

# Analysis the efficiency of multi-input-multi-output (MIMO) transmit receive systems

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## ABSTRACT

Transmit antennas are chosen in multi-input-multi-output (MIMO) systems. Effective in improving system capacity while lowering RF connection costs and simplifying the system. Complete method with greatest accuracy for joint transmits and receive antenna selection (JTRAS), capable of scanning all subsets of both transmitting and receiving antennas for the optimal solution. However, when as the number of antennas but also computational complexity increase grows too great, limiting its application. Antennas are coded fractionally channel capacity maximizing coding is used as a basic criterion in this paper, and an intelligent algorithm Particle swarm algorithm, generic algorithm are used to pick antennas. The simulation results show that both algorithms are capable of performing antenna selection.

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## 1. INTRODUCTION

Multiple-input-multiple-output (MIMO) systems can vastly increase the functionality of wireless transmission networks and communication systems [1]. In addition, compared to systems with a single input and output, it can significantly increase system performance without sacrificing bandwidth [2]. A notable advancement in smart antenna technology for mobile communications is the ability to significantly increase spectrum utilization through the use of additional antennas, space-time coding, and other methods [3]. On the other hand, using the same amount of radio frequency RF connections as the antenna to guarantee typical MIMO system communication significantly raises system complexity and implementation costs, making the MIMO system much larger than usual [4]. As a result of the communication system's limitations, candidacy and promotion are limited. As a result, antenna selection is critical, with the focus on meeting particular criteria for the antenna. The exhaustive algorithm (EA) [5] is the best strategy for choosing antenna subsets since it can calculate all potential subset combinations and choose the one that will result in the best system performance [6].

The algorithm's complexity remains high, and its performance in terms of simplicity of use is poor. As a result, numerous academics have devised joint transmits and receive antenna selection (JTRAS) methods [7] to lower the algorithm's computational complexity from various angles, while maintaining a while reducing the computational complexity of the method, relatively high channel capacity. As an alternative, the AS is based on the channel matrix's max. Column's minimum parameterization [8]. The Frobenius maximum parameter setting [9] has no matrix operation and has a minimal computational complexity. The number of

reception antennas is equal to the number of transmitting antennas in a fast and global antennas system (AS) algorithm [10]. An antenna replacement process that is improved iteratively in real time order to overcome the limitations of the traditional method of selecting an antenna with maximum square volume (SMV) [11] while maintaining as grateful performance as the SMV model [12].

A low-complex AS model [13] that maximizes design interference between users and, by maximizing user-received power, identifies the subset of antennas with the largest design interference. Interestingly, the BAB algorithm, inspired by the branch and link (BAB) [14] adapter for increase channel capacity (CC) [15] by three orders of magnitude, finding a subset of air is also utilized to choose a subset of antennas. When there are a lot of antennae, it's a bad idea to use this strategy.

It has been demonstrated that a good algorithm can help solve AS difficulties and even replace EA in the real world [16]. Intelligent algorithms are built on the concepts of natural laws and are used to solve problems. In recent years, intelligent algorithms such as genetic algorithms (GA) for industrial applications, complex optimization problems, and particle swarm algorithms (PSO) for optimizing functions in neural networks, education, and medicine [17] have demonstrated promising results in solving practical problems. As a result, combining AS with using intelligent algorithms, one can think differently and a new avenue for investigating new AS technologies. The calculation complexity is substantially enhanced. Particularly as it relates to large antennas, the budget volume rises rapidly and the AE computation time is excessive, making it challenging to obtain results quickly and minimizing its use [18]. The JTRAS algorithm [19] has been presented to increase the performance of the AS system. It delivers good results in terms of channel capacity [20].

This study discusses not only how well algorithms are used, but also how well algorithms are used. PSO and GA. In addition to the heuristic algorithms used, the simulation is superior to the natural biological population, compared to high computational complexity throughput, parallel opacity compression, convergence. These algorithms are built around a set of parameters that must be implemented first. Both methods can be used to solve real-world problems by including them into the AS problem. In this scenario, we'll utilize the fractional crypton (FC) method, which is based on an algorithm that's used to decrypt the process's regular operation, and the algorithm's operation is handled by the user. A specific algorithm for determining antenna faults and determining whether or not an algorithm is efficient and inherent in its functioning.

**2. METHOD**

**2.1. System model**

In order to obtain maximum channel capacity, the MIMO system uses multiple antennas at the transmitting and receiving ends. Information is also received and received through numerous antennas between the transmitting and receiving ends. Multi-antenna systems can increase system capacity, enhance wireless transmission quality, and consistently increase system throughput without using more spectrum resources or transmission power. Multi-antenna receivers can decouple and decode these data streams using space-time coding, achieving spatial diversity. Assuming a MIMO system with a transmitting antenna  $N_t$  and a receiving antenna  $N_r$ , the transmitted information stream is encoded in space-time at the end of the transmission to form an identical data stream  $N_t$ , which is simultaneously transmitted by the  $N_t$  antenna and received by the  $N_r$  antenna after crossing the spatial channel.

Because the receives several independent copies of the signal from the same information from a multichannel carrier and the signal does not deep fade at the same time, there will always be at least one copy of the signal with sufficient power. Signal-to-noise ratio (SNR) of an antenna. However, because a MIMO system relies on several RF links to provide enough communication, the system's complexity would drive up prices. As a result, AS is a critical technology for reducing keeping the advantages of MIMO technology while minimizing processing complexity and hardware costs.

As seen in Figure 1, we represent the subset of antennas chosen by the AS algorithm between  $N_t$  and  $N_r$  with  $L_t$  and  $L_r$ , satisfying the conditions that  $N_t > L_t$  and  $N_r > L_r$ . Furthermore, under the assumption that the symbols sent to all antenna cell are unrelated and the power is normalized,  $H$  is an arbitrary channel matrix expressed as an unselected  $N_t N_r$  channel matrix. The signal transmitted to the receiver in the event of flat frequency fading can be stated as follows [21]:

$$R = \begin{pmatrix} L_1 \\ L_2 \\ \vdots \\ L_{r1} \end{pmatrix} = \sqrt{\frac{\rho}{L}} \cdot \begin{bmatrix} h_{11} & \cdots & h_{1L_t} \\ \vdots & \ddots & \vdots \\ h_{L_r1} & \cdots & h_{L_rL_t} \end{bmatrix} \cdot \begin{pmatrix} r_1 \\ r_2 \\ \vdots \\ r_{L_t} \end{pmatrix} + \begin{pmatrix} w_1 \\ w_2 \\ \vdots \\ w_{L_r} \end{pmatrix} = \sqrt{\frac{\rho}{L}} HS + w \tag{1}$$

Where  $W$  is the white-noise Gaussian plug (AWGN) with a 1/2 inch variation in the real and the imaginary part,  $R$  is the receiver signal vector,  $S$  is the transmit signal vector, is the average signal-to-noise ratio of each

transmitter's transmit antenna, and  $S$  is the transmit signal vector. The system capacity signal, which denotes the communication system's maximum transmission speed, is one of its most crucial signals. A MIMO system's channel capacity is expressed as follows [22]:

$$C = \text{ldbet} \left( I_{Lr} + \frac{\rho}{L_t} H_{LrL_t} H_{LrL_t}^H \right) \quad (2)$$

the conjugate transition where the matrix unit  $L_t L_r$ . the channel  $H$  matrix's fading channel from broadcast antenna  $j$  to reception antenna  $i$ .  $H_{ij}$  has a Gaussian distribution that is sufficiently independent and has a mean deviation of  $1/2$  from zero. The  $C$  channel's capacity and channel efficiency (measured in bits/Hz) are numerically equivalent. The channel exhibits significant fading, and the coverage follows the Rayleigh distribution. In order to increase channel capacity, the goal of antenna selection is to choose a new channel matrix in  $H$  [23].

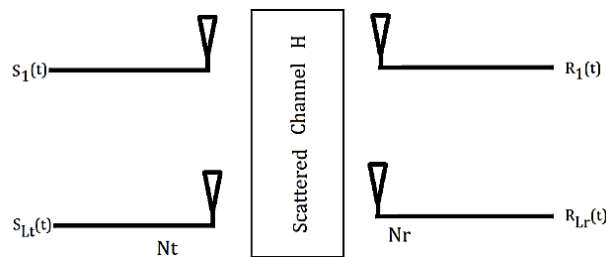


Figure 1. Model of the system

## 2.2. Genetic coding

Some of the AS encoding methods are binary encoding, for example B. Using 0.1 mask for antenna coding, but the number of antennas required in the process of Swarm information algorithm is different. Therefore, it is difficult to ensure that a number of antennas are selected [24]. To solve this problem, this paper looks at burst coding (FC) to avoid the number of antennas mismatching the problem to ensure complete operation. In particular, a random decimal coding of 0 to 1 was used for the  $N_t+N_r$  antennas and a numerical index was chosen from the largest to the smallest number of antennas required [25].

For instance, the  $N_t=4$ ,  $N_r=3$ ,  $L_t=2$ ,  $L_r=2$  settings for the following GA: The number of genes depends on the number of antennae; the first bit is  $N_t$  in Figure 2, which depicts how chromosomes are coded. The last  $N_r$  bit in the transmission identifies the receiving antenna [26]. On the premise that the transmitter selects 2/4, then the transmitter selects the 2,4 and 2/3 receiving antennas, then selects 1,2  $L_t$  and  $L_r$  are chosen starting with a random decimal number, and then sorted from largest to smallest. Two clever techniques have been applied in this research to resolve AS issues [27].

## 2.3. Genetic algorithm

Genetic algorithms are a type of random search strategy that mimics evolution's laws. The biological world is a bionic algorithm with a powerful all-encompassing quest of perfection, including various people at a higher level [28]. According to the norms of superiority and inferiority, the condition is handed on to the next generation, with some individuals of lesser fitness eventually departing from the population and others of higher fitness increasing. Figure 2 depicts the AS process based on a genetic algorithm. Table 1 illustrates the steps of the AS process that based on a genetic algorithm.

## 2.4. Particle swarm algorithm

The predatory behavior of bird flocks is modelled by a computer program known as the particle swarm algorithm (PSA). Based on the population intelligence hypothesis, PSO is a stochastic search and optimization technique. Unlike GA, the PSO avoids the usage of complicated genetic methods by using a global population-based search technique and a fundamental concept of speed and displacement [29]. However, as all particles converge to the ideal solution in the case of convergence, the particles tend to homogenize, resulting in a substantial decrease of the convergence rate in later phases. The AS process is depicted in Figure 3 using the particle swarm technique Table 2 illustrates the summary explanation of the steps [30].

Table 1. Process steps of AS which based on GA [26]

Step No.	Process	Operation
Step 0	Set the parameters	The number of chromosomes, algorithm iterations, MIMO system sending and receiving antennas, number of selected antennas, crossover probability, variation probability, and other critical algorithm parameters must all be determined.
Step 1	Initialization	Older adults make up a sizable portion of the population. A chromosome's number of genes is equal to the total number of antennas on its transmitting and receiving ends, or $N_r + N_t$ . A random decimal number between 0 and 1 is used to represent each gene, and this number is ordered from highest to lowest to determine the correct position. There is a specific set of antennas for each chromosome.
Step 2	Find and modify the chromosomal copy.	Identify and adjust the chromosome copy. Each chromosome corresponds to an antenna network and each selected antenna corresponds to the $H_s$ matrix channel.
Step 3	Chromosome transplantation	Chromosome transplantation. In this article, a single central location is used to create random intervals in the chromosomal series, and when interference is used, these two molecules are replaced with a probability after that point for creating a new chromosomal structure.
Step 4	Function of the chromosome	The probability of the difference is equal to the random number between 0 and 1 arose in the place of change instead of the origin of nature.
Step 5	Population updating	The chromosomal alterations of the cell group are calculated after mutation and mutation, and the chromosome has the highest population density, and is controlled by the largest chromosomal alignment in the actual population, whoever larger, the chromosome is added to a larger setting. Population. In effect in infant chromosome groups and vice versa. A new population was obtained by repeated iterations on the chromosome created in each group.
Step 6	End	Up until the predetermined number of repetitions, repeat steps 2 through 5 above. The optimal antenna combination needed is the chromosome that will work best for the final population. Finally, the calculation of the antenna numbers for the transmitter and receiver produces excellent-performing $L_t$ and $L_r$ antennas based on the required selection.

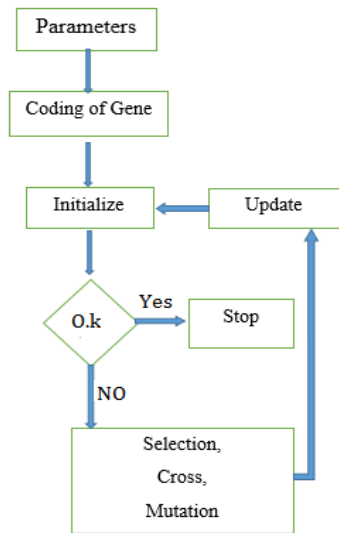


Figure 2. Flowchart of the (AS) based on (GA)

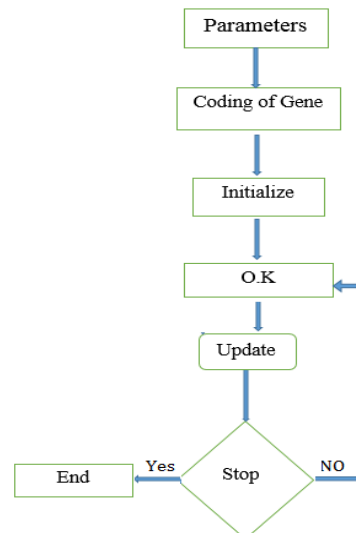


Figure 3. Flowchart of the (AS) based on PSO

Table 2. Process steps of AS which based on PSO [26]

Step No.	Process	Operation
Step 0	Set the parameters	Define the necessary parameters required by the method, which include acceleration constants $C_1$ , inertia weights, and so on, in addition to those listed at the start.
Step 1	Create a starting point and a fitness value.	Initialize the particle's velocity and position, where each particle's position and speed are represented by a decimal code and each particle is made up of a number of antennas; next, calculate the population's suitability value; compare each particle's suitability value to the value of the individual extreme; and finally, compare each particle's benefit value to the population's overall benefit. The appropriateness value of each particle, if it is higher, then takes the place of the global polarity.
Step 2	Update	Update the particle's velocity and location according to (3) and (4), where $P_i$ represents the individual extreme, $P_g$ represents the global extreme, $c_1$ , $c_2$ represents the learning factor, and $r_1$ , $r_2$ represents a random number evenly throughout the interval. [0,1]. $V = \omega \cdot v + C_1 r_1 (P_i - x) + C_2 r_2 (P_g - x) \tag{3}$ $X = x + v \tag{4}$
Step 3	Judgment	The best solution number is printed and solved if the best solution is satisfied or the allotted number of iterations has been reached; if not, step 2 is performed to continue the search.

### 3. RESULTS AND DISCUSSION

The results of the two algorithms were obtained under condition when the following parameters are set to: signal-to-noise ratio (SNR=4), population, population size=20, number of iterations ( $G=200$ ), ( $N_t=10$ ), ( $N_r=10$ ), ( $L_r=5$ ). From Figure 4, it can be seen that the two algorithms are used. The best solution number is printed and solved if the best solution is satisfied or if the given number of iterations is reached; if not, repeat step 2 to continue the search. In comparison of the maximum channel capacity (MCC) with the SNR in Figure 5, it can be seen that the optimal values and the best EA of the two algorithms are very close to each other and the MCC increases with the SNR.

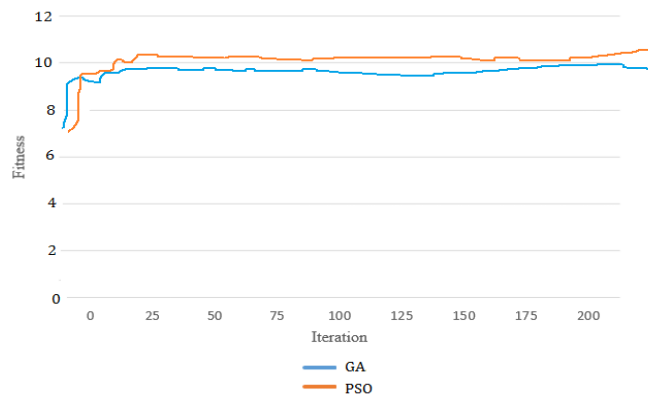


Figure 4. Fitness values versus iterations increase

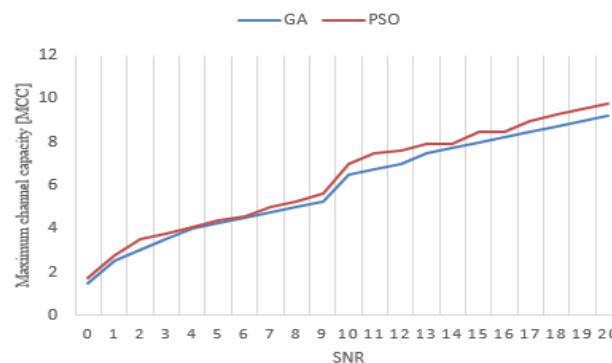


Figure 5. Maximum channel capacity (MCC) versus signals to noise ratio (SNR)

Setting the initial value of the ( $G=100$ ) and the population, pop size=20, then running the simulation for 20 iterations, Table 3 shows the results of the two methods in terms of optimal speed, accuracy, and stability. The findings acquired using the complete census method are regarded as the best option. The table demonstrates that the accuracy of the two algorithms for resolving AS problems in MIMO systems goes from highest to lowest over  $PSO > GA$  in terms of the ratio of the intelligent algorithm's maximum channel capacity to the EA solution. The PSO accuracy exceeds 90% for both antenna counts, and the accuracy is comparable for 10 and 15 antennas. Transmitting and receiving antennas, respectively. It is also clear that the PSO has a higher accuracy than the GA. Thus, PSO is extremely close to the optimal solution in case of solving the AS problems.

The standard deviation of the best answer for 20 consecutive cycles is used to determine stability, with the smallest deviation indicating the most stable estimator. Table 4 demonstrates that the resulting PSO has a lower standard deviation than the other two algorithms, showing that the PSO can find having a higher probability and fewer errors, the ideal value the other two algorithms have similar levels of stability. The intelligence estimates' stability and speed of search are shown in Tables 4 and 5, respectively. The number of iterations required to achieve a connection in the first is defined as the search speed, and the comparison demonstrates that the number of iterations required to obtain a total grows as the number of antennas increases for both algorithms. The GA has a faster search speed than PSO. Table 3 is determining the intelligent algorithm's speed.

Table 3. Intelligence estimates accuracy

PSO GA	
Nt=5 Nr=5 Lt =2 Nr=2	98.04% 96.10%
Nt=10 Nr=10 Lt =4 Nr=4	91.85% 87.18%
Nt=15 Nr=15 Lt =5 Nr=5	92.26% 85.75%

Table 4. Intelligence estimates stability

PSO GA	
Nt=5 Nr=5 Lt =2 Nr=2	0.022 0.038
Nt=10 Nr=10 Lt =4 Nr=4	0.034 0.048
Nt=15 Nr=15 Lt =5 Nr=5	0.018 0.047

Table 5. Intelligence estimates search speed

PSO GA	
Nt=5 Nr=5 Lt =2 Nr=2	22.32 17.98
Nt=10 Nr=10 Lt =4 Nr=4	35.15 23.24
Nt=15 Nr=15 Lt =5 Nr=5	48.01 39.05

#### 4. CONCLUSION

In this paper, the efficiency of the two intelligent algorithms, GA and PSO for the selection of the MIMO system by the transmitting and receiving antennas JTRAS have been investigated and analyses by using the FC approach. The simulation results indicate that the PSO has higher accuracy and stability than GA, however PSO has a slower search speed in comparison to GA. Both algorithms are substantially less difficult than the whole algorithm, allowing for the employment of the most suited algorithm as needed. Large MIMO systems will be available in the future other than 5G because ecause the Large MIMO systems and a large number of antennas might be useful in the tens or hundreds. So, intelligent JTRAS algorithms in MIMO systems must be important.





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