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Feasibility of Less Complex Viterbi Decoder Based on Neural Networks for Effective Transmission of Medical Images

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Abstract

Convolution coding is the most commonly used channel encoding technique for reliable data transmission. At the receiver's end, Viterbi decoder is used for extracting the message bits. Though these decoders can correct any number of errors, complexity of the decoder increases with the number of bit errors. Hence research began in this area, to design decoders which are less complex and yet provides accurate results. In this paper, a five layered feed forward neural network is developed to decode the image pixels which are convolutionaly encoded. The decoded intensities are then converted into an image and the edges are detected from the images. Edges are regarded as useful information because segmentation of the Region of Interest (ROI) is performed on the edge detected image. Performance of the proposed technique is measured in terms of Root Mean Square Error (RMSE) and Peak Signal to Noise Ratio (PSNR). It is found that irrespective of the images, RMSE is significantly less and PSNR is high and the true edges are retained in the image. The proposed technique is scalable as it is not dependent on the size of the image but on the gray levels of the image.

Keywords: Convolutional coding, Viterbi decoder, BPN, PSNR, RMSE

1 Introduction

In this technological era, large number of videos/images is transmitted and received through internet in the areas of telemedicine, defense, videoconferencing etc. It is essential to ensure reliable image communication especially in the areas of telemedicine and defense. In spite of highly efficient source encoding techniques, errors are introduced due to noise in the wireless channel. Claude Shannon proposed that reliable communication is possible in noisy channel if the code rate is lesser than the channel capacity. It led to the invention of Reed-Solomon codes, convolution codes, Turbo codes and LDPC codes for channel encoding and decoding. Of the above codes, convolution codes are the most widely used codes for channel encoding. Here the code bits are generated using ex-or gates from the time shifted message bits. These codewords are then sent through the channel. At the receiver’s end, Viterbi decoders are used to obtain the message bits from the codewords [5]. Viterbi decoders use Trellis diagram for decoding the bits. It is capable of correcting n-bit errors efficiently. If ‘n’ increases the time and area complexities of the decoder increases. Hence it is necessary to develop a less complex, low area high speed architecture that accurately decodes the message bits.

In this paper, feasibility of soft computing technique for determining the message bits from one-bit corrupted codewords is studied. A five layered Back Propagation Network is used for obtaining the message bits from the corrupted codewords [6, 7, 8]. Instead of choosing random numbers for testing, the proposed technique is tested with image intensity values and performance is measured in terms of Root Mean Square Error (RMSE) and Peak Signal to Noise Ratio (PSNR) for the edge detected image. This paper is organized as follows section II describes the related work, section III proposed methodology, results are discussed in section IV, section V provides the conclusion and future work.

2 Related work

In recent years, considerable research is carried out to use neural networks for decoding convolutionaly encoded message bits. In this section a brief survey is provided on the application of Back Propagation Network and recurrent neural network (RNN) for replacing Viterbi Decoder.

Qolamrez Nadalinia charei et al (2013) proposed a multi-layer perceptron consisting of three layers for implementing soft decision in Viterbi decoders. The proposed network had 12 neurons in the input layer 24 neurons in the hidden layer and 1 neuron in output layer. The network is trained with Scaled Conjugate Gradient (SCG). Here convolutional codes are generated, BPSK modulated and added with AWGM noise for certain SNR. The neural network is trained with 1000 exemplars (1dB SNR) and tested with 1000 exemplars. The proposed technique decreased bit error rate even for lesser SNR, thereby improving the performance of the system. Padma Priya et al (2013) used ANN for reducing BER in Viterbi decoder. The proposed technique involves the following steps: Initially binary data is convolutionaly encoded and are converted into OFDM symbols. At the receiver's end, Viterbi decoder is implemented using multilayered perceptron. Also the performances of various modulation techniques were analyzed. It was found that BPSK provided the best results when compared to other techniques.

Klaus Hueske et al (2007) proposed recurrent neural network (RRN) based Viterbi decoder in order to reduce the decoding errors of Viterbi decoder, the number of neural activation function and step values of RRN are optimized. It is found that sigmoid function provides better results than signum function in terms of bit error rate. Inverse encoder initialization technique is used for initializing the weights of the neurons. It resulted reducing the computational complexity by decreasing the number of iteration needed to obtain the desired BER. Hence the proposed optimized RNN provides better results than the conventional ANN technique.

Edmund Coersmeier et al (2007) used unsupervised RNN for decoding convolution codes. BER and number of iterations are optimized. In order to reduce the computational complexity, the number of self-feedback of the neurons is adjusted. Mean field annealing is used for obtaining the global minima instead of local minima. The proposed technique resulted in higher speed due to the hardware implementation. Steven M Berber et al (2004) strongly believed that artificial neural network can be used for decoding convolution codes. Viterbi decoder was realized with a RNN form different decoding cases namely parallel and sequential technique and total search method. Additive white Gaussian noise was introduced and the performance was measured in terms of BER for data blocks of 100 bits. It was found that even for lower SNR, the proposed decoder performed better than conventional techniques.

3 Proposed methodology

Initially a set of mammographs are obtained from Mini-Mias database. The images are converted into gray scale. Gray level intensities of the pixels are obtained. Eight bit binary equivalent is obtained for the intensities of the image. Convolution coding are obtained for the eight bit binary equivalent of the pixel intensities. The block diagram of the proposed neural network for convolutional coding and decoding are shown in Fig 1- 2 respectively.

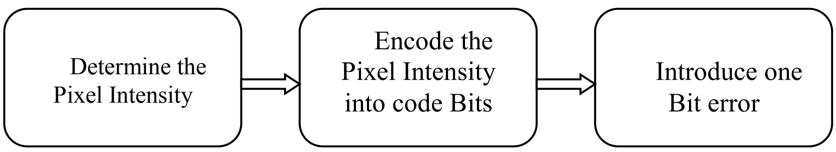

Fig.1. Encoding at the transmitter end

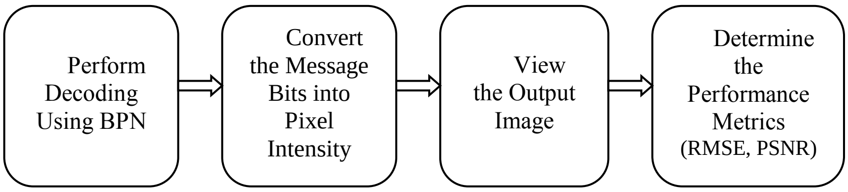

Fig.2. Decoding at the receiver end

Five layered Feed forward network architecture is used for encoding and decoding the message bits using convolutional coding. It consists of an input layer, three hidden layers and one output layer. The number of neurons in the input and output layer is 8:10 respectively for encoding and 10:8 for decoding. The number of hidden layers and neurons in each hidden layer are left unchanged. The activation functions for the hidden and output layers are tansigmoidal and pure linear respectively.

In the forward direction (Using feed forward network, one bit error is introduced in the code word. These code words are then fed to the neural network to obtain the message bits. Once the message bits are obtained at the decoder's end, the decimal equivalent is obtained and the intensities are fixed in the appropriate co-ordinate positions. The image is then displayed for subjective analysis. Edges are then obtained using canny edge detector. Of the various image processing operations, edge detection is specifically chosen because it is an important step in image segmentation used for abnormality extraction. In order to assess the performance of the proposed architecture, edges are also obtained for the original mammograph image. Performance is measured in terms of RMSE and PSNR between the edges of the actual and the received edges.

4 Results and discussion

In this work, three different mammograph images are considered with different size, shape and position if the tumor region. The spatial resolution of the mammograph is 314 X 235. Pixel intensities range from 0-255. Pixel intensity is represented with its eight bit binary equivalent. One bit convolutional coding for the pixel intensities is obtained with the neural network in order to have randomness in the error. Message bits obtained from the noisy convolution codes are used for reconstructing the mammographs at the receiver's end. Gray scale version of two mammographs is shown Fig 3.

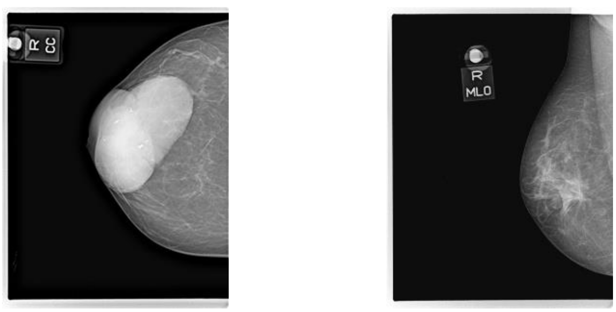

Fig. 3. Original mammographs depicting cancer

In the first mammograph, caner is depicted as a definite higher intensity region whereas in the second mammograph, cancer region is not that clearly visible. Fig 4 depicts the reconstructed mammographs. From the images, on subjective analysis, it is found that the reconstructed images are an approximate reproduction of the original images.

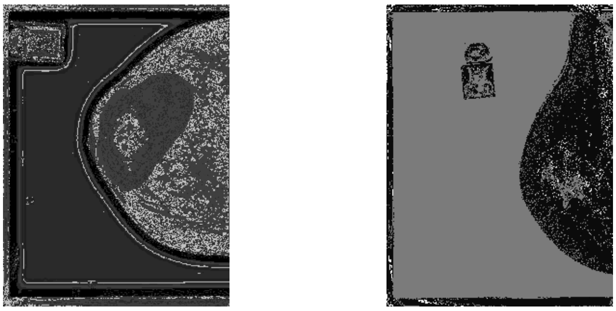

Fig. 4. Reconstructed mammographs

Fig 5 and 6 depict the edges of the original and reconstructed images. From the Fig 5 and 6 it is found that the actual edges are retained in the reconstructed images. Root Mean Square Error (RMSE) and PSNR for the edge images are shown in Table 1. From the Table, it is found that irrespective of the input mammograph images, RMSE is less and PSNR is significant.

Fig. 5. Edges from the original mammographs

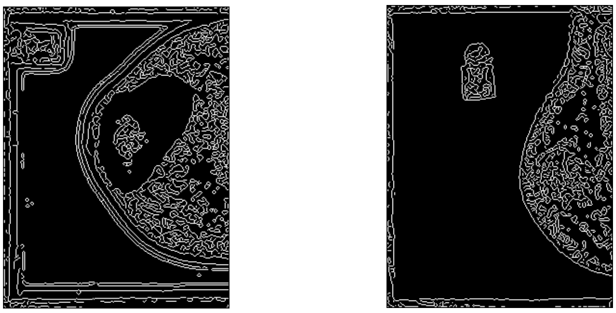

Fig. 6. Edges from the reconstructed mammographs

Table 1: RMSE and PSNR between edge detected images

Image	RMSE	PSNR
Image #1	0.3849	17.8308
Image #2	0.4044	16.805
Image #3	0.3652	18.8811
Image #4	0.3244	21.2502
Image #5	0.3187	21.6027

It is found that as the number of edges increases, RMSE decreases and PSNR increases. On the other hand when the number of edges decreases, RMSE increases. Hence the proposed technique is suitable for low resolution mammographs.

5 Conclusion and future work

In this paper, an efficient neural network based Viterbi decoder is designed for obtaining the message bits from one bit error convolution codes. The performance of the proposed technique is assessed in terms of its ability to effectively reconstruct the images. It is found that the proposed technique results in less complex networks which result in an efficient reconstruction of mammographs. The proposed method retains the edge information and removes the psycho visually redundant data from the image. Higher PSNR and lower RMSE is obtained for low resolution images.

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