CHAPTER 7

CONCLUSION

7.1 SUMMARY OF THE THESIS

Digestive system is one of the most important systems in which the stomach plays a major role. Many people around the world are suffering from stomach dysrhythmias associated with gastric motility disorders such as dyspepsia (improper digestion), unexplained nausea (vomiting sensation), vomiting, abdominal pain, stomach’s ulcer, gastroesophageal reflux diseases, etc., due to junk food, adulteration, etc. In today’s world, the physician is diagnosing the digestive disorders using endoscope which is an invasive one. EGG is a non-invasive procedure which acts as a preliminary investigation before the endoscopy procedure. In this thesis, several methods are proposed for acquisition of EGG. Analysis of the recorded EGG signal for classification of digestive system disorders is performed using statistical parameters, wavelet transform based approach and neural networks.

7.1.1 Proposed Methods of EGG Acquisition

EGG acquisition is performed with five different approaches namely Method A, Method B, Method C, Method D and Method E. These methods are a non-invasive and painless because the detection of electrical signal is performed cutaneously from the stomach. It is an initial mode of investigation for gastric disorders before encouraging the Endoscope
procedure for uncomplicated gastric disease and benign. The detection of normal subject and abnormal subject is achieved initially by microcontroller, using passive electrode with virtins software in visual basic software. Then the set-up is slightly modified by replacing the microcontroller with DAQ and LabVIEW software. Further it is improved by replacing the passive electrodes by active electrodes and to make the acquisition system cost effective, a datascope is used instead of DAQ. Complete database is created with different age groups and sex for more than thousand samples in each category for both preprandial and postprandial condition in consultation and guidance of the physician. Based on the quality of the signal acquired, Method E with active electrode, improved signal conditioning unit, biokit software along with datascope gave clean EGG signal that was used to create the database with conditional probability.

7.1.2 Statistical Analysis of EGG

Statistical analysis of EGG is performed with the statistical parameters such as Mean, Root Mean Square value (RMS), Kurtosis, Mode, Median, Variance, and Standard Deviation. Approximately 490 samples randomly selected, as 70 samples for each subject are considered for the statistical analysis. The data acquired for both preprandial and postprandial condition is used to fix the frequency range and amplitude as a threshold value for various disorder subjects and normal subjects in consultation and guidance with the physician.

Comparison is done under preprandial condition and postprandial condition for the various disorder subjects and normal subject with respect to key parameters frequency, amplitude and power spectrum along with statistical parameters. In addition to this analysis and comparison, the
correlation values are calculated for 70 samples of different disease condition. It is observed that the correlation values of various diseases included for the investigation differs significantly from that of the normal subject. Further, Navie Bayseian Classification is performed and 78% sensitivity, 96.3% specificity and 78 % classification Accuracy is observed.

7.1.3 Wavelet Analysis of EGG

In Wavelet analysis, the EGG signal is analyzed with Continuous Wavelet Transform (CWT) and Discrete Wavelet Transform (DWT). In CWT, the db4 wavelet is used to get wave pattern of EGG signal in 3D plot using MATLAB. From the plot, it is observed that the presence of peak pattern to represents the cycle of EGG signal. EGG is classified according to number of peaks present. The normal subject have 3 cpm indicated by 3 peaks, where as bradygastria, dyspepsia, nausea, tachygastria, ulcer and vomiting have 1.5cpm, 4cpm, 3.5cpm, 8cpm, 7cpm and 6cpm respectively for the signals obtained from the physician. The recorded EGG in the laboratory setup showed irregular peaks and Sensitivity 83.5%, Specificity 97 % and Classification Accuracy 82.5% was found.

In DWT, EGG signal is subjected to 3 levels of decomposition with Daubechies mother wavelet i.e., first decomposed using db4 wavelet till level 3. The wavelet coefficients approximation and detailed measured. The Sensitivity 88.5%, Specificity 98 % and classification accuracy 87% was found.
7.1.4 Neural Network Based Classification

Neural Network models are developed for the classification of EGG signals. ART1-NN, LVQ and ANN with MRAN algorithm are used to investigate the digestive system disorders with EGG data from the database. MRAN algorithm fixed 15 neurons in the hidden layer for maximum efficiency and it is also observed that the classification accuracy is around 96% for the number of hidden neurons 15 and above. The configuration of network is fixed as 60-15-7 and this network is trained with 9 different training algorithm for different error goals 0.1, 0.01 and 0.001. The epoch, time and performance are tabulated and plotted to rank the training algorithms for the classification of digestive system disorders. Based on confusion matrix, the Sensitivity, Specificity and Classification Accuracy determined for ART1 NN is 71%, 95% and 69.5% respectively, for LVQ NN is 91%, 98.4% and 92% respectively and for BP-MRAN NN it is found to be 94%, 98.5% and 96% respectively. The BP-MRAN with RP algorithm gave the best performance.

7.1.5 Fuzzy c-means clustering

Fuzzy c-mean algorithm is applied to the EGG signals to investigate the digestive system disorders. The number of clusters was fixed as 7 corresponding to 7 classes of EGG signals, the termination criterion is fixed as ε= 0.00001 or maximum number of iterations as 100. Comparative study shows that better results are obtained with FCM. 97% Sensitivity, 98.8% Specificity and 97% Classification Accuracy was obtained for 500 sample data set.
7.2 PERFORMANCE COMPARISON

Consolidating the work made, Table 7.1 list the Sensitivity, Specificity and Classification Accuracy obtained for various techniques applied in this thesis for the classification of EGG signals. Analyzing the various classification methods, it is noted that both the Sensitivity and Specificity of FCM are the highest compared to those of other techniques. Hence classification accuracy is also the highest for FCM. This is because FCM is unsupervised and it always converges. The next better classifier is Back Propagation Neural Network with MRAN. This is because of the relative contribution of each hidden neuron to the overall network output. The time complexity is also less for FCM. So, it is concluded that, of all the seven techniques, Fuzzy c-means clustering technique is the best, giving 97% classification accuracy with computation time of about 8 seconds compared to all other techniques. The analysis made may support the physician towards the investigation of the digestive system disorders noninvasively using EGG with fair amount of accuracy before going in for the endoscopic procedure which is an invasive technique.
Table 7.1 Performance comparison of all techniques

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Techniques</th>
<th>Sensitivity %</th>
<th>Specificity %</th>
<th>Classification Accuracy %</th>
<th>Time (Seconds)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Naïve Bayesian Classification [NBC]</td>
<td>78.0</td>
<td>96.3</td>
<td>78.0</td>
<td>45</td>
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<tr>
<td>2</td>
<td>Continuous Wavelet Transform [CWT]</td>
<td>83.5</td>
<td>97.0</td>
<td>82.5</td>
<td>36</td>
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<td>3</td>
<td>Discrete Wavelet Transform [DWT]</td>
<td>88.5</td>
<td>98.0</td>
<td>87.0</td>
<td>30</td>
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<td>4</td>
<td>ART1 Neural Network</td>
<td>71</td>
<td>95.0</td>
<td>69.5</td>
<td>53</td>
</tr>
<tr>
<td>5</td>
<td>Learning Vector Quantization [LVQ NN]</td>
<td>91</td>
<td>98.4</td>
<td>92.0</td>
<td>24</td>
</tr>
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<td>6</td>
<td>Back Propagation Neural Network with MRAN</td>
<td>94</td>
<td>98.5</td>
<td>96.0</td>
<td>15</td>
</tr>
<tr>
<td>7</td>
<td>Fuzzy C-means Clustering [FCM]</td>
<td>97.0</td>
<td>98.8</td>
<td>97.0</td>
<td>8</td>
</tr>
</tbody>
</table>
7.3 FUTURE WORK

The following are a few constructive suggestions for future work.

- Database creation can be extended for disorders other than that mentioned in this thesis like diarrhea, heartburn, hepatitis etc.

- Cross correlation values of the different disorders can be considered as an input to the neural network for further classification.

- The threshold values obtained for the classification digestive system disorders with wavelet analysis can be considered as an input to the neural network to improve the correct classification efficiency to maximum by selecting suitable neural network.

- Specific disorders of EGG and endoscope image can be correlated in the investigation of digestive system disorders like cancer.

- An expert system can be developed as an aid for the physician to determine the type of disorder.