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Investigation of Effective Decoding Technique for Convolutional Codes

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Abstract: *Error detection and correction codes are essential for wireless communication to ensure the reliable transmission of data. It helps to mitigate the drawbacks in a noisy transmission channel. The decoder at the receiving end will first employ the error-correction bits to determine whether there is an error in the received data, and then to correct the errors if they fall within the error-correction capability of the code. One such error correction technique is convolutional coding. The objective of this paper is to analyze the bit error performance of different decoding techniques of convolutional code and ensures an effective decoding technique with improvement in performance. Several decoding techniques of convolutional code reduces the bit error occurs through transmission but a better performance can be obtained with the iterative decoding method of convolutional codes.*

Keywords - *Convolution code, cyclic redundancy check, multiple attempt decoding, Puncturing, Viterbi algorithm.*

I. INTRODUCTION

Efficiency and reliability of data transmission in wireless communication depends on the factors fading and interference in the channel. These effects can be mitigated by forward error correction techniques. Convolution and block codes are the two main categories of forward error correction codes. Block codes are processed in block wise manner. Examples of block codes are hamming code, reed Solomon code, turbo codes, Low parity check codes etc. The information bits are spread along the sequence in convolution code. These codes are mostly decoded with the technique called viterbi decoding. Convolution codes are simple to implement and has many real time application over block codes. As the constraint length of the convolutional code increases decoding process becomes more complex. This paper deals with the comparison of different decoding techniques to reduce the bit error rate and system complexity. The paper has been organized as follows: Section II explains related works on decoding algorithms of convolutional codes. Section III includes the Iterative decoding Algorithm of convolutional codes and section IV includes simulation and results of iterative decoding. Section V concludes the paper.

II. RELATED WORKS

2.1 Conventional Viterbi algorithm

Conventional Viterbi algorithm [1] exhibits and exploits fundamental property of convolutional codes. It decodes an L branch tree by performing L repetitions of one basic step. The decoder considers all q^k paths for the first K branches, where K is the branch constraint length of the code and computes all q^k likelihood functions. The decoder then compares the likelihood function for the q paths. It thus performs q^{k-1} comparisons each among q path likelihood functions. The path corresponding to the greatest likelihood function in each comparison is denoted as survivor. Only the q^{k-1} survivors of as many comparisons are preserved for further consideration; the remaining paths are discarded.From the simulation results [1] it is clear that with the Viterbi decoding algorithm we can obtain a SNR of around 8dB at a BER of 10^{-3}, whereas SNR of around 9.5dB is obtained for the uncoded data.ie, 1.5dB gain is provided by Viterbi algorithm.

2.2 List Viterbi Decoding

This algorithm [2] produces a list of L globally best path after a trellis search. LVA can be applied to a concatenated communication system which consist of an inner code (convolutional) and an outer code (error detecting code).Analysis of LVA shows that gains of 3-4.5db are obtained at an error probabilities of about 10^{-4} when the inner decoder, which is a conventional Viterbi decoder, is replaced by the LVA. Two algorithms of LVA (i) Parallel LVA,(ii) Serial LVA are presented here. Parallel LVA finds the L best Candidates simultaneously by computing the best L paths at every time instant. Serial LVA iteratively produces the k^{th} best candidate based on the knowledge of previously found k-1 candidates. Since it computes the k^{th} best candidate only when the previously found k-1 candidates are in error, it avoids many unwanted computations of the parallel algorithm. It results in an increase in effective time diversity of code. This will in turn results in an increasing coding gain with increased SNR. Gain of 3-4.5 is obtained at an error probability of about10^{-4}.

2.3 Combined LVA and SOVA
Comparison of the LVA and SOVA (soft output Viterbi algorithm) results in an extended versions of LVA and SOVA with low complexity. List-SOVA uses the reliability information of the SOVA output to produce a list of L best path by List VA and has a complexity lower than that of conventional LVA. Another algorithm called Soft-LVA (Soft Symbol Output Viterbi algorithm) accepts the list output of the LVA and calculates the reliability information of each decoded information bits. Compared to the LVA, the List-SOVA is superior for short block lengths and average SNRs or long block lengths and high SNRs superior. This superiority is obtained due to the cost of far higher decoding delays than for the LVA and a higher complexity than the LVA for short lists. Comparison of Soft-LVA with the LVA [4] shows that coding gains of about 1.0db with a list of 16 can be obtained with the Soft-LVA. The SOVA achieves in the same comparison coding gains about 1.4 db.

2.4 Continuous List Viterbi Algorithm
To obtain a combined error correction-detection decoder a communication system can be implemented with concatenated convolutional codes and cyclic redundancy check (CRC).Several algorithms have been proposed earlier for producing the best sequences through a terminated trellis such as LVA etc. Terminating the trellis, which is called block-by-block transmission, is necessary for these algorithms since they require known starting and ending states. As this termination requires a tail, it leads to an overhead. To eliminate the overhead, a new family of LVAs for continuous transmission called CLVA has developed i.e., transmission without termination tails [3]. The LVA finds an ordered list of sequences through a trellis with the best path metrics. The CRC decoder is then used to select one output path from the list of L-best outputs of LVA that corresponds to a valid CRC code word. Compared to continuous LVA with the regular VA a gain of about 1 dB is obtained.

2.5 Sequential Opportunistic Decoding With Puncturing
Sequential Opportunistic Decoding with Puncturing (SOD-P) yields a reduction in the BER with the use of puncturing and thus reduces the probability of a retransmission request [5]. The deletion of bits from a code word is termed as puncturing. The puncturing operation is done on the received signal not on the transmitted signal. The received signal is decoded, with no bits deleted. The output is fed through a Cyclic Redundancy Check. If there is an error, a set of bits from the received signal are replaced with zeros. The new punctured signal thus obtained is decoded. If this attempt fails, it retains previous bits which were replaced by zero bits, and another set of bits are punctured. Then it is decoded again. The process continues until the frame is decoded with minimum error or all sets of bits to be replaced have been exhausted. If all these attempts fail, a retransmission request of same data is sent to the transmitter. When the retransmission is not possible, the output of the decoder in the first attempt is accepted as the received signal with minimum error because it has least number of error bits compared to that of other attempts. Simulations are carried out on BER as a function of SNR in the system which utilizing SOD-P, for (NCB) Number of subcarriers =1 and NCB =4.The use of SOD-P results in a significant reduction in the error rate.

2.6 Rate distortion Approach for Reed-Solomon (RS) codes
This approach is based on using multiple trials of a simple RS decoding algorithm with rate distortion approach. It erases or flips a set of symbols/bits in each trial. An appropriate distortion measure should be chosen so that the decoding is successful if and only if the distortion between the error pattern and erasure pattern is smaller than a fixed threshold. In this algorithm, based on the received signal sequence it computes a reliability matrix Π. From Π determine the probability matrix P. Then compute the RD function of a source sequence (error pattern) with probability of source letters derived from P and the chosen distortion measure. Determine the optimal input probability distribution matrix Q from P. Randomly generate a set of erasure patterns using the test-channel input-probability distribution matrix Q. Multiple attempts of decoding is done using the set of erasure patterns to produce a list of candidate code words. Use the maximum-likelihood (ML) rule to pick the best code word on the list. Compared to conventional hard decision decoding, rate distortion approach [7] results in a 0.3db gain.

The survey shows that various decoding techniques discussed here increases the BER performance of the system. The TABLE 1 shows the comparison result obtained from the survey.

Table - 1 Gain comparison chart

COMPARISON	GAIN in dB
Between Uncoded and ViterbiAlgorithm	1.5dB
Between Viterbi and List Viterbi Algorithm	2.0dB
Between Hard output decoding and Soft-LVA	1.0dB
Between Viterbi and CLVA decoding	0.5dB
Between LVA and CLVA decoding	1.0dB

Compared to Viterbi algorithm, gain comparison chart indicates an increase in gain can obtained from the modified Viterbi algorithms which were discussed in this section. Even though these methods provide better BER performance, it increases computational complexity and makes the hardware modifications difficult. In order to overcome this multiple attempt decoding was proposed.

III. ITERATIVE DECODING ALGORITHM

Multiple Attempt decoding means multiple runs of a Viterbi decoding with a different erasure patterns. The algorithm is used when an erroneous frame occur in the first attempt [9]. It divides the received sequence into multiple sections and replaces a symbol from each section with zero bits. The resultant sequence is then decoded, and checked through cyclic redundancy check (CRC). If CRC fails, this algorithm replaces a set of symbols with zero bits and retains the previous set of erased symbols. This procedure continues until the iteration reaches the puncturing period N. This method does not make any change in specifications of the transmitter and the hardware at the receiver but a change in software part is observed. By erasing a set of symbols in the erroneous received sequence, a reduction in the Euclidian distance between the actual transmitted Code word and the resultant received sequence are achieved. This may results the correct decoding and thereby reduces the frame error rate. The fig. 1 shows the block diagram of convolutional coding with MAD algorithm.

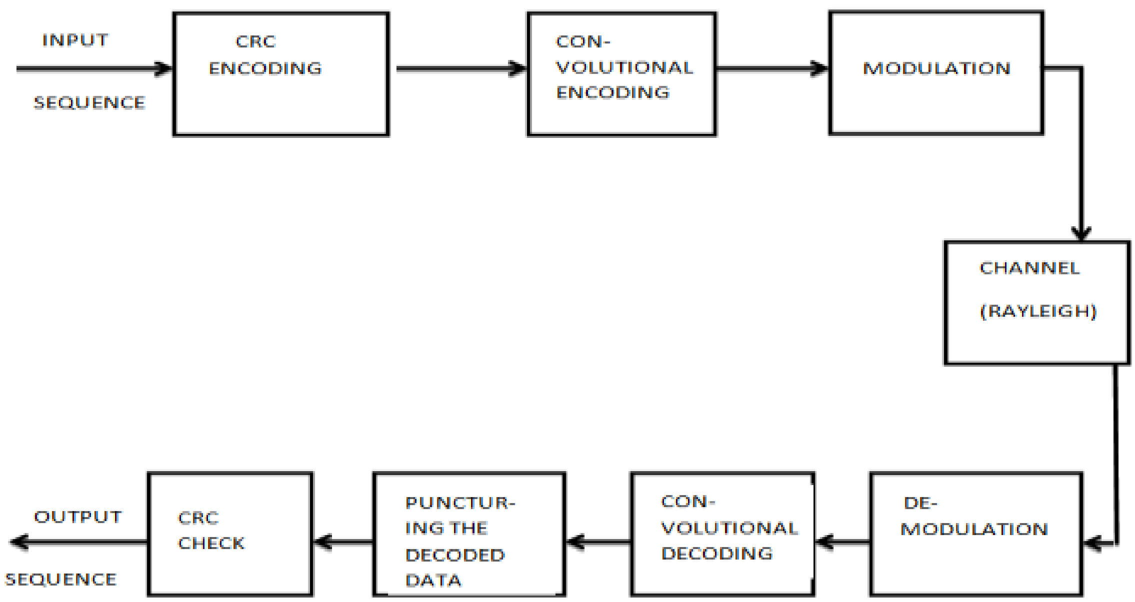

Figure.1 Block diagram of convolutional code using multiple attempt decoding.

IV. SIMULATION AND RESULTS

Simulations were conducted by MATLAB software of version 8.5.The parameters used for the simulation of multiple attempt decoding of convolutional coding is listed in the table below.

Table 2 Simulation Parameters for convolutional code with MAD

Parameters	**Values**
Uncoded bits, β	180
CRC polynomial	1001
Code rate , R	0.5
Constraint Length, K	3
Generator polynomials	{111,101}
Puncturing period, N	35

Conventional decoder with rate ½ and K=3 are used for the simulation purpose and the graph obtained as a result is shown in the fig2.

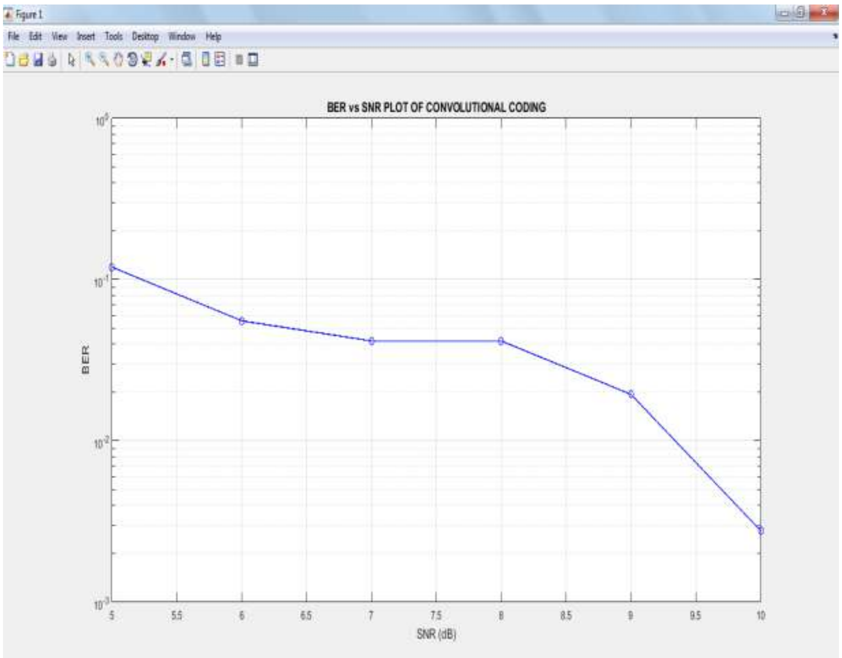

Figure2. BER plot of convolutional code

The graph shows that BER of 0.0003 is obtained at an SNR of 10dB. Multiple attempt decoding ensures a better performance than the conventional decoding of convolution codes. With the parameters specified in the Table I convolution codes were decoded using multiple attempt decoding. Fig3. shows the BER plot obtained with convolutional MAD.

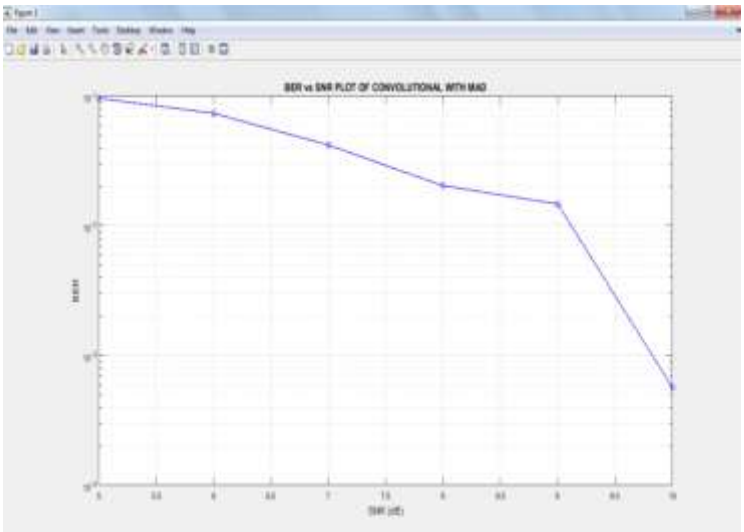

Figure3. BER plot of convolutional MAD

The resulting graph shows that convolutional decoding with multiple attempt algorithm results a BER of 0.00006 at 10dB SNR. It is clear that an improvement in bit error performance is obtained from the iterative decoding method.

V. CONCLUSION

Channel coding for error detection and correction helps to mitigate the drawbacks of a noisy transmission channel. The decoder at the receiving end will first employ the error-correction bits to determine whether there is an error in the received data, and then to correct the errors if they fall within the error-correction capability of the code. In this paper various decoding techniques of convolutional codes are studied. A performance improvement in terms of error probability has been observed in these algorithms. Simulation results shows that multiple attempt decoding provides reduction in bit error rate while maintaining low complexity. Since turbo provides better performance than convolution code turbo with MAD may results in a better performance rather than other error correction codes.

REFERENCES

[1] A. J. Viterbi, "Error Bounds for Convolutional Codes and an Asymptotically Optimum Decoding Algorithm," IEEE Transactions on Information Theory, vol. IT-13, pp. 260–269, April 1967.
[2] N. Seshadri and C.-E. W. Sundberg, "List Viterbi Decoding Algorithms with Applications," IEEE Transactions on Communications, vol. 42, pp.313–323,February/March/April 1994.
[3] B. Chen and C.-E. W. Sundberg, "List Viterbi Algorithms for Continuous Transmission," IEEE Transactions on Communications, vol. 49, pp.784–792, May 2001.
[4] C. Nill and C.-E. W. Sundberg, "List and Soft Symbol Output Viterbi Algorithms: Extensions and Comparisons," IEEE Transactions on Communications, vol. 43, pp. 277–287, February/March/April 1995.
[5] O. Jegbefume, M. Saquib, and M. Torlak, "Artificial Code Puncturing for Wireless Networks," *in Proc. IEEE Wireless Communications & Networking Conference (WCNC'08)*,Las Vegas, NV, March/April 2008,pp. 3181–3185.
[6] A. K. Desiraju, "*Multiple Attempt Decoding of Convolutional Codes over Rayleigh Channels*," Master's thesis, The University of Texas at Dallas, May 2013.
[7] P. S. Nguyen, H. D. Pfister, and K. R. Narayanan, "On Multiple Decoding Attempts for Reed Solomon Codes: A Rate-Distortion Approach," IEEE Transactions on Information Theory, vol. 57, pp. 668–691, February 2011.
[8] L. Perez, "*Turbo Codes*" chapter 8 of Trellis Coding by C. Schlegel. IEEE Press, 1997.
[9] Arun Desiraju, Murat Torlak and Mohammad Saquib, "Multiple Attempt Decoding of Convolutional Codes Over Rayleigh Channels," IEEE Transactions on Vehicular Technology,vol.64,pp. 3426 – 3439,September 2014
[10] S. Lin and D. J. Costello, Error Control Coding: Fundamentals and Applications. Pearson-Prentice Hall, NJ, 2004.
[11] Ashly Joseph, Asst. Prof. Mr. Noble C Kurian "A Comparative Study on Various Decoding Techniques of Convolutional Codes," *International Journal of Innovative Research in Computer and Communication Engineering (IJIRCCE), Vol. 3, Issue 8*, and August 2015.