Multi-user Detection on DS-CDMA UWB System Using QDPSO Algorithm

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Abstract. To effectively restrain multiple access interference (MAI) in DS-CDMA UWB communication system and lower bit error rate, on the basis of discrete particle swarm optimization (DPSO) algorithm, combining quantum computing technology, an improved quantum DPSO (QDPSO) algorithm is got, and then the multi-user detection technology based on QDPSO algorithm is proposed. It mainly includes several key steps, such as initialization on particle indicating user information, calculation on target function for multi-user detection, particle update and optimizing etc. Simulation experiment and comparative analysis show that the bit error rate performance of QDPSO detection algorithm is best and can effectively restrain the influence of MAI, its effect is much better than DPSO and traditional detection algorithm (TA).

Keywords: Multi-user Detection, DS-CDMA UWB system, Quantum Discrete Particle Swarm Optimization (QDPSO), Multiple Access Interference (MAI), Bit Error Rate.

1 Preface

UWB [1] (Ultra-wideband) is a kind of pulse communication, which is using pulse lasting time very short to carry information. In DS-CDMA UWB multi-user communication system, different users are distinguished by different pseudo random sequence, and the main interference is that of multi-access (MAI). Multi-user detection technology [2-3] can reduce or eliminate the MAI and improve Bit Error Rate (BER) detection performance of the system. Now it has become a focus topic for scholars at home and abroad in wireless communication technology. For example, traditional detection algorithm (TA) [4-5] use the matched filter to detect directly and other intelligent detection algorithms [6-7], etc.

Discrete Particle Swarm Optimization [8-9] (DPSO) algorithm is a new type of intelligent algorithm. It is different from basic PSO algorithm for the solution of function optimization problems in continuous space, and it has the advantages of high convergent speed, easy to seek the global optimal solution for solving the function Optimization problem in discrete space, especially in solving combinatorial
optimization problem in practical projects. So it can be used in multi-user detection technology on DS-CDMA UWB System.

Therefore, A kind of Quantum DPSO (QDPSO) algorithm[10-11] is proposed and researched based on DPSO algorithm, that is, combined advantage of quantum computing, introducing the concept judge factors- quantum particle q, define update function and explore theory basis of multi-user detection technology with QDPSO, which provide a new idea for multi-user detection problems.

2 Methods and Principle

The basic principle of multi-user detection is to see all users’ signals as useful signals in detection processing, and other user's information is predictable in a certain extent, therefore can comprehensive use all kinds of information which include the interference user’s and inherent characteristics of the user waveform information, joint process the received signal and to inhibit or even eliminate MAI in the maximum possible, thus achieve the purpose of more accurate detection of the target user signal and improve the performance of the receiving system. The model of multi-user detection system can be expressed in Fig. 1.

![Multi-user detection system model diagram](image)

**Fig. 1.** Multi-user detection system model diagram

### 2.1 DPSO Algorithm

Kennedy and Eberhart proposed PSO algorithm in 1995, and then they proposed DPSO algorithm which can solve the problem of discrete space in 1997. The position and velocity of particles functions can be expressed as formula (1) and (2):

\[
v_{id}^{t+1} = wv_{id}^{t} + c_1 r_1 (P_{bestid}^{t} - x_{id}^{t}) + c_2 r_2 (C_{bestid}^{t} - x_{id}^{t})
\]

\[
x_{id}^{t+1} = x_{id}^{t} + v_{id}^{t+1}
\]

\[
x_{id}^{t} = \begin{cases} 0, & \text{rand} \geq \text{sig}(v_{id}^{t+1}) \\ 1, & \text{others} \end{cases}
\]

\[
sig(v_{id}^{t+1}) = \frac{1}{1 + \exp(-v_{id}^{t+1})}
\]