A PARTICLE SWARM ALGORITHM FOR SYMBOLS DETECTION IN MIMO-OFDM SYSTEM

Hemant Verma

Email: hemantjec2009@gmail.com
Assistant Professor, Department of Electronics & Communication, Technocrats Institute of Technology, Bhopal, India

ABSTRACT:

The fast development of wideband specialized gadgets, for example, advanced cells and tablets, has significantly expanded the throughput necessities of correspondence frameworks. Various data different yield orthogonal recurrence division multiplexing (MIMO-OFDM) has been broadly perceived as the potential innovation to accomplish this necessity. The MIMO beneficiary contains a portion of the testing elements like outlining of a low multifaceted nature, low vitality, less-BER, superior and high throughput recipient. The PSO calculation is completed by mimicking as far as both FFT and Wavelet plan which brings about better execution and diminished BER when actualized utilizing WPT. In this paper, PSO calculation based identification of elite MIMO framework utilizing wavelet balance is proposed. The proposed system is free of number of transmit and get reception apparatus furthermore on heavenly body size. PSO calculation construct discovery gives ensure in light of Signal-to-Noise (SNR) proportion which is free of settled throughput and diminishment in Bit Error Rate (BER) with independent of star groupings.

KEYWORDS: *Particle swarm optimization, MIMO-OFDM, Symbol detection.*

1. INTRODUCTION

The late expansion of portable deivces, for example, advanced cells and tablets, has significantly expanded the interest for high-throughput and astounding remote correspondence frameworks. Thus, future remote correspondence frameworks must give amazing transmission over versatile remote situations. In this way, numerous remote correspondence frameworks receive various info different yield orthogonal recurrence divisions multiplexing (MIMO-OFDM) to accomplish this objective. This is basically in light of the fact that the MIMO procedure productively expands the channel limit with various reception apparatuses and OFDM effectively manages extreme remote situations, for example, the multipath impact and versatile environment. To accomplish a higher information rate, numerous remote frameworks, for example, WiMax [1], WiFi [2], and 3GPP- LTE [3], build the MIMO measurement and subcarrier number. Be that as it may, primary difficulties of MIMO-OFDM frameworks lie in the high execution unpredictability created by tone-by-tone MIMO identification. In this manner, numerous analysts created MIMO recognition calculations [4]–[5] to lessen equipment many-sided quality. There is no known single advancement system accessible for taking care of all improvement issues. A considerable measure of improvement techniques have been produced for taking care of diverse sorts of enhancement issues lately. The present day streamlining routines (here and there called nontraditional advancement strategies) are effective and prominent systems for taking care of complex designing issues. These techniques are molecule swarm improvement calculation, neural systems, hereditary calculations, subterranean insect state enhancement, simulated resistant frameworks, and fluffy streamlining [6] [7].

The Particle Swarm Optimization calculation (shortened as PSO) is a novel populace based stochastic pursuit calculation and an option answer for the complex non-straight improvement issue. The PSO calculation was initially presented by Dr. Kennedy and Dr. Eberhart in 1995 and its essential thought was initially roused by reproduction of the social conduct of creatures, for example, fowl running, fish educating et cetera. It is in view of the characteristic procedure of gathering correspondence to share singular learning when a gathering of fowls or bugs look sustenance or relocate et cetera in a seeking space, albeit all winged animals or creepy crawlies don't know where the best position is. In any case, from the way of the social conduct, if any part can figure out an alluring way to go, whatever remains of the individuals will take after rapidly. The PSO calculation fundamentally gained from creature's movement or conduct to take care of enhancement issues. In PSO, every individual from the populace is known as a molecule and the populace is known as a swarm. Beginning with an arbitrarily instated populace and moving in haphazardly picked bearings, every molecule experiences the looking space and recalls the best past positions of itself and its neighbors. Particles of a swarm convey great positions to one another and alterably modify their own position and speed got from the best position of all particles. The following step starts when the sum total of what particles have been moved. At long last, all particles tend to fly towards better and better positions over the looking procedure until the swarm move to near an ideal of the wellness capacity of the fitness function $f\colon\ R^n - R$.

The PSO strategy is turning out to be exceptionally prevalent in light of its effortlessness of execution and also capacity to quickly merge to a decent arrangement. It doesn't require any angle data of the capacity to be upgraded and utilizes just primitive numerical administrators. As contrasted and other improvement strategies, it is speedier, less expensive and more effective. Moreover, there is couple of parameters to conform in PSO. That is the reason PSO is a perfect streamlining issue solver in enhancement issues. PSO is appropriate to illuminate the non-straight, non-arched, ceaseless, discrete, whole number variable sort issues.

The paper is organized as follows. In section II, the conventional MIMO-OFDM system is described. In section III, Vector representation of PSO model, PSO model and fitness evaluation is presented. In section IV, the performances of the proposed PSO algorithm for detection are compared. Finally, conclusions are drawn in section V.

2. MIMO-OFDM SYSTEM

A. MIMO-OFDM system model

Figure 1 shows the block diagram of the MIMO-OFDM system. For this system, we consider the N_{tx} transmit, N_{rx} receive antennas, n OFDM symbols, and K subcarriers.

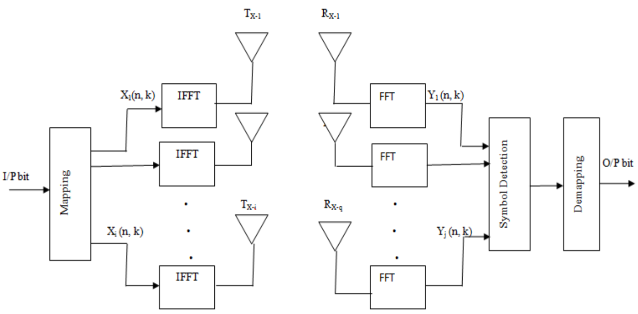

Fig. 1 MIMO-OFDM system.

A vector of the data information is mapped onto complex images considering the balance sort. The transmitted image vector is communicated as:

$$X[n, k] = [X_1(n, k), ...,X_{Ntx}(n, k)]^T \quad k = 0, ...,K - 1, \qquad (1)$$

where $X_I\,[n, k]$ is the symbol that is transmitted at the n_{th} symbol, k_{th} subcarrier, and i_{th} antenna, and $[.]^T$ indicates the transpose operation. By applying inverse fast Fourier transform (IFFT), symbol vectors are turned into the OFDM symbol:

$$X_n[m] = \frac{1}{\sqrt{KN_{tx}}}\sum_{k=0}^{K-1} X\left[n,k\right]\exp\left(j2\pi m/k\right) \qquad (2)$$

Where m = 0,…….,K – 1;

Next, the cyclic prefix (CP) is added to avoid inter-symbol interference (ISI) and the signal vectors are fed through the i^{th} transmitter antenna. After removing the CP from the received signal vector at the q^{th} receiver antenna, the fast Fourier transform (FFT) is taken as:

$$Y[n,k] = \frac{1}{\sqrt{K}}\sum_{m=0}^{K-1} y[m]\exp\left(-j2\pi km/K\right) \qquad (3)$$

Where n = 0,…….,K -1;

The received signal vector can be expressed as:

$$Y_q[n,k] = \sum_{i=1}^{N_{tx}} H_i[n,k]X_i[n,k] + W_q[n,k] \qquad (4)$$

where $H_i[n, k]$ is the channel impulse response vector and $Wq[n, k]$ is the additive white Gaussian noise [8].

B. ML symbol detection in the MIMO-OFDM

The estimations of the data symbols are obtained by maximizing the following metric:

$$X^* \triangleq \arg\max P\left(Y/X\right) \qquad (5)$$

The Next, the ML algorithm detects the symbols by minimizing the squared Euclidian distance to target vector Y over the N_{tx} dimensional discrete search set:

$$X^* = \arg\min\left\|Y - HX\right\|^2 \qquad (6)$$

For the ideal arrangement of the ML recognition, all conceivable M_{Ntx} blends of the transmitted images must be looked. Consequently, the computational intricacy increments with the transmitter receiving wire [9]. Consequently, we propose heuristic methodologies so as to diminish the computational unpredictability of the image identification in the MIMO-OFDM framework.

C. FFT and IFFT transformation techniques:

The Inverse Fast Fourier Transform (IFFT) at the transmitter side and Fast Fourier Transform (FFT) at the collector side are the two imperative types of gear utilized for the instrument of MIMO frameworks. In both wired and remote correspondence, the part of FFT and IFFT demonstrates the upside of decreasing the impacts of channel blurring). The cyclic prefix is included request to lessen the Inter Symbol Interference (ISI) and the impact of cyclic prefix decreases the transfer speed and execution misfortune (Bhagawat, P., 2009). To defeat this issue FFT and IFFT structure is supplanted by Wavelet Packet Transformation (WPT) at the beneficiary side and Inverse Wavelet Packet Transformation (IWPT) at the transmitter side of MIMO frameworks.

D. Wavelet based MIMO system:

Customarily Fourier change outfits data just about the ghastly qualities and instrument taking into account stationary sign. When all is said in done, all ongoing signs are non-stationary. Keeping in mind the end goal to conquer this disadvantage, Wavelet based MIMO is utilized under the proposed calculation. With help of development channel, wavelet can be gotten. The proposed calculation contains two channel banks to partition the recurrence into lower and more elevated amounts. Every sign segment is mapped to the recurrence area and the yield got as wavelet bundle change which compares to the specific recurrence band. The testing is done to diminish the excess and number of coefficients utilized. The components of wavelet over FFT are as per the following.

1. It accomplishes transmission coordination.
2. It gives signal assorted qualities like spread range.
3. No restriction of sub bearer.
4. High level of adaptability.

3. PSO FOR MIMO-OFDM SYSTEM

A. Particle Swarm Optimization (PSO)

PSO has a few properties comparative with other developmental systems, for example, Genetic calculations (GA), like GA.PSO likewise chooses introductory populace haphazardly from arrangement pursuit space. PSO does not utilize the lavish administrators like hybrid and change like GA. PSO is an iterative calculation it utilizes numerous cycle to locate the ideal arrangement. PSO utilizes the idea of worldwide best (gbest) and nearby best (pbest) to locate the ideal arrangement. Neighborhood best (pbest) is the arrangement which is the best arrangement found for a specific molecule and worldwide best (gbest) is the arrangement which is the best arrangement discovered amongst all particles.

The Particle swarm enhancement (PSO) is a populace based heuristic inquiry method. To begin with the beginning populace is chosen haphazardly from the arrangement hunt space than the position of particles are redesigned until the greatest furthest reaches of emphasis or craved practical arrangement found. For an n-dimensional search space, at generation or iteration t the i^{th} particle of the swarm is represented by an n-dimensional vector, $X_i(t) = (x_{i1};x_{i2};\ \ldots;x_{in})$. At generation t the velocity of this particle is represented by another n-dimensional vector $V_i(t) = (v_{i1};v_{i2};\ ::::;v_{in})$. The previously best visited position of the i^{th} particle is denoted as $P_i(t) = (p_{i1};\ p_{i2};\ldots\ p_{in})$. 'g' is the index of the best particle among the all particles. The velocity of the i^{th} particle is manipulated using the velocity update equation given by

$$v_{id}(t+1) = v_{id}(t) + c_1r_1(p_{id}(t)-x_{id}(t))+c_2r_2(p_{gd}(t)- x_{id}(t)) \qquad (7)$$

and the position is manipulated using

$$x_{id}(t+1) = x_{id}(t)+v_{id}(t) \qquad (8)$$

where $d\ (d = 1;2\ldots\ldots n;)$ denotes the dimension index and $i\ (i = 1;2\ldots\ldots\ldots S)$ denotes particular particle in swarm, where S is the size of the swarm; c_1 and c_2 are constants, called cognitive and social scaling parameters respectively (usually, $c_1 = c_2;\ r_1$, r_2 are random numbers, uniformly distributed in [0;1]); t is the index of current generation or population.

In fig. 2 it is shown that at each generation or iteration t, a particle x_i denoted by solid circle updates its velocity and position. The new velocity $v_i(t+1)$ is the sum of three terms: the previous velocity $v_i(t)$, and two terms proportional to the distance from pi, the best position visited so far by the particle, and from *pg*, the best position visited so far by the whole swarm. The new position of the particle is then computed by just adding the new velocity. After calculating new velocity new position is calculated using the equation *(8)*. The performance of each particle is measured according to predefined fitness function, which is related to the optimization problem to be solved. The manipulation of velocity and position is done until the desired feasible solution find. By using the distance from individual best and distance from groups best position in PSO particles try to converge towards the feasible solutions. Only above two update equation is used in PSO to calculate the solutions that is why it is simple to implement. This is classical Particle swarm optimization to improve the performance a new parameter is introduced into the update equation.

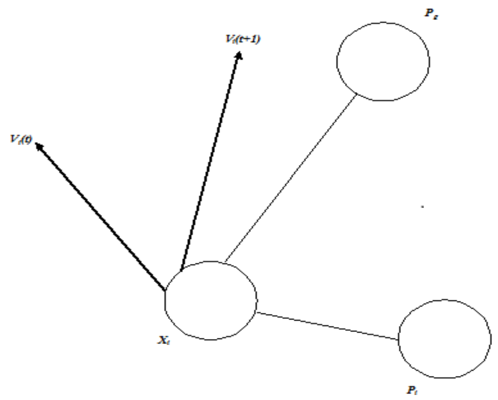

Fig. 2 Particle movement

B. Modified Particle Swarm Optimization

The velocity equation

$$v_{id}(t+1) = w*v_{id}(t)+c_1r_1(p_{id}(t)-x_{id}(t))+c_2r_2(p_{gd}(t)-x_{id}(t)) \quad (9)$$

The w assumes the part of adjusting the worldwide pursuit and nearby inquiry.It can be a positive consistent or even a positive straight or nonlinear capacity of time.

C. PSO based MIMO-OFDM Detection.

Here we abuse tightfisted double decision PSO calculation's capability to advance MIMO image identification. A critical stride to actualize PSO is to characterize a wellness work; this is the connection between the streamlining calculation and the genuine issue. Wellness capacity is special for every advancement issue. The wellness capacity utilizing the directions of the molecule gives back a wellness quality to be doled out to the present area. In the event that the worth is more prominent than the quality from an optimistic standpoint (pbest) for every molecule, or worldwide best (gbest) of the swarm, then past areas are redesigned with the present areas. The speed of the molecule is changed by relative areas of pbest and gbest as demonstrated in Figure

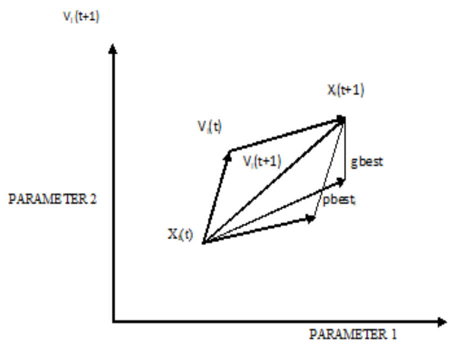

Fig. 3 Vector representation of PSO model

Once the speed of the molecule is resolved, it just moves to the following position. After this procedure is connected on every molecule in the swarm, it is rehashed till the most extreme number of emphasess is come to. PSO calculations stream graph is indicated in Figure 4. This exploratory-exploitive advancement methodology can be reached out to MIMO recognition enhancement issue talked about underneath.

The real test in outlining Binary PSO based MIMOOFDM finder was determination of BPSO parameters that fit the image recognition improvement issue. The essential wellness capacity utilized by the streamlining calculation to focalize to the close ideal arrangement is (10) that is least Euclidian separation. Choice of introductory speculation is a key for these calculations to perform. In this manner, our finder takes the yield of ZF-VBLAST as its starting arrangement surmise. This informed conjecture empowers the calculation to reach more refined arrangement iteratively by guaranteeing quick merging. Expecting arbitrary introduction does not ensure union to sensible arrangement in lesser emphases.

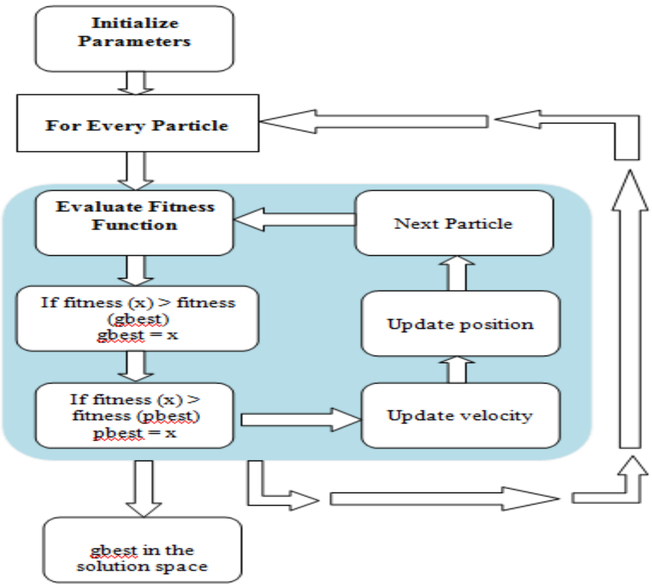

Fig. 4 PSO flow diagram.

The proposed detection algorithm is detailed belows:

1) We take the output of ZF-VBLAST such as $x_i \in \{0, 1\}$ as initial particles (initial solution bit string) instead of selecting randomly from the solution space.

2) The algorithm parameters are initialized. 'v_{id}' is initialized to zero (equal probability for binary decision), '$pbest_{id}$' and
'$gbest_d$' are initialized to maximum Euclidean distance depending upon the QAM size.

3) Evaluate the fitness of each particle (bit):

$$f = \|y - Hx\|^2 \qquad (10)$$

Least Euclidean separation for every image speaks to the fitness of arrangement. Impact on the Euclidean separation because of hunt space bits is measured. Find the global best performance '$gbest_d$' in the population that represents the mimimum Euclidean distance found so far. Record the personal best '$pbest_{id}$' for each bit along its previous values.

4) For each search space bit at the d^th side of the bit string of particles x_i, compute bits velocity using following velocity update equation of PSO :
$v_{id}(k) = v_{id}(k-1) + \phi_1 rand_1[pbest_{id} - x_{id}(k-1)]$

$+ \o_2 rand_2 [gbest_d - x_{id} (k-1)]$

with $v_{id} \in \{-v_{max}, v_{max}\}$. *(11)*

5) The particle position is updated using the following binary decision rule:

If $rand\ 3 < S(v_{id}(k))$, then $x_{id}(k) = 1$, else $x_{id}(k) = 0$. *(12)*

6) Goto step 3 until maximum number of iterations is reached.

The number of iterations depends on system and requirement. The number of iterations usually kept less than 25 to avoid complexity. Solution gets refined iteratively.

Here 'k' is the number of iterations, *rand* is a random number generated uniformly in [0,1] and '*S*' is sigmoid transformation function.

$$S(v_{id}(k)) = \frac{1}{1+\exp(-v_{id}(k))} \qquad (13)$$

The parameter 'v_i' is the particles predisposition to make 1 or 0, it determines the probability threshold for this choice. The individual is more same to choose 1 for higher $v_{id}(k)$, whereas its lower values will result in the choosing of 0. Such a threshold should to stay in the range of [0,1]. The sigmoid logic transformation function maps the value of $v_{id}(k)$ to a range of [0,1]. The parameters $\varphi 1$ and $\varphi 2$ are positive acceleration constants used to scale the contribution of cognitive and social elements such that $\varphi 1 + \varphi 2 < 4$ [10]. These are used to stochastically vary the relative pull of *pbest* and *gbest*. v_{max} sets a limitation to further exploration after the particles have converged. Its values depend on problem, usually set in the range of [-4, +4].

4. SIMULATION AND NUMERICAL RESULTS

This section provides some simulation and numerical results to prove the performance of the reported MIMO-PS detector. We evaluate the PSO based MIMO detectors performance for a 12x12 MIMO system using BPSK symbol detection scheme. The SER versus SNR and computing time plots for a 12x12 , BPSK symbols, MIMO-OFDM system given in Figure 5 and Figure 6, the proposed detection techniques gives improved BER & SNR performance as compared to ML, ZF, MMSE, GTA & EP-10 with some complexity overhead.

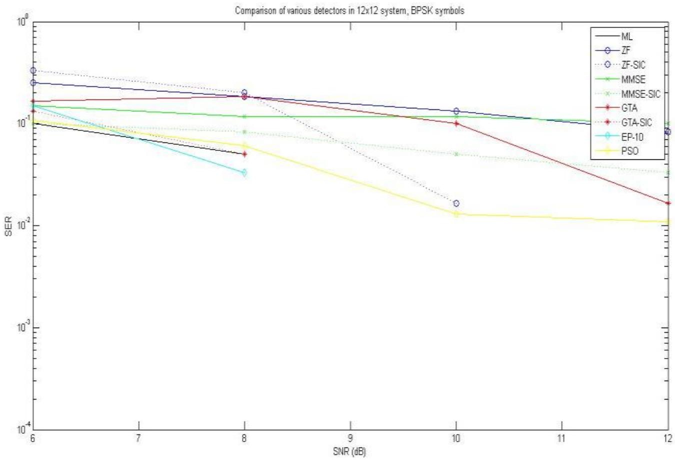

Fig. 5 SER versus SNR for BPSK symbol, 12×12 MIMO system.

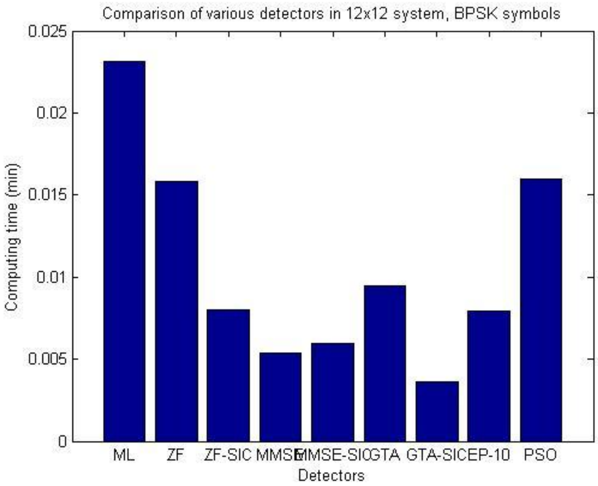

Fig. 6 MIMO Detectors computing time plot.

5. CONCLUSION

The efficient detector is simulated with reduced delay achieving low symbol error rate and signal to noise ratio. It scalable to supports higher number of antennas. The future work of this paper includes the implementation of proposed algorithm in real time wireless communication, in order to increase the throughput and decreased response time in real time applications for achieving higher performance.

REFERENCES

[1] Judson, I.R., 2011. Investigating Topology Control and Cognitive Radios to Exploit Television Whitespace in Building parse Broadband Networks.

[2] IEEE Standards Association, 2011. *IEEE 802.11 n-2009 Amendment 5: Enhancements for Higher Throughput*. Tech. Rep., Institute of Electrical and Electronics Engineers (IEEE).

[3] Park, C.S., Wang, Y.P.E., Jongren, G. and Hammarwall, D., 2011. Evolution of uplink MIMO for LTE-advanced. *IEEE Communications Magazine*, *49*(2), pp.112-121.

[4] Viterbo, E. and Boutros, J., 1999. A universal lattice code decoder for fading channels. *IEEE Transactions on Information theory*, *45*(5), pp.1639-1642.

[5] Liang, Y.C., Kit, D.K., Attallah, S., Leon, W.S. and Xu, C., 2005, December. Dynamic QRDM receivers for MIMO beamforming systems with imperfect channel state information. In *2005 5th International Conference on Information Communications & Signal Processing* (pp. 801-805). IEEE.

[6] Rao, S.S., 2009. *Engineering optimization: theory and practice*. John Wiley &

[7] Talbi, E.G., 2009. *Metaheuristics: from design to implementation* (Vol. 74). John Wiley & Sons.

[8] Liang, Y.M., Luo, H.W. and Huang, J.G., 2006. RLS channel estimation with adaptive forgetting factor in space-time coded MIMO-OFDM systems. *Journal of Zhejiang University-SCIENCE A*, *7*(4), pp.507-515.

[9] Khan, A.A., Bashir, S., Naeem, M., Shah, S.I. and Li, X., 2008. Symbol detection in spatial multiplexing system using particle swarm optimization meta-heuristics. *International Journal of Communication Systems*, *21*(12), pp.1239-1257.

[10] Eberhart, R.C., Shi, Y. and Kennedy, J., 2001. *Swarm Intelligence (Morgan Kaufmann series in evolutionary computation)*. Morgan Kaufmann Publishers.