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Transmit Antenna Optimization in Massive MIMO Technology with EE, SE Trade off

Inumula Veeraraghava Rao, V. Malleswara Rao

Abstract: ***Massive MIMO Technology showed its unique characteristics and capabilities for future wireless communications where high data transmission rates are desired for fast growing 5G applications. High data transmission rates need more number of antennas at base station which comprised of increased system complexity and hardware cost. A proven method for reducing number of RF (radio frequency) chains at base station is Transmit Antenna Selection algorithm. In this paper an effective approach for TAS and optimizing the number of antennas at base station for desired data rates have been proposed and a Tradeoff between SE (Spectral Efficiency), EE (energy Efficiency) are discussed. MVGSA (modified velocity Gravitational Search algorithm) discussed for optimization of Transmit Antennas along with Improved SE and EE other effective algorithms are compared with multi objectives and data transmission rates. MVGSA proved with Improved SE and EE with Effective TAS.***

Index Terms: Massive MIMO, Transmit Antenna Selection, Energy Efficiency, Spectrum Efficiency, MVGSA

I. INTRODUCTION

5G is the immense future technology there is huge demand for the high data transmission rates with fast growing technologies like IOT, Artificial Intelligence need a methodologies where faster data rates required. The existing 4G technology algorithms may have drawback of providing higher data rates with limited antenna at base stations, Massive MIMO is the technique to serve the day to growing user with expected higher data rates. Massive MIMO require more number of antennas at base station which increases the Power requirements and also affect the Spectrum Efficiency. MVGSA [1] algorithm provide a solution for the EE and SE improvements. Due to the increase antenna number there is huge impact on sum rate capacity, to address this Greedy Algorithm [2] introduced in maximizing sum rate capacity in down link communication. Arrangement of multiple antenna structure addressed in ULA, UCA [3] to make more appropriate compaction in terms of size, with increased data transmission there is error pattern generation with channel interference to make error recovery Low Complexity error recovery [4] algorithms discussed.

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* Correspondence Author
I. Veeraraghava Rao*, Department of ECE GITAM (Deemed To be University), Rushikonda, Visakhapatnam, India. Email: raghva.inumula@gmail.com
Dr. V. Malleswara Rao, Department of ECE GITAM (Deemed To be University), Rushikonda, Visakhapatnam, India. Email: malleswararao.veera@gitam.edu,

Channel Optimization [5] for improving capacity of spectrum discussed with conversion of non-sparse MIMO to quasi sparse MIMO, to differentiate and to compare the performance of sum rate in fading channel and Time Selective [6] made available for massive MIMO. It finally concluded with MVGSA is the better algorithm to provide TAS (Transmit Antenna Selection) with improve SE and EE, a tradeoff made between SE and EE using different algorithms also discussed.

II. LITARUTURE REVIEW

A. Related Works

In 2019 I.V.Rao [1] has introduced Modified Velocity Gravitational Search Algorithm for optimizing Transmit Antennas at base station and also improving the Energy and Spectral Efficiency. This algorithm compared over convention algorithms like PSO, GA, ABC, GSA found to be good in optimization of Transmit Antennas and SE, EE parameters. A conventional GSA algorithm proposed with modified velocity and position to find the global best solution. MVGSA found to be the best solution for TAS and Enhancement of SE and EE.

In 2018 Aritra Konar [2] has introduced a novel transmit antenna selection algorithm in multi user Massive MIMO system. His investigation proved that transmit antenna selection also maximizes SE and EE by reducing power utilization at base station for this he considered Greedy algorithms for obtaining the combinational selection constraints for improving down link sum rate capacity. He proved that only greedy algorithm provides near optimal solution and also found when ZFB designed a loss in performance of sum rate.

In 2015 Xiang Gao [3] had investigated on performance evaluation of Massive MIMO system depends on Measured Propagation Data, he dealt with enhancement of sum rate capabilities for Multi User System where the users are located very near and far to the LOS. He found that the Massive MIMO provides better orthogonality between channels and better stability characteristics when compared with MIMO system. The proposed methodologies ULA and UCA performance observed very near to the IID Rayleigh Channels.

In 2017 Manish Mandloi [4] had suggested a technique for error recovery in transmitted vector symbols for an application of uplink Massive MIMO system with low complexity. This methodology found that enhanced error recovery accuracy over the recently proposed methods and also improved BER performance. Initially he started with conversion of Non sparse MIMO system into Quasi sparse error system by considering initial estimate of transmitted vector symbols In 2015

Wan A.W.M Mahyiddin [5] had investigated in time selective channels for the performance of
Massive MIMO system by using a method of Gaussian Markov Rayleigh Fading channel. He found a unique solution for the interference effect in time selective channels when constant amplitude pilots are used and also investigated on distinguished sum rates are generated for block fading and time selective channels.

In 2016 Said. E. Khamy [6] had introduced a novel technique to enhance the performance of Multi user MIMO system with TAS technique and transmit beam forming. He also investigated on different beam forming techniques for transmit antenna over Rayleigh fading channels. In his proposed method Linear Transmit Beam forming (MRT BF) provided with maximized capacity & minimized error probability, he also worked on reduction of RF chains, system complexity, hardware cost. The proposed MRTBF method excellent at smaller values of $\frac{E_b}{N_o}$ for CM AS and PM.

Table 1: Review on Conventional TAS Techniques in Massive MIMO Systems for EE, SE improvement

Author [citation]	Adopted methodology	Features	Challenges
I.V.Rao, [1]	Modified Velocity Gravitational search Algorithm	Improved EE & SE, Optimized TAS.	Finding Global Best Solution in Solution Space
Aritra Konar [2]	Greedy Algorithm	Maximize Down Link Sum Rate Capacity.	Sum Rate Loss for ZFB Design
Xian Gao [3]	Uniform Linear Array, Uniform Cylindrical Array.	Compact in Size, Performance close to IID Rayleigh Channels	Singular value spread when user located close to LOS
Manish Mandloi [4]	Low Complexity Error Recovery, Matrix Inversion	Non Sparse Massive MIMO into Quasi Sparse Error System	computational Complex, Conversion Rate
Wan A.W.M. Mahyiddin [5]	Gaussian Markov Rayleigh Fading	Difference Sum Rate Between Time selective & Fading Channels	Variable Amplitude pilots
Said. E. Khamy [6]	MRTBF, ZF, MMSE BF.	Error Probability Minimize, Capacity Maximize	Joint Transmit and user Scheduling, channel Matrix

B. Review

From Table 1, recent algorithms are compared to optimizing the Transmit Antenna Selection in Massive MIMO and Multi user Massive MIMO systems, where thousands of antennas are posed at base station to target high data transmission rates. At first MVGSA [1] algorithm considered where it has the improved SE and EE with Transmit Antenna Selection, but it will have challenge of providing global solution in solution space, Greedy Algorithm [2] introduced for maximizing Down Link Sum Rate Capacity in Massive MIMO but it suffered with ZFB design. Uniform Linear Array, Cylindrical Array [3] provide the compact in size of system, its performance almost close to IID Rayleigh channels but it has a challenge that user location close to LOS, In Low Complexity Error Recovery Algorithm [4] found longer time to convert Non Sparse MIMO into Quasi Sparse MIMO but provided with accurate Error recovery from vector Symbols. In Gaussian Markov Rayleigh Fading [5] algorithm measured the Time Selective and Fading Channels performance but suitable to constant amplitude pilots, In MRTBF [6] algorithm Error Probability Minimization and Capacity maximization but suffered with Joint Transmit user scheduling.

III. METHODOLOGY

Precoding is a method in which transmitter maintains the variations in the stream of information by assigning weights to the information, assume $\boldsymbol{S}$ is the amount of information $\boldsymbol{H}$ is the Channel, $\boldsymbol{N}$ is the additive Gaussian noise then the received amount of information $\boldsymbol{R}$ given as

$$\boldsymbol{R} = (\boldsymbol{S})\boldsymbol{H} + \boldsymbol{N} \qquad (1)$$

From equation (1) Receiver must have the knowledge of $\boldsymbol{H}$ and $\boldsymbol{N}$, where it will raises the complexity of the receiver but most of the practical receivers are simple because of cost and size so that the TX with Precoding methods has to code the information stream as $\boldsymbol{S/H_{EST}}$ then the received information as

$$\boldsymbol{R} = \left(\frac{\boldsymbol{S}}{\boldsymbol{H_{EST}}}\right)\boldsymbol{H} + \boldsymbol{N} \qquad (2)$$

If the prediction is corresct then $\mathbf{H}_{\mathbf{EST}} = \mathbf{H}$, then the received signal becomes R = S + N, it is evident that the Precoding Methods minimize error in receiver. The following are the best used linear Precoding methods to achieve EE and SE in Massive MIMO Technology.

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Zero Forcing: Pre Coding is a Pre Processing Technique at Base station which exploits CSIT (Channel State Information at the Transmitter) to match transmission to the instantaneous channel conditions. The Most Common Linear Pre Coding Scheme is Zero Force Scheme it is a simple method which decouples the multi user channel into multiple independent sub channels and reduce the design to power allocation problem, the Zero Force pre coder completely eliminates the interference at the receiver the performance of ZF *pre coding* decreases depending on the accuracy of *CSIT.*

Matched Filtering: Matched filter Maximizes SIR (Signal to Interference Ratio) at the receiver and it is optimum for high SNR region.

MV-GSA: (*Modified Velocity Gravitational Search Algorithm*)

MV-GSA algorithm proposed on the basis of Particle mass and the gravitational effect on the particle mass, initially the velocity of the particle estimated as

$$V_{i+1} = rand \; x \; V_i \; x \; a_i$$

V_{i+1} Velocity of mass,

V_i Current velocity of particle,

a_i Acceleration of particle

Velocity mass of particle is replace with acceleration and position then new velocity of particle estimated as

$$V_{i+1} = rand \; x \; V_i + rand(a_i - y_i)$$

Where **rand** is uniform random variable

y_i Current position of particle

Even though Massive MIMO addressed with MVGSA for better transmit antenna selection and optimization it is still under intensive research going on pilot contamination and Multi objective problems, this PILOT contamination will be addressed effectively in SLnO (Sea Line Optimization) and its enhanced version for TAS.

IV. PERFORMANCE COMPARISION

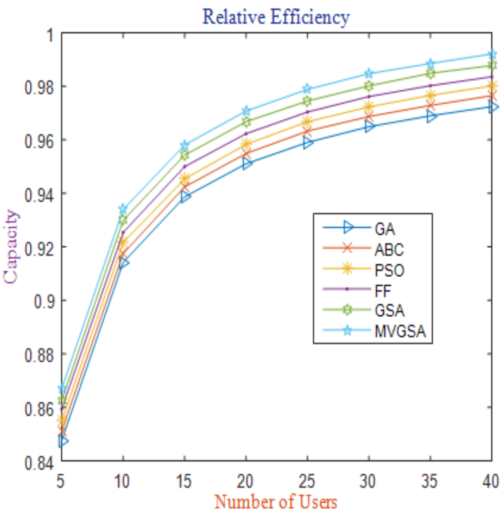

Fig 1. Relative Efficiency using Zero Force Precoding

From the Figures 1, a comparison made with different algorithms which are available for Precoding methods to Maximize EE and SE, MV-GSA will be the better in ZF in performance criteria

EE an SE with respect to the Number of Antennas

The EE is defined as the number of bits transferred per Joule of energy.

$$EE = \frac{C}{P_{sum}}$$

$$f_{EE}\,(N_t, P_t) = \frac{B.K.log_2\left(1+\frac{P_t(N_t-K)}{K\bar{\alpha}_{-1}\sigma^2}\right)}{\frac{B.P_t}{\eta} + N_t P_{BC} + P_{etc}}$$

The Spectral Efficiency is defined as the sum-rate per unit of bandwidth.

$$f_{SE}\,(N_t, P_t) = K\,log_2\left(1 + \frac{P_t(N_t-K)}{K\bar{\alpha}_{-1}\sigma^2}\right)$$

The Energy Efficiency and Spectral Efficiency is related as

$$f_{EE} = \frac{B.f_{SE}}{\frac{B\left(2^{\frac{f_{SE}}{K}}-1\right).\frac{K\bar{\alpha}_{-1}\sigma^2}{N_t - K}}{\eta} + N_t P_{BC} + P_{etc}}$$

By using velocity and position parameters in, the Estimation EE (Energy Efficiency) and SE (Spectrum Efficiency) vales are related with above analysis and this analysis place for optimizing number of antennas at base station in MVGSA algorithm.

V. CONCLUSION

In Massive MIMO Technology transmit antenna selection with Energy and Spectral efficiency is a challenging task, According to the existing contemplated algorithms they may produce either Energy minimization or Spectral Efficiency only, to enhance both EE and SE an improved Parametric Optimization Method which will be employed owing to its small parameters is required, In Massive MIMO the multi objective problem and PILOT contamination will be challenging task when more users are communicating with base station loaded with thousands of antennas, for solving these challenges we may chose MVGSA along with SLnO in future work.

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AUTHORS PROFILE

Inumula Veeraraghava Rao M.Tech, (PhD) Pursuing PhD in GITAM(Deemed to be University) having keen interest in Wireless Communication for maximizing EE and SE in 5G applications.

Dr. V. Malleswara Rao, working as a Professor in GITAM (Deemed to be University) from past 30 years, He is been published more than 75 articles in national and international Journals.