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Grayscale To Colour Enhancement Of Liver Ct Scan Images And Classification Of The Hepatic Lesions

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ABSTRACT

Liver diseases are varied and most of them involve morbidity and mortality. The most common of them are the hepatic lesions which are of multiple types and each require different methods of diagnosis and treatment. Computerised Tomography (CT) is the most common modality for detection of liver lesions.The CT image is in grayscale hence the internal differences are difficult to detect and so the diagnosis becomes complex. To remove this difficulty the image has been converted to an image with contrasting colours. This improves its sensitivity and specificity. The image has been initially preprocessed to remove noise and other non-linearities and then enhanced from grayscale to colour. In the image if a lesion is identified in the liver then that region alone is extracted using the ROI segmentation. It is then classified as benign(non-cancerous) or malignant(cancerous) [using the SVM classifier]. This is done since each of the lesion types require different methods of treatment, surgical or non-surgical.

KEYWORDS--Normalization, Thresholding, Gray Level Co-occurrence Matrix (GLCM), SVM (Support Vector Machine)

I. INTRODUCTION

Liver is the largest and one of the most vital organs in the human body and supports almost every other organ. Because of its strategic location and multidimensional functions it is prone to many diseases. A Lesion is a region in an organ or tissue which has suffered damage through a disease such as wound, ulcer or tumour. Liver lesions represent a heterogenous group of pathology ranging from benign to malignant. They can be detected by Medical Imaging such as CT scan, MRI (Magnetic Resonance Imaging) etc**.** Each of them require different methods of diagnosis and treatment. Hence the classification of lesions of the liver was taken up in this work.

Mainly two modalities are used for classification of liver lesions which are CT and MRI. But since the MRI scan is costlier compared to CT, takes more time and is not available at all places hence CT scans have been used here. Since the CT scan is in Grayscale it is very tough to identify the minute differences. Hence it is difficult for clinicians to study the image and diagnose.So the CT images have been shown using contrasting colours. This has been done using Image Enhancement.

The classification of the lesions using CT scans is done by injecting contrast and observing the behavior of the lesions at different time periods after injection of contrast (i.e Arterial phase (20-40 seconds), Portal Venous phase (50-70 seconds) and Delayed phase (3 minutes). Although in recent years the quality of CT images has been significantly improved, the scope of image interpretation by human beings is sometimes limited. This necessitates the need for an automated system to detect and classify the liver anomalies.

II. IMAGE ENHANCEMENT, FEATURE EXTRACTION AND CLASSIFICATION

The main steps involved in this study are given below.

A. *Image Preprocessing* - This is the initial process carried out in this proposed system. This includes image preprocessing to reduce the noise and improve the image quality.

B. *Image Segmentation* – It means partitioning an image into multiple segments. The goal of segmentation is to simplify or change the representation of an image into something that is more meaningful and easier to analyse. Here the fuzzy clustering segmentation is used because of its advantages in segmenting medical images compared to other methods.

C. *Image Enhancement* – This is the second major step. Image Enhancement is the process of adjusting a digital image so that the results are more suitable for display or image analysis. Here the grayscale CT scan image is enhanced into an image with contrasting colours.

D. *Feature Extraction* – Here the ROI (Region of Interest) i.e the lesion region is alone selected and extracted which aids in the classification of lesions.

E. *GLCM (Gray Level Co-occurrence Matrix)* This matrix calculates the texture of the image for the purpose of classification.

F. *Classification* – Firstly it is identified whether the liver contains a lesion or not. If it contains a lesion then it is classified as benign (for eg. Simple cyst, Hemangioma etc) or malignant (eg. Hepatocellular carcinoma).

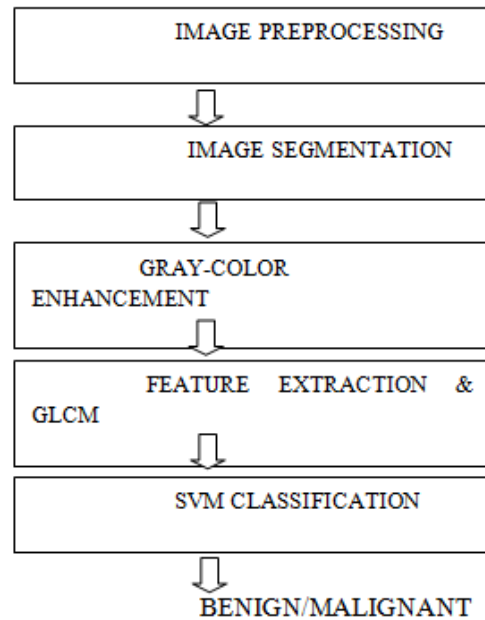The most important steps in this work have been represented in the form of a flow chart as given below.

Fig 1. Flowchart representation of the steps

The main goal of preprocessing is to improve the image quality to make it ready for further processing. Here in the preprocessing step the noise present in the image is removed. The Median Filter is used for this purpose. It is a non linear filter and is efficient in removing salt and pepper noise. It tends to keep the sharpness of the image while removing noise.
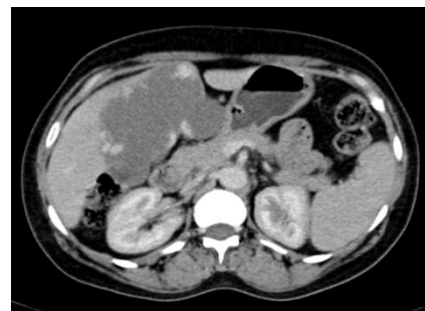

Fig 1: Original Liver CT scan image

Fig 2. CT liver image after preprocessing using Median filter

Image segmentation aims to partition an image ino a set of non-overlapping regions whose union is the original image. The regions that appear the same would produce corresponding features that are near to each other whereas regions that appear different would produce corresponding features that are far apart. Thus the process of segmenting an image is equivalent to the process of grouping image samples with similar features into regions (clusters).

Clustering is the process of partitioning a set of feature vectors into clusters. There are many clustering algorithms, each having its own peculiar characteristic.

The fuzzy clustering method assigns each training vector a set of membership values, one for each cluster, rather than assigning each training vector to one and only one cluster. Since it is more realistic, several research results have indicated that it is superior to the other clustering algorithms. Hence the Fuzzy Clustering segmentation has been used in this paper.

The figure below shows the CT image after segmentation.

Fig 3. Liver CT image after Fuzzy Clustering segmentation

The task of colouring a gray scale image involves assigning RGB values to an image which varies along only the luminance value.

The general procedure for converting the gray-scale image to color image requires a few simple steps as indicated in [2].

Step 1: Each image is converted into the lxy color space. Jittered sampling is used to select a small subset of pixels in the color image as samples.

Step 2: Next each pixel in the gray-scale image is gone though in scan-line order and the best matching sample is selected in the color image using neighborhood statistics.

Step 3: The best match is determined by using a weighted average of pixel luminance and the neighborhood statistics.

Step 4: The chromaticity values (x,y) of the best matching pixel are then transferred to the gray-scale image to form the final image.

Step 5: Color transfer using sample blocks involves the same for the whole image matching procedure but only between the source and target sample blocks.

The colored pixels in the target sample block regions are then used as the source pixels for conversion of color to the remaining non-colored pixels using a texture synthesis approach as in [2].

The figure below shows the CT scan image of the liver after Image Enhancement from gray to colour.
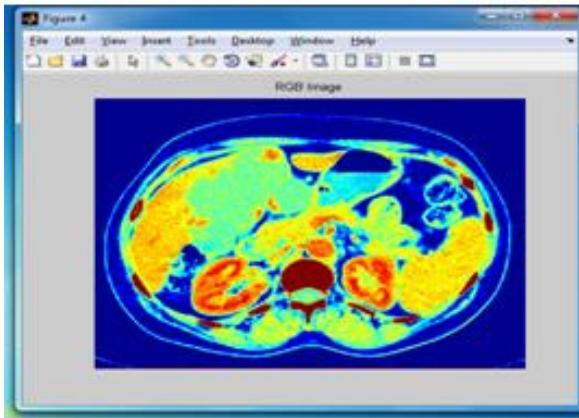

Fig 4. CT Liver image after Enhancement from grayscale to colour

The feature extraction is based on the region of interest (ROI). Initially thresholding operation is carried out to separate out the abnormal lesion from normal liver tissue. The suitable threshold value is obtained from the valleys of the histogram-plot of the pre-processed image. The binary image obtained upon thresholding is now multiplexed with the original input image to correctly produce the segmented liver lesion. This forms the Region of Interest (ROI) for the forthcoming classification process.
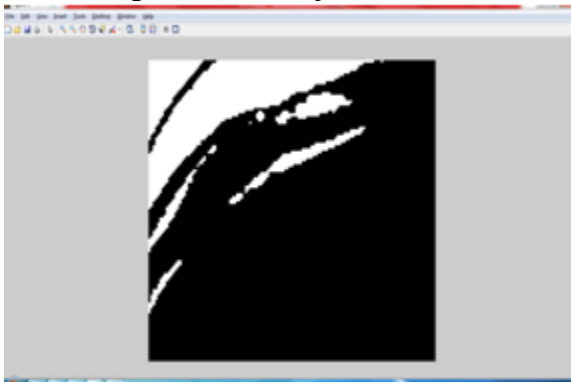

Fig 5. The lesion region (ROI) extracted from the image

The final process is the classification. This utilizes the training dataset to classify the liver lesions. The extracted ROIs can be distinguished as either cancerous or not using their texture properties. Gray Level Co-occurrence Matrix (GLCM) is one of the most popular ways to describe the texture of an image. A GLCM denotes the second order conditional joint probability densities of each of the pixels, which is the probability of occurrence of grey level i and grey level j within a given distance 'd' and along the direction 'θ' as in [3].

Support vector machines are supervised learning models with associated learning algorithms that analyze data and recognize patterns, used for classification The basic SVM takes a set of input data and for each given input, predicts, which of two classes forms the input, making it a nonprobabilistic binary linear classifier. From given set of training examples, each marked as belonging to one of two categories, an SVM training algorithm builds a model that assigns new examples into one category or the other. In the proposed method we are using linear classifier. Best hyper plane is the one that represents the largest separation or margin between the two classes. So we choose the hyperplane so that the distance from it to the nearest data point on each side is maximized. If such a hyper plane exists, it is known as the maximum margin hyperplane and the linear classifier it defines is known as a maximum classifier. This is explained in detail in [3].
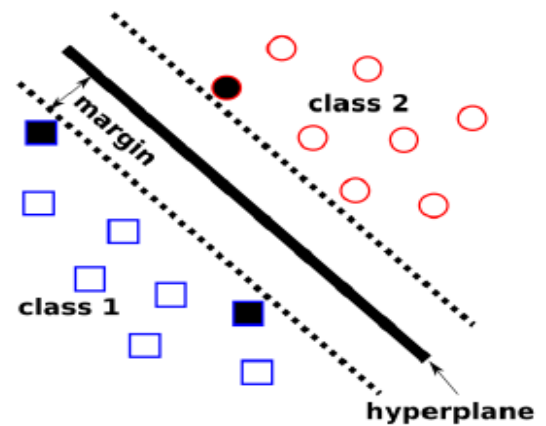

Fig 6. Maximum Margin Classifier

III. RESULTS AND DISCUSSION

For simulation 30 abdominal CT scan images provided by the department of gastro surgery, JIPMER have been taken. These are of 3 patients having simple cyst, hemangioma and hepatocellular carcinoma in the liver and they are of different phases after contrast injection.

Classification results using the Support Vector Machine for a set of 5 CT scan images have been represented below. This method of classification has an accuracy of 96%.

Image	Output
Image_1	Benign
Image_2	Malignant
Image_3	Malignant
Image_4	Malignant
Image_5	Benign

Table 1:Tumor Classification Using SVM

IV. CONCLUSION

In this work the CT scan images have been enhanced from grayscale to colour to indicate the minute differences and for easier diagnosis for clinicians. Also a robust system has been developed to identify if the liver is normal or not and if a lesion present in the abnormal liver it has been classified whether it is benign or malignant. Most of the benign lesions do not require surgery for treatment but a few of them do. But all the malignant lesions are life threatening and therefore surgery is the only option. The gold standard test to identify the type of lesion is biopsy which also involves a surgery to obtain the lesion sample i.e it is invasive. This has been avoided to a certain extent by classifying the hepatic lesions using Image segmentation with about 96% accuracy. In future further classification of the types of benign (e.g simple cyst, hemangioma etc) and malignant (hepatocellular carcinoma etc) lesions shall be attempted with more accurate Image Processing Techniques which may even overcome the need of biopsy.

VI.REFERENCES

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