Fuzzy logic based Adaptive Modulation Using Non Data Aided SNR Estimation for OFDM system

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Abstract : As demand for high quality transmission increases increase of spectrum efficiency and an improvement of error performance in wireless communication systems are important . One of the promising approaches to 4G is adaptive OFDM (AOFDM) . Fixed modulation systems uses only one type of modulation scheme (or order), so that either performance or capacity should be compromised Adaptive modulated systems are superior to fixed modulated systems, since they change modulation order depending on present SNR. In an adaptive modulation system SNR estimation is important since performance of adaptive modulated system depends of estimated SNR. Non-data-Aided (NDA) SNR estimation systems are gaining importance in recent days since they estimate SNR range and requires less data as input .In this paper we propose an adaptive modulated OFDM system which uses NDA(Non-data Aided) SNR estimation using fuzzy logic interface.The proposed system is simulated in Matlab 7.4 and The results of computer simulation show the improvement in system capacity .

Key words : Fuzzy logic , Adaptive Modulation , NDA SNR estimation , OFDM

1. Introduction

Orthogonal Frequency Division Multiplexing (OFDM) is a special form of multi-carrier transmission technique in which a single high rate data stream is divided into multiple low rate data streams. These data streams are then modulated using sub carriers which are orthogonal to each other. In this way the symbol rate on each sub channel is greatly reduced, and hence the effect of inter symbol interference (ISI) due to channel dispersion in time caused by multipath delay spread is reduced. Guard interval can also be inserted between OFDM symbols to reduce ISI further. The orthogonality between sub carriers can be maintained, even though the signal passes through a time-dispersive channel by cyclically extending the OFDM symbols into guard interval

The channel performance may be highly fluctuating across the sub carriers and varies from symbol to symbol [1]. If the same fixed transmission scheme is used for all OFDM sub carriers, the error probability is dominated by the OFDM sub carriers with highest attenuation resulting in a poor performance. Therefore, in case of frequency selective fading the error probability decreases very slowly with increasing average signal-to-noise ratio (SNR) [2].

The combination of adaptive modulation with OFDM was proposed as early as 1989 by Kalet

which was further developed by Chow [3] and Czylwik [2]. Specifically the results obtained by Czylwik showed that the required SNR for the BER target 10-3 can be reduced by 5dBto 15dB compared to fixed OFDM depending on the scenario of radio propagation.

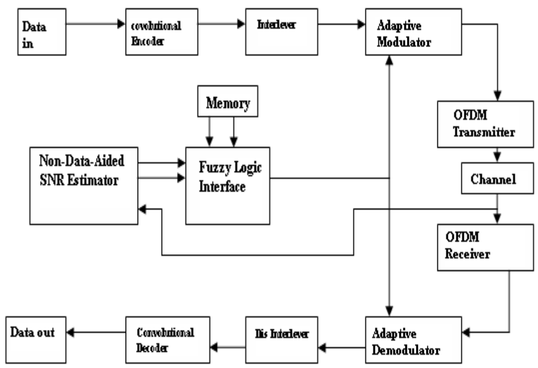
The performances of turbo-coded adaptive modulation are investigated in [4]. Three different modulation mode allocation algorithms were discussed and compared. Further studies on the application of turbo code in adaptive modulation and coding is conducted in [5]. This paper proposed an optimal approach based on prediction of the average BER over all sub carriers. In [6], an adaptive OFDM system with changeable pilot spacing has been proposed. The results showed that a significant improvement in the BER performance is achieved with sacrificing a small value of the total throughput of the system. A work is done on several strategies on bit and power allocation for multi-antenna assisted OFDM systems in [7]. They found out that sometimes power and bit adaptation is required for efficient exploitation of wireless channels in some system conditions. The performance analysis of OFDM systems with adaptive sub carrier bandwidth is investigated by [8]. Further investigations on sub carrier adaptive modulation scheme of pre coded OFDM is presented in [9] under multipath channels

In modem wireless digital communication, the precise Knowledge of SNR is important. Many algorithms require the knowledge of SNR for their optimal performance, and on the other hand, the value of SNR estimation can give us some information to select better performance algorithms in a certain SNR range for adaptive demodulation. In addition, SNR estimation is typically employed in power control, mobile assisted hand-off and soft decoding procedure. Lots of SNR estimators are data-aided (DA) in the sense that the training sequence limits system through-out. Therefore the problem of non-data-aided (NDA) SNR estimation has been investigated in some papers recently, but they have almost all studied the SNR estimation only for MPSK signals and to the best. of our knowledge, the research results of SNR estimation for amplitude and phase modulated signals such **as** QAM signals haven't been seen Compared with the simple constellation modulation signals, i e PSK, the SNR estimation of QAM and, especially, the high-order QAM signal **is** more difficult. By using the way of statistics' like [I1]. [12], this paper deduces a NDA SNR estimation algorithm for QAM signals in AWGN channels.

This paper was organized as follows , proposed system was shown in section 2 , section 3 shows results and finally paper was concluded in section 4.

2. Proposed Scheme

Adaptive modulation system proposed by [18] K.seshadri Sastry and Dr .M.S.prasad Babu was modified in proposed scheme .In this Section, we explain OFDM system with adaptive modulation using Non data Aided SNR estimation. The proposed scheme is depicted in Fig. 1. The proposed system was simulated in Matlab 7.4 , Parameters of the simulated system are as follows , IFFT Size is 512 , Number of sub carriers are 512 , Number of sub bands are 32 , Number of sub carriers per sub band are 16 , Guard Time Duration is 128 , Frame size is 6 , SNR 1-35 dB , Modulation schemes used are MPSK, MQAM , convolutional coder with code rate 2/3 , Bandwidth 5MHz , Carrier Frequency 2 GHz , Sampling Frequency 5.4MHz .The transmit signals of the base station are created through convolutional encoder, modulated, inverse fast Fourier transform (IFFT), injection of guard interval (GI) and transmitted. The proposed scheme uses Adaptive Modulation that use 6 modulation orders. SNR estimation and change of modulation order are carried by FIS (Fuzzy Interface System)

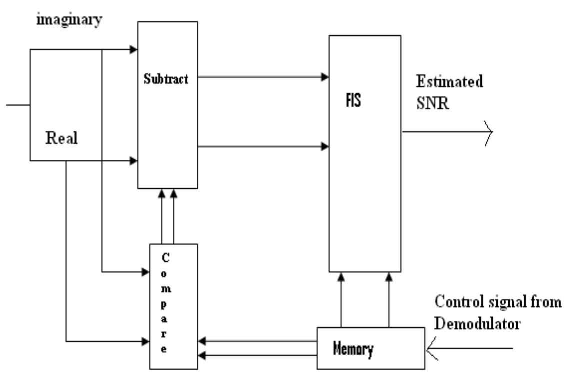


Adaptive modulation is advantageous than fixed modulation scheme since it responds to channel condition and maintains good performance (Bit Error Rate) and speed (capacity). But if the decision making system is not efficient then response of the system to changing conditions of channel is not good (that is either BER or capacity of the system is compromised) In this case the advantages of using adaptive modulation over fixed modulation is very less.

By employing Fuzzy logic in decision making system modulation levels can be changed very efficiently with changing conditions of channel.

2.1 Non-Data-Aided SNR Estimation

Non data Aided SNR Estimation Proposed in [19] proposed by K.Seshadri Sastry and Dr. M.S.Prasad Babu is used in proposed scheme. The Non Data Aided SNR estimation algorithm for QAM signals is derived based on a statistical ratio of observables over a block of data The Non-data-Aided SNR estimator block estimates instantaneous SNR of the received signal .Based on the instantaneous SNR calculated, the best modulation order will be chosen for the next transmission frame . In Non-Data-Aided SNR estimation block , Incoming bits are divided to imaginary and real parts (imaginary part consists of Quadrature information and Real part consists of Phase information).Imaginary and real part information is provided to subtract block and Compare block. Since in quadrature amplitude modulation more than one quadrature value and phase values are present, memory block consists of information of all quadrature components and phase components used in QAM modulator and demodulator , which was provided to Compare block. The Compare block compares incoming value with values in memory and picks nearest value in memory to incoming value. Compare block sends the value to subtract block which subtracts the incoming value from value provided by Compare block which will yield the deviation or difference.



Subtract block provides real value difference and imaginary value difference to FIS block. FIS block compares input data with data provided by memory block and computes SNR which was delivered as output . Modeling and operation of FIS block is explained in section 2.2

2.2 Memory Block

Memory block provides inputs to FIS block and compare block. In the proposed system SNR is calculated by amount of deviation . Fig2 shows amount of deviation and corresponding SNR value for Phase component and Fig 3 shows amount of deviation and corresponding SNR value for Quadrature component The deviation caused by the real and imaginary components from the actual values decides the SNR(Signal to Noise ratio) . The information of actual values (quadrature and phase components of Modulator and demodulator) and SNR to corresponding deviation is provided by memory block.

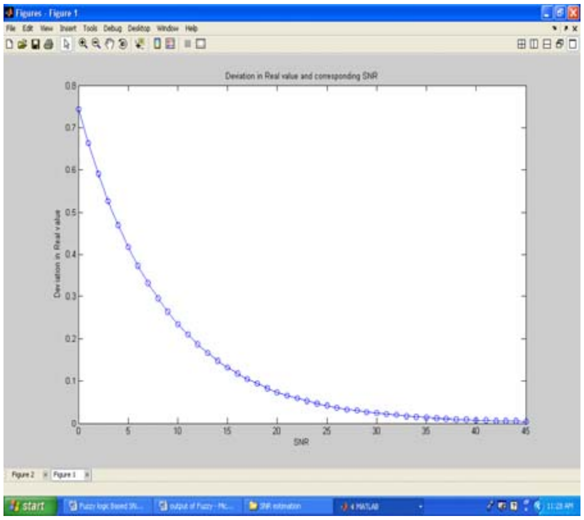


Fig 2 Deviation real values and corresponding SNR

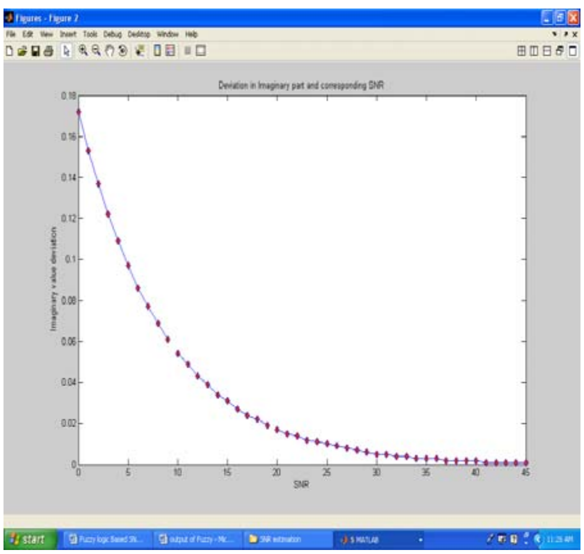


Fig 3 Deviation Imaginary values and corresponding SNR

For a system having variable modulation (adaptive modulation system) modulation order will change (constellation will change with modulation order) . When modulation order changes , the demodulator sends a control signal to memory to change the information of constellation

2.3 Fuzzy Logic Interface

Fuzzy Logic Interface block is an important component in Adaptive modulation system . In the proposed system it is used to calculate instantaneous SNR and to control modulation order . The overall performance of the system depends on Fuzzy logic Interface block. It takes two inputs from Non data Aided SNR estimation block, two inputs from memory. Working of Fuzzy logic interface block can be explained as follows , according to the inputs received from Non data Aided SNR estimation block and present modulation scheme (input from memory) fuzzy logic interface block controls the modulation order. . Fuzzy logic interface block is modeled in Matlab 7.4 Fuzzy Interface editor.

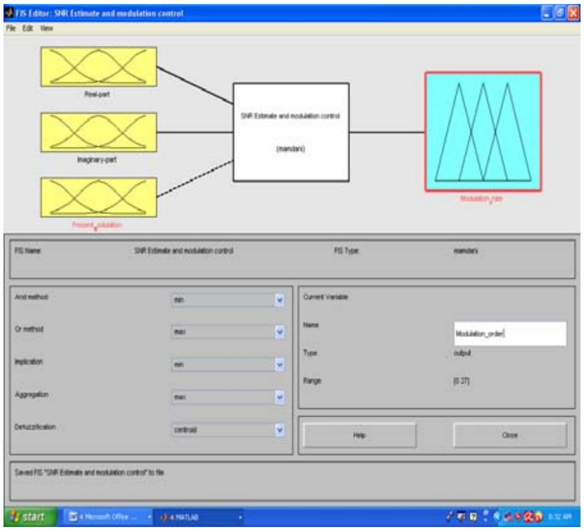


Fig 5 Fuzzy logic Interface system

Fuzzy interface System was shown in Fig 5 . . It consists of three input variables namely imaginary , real and present modulation . It consists of one output variable namely modulation order which controls the modulation order of adaptive modulation and demodulation blocks

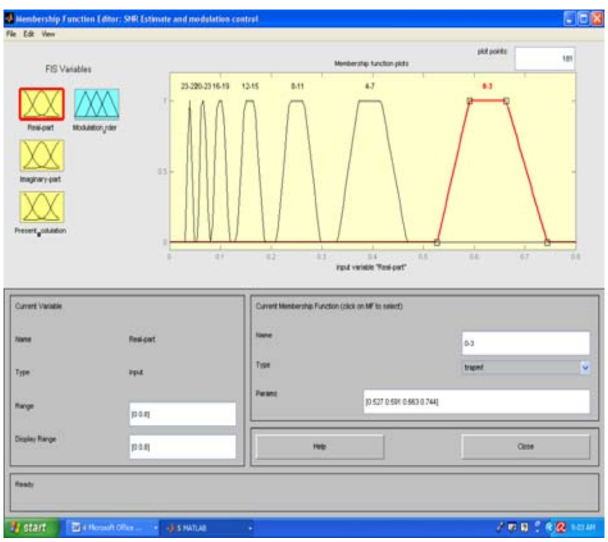


Fig 6 Input function Real part

The membership functions of input variables are shown in Fig 6 ,Fig 7 and the membership functions of output variable is shown in Fig 8 . Input variable "real part" consists of seven membership functions which gives the deviation from original value

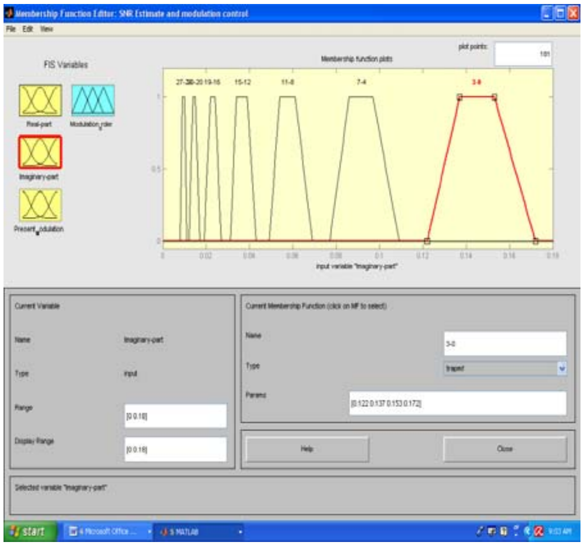


Fig 7 Membership function of Input variable Imaginary part

Input variable "imaginary part" also consists of seven membership functions and out put variable 'modulation order" consists of seven membership functions named 4 QAM ,8QAM , 16QAM , 32QAM, 64QAM , 128QAM and 256QAM as shown in Fig 8.

Fig 8 Output function modulation order

Rules are edited in rules editor which was shown in Fig 9 . Final output is shown and explained in section 3

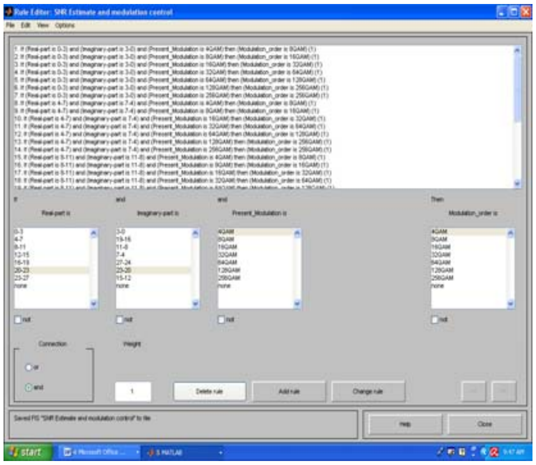


Fig 9 Rules Editor

3.Results

The above proposed system was simulated in Matlab7.4. Using fuzzy logic in decision making and in SNR estimation is a good choice because ordinary (non fuzzy) system is controlled by plain if and else , for example if for poor SNR(Signal To Noise Ratio) range is declared as 0 to 4 , if input is 4.1 then the input is not considered as poor SNR (But it is poor). If we use fuzzy logic in above case 4.1 is also considered as poor SNR (Signal To Noise Ratio). So using FIS (Fuzzy interface system) increases the performance adaptive modulation system.

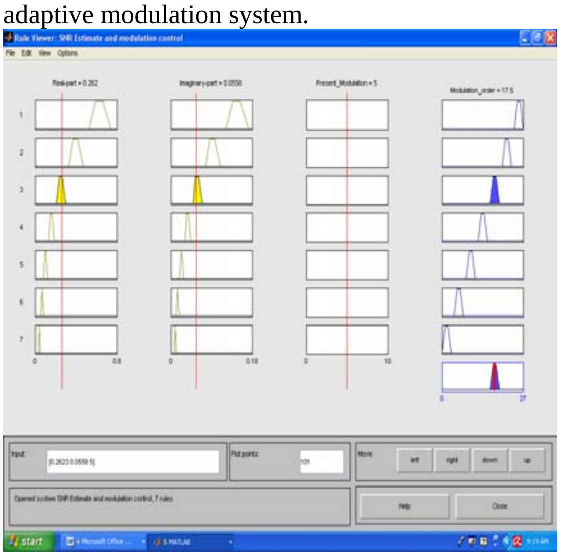


Fig 9 simulation result

Fig 9 shows the output of FIS (fuzzy interface system) for given set of inputs, output is selected based on given rules. Bit Error Rate performance of the simulated system is shown in Fig 10.

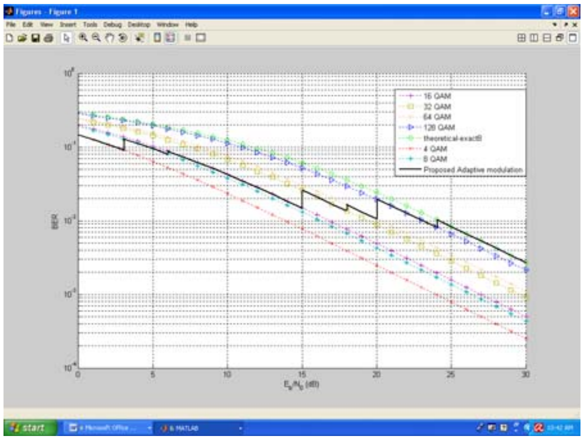


Fig 10 BER 8 BER comparison of proposed scheme and fixed modulation schemes.

Plot showing the comparison of performances of adaptive modulated OFDM system using fuzzy logic and ordinary control logic is shown in Fig 9.

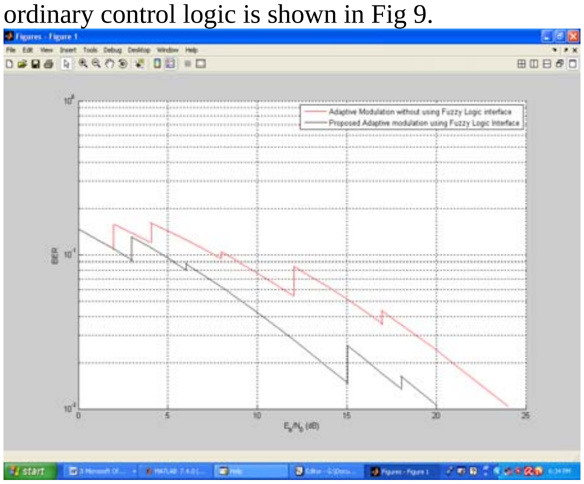


Fig11 Comparing Adaptive modulation schemes using Fuzzy Logic interface and using ordinary control logic

It was shown that OFDM system using Fuzzy logic and Non Data Aided SNR estimation performs better than OFDM system using ordinary control logic.

4.Conclusion

Using Fuzzy Logic Interface and Non-Data-Aided SNR estimation in implementing adaptive modulation for OFDM system increases performance of system since it responds to channel condition and maintains good performance (Bit Error Rate) and speed (capacity) efficiently than system using ordinary control logic (Plain if and else Conditions).

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