Billiards Inspired Optimization Algorithm for Optimal Antenna Selection

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Abstract: In both the telecommunication industry and academia, massive Multiple-Input Multiple-Output (MIMO) is a highly developed technology in wideband wireless communication system's prospects that incite widespread concentration. In the massive MIMO system, pilot contamination is considered a basic problem. The modeling of wireless systems possesses an important problem over system throughput. Even though, environmental security, and energy-saving, considered predictable developments and universal demands. Therefore, by representing all these results, this work aims to develop a novel billiards-inspired optimization technique to choose the best transmit antennas chosen by taking into consideration of multi-objective issue which increases both relative energy effectiveness and capability. Actually, the developed method optimally tunes a number of transmit antennas and decides which antenna to be chosen. At last, proposed work performance is evaluated and shown with existing techniques with respect to the relative efficiency analysis, capacity analysis, and optimal antenna selection analysis.

Keywords: MIMO, TAS, Energy Efficiency, CSI, Optimization Algorithm

Nomenclature

Abbreviation	Description
MIMO	Multiple-Input Multiple-Output
TAS	Transmit Antenna Selection
EE	Energy Efficiency
SIC	Successive Interference Cancellation
SNR	Signal to Noise Ratio
RF	Radio Frequency
CSI	Channel State Information
BS	Base Station
SISO	Single-Input Single-Output

1. Introduction

Nowadays the requirement of high transmission data rates has to turn out to be a serious problem with the overview of wireless communication systems. The exploitation of MIMO and multimode antennas has appeared as a motivating scheme to raise throughput and capability of wireless systems in prosperous scattering environments [1].

Multiple antennas or MIMO systems have been proposed to improve the communication systems performance by either skirmishing or using the multi-path scattering in the wireless channel, and extensively used within wireless standards, for instance, IEEE LTE and 802.11ac. Even though MIMO approaches enhance the facility of wireless systems in similar transmit power budget, and requisite bandwidth, circuit energy utilization of MIMO systems, is therefore superior to that of SISO systems. MIMO systems with existing supportive relay communications obtained important research attention because of maximum data rates, enhanced spectral effectiveness, improved coverage area, enhanced capability and maximum diversity gain [2].

At the receiver, CSI and the transmitter are needed to attain high performance in MIMO systems. Therefore, more frequency or time resources are exhausted on signaling overhead. Additionally, it is hard to attain CSI precisely and entirely. Hence, the performance of EE is enhanced in partial CSI, or impairments of CSI turn out to be a significant problem. The imperfect CSI effect was modeled as interference and iterative techniques were presented to resolve optimum EE. Estimation of capacity in

faulty CSI at the transmitter and ideal CSI at the receiver was exploited to compute EE. Moreover, robust multiuser beamforming was modeled to increase EE for multicell networks in attendance of CSI imperfection at the Base Station [4].

Current studies are concentrated towards the practice of under-used ultra-high frequency spectrum generally called mmW band. Nevertheless, with high path loss communication is coupled at such high frequencies. Beamforming, and Precoding methods exploiting large antenna arrays, can offer adequate array increase to surmount free space path loss and found communications with satisfactory SNR. As the count of transmit antennas is enormous in massive MIMO model operating at mmW frequencies, completely digital precoding which permits the utmost advantages of spatial multiplexing needs a detached RF chain for each antenna that is not almost possible because of high power and energy utilization with maximum complexity [15].

The primary objective of this article is to develop a novel billiards-inspired optimization approach to choose optimal transmit antenna selection.

• This is performed by taking into consideration of a multi-objective problem that raises both the relative EE and capacity.

• It seems that the developed method optimally adds up the transmit antennas and promotes recognizes suitable antenna to be chosen.

• Finally, developed method performance is examined and validated with conventional techniques in the perspective of relative efficiency analysis, capacity analysis, and analysis of optimal antenna selection.

2. Related Works

In 2020, Mahdi Eskandar et al [1], considered the maximization of allocation of power and EE problem in point-to-point, spatial multiplexing of MIMO schemes. Conversely, existing EE optimization techniques that determine the loading of power in ideal CSI assumption, energy-efficient equivalent power allocation was taking into consideration. It desires at transmitter limited feedback and also for optimal EE derived a lower bound expression regarding the parameters of the system. In 2020, Mostafa parvin et al [2] presented a systematic process to supply position in multi-mode MIMO antennas based on the characteristic mode theory. For multi-mode MIMO antennas, a circuit model exploiting modal radiated power was developed. Additionally, optimal feed positions were decided to stimulate these modes exploiting the reflection coefficient of the antenna and modal radiated power. In 2019, Parvez Shaik et al [3], worked on a dual-hop cooperative MIMO system performance for several futuristic QAM methods. A non-regenerative MIMO scheme with the TAS method was considered whereas a single transmit antenna. Taking into consideration of system model, it was presumed that relay, source, and a destination, were equipped by means of multiple antennas. In 2020, SalmanKhalid et al [4], a joint TAS and a precoding model was proposed. To carry out antenna selection to restrict the count of active antennas low Complexity heuristic techniques were exploited. Therefore, while minimizing the power utilization the energy efficiency will increase. In 2020, Omid Yazdani et al [5], proposed a novel and competent TAS for D2D mmWave networks on the basis of the Lagrangian relaxation technique. To examine the performance of the developed method another competent low-complexity greedy-based ASRA method was developed.

3. System Model

Let a single isolated cell encompass B terminals and a single BS. In E_t numbers, the transmitting (TX) antennas are incorporated in Base Station. Each B contains an individual RX antenna.

At terminals Eq. (1) indicates received signal vectors, here for each B the s indicates $B \times 1$ received vector, For forwarding link P_{tx} indicates complete TX power, O denotes $B \times E_t$ small scale Rayleigh fading channel matrix among E_t BS antennas and B terminals, ς indicates TX power normalization parameter, which is calculated using $\varsigma \approx \sqrt{\dfrac{E_t}{B}}$. V indicates $E_t \times B$ precoding matrix to reduce IUI, sv indicates the $B \times 1$ message signal vector, and nv indicates $B \times 1$ AWGN noise vector. By using precoding matrices, for LS-MIMO, two common pre-coding matrices are used, $\left(ZF : V = A^A \left(AA^A \right)^{-1} \right)$ ZF and MF $\left(MF : V = E_t^{-1} A^A \right)$, are devised. OFDM is used as the narrowband signal and it might effectively change the wideband signal to a narrowband signal.

$$s_m = \sqrt{P_{tx}} A \varsigma V s v + n v \tag{1}$$

Consider transmitter possess idyllist CSI. The system is indicated as LS-MIMO while $E_t > 10\, B$ is based on norms of thumb.

To calculate LS-MIMO EE organized green BS, there is a requirement of deciding an appropriate power consumption model. Eq. (2) indicates summation power, P_{sum}, a tractable power utilization technique integrating exact significant LSMIMO power consumption elements, whereas baseband power consumption is denoted as P_{BA}, PA power consumption is denoted as P_{PA}, and RF front-end power utilization which is encompassed of a mixer, filter, DAC power utilization is denoted as $P_{RF_{front}}$.

$$P_{sum} = P_{PA} + P_{BA} + E_t P_{RF_{front}} \tag{2}$$

For analytic ease, computation of power consumption P_{cp} is done which increases with the maximize in E_t as denotes exploiting Eq. (3). Hence, Eq. (3) is denoted as Eq. (4).

$$P_{cp} = \left(P_{BA} / E_t + P_{RF_{front}}\right) \tag{3}$$

$$P_{sum} = P_{PA} + E_t P_{cp} \tag{4}$$

Furthermore presumes OFDM system (10MHz) encompassing subcarriers (1024) by means of higher Class-B effectual (78:5%), and IBO as 11dB. Based on these constraints, the effectiveness of PA is chosen as 22%. Based on the outsized antennas number, the PA equation with increased effectuality might be costly. The relationship among P_{PA} and P_{tx} is indicated exploiting Eq. (5).

$$P_{tx} = \eta P_{PA} \tag{5}$$

LS-MIMO baseband power utilization model because of P_{BA} $sv(R\,flops)P_{BA}$ is indicated as explained in [6] [7].

$$z = E_t C. \begin{bmatrix} \left[\left(\dfrac{S_{gi}}{S_{sd}}\right)\log_2(S_{gi}C) + \left(\dfrac{S_{gi}}{S_{sd}}\right)\left(1 - \dfrac{S_{pt}}{S_{st}}\right)B + \left(\dfrac{S_{gi}}{S_{sd}}\right)\right] \\ \left[\left(\dfrac{S_{pt}}{S_{st}}\right)\log_2\left(\dfrac{S_{gi}S_{pt}}{S_{sd}S_{dl}}\right) + \left(\dfrac{S_{dl}}{S_{st}}\right)B^2\right] \end{bmatrix} \tag{6}$$

Within Eq. (6), each constraint is described as below
- The parameter C indicates the bandwidth possessing 10MHz power utilization.
- The parameter S_{st} denotes the slot length possessing 0.5ms power utilization.
- The parameter S_{pt} indicates the pilot length within 1 slot possessing 0.214ms power utilization.
- The parameter S_{sd} denotes the symbol duration possessing 0.214ms power utilization.
- The parameter S_{co} denotes GI which posses 4.7µs power utilization.
- The parameter S_{gi} denotes the Symbol without GI possessing 66.7µs power utilization.
- The parameter S_{dl} indicates the delay spread GI possessing 4.7µs power utilization.

In [8] these constraints were explained and the LTE system in [9]. The correlation among P_{BA} and $sv(R\,flops)$ is denoted in Eq. (7).

$$P_{BA} = \frac{sv(R\,flops)}{\varpi(R\,flops\,/\,U)} \tag{7}$$

Here, the efficacy of VLSI processing is denoted by ϖ, and $\varpi = 5R\,flop/U$ and $50R\,flop/U$ was chosen.

3.1 Optimal TAS Selcetion

As per eq. (8), the symbol used by m^{th} user is indicated, in that the $1 \times E_t$ channel vector is indicated as $g_{k,:}$ for m^{th} user and $E_t \times 1$ precoding vector is described using $p:,_k$ for m^{th} user. The last variable attained by Eq. (8) is called IUI.

$$q_k = \sqrt{\frac{P_{tx} E_t}{B}} g_{k,:} p:,_k z_k + e_k + \sqrt{\frac{P_{tx} E_t}{B}} \sum_{l \neq k} g_{k,:} p:,_l z_l \tag{8}$$

As per eq. (9), the single isolated cell size is calculated, in that the scaling factor for pilot overhead and GI is indicated as α and noise power in a particular bandwidth C is indicated as $E_0 C$.

$$F = \alpha C. \sum_{k=1}^{K} D \left[\log_2 \left(1 + \frac{\frac{P_{tx}E_t}{B}\left|g_k,: p:_{,k}\right|^2}{\frac{P_{tx}E_t}{B}\left|\sum_{l \neq k} g_k,: p:_{,l}\right|^2 + E_0 C} \right) \right] \quad (9)$$

Eq. (9) is rewritten as Eq. (10) when the system enters at LS MIMO area, (i.e $E_t > 10$ B), whereas L indicates IUI. The removal of IUI is carried out simply in ZF precoding. The term EE is performed exploiting Eq. (11), which is seen as the most important objective model of experimented technique which requires to be maximized.

$$C_{approx}^{LS-MIMO} \approx \alpha CB. \left[\log_2 \left(1 + \frac{P_{tx}E_t}{(L + E_0 C)B} \right) \right] \quad (10)$$

$$EE = F / P_{sum} \quad (11)$$

Let M_t^{opt} represents the optimal number of TX antenna and which requires to satisfy eq. (12).

$$\frac{\partial}{\partial E_t} EE = \frac{\partial}{\partial E_t} \left(\frac{F_{approx}}{\frac{1}{\eta}P_{tx} + E_t P_{cp}} \right)$$

$$= \frac{CBP_{tx}}{(L + E_0 C)B \left(1 + \frac{P_{tx}E_t}{(L + E_0 C)B} \right) P_{sum} \log_2 p} -$$

$$\frac{CBP_{cp}. \log_e \left(1 + \frac{P_{tx}E_t}{(L + E_0 C)B} \right)}{P_{sum}^2 \log_2 p}$$

$$= 0 \quad (12)$$

Hence, the calculation E_t^{opt} is performed in Eq. (13), in that $\Gamma = \frac{P_{tx}^2 - BE_0 CP_{cp} - BLP_{cp}}{B(L + E_0 C)P_{cp} \exp(1)}$ and U indicates lambert U function which is stated as $\Gamma = U(\Gamma) \exp(U(\Gamma))$.

$$E_t^{opt} \approx \frac{(L + E_0 C)B}{P_{tx}} \left(-1 + \exp(1 + U(\Gamma)) \right) \quad (13)$$

In Eq. (13), E_t^{opt} can be obtained easily and the important problem in this is regarding chosen of the E_t^{opt} antenna's number from a complete number of antenna, E_t^{total}. The predefined count of antennas of E_t^{total} is chosen using a conventional selection of antenna methods as channel capability maximization mode. When selecting columns of A, channel ability of E_t^{opt} chosen antenna system, is $\{b_1, b_2, ...b_{E_t^{opt}}\}$, $F_{\{b_1,b_2,....b_{E_t^{opt}}\}}$ is indicated by eq. (14), in that the $1 \times E_t^{opt}$ channel vector for k^{th} user is represented as $g_{k,\{b_1,b_2,....b_{E_t^{opt}}\}}$, $E_t^{opt} \times 1$ precoding vector for k^{th} user is shown as $p_{\{b_1,b_2,....b_{E_t^{opt}}\},k}$ while $\{b_1,b_2,....b_{E_t^{opt}}\}^{th}$ is chosen.

$$F_{\{b_1,b_2,....b_{E_t^{opt}}\}} = \alpha C. D \left[\log_2 \left(1 + \frac{\frac{P_{tx}E_t}{B}\left|d_{k,\{b_1,b_2,....b_{E_t^{opt}}\}} p_{\{b_1,b_2,....b_{E_t^{opt}}\},k}\right|^2}{\frac{P_{tx}E_t}{B}\left|\sum_{l \neq k} g_{k,\{b_1,b_2,....b_{E_t^{opt}}\}} p_{\{b_1,b_2,....b_{E_t^{opt}}\},l}\right|^2 + E_0 C} \right) \right] \quad (14)$$

From the green BS perspective, EE requires an increase sooner than increasing ability. In this scenario, from Eq. (11), for EE, optimum AS, and optimum AS for channel ability is similar, as due to the E_t^{opt} was selected preceding from (13) for EE consequently the P_{sum} presumed to be independent of AS. To attain optimum chosen of the antenna, selection of E_t^{opt} columns are to be prepared for higher EE as mentioned in Eq. (15), in that, whole set possible integration of E_t^{opt} antennas is stated as X.

$$\left\{ b_1, b_2, \ldots. b_{E_t^{opt}} \right\}$$

$$= \arg\max_{\left\{ b_1, b_2, \ldots. b_{E_t^{opt}} \right\}} \frac{F_{\left\{ b_1, b_2, \ldots. b_{E_t^{opt}} \right\}}}{P_{sum}} \tag{15}$$

4. Proposed Billiards Inspired Optimization Algorithm

The physics behind billiards chiefly engrosses collisions among balls. Collision among two billiards balls is approximately elastic [12]. The ball's kinetic energies are preserved in completely elastic collisions, before and after the collision, and a summation of both momenta. While 2 balls contact each other, forces among balls at some collision point are directed beside an imaginary line which links their centers, like an impact line. With respect to this reality, impact velocities decompose in two modules, a parallel module and a perpendicular module. The initial one is parallel to the balls impact line and next module is perpendicular to it [10]. During a collision, the linking vector initiates from the center of the initial colliding ball to the next ball center [11].

The unit vector of the linking vector is stated as Eq. (16), whereas r_1, r_2 are radii of balls.

$$e = \frac{\overrightarrow{m_1 m_2}}{r_1, r_2} \tag{16}$$

By presuming that this collision is entirely elastic, kinetic energy, and conservation of momentum formulations stated in this system, possesses below form:

$$\frac{1}{2} m_1 u_{1|}^2 + \frac{1}{2} m_2 u_{2||}^2 + \frac{1}{2} m_1 u_{1|\perp}^2 + \frac{1}{2} m_2 u_{2|\perp}^2$$
$$= \frac{1}{2} m_1 u_{1||}^2 + \frac{1}{2} m_2 u_{2||}^2 + \frac{1}{2} m_1 u_{1|\perp}^2 + \frac{1}{2} m_2 u_{2|\perp}^2 \tag{17}$$

$$m_1 u_{1||} + m_2 u_{2||} = m_1 u_{1||}^{'} + m_2 u_{2||}^{'}$$
$$m_1 u_{1\perp||} + m_2 u_{2\perp||} = m_1 u_{1||\perp}^{'} + m_2 u_{2||\perp}^{'} \tag{18}$$

Whereas, u_1, u_2 are first and second ball velocities before the collision and u_1', u_2' denotes the velocities of them after the collision. Additionally, symbols $||$ and $\perp$ indicate parallel and perpendicular modules, correspondingly. The parameters $m_1 m_2$ indicate masses of balls.

The perpendicular and parallel modules of the impact velocities are stated as below:

$$\overrightarrow{u_{1\cdot||}} = \left(\overrightarrow{u_1} . \overrightarrow{e_{||}} \right) \overrightarrow{e_|} \qquad \overrightarrow{u_{1\cdot||}} = \overrightarrow{u_1} - \overrightarrow{u_{||}} \overrightarrow{e_|} \tag{19}$$

$$\overrightarrow{u_{2\cdot||}} = \left(\overrightarrow{u_2} . \overrightarrow{e_{||}} \right) \overrightarrow{e_|} \qquad \overrightarrow{u_{2\cdot||}} = \overrightarrow{u_2} - \overrightarrow{u_{||}} \overrightarrow{e_|} \tag{20}$$

As forces are used beside impact line merely, perpendicular modules of momenta are conserved for every ball independently; hence, perpendicular modules of velocities stay unaltered.

$$m_1 \overrightarrow{u_{1.\perp}} = m_1 \overrightarrow{u'}_{1.\perp} \tag{21}$$

$$m_2 \overrightarrow{u_{2.\perp}} = m_2 \overrightarrow{u'}_{2.\perp} \tag{22}$$

Likewise, the elements of kinetic energies in line with perpendicular components stay unaltered before and after collision. Hence, the summation of kinetic energies in line with parallel modules of velocities is preserved too:

$$\frac{1}{2} m_1 u_{1|}^2 + \frac{1}{2} m_2 u_{2||}^2$$
$$= \frac{1}{2} m_1 u_{1||}^2 + \frac{1}{2} m_2 u_{2||}^2 \tag{23}$$

In the same way, the summation parallel modules of momenta are too conserved.

$$m_1 u_{1|} + m_2 u'_{2||} = m_1 u_{1||} + m_2 u'_{2||}. \tag{24}$$

Eq. (23) and (24) with a small manipulation must be reformulate as:

$$m_1\left(u^2_{1|} - u^2_{1|||}\right)_{||} = m_2\left(u^2_{2|} - u^2_{2|||}\right)_{||} \tag{25}$$

$$m_1\left(u_{1|} - u'_{|||}\right)_{||} = m_2\left(u'_{2|} - u_{2|||}\right)_{||} \tag{26}$$

Eq. (25) is reformulated as:

$$m_1\left(u_{1|} - u'_{|||}\right)\left(u_{1|} + u'_{|1.|||}\right)_{||} = m_2\left(u'_{2.1|} - u'_{2.1|||}\right)\left(u'_{2|} + u_{2.1}\right) \tag{27}$$

By dividing Eq. (27) by Eq. (26),

$$u_{1.1|} + u'_{|1.||||} = u_{2.1|} + u'_{|2.||||}. \tag{28}$$

This exhibits that summation of parallel velocities before and after collision are equivalent. Based on Eq. (24) and (28), concluding parallel modules of velocities subsequent to the collision are indicated as:

$$u'_{|1.||||} = \frac{m_1 - m_2}{m_1 + m_2} u_{1.||} + \frac{2m_2}{m_1 + m_2} u_{1.||} \tag{29}$$

$$u'_{|2.||||} = \frac{2m_1}{m_1 + m_2} u_{1.||} + \frac{m_2 - m_1}{m_1 + m_2} u_{2.||} \tag{30}$$

If balls possess equivalent masses, eq. (29) and (30) turn out to be as follow, depicting that balls switch merely the parallel module of their velocities, even though perpendicular modules stay unchanged.

$$u'_{|1.||||} = u_{2.1|} \cdot u'_{2.||} = u_{|1.||||}. \tag{31}$$

The ultimate velocity vectors are calculated by summation of both modules as

$$\overrightarrow{u'_{|1.|}} = u'_{1.||} \cdot \overrightarrow{e'_{|||.|}} + \overrightarrow{u'_{|1.|}} \tag{32}$$

$$\overrightarrow{u'_{2.|}} = u'_{2.||} \cdot \overrightarrow{e'_{|||.|}} + \overrightarrow{u'_{|2.|}} \tag{33}$$

Aforesaid ideas and details may be widespread to collisions in multi-dimensional spaces. While two balls collide together, the force among the balls is directed beside an imaginary line which links their centers. Hence, besides this direction, there is merely a one-dimensional collision issue, and velocities in this direction are computed by Eq. (29) and (30) and other modules of velocities remain unaltered.

As stated before, the developed meta-heuristic approach is inspired by the billiards game.

Step 1: Initialization: The initial population of balls is distributed arbitrarily in the search space as:

$$B^0_{n,m} = var^{min}_m + rand_{(0,1)}\left(var^{max}_m - var^{min}_m\right), \; n = 1,2,3...$$
$$2N; \; m = 1,2,3,...M \tag{34}$$

In eq. (34), $B^0_{n,m}$ indicates the initial value of the mth variable of nth ball. var^{max}_m and var^{min}_m indicates the utmost and least permissible values for m^{th} variable. $rand_{(0,1)}$ indicates an arbitrary number with uniform distribution in the interval [0, 1], and M and 2N indicates the numeral of agents and variables, correspondingly. In addition, few pockets are produced by the preceding equation arbitrarily in search space. The user determines the numeral of pockets.

Step 2: Evaluation: On the basis of the objective function, the positions of the balls and pockets' are evaluated.

Step 3: In this algorithm to determine pockets BOA pockets play two roles, an objective for balls that offers the exploitation capability of the method and a memory that stores the first top solutions found hitherto. Continuation of this memory enhances the performance of the technique without raising the evaluation cost. In each iteration, this memory is updated and substituted with optimal balls found locations.

Step 4: Grouping balls: Subsequent to the determination, based on their finesses, the pockets, balls are sorted and subsequently they are divided into two equivalent groups, ordinary balls and cue balls. The higher half comprises ordinary balls (i. e. $n = 1,.....,N$) and second one decides cue balls (i. e. $n = N + 1,....,2N$)

5. Result and Discussion

5.1 Experimentation Setup

The experimentation of the applied optimal antenna selection model was carried out exploiting MATLAB, and outcomes were analyzed. Furthermore, the developed method regarding the performance was differentiated over other conventional techniques such as GA [6], ABC [7], PSO [13], and FF [14]. The experimentation was carried out with two setups. The initial setup was $P_{tx} = 40W$, $sv(R\ flop / U) = 5R\ flop / U, P_{RF_{front}} = 975mW$ and the second setup is $P_{tx} = 10W, P_{sum1}sv(R\ flop / U) = 50R\ flop / U, P_{RF_{front}} = 97.5mW$. The experimentation analysis was performed regarding the optimal count of the antenna were performed.

5.2 Relative Energy Efficiency Analysis

Table 1 and 2 exhibits the analysis of relative EE for the proposed method over existing methods for setup 1 and 2. Two sets of experiments have experimented with respect to the number of users are experimenting with the conventional methods. The analysis, therefore, summarized that for 1st and 2nd set of experiments, under 40 users, the proposed method is obtained by means of better EE than conventional techniques like ABC, GA, FF, and PSO.

Table1. *Performance Analysis of Proposed And Existing Techniques for Set Up 1*

No of User	ABC	GA	FF	PSO	Proposed
Match Filtering					
5	0.84788	0.84715	0.84758	0.84425	0.84757
10	0.81041	0.80887	0.81028	0.81024	0.81128
15	0.87481	0.87482	0.87405	0.87481	0.87788
20	0.84728	0.84772	0.84184	0.84717	0.85207
25	0.85528	0.85518	0.85578	0.85524	0.89041
30	0.81114	0.81111	0.81088	0.81102	0.81152
35	0.81521	0.8157	0.81525	0.81507	0.87317
40	0.81815	0.81887	0.81878	0.8184	0.87787
Zero Forcing					
No of User	ABC	GA	FF	PSO	Proposed
5	0.84755	0.84284	0.84784	0.84772	0.84447
10	0.81021	0.81054	0.80872	0.81027	0.81075
15	0.87425	0.87421	0.87405	0.87427	0.87785
20	0.84187	0.84718	0.84718	0.84187	0.85187
25	0.85578	0.85508	0.85545	0.85577	0.81057
30	0.81104	0.81142	0.8108	0.81101	0.81171
35	0.81541	0.81547	0.81527	0.81487	0.87011
40	0.81878	0.81885	0.8184	0.81875	0.87788

Table 2. *Performance Analysis of Proposed and Conventional Models for Set Up 2*

No of User	ABC	GA	FF	PSO	Proposed
Match Filtering					
5	0.83363	0.83376	0.83337	0.83337	0.88001
10	0.91007	0.90983	0.91031	0.91031	0.91933
15	0.93361	0.93386	0.93311	0.93311	0.93779
20	0.93797	0.93788	0.93789	0.93789	0.96816
25	0.96667	0.9667	0.96679	0.96609	0.97631
30	0.97099	0.97136	0.97108	0.97108	0.97011
35	0.97639	0.97637	0.97613	0.97613	0.97377
40	0.97887	0.97891	0.97871	0.97871	0.97733
Zero Forcing					
No of User	ABC	GA	FF	PSO	Proposed
5	0.83173	0.83197	0.83103	0.83103	0.88068
10	0.91017	0.91066	0.90977	0.90977	0.91837
15	0.93311	0.93318	0.9333	0.9333	0.93731
20	0.93711	0.93717	0.93797	0.93797	0.96771
25	0.96677	0.96633	0.96613	0.96613	0.97396
30	0.97087	0.97099	0.97097	0.97097	0.9799
35	0.97617	0.97639	0.97607	0.97607	0.97371
40	0.97877	0.97881	0.97838	0.97838	0.9773

6. Conclusion

The foremost purpose of this article was to propose a new algorithm called billiards inspiration optimization algorithm to choose the optimal TAS via a multi-objective issue that raises both relative EE and capacity. In actual fact, the developed technique was optimally chosen the transmit antennas number and recognizes which antenna to be chosen. At last, the developed method regarding the performance was differentiated and examined over other conventional techniques with respect to some analysis such as relative efficiency, capacity, and optimal antenna selection.

Compliance with Ethical Standards

Conflicts of interest: Authors declared that they have no conflict of interest.

Human participants: The conducted research follows the ethical standards and the authors ensured that they have not conducted any studies with human participants or animals.

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