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A Review on Particle Swarm Optimization for Communication Engineering

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Abstract: Today digital communications is at an advanced level. Performance of digital communication system is also play critical Performance optimization of digital communications systems can be done by fine-tuning of parameters of modern digital communications systems. The accurate knowledge of the parameters characterizing the quality of a communication channel is extremely important for efficient data transmission. The application of the Particle Swarm Optimization (PSO) algorithm successfully applied to wide range of engineering problems. In very recent this algorithm becomes very popular due to its simplicity and effectiveness. Researchers have explored PSO algorithm for communication engineering applications. This algorithm can be successfully applied to various digital communication systems for improving performance. The purpose of this paper to explore the different applications of PSO in digital communication system.

Keywords: Digital communication system; Particle swarm optimization.

1. INTRODUCTION

Several evolutionary algorithms have emerged in the past years from biological entities behavior and evolution. Darwin's theory of evolution is natural selection is inspiration source of for EAs. EAs are widely used for the solution of single and multi-objective optimization problems. Swarm Intelligence (SI) algorithms are also a special type of EAs. SI can be defined as the collective behavior of decentralized and self organized swarms. SI algorithms among others include Particle Swarm Optimization (PSO) [1] and Ant Colony Optimization [2].

2. PARTICLE SWARM OPTIMIZATION

PSO is an evolutionary optimization algorithm that is formed form the swarm behavior of bird flocking and fish schooling [3]. PSO is an easy to implement with less computational complexity. Particle Swarm Optimization (PSO) is a powerful method of optimization that has been widely used for solving different optimization problems. It is widely used to find the global optimum solution in a complex search space.

3. PERFORMANCE OPTIMIZATION OF DIGITAL COMMUNICATIONS SYSTEMS

Today digital communications is at an advanced stage. Competitive market has created immense pressure on performance of particular product. Performance optimization of digital communications systems can be done by fine-tuning of parameters of modern digital communications systems. The accurate knowledge of the parameters characterizing the quality of a communication channel is extremely important for efficient data transmission [4].
These optimization algorithms have been applied to various fields in digital communication and these are microwave filter design, antenna arrays synthesis, cell to switch assignment problem in cellular networks [5], peak to average power ratio (PAPR) reduction of OFDM signals with the partial transmit sequences (PTS) approach. As per Shannon result states that the data rate of a communication channel is a function of the signal-to-noise ratio (SNR). When noise level increases then quality of transmission is also affected. Information transmitted over a communication channel decreases as the noise increases. So, it is very important to reduce noise by proper design of communication system.
In this report discuss on theoretical as well as detailed explanation of the PSO algorithm. Apart from this, advantages and disadvantages, the effects of the various parameters have been discussed. Finally, this dissertation presents improved version of PSO also.

4. APPLICATIONS OF PSO FOR COMMUNICATION ENGINEERING

Optimization play important role in different areas of digital communication systems. Recently evolutionary algorithm is emerged to solve complicated problems and PSO is one of the powerful evolutionary optimization algorithms.

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Researchers already explored PSO in different domains of digital communication systems [6]–[10], [5], [11]. Literature review addressed on two aspects, first is PSO application in digital communication system and second is PSO advancement.

a. **W. Fang, J. Sun, H. Chen, and X. Wu, "A decentralized quantum-inspired particle swarm optimization algorithm with cellular structured population," Inf. Sci. (Ny)., vol. 330, pp. 19–48, 2016.** They proposed a decentralized form of quantum-inspired particle swarm optimization with cellular structured population (called cQPSO) for keeping the population diversity and balancing the global and local search. Particles are distributed in a two-dimensional grid in cQPSO and only allowed to interact with their neighbors according to the specified neighborhood. Theoretical studies based on the theory of probabilistic metric space are made to analyze the global convergence of cPSO. Performance of cQPSO investigated on 42 benchmark functions with different properties and compare with different sets of PSO variants and other evolutionary algorithms.

b. **O. S. Moraes, J. F. Mitre, P. L. C. Lage, and A. R. Secchi, "A robust parallel algorithm of the particle swarm optimization method for large dimensional engineering problems," Appl. Math. Model., vol. 39, no. 14, pp. 4223–4241, 2015.** The application of the PSO algorithm to large engineering problems is strongly limited by computational cost. These limitations are large number of particles needed to optimize the many-variable function, the high computational cost of its evaluation and the lack of adequate criteria to early detect the approach of the global optimum. First two cost sources can be mitigated by a parallel implementation of the PSO algorithm and third one need the development of a robust convergence criterion. To addresses these issues a new convergence criterion in asynchronous parallel implementation of PSO proposed by authors. Proposed optimization is examined for different benchmark test functions. The proposed method was successfully applied to an actual estimation problem with 81 parameters.

c. **Majhi and G. Panda, "Distributed and robust parameter estimation of IIR systems using incremental particle swarm optimization," vol. 23, pp. 1303–1313, 2013.** Two learning algorithms have been reported for distributed estimation using the data collected from sensor nodes, are incremental least mean square (ILMS) and diffusion least mean square (DLMS). These algorithms are derivative based and have a tendency of stuck in local minima particularly for multimodal cost function. In this paper two population based incremental particle swarm optimization (IPSO) algorithms proposed for estimation of parameters of noisy IIR systems. Proposed IPSO algorithms provided poor performance when the measured data is contaminated with outliers in the training samples. To get this problem solution a robust distributed algorithm proposed for IIR system identification task. The simulation results of benchmark IIR systems demonstrated that proposed algorithms provide excellent identification performance.

d. **G. Karimi and A. Lotfi, "An analog / digital pre-distorter using particle swarm optimization for RF power amplifiers," Int. J. Electron. Commun., vol. 67, no. 8, pp. 723–728, 2013.** A novel pre-distorter presented using the PSO for an RF power amplifier linearization. PSO was used for in order to design of an efficient pre-distorter for the linearization of the output of an RF power amplifier. The PSO is implemented to estimate and optimize the coefficient parameters of the work function in pre-distorter block diagram. The proposed method using PSO found efficient because of independent nature of the output of the power amplifier. The proposed method has been simulated with two-tone input signal and compared with output power spectrum.

e. **H. Lu, "Particle swarm optimization assisted joint transmit / receive antenna combining for multiple relays in cooperative MIMO systems," Appl. Soft Comput. J., vol. 12, no. 7, pp. 1865–1874, 2012.** A novel relay resource utilization scheme was presented that uses the PSO algorithm to jointly search the antenna combining (AC) matrices of multiple relays in cooperative MIMO systems. The relays utilize AC matrices to weight and combine signals transmitted by the source node, and then forward the weighted signal to the destination node. Relays can reduce the number of radio frequency (RF) chains used for transmit/receive antenna elements and resultant lower the hardware costs of deploying RF chains. So, reduction in RF chains requires less power than relays that use all the RF chains. Computer simulation has been used to demonstrate the performance of proposed scheme with other existing approaches in some scenarios.

f. **S. Yogi, P. K. R. Subhashini, P. J. K. Satapathy, and S. Kumar, "Equalization of Digital Communication Channels Based on PSO algorithm," in IEEE International Conference on Communication COntrol and COmnputing Technologies (ICCCCT), 2010, pp. 725–730.** Inter symbol interference is one of main obstacles to reliable communications. To obtain reliable data transmission, an adaptive equalizer is required at the receiver to remove the effects of non-ideal channel characteristics. Equalization of communication channels using Functional Link Artificial Neural Networks (FLANNs) approach is proposed by authors. A novel method of training

the FLANNs is described using PSO Algorithm. In their work, performance of the proposed network has been compared with the conventional LMS based channel equalizer and FLANN trained with BP algorithm based equalizer and results show that the proposed algorithm improves the classification capability of the FLANNs in differentiating the received data.

g. **G. He and N. Huang, "A new particle swarm optimization algorithm with an application," Appl. Math. Comput., vol. 232, no. 70831005, pp. 521–528, Apr. 2014.** A new particle swarm optimization algorithm (NPSO) is presented for dealing with the portfolio model from stocks market, in which the optimal and sub-optimal positions of each particle are considered in the iteration process, and the crossover operation is used to avoid premature. Performance of NPSO compared with existed PSO. Later this proposed NPSO algorithm used to solve a discontinuous programming model.

5. CONCLUSION

Finding optimum performance is most prime requirement in of communication system and in day to day increasing complexity of communication system made it as challenging task to design accurate device for it. Many optimization techniques are used for this purpose but PSO is shown it suitable for this purpose due to simplicity and fast convergence rate. PSO showed better performance for these test function than it will show better performance for digital communication system also.

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