A Systematic Process and Steps to Analyze Various Applications of PSO and its Effective Implementation in Industries

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Abstract— This paper presents the particle swarm optimization (PSO) algorithm for solving the optimal distribution system problem for power loss minimization. The proposed methodology determines control variable settings, such as number of shunts to be switched, for real power loss minimization in the transmission system. The problem is formulated as a nonlinear optimization problem. The PSO is relatively new and powerful intelligent evolution algorithm for solving optimization problems. It is a population based approach. The proposed approach employs the PSO algorithm for the optimal setting of optimal power based on loss minimization (LM) function. The proposed approach has been examined. The obtained results are compared with those using other techniques in a previous work to evaluate the performance. Particles swarm optimization (PSO) has shown to be an efficient, robust and simple optimization algorithm. Most of the PSO studies are empirical, with only a few theoretical analyses that concentrate on understanding particle trajectories. This paper overviews current theoretical studies, and extend these studies to applications in mechatronics systems such as identification control, gains and optimization in design. Experimental results are provided to support the conclusions drawn from the theoretical findings. A new alignment method based on the particle swarm optimization (PSO) technique is presented. The PSO algorithm is used for locating the optimal coupling position with the highest optimal power with three degrees of freedom alignment. This algorithm gives interesting results without a need to go through the complex mathematical modeling of the alignment system. The proposed algorithm is validated considering particle tests considering the alignment of two Single Mode Fibers (SMF) and the alignment of SMF and PCF fibers.

Key words: Particle Swarm Optimization; Single Mode Fiber; Loss Minimization

I. INTRODUCTION

Particle swarm optimization is a stochastic population based optimization approach, first published by Kennedy and Eberhart in 1995. Since its first publication, a large body of research has been done to study the performance of PSO, and to improve its performance. Form the studies, much effort has been invested to obtain a better understanding of the convergence properties of PSO. These studies concentrated mostly on a better understanding of the basic PSO control parameter, namely the acceleration co-efficient, inertia weight, velocity clamping, and swarm size. From these empirical studies it can be concluded that the PSO is sensitive to control parameters choices, specifically the inertia weight, acceleration co-efficient and velocity clamping. Wrong initialization of these parameters may lead to divergent or cyclic behavior

Among existing evolutionary algorithms, the best known branch is the real coded genetic algorithm (RGA). RGA is a stochastic search procedure based on the mechanics of natural selection, genetics and evolution. Compared with RGA, PSO has some attractive characteristics. It has memory, so knowledge of good solutions is retained by all the particles, where as in RGA, previous knowledge of the problem is discarded once the population changes. It has constructive co-operation between particles, that is, particle in the swarm share information among themselves.

To date, PSO has been successfully applied to optimizing various continuous nonlinear functions in practice. Such as, we using the PSO algorithm, a novel design method for the self-tuning PID control in a slider-crank mechanism system, and we propose an effective method for singularity control of a fully parallel robot manipulator using the particle swarm optimization (PSO) and grey prediction (GP). In system identification, we adopt the PSO to find the parameters of the Scott-Russell (SR) mechanism and the piezoelectric actuator.

The subject of minimizing distribution systems losses and the problem of optimal power flow (OPF) have gained a lot of care due to the high cost of electric energy; therefore, much of current research on distribution automation is focused on the minimum loss conjuration problem. There are many alternatives obtainable for reducing losses at the supply level: reconguration, capacitor installation, load balancing, and introduction of higher voltage levels. The OPF problem solution aims at optimizing exact objective functions such as loss of power by regulating the power control variables and at the same time satisfying the equality and the inequality constraints. The inequality constraints are the upper and the lower limits at the control and some state variables, while the equality limits are the power equations.

The class of complex systems sometimes referred to as swarm systems is a rich source of novel computational methods that can solve difficult problems well and reliably. When swarms solve problems in nature, their skills are usually attributed to swarm intelligence; perhaps the best-known examples are colonies of social insects such as termites, bees, and ants. In recent years, it has showed possible to identify, abstract, and exploit the computational principles underlying some forms of swarm intelligence, and to array them for scientific and industrial resolves. One of the best-developed systems of this type is particle swarm optimization (PSO).

In PSOs, which are inspired by flocks of birds and shoals of fish, a number of simple entities, the particles, are placed in the parameter space of some problem or function,

and each evaluates the fitness at its current location. Each particle then controls its movement done the limit space by merging some aspect of the history of its own fitness values with those of one or more members of the swarm, and then moving through the limit space with a velocity firm by the locations and treated fitness values of those other members, along with some random worries. The members of the swarm that a particle can interact with are called its social neighborhood. Together the social neighbor hoods of all particles form a PSOs social network.

II. APPLICATIONS OF PSO

A. Biomedical

Biological, medical and pharmaceutical applications are also very popular with approximately 4% of all application papers in the IEEE Xplore database covering these areas. Applications include: human tremor analysis for the diagnosis of Parkinson's disease, inference of gene regulatory networks, human movement biomechanics optimization, phylogenetic 5 tree reconstruction, cancer classification and survival prediction, DNA motif detection, gene clustering, identification of transcription factor binding sites in DNA, biomarker selection , protein structure prediction and docking, drug design, radiotherapy planning, analysis of brain magneto encephalography data, RNA secondary structure determination electroencephalogram analysis , biometrics.

B. Control

Control applications have one of the largest shares (7%) of application papers in the IEEE Explore database. Application areas include: automatic generation control tuning, design of controllers, traffic flow control, adaptive inverse control, predictive control, PI and PID controllers, strip flatness control, ultrasonic motor control, power plants and systems control, control of chaotic systems, process control, adaptive PMD compensation in WDM networks, fractional order controllers.

C. Engines and Motors

Around 10 papers (1.5%) in the applications bibliography deal with the design or optimization of engines and electrical motors. Topics include: engine data classification, locomotive torque control, motor control in electric and hybrid vehicles, induction motor speed control, direct motor torque control, fault and parameter estimation in induction motors, optimization of internal combustion engines, optimization of nuclear electric propulsion systems.

D. Faults

The detection or diagnosis of faults and the recovery from them occupies approximately (2.4%) of the application papers in the bibliography. Topics include: fault diagnosis of steam-turbine generators, circuits that automatically recover from component failure, gearbox fault diagnosis, automatic defect classification in semiconductor wafers, service restoration in power distribution, fault-tolerant power systems, missing sensors restoration, fault diagnosis in digital circuits, test pattern generation for circuits, software fault detection, defensive islanding of power system, power transformers fault diagnosis, optimization of repairable systems, diagnosis of faults in motors.

E. Fuzzy and Neuro-fuzzy

Around 26 papers (4% of the bibliography) attack problems in the area of fuzzy and neuro-fuzzy systems and control. These include: design of neuro-fuzzy networks, fuzzy rule extraction, fuzzy control, membership functions optimization, fuzzy modelling fuzzy classification, design of hierarchical fuzzy systems, fuzzy queue management.

F. Prediction and forecasting

About 3% of the papers on applications in the bibliography have to do with prediction and forecasting. Topics include: water quality prediction and classification, prediction of chaotic system, ecological models, meteorological predictions, electric load forecasting, and battery pack state of charge estimation, time series
prediction, predictions of elephant migrations , prediction of the flow stress in steel, prediction of surface roughness in end milling, stream flow forecast, urban traffic flow forecasting.

G. Power systems and plants

A large proportion (6%) of the application papers in the bibliography deals with power generation and power systems. Specific applications include: automatic generation control, power transformer protection, load forecasting , STATCOM power system, fault-tolerant control of compensators, optimal power dispatch , power system performance optimization, secondary voltage control, power control and optimization, design of power system stabilizers, control of photovoltaic systems, large-scale power plant control, operational planning for cogeneration systems, analysis of power quality signals, generation planning and restructuring, hybrid power generation system, optimal strategies for electricity production, power loss minimization, production costing and operations planning.

H. Robotics

Numerous papers describing PSO applications in robotics are present in the literature. These cover about 3% of the applications' bibliography. Topics include: control of robotic manipulators and arms, motion planning and control, robot running, collective robotic search, unsupervised robotic learning, path planning, obstacle avoidance, swarm robotics, unmanned vehicle navigation, soccer playing, robot vision, transport robots, odour source localization, environment mapping, voice control of robots.

I. Scheduling

About 6% of the bibliography deals with scheduling applications. These include: generator and transmission maintenance scheduling, flow shop scheduling, hydrothermal scheduling, optimal operational planning of energy plants, blending scheduling, power generation scheduling, tasks scheduling in distributed computer system, scheduling in battery energy storage systems, job-shop scheduling , radar time management, project scheduling, train scheduling, timetable scheduling, production scheduling ,assembly scheduling, manufacturing scheduling.

III. DEMERITS OF PSO

1) The fitness function can be non-differentiable (only values of the fitness function are used). The method can be applied to optimization problems of large dimensions, often producing quality solutions more rapidly than alternative methods.
2) There is no general convergence theory applicable to practical, multidimensional problems. For satisfactory results, tuning of input parameters and experimenting with various versions of the PSO method is sometimes necessary. Stochastic variability of the PSO results is very high for some problems and some values of the parameters. Also, some versions of the PSO method depend on the choice of the coordinate system.
3) Original PSO approach (1995) is to optimize the solution using global top there is chance to trap in local area. No suggestion is provided for such situation. As the algorithm considers the best value found by neighbors it is more efficient for small number of particles. As the number of particles increases, gbest version is more beneficial. A Modified Particle Swarm Optimizer (1998) works better but only small benchmark function it uses to test. There is difficulty to select probable value of inertia weight.

IV. THE PRESENT RESEARCH SITUATION OF THE PSO ALGORITHM

The PSO method is based on swarm intelligence. The research on it is just at the beginning. Far from the Genetic algorithm (GA) and the simulated annealing (SA) approach, the POS has no systematical calculation method and it has no definite mathematic foundation. At present, the method can only be used successfully in the aspect of Evolutionary neural link, and its other applications are still being explored. By the national papers on it, the research on PSO concerns mostly the mathematic foundation and application research. The mathematic foundation includes the mechanical principle of PSO itself, the prove of its convergence and Robustness and etc. In the openly published forms, there are fewer papers about the study on its mathematic basis, the prove on the convergence and the estimate of the speed of the convergence has not been found., which demands the research on the PSO should be perfected; The application research involves continuing its advantages, overcoming its shortcomings and developing its application choices. The study on PSO should be focused on the following :some modern technologies should be applied to PSO to design the improved PSO; PSO can be combined with the other intelligent optimization methods to design

V. THE IMPROVEMENT OF PSO ALGORITHM

The compound PSO put forward by Angeline is based on the basic mechanism and the selection mechanism created during the development of the computers (Angeline P J, 1999). Due to PSO's depending on Pbest and Gbest during its searching, the area to be searched will be confined greatly. The introduction of the selection mechanism will solve the problem gradually. The test result shows although selection has better effect than basic PSO in the most tested functions, the result is less satisfying as far as the function "Griewank" is concerned. As a result, this method improve PSO's searching ability for the partial, meanwhile, it makes the searching for the whole area less powerful.

VI. THE BLENDING OF THE PSO ALGORITHM AND THE OTHER INTELLIGENT ALGORITHM

The main process of the particle swarm optimization algorithm put forward by Gaoying based on depends on the main process of basic particle swarm optimization algorithm (Gao Ying, Xie Shengli,2004). To introduce the simulated annealing (SA) approach, hybrid algorithm in the hybrid particle swarm optimization algorithm and mutation algorithm in the mutation particle swarm optimization algorithm are adapted to regulate further the optimized swarm. Angeline introduces the selection particle and the better particles selected after each generation is reproduced into the next generation to ensure the particle swarm has the better property. This algorithm has a better effect on the single peaks function. Higash(Higashi N,Iba H ,2003) and the other persons put forward their own mutation algorithms. By introducing the mutation particle, the algorithms escape the attraction of the optimized point in the partial area to improve the searching ability for the whole area. Inspired by the ants' behavioral pattern in their searching food, Italian Colorni and Dorigo(Colorni A,Dorigo M,Maniezzo V,et al,1991;Dorigo M,Maniezzo V,Colorni A,1996),ACO put forward originally Ant Colony Optimization, another kind of intelligent optimization algorithm.

VII. FUTURE SCOPE FOR RESEARCH

Particle swarm optimization is a new heuristic optimization method based on swarm intelligence. Compared with the other algorithms, the method is very simple, easily completed and it needs fewer parameters, which made it fully developed. However, the research on the PSO is still at the beginning, a lot of problems are to be resolved. The research on PSO will be mainly concentrated on the following:

1) The math's basic theory of the Algorithm Although PSO's application has been proved to be effective, its theoretical foundation is rather weak. Clerc and Kennedy (Clerc M,Kennedy J ,2002)make a analysis on the convergence of the method from the point of math's. By analyzing the stability of the condition transmitting matrix, they find the limited conditions where the particle can move stably. Based on this, Bergh makes the further analysis on it
2) Topology of the particle swarm Research on the topology of the new pattern particle swarm which has a better function can be carried out. The neighboring topology of the different particle swarms are based on the imitation of the different societies. It is meaningful to the use and spread of the algorithm to select the proper topology to enable PSO have the best property and do the research on the suitable ranges of different topologies.

VIII. CONCLUSION

This paper has proposed the PSO algorithm as a new evolutionary technique to optimize the power loss. The proposed approach utilizes the local and the global capabilities to search for optimal loss reduction by installing the shunt compensator. The approach can be applied for a wide range of Power System optimization problems. The picture we obtain is that of a technique with an immense scope of applications, ranging from biological and medical to electrical, electronic, and electromagnetic, to practical computational intelligence applications, to combinatorial problem solving, to image analysis, signal processing and graphics, to robotics. What is particularly amazing is the rate of growth of PSO publications most of which are in fact about applications of the technique. The number of publications reporting PSO applications has grown nearly exponential for the last few years, and seems to show no sign of slowing down at the present moment.

What makes PSO so attractive to practitioners? Clearly, the algorithm shines for its simplicity and for the ease with which it can be adapted to different application domains and hybridized with other techniques. This is perhaps what most people want from a practical problem solver: being able to learn the basics of a new technique quickly, and being able to use it as a building block to be mixed and matched with whatever tools they are already familiar with. Also, the PSO routinely delivers good optimization results. Most people will not care as to whether their new tool is guaranteed to give the absolute best performance on a problem. What they want is something simple and reliable. Finally, probably the PSO has, at the moment, in the mind of many people the sort of magical black box flavor that attracted so many researchers to other areas of artificial/computational intelligence (such as neural network, genetic algorithms, or fuzzy systems) before.

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