論文
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The Study on Nonlinear Compensation Characteristics of Multi-tap Update Algorithm in Broadband PCS Channel

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Abstract

The diversity reception and the equal gain combining technique are applied to the compensation of the distortion of channel, which occurs in transmission of data at rapid speed.

DSSS BPSK system which has the receiving structure with the compensation algorithm is formed on the diversity branch, and the characteristics of the system are evaluated at the view point of the average bit error rate due to the SNR.

In addition, the multi-tap update algorithm which is superior for the data compensation is suggested. Moreover, using the American Joint Technical Committee PCS RF channel characterization and system deployment model standard, the suggested multi-tap update algorithm is compared and analyzed with the view-point of the average bit error rate and convergence speed for evaluating the realistic efficiency of the system.

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1. Introduction

Radio mobile communication that get into the spotlight by information transmission medium of information society is developing by expectation during society whole as well as individual's desire. But, efficient design of communication system is required by user's increase and diversification of information. Also, distortion of communication channel became big obstacle in development of radio mobile communication.

Radio mobile communication channel is occurred distortion such as intersymbol interference, interference between different user, signal reception of multipath and noise that change according to time. A signal processing technology that can remove these distortion for reliable communication is essential.

Truin examined reception structure that use multipath diversity to overcome multipath phenomenon in 1984[1]. Estimated performance of DPSK DS/SSMA system using this result. Also, to suppression intersymbol interference, Pursley estimated performance of diversity reception PSK DS/SSMA system that divide receiver into branches and conform each branch in each other pseudo noise sequence[2].

Accordingly, in this paper, used to American Joint Technical Committee PCS RF channel characterization and system deployment model standard for estimation of system that is near in actual state[3]. Modeled channel because uses Doppler phenomenon, time delay and transmission power loss by parameter in multipath transmission and uses this model and evaluated average bit error rate of DS BPSK system to computer simulation. Also, when transmit data at high speed, used non-linear tap delay line structure to L diversity branches to overcome intersymbol interference that can happen. Tap delay line's tap coefficient introduced structure that update tap coefficient because use compensation algorithm so that can adapt to time variant channel.

Extend this convergence characteristics of compensation algorithm has low limit value about tap delay line's tap number and compensation ability of data suggested excellent multi-tap update algorithm.

2. Channel Modeling

In the case of direct sequence spread spectrum method, must drop more than a chip that do least between signal components to separate signal component that is received through two paths. If T/T_c is much bigger more than average path number, probability that delay differential between two paths is smaller than a chip is very small. Like this, reached signals can treat by one fading signal in receiver. Also, can model channel by equivalent low pass impulse response's linear filter as following if bandwidth of transmission of a message signal is bigger than coherent bandwidth of channel and each path characteristic's change is slow[4].

$$h(t)=\sum_{l=1}^{L}\beta_l\delta(t-t_l)\exp(j\Phi_l) \qquad (1)$$

Where, β_f, t_l and Φ_l are a random variable that mark gains of each l times path, time delay and phase respectively. L is path number reaching in receiver element and $\delta(\cdot)$ is Kronecker delta function.

Channel that use in simulation in this paper establishes by standard in 1994 preparation for RF channel characterization, system deployment modeling and performance evaluation of personal mobile communication in American JTC and was notified publicly. Because height of antenna differs with existent cellular method with PCS's cell size, modeling of new channel is required.

Wideband tap delay line model supposes that it is a complex Gaussian WSSUS model. In order to model this, it should be defined about different environment with Doppler spectrum that display time variant statistics and average power to path delay. Itis shown that physical environment of PCS channel in table 1. Each environment used channel model who express environment that often can happen at here although cause wide change in the extent.

Indoor		Residential
		Office
		Commercial
Outdoor	Pedestrian	Urban high-rise
		Urban/suburban Low-rise
		Residential
	Vehicular	Urban high-rise
		Urban/suburban Low-rise
		Residential

Table 1. Physical environment of PCS

It is equation (2) if is known that $x(t)$ and $y(t)$ are complex low pass signal of channel input and output each.

$$y(t)=\sum_{n=1}^{N}\sqrt{P_n}\,g_n(t)x(t-\tau_n)+n(t) \quad (2)$$

Where, P_n is power of n times weight and $g_n(t)$ is complex Gaussian process that add n times equal signal. τ_n is time shift. Define Doppler spectrum of tap weight $\{g_n(t)\,;n=1,2,\cdots,N\}$, tap delay term $\{\tau_n(t)\,;n=1,2,\cdots,N\}$ and value of tap weight $\{P_n(t)\,;n=1,2,\cdots,N\}$ to define channel model such as equation (2) perfectly. Result is as following.

$$g_n(v)=\frac{1}{\pi}\frac{1}{\sqrt{\left(\frac{V}{\lambda}\right)^2-v^2}} \quad |v|<\frac{V}{\lambda} \quad (3)$$

Where, equation (3) is equal with classical narrow-band channel modeling. Also, figure 1 is represent process that create n times tap weight $g_n(t)$.

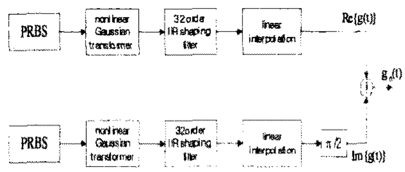

Figure 1. Block diagram of tap weight generation process

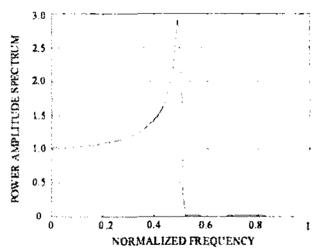

Figure 2. Power amplitude spectrum of a designed IIR filter

Figure 2 is shown that form of classic Doppler spectrum using in outdoor channel model of implement IIR filter. Accordingly, broadband PCS channel model's block diagram to use in simulation is figure 3.

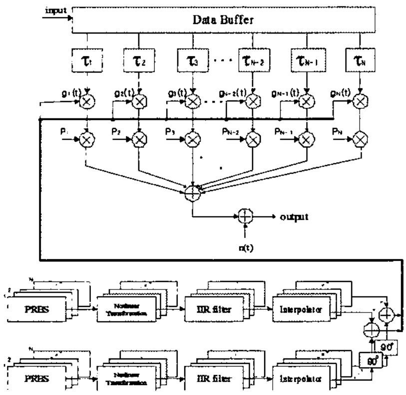

Figure 3. Block diagram of PCS channel model

3. Multi-tap Update Algorithm

Root mean square of existent tap update algorithm does not improve more even if signal tap algorithm increases tap number. Therefore, in this paper, used tap number did to reduce convergence rate as is same. I proposed multi-tap update algorithm (MTU) that one input data I times repeatedly handle and does tap coefficient update. Block diagram is figure 4 in reply. Tap coefficient update equation of existent, sequential least mean square algorithm is equation (4)

$$w(n) = w(n-1) + \sum_{i=0}^{I} k(n-1)\xi_i^*(n) \quad (4)$$

$$\xi_i^*(n) = d(n-i) - w_i^H(n-1)u(n-i) \quad (5)$$

H is Hermitian transformation and * is conjugate complex number. It is equation (6) if substitutes equation (5) to equation (4) and yields expected value. Where, $\alpha = n - M - 1$.

$$E[w(n)] = \left(I - \frac{1}{\alpha}\right)E[w(n-1)] + \frac{1}{\alpha}w_{opt} \quad (6)$$
$$+ \sum_{i=1}^{I}\left\{\frac{1}{\alpha-i}(w_{opt} - E[w_i(n-1)])\right\}$$

Also, it is equation (7) if defines as new vector that expected value of $w(n)$ and optimum tap coefficient w_{opt}'s difference and arranges substituting to equation (6).

$$f(n) = \left(I - \frac{1}{\alpha}\right)f(n-1) - \sum_{i=1}^{I}\frac{1}{\alpha-i}f_i(n-1) \quad (7)$$

It is equation (8) if express equation (7) by arbitrary j times element [5].

$$f_0(n,j) = f_0(n-1,j)\left(1 - \sum_{k=0}^{I}\frac{1}{\alpha-k}\right)^{I+1} \quad (8)$$

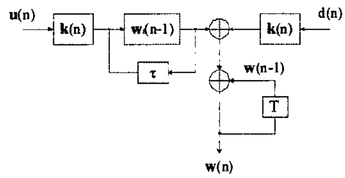

Figure 4. Signal flow graph representation of the proposed algorithm

4. Result and discussion

In this chapter, I had computer simulation about algorithm that is proposed in broadband PCS channel. Modulation method used DSSS BPSK and frequency of carrier is 1920MHz and transmission speed of spread data is 10 Mcps. Update number of times of proposed multi-tap update algorithm fixed by 3 times considering complexity and performance improvement of system. Each parameter established by $\delta = 0.04$, $\lambda = 0.98$. Considered outdoor urban/suburban low-rise environment of high speed that is the most inferior environment among various channel environment and tap delay line parameter connected with this appeared in table 2.

# of tap	channel A		channel B		channel C	
	Rel. Delay (nsec)	Avg Power (dB)	Rel. Delay (nsec)	Avg Power (dB)	Rel. Delay (nsec)	Avg Power (dB)
1	0	-1.6	0	-2.5	0	-4.8
2	100	-5.1	300	0.0	300	-0.3
3	200	0.0	8900	-12.8	800	-7.4
4	500	-7.6	12900	-10.0	8000	0.0
5	1200	-6.9	17100	-25.2	27000	-6.5
6	1600	-27.6	20000	-16.0	55000	-9.8

Table 2. tapped delay line parameter (classic fading)

Figure 5 is average bit error rate about non linear tap structure. Can confirm in picture that MTU algorithm displays lesser error rate than RLS algorithm. Also, figure 6 displays BER special quality about RLS and MTU algorithm in circumstance that channel environment is more worse. Thus, I can not get sequence that want even if combine algorithm that is excellent in non linear tap delay line structure for data compensation if environment of channel changes very fast.

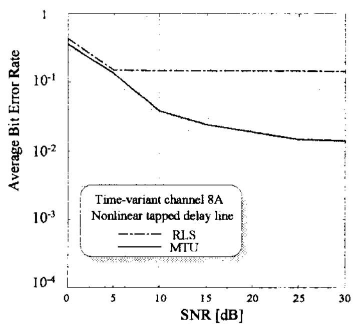

Figure 5. BER of nonlinear tap delay line

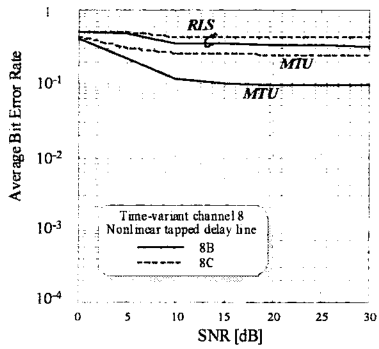

Figure 6. BER performance curve

Figure 7 is a thing to confirm elevation of performance according to number of diversity branch. Investigated changing diversity number of branch about 3 channel circumstance (A, B, C) considering in this paper. Performance can see big difference in case do not with occasion that use diversity and is distinguished. Certainly as channel circumstance is good.

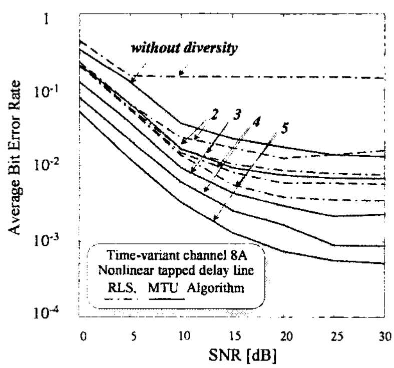

Figure 7. BER curve with varying diversity branch

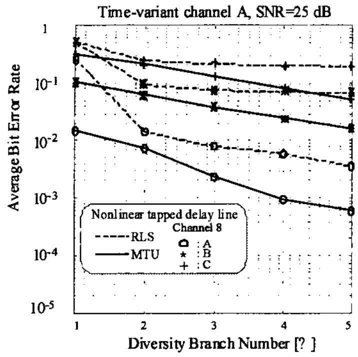

Figure 8. BER curve with varying branch number

Figure 8 compared BER performance curve by diversity branch about MTU algorithm with RLS in outdoor low-rise urban/suburban environment among time variant channel. As number of branch increases, average bit error rate decreases about 10^{-1}~10^{-2}. Also, proved excellency of MTU algorithm proposing than RLS algorithm knowing in non linear compensation algorithm.

5. Conclusions

In this paper, I use non linear tap delay line structure to compensate serious frequency selective fading and transmission loss that happen in broadband PCS channel. Tap coefficient of each delay line structure applied existent RLS algorithm and proposing MTU algorithm to do update. Does data send-receive at 10 Mcps' speed to DSSS BPSK system that have carrier wave of 1920MHz and estimated performance of reception system in view of mean square error and average bit error rate.

As a result, signal of high speed that pass time variant channel can not expect improvement of performance even if increase SNR. Also, excellent compensation algorithm, RLS algorithm did not cope in channel that changed fast. But, proposed MTU algorithm could confirm than RLS algorithm that average BER is improved more than about 10^{-1}.

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