Performance Comparison of A3D Turbo code with other Turbo codes using Noise adaptive approach

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Abstract-The performance of the code was improved for a wide range of block lengths and coding rates with very low error rates by introducing a third component in conventional turbo codes. But the parameters such as permeability and permittivity rates were static under noisy environments and hence their adaptability to noisy environment was poor. The proposed A3D-TC has overcome the aforesaid problem. The parameters are made adaptive by generating a Genetic Algorithm (GA) based knowledge source. The bit error rate was minimized by generating parameters based on noise and signal strengths. This paper compares A3D-TC and 3D-TC along with other turbo codes like DVB-RCS-TC and 16 state DB-TC.

Key words- *A3D-TC, Genetic Algorithm, permeability rate, permittivity rate, 3D-TC, DVB-RCS-TC, 16 state DB-TC.*

I. INTRODUCTION

Wireless Mobile communication is one of the fastest growing fields in the telecommunication industry. They provide access to the capabilities of the global network at any time, irrespective of the location or mobility of the user. Due to the progress of Internet and cellular communication, the present and future mobile communication for data transmission is done at high bit rates which is used for many services like video, high quality audio and also many network related applications.

In this regard, communication system plays a vital role which consists of concatenation of modulation, a noisy medium, and a demodulation scheme [1]. The information here, is transferred with the aim of achieving reliable communication at transmission rates approaching channel capacity given by Shannon and is known as Shannon limit. So, to ensure reliable communication, E_b / N_o should be maintained at -1.6dB irrespective of how powerful an error control code is. The information has to be protected from the errors introduced in the communication channel. The information sequence that has to be transmitted may consist of several parts that have different degrees of significance and hence require different levels of protection against noise. This protection is done by a method called coding, where information is disguised by using different codes. Therefore the role of error correction codes becomes more prominent.

Forward Error Correction (FEC) has been a commonly used mechanism for error protection and also to improve the reliability of transmission [2]. The use of FEC codes in communication system is an integral part of ensuring reliable communication and these codes have become inevitable in wireless based digital communication systems as they allow the system to operate at lower SNR ratio [3].

II. THE ADAPTIVE THIRD COMPONENT TURBO CODES (A3D-TC)

In A3D-TC,as shown in Fig. 1. The third component parameters are made adaptive. This is accomplished by generating a Genetic Algorithm (GA) based knowledge source and feeding it to feed forward neural network [4]. The network outputs third component parameters according to the noise and signal strengths so that bit error rate at decoding section can be minimized in an effective way. The permeability and permutation rates are found with respect to the different noise strength. The data so obtained is utilized to train Artificial Intelligence (AI).

The block diagram of A3D-TC encoder and decoder is given in Fig. 1 and 2.

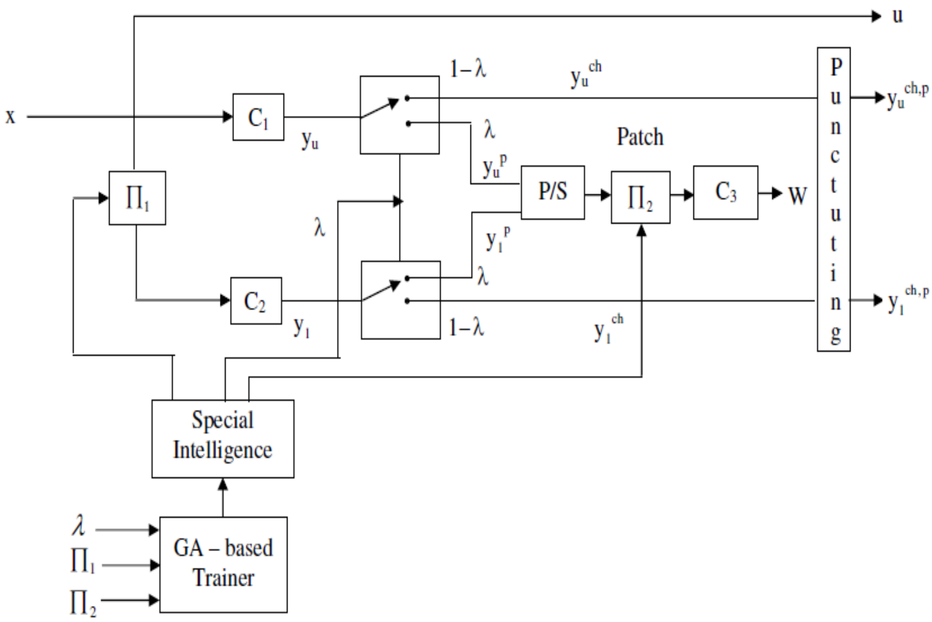


Fig 1: A3D-TC Encoder

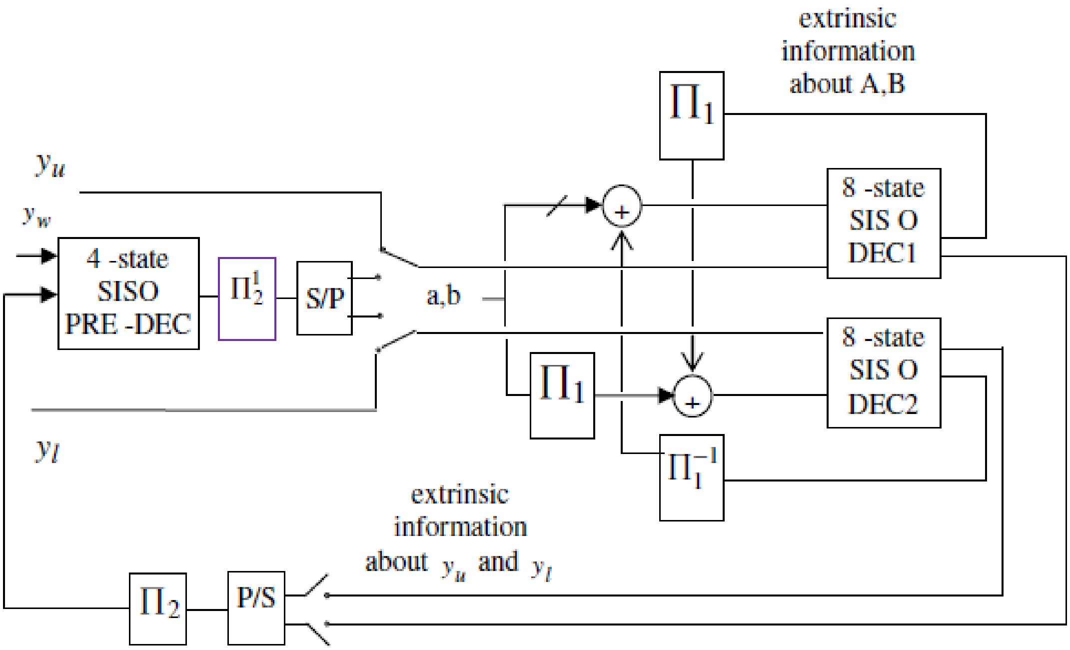


Fig. 2: A3D-TC Decoder

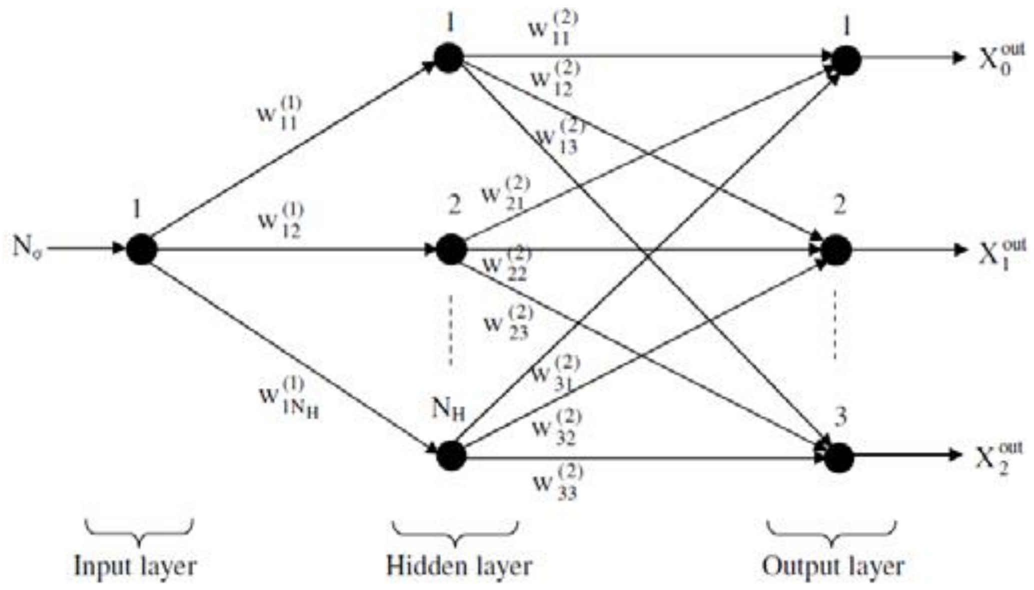


Fig. 3: Structure of feed forward neural network used for A3D-TC Encoder

The AI technique uses a classifier which will feed forward neural network. The classifier is trained in such a way that the permeability rate and permutation rates are decided as per the strength of the noise. As per the decision level, different states of connections are established with post encoder and hence the third component is determined. Such third component will be dynamically varying when the strength of the channel noise varies [4].

The conventional third component decoder is not disturbed by the addition of special intelligence [5], given in Fig. 2. Here, the feed forward neural network is used as the special intelligence. The structure of neural network is given in Fig. 3.

III. KNOWLEDGE FEEDING

For the special intelligence appropriate prior knowledge is given which is called as training (or) learning. This is accomplished by generating a precise training dataset, in which noise variance is considered as input for which suitable A3D-TC parameters are generated. The process of prior knowledge feeding includes the generation of knowledge source and then training.

The working of A3D-TC is elaborated as:

- Pre analysis is done using Genetic Algorithm. i.e., a knowledge source is generated using Genetic Algorithm.
- For this knowledge source three parameters (λ, Π_1, Π_2) are generated at different noise variances. For e.g., at 0.1, 0.2, 0.3 i.e., by giving 10%, 20% or may be 30% of the noise.
- Simulation of noise environment is done by GA operation.
- For this, chromosomes are generated. Each chromosome is having three genes.
- This becomes the solution for GA operation.

The main objective is –

- Given a noise variance, it generates some optimal solutions which are the outputs. For e.g., λ, Π_1, Π_2 are all optimal solutions.
- To minimize the bit error rate (BER), the fitness function of GA is found out.
- For this, i.e., if noise variance N_σ = 0.1
- Random chromosomes are generated, i.e., the population pool with around ten chromosomes, whose pool size is taken as ten.
- These ten chromosomes are selected based on the above three parameters and their corresponding fitness is evaluated for all the ten chromosomes.
- Among these ten chromosomes, the best five are selected by arranging them in the ascending order.
- For the selected best five chromosomes, crossover and mutation is done.
- In Random mutation the characteristics of the chromosomes are changed so that they are well suited for any type of environment.

- Neural network generates the fourth output from the knowledge of the remaining three inputs and their corresponding outputs.
  This helps in reducing number of iterations and also computational time is also reduced.

The A3D-TC is implemented and validated in the working platform of MATLAB (version 7.12). The experimentation is done over A3D-TC and conventional 3D-TC for various noise variances. Prior to experiment, knowledge source is developed with GA parameters. Then it is evaluated for different ANN structures by varying noise variance to analyze the influence of network structure in turbo code performance. For every structure, ten experiments are carried out. Average performance is determined for every network structure and is directly compared with conventional 3D-TC.

TABLE I: BER performance of 3D-TC and A3D-TC with network structure having (i) 20 hidden neurons, (ii) 30 hidden neurons and (iii) 40 hidden neurons for different noise variances from different rounds of experiments

20 Neurons

Experiment No	*Noise Variance*							
	0.15		*0.25*		*0.35*		*0.45*	
	3D-TC	*A3D-TC*	*3D-TC*	*A3D-TC*	*3D-TC*	*A3D-TC*	*3D-TC*	*A3D-TC*
1	0.1587	0.1581	0.1045	0.1040	0.0747	0.0743	0.1274	0.0271
2	0.0752	0.0750	0.1411	0.1410	0.1377	0.1372	0.0599	0.0593
3	0.1284	0.1281	0.1030	0.1010	0.0747	0.0744	0.0189	0.0183
4	0.1162	0.1160	0.1289	0.1283	0.1250	0.1210	0.1348	0.1344
5	0.1250	0.1210	0.1143	0.1141	0.1191	0.1190	0.1079	0.1072
6	0.1440	0.1410	0.1670	0.1630	0.0649	0.0647	0.0267	0.0261
7	0.1108	0.1105	0.0586	0.0583	0.0571	0.0570	0.0508	0.0503
8	0.1187	0.1183	0.0771	0.0770	0.0884	0.0881	0.0427	0.0421
9	0.1470	0.1430	0.0879	0.0871	0.0601	0.0600	0.0859	0.0852
10	0.1528	0.1490	0.1279	0.0852	0.1177	0.1803	0.0503	0.0360

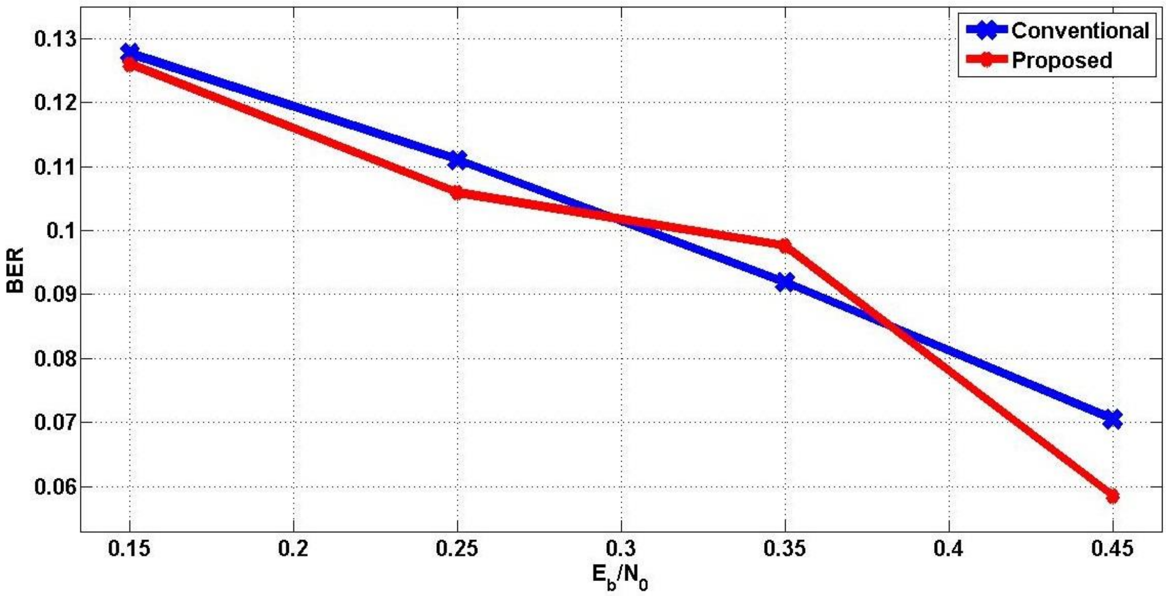
30 Neurons

Experiment No	*Noise Variance*							
	0.15		*0.25*		*0.35*		*0.45*	
	3D-TC	*A3D-TC*	*3D-TC*	*A3D-TC*	*3D-TC*	*A3D-TC*	*3D-TC*	*A3D-TC*
1	0.1094	0.1091	0.1274	0.1271	0.1113	0.1111	0.0244	0.0242
2	0.1323	0.1322	0.1143	0.1141	0.0864	0.0861	0.0407	0.0405
3	0.1426	0.1423	0.0544	0.0543	0.0918	0.0913	0.0238	0.0235
4	0.1733	0.1731	0.1187	0.1183	0.0408	0.1403	0.0422	0.0421
5	0.1313	0.1310	0.0615	0.0612	0.1089	0.1081	0.0574	0.0571
6	0.0649	0.0645	0.1299	0.1295	0.0854	0.0851	0.0786	0.0781
7	0.0972	0.0970	0.1216	0.1213	0.0513	0.1511	0.0605	0.0603
8	0.1187	0.1185	0.1230	0.1210	0.1025	0.1023	0.0186	0.0183
9	0.1558	0.1555	0.1025	0.1023	0.1211	0.1121	0.1465	0.1461
10	0.1436	0.0718	0.0586	0.0619	0.1133	0.0675	0.0854	0.0548

40 Neurons

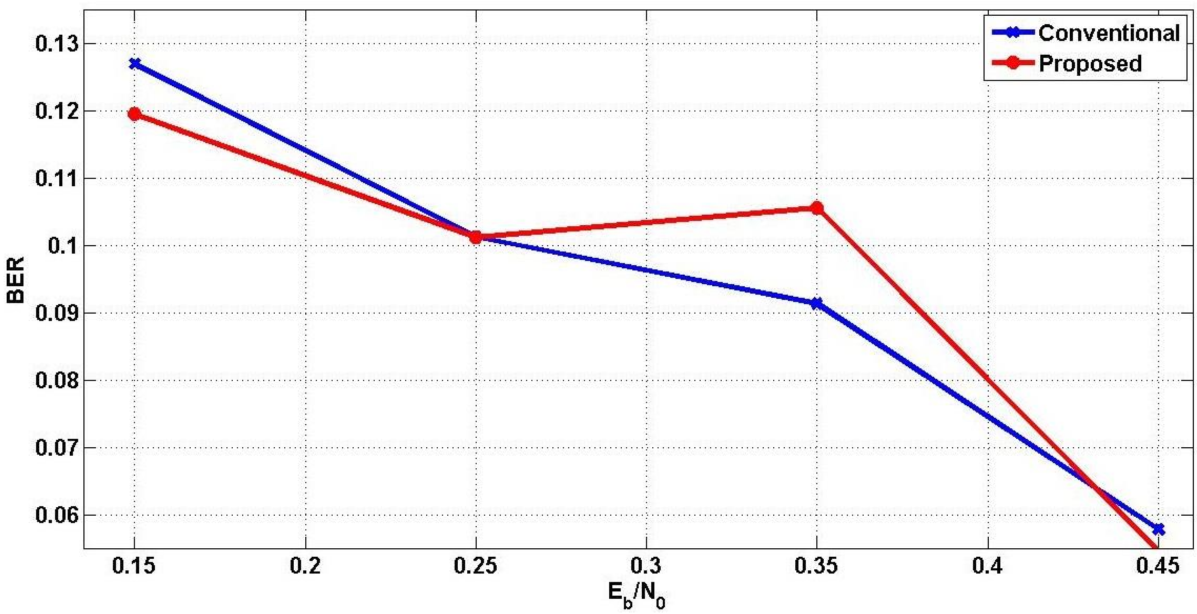
Experiment No	*Noise Variance*							
	0.15		*0.25*		*0.35*		*0.45*	
	3D-TC	*A3D-TC*	*3D-TC*	*A3D-TC*	*3D-TC*	*A3D-TC*	*3D-TC*	*A3D-TC*
1	0.0898	0.1234	0.0771	0.1587	0.1089	0.1113	0.0562	0.0274
2	0.1147	0.1509	0.0388	0.0752	0.1216	0.0864	0.0752	0.0143
3	0.1382	0.1119	0.1143	0.1284	0.0221	0.0918	0.0461	0.1544
4	0.1445	0.1328	0.0962	0.1162	0.0664	0.0408	0.0791	0.0187
5	0.1499	0.1019	0.1177	0.1250	0.1143	0.1089	0.0894	0.1615
6	0.1074	0.1267	0.1450	0.1440	0.1265	0.1854	0.0747	0.0299
7	0.1201	0.1518	0.1392	0.0108	0.0962	0.1513	0.0615	0.1216
8	0.1323	0.1447	0.1104	0.0187	0.1563	0.1025	0.0845	0.0123
9	0.1440	0.1159	0.1426	0.1470	0.1128	0.0211	0.0615	0.0025
10	0.1094	0.1020	0.0972	0.1060	0.1230	0.0335	0.1226	0.0674

20 Neurons



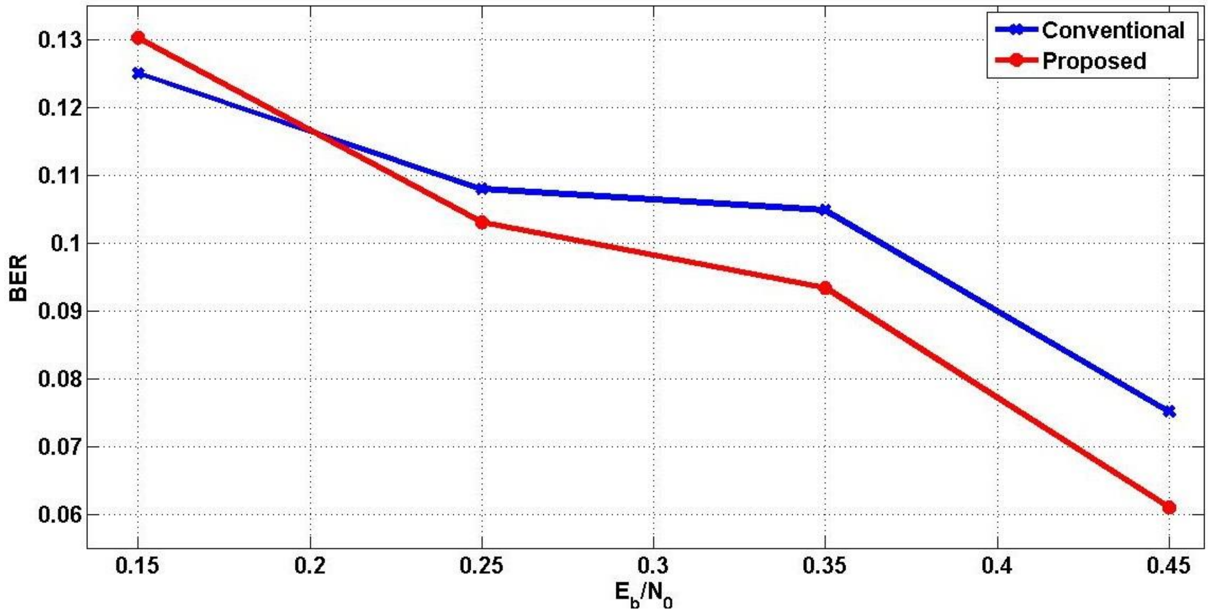
(i)

30 Neurons



(ii)

40 Neurons



(iii)

Fig. 4: Comparative Chart for BER vs E_b/N_o performance between A3D-TC (proposed) and 3D-TC (conventional) for network structure with (i) 20, (ii) 30 and (iii) 40 hidden neurons.

It is noticed that A3D-TC using Genetic Algorithm exhibits minimum BER in majority of the experiments except in few noisy environments. However, the **failure deviation** of A3D-TC is very **less** than success deviation of 3D-TC.

IV. COMPARISON OF DIFFERENT TURBO CODES

The performance of A3D-TC has been compared with other turbo codes like 3D-TC, DVB-RCS-TC and 16 state DB-TC. The performance of these codes is shown in the Fig. 5. It can be inferred from the figure that A3D-TC performs better when compared to 3D-TC and DVB-RCS TC. Though the performance of 16 state DB TC at around 2.48 E_b/N_o is better but the overall performance of A3D-TC predominates.

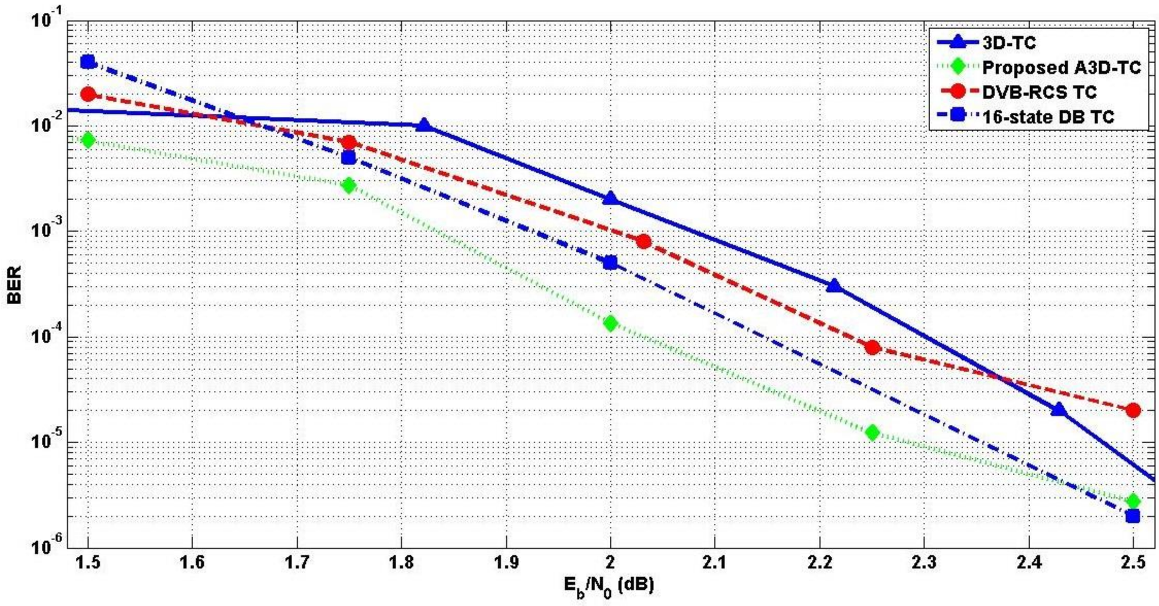


Fig 5: Comparison of A3D-TC with other turbo codes.

V. CODING EFFICIENCY

Coding efficiency is a widely accepted term which illustrates the speed, reliability and programming methodology followed in developing codes for a specific application.

The main aim behind this is to minimize the resource consumption and time as much as possible with low risk to the operating environment.

The efficiency of a coding system is the ratio of the average information per symbol to the average code length. The maximum possible is 1 and can theoretically be obtained using a prefix code.

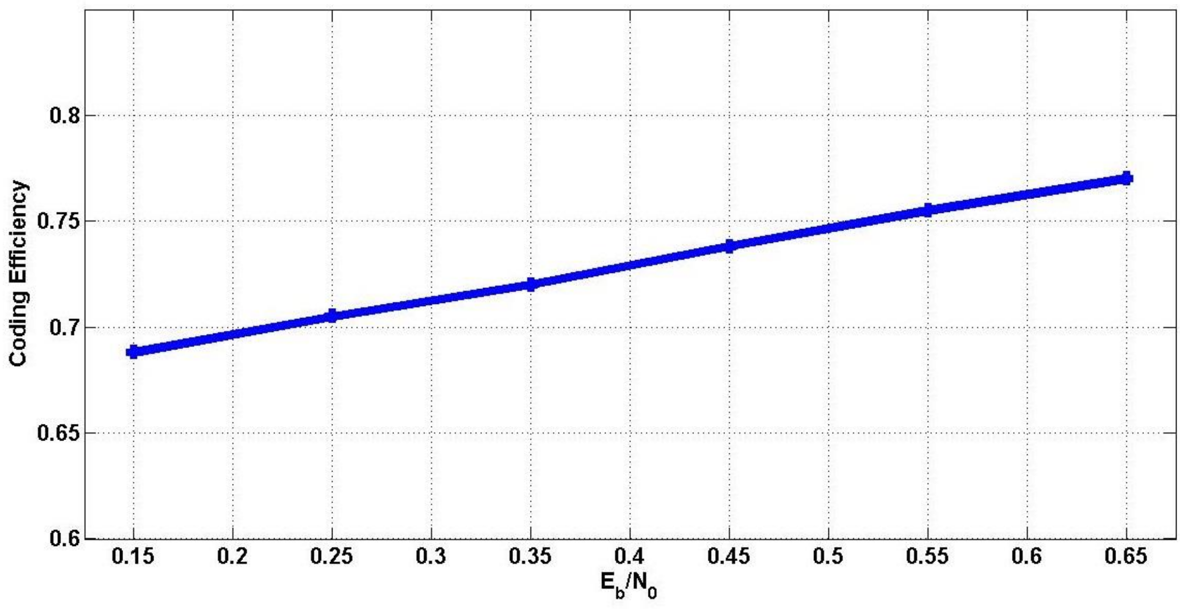


Fig 6: Coding efficiency v/s E_b/N_0

VI. CONCLUSION

The experimental results show that A3D-TC achieves minimum BER than 3D-TC. Hence, it can be concluded that A3D-TC is performing better because of the nature of experimental results i.e.,

(i) It is capable of achieving minimal BER while increasing network complexity.
(ii) Lesser failure deviation over success deviation.
(iii) It reduces the number of iterations generated, while maintaining the speed.

Hence, A3D-TC using Genetic Algorithm can be more preferred

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