Liver Image Analysis using Color and Texture Descriptors

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Abstract—Microscopic imaging is increasingly becoming useful in analyzing problems and processing techniques in digital image processing. Liver failure is caused by improper functioning of hepatocyte cells that leads towards various liver diseases if not detected earlier. The automated system is proposed for normal and suspected liver samples detection. Features selection is based on texture and color properties of microscopic images. In classification, SVM classifier with Radial basis function is used to correctly classify the abnormal liver images contained hepatocyte cells. Performance of proposed system is tested on mice liver dataset and 83% accuracy is achieved.

Keywords—Hepatic Failure; Microscopic Images; Color Autocorrelogram; Hepatocytes; SVM Classifier

I. INTRODUCTION

Automated system development in medical imaging has unlocked various opportunities to support medical professionals. Hepatic failure is the massive liver destruction due to abnormal hepatocyte cells functioning. This disease can lead towards various severe liver diseases if not detected and treated earlier. Hepatocytes are liver cells that store proteins and help in synthesizing them. Liver viruses, alcoholism and exposure to toxins are threat aspects causing liver damage that leads towards liver failure. Ischaemic hepatitis, viral hepatitis, alcohol, drugs, cirrhosis are liver disorders that result in improper functioning of liver enzymes in hepatocytes. The objective of this research is to differentiate abnormal hepatocytes images from normal images based on extraction of color and texture based features. Chronic liver injury results in hepatocyte damage, which triggers activation of hepatic stellate cells (HSC) [1]. Hepatocellular damage may be caused by fatty cells change, diffuse or massive necrosis, acute and chronic hepatitis, fibrosis, cirrhosis and granuloma formation [2]. Color and texture based differences can be visually observed in liver microscopic images for discrimination as shown in Figure 1.

Fig. 1: Normal and Abnormal liver image

Infected hepatocytes can synthesize massive quantities of proteins which appear in cells and serum as spheres and tubules 22nm in diameter [2]. Research on liver hepatocytes has not been used for hepatic failure detection in past research. The paper is described in four sections. The related work review is given in section II, proposed method is described in section III, section IV includes results and conclusion is given in section V.

II. RELATED WORK

Computer aided diagnostic (CAD) systems are being developed for automated detection of different diseases [3-5]. The previous methods used for detection and counting of hepatocytes in liver images are at cell level in image processing. They pre-processed their images and used segmentation based methods on dataset of about 5-6 images. There is
need to perform complete image analysis on larger dataset for reliable system performance. Hepatocyte liver cells from microscopic images are counted by automated system [6]. They enhanced their image following by segmentation with local adaptive threshold method. Morphological operations used for cell identification is based on sizes. Counted cells are 88% correctly observed.

M. S Gadkari et al. [7] counted cells by geometric analysis of cells in clusters and improved 17% counting accuracy [6]. They segmented their image and counted total number of liver cells based on shape of clusters. Cell is classified as single cell or cluster based on threshold that depends on its size. C. Boldak et al. [8] used elliptical modeling method to count hepatic cells. They enhanced the cell image fragments with darker nuclei. They approximate the ellipse equation from contour points of cell nuclei.

They calculated the fitness of every ellipse for better performance measure in counting hepatic cells. T. Ivanovska et al. [9] preprocessed liver images by various smoothing filters comparison. They used Otsu’s threshold method for segmentation and Hough transform for detecting hepatocytes in histological images of liver. Sensitivity and specificity measures are used for system performance.

The dataset of mice in normal and abnormal conditions is collected from Ulm university of Germany after inducing FOXO3 proteins to observe the liver changes in the body [10]. FOXO3 is the member of FOXO, subgroup of Forkhead proteins family [11]. This induced proteins results some cell changes in mice liver known as abnormal condition. In this paper, intelligent system is proposed to detect the hepatic failure by identification of abnormal hepatocyte images. Color and texture based differences are visualized to select these features. This feature set of 94 images are used to classify the images based on their color and texture properties.

### III. PROPOSED METHODOLOGY

Hepatic abnormalities have to be analyzed earlier to lessen liver failure occurrence. Hexagonal shape hepatocytes are observed in liver microscopic sample. The presence of hepatocytes with multiple nuclei in liver images indicates the liver image as abnormal hepatocyte image. On this basis, abnormal image is differentiated from normal image as shown in Figure 2. The proposed method follows steps for desired automated system. The proposed methodology flowchart is shown in Figure 3. Our proposed method begins with the data acquisition of liver microscopic image. The input image is analyzed for feature extraction to make feature set based on varying properties. This paper describe color features namely Color autocorrelogram, color moments, color histograms and Gabor wavelet used in extracting texture properties from image.

#### A. Feature Extraction

Hepatocyte in mice liver are analyzed for feature extraction under normal and abnormal conditions.

![Fig. 2: Normal and Abnormal hepatocytes images](image)

Color and texture features are selected because of image visual changes in making 94 feature vectors for classification.

- **Color Autocorrelogram**
This color based feature captures the spatial correlation of same colors information in an image. A color correlogram (henceforth correlogram) expresses how the spatial correlation of pairs of colors changes with distance (the term “correlogram” is adapted from spatial data analysis [12]).

Fig 4: Normal and Abnormal image in RGB Color space

This color descriptor describes local spatial correlation of colors globally and is used to differentiate images effectively [13]. It is easy to compute. Autocorrelogram [14, 15] provides the probability of finding pixels of same color at some specified ‘k’ distance in equation 1.

\[
\gamma_{k}\left(0^{(k)}\right) = \text{Pr}_{p_{1} \in I, p_{2} \in I} \left[|p_{1} - p_{2}| = k\right] \tag{1}
\]

‘p’ describes pixel image of color ‘c’. It provides complex computation but it is more stable to color change, brightness and large changes in image than color histogram.

- **Color Moments**

Color moments describe color distribution of an image. Mean and standard deviation in each channel of color space are calculated. Feature vector of 6 dimension in RGB color space is used in feature extraction. RGB color space results of normal liver image and abnormal hepatocytes image are shown in Figure 4.

- **Color Histogram**

A color histogram captures color distribution in an image. It describes the number of pixel occurrence of each color in image. Different color spaces are used to analyze the color features. HSV color space is used in proposed system to describe color distribution information in each channel of the color space. Normal and abnormal images with their histograms are shown in HSV color space in Figure 5.

![Fig 5: Liver image comparison in HSV](image)

- **Gabor Wavelet**

Gabor filter is used in texture based image analysis. The image used 4 scales and 6 orientation to construct 24 filters. Gabor filtered image results feature vector of 1x48 size as mean square energy and mean amplitude are calculated as texture features of filtered image in feature extraction method.

A. **Classification**

Support Vector Machine (SVM) classifier is widely used to classify the objects into their perspective classes based on extracted features. In proposed methodology, selected number of features is tested. We have implemented automated system that used this classifier with kernels for classification into normal and abnormal hepatocyte images.

<table>
<thead>
<tr>
<th>DATABASE FROM UNIVERSITY</th>
<th>TOTAL IMAGES</th>
<th>NORMAL IMAGES</th>
<th>ABNORMAL IMAGES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ulm University</td>
<td>94</td>
<td>28</td>
<td>66</td>
</tr>
</tbody>
</table>

### IV. EXPERIMENTAL RESULTS

The proposed system for normal and abnormal hepatocytes classification is accomplished using 94 microscopic images database of size 1296 × 972. This liver dataset consists of abnormal images and normal images as shown in Table I. The training
classifier is trained by the shuffled input data. SVM is supervised learning method that discriminates different classes and draw separating boundary between the complex features. In this method, features are classified on the basis of color and texture changes. Each feature is tested by SVM classifier. Confusion matrix of classification results is given in Table II. Least square SVM is applied using LS-SVM toolbox to implement SVM with radial basis function (RBF) kernel. For image classification, 2 cross validation is used for data evaluation. The feature set of 408 features is tested with some SVM kernel: linear, polynomial, quadratic, RBF and MLP. And system performance is evaluated by RBF as results found to be better than other function.

### TABLE II. CONFUSION MATRIX

<table>
<thead>
<tr>
<th>SYSTEM PERFORMANCE</th>
<th>ABNORMAL IMAGES</th>
<th>NORMAL IMAGES</th>
</tr>
</thead>
<tbody>
<tr>
<td>ABNORMAL IMAGES</td>
<td>69</td>
<td>14</td>
</tr>
<tr>
<td>NORMAL IMAGES</td>
<td>2</td>
<td>9</td>
</tr>
</tbody>
</table>

Features are ranked for evaluation and highest accuracy with 200 number of features is achieved as shown in Table III. Features performance is precisely calculated as mean and standard deviation measures. The proposed system provides more than 80% accurate results in classifying correct class.

### TABLE III. SVM WITH KERNEL ACCURACY

<table>
<thead>
<tr>
<th>Kernel Function</th>
<th>Mean ± Std</th>
</tr>
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<tbody>
<tr>
<td>Linear</td>
<td>0.6819 ± 0.15</td>
</tr>
<tr>
<td>MLP</td>
<td>0.401 ± 0.11</td>
</tr>
<tr>
<td>Polynomial</td>
<td>0.779 ± 0.07</td>
</tr>
<tr>
<td>Quadratic</td>
<td>0.80 ± 0.09</td>
</tr>
<tr>
<td>RBF</td>
<td>0.834 ± 0.05</td>
</tr>
</tbody>
</table>

This proposed automated system would be beneficial to ophthalmologists. The methods discussed in literature review could be implemented on this dataset. And the extracted features proposed in this work are easy to compute and are not time consuming.

### V. CONCLUSION

In this paper, proposed system is used to classify the microscopic liver samples into normal and abnormal images. Feature set used color autocorrelogram, color moments, color histogram and texture features for classification with SVM kernels. Detection of abnormal liver hepatocytes earlier by an automated system is important to prevent liver function disorder.

### REFERENCES