**COMPARATIVE STUDY OF LINEAR PRECODING TECHNIQUES**

**Abstract:**

The Linear Pre-coding techniques of Maximum Ratio Transmission (MRT) will be implementing on 5G MIMO environment. Along with the other linear pre-coding techniques such as, Zero Forcing (ZF) and Minimum Mean Square Error (MMSE) will also be implemented and made comparison between later two techniques with proposing MRT technique and the parameters are verified through simulation. The results showed that the proposed MRT has a low bit-error rate compared with the existing techniques.

**Keywords:** Maximum Ratio Transmission (MRT), Linear pre-coding Algorithm, 5G mobile communication technology, MIMO.

**Literature Survey**

**[1] W. C. Jakes, Jr., Mobile Microwave Communication. New York Wiley, 1974:**

A multiplicity of autonomous terminals simultaneously transmits data streams to a compact array of antennas. The array uses imperfect channel-state information derived from transmitted pilots to extract the individual data streams. The power radiated by the terminals can be made inversely proportional to the square-root of the number of base station antennas with no reduction in performance. In contrast if perfect channel-state information were available the power could be made inversely proportional to the number of antennas. Lower capacity bounds for maximum-ratio combining (MRC), zero-forcing (ZF) and minimum mean-square error (MMSE) detection are derived. A MRC receiver normally performs worse than ZF and MMSE. However as power levels are reduced, the cross-talk introduced by the inferior maximum-ratio receiver eventually falls below the noise level and this simple receiver becomes a viable option. The tradeoff between the energy efficiency (as measured in bits/J) and spectral efficiency (as measured in bits/channel use/terminal) is quantified. It is shown that the use of moderately large antenna arrays can improve the spectral and energy efficiency with orders of magnitude compared to a single-antenna system.

**Summary:** With the use of moderately large antenna arrays the efficiencies of energy and spectrum has improved with many orders than a one-antenna system.

**[2] Rusek F, Persson D, Lau B K, et al. Scaling up MIMO: Opportunities and challenges with very large arrays [J]. Signal Processing Magazine, IEEE, 2013, 30(1): 40-60:**

Massive multiple-input multiple-output (MIMO) techniques have the potential to bring tremendous improvements in spectral efficiency to future communication systems. Counterintuitively, the practical issues of having uncertain channel knowledge, high propagation losses, and implementing optimal non-linear precoding are solved more or less automatically by enlarging system dimensions. However, the computational precoding complexity grows with the system dimensions. For example, the close-to-optimal and relatively “antenna-efficient” regularized zero-forcing (RZF) precoding is very complicated to implement in practice, since it requires fast inversions of large matrices in every coherence period. Motivated by the high performance of RZF, we propose to replace the matrix inversion and multiplication by a truncated polynomial expansion (TPE), thereby obtaining the new TPE precoding scheme which is more suitable for real-time hardware implementation and significantly reduces the delay to the first transmitted symbol. The degree of the matrix polynomial can be adapted to the available hardware resources and enables smooth transition between simple maximum ratio transmission and more advanced RZF. By deriving new random matrix results, we obtain a deterministic expression for the asymptotic signal-to-interference-and-noise ratio (SINR) achieved by TPE precoding in massive MIMO systems. Furthermore, we provide a closed-form expression for the polynomial coefficients that maximizes this SINR. To maintain a fixed per-user rate loss as compared to RZF, the polynomial degree does not need to scale with the system, but it should be increased with the quality of the channel knowledge and the signal-to-noise ratio.

**Summary:** For maintaining a fixed per user rate loss as compared to RZF, the degree of polynomial need not to vary, but it should be increased with the quality of the channel knowledge and SNR.

**[3] Zarei S, Gerstacker W, Schober R. A low-complexity linear precoding and power allocation scheme for downlink massive MIMO systems[C]//Signals, Systems and Computers, 2013 Asilomar Conference on.IEEE, 2013: 285-290:**

In wireless communication fading of channels is the serious cause of the received degraded signals. The effect of fading can be minimized by using various time and space domain techniques. However, space domain techniques are preferred over the others due to its advantages. In this paper, comparison of the wireless MIMO system under Almouti's and maximum ratio combining schemes is presented. Basic idea in these schemes is to transmit and receive more than one copy of the original signals. Using two transmitter antennas and one receiver antenna, the scheme provides the nearly same diversity order as the maximal-ratio receiver combining (MRRC) with one transmitter antenna, and two receiver antennas. Results for one transmitter and four receivers under MRRC is also presented and compared. Finally, results are presented while varying the average transmitted power.

**Summary:** Comparison of the Maximum ratio combining and Almouti’s schemes for transmitting and receiving more than one copy of original signals.

**[4] Zarei S, Gerstacker W, Muller R R, et al. Low-complexity linear precoding for downlink large-scale MIMO systems[C]//Personal Indoor and Mobile Radio Communications (PIMRC), 2013 IEEE 24th International Symposium on. IEEE, 2013: 1119-1124:**

The performance of linear precoding schemes in downlink Massive MIMO systems is dealt with in this paper. Linear precoding schemes are incorporated with zero forcing (ZF) and maximum ratio transmission (MRT), truncated polynomial expansion (TPE), regularized zero force (RZF) in Downlink massive MIMO systems. Massive MIMO downlink output is evaluated with linear precoding included. This paper expresses the performance of achievable sum rate linear precoding with variable signal-to-noise (SNR) ratio and achievable sum rate and several transmitter-receiver antennas, such as imperfect CSI, less complex processing and inter-user interference. The transmitter has complete state information on the channel. The information narrate how a signal propagates to the receiver from the transmitter and reflects, for example, the cumulative effect of distance scattering, fading, and power decay. They show that the performance analysis of two linear precoding techniques,i.e.Maximum Ratio Transmission (MRT) and Zero Forcing (ZF) for downlink mMIMO output network over a perfect chain. The results show the improved ZF precoding achievable sum rate compared to the MRT precoding schemes and also compared the average achievable rate RZF and TPE.

**Summary:** Comparison of linear pre-coding techniques such as, MRT and ZF.

**Existing System:**

**Zero Forcing:**

Zero Forcing (ZF) pre-coding technique is applied for massive MIMO 5G environments to eliminate interference among users. ZF produces a matrix which is a Pseudo-Inverse of the channel matrix of the user. ZF’s matrix is calculated at the transmitting side. The intention of ZF is to minimize the interference between the users but it is susceptible to noise when a large number of users are present. Initially, ZF was created for cancelling out the interference between users but with a loss of signal at very low level which makes it not suitable for environments where a large number of users are present.

**Minimum Mean Square Error:**

Minimum Mean Square Error or (MMSE) is modified version of the Zero Forcing (ZF). The intention is make the system to handle other users without forcing them to zero for minimizing the interference. The only difference between the existing ZF and the modified MMSE is value of the Beta which is the ratio of total power and noise power of the signal. At a very high SINR environments the value of the beta becomes zero resulting in traditional ZF implementation. When, the SINR is low the MMSE will be implemented. When the signal-to-noise ratio is small, it becomes larger, and MMSE pre-coding matrix, at the cost of allowing partial interference to be retained, tries to maximize the received SNR.

**Disadvantages:**

1. The existing method results in a low Bit-error rate but, still not up to the required level.
2. The existing method is inconsistent at massive MIMO 5G environments.

**Proposed System:**

**Linear Pre-Coding:**

We studied the performance of existing ZF and MMSE, now we implement the proposing technique that is Maximum Ratio Transmission (MRT). Generally, the MRT not cares about the interference among users. Initially, there exists N number of transmit antennas and M number of receiving antennas. Channel contains NXM statistically independent coefficients. The coefficient of channel is made available for both transmitter and receiver for pre-coding and decoding purposes. The transmitted bit always pre-coded such that, received signal vector is always or most times the product of transmitted signal vector and the noise of the channel,

x = Hs + n

Where, s = transmitted signals which is given by, s =

n = Noise signals which is given by, n =

In order to generate the transmission weight vector from the channel matrix, a linear transformation is required, that is,

Where, G =

The transmitted signal is then transmitted as,

The pre-coding of the kth user in the cell as,

**Advantages:**

* The main advantage of linear pre-coding technique of maximum ratio combining is its low bit-error rate compared to existing techniques.
* The MRT is good at low SNR environments.

**Applications:**

* Applications of are: MIMO environments, Beam Forming, Satellite Communication.

**Software & Hardware Requirements:**

**Software:** Matlab 2020a or above

**Hardware:**

**Operating Systems:**

* Windows 10
* Windows 7 Service Pack 1
* Windows Server 2019
* Windows Server 2016

**Processors:**

Minimum: Any Intel or AMD x86-64 processor

Recommended: Any Intel or AMD x86-64 processor with four logical cores and AVX2 instruction set support

**Disk:**

Minimum: 2.9 GB of HDD space for MATLAB only, 5-8 GB for a typical installation

Recommended: An SSD is recommended A full installation of all MathWorks products may take up to 29 GB of disk space

**RAM:**

Minimum: 4 GB

Recommended: 8 GB

**Learning outcomes:**

* Introduction to Matlab
* What is EISPACK & LINPACK
* How to start with MATLAB
* About Matlab language
* Matlab coding skills
* About tools & libraries
* Application Program Interface in Matlab
* About Matlab desktop
* How to use Matlab editor to create M-Files
* Features of Matlab
* Basics on Matlab
* What is an Image/pixel?
* About image formats
* Introduction to Image Processing
* How digital image is formed
* Importing the image via image acquisition tools
* Analyzing and manipulation of image.
* Phases of image processing:
* Acquisition
* Image enhancement
* Image restoration
* Color image processing
* Image compression
* Morphological processing
* Segmentation etc.,
* How to extend our work to another real time applications
* Project development Skills
  + Problem analyzing skills
  + Problem solving skills
  + Creativity and imaginary skills
  + Programming skills
  + Deployment
  + Testing skills
  + Debugging skills
  + Project presentation skills
  + Thesis writing skills