**6. RESULTS AND CONCLUSIONS**

**6.1. Results**

The simulation results of the speech recognition system are obtained using LPC, MFCC, and Spectrogram feature extraction techniques. At first step set of words for training and test steps are selected. The system is trained with set of words and tested with other words. Two groups of 30 words are taken. Every word was recorded two times. The feature extraction methods (LPC, MFCC, and Spectrogram) are applied, and then ANN is used for pattern matching. The neural network was designed using various numbers of hidden layers. For each ANN the Recognition Rate (R.R) was obtained as shown in table 6.1.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| No. of hidden  layers  Method | 1 hidden layer | 2 hidden layers | 3 hidden layers | 4 hidden layers |
| LPC | **73.3 %** | 73.3 % | 66.67 % | 66.67 % |
| MFCC | **83.33 %** | 70 % | 73.3 % | 66.67 % |
| Spectrogram | 73.33 % | 70 % | **76.67 %** | 63.3 % |

Table 6.1: Recognition rates of the system for not trained words.

For each method the numbers of neurons in the input layer are different. The number of input neurons for LPC method was 420, for MFCC was 613 neurons, and for Spectrogram was 4235. In hidden layers the number of neurons also differs depending on the method used in feature extraction stage. Because of every method uses different number of output data, the number of neurons in hidden layer was computed according to equation (6.1).

Where *H* is the number of hidden neurons, *N* is the number of input neurons, *M* is the number of output neurons, and *T* is the number of input data (number of input neurons multiplied by number of trained words).

In next stage the simulation results were obtained using trained words. Different numbers of hidden layers were used for testing the network, and the R.R was obtained for each example. Table 6.2 shows the simulation results of speech recognition system using different method and different number of hidden layers.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| No. of hidden  layers  Method | 1 hidden layer | 2 hidden layers | 3 hidden layers | 4 hidden layers |
| LPC | 100 % | 100 % | 100 % | 100 % |
| MFCC | 100 % | 100 % | 100 % | 100 % |
| Spectrogram | 100 % | 100 % | 100 % | 100 % |

Table 6.2: Recognition Rates of the system for trained words.

The same values of training parameters of artificial neural network used for not trained words were used for trained words.

In next step the simulation results were obtained using trained words. In this simulation different rates of SNR in dB were added to the speech signals. 30dB, 20dB, 15dB, 10dB, and 5dB were added to the speech signals for every method. The result recorded in Table 6.3 shows the relationship between R.R and SNR for LPC, MFCC, and Spectrogram respectively.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| SNR  Method | 30 dB | 20 dB | 15 dB | 10 dB | 5 dB |
| LPC | **70 %** | 26.6 % | 20 % | 16.67 % | 23.3 % |
| MFCC | **100 %** | 96.67 % | 96.67 % | 96.67 % | 96.67 % |
| Spectrogram | **100 %** | 100 % | 100 % | 93.3 % | 86.67 % |

Table 6.3: Recognition rates of the system for trained words with different values of SNR.

**6.2. Conclusions**

In this thesis Isolated words Speech Recognition system was designed using MATLAB program. Three different feature extraction methods (LPC, MFCC, and Spectrogram) and ANN based classification were used to develop the system. The system was tested with trained and not trained words and the results were recorded as Recognition Rate (R.R).

Simulation results have shown that LPC method has less number of output data (420 neurons in the input layer of the network) comparing with other two methods (613 neurons for MFCC method, and 4235 neurons for Spectrogram method). The best recognition rate achieved with not trained words was 73.3 % and the best recognition rate achieved with trained words was 100 % without adding noise to the speech signals. This means that this method is not useful for noising speech signals.

Using MFCC and Spectrogram methods and trained words better recognition rates were achieved. For MFCC method the R.R was 83.3 % with not trained words and 100 % with trained words. For Spectrogram method the R.R was 76.67 % was achieved with not trained words and 100% with trained words. The performance of MFCC method is better than Spectrogram method. The number of the output data for MFCC method was 613, and for Spectrogram method was 4235. The MFCC method was not affected by noise as seen in table 6.3. The results of Spectrogram method was affected in high noise (5 dB SNR). The number of hidden layers in the neural network does not affect the results of the system (just small effect with not trained words, and no effect with trained words).

Speech recognition system was designed using MATLAB package. MATLAB is a good environment to develop different feature extraction method. For classification purpose artificial neural networks was used. Different structures were tested for synthesis of the optimal architecture of N.N based speech recognition System.