Comparative Detection of Kidney Diseases using Ultrasound B-Mode Images

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Abstract—The objective of this work is the computer-aided indication of kidney abnormalities by using local features from given kidney ultrasound B-mode pictures. Features based detection provides the closest structural information such as edges, corners, gradient, orientations, and other local stuff from given images. In this work, detection of kidney diseases has done using Viola-Jones framework with two different features. The features namely Histogram of oriented gradients and Local Binary Patterns are used to detect kidney diseases. The framework is computed using an Adaptive Boosting algorithm with local features. The Algorithm used for this framework would concentrate on the consistency of features at separate iteration of classifiers. These iterations have moved with updated weights. Final results provided based on resultant weight and its reduced rate of weight error. Among these features, Histogram of Oriented Gradient features provides the best results than Local binary pattern feature. The detection accuracy for Histogram of oriented Gradient is given by 96.87%.

Index Terms—Adaptive boosting, Histogram of oriented Gradient, Local binary pattern feature, Ultrasound, Viola Jones

I. INTRODUCTION

The computer-aided medical diagnosis has been playing an important role in the medical industry. Several no of modalities are evolved at present days to diagnose crucial diseases on living beings. Many of the medical devices processing radio waves with the magnetic field would make trouble on some kind of patients. Some kind of devices used ionized radiations would increase the possibility of cancer. Medical Ultrasound imaging [1] is only the device does not process any harmful radiation on diagnosis. It uses the principle of the piezoelectric effect that the transducer produces sound waves on the body and reflected back as an image to the system. Sonography is a real-time diagnostic method not only used to view the static portion of the body and it also used to view the movement of organs blood flow and dynamics of the living body. In order to reduce the radioactive diagnosis, optimized diagnosis through ultrasound images should be developed. Kidney damages are acting as key for critical diseases such as diabetes, hypertension and cardiac diseases. The primary disease of kidney is described as stone. [2] It reduces excretion functionality by blocking filtered content from the kidney region. Second main disease for kidney is specified as Cystic kidney [3]. It has the structure of fluid filled region covered by thin walled membrane, severity of Cyst may lead to abscess.

Third important disease, for kidney is specified as Renal Cell Carcinoma (RCC) [4]. It seems to be a tumor with abnormal growth of cancerous cells even up to upper region of the abdomen. Each disease can be diagnosed through ultrasound imaging in accordance with their property of echogenicity. Generally, images are originated as combination of pixels which contains some intensity values. The geometrical transformation between each pixel with its intensity values would be considered as the feature description. The feature-based detection yields improved accuracy on automatic object detection. The unique pattern of pixel intensities has obtained by moving a simple kernel over the input image. This pattern would be considered as a tool for object detection. In this work, two features namely Histogram of oriented gradients (HOG) and Local binary pattern (LBP) compared for kidney diseases detection

II. RELATED WORK

Ultrasound images usually intruded by multiplicative noises during the image acquisition. Scattering back of sound waves from the tissue region causes the addition of artifacts in the sonogram. Ultrasound play a vital role on renal diseases diagnosis. [5] Various knowledge and discussion have analyzed relevant to urologic ultrasound. The speckle artifacts presence in the sonogram have treated with denoising filters [6] such as scalar and adaptive filters. Adaptive filters are highly responding speckle reduction whereas scalar filters are failed to preserving edge information. Medical images are generally constituting the gray scaled orientations and gradients. So, the texture-based image analysis [7] would produces noteworthy outcomes by perceiving precised homogeneity on input stuff. Local binary patterns descriptors are texture-based feature which is well suited for medical image investigations HOG [8] produces best performances among two different spatial feature extraction methods. The multiple classifier technique implemented with the spatial features. Boosting algorithm [9] is a combination of classifiers nicely worked out in the field of object detection. Adaptive boosting predicts the object based on binary classification problem. Boosting [10] is used for image segmentation with supervised label has produced the significant results.

III. CONTRIBUTION TO THE WORK

In this work, various kind of diseases have been detected by the proposed framework. This paper organized as follows
IV. METHODOLOGY

A. Preprocessing

The variations occurred in transducer during the transmission of sound waves produces speckle patterns. These patterns are muddled edge information on input image. In this work speckle noises are reduced using a special kind of filter named as Anisotropic diffusion filter (ADF). ADF is a nonlinear diffusion proposed by Perona Malik model [11] which effectively reduces the speckle content present in the image. The objective of this model is coming from the equation (1)

\[ u_t = \frac{\partial u}{\partial t} = div (g \parallel \nabla u \parallel^2) \cdot \nabla u \]  

Where \( u \) is the state of noisy image with diffusion coefficient, \( g \parallel \nabla u \parallel^2 \) is represented as amount of smoothing has performed with respect to x and y coordinates.

Given Fig. 1. (a) denotes the 640X 480-dimension input ultrasound image, Fig. 1. (b) Speckle reduced and preprocessed ultrasound sound image.

B. Detection of Kidney Diseases

In this section, detection of kidney diseases has performed using two methods. First method described about feature extraction and second method described about classification for detection. The two important spatial feature extraction method is used for this work is namely HOG and LBP. For diagnosing the portion of diseases have done using Adaboost classifier.

1. Feature Extraction Using Local Binary Pattern

Local binary pattern (LBP) [13] is a vision feature set yields by using texture information of an image.it sets label for neighborhood pixels in accordance with center pixel. The labelling of each pixels is based on binary thresholding. Let 3X3 size of image have 28 combination with 256 labels have assigned to the neighborhood pixels. For the circular neighborhood a sampling value p is taken around Radius r. The following equation depicts the evolution of local binary circular pattern.

\[ LBP_{p,r} = \sum_{n=0}^{n=2^6-1} s(x_{r,n} - x_{0,0})^{2^n} \]  

\[ s(x) = \begin{cases} 1, & \text{if } x \geq 0 \\ 0, & \text{if } x < 0 \end{cases} \]  

\[ \phi_{ij} = \tan^{-1} \left( \frac{y_{ij}}{x_{ij}} \right) \]  

\[ m_{ij} = \sqrt{x_{ij}^2 + y_{ij}^2} \]  

Where p and r represent sampling point and radius of the kernel, n represent the number of labels produced by the LBP.

![Fig. 1. (a) Input Ultrasound image Fig. 2. (b) Preprocessed output image](image)

![Fig. 3. (a) 3X3 Input image, (b) Labelled image, (c) Pattern obtained after labelling](image)

Above fig. 1.1. represents 3X3 input image, Binary label obtained based in thresholding with use of center pixel and fig. 1.1. (c) describes pattern obtained after labelling.

2. Feature Extraction using Histogram of Oriented Gradients

HOG [12] is the vision feature sets acquired based on local information of an image. Hog feature mainly focused on gradient magnitude and orientation of an image. The histogram of gradient and orientations have calculated after dividing an image in to subsets. It processes closely compacted cells of image matrix and uses overlapping local contrast normalization for precise detection. It is invariant to the image transformation for both geometric and photometric. The following steps has been used for describing HOG features.

i. Division of input image as sub called cells, and for each cell compute a histogram of gradient directions or edge orientations for the pixels within the cell.

ii. Discretize each cell into angular bins according to the gradient orientation

iii. First input image has preprocessed with single dimension derivative mask is applied with both vertical and horizontal direction it would makes easier for image gradient computations. The discrete derivative mask is given by

\[ H_x = [-1, 0, 1] \]  

\[ H_y = [-1, 0, 1]^T \]  

\[ X = [x_{ij}] = G \odot H_x \]  

\[ Y = [y_{ij}] = G \odot H_y \]  

iv. Compute angle for gradient of each subdivided cell by using the equation (3)

\[ \phi_{ij} = \tan^{-1} \left( \frac{y_{ij}}{x_{ij}} \right) \]  

and length of the gradient vector magnitude is calculated by using equation (4)

\[ m_{ij} = \sqrt{x_{ij}^2 + y_{ij}^2} \]
After computing angle and gradient magnitude of the input image, the 9-bin unsigned histogram bin has been created. The values of the orientation and the gradient magnitude is compared and placed into the corresponding bin.

![Image](image1.png)  
**Fig. 2.** (a) input ultrasound(b) Hog feature extracted image.

Above figure 2. (a) shows input ultrasound image for feature extraction and 2. (b) shows the HOG feature extracted image.

<table>
<thead>
<tr>
<th>Bin</th>
<th>Frequency</th>
</tr>
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<tbody>
<tr>
<td>0-10</td>
<td>4</td>
</tr>
<tr>
<td>10-20</td>
<td>6</td>
</tr>
<tr>
<td>20-30</td>
<td>8</td>
</tr>
<tr>
<td>30-40</td>
<td>10</td>
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<td>80-90</td>
<td>20</td>
</tr>
<tr>
<td>90-100</td>
<td>22</td>
</tr>
</tbody>
</table>

![Image](image2.png)  
**Fig. 4.** (a) HOG orientation of the image, Fig. 4. (b) gradient magnitude of the image, fig. (c) descriptor bin

The above given images Fig. 4. (a) represent HOG orientation of the image, and Fig. 4. (b) represent gradient magnitude of the image, the values corresponding to orientation and magnitude is placed in histogram bin showed in fig 4. (c) Finally, 144 hog feature vectors is consumed from 4X4X9 Matrix.

3. Adaboost classifier for detection of kidney diseases

AdaBoost [14] may be a common boosting technique that helps you mix multiple weak classifiers into one strong classifier. Generally weak classifiers are inefficient to find the correct samples on learning. Misclassification may due to lack of information on learning with weak classifiers. For this algorithm the two type of classes has been used namely positive diseased image and negative image normal images. Both samples have been trained with weight. The weighted error rate has predicted on training of weak sample distribution. Update the weights until the point that accomplishing an insignificant error rate. The trained sample with reduced error rate has been taken as strong classifier, Fig 4. describes the architecture of Adaboost classifier

![Image](image3.png)  
**Fig 5: Adaboost classifier architecture**

The above algorithm $x_t$ represents the domain of samples and the $y_i$ denotes the class of the samples whether it is diseased or non-diseased. $D_t$ denotes the distribution of samples with the classifiers. The weak sample of the classifiers have denoted by $h_t$. The $\epsilon_t$ error rate is calculated with weak samples of classifier $D_t$ and $h_t$. The final strong classifier for the diseased samples is given by $H(x)$.

![Image](image4.png)  
**Fig 6.** (a) input ultrasound, (b)Cyst detected using Adaboost algorithm.

Above Fig. 6. (a) shows input ultrasound image and Fig. (b) represents Cyst detected kidney image.

V. EXPERIMENTAL RESULTS

1. Training with Adaboost classifier

Ultrasound b mode images have collected from various renal specialty clinics. Input images have been resized in to 640 X 480 dimension 300 images with different category has subjected for processing. For training 210 images with diseases and non-diseased images has taken. Two types of features namely Hog and LBP are used for training. For testing 90 images with diseased and non-diseased images have taken. Detection of kidney diseases using HOG features shows the best results than LBP feature.

2. Performance measure

The performance measure for detection of kidney diseases have computed based on findings of predicted results. The following factors such as true negative false positive and false negative are considered for calculating accuracy, precision,
Recall, f-measure and other performance metrics. In this work confusion matrix given in table 1 and 2 is devised for obtaining a performance measure.

<table>
<thead>
<tr>
<th>Detection of Kidney Diseases</th>
<th>Accuracy (%)</th>
<th>Precision (%)</th>
<th>Recall (%)</th>
<th>F-Measure (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>HOG</td>
<td>91.11</td>
<td>97.61</td>
<td>97.61</td>
<td>97.61</td>
</tr>
<tr>
<td>LBP</td>
<td>83.69</td>
<td>93.75</td>
<td>96.75</td>
<td>95.22</td>
</tr>
</tbody>
</table>

The below table 3. shows the comparative performance metric is calculated based on confusion matrix

VI. CONCLUSION AND FUTURE WORK

In this work renal ultrasound images are taken to detect the various type anomalies present pelvic kidney region. Boosting based detection is used for diseases detection. Two important features namely local binary pattern and Histogram of oriented gradient have used for detection of various kidney diseases, LBP computes minimal description while compared to HOG features. It only concentrates on labeling of neighborhood elements whereas HOG computes gradient magnitude and as well as orientation of the input image, so the detection performance for the kidney disease using Hog feature is slightly greater than LBP feature. In future, detection methods would focus on more invariant techniques for precise detection accuracy.

REFERENCES


