Intelligent Anti-Jamming Decision Method Based on the Mutation Search Artificial Bee Colony Algorithm for Wireless Systems

Fang Ye, Zitao Zhou, Hongbo Tian, Qian Sun, Yibing Li*, Tao Jiang
College of Information and Communication Engineering,
Harbin Engineering University,
Harbin, China
Email: yefang0923@126. com, beacher99510150@163.com, tianhongbo0827@126.com, sunqian215@126.com, liyibing0920@126.com, jiangtao215@126.com

***Abstract*—Wireless systems are vulnerable to various kinds of jamming attacks due to the development of complexity of electromagnetic environment. Intelligent anti-jamming decision for multi-domain, which is more flexible than traditional single-domain technique, has attracted much more attention. However, poor decision-making speed and robustness of decision-making algorithm lead to a non-optimal communication scheme in huge decision space. An anti-jamming decision method based on the mutation search artificial bee colony algorithm (MSABC) is proposed in this paper. Numerical investigations show that the proposed algorithm can find a better communication scheme that reduces the normalized transmitting power while maintaining the normalized rate.**

Keywords—Wireless communication, Anti-jamming decision, Artificial bee colony algorithm, Mutation search

I. Introduction

The broadcast characteristics of wireless communication systems make them vulnerable to electronic jamming attacks [1-2]. The common anti-jamming technique such as frequency hopping, spread spectrum are all anti-jamming techniques with a fixed anti-jamming tolerance. Hence, intelligent anti-jamming decision for multi-domain, which has a flexible anti-jamming tolerance, was introduced into anti-jamming system.

In the existing works on intelligent anti-jamming decision, literatures employ joint decision-making in two domains to mitigate jamming. The author in [3] proposed an anti-jamming decision method through jointly optimized rate adaption (RA) and frequency hopping (FH) technique but irrespective of the transmitting power. An anti-jamming decision engine adopting frequency and power allocation adaptation algorithm was proposed in [4]. But the author ignored modulation mode and encoding rate. The author in [5] proposed a rule-reduced genetic algorithm, but the channel aggregation used to compress the decision space results in a non-specific decision of channel number. Artificial bee colony algorithm which has a better performance than others was introduced into intelligent anti-jamming decision for multi-domain in [6]. However, when the decision-making space becomes larger, the algorithm cannot obtain the optimal communication strategy.

II. System Model

Considering the scenario that the jammer is within the transmission range of receiver (Rx) but not transmitter (Tx) shown in Fig.1. The priori information of channel can be accurately learned by physical carrier sensing equipment.

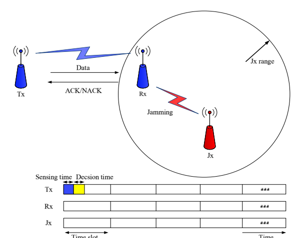

Fig. 1. Anti-jamming scenario of wireless communication system

The system model is shown as follows: The system has K non-overlapping communication channels represented as follows:

$$\mathbf{F}=\left\{f_0, f_1, ..., f_{K-1}\right\} \tag{1}$$

where $\mathbf{F}$ is the set of channels, the Tx and Rx only occupies one channel per time.The Tx has N available transmitting power levels, which is represented as follows:

$$\mathbf{P_R}=\left\{P_{R0}, P_{R1}, ..., P_{R(N-1)}\right\} \tag{2}$$

where $\mathbf{P_R}$ is the set of transmitting power.The Tx has N available transmitting power levels, which is represented as follows:

$$\mathbf{R}=\left\{R_0, R_1, ..., R_{M-1}\right\} \tag{3}$$

where $\mathbf{R}$ is the set of transmission rates. Assuming that the jamming power randomly exists in all communication channels, The SINR is expressed as follows:

$$\text{SINR} = \frac{\beta P_{Rj}}{\alpha P_{Jk} + \sigma^2} \qquad k=0,1,...,K-1 \quad 0 \le j \le N-1 \tag{4}$$

where P_{Rj} is the transmission power at Tx, P_{Jk} is the jamming power emitted by jammer in the kth channel, the received jamming power at Rx will be attenuated by a factor $\alpha\left(0 \le \alpha \le 1\right)$. The fading channel gains is $\beta\left(0 \le \beta \le 1\right)$.

III. PROPOSED ALGORITHM

The paper introduces the mutation thought of genetic algorithm into searching. Each position's code of an individual is mutated according to the mutation search probability expressed as *cr*, and *cr* doesn't change for each position's mutation. This improves directionality of searching. The mutation search equation can be expressed as follows:

$$X_k^j = \begin{cases} X_i^j \oplus 1 & rand < cr \\ X_i^j & rand \ge cr \end{cases} \qquad j = 1,2,......,g \tag{5}$$

The formula to calculate fitness is expressed as follows:

$$f\left(i\right) = \omega_1\left(1 - \frac{P_{Ri}}{P_{R\max}}\right) + \omega_2\left(\frac{R_i}{R_{\max}}\right) \tag{6}$$

The flow table of MSABC algorithm is shown in Table I:

TABLE I. PROPOSED ALGORITHM

Proposed Algorithm Mutation Search Artificial Bee Colony Anti-Jamming Decision Algorithm

Initialization: 1.Initialize the population of communication strategy. Judging the constraints of all strategies, eliminate invalid strategies to ensure NP initial strategies are all feasible strategies.
Mining bees mode: 2. Searching for new strategy according to (5).
3.Calculate the fitness of new strategy, compare the fitness of new strategies with the original one. Select the better one according to greedy criterion.
Observing bees mode: 4. Calculate the selection probability of each strategy according to greed criterion.
5.Searching for the new strategy according to the selection probability. Calculate the fitness, compare, and then select, which is the same as mining bees
6. Globally generate new random strategies to replace the strategies that exceed limit.
Optimal strategy derivation:
7. **If** iter < maxcycle **do**
    go to 2
else do
    find out the global optimal value and corresponding strategy
end

IV. PERFORMANCE EVALUATION

The paper uses the proposed MSABC algorithm, ABC algorithm and RRGA algorithm to make anti-jamming decision in two jamming environments. The convergence curves of three algorithms are shown in Fig. 2. It can be seen from Fig. 2, the normalized objective function value obtained by the proposed algorithm when it converges is higher than the other two algorithms under different jamming environments. And the proposed algorithm reaches the optimal value within 100 iterations while the ABC algorithm and RRGA algorithm need about 150 iterations, which shows that the proposed algorithm is better than the other two algorithms in the convergence speed.

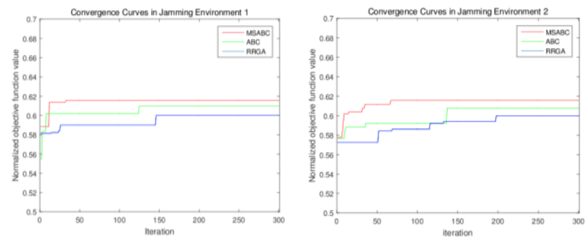

Fig. 2. The convergence curves of different algorithms in two jamming environments $\left(\omega_1=1/2, \ \omega_2=1/2\right)$

V. CONCLUSION

In this paper, a new intelligent anti-jamming decision algorithm called mutation search artificial bee colony (MSABC) algorithm is proposed. To achieve the goal of balancing maximizing the normalized transmission rate and minimizing the transmitting power, a normalized objective function is derived and the constraints are guaranteeing the regular communication. The simulation shows that the convergence speed and the robustness of the proposed algorithms are also better than the others.

ACKNOWLEDGMENT

The paper is funded by the National Natural Science Foundation of China (Grant No.61701134), National key research and development program of China (Grant No. 2006YFF0102806), the Natural Science Foundation of Heilongjiang Province, China (Grant No.F2017004), and the Fundamental Research Funds for the Central Universities of China (No. HEUCFM180802 and No. HEUCFM180801), and the International Exchange Program of Harbin Engineering University for Innovation oriented Talents Cultivation.

REFERENCES

[1] H Li, Y Qian, Z Fang. Simultaneous transmit and receive based cognitive anti-jamming for cyberspace datalink [J]. Press of Chinese Journal of Aeronautics, 2016, (11):3476-3484.

[2] Abdel-Rahman M J, Krunz M. Game-theoretic quorum-based frequency hopping for anti-jamming rendezvous in DSA networks[C]// IEEE International Symposium on Dynamic Spectrum Access Networks. IEEE, 2015:248-258.

[3] Hanawal M K, Abdel-Rahman M J, Krunz M. Joint Adaptation of Frequency Hopping and Transmission Rate for Anti-Jamming Wireless Systems[J]. IEEE Transactions on Mobile Computing, 2016, 15(9):2247-2259.

[4] Shajaiah H, Mahal J, Clancy C. Resource management with anti-jamming capability for cognitive space communication systems[C]// Military Communications Conference, Milcom 2016 -. IEEE, 2016:144-149.

[5] Hui J, Song X, Miao W, et al. A Fast Anti-jamming Decision Method Based on the Rule-Reduced Genetic Algorithm[J]. Ksii Transactions on Internet & Information Systems, 2016, 10.

[6] Hui X, Niu Y, Yang M. Decision method of anti-jamming communication based on binary artificial bee colony algorithm[C]// International Conference on Computer Science and Network Technology. IEEE, 2016:987-991.