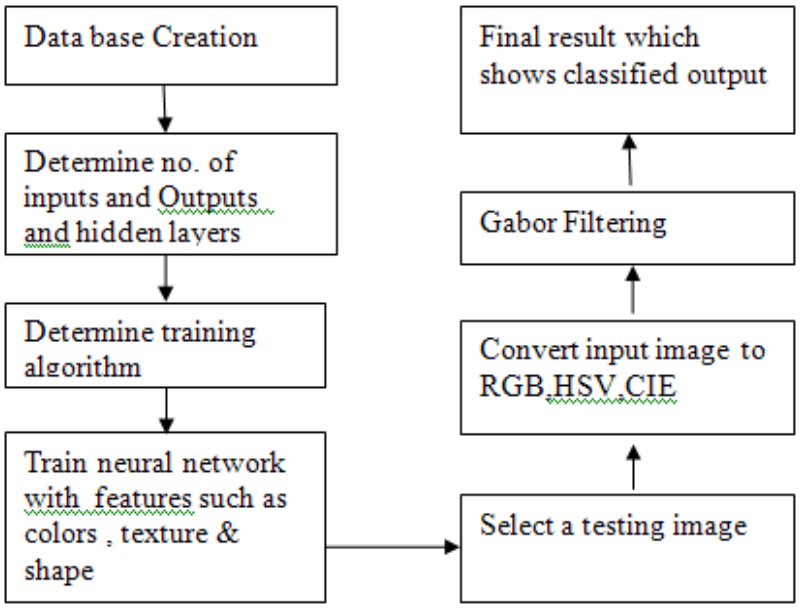


2.1. 3. Papillary Renal Cell Carcinoma

Blood stains concentrated in one area and violet or blue scars and small cells shows papillary renal cell carcinoma.



The flowchart below shows the overall work flow of the system.

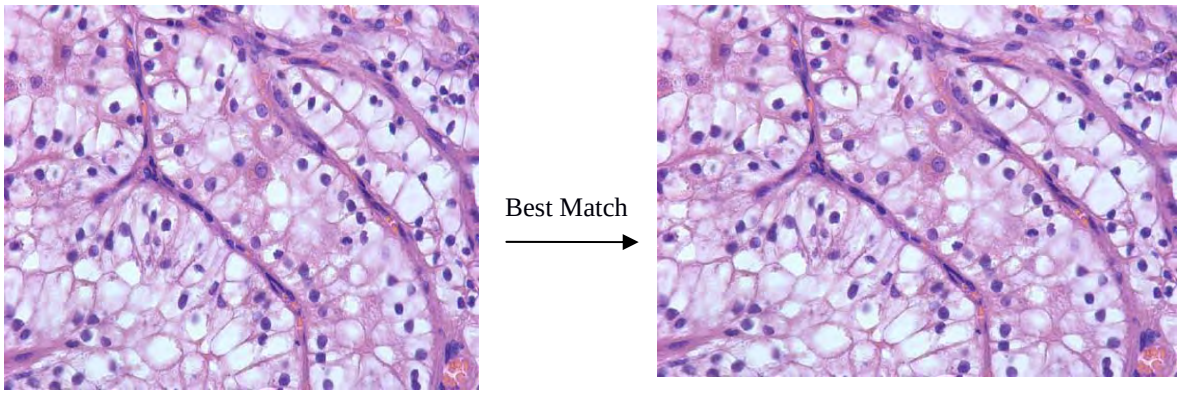


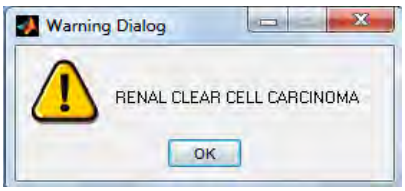
3. Results and Discussions:

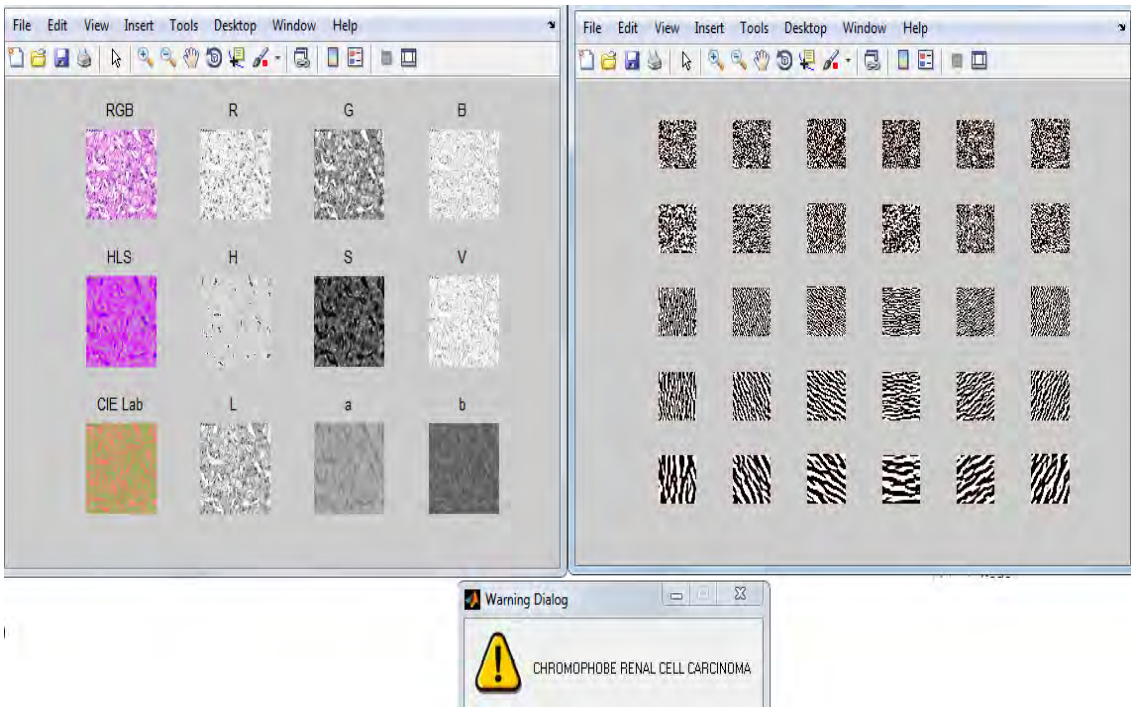
It is found that our classifier produced correct output while giving any of the untrained image included in our database as input.

In image processing, a Gabor filter, named after Dennis Gabor, is a linear filter used for edge detection. Frequency and orientation representations of Gabor filters are similar to those of the human visual system, and they have been found to be particularly appropriate for texture representation and discrimination. In the spatial domain, a 2D Gabor filter is a Gaussian kernel function modulated by a sinusoidal plane wave. Simple cells in the visual cortex of mammalian brains can be modeled by Gabor functions. Thus, image analysis with Gabor filters is thought to be similar to perception in the human visual system. Gabor filters can serve as excellent band-pass filters for one-dimensional signals.

3.1. *Output Of Neural Network Classifier*







4.Conclusion

The first step in tumor detection is to segment out the kidney portion from the abdominal CT image.This was done with a semi-automated segmentation method. The strength of the semi-automatic segmentation method is its general nature which allows it to be applied robustly to multiple organs without specialization and individual parameter settings. One of the advantages of semi-automatic segmentation is that segmentation result can be obtained as necessary for the application on hand. This study shows that semi automated segmentation method will reduce errors occurring while doing manual segmentation. Experimental results were obtained by using matlab.

FCM clustering is an unsupervised clustering technique applied to segment image into clusters with similar spectral properties. It utilizes the distance between pixel and cluster centers in the spectral domain to compute the membership function. Th pixels on an image are highly correlated, and this spatial information is an important characteristic that can be used to aid their labelling . In this paper improvement in the accuracy of results are obtained by incorporating noise removal steps while doing fuzzy c means clustering. Final stage in tumor detection is to decide whether it is a malignant tumor or a mass. Also classification among the types of kidney tumors are also done by designing an artificial neural network. Improvement in algorithm can be done by training the network with more image features.

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