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A New Approach for Channel Estimation in Mimo Ofdm System

KEYWORDS: MIMO, OFDM, DIVERSITY, SNR, SER, MSE.

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ABSTRACT *In this paper, we study a new approach for channel estimation in MIMO OFDM system using Fuzzy based Kalman filter. We employ Kalman filtering for channel tracking in order to improve diversity gain. For channel estimation we used Minimum Square Error (MSE) Equalizer and compared the graphs of First order, second order and Extended Kalman filter with Fuzzy based Kalman filter. Simulation results shows that Fuzzy method can predict and estimate the channel accurately.*

I Introduction

For future wireless communication it is demands of high data rate, reliability and to achieve full diversity we use Multiple Input Multiple Output (MIMO) technology [1]. For high data rate signal transmission we use Orthogonal Frequency Division Multiplexing (OFDM) [2] - [4]. Then the OFDM combined with MIMO technology called MIMO-OFDM system is used to increase the diversity gain. Channel equalization is an important issue for wireless communication systems [5]. In order to provide good results at the receiver side the systems needs an accurate equalization of the channel [6]. The main intention behind this paper is to improve the channel estimation by using MSE equalizer. Here we used Fuzzy based Kalman filter to predict and estimate the channel. Kalman filter keeps the record of probable state of system.

In this paper part-II includes the proposed system model; Part-III includes performance analysis of Fuzzy based Kalman filter, in part-IV we discussed the obtain results and finally concluded.

II Proposed System Model

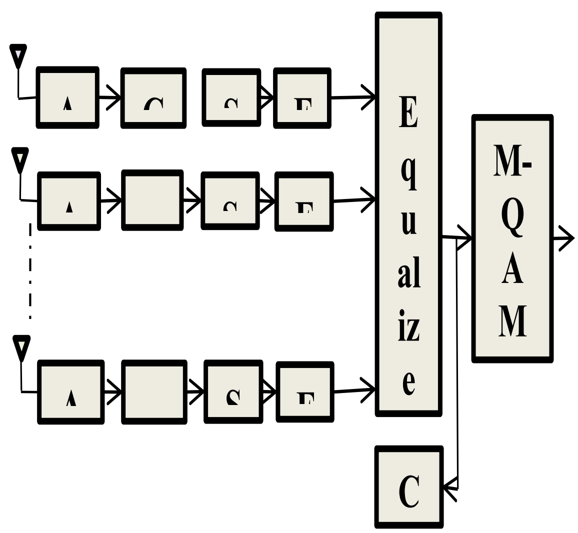

Figure 1: Proposed System Model

The proposed system model is shown in figure 1. For high data rate transmission, we assumed that the channel is time invariant during OFDM block symbol. After removing the cyclic prefix and passing FFT modulation, the received signal of the

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nth OFDM block symbol at the mth sub channel can be expressed as

$R_n(m) = C(s_n(m))\,H_n(m) + v_n(m)$

For $m = 0, 1, 2 \ldots N_c - 1$, where $R_n(m) \in C^{T_s \times N_r}$ is the received signal.

$H_m(n) \in C^{N_t \times N_r}$ is the frequency response of nth OFDM Block symbol on mth sub carrier.

$v_m(n) \in C^{T_s \times N_r}$ is the additive white gaussian noise.

III. Performance analysis of Fuzzy based Kalman filter

Law z:

$$\text{if } F_z \text{ is } \hat{v}_{n-1}$$

$$\text{then } Y_n = D_{z,n-1} Y_{n-1} + W_n$$

$$R_n = J_n Y_n = V_n$$

$$D_{z,n-1} = \begin{bmatrix} 1 & 0 & \ldots\ldots & 1 \\ 0 & a_{1,n-1(q)} I_{N_t N_r} & & a_{2,n-2} I_{N_t N_r} \\ \vdots & I_{N_t N_r} & & 0_{N_t N_r} \end{bmatrix}$$

$\hat{v}_{n-1}$ is the Premise variable.

$a_{1,n}(z)$ is the coefficient of Auto regressive Process matching to velocity of mobile station.

F_z is the fuzzy set.

$$Y_n = \frac{\sum_{z=1}^{Z} F_z(\hat{v}_{n-1})(D_{z,n-1}Y_{n-1} + W_n)}{\sum_{z=1}^{Z} F_z(\hat{v}_{n-1})}$$

$$\sum_{z=1}^{Z} \mu_z(\hat{v}_{n-1}) D_{z,n-1} Y_{n-1} + W_n$$

$$R_n = J_n Y_n = V_n$$

$$\mu_z(\hat{v}_n) = \frac{F_z(\hat{v}_n)}{\sum_{z=1}^{Z} F_z(\hat{v}_n)}, \qquad \sum_{z=1}^{Z} \mu_z(\hat{v}_n) = 1$$

$$Y_n = G(Y_{n-1}) + W_n$$

$$= \sum_{z=1}^{Z} \mu_z(\hat{v}_{n-1}) D_{z,n-1} Y_{n-1} + \Delta G(Y_{n-1}) W_n$$

$$R_n = J_n Y_n = V_n$$

Where

$$\Delta G(Y_{n-1}) G\left(Y_{n-1} - \sum_{z=1}^{Z} \mu_z(\hat{v}_{n-1}) D_{z,n-1} Y_{n-1}\right.$$

$$E\{[\Delta G(Y_{n-1})(\Delta G Y_{n-1})^H]\} \leq Z I_{2NtNr+1}$$

Evaluation rule z:

$$\text{if } F_z \text{ is } \hat{v}_{n-1|n-1}$$

$$\text{then } Y_{z,\, n|n} = D_{z,\, n-1} \hat{Y}_{n-1|\, n-1} + k_{z,n} e_n$$

Where

$$e_n = R_n - J_n \hat{Y}_{n\,|\,n-1}$$

for zth estimation rule, $k_{z,n}$ is the fuzzy based kalman gain with **z=1, 2, 3, 4……Z.**

$$\hat{h}_{n|n} = U\, \hat{Y}_{n\,|\,n}$$

$$U = \left[\, 0_{N_t N_r \times 1} \quad I_{N_t N_r} \quad 0_{N_t N_r} \right]$$

IV Result and Discussion

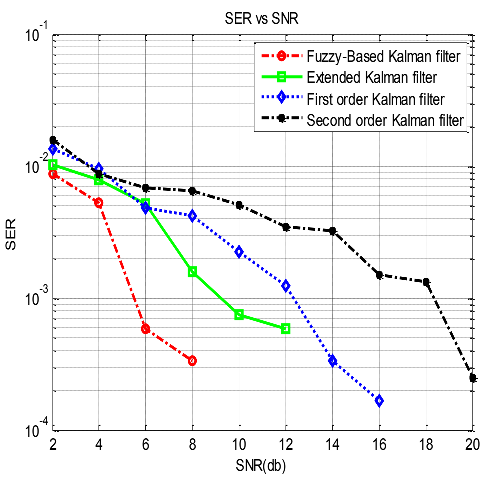

Figure 2: SER vs.SNR without Channel Estimation

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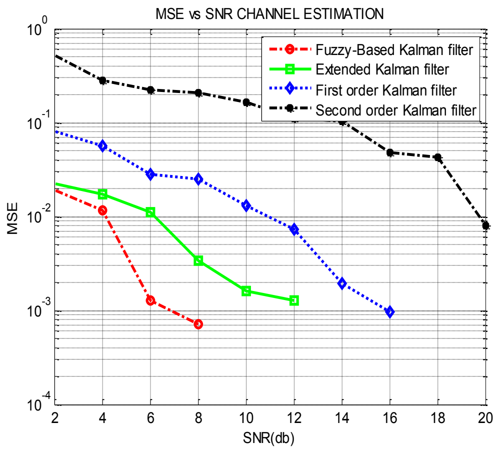

Figure 3: MSE vs. SNR for Channel Estimation

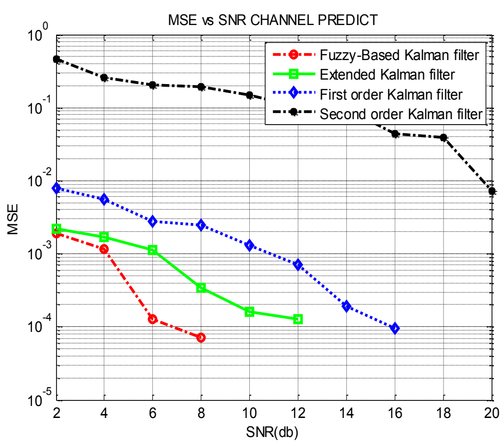

Figure 4: MSE vs. SNR for Channel Prediction

The figure 2 shows the graph of SER with SNR without Channel Estimation. At 4 dB SNR the SER is approximately equal to 1. As signal to noise ratio increases the bit error rate decreases. Because as per the definition of BER which is inversely proportional to SNR. So at 6 db SNR the fuzzy based Kalman Filter is 1.5×10^{-3}. As compare to other filters fuzzy kalman filter can perform better.

Figure 3 shows the graph of MSE vs. SNR for Channel Estimation. For our convenience we compared the result of fuzzy Kalman filter with extended, second order and first order Kalman filter. At 8dB SNR the fuzzy Kalman filter is 3.2×10^{-3}.

Figure 4 shows the graph of MSE with SNR for Channel Prediction. Here we can predict the channel based on SNR value. At 8 dB SNR the fuzzy Kalman filter is 3.2×10^{-4}.

The result is simulated using MATLAB for different QAM and different antenna configurations applied to MIMO with MSE equalization and are shown in figure 2 to 4.

Conclusion

In this paper we studied the problem of MIMO OFDM channel estimation for communication systems. For such systems we proposed a new approach called Fuzzy based Kalman filter. Here we compared the graphs of First order, Second order and Extended Kalman filter with Fuzzy based Kalman filter. As MSE increases SNR decreases. As compare to other three filters, Fuzzy based Kalman filter performance is good.

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