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A PATH FOR HORIZING YOUR INNOVATIVE WORK

ERROR CORRECTION SYSTEM USING ARTIFICIAL NEURAL NETWORK

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Abstract: The use of error correcting code has proved to be an effective means to overcome data corruption in digital communication channels. In digital communication, Convolutional encoder is widely used for error correcting of data which transmitted through the noisy channel. The Viterbi decoder is used for decoding Convolutional encoded data. Viterbi decoding consists of computing the metric for two paths in the Trellis diagram and eliminating one which is of higher value. A peculiar situation arises when two metrics have the same value. In this case, the decoder selects an arbitrary bit. This ambiguous situation is eliminated using neural network. The Adaptive Resonance Theory-1 (ART-1) has been developed to avoid the stability-plasticity dilemma in competitive networks learning. The stability-plasticity dilemma addresses how a learning system can preserve its previously learned knowledge while keeping its ability to learn new patterns. The Convolutional encoder has been designed using Shift register, mod-2 adders and a commutator. It is interfaced with the Personal Computer through the Centronic port for decoding. The ART-1 algorithm has been implemented in "C" Language. The ART-1 based decoding program decodes the encoded data from the Convolutional encoder. The output of ART-1 based decoder exactly matches the data input to the encoder.

Keywords: Artificial Neural Network (ANN), Convolutional Encoder, Vitebi Decoding Algorithm, ART-1.

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PAPER-QR CODE

INTRODUCTION

The purpose of forward error correction (FEC) is to improve the capacity of a channel by adding some carefully designed redundant information to the data being transmitted through the channel [1,2]. The process of adding this redundant information is known as channel coding. One of the widely used for error correction of data consists of convolutional coding with Viterbi decoding algorithm. The ambiguous situation arising in the Viterbi decoder is eliminated when the artificial neural network (ANN) is used for decoding of data. This paper will primarily focus on the Adaptive Resonance Theory-1 (ART-1) which one of the model of Artificial Neural Network (ANN). The following sections will describe algorithms for generating random binary data, convolutionally encoding the data, passing the encoded data through a noisy channel, quantizing the received channel symbols, and performing ART-1 based decoding to recover the original binary data.

a. Viterbi Decoding

Decoding algorithm used with convolutional encoding is the Viterbi decoding developed by Andrew J Viterbi. It is based on the principle of maximum likelihood of events [1, 2]. The maximum likelihood receiver implies selecting a code word closest to the received word. Basically, Viterbi decoding consists of computing the metric for two paths in the Trellis diagram and eliminating one, which has higher value. The decoding is based on the Trellis diagram. The algorithm involves calculating the hamming distance between the received signal and the entire trellis path entering each state [2,3]. When two paths enter the same state, then one having the best metric (the surviving path) is chosen; for all states. The decoder continues in this way to advance deeper into the trellis diagram [4, 5]. The Viterbi decoder is implemented either by using hardware circuits or a software program. In the peculiar situation when two metrics have the same value the decoder selects the arbitrary bit. This ambiguous situation is eliminated using neural network in the Viterbi decoder.

b. Adaptive Resonance Theory – 1 (ART-1)

Adaptive Resonance Theory – 1 (ART-1) proposed by Carpenter and Grossberg (1976) is a self organizing artificial neural network. There is vast potential for the characteristics of its imitating the human brain nerve system working in neuro-physiology and psychology [6]. One of the nice features of human memory is its ability to learn many new things without necessarily forgetting things learned in the past. Conventional artificial neural network have failed to solve the Stability-Plasticity dilemma [6, 7]. A network remain open to new learning (remain plastic) without washing away previously learned codes. The adaptive resonance theory (ART) has been developed to avoid the stability-plasticity dilemma in competitive networks learning. The

stability-plasticity dilemma addresses how a learning system can preserve its previously learned knowledge while keeping its ability to learn new patterns [8, 9, 10].

II. Design and Methodology

a. Convolutional Encoding

Convolutionally encoding of the data is accomplished using a shift register and associated combinatorial logic that performs modulo-two addition. A typical convolutional encoder of constraint length N=3, rate= ½, and vector connection code (111,101) is shown in figure 1. The input bits are stored in fixed length shift registers and they are combined with the help of mod-2 adders. Whenever the message bit is shifted to position 'm' the new values of 'v1' and 'v2' are generated depending upon m, m1 and m2. The m1 and m2 store previous two message bits. The current bit is present in 'm'. Thus we can write:

V1=m ^ m1^ m2 (^ - ExOR operation)

V2=m ^ m2

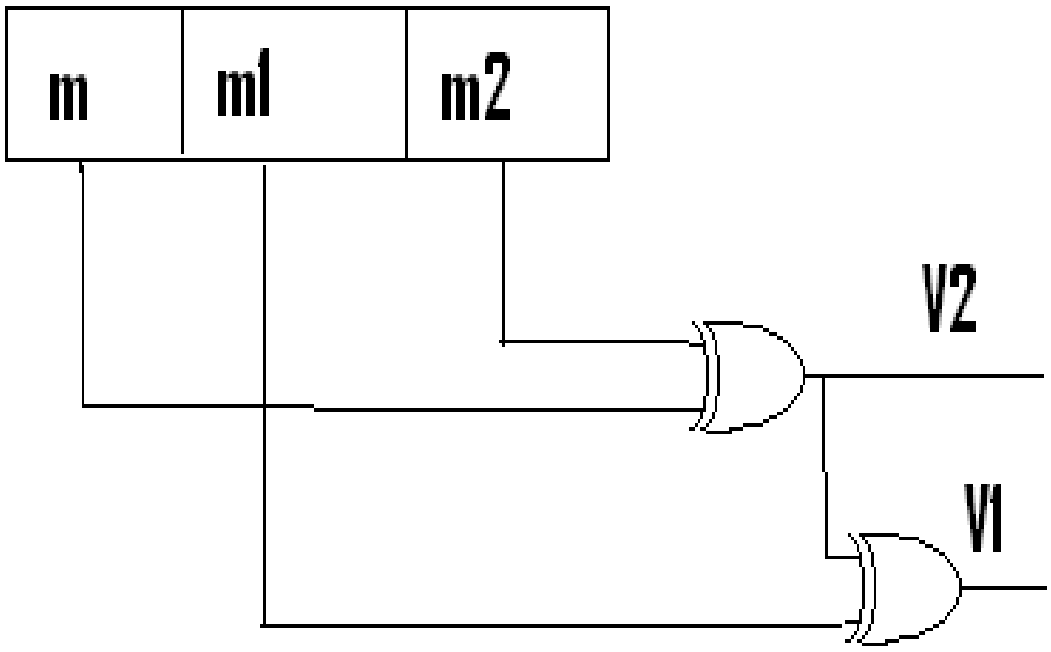

Fig-1: convolutional encoder N=3, rate =1/2, code conversion vector (111,101)

b. The Adaptative Resonance Theory (ART-1)

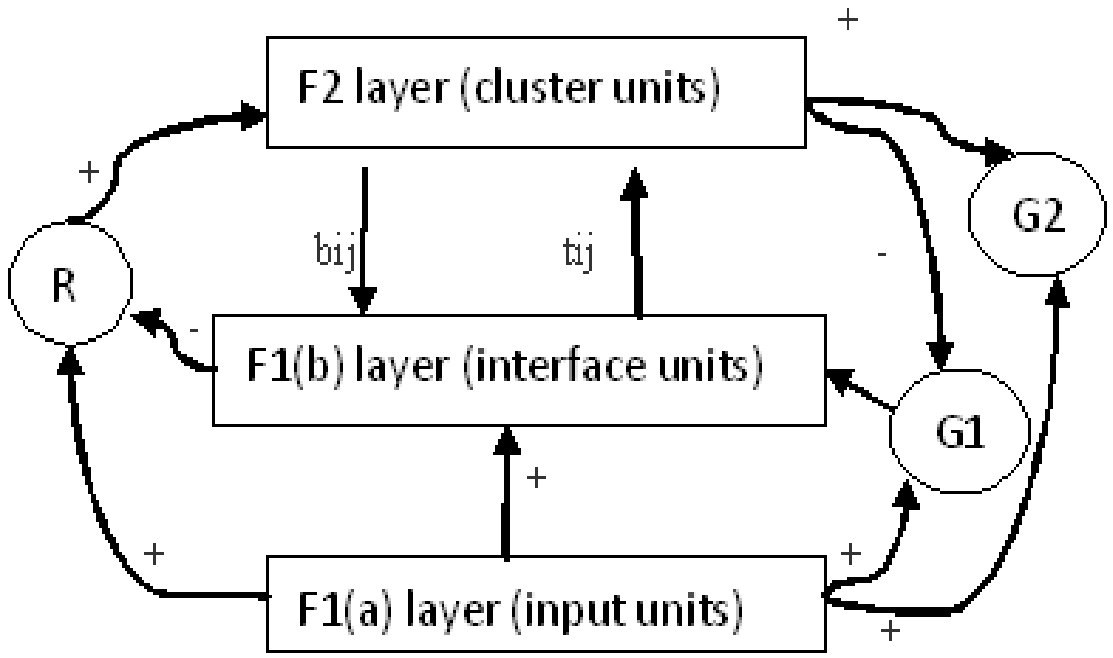

Fig 2: Structure of supplemental units of ART-1

Fig 2 shows the Structure of supplemental units of ART-1. It involves three groups of neurons.

1) Input processing field – F_1 layer
2) Cluster units – F_2 layer
3) Reset mechanism – that controls the degree of similarity of patterns placed on the same cluster.

Binary input vector is presented to F_1(a) layer and is then received by F_1(b). The F_1(b) layer sends the activation signal to F_2 layer over weighted interconnection path. Each F_2 will calculate the net input. The unit with largest net input will be the winner that will have activation d=1. All other units will have activation as zero. That winning unit alone will learn the current input pattern. The signal sent from F_2 to F_1(b) through weighted interconnections is called as top-town weight. The X unit remain 'on' only if they receive non-zero weight from both the F_1(a) and F_2 units. The norm of the vector ||x|| will give the number of components in which top-down weight vector for the winning unit (t_{ij}) and the input vector S are both '1'. Depending upon the ratio of norm of x to norm of S(||x||/||S||), the weights of the winning cluster unit are adjusted. The whole process may be repeated until either a match is found or all neurons are inhibited.

III. Experimental Work

a. Complete error correcting System

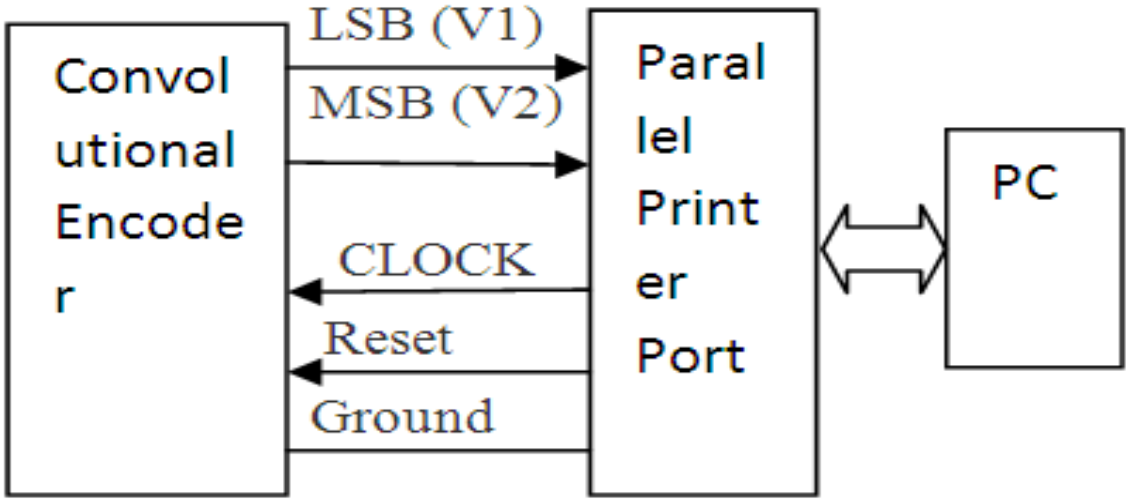

Fig 3 Covolutional encoder interface with PC

The convolutional encoder is interface with PC through parallel printer port as shown fig 4. The explanation of each block is as follows:

b. Implementation Convolutional encoder

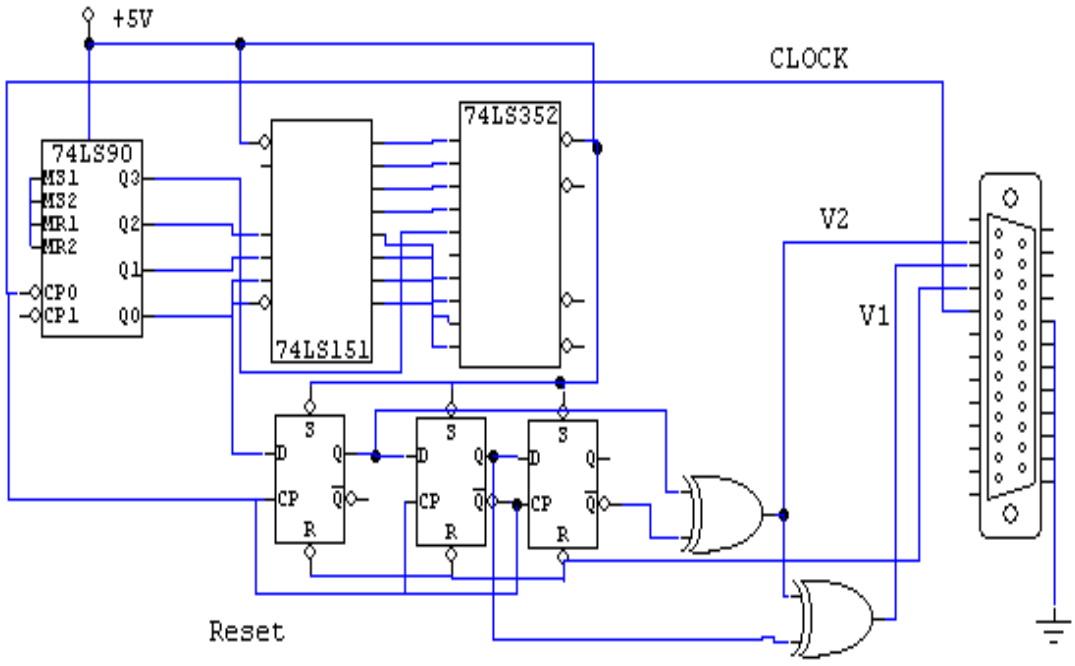

Fig 4 circuit diagram of convolutional encoder

Fig 3 shows the circuit diagram of convolutional encoder. It consists of shift register, mod-2 adder and commutator IC's. The clock is generated from PC through PPP. IC 7490 (decade counter) as a mod-8 counter for generating clock to the IC 74393 and selecting data input for IC 74151 (8:1 MUX). IC 74393 (8-bit counter) is used for generating combination of 8-bits which serve as the data input for IC 74151. IC 74151 is used for selecting a data input or also called as sequence generator. IC 7474 (D flip flop) as a shift register which takes the data from the IC 74151 and give to the next 7474 IC. IC 7486 (XOR gate) is used for XO Ring the output of IC 7474. There are three 7474 IC's and two XOR gates. The output of XOR gate (V1 & V2) are given to ART-1 based decoder which is stored in PC through parallel printer.

c. ART-1 Algorithm

The training algorithm of ART-1 network as follows:

Step 1: Initialize parameters $L>1$ and $0 \le \rho \le 1$. Initialize weights $0 < b_{ij}(0) L/(L-1+n)$, $t_{ij}=1$

Step 2: while stopping condition is false, perform Steps 3-14

Step 3: for each training input, do steps 4-13.

Step 4: Set activations of all F_2 units to zero.

Set activations of $F_1(a)$ units to input vector s.

Step 5: Compute the norm of s: $||s|| = \sum_i Si$

Step 6: send input signal from $F_1(a)$ to $F_1(b)$ layer , $x_i=s_i$

Step 7: for each F2 node that is not inhibited.

If $y_j \neq -1$, then $y_j = \sum_i bij\ Xi$

Step 8: while reset is true, perform step 9-12

Step 9: find J such that $y_J \ge y_j$ for all nodes j

If $y_j = -1$, then all the odds are inhibited and this pattern cannot be clustered

Step 10: Re-compute activation x of $F_1(b)$. $X_i = s_i\ t_{Ji}$

Step 11: Compute the norm of vector

x: $||x|| = \Sigma\ X_i$

Step 12: Test for reset, If $(||x||/||s||) < \rho$, then $y_J=-1$(inhibit node J) (and continue executing step again) if $(||x||/||s||) \geq \rho$, then proceed to step- 13

Step 13: Update the weights for node J

$b_{ij}(new)=Lx_i/(L-1+||x||)$, $t_{Ji}(new)=x_i$

Step 14: test for stopping condition

The stopping condition may be no weight changes, no units reset or maximum number of epochs searched. In winner selection, if there is a tie, take J to be the smallest such index. Also t_{ji} is either 0 or 1, and once it is set to 0 during learning, it can be never set back to 1 because of stable learning method. The typical values of parameters are given in table 1 and flowchart of ART-1 algorithm shown in fig 4.

TABLE 1: Typical values of parameters used in ART-1 algorithm

Parameter	Range	values
L	L>1	2
P	$0 \leq \rho \leq 1$ (vigilance parameter)	0.9
b_{ij}	$0<b_{ij}(0)<L/(L-1+n)$(bottom-up weights)	1/1+n
t_{ji}	$t_{ji}(0)=1$ (top down weights)	1

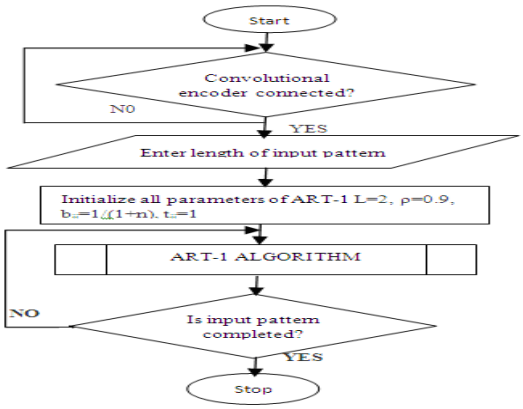

Fig 4. Flowchart of ART-1 Algorithm

IV. Results and Discussion

The encoder has the constraint length N=3 and vector connection code [111101] for mod-2 adders. 16-bit output sequence is generated corresponding to the input data bits. The Convolutional encoder has some special features as follows: Input data are generated by the counter system. Clock required is obtained from the computer's parallel printer port (Centronic) using the instruction outport. Reset signal is generated by computer "C" programming [19,20]. Reset is used instead of including dummy bits into input data stream. The ART-1 based decoding program decodes the encoded data from the convolutional encoder. The output of ART-1 based decoder exactly matches the data input to the encoder. The inputs for the ART-1 based decoder are a 8-bits, 16-bits or 32-bits. The output of the decoder exactly matches with the data input to the encoder as seen in table 2.

Table 2. Input-Output data display

Input	Encoder output	Output of ART-1 Based decoder
00000001	0000000000000011	00000001
00011111	0000001101101010	00011111
01101011	0011010100100001	01101011
11011111	1101010001101010	11011111
11111111	1101101010101010	11111111

V. CONCLUSION

ART-1 based error correcting system is proved to be efficient for error free digital communication. Other areas of applications of the ART-1 technique are industrial design and manufacturing, the control of mobile robots, tool failure monitoring, circuit design, face recognition, signature verification, remote sensing, sonar and RADAR recognition and so on.

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