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STUDY OF PSO OPTIMIZED PID CONTROLLER

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Abstract: This paper presents optimization technique to optimize PID controller usind PSO, the parameters (Kp,Ki & Kd) of which are being selected from optimizations made by PSO. The best output from PSO is selected and then feeded into the SVC (which is used to show PID controller)parameters to get the optimized output of the same. An algorithm has been developed for the same based on PSO. The best and optimized output from the algorithm is seen. A 800KM transmission line and SVC is modeled in the MATLAB . The outputs can be checked with optimized PSO and without PSO optimization. We find that the SVC with PSO optimization is far better then without optimization.
Keywords: Stable Processes; Modified Particle Swarm Optimization (MPSO); Proportional–Integral–Derivative (PID) controller; Automatic voltage regulator (AVR).

I. INTRODUCTION

Proportional–Integral–Derivative (PID) control is the most efficient and widely used feedback control strategy, due to its simplicity and satisfactory control performance. The wide use of PID control has sustained research on finding the key methodology for PID tuning to obtain best possible performance out of the PID control. Optimal control performance can only be achieved after identifying the finest set of proportional gain (Kp), integral gain (Ki) and derivative gain (Kd).

The PSO technique is one of the modern heuristic evolutionary algorithms, which was first introduced by Kennedy and Eberhart [1]. PSO algorithm is a population-based optimization process that has been found to be robust in solving continuous nonlinear optimization problems. They proposed a concept of evolution based on swarm intelligence technique namely PSO, which optimizes a problem by iteratively trying to improve a particle solution to a given measure of quality.

Asifa and Vaishnav [2] proposed PID tuning based on PSO for third order systems, which gives better result over conventional methods like Zeigler Nichols, Tyreus Luyben and Internal model control. Huang [3] suggested self-tuning of PID parameters based on the modified PSO that used “partial particle moving direction changing”.

It holds on the properties of simple structure, fast convergence, and at the same time enhances the variety of the populations, extends the search space, and does not increase the computational complexity. Rahimian and Raahemifar [4] presented a method to design the optimum PID controller parameters for a high order AVR. In this approach a new time-domain cost function with less number of iterations is explained. Pan [5] suggested an optimal PID controller with and without fuzzy by minimizing the fitness function i.e. Integral Time Absolute Error (ITAE) and squared the controller output for a networked control system (NCS). Tuning process is done for a higher order and a time delay system using Genetic Algorithm (GA) and PSO.

Dong Hwa Kim [6] proposed a hybrid AVR system (GA–BF system) based on the conventional GA (Genetic Algorithm) and BF (Bacterial Foraging) which is the social foraging behavior of bacteria.

S. Panda [8] suggested the design and performance analysis of PID controller for an AVR system using simplified PSO also known as Many Optimizing Liaisons (MOL) algorithm. In MOL, randomly choose the particle to update the position and velocity, instead of iterating over the entire swarm to tune the behavioural parameters.

Wang [9] presented self-tuning of PID controller with variable parameters in auto-chlorination control process of tap water using simple PSO and compared results with fuzzy PID controller. In this method, PID parameters are adjusted online according to deviation in output response. Selamat [10] suggested use of PSO in multivariable PID controller tuning for multiple input multiple output process.

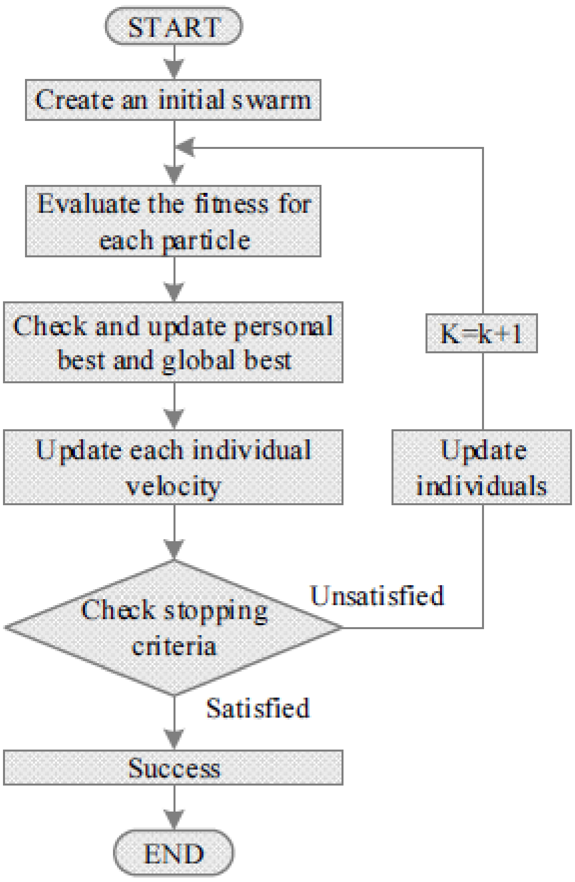
This paper proposes a new modified PSO algorithm and uses it to solve the PID controller design problem for stable processes. The remainder of this paper is organised as follows. Section 2, introduces the control structure for stable process. Section 3, describes the standard PSO algorithm. In section 4, the modified PSO algorithm is clearly presented. Section 5, describes the simulation results and conclusion is given in section 6.

II. CONTROL STRUCTURE

A proportional-integral-derivative (PID) controller is a generic control feedback controller widely used in industrial control systems. A PID controller calculates an ‘error’ value as the difference between a measured process variable and a desired output.

The controller attempts to minimize the error by adjusting the process control inputs.

The PID controller calculation algorithm involves three separate constant parameters, and is accordingly sometimes called three-term control the proportional, the integral and In this paper the application of particle swarm optimization (PSO) for the optimal location and optimal sizing of the SVC with consideration of active power loss reduction and voltage deviation minimization in the power system is highlighted. Particle swarm optimization is a population based stochastic optimization method. This algorithm was inspired from the social behavioral pattern of organisms, such as Bird flocks, fish schools, and sheep herds where aggregated behaviors are met, producing powerful, collision-free, synchronized moves. In such systems, the behavior of each swarm member is based on simple inherent responses, although their collective outcome is rather complex from a macroscopic point of view. For example, the flight of a bird flock can be simulated with relative accuracy by simply maintaining a target distance between each bird and its immediate neighbors. This distance may depend on its size and desirable behavior. The swarms can also react to the predator by rapidly changing their form, breaking into smaller swarms and re-uniting, illustrating a remarkable ability to respond collectively to external stimuli in order to preserve personal integrity. The PSO algorithm consists of a number of particles that collectively move through the search space of the problem in order to find the global optima. Each particle is characterized by its position and fitness. Subsequently, the PSO algorithm updates the velocity vector for each particle then adds that velocity to the particle position. The velocity updates are influenced by both the best global solution associated with the highest fitness ever found in the whole swarm, and the best local solute on associated with the highest fitness in the present population.



III. PROBLEM FORMULATION

For minimizing the load voltage magnitude deviation and loss of power system the determination of the optimal location and the optimal parameter setting of the SVC in the power network is the main objective. For this the performance index is selected:

Min F = F1+F2 = Ploss + VD (1)

Where,

Ploss = network real power loss

VD = voltage deviation

Equality constraints:

$$PGi - PDi - Vi \sum_{j=1}^{Ng} V_j \,(Gij \cos(\theta i-\theta j) + Bij \sin(\theta i-\theta j)) = 0$$

i = 1, 2, ----- NB ---- (4)

$$QGi - QDi - Vi \sum_{j=1}^{Ng} V_j \,(Gij \sin\theta ij - Bij \cos\theta ij) = 0$$

i = 1, 2, ----- NB ---- (5)

Inequality constraints:

$Pgi^{min} \leq Pgi \leq Pgi^{max}$ (6)

$Qgi^{min} \leq Qgi \leq Qgi^{max}$ (7)

$Vi^{min} \leq V i \leq Vi^{max}$ (8)

where,

F is the objective function.

Pgi is the acrive power generation at bus i . Qgi is the active power load at bus i.

Pdi is the active power load at i.

Qdi is the reactive power load at bus i. Vi is the voltage magnitude at bus i.

Vj is the voltage magnitude at bus j. Vref is the reference voltage magnitude

Gij, Bij are mutual conductance and susceptance between bus i and bus j

Xsvc is the reactance of SVC

θij is voltage angle difference between bus i and j NB is total number of buses excluding slack bus NPQ is number of PQ buses

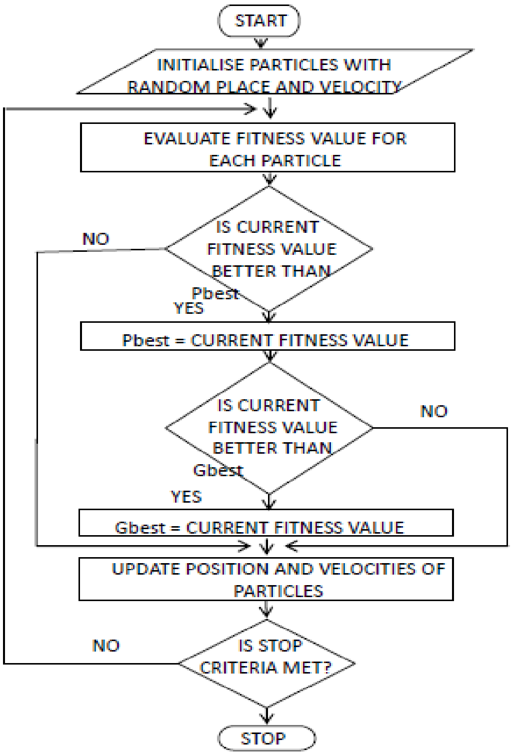
PARTICAL SWARM OPTIMIZATION (PSO):

Mr. Kennedy and Mr. Eberhart first introduced the PSO in the year of 1995.[6] PSO has its roots

PSO BASED PID CONTROLLER

In PSO algorithm, the system is initialized with a population of random solutions, which are called particles, and each potential solution is also assigned a randomized velocity [19]. PSO relies on the exchange of information between particles of the population called swarm. Each particle adjusts its trajectory towards its best solution (fitness) that is achieved so far. This value is called pbest. Each particle also modifies its trajectory towards the best previous position attained by any member of its neighborhood. This value is called *gbest.* Each particle moves in the search space with an adaptive velocity.

The fitness function evaluates the performance of particles to determine whether the best fitting solution is achieved. During the run, the fitness of the best individual improves over time and typically tends to stagnate towards the end of the run. Ideally, the stagnation of the process coincides with the successful discovery of the global optimum.



in artificial life and social psychology as well as in engineering and computer science. It utilizes a population of individuals, called particles, which fly through the problem hyperspace with some given initial velocities.

In each iteration the velocities of the particles are stochastically adjusted considering the historical best position of the particles and their neighborhood best position; where these positions are determined according to some predefined fitness function

IV. IMPLEMENTATION OF PSO ALGORITHM

The optimal values of the PID controller parameters Kp, Ki and Kd, is found using PSO. All possible sets of controller parameter values are particles whose values are adjusted so as to minimize the objective function, which in this case is the error criterion, which is discussed in detail. For the PID controller design, it is ensured the controller settings estimated results in a stable closed loop system.

Selection of PSO parameters

To start up with PSO, certain parameters need to be defined. Selection of these parameters decides to a great extent the ability of global minimization. The maximum velocity affects the ability of escaping from local optimization and refining global optimization. The size of swarm balances the requirement of global optimization and computational cost. Initializing the values of the parameters is as per table.

Population size	100
Number of iterations	100
Velocity constant,c1	2
Velocity constant,c2	2

RESULTS

Analysis shows that the design of proposed controller gives a better robustness, and, the performance is satisfactory over a wide range of process operations. Simulation results show performance improvement in time domain specifications for a step response. Using the PSO approach, global and local solutions could be simultaneously found for better tuning of the controller parameters.

V. CONCLUSION

In this paper, a systematic design method aiming at enhancing PID control for complex processes is proposed. It is proposed both analytically and graphically that there is a substantial improvement in the time domain specification in terms of lesser rise time, peak time, settling time as well as a lower overshoot. PSO presents multiple advantages to a designer by operating with a reduced number of design methods to establish the type of the controller, giving a possibility of configuring the dynamic behavior of the control system with ease, starting the design with a reduced amount of information about the controller (type and allowable range of the parameters), but keeping sight of the behavior of the control system. The performance of the above said method of tuning a PID controller can even be proved to be better than the method of tuning the controller after approximating the system to a FOPTD model, and using the traditional techniques, regarding which a rich literature is available. So this method of tuning can be applied to any system irrespective of its order and can be proved to be better than the existing traditional techniques of tuning the controller.

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